Memorandum

To: Jason Charest, CCRPC
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Date: December 20, 2023

Project #: 58644.13

From: Karen Sentoff

Re: City Center Transportation Analysis

Introduction

As the City of South Burlington contemplates the phasing of anticipated development and long planned connections through the newly established City Center area, understanding the potential traffic redistribution and transportation infrastructure improvements that may be required is key to planning transportation in the area. An evaluation of the transportation implications of new development and new connector roadways within City Center was conducted to identify transportation infrastructure and investments necessary to support growth in City Center. The evaluation included the following elements:

- Review existing conditions;
- Collect traffic turning movement volume data and synthesize;
- Develop base network;
- Develop scenarios and program in regional model;
- Run future scenarios in regional model;
- Evaluate base and future scenarios at intersection scale;
- Assess potential mitigation or infrastructure improvements to support growth; and,
- Evaluate signal and multi-way stop condition warrants for future conditions.

The approach leveraged the CCRPC's regional travel demand model to evaluate a mix of projected land use and planned transportation network connections that are anticipated in the coming years through the City Center area of South Burlington. The evaluation focused on the intersections along Market Street to assess the accommodation of future shifts in travel patterns through the area based on anticipated phasing of development and connector roadways.

Existing Conditions

City Center is concentrated around Market Street in South Burlington, VT. Market Street runs east-west from Dorset Street and the University Mall (U Mall) entrance on the western terminus to Hinesburg Road (VT 116) on the eastern terminus. The general cross-section of Market Street has one travel lane in each direction, parallel parking on both sides of the road, a greenbelt or tree belt, and side paths running parallel to the roadway on both sides. The cross-section narrows at intersections and midblock crossings to provide short, two-lane crossings for pedestrians. The eastern end of the road is the exception to the general cross-section where there is only one parallel parking lane on the south side of the road.

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The western terminus of Market Street at Dorset Street is a four-way signalized intersection. The current configuration of the intersection includes at least two approach lanes on each leg. Dorset northbound has two approach lanes, one through and one shared through/right turn lane. This approach has a left turn prohibition that limits northbound traffic on Dorset Street to enter the U Mall parcel at Garden Street. The southbound approach consists of four lanes, with dedicated left and right turn lanes. The U Mall approach has two left turn lanes and a shared through and right lane. Market Street has a dedicated right turn lane and shared through left turn lane. Each leg of the intersection has marked crosswalks and pedestrian signal heads. Both Market Street and Dorset Street have side paths on both sides of the road.

The eastern terminus at Hinesburg Road is a three-way intersection, with the Market Street approach stop controlled. Market Street has a two-lane approach to the intersection, with dedicated left and right turn lanes. The northbound Hinesburg Road approach has a dedicated left turn lane. The southbound approach is a single lane approach with a painted median. The side paths parallel to Market Street terminate at the intersection with connection to the north-south sidewalk on the western edge of Hinesburg Road. There is a marked crosswalk across the stop-controlled Market Street leg of the intersection.

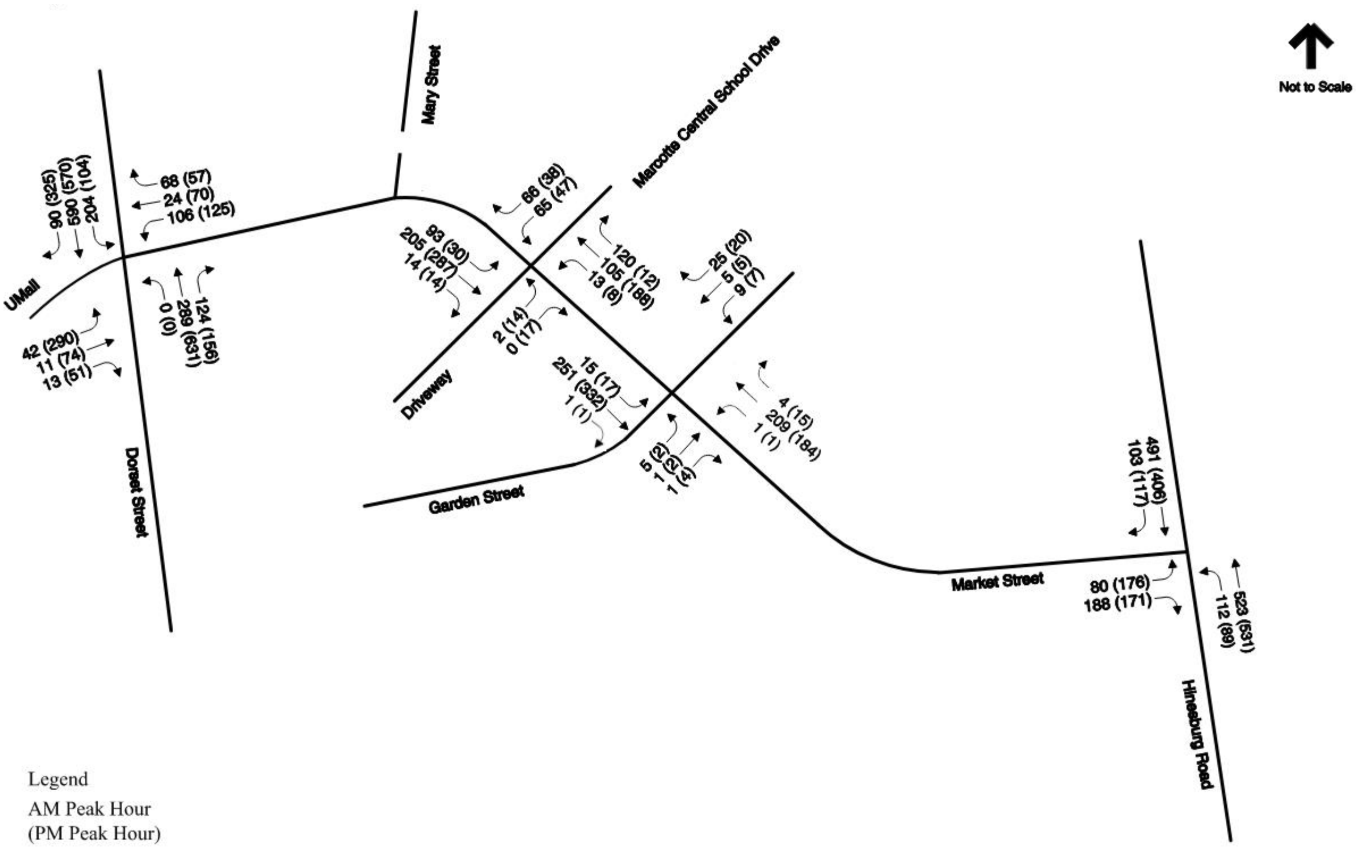
The remaining intersections along the length of Market Street include Mary Street, Marcotte Central School access, and Garden Street. Each intersection currently provides access to adjacent uses, but no roadway connectivity beyond to other facilities or areas. The intersections of Market Street with Mary Street and with Garden Street are currently uncontrolled. The intersection of Market Street with the Marcotte Central School access was recently changed to an all-way stop controlled intersection. For the purposes of evaluation, the Mary Street and Garden Street intersections were assumed to be two-way stop controlled with stop conditions for the side streets and the Marcotte Central School intersection was all-way stop controlled.

