

Madison BRT Transit Corridor Study

Proposed BRT Travel Time Estimation Approach

This paper presents proposed methodology and estimates of bus rapid transit (BRT) travel times for use in the Madison BRT Transit Corridor Study. The objective is to develop reasonable estimates of BRT travel times, for use in travel demand modeling/ridership forecasts, fleet sizing and estimating daily and annual revenue bus-hours of service, for use in O&M cost estimation. Travel time components include:

- Time when the bus is in-motion, both in free flow and congested conditions;
- Time when the bus is stopped at a bus station to pick-up and drop-off passengers; and
- Time when the bus is stopped at traffic signals.

Proposed assumptions for each of these components are described in the following sections of this paper.

In-Motion Bus Times

In-motion bus time is a function of acceleration and deceleration from and to a stopped condition, and the average operating speed between accelerating and decelerating and driving distance, and traffic congestion. Acceleration and deceleration rates vary depending on the type of vehicle. Research literature suggests that acceleration rates typically are 2.0 to 2.5 mphps (decreasing when accelerating to speeds above 20 mph) and deceleration rates are typically 2.0 mphps. Acceleration rates for articulated buses are less than for standard 40' buses, and hybrid buses tend to have higher acceleration rates than diesel buses. Since vehicle type is yet undefined in this feasibility study, it is proposed that a 2.0 mphps acceleration rate be used (gradually decreasing to 1.25 mphps when accelerating to 40 mph), and a constant 2.0 mphps deceleration be used.

It is proposed that existing posted speed limits be used as the maximum allowable speed between stations. Table 1 presents posted speeds on road segments proposed for BRT service.

Maximum assumed operating speeds have been reduced in areas where there is known to be high levels of congestion. (e.g., University Avenue/Park Street area). Table 2 identifies areas where speeds lower than the posted speed limit have been assumed due to congestion. It is important to note that the calculated average speed between stations will be much lower than the maximum speed assumptions shown in Tables 1 and 2, once traffic signal delay and bus stops are taken into account.

**Table 1
Posted Speed Limits on Proposed BRT Road Segments**

Corridor	Street	From/To	Posted Speed (mph)
Central	Gorham/Johnson St.	State St. to Bassett St.	25
	Univ./Johnson St.	Bassett St. to Park St.	25
	State Street	Gorham/Johnson St. to Capitol Sq.	unknown
	Washington Ave.	Capitol Sq. to Baldwin St.	35
East	Washington Ave.	Baldwin St. to Wright St.	35
	Wright St.	Washington Ave. to Anderson St.	25
	Anderson St.	Wright St. to Sloughton Rd.	35
	Sloughton Rd.	Anderson St. to Washington Ave.	35
	Washington Ave.	Sloughton St. to East Towne Mall	45
West	University/Johnson St.	Park St. to Campus Dr.	25
	Campus Dr.	University Ave. to University Ave.	40
	University Ave.	Campus Dr. to Segoe Rd.	35
	Segoe Rd.	University Ave. to Sheboygan Ave.	30
	Sheboygan Ave.	Segoe Rd. to Whitney Way	30
	Whitney Way	Sheboygan Ave. to Mineral Point Rd.	30
	Mineral Point Rd.	Whitney Way to High Point Road	40
<i><u>Alt. Odana Rd. Alignment</u></i>			
	Whitney Way	Mineral Point Rd. to Tokay Blvd.	35
	Tokay Blvd.	Whitney Way to Odana Rd.	30
	Odana Rd.	Tokay Blvd. to Gammon Rd.	30
	Gammon Rd.	Odana Rd. to West Towne Mall	35
North	Washington Ave.	Baldwin St. to First St.	35
	Fordem Ave.	Johnson St. to Sherman Ave.	30
	Sherman Ave.	Fordem Ave. to Northport Dr.	30
South	Park St.	University Ave. to Regent St.	25
	Park St.	Regent St. to Badger Road	30
	Badger Rd.	Park St. to Fish Hatchery Rd.	30
	Fish Hatchery Rd.	Badger Rd. to Post Rd.	30
	Fish Hatchery Rd.	Post Rd. to Caddis Bend	40