Along Market Street, each side street has a marked crosswalk with appropriate curb ramps and detectable warning surfaces to cross the side street leg of the intersection. In addition, crossings of Market Street are available that are marked, accessible (i.e., curb ramps and detectable warnings), and conspicuously signed (i.e., high visibility gate-posted signage) are available at the eastern leg of the Mary Street intersection, both the east and west legs of the Garden Street intersection, and at the eastern edge of Market Street Park. The Central School access intersection also has marked and accessible crossings across all four stop-controlled approaches.

Base Network Development

The base network was developed based on observed traffic patterns along Market Street. Turning movement counts were conducted at the existing intersections of Market Street with Dorset Street, Marcotte Central School, Garden Street, and Hinesburg Road. Counts were collected on Thursday, April 13th, 2023. Peak hours were observed in the morning between 7:30 AM and 8:30 AM and in the evening between 3:15 PM and 4:15 PM along Market Street. Observed peak hours on Dorset Street and Hinesburg Road differed slightly, where the Market Street / Dorset Street AM peak hour was between 9 AM to 10 AM and Market Street / Hinesburg Road PM peak hour was between 4:30 PM to 5:30 PM. For modeling purposes, the global peak hours on Market Street of 7:30 AM and 3:15 PM were used. The peak hour data were seasonally adjusted by a factor of 1.18 to represent the design hour volume for the turning movements, adjusting to reflect the 30th highest volumes of the year. The seasonally adjusted peak hour data for each intersection is depicted in **Figure 1**.

Figure 1. Peak Hour Base Network



Scenario Development

Given the anticipated development patterns and anticipated phasing for the network connections, scenarios were developed to test the various stages of projected growth and transportation infrastructure in the City Center area. The scenarios were developed and programmed in the regional model to represent the additional growth anticipated in the area and progressively add new network connections, while accounting for background growth in the region.

For the anticipated roadway network changes, the changes were programmed into the regional model master network. This included adjustment to the geometry of Garden Street to reflect the designed (connection to Midas Drive) and constructed (southern segment) alignments, addition of Mary Street connecting through to Williston Road, and addition of a north-south connector through the Blue Mall parcel between Garden Street and Market Street. The connector roadways are depicted in **Figure 2**. Each of these connectors were programmed as two-lane facilities serving two-way traffic with a 25-mph speed limit. The addition of network connectors to the future scenarios was cumulative, so that each subsequent scenario added an additional network connector roadway.

Figure 2. City Center Roadway Network Connectors

For the area's anticipated growth, scenario development entailed review of the anticipated parcel build out. Build out included permitted projects (in bold) in the near-term, planned or anticipated projects (plain font) in the mid-term, or hypothetical development (in italics) in the long-term. The projects identified included new developments or future infill developments in the following areas:

- **Union Place (303 Market Street)**
- **Prospect Place (112 Garden Street)**
- **Catamount Run (Lot B and Lot N)**
- **1068 Williston Road**
- Lot M4
- Lot M6
- Lot G
- Market & Hinesburg
- *155 Market Street*
- *Blue Mall*
- *2 Market Street*
- *Mary Street*

The distribution of these anticipated developments across various parcels or areas provided the basis for which traffic analysis zones (TAZ) in the regional model required adjustments to growth compared to previously programmed land use. For each anticipated type of development, the land use adjustments were estimated either by the number of household units for residential development or by the number of employees in retail, commercial, institutional, and accommodations use types. The anticipated gross floor areas for each type of non-residential development were provided and, in combination with the appropriate land use code (LUC), the number of trips and subsequent number of employees were assigned based on estimates from the Institute of Transportation Engineers *Trip Generation Manual 11th Edition*.

The land use inputs for the regional model were adjusted based on the number of households and employees for each affected TAZ, considering the previously programmed land use growth for each time horizon. For households, the growth previously programmed for the selection of TAZs was inadequate compared to the anticipated development, therefore the number of additional anticipated units above the previously programmed households was applied. For employees, the number of anticipated employees was closer to previously programmed growth in the area and therefore the refined estimates replaced the previously programmed employee numbers. Both employees (by use type) and household units were redistributed to TAZs identified in the anticipated parcel build out.

The roadway network connectors, future land use scenarios, and anticipated local developments were combined to create five scenarios. These scenarios are described in **Table 1** in terms of the scenario name, roadway network connectors, model land use inputs, additional total household units, and total change of employees accounted for within the City Center TAZs. Note that the roadway network additions per scenario were cumulative such that connectors were added to the previous scenario and not evaluated individually.

Table 1. Network and Development Scenarios

			Households		Employees*	
Scenario	**Roadway Network**	**Land Use**	**Previous Regional Model Assumption**	**Additional Units for Planned Development**	**Previous Regional Model Assumptions**	**Updated Totals for Planned Development**
Model Base	Updated Base	2025				
No Build	Garden Street South	2030	90	559	173	243
Partial A	Garden Street North	2035	91	92	174	135
Partial B	Mary Street					
Full	Blue Mall Connection	2040	90	332	171	196

* ITE Units to Trips to Employees based on LUC

The first scenario was an updated base model to reflect changes to demand distribution locally to better reflect the activity along Market Street and within City Center. A comparison of the base model scenario with observed count data along Market Street revealed a percent difference of approximately 30% on average in the AM peak hour and 8% on average in the PM peak hour. The updated base model served as the base against which relative change for each subsequent scenario was measured. The relative change represented by each of the other four scenarios was then applied to the adjusted base network to evaluate the transportation network at the localized scale. These scenarios are illustrated in **Figure 3** through **Figure 6** on the following pages.

Figure 3. 2030 No Build

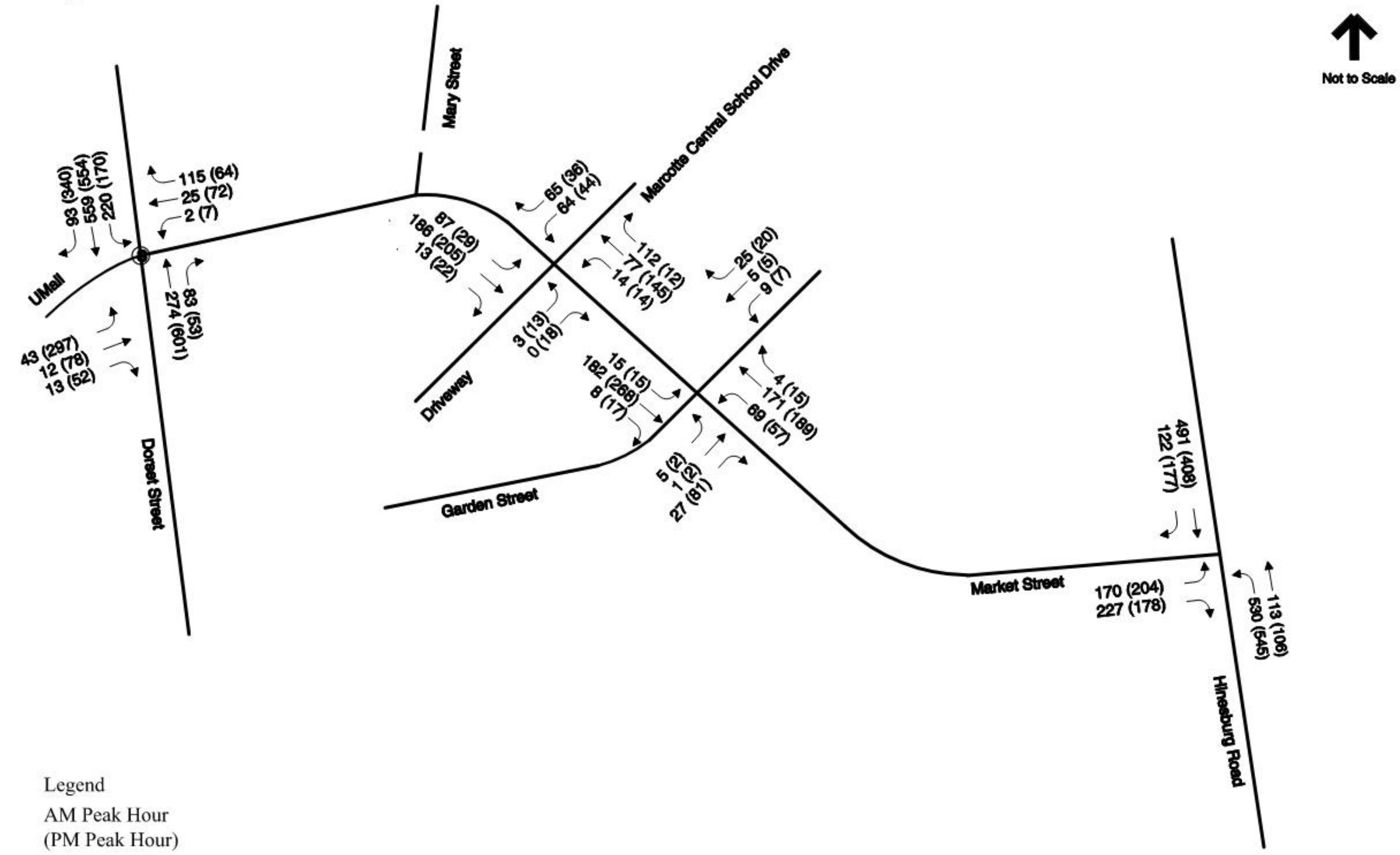


Figure 4. 2035 Partial A

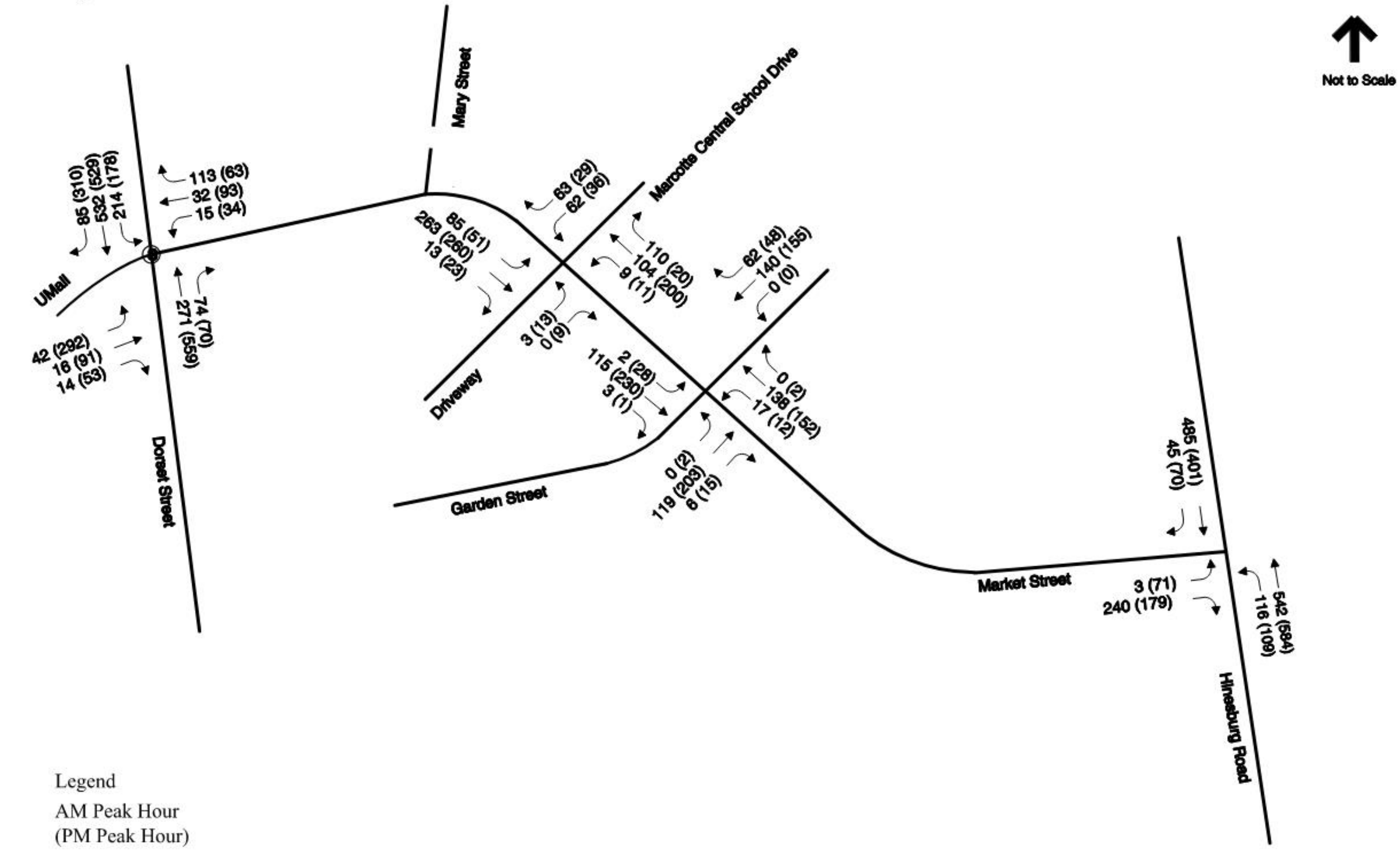