**Table 2
BRT Road Segments With Reduced Max. Speed Assumptions**

Corridor	Roadway	Segment	Reduced Speed
Central	Washington Ave.	Capitol Sq. to Webster St.	10 mph
	Washington Ave.	Webster St. to Blair St.	25 mph
	State Street/Gorham St.	Capitol Sq. to Bassett St.	10 mph
	University Ave.	Bassett Street to Park St.	20 mph
South	Park Street	Univ. Ave. to Regent St.	25 mph
East	Anderson St.	Wright St. to Stoughton Rd.	25 mph
West	Mineral Pt. Road	Yellow Stone Dr. to Westfield Rd.	30 mph
West (Alt. Alignment)	Odana Road	Grand Canyon Dr. to West Towne Mall	25 mph

Bus Stop Dwell Times

The time spent at each stop is dependent on characteristics such as:

- The number of passengers boarding and alighting
- The number of doors available for boarding and alighting
- Passenger volumes inside the bus
- Fare collection method (i.e., on-board or off-board)
- ADA/wheelchair and bicycle boardings and alightings and procedures to accommodate them (e.g., kneeling, ramp deployment, securement procedures inside the bus, exterior bike racks)
- Proportion of trips that pass the stop without stopping

Although some lower use stops may be passed without stopping, travel time estimates for this study will assume buses come to a complete stop at each designated BRT station/stop. Off-board fare collection is assumed, thus allowing for the use of both bus doors for boarding activity and a uniform dwell time regardless of projected boardings, except for very high use stops.

It is recommended that stations be classified as “moderate” vs. “high” ridership activity, and that typical ridership activity stations are assigned an average station dwell of 15 seconds, and high ridership activity stations are assigned an average station dwell of 30 seconds. Although actual dwell times can sometimes be lower, these values provide some allowance for the potential presence of bicycle users, ramp deployments, and other unpredictable events. It is also proposed that stops at existing or proposed relocated transfer points are assigned a higher dwell time. Additional dwell time assumptions are as follows:

- One-minute dwells have been proposed at the relocated North Transfer Point at Aberg for the North Corridor Alignment
- One-minute dwells are proposed at the East Towne Mall Station for the East Corridor Alignment

- Two-minute dwells are proposed at the South Transfer Point for the South Corridor Alignment (to allow some time for buses to turn into/out of the transit center)
- Two-minute dwells are proposed at the West Transfer Point for the West Corridor Alignment – Odana Road alternative (to allow some time for buses to turn into/out of the transit center)
- Two-minute dwells are also assumed at Mineral Point Road Station for the West Corridor Alignment – Mineral Point Road alternative. It is assumed the West Transfer Point is relocated to this location under this scenario.

Table 3 presents a list of proposed BRT stops and proposed station classifications for each proposed corridor. Stations in Table 3 that have been assigned 30-second station dwells are at locations where there is a nearby major trip generator.