Figure 5. 2035 Partial B

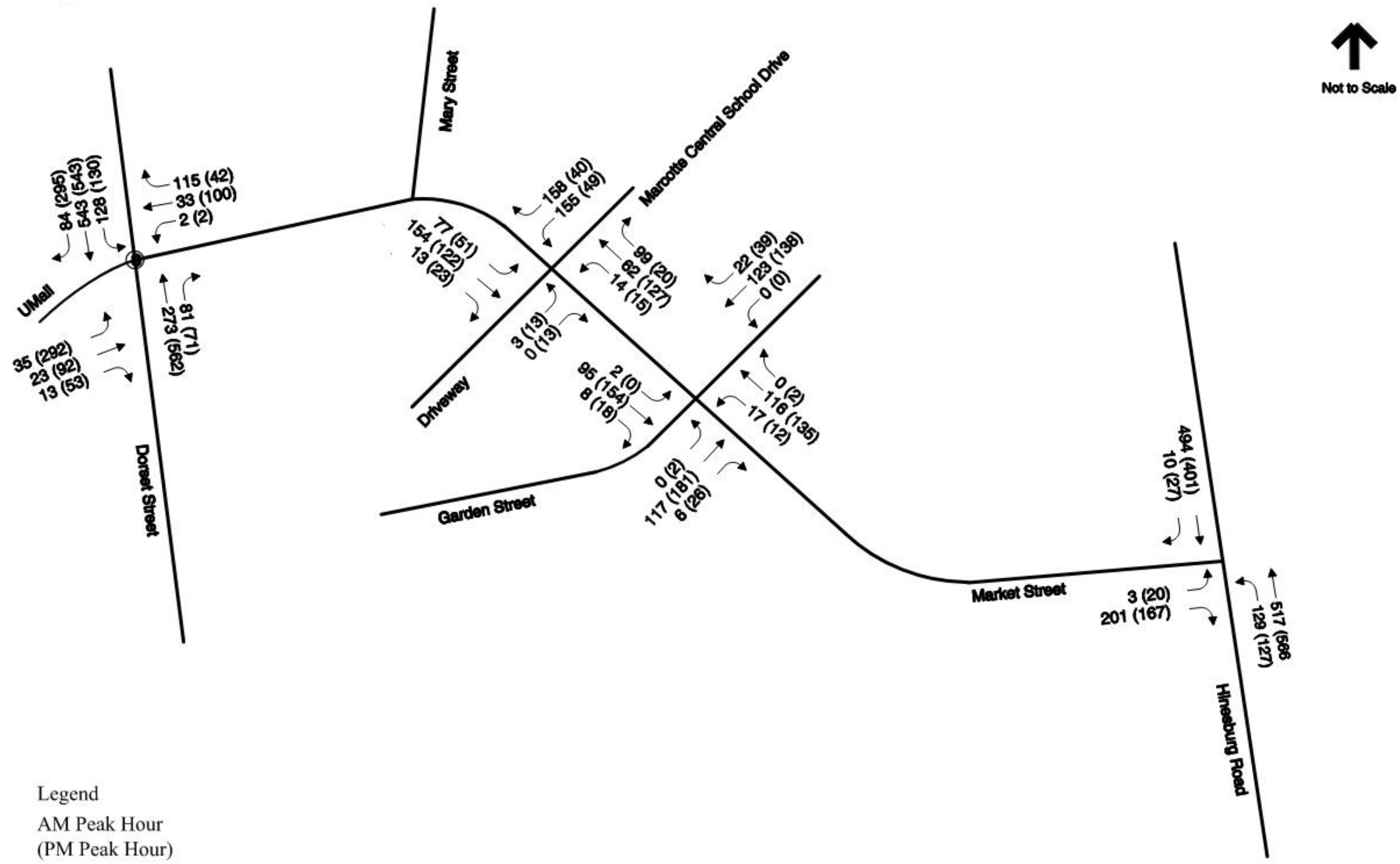
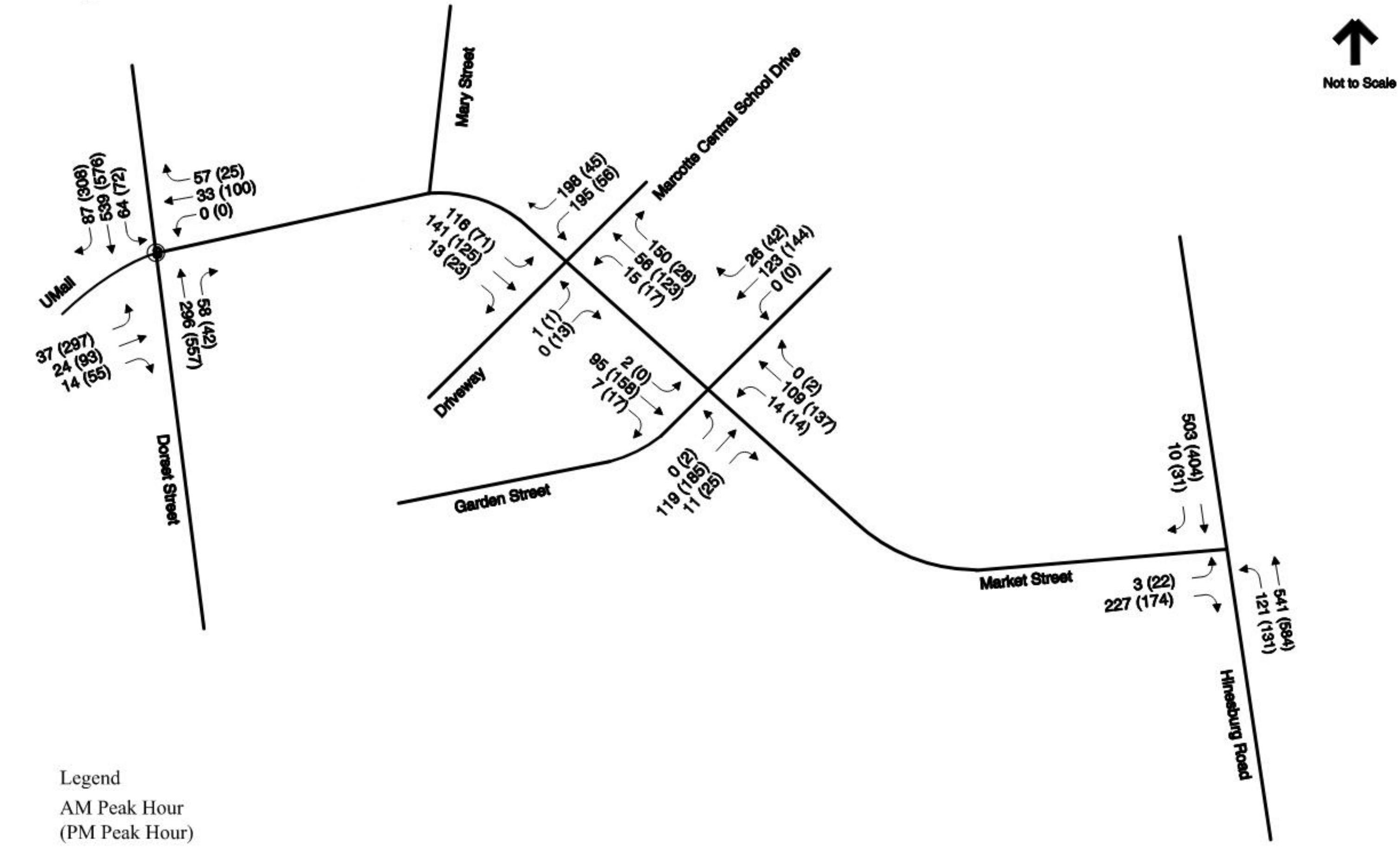


Figure 6. 2040 Full Build



Scenario Evaluation

The five model scenarios were coded into the regional model and evaluated. The vehicular volumes and turning movement counts were extracted from the model for AM and PM peak periods. Each scenario's turning movement estimates were then compared to the model base. The relative change between each scenario and model base was applied to the adjusted base network scenario to represent the updated volumes for each scenario. The updated vehicular volumes were entered into Synchro to evaluate the capacity of each intersection in the study area.

Although only vehicular volumes were extracted from the model for the purposes of this evaluation, it is important to note that the model applies assumptions regarding mode split and walkability. Still the vehicular volumes were anticipated to remain slightly conservative as the emphasis on mixed use and other modes (i.e., transit, bike, pedestrian) in the City Center area is likely to produce more aggressive internal capture, mode split, and future transportation demand management compared to the modeled outcomes.

The adjusted base network was considered the base scenario for evaluation purposes. Observed pedestrian counts were used in the base scenario and were grown by 5% for each subsequent scenario. Heavy vehicle percentages were used from the count data consistently through the scenarios and limited to a maximum 10% on approaches that exceeded that percentage as they were low volume and currently serving construction vehicles. This represented a conservative scenario in terms of heavy vehicle mix.

The signalized intersection of Market Street and Dorset Street was evaluated for each scenario. For signalized intersections, HCM 2000 was used to evaluate capacity and to account for exclusive pedestrian phasing. The capacity analysis, including volume-to-capacity (v/c), delay (seconds), level of service, and 95th percentile queues (feet), are summarized for each lane group and approach in **Table 2**.

Based on analysis, the Market Street and Dorset Street intersection currently operates at LOS C and LOS E overall in the AM and PM peak hours, respectively. As demonstrated by the No Build scenario and subsequent scenarios, the connector roadways through City Center generally alleviated delay at the intersection and shorten queues, improving operations to LOS D in the PM peak hour compared to the base scenario, which is considered a level of service typical of a downtown intersection. The improvement was particularly evident for the northbound approach, which improved from LOS F to LOS E with the addition of the southern segment of Garden Street (i.e., No Build Scenario) and continued to improve as the network was further connected throughout City Center, even with significant growth anticipated through the area.

Table 2. Signalized Intersection Capacity Analysis

		2023 Base Scenario				2030 No Build				2035 Partial A				2035 Partial B				2040 Full Build			
	Intersection	v/c	Delay	LOS	Queue (ft)	v/c	Delay	LOS	Queue (ft)	v/c	Delay	LOS	Queue (ft)	v/c	Delay	LOS	Queue (ft)	v/c	Delay	LOS	Queue (ft)
	Market Street / Dorset Street																				
AM	**Overall**	**0.42**	**23.9**	**C**		**0.31**	**21.9**	**C**		**0.32**	**22.5**	**C**		**0.29**	**22.3**	**C**		**0.29**	**22.0**	**C**	
AM	UMall EB	0.22	35.6	D		0.23	35.5	D		0.22	34.5	C		0.18	32.2	C		0.18	31.8	C	
AM	UMall EBL	0.22	43.3	D	28	0.23	43.4	D	29	0.22	43.3	D	28	0.18	42.5	D	25	0.18	41.9	D	25
AM	UMall EBTR	0.03	22.0	C	22	0.03	22.0	C	23	0.04	22.1	C	26	0.05	22.1	C	31	0.05	21.9	C	32
AM	Market Street WB	0.47	34.6	C		0.08	29.7	C		0.14	29.9	C		0.09	29.8	C		0.09	29.4	C	
AM	Market Street WBTL	0.47	37.4	D	123	0.07	29.6	C	35	0.14	30.4	C	52	0.09	29.8	C	42	0.09	29.8	C	40
AM	Market Street WBR	0.04	29.3	C	0	0.08	29.7	C	10	0.07	29.7	C	9	0.08	29.7	C	10	0.04	29.2	C	0
AM	Dorset Street NB	0.63	40.1	D	140	0.57	38.4	D	127	0.6	40.0	D	126	0.56	38.1	D	126	0.54	36.5	D	128
AM	Dorset Street SB	0.35	13.0	B		0.36	12.9	B		0.34	12.8	B		0.3	12.5	B		0.3	12.5	B	
AM	Dorset Street SBL	0.35	14.6	B	#138	0.36	14.5	B	146	0.34	14.3	B	142	0.21	12.9	B	88	0.11	12.2	B	50
AM	Dorset Street SBT	0.33	13.4	B	176	0.31	13.2	B	166	0.29	13.1	B	157	0.3	13.2	B	162	0.3	13.4	B	162
AM	Dorset Street SBR	0.06	7	A	24	0.06	7	A	24	0.06	7	A	23	0.06	7	A	23	0.06	7	A	23
PM	**Overall**	**0.7**	**63.9**	**E**		**0.54**	**46.4**	**D**		**0.57**	**42.2**	**D**		**0.53**	**42.8**	**D**		**0.51**	**38.1**	**D**	
PM	UMall EB	1.01	73.7	E		1.01	74.3	E		1.02	74.3	E		0.96	62.4	E		0.92	55.9	E	
PM	UMall EBL	1.01	96.1	F	#169	1.01	97.2	F	#173	1.02	100.0	F	#172	0.96	82.6	F	#166	0.92	73.1	E	#163
PM	UMall EBTR	0.16	21.8	C	73	0.17	21.7	C	77	0.2	22.2	C	88	0.2	21.8	C	88	0.2	21.5	C	89
PM	Market Street WB	0.72	44.2	D		0.21	30.5	C		0.38	32.7	C		0.27	31.3	C		0.26	31.5	C	
PM	Market Street WBTL	0.72	48.6	D	#203	0.21	31.4	C	77	0.38	34.4	C	116	0.27	32.2	C	95	0.26	32.1	C	94
PM	Market Street WBR	0.04	29.2	C	0	0.04	29.3	C	0	0.04	29.3	C	0	0.03	29.1	C	0	0.02	29.0	C	0
PM	Dorset Street NB	1.16	125.2	F	#370	1.03	79.4	E	#298	0.96	63.4	E	#274	1	71.7	E	#284	0.92	56.7	E	#268
PM	Dorset Street SB	0.39	16.4	B		0.45	17.1	B		0.47	17.0	B		0.37	16.8	B		0.44	19.0	B	
PM	Dorset Street SBL	0.27	19.8	B	77	0.45	22.7	C	#131	0.47	23.0	C	#145	0.34	21.0	C	95	0.24	21.8	C	59
PM	Dorset Street SBT	0.39	19.0	B	178	0.38	19.0	B	173	0.36	18.7	B	164	0.37	19.5	B	171	0.44	22.2	C	184
PM	Dorset Street SBR	0.21	10.8	B	42	0.22	11	B	43	0.2	10.8	B	41	0.19	10.7	B	41	0.2	12.3	B	41

 # indicates the 95^{th} percentile queue exceeds capacity and queues may be longer than noted

The unsignalized intersections in City Center were similarly evaluated for each scenario. For unsignalized intersections, HCM 6th Edition was used to evaluate capacity. The capacity analysis, including volume-to-capacity (v/c), delay (seconds), level of service, and 95th percentile queues (vehicles), are summarized for each movement in **Table 3**.

The intersections of Market Street with Marcotte Central School and with Garden Street both operate with less than 15 seconds of delay on any given approach, resulting in LOS B or better, in the current and No Build scenarios. When the northern segment of Garden Street is connected to Midas Drive in the Partial A Scenario, the delay in the PM peak hour on the stop controlled Garden Street approaches is expected to increase to less than 25 seconds of delay. As traffic shifts to use the Garden Street connection between Dorset Street and Williston Road, the intersection approaches are expected to maintain LOS C. Connecting Mary Street is expected to alleviate some of this delay, with delays of less than 20 seconds on the Garden Street approaches expected in the subsequent scenarios. Given the shift of volumes anticipated at the Garden Street intersection, additional analysis to evaluate the potential for multi-way stop control was conducted for each scenario and detailed below.

The intersection of Market Street with Hinesburg Road currently operates with LOS D and LOS F on the Market Street approach in the AM and PM peak hours, respectively. The delay is expected to increase significantly when the southern segment of Garden Street is connected in the network resulting in LOS F operation, with nearly a minute and a half of delay expected in the AM peak hour and almost two minutes of delay expected in the PM peak hour. Although this delay is expected to be partially mitigated with the addition of the northern segment of Garden Street in the network, the Market Street approach is expected to continue to operate at LOS C overall and the eastbound left at LOS D/E in the AM and PM peak hours consistently in the subsequent scenarios. Given the anticipated volume and delay at the Market Street and Hinesburg Road intersection in future scenarios, signal warrants for the intersection were evaluated for each scenario and detailed below.

Table 3. Unsignalized Intersection Capacity Analysis

		2023 Base Scenario				2030 No Build				2035 Partial A				2035 Partial B				2040 Full Build			
	Intersection	v/c	Delay	LOS	Queue	v/c	Delay	LOS	Queue	v/c	Delay	LOS	Queue	v/c	Delay	LOS	Queue	v/c	Delay	LOS	Queue
AM	Market Street / Marcotte School																				
AM	Market EB	0.392	10.4	B	1.9	0.354	9.9	A	1.6	0.451	11.1	B	2.3	0.334	10.4	B	1.5	0.4	11.9	B	1.9
AM	Market WB	0.284	9.0	A	1.2	0.239	8.6	A	0.9	0.27	9.0	A	1.1	0.228	9.1	A	0.9	0.306	10.2	B	1.3
AM	Driveway NB	0.003	8.6	A	0	0.005	8.4	A	0	0.005	8.7	A	0	0.005	8.6	A	0	0.005	9.1	A	0
AM	Marcotte School SB	0.179	9	A	0.6	0.172	8.8	A	0.6	0.174	9.1	A	0.6	0.41	11	B	2	0.541	13.8	B	3.3
AM	Market Street / Garden Street																				
AM	Market EB	0.012	7.8	A	0	0.011	7.8	A	0	0.016	7.7	A	0	0.001	7.6	A	0	0.001	7.6	A	0
AM	Market WB	-	0	A	0	0.052	7.9	A	0.2	0.012	7.6	A	0	0.012	7.6	A	0	0.01	7.6	A	0
AM	Garden NB	0.015	14.1	B	0	0.052	11	B	0.2	0.237	13.9	B	0.9	0.209	12.7	B	0.8	0.216	12.6	B	0.8
AM	Garden SB	0.064	11.3	B	0.2	0.068	11.7	B	0.2	0.351	14.6	B	1.6	0.244	13	B	1	0.245	12.8	B	1
AM	Market Street / Hinesburg Road																				
AM	Market EB	0.519	26.2	D		1.133	84.1	F		0.436	16.8	C		0.361	15.4	C		0.413	16.4	C	
AM	Market EBL	0.519	51.2	F	2.5	1.133	173.6	F	9.3	0.032	28.8	D	0.1	0.032	28.8	D	0.1	0.033	29.5	D	0.1
AM	Market EBR	0.356	15.5	C	1.6	0.436	17.1	C	2.2	0.436	16.5	C	2.2	0.361	15.1	C	1.6	0.413	16.1	C	2
AM	Hinesburg NB	0.117	1.6			0.12	1.6			0.115	1.6			0.125	1.8			0.119	1.6		
AM	Hinesburg NBL	0.117	9.3	A	0.4	0.12	9.4	A	0.4	0.115	9	A	0.4	0.125	9	A	0.4	0.119	9	A	0.4
AM	Hinesburg NBT	-	0	A	-	-	0	A	-	-	0	A	-	-	0	A	-	-	0	A	-
AM	Hinesburg SB		0				0														
PM	Market Street / Marcotte School																				
PM	Market EB	0.407	10.4	B	2.0	0.307	9.3	A	1.3	0.403	10.3	B	2.0	0.235	8.7	A	0.9	0.264	8.9	A	1.1
PM	Market WB	0.262	9.2	A	1.0	0.21	8.6	A	0.8	0.284	9.2	A	1.2	0.194	8.4	A	0.7	0.202	8.4	A	0.8
PM	Driveway NB	0.043	8.3	A	0.1	0.041	7.9	A	0.1	0.031	8.3	A	0.1	0.033	7.8	A	0.1	0.017	7.4	A	0.1
PM	Marcotte School SB	0.119	8.7	A	0.4	0.105	8.3	A	0.4	0.091	8.5	A	0.3	0.113	8.2	A	0.4	0.13	8.3	A	0.4
PM	Market Street / Garden Street																				
PM	Market EB	0.013	7.9	A	0	0.012	7.9	A	0	0.022	7.8	A	0.1	-	0	A	0	-	0	A	0
PM	Market WB	-	0	A	0	0.049	8.2	A	0.2	0.01	8	A	0	0.009	7.8	A	0	0.011	7.9	A	0
PM	Garden NB	0.019	13.7	B	0.1	0.147	12.3	B	0.5	0.551	24.6	C	3.2	0.423	17.5	C	2.1	0.441	18.3	C	2.2
PM	Garden SB	0.062	12.4	B	0.2	0.072	13.7	B	0.2	0.469	20.4	C	2.4	0.35	15.9	C	1.6	0.373	16.4	C	1.7
PM	Market Street / Hinesburg Road																				
PM	Market EB	0.917	54.8	F		1.244	116.4	F		0.42	21.2	C		0.12	14.7	B		0.281	15.1	C	
PM	Market EBL	0.917	94.9	F	7.2	1.244	205.5	F	11.5	0.42	40.9	E	1.9	0.12	29.6	D	0.4	0.138	31.2	D	0.5
PM	Market EBR	0.291	13.6	B	1.2	0.316	14.3	B	1.3	0.294	13.4	B	1.2	0.268	12.9	B	1.1	0.281	13.1	B	1.1
PM	Hinesburg NB	0.085	1.3			0.11	1.5			0.103	1.4			0.115	1.6			0.12	1.6		
PM	Hinesburg NBL	0.085	8.8	A	0.3	0.11	9.2	A	0.4	0.103	8.8	A	0.3	0.115	8.7	A	0.4	0.12	8.7	A	0.4
PM	Hinesburg NBT	-	0	A	-	-	0	A	-	-	0	A	-	-	0	A	-	-	0	A	-
PM	Hinesburg SB		0				0				0				0				0		

Market Street and Garden Street

The Market Street and Garden Street intersection was anticipated to receive significantly more traffic on the Garden Street approaches in future scenarios. As such, the Market Street and Garden Street intersection was evaluated using the multi-way stop control methodology outlined in the *Manual on Uniform Traffic Control Devices* (MUTCD)[1] to determine if multi-way stop control was warranted at this location. For the intersection, the hourly distribution of vehicular volumes was estimated based on three adjacent count locations[2]. For the base scenario, the hourly distribution was used in conjunction with the peak hour turning movement count conducted as part of this study to develop a 24-hour distribution of volume. For each subsequent scenario, a 24-hour distribution of volume was developed based on the peak hour volume estimates for each scenario and the average hourly distribution based on the count locations.

The MUTCD provides criteria that should be considered for installation of a multi-way stop sign, including the following:

- Criteria A indicates that if a signal is justified, a multi-way stop sign may be an interim measure while waiting for signal installation;
- Criteria B indicates that five or more crashes in the previous 12 months could be mitigated with multi-way stop control (i.e., left-turn, right-turn, and right-angle crash types);
- Criteria C provides minimum volume criteria based on the following:
  - 1. Vehicular volume entering from the major street approaches averages at least 300 vehicles per hour for any 8-hours of an average day; and,
  - 2. Vehicular, pedestrian, and bicycle volume entering from the minor street approaches averages at least 200 units per hour for the corresponding 8-hours with an average delay to the minor street approach of at least 30 seconds per vehicle for the highest hour; but,
  - 3. If 85th percentile speeds on the major street are 40 mph or greater, the vehicular volumes are 70 percent of the thresholds for the major (C.1) and minor (C.2) street approaches.
- Criteria D provides that where no single criterion is met but Criteria B, C.1, and C.2 are met to 80 percent of the thresholds.

Criteria C was the primary focus of this analysis as traffic signal warrants were not anticipated to be satisfied for Criteria A and there were not yet crash data that reflect the future scenario conditions for Criteria B. The volume thresholds from Criteria C.1 and C.2 were met for Partial A and were met for Partial B and Full Build scenarios when the major street was considered Garden Street, switching Market Street to the minor street. Although the volume thresholds were met for the intersection in these future scenarios, the average delay on the minor street approaches was not anticipated to exceed the 30 second threshold in C.2. As such, the conditions for multi-way stop were not satisfied as reflected in **Table 4**. Criteria C.3 does not apply as 85th percentile speeds do not meet the 40 mph criteria. Criteria D was checked, but the average delay was not expected to exceed 80% of the threshold either.

[1] Manual on Uniform Traffic Control Devices, FHWA, 2012

[2] VTrans Transportation Data Management System Count Locations D133, D211, and D559

Table 4. Multi-way Stop Criteria C Conditions

Scenario	Multi-way Stop Warrant Warrant Met	Condition C.1 Volume Any 8 Hour Avg > 300 vph Major Street	Condition C.2 Volume Same 8 Hour Avg > 200 vph Minor Street	Condition C.2 Delay Minor Street Delay > 30 sec Minor Street
Base	no	yes	no	no
No Build	no	yes	no	no
Partial A	no	yes	yes	no
Partial B*	no	yes	yes	no
Full*	no	yes	yes	no

**indicates scenario tested with Garden Street volumes considered the major street approach*

Although this analysis indicated that a multi-way stop was not anticipated to be warranted for future scenarios, careful consideration of the switch between Market Street serving greater volumes to Garden Street serving greater volumes in future conditions at this intersection should be revisited. As Garden Street continues to be more trafficked and traffic patterns shift as a result of development and network connectivity, the intersection volumes, delays, and crash patterns should be monitored and evaluated to determine if a multi-way stop is warranted in a future, observed condition.

Market Street and Hinesburg Road

The Market Street approach to Hinesburg Road was anticipated to continue to experience delays into future scenarios given the current configuration and control. As such, potential mitigations for the intersection were explored.

Opening the northern segment of Garden Street simultaneous to the southern segment of Garden Street may be one approach to mitigating delay at the Market Street and Hinesburg Road intersection. Given the improvements required to connect Midas Drive to Garden Street and to realign and upgrade the signal at the White Street / Midas Drive / Williston Road intersection, other mitigations to address delays at the Market Street and Hinesburg Road intersection were considered.

Although an all-way stop condition at the intersection of Market Street and Hinesburg Road would mitigate the delay on the Market Street approach, the delay on the northbound and southbound approaches on Hinesburg Road (VT-116) would increase significantly, resulting in LOS E or LOS F on one or both approaches in each scenario. Signalization of the intersection, however, would improve the operations to LOS A overall across all scenarios. The eastbound left would see the most delay at the intersection (LOS B) and serve the lowest volume in the future, full build out scenario. To further evaluate the congestion mitigation of signalizing the Market Street and Hinesburg Road intersection, signal warrants were assessed for the intersection across the future scenarios.

The Hinesburg Road and Market Street intersection was evaluated using the traffic signal warrant methodology outlined in the *Manual on Uniform Traffic Control Devices* (MUTCD)[3] to determine if a signal was warranted at this location. For the intersection, the hourly distribution of vehicular volumes was estimated based on three adjacent count locations[4]. For the base scenario, the hourly distribution was used in conjunction with the peak hour turning

[3] Manual on Uniform Traffic Control Devices, FHWA, 2012
[4] VTrans Transportation Data Management System Count Locations D133, D211, and D559

movement count conducted as part of this study to develop a 24-hour distribution of volume. For each scenario, a 24-hour distribution of volume was developed based on the peak hour volume estimates for each scenario and the average hourly distribution based on the count locations.

The warrant analysis was conducted with the assumption that both the Market Street and Hinesburg Road approaches were 2-lane approaches, given the dedicated northbound left on Hinesburg Road and dedicated left- and right-turn lanes on Market Street. It is noted that the MUTCD provides guidance that each of these could be considered single lane approaches[5]. For the purposes of the warrant analysis, the 2-lane approach assumption provides a more conservative estimate of whether the warrants are satisfied.

Warrant 1 – Condition A, the minimum vehicular volume, is used for intersections where a large volume of intersecting traffic is present. The warrant requires:

- total hourly volume for the major street satisfies the thresholds of Condition A for any eight-hours (600 vehicles per hour for a condition with two approach lanes on the major and minor streets); and,
- higher hourly volume of the minor street satisfies the thresholds of Condition A for the corresponding eight-hours (200 vehicles per hour for a condition with two approach lanes on the major and minor streets).

Warrant 1 – Condition B, the interruption of continuous traffic, is used for intersections where the major street traffic volumes are so high that the minor street suffers lengthy delays. The warrant requires:

- total hourly volume for the major street satisfies the thresholds of Condition B for any eight-hours (900 vehicles per hour for a condition with two approach lanes on the major and minor streets); and,
- higher hourly volume of the minor street satisfies the thresholds of Condition A for the corresponding eight-hours (100 vehicles per hour for a condition with two approach lanes on the major and minor streets).

Warrant 2 is used for cases where the volume of intersecting traffic is the primary justification for considering installation of a signal. The warrant requires:

- total hourly volume for the major street satisfies the thresholds of Warrant 2 for any four-hours; and,
- higher hourly volume for the minor street satisfies the thresholds of Warrant 2 for the corresponding four-hours (115 vehicles per hour or more for a condition with two approach lanes on the major and minor streets measured against a curve dependent on the major street volume).

As summarized in **Table 5**, the scenarios meet the eight-hour traffic signal warrants in all cases and the four-hour warrant in all but one case. It is notable that even with the addition of connector roads to provide alternative routes through the City Center area, the eight-hour and four-hour warrants continue to be met with conservative assumptions for future anticipated conditions at this intersection.

[5] Manual on Uniform Traffic Control Devices Section 4C.01 Guidance 09

Table 5. Traffic Signal Warrant Analysis

	Warrant 1 - 8-Hour Vehicular Volume			Warrant 2 - 4-Hour Vehicular Volume	
Scenario	Warrant Met	Condition A Hours Met	Condition B Hours Met	Warrant Met	Hours Met
Base	yes	9	10	yes	8
No Build	yes	12	10	yes	11
Partial A	yes	8	10	yes	5
Partial B	yes	6	9	no	3
Full	yes	2	9	yes	4

Conclusions & Recommendations

This analysis supports growth in City Center by identifying infrastructure improvements to accommodate shifting travel patterns resulting from anticipated development and planned connections through the area. An evaluation of the transportation implications of phased in development and new connector roadways leveraged the CCRPC's regional travel demand model as the test environment. Assessing the transportation network at the intersection scale along Market Street revealed the following key takeaways:

- Opening the southern segment of Garden Street alleviates delay and queuing on the northbound approach of Dorset Street at Market Street despite the anticipated increases in development traffic over time;
- Even at full build out, the two-way stop-controlled Garden Street approaches to the Market Street intersection are anticipated to accommodate the demand with a LOS C and vehicle queues of 2 vehicles;
- Multi-way stop control was not warranted for the Market Street and Garden Street intersection based on the projected scenarios, but should be monitored and revisited once future conditions are realized;
- The Market Street approach to the Hinesburg Road intersection currently operates at LOS F with nearly a minute of delay in the PM peak hour;
- Opening the southern segment of Garden Street is anticipated to increase delay significantly at the Market Street and Hinesburg Road intersection.

Given the current and anticipated delays at the Market Street and Hinesburg Road intersection, mitigation is recommended and should be implemented prior to opening the southern segment of Garden Street. Mitigation could include the simultaneous opening of the northern segment of Garden Street; however, this entails realignment of White Street to meet Midas Drive, upgrades to the signal at the Midas Drive / White Street / Williston Road intersection, and connection of Midas Drive to Garden Street. This mitigation also does not address future delays that are anticipated for the Market Street approach to the Hinesburg Road intersection. Therefore, signalization of the Market Street and Hinesburg Road intersection is recommended, as this infrastructure improvement would accommodate the anticipated shift in traffic due to the opening of the southern segment of Garden Street and address future delays anticipated at the Market Street and Hinesburg Road intersection through the full build out scenarios. In support of this mitigation, it was demonstrated that signal warrants were satisfied for current and future scenarios.