**Table 3
BRT Station/Stop Designations and Dwell Times**

Corridor	Station ID	Station Name	Station Class.	Station Dwell
Central	C400w	Park Street	High	0:00:30
	C300w	Bassett Street	High	0:00:30
	C200w	State Street	High	0:00:30
	C100	Capitol Square	High	0:00:30
	C200e	Webster Street	Moderate	0:00:15
	C300e	Blair Street	Moderate	0:00:15
	C400e	Paterson Street	Moderate	0:00:15
	C500e	Baldwin Street	Moderate	0:00:15
East	E100	First Street	Moderate	0:00:15
	E200	Fourth Street	High	0:00:30
	E300	Milwaukee Street	Moderate	0:00:15
	E400	Starkweather Creek	Moderate	0:00:15
	E500	Melvin Court	Moderate	0:00:15
	E600	Wright Street	Moderate	0:00:15
	E700	Madison College	High	0:00:30
	E800	Mendota Street	Moderate	0:00:15
	E900	Thierer Road	Moderate	0:00:15
	E1000	East Towne Mall	High	0:01:00
West	W100	Mills/Charter Street	High	0:00:30
	W200	Randall Avenue	High	0:00:30
	W300	Farley Avenue	Moderate	0:00:15
	W400	Shorewood Boulevard	Moderate	0:00:15
	W500	Midvale Boulevard	Moderate	0:00:15
	W600	Sheboygan Avenue	Moderate	0:00:15
	W700	Eau Claire Avenue	Moderate	0:00:15
	W800	Regent Street	Moderate	0:00:15
	W900a	Mineral Point Road (MPR align)	High	0:02:00
	W900b	Mineral Point Rod (Odana Rd align)	Moderate	0:00:15
	W1000	Rosa Road	Moderate	0:00:15
	W1100	Yellow Stone Drive	Moderate	0:00:15
	W1200	Westfield Road	High	0:00:30
	W1300	High Point	High	0:00:30
	W1000A	West Transfer Point	High	0:02:00
W1100A	Research Park Boulevard	Moderate	0:00:15	
W1200A	Grand Canyon Drive	Moderate	0:00:15	
W1300A	West Towne Mall	High	0:00:30	
North	N100	Sherman Terrace	Moderate	0:00:15
	N200	Commercial Avenue	Moderate	0:00:15
	N300	Aberg	High	0:01:00
	N400	Vahlen Street	Moderate	0:00:15
	N500	Trailsway	Moderate	0:00:15
	N600	Warner Park	High	0:00:30
South	S100	Regent Street	Moderate	0:00:15
	S200	W. Washington Avenue	Moderate	0:00:15
	S300	Erin Street	Moderate	0:00:15
	S400	W. Olin Avenue	Moderate	0:00:15
	S500	Wingra Creek	Moderate	0:00:15
	S600	Bram Street	Moderate	0:00:15
	S700	Villager Mall	Moderate	0:00:15
	S800	South Transfer Point	High	0:02:00
	S900	Badger Road	Moderate	0:00:15
	S1000	Greenway Cross	Moderate	0:00:15
	S1100	Post Road	Moderate	0:00:15
	S1200	Caddis Bend	Moderate	0:00:15

Stations highlighted reflect alternative West Corridor alignment that is under consideration.

Traffic Signal Delay

The next component of BRT travel times is time spent in a stop condition at traffic signals. Traffic signal delay will vary considerably, for characteristics such as cycle time, phasing and signal progression will influence the probability that a bus arrives at a signal during the red phase of the cycle. Locations and length of delay will also vary by bus trip. Since this is a feasibility study, it is appropriate to define global assumptions regarding traffic signal characteristics, to calculate an average delay for each signalized intersection (recognizing that buses will not incur this delay at each signalized intersection).

The City of Madison Traffic Engineering Division provided cycle length information for each signalized intersection along the proposed BRT corridors, shown in Table 3. Actual cycle lengths in the p.m. peak period typically range from 80 to 110 seconds, with a majority of signals exhibiting a 90 second cycle length. For signals where there is a range in potential cycle length, the maximum length has been used. For signals where there is no specified cycle length, a 90 second cycle time has been assumed, with the exception of Stoughton Road and Anderson Street, where a 120 second cycle time has been used.

The Traffic Engineering Division also provided typical green time splits for the major arterial through movement for select intersections. Green time splits typically ranged from 70 to 80 percent for the through movements. Green time splits around Capitol Square, however, were much less. In addition, there are several locations along proposed BRT alignments where buses will be turning left onto other streets, resulting in additional delay time for the bus. For purposes of this feasibility study, typical green time assumptions, as a percentage of the cycle time, are as follows:

- Arterial through movements – 75%
- Downtown and University area – 50%
- Non-downtown right turn movements – 75%
- Non-downtown left turn movements – 25%

The next element in calculating traffic signal delay is consideration for transit signal prioritization (TSP). The Traffic Engineering Division has indicated that pedestrian timing provided for crossing the major street exceeds the programmed side street splits, and therefore, it may not be possible to provide TSP at many intersections. For purposes of this study, TSP has only been assumed at signalized intersections in suburban areas, where the volume of pedestrian crossings are likely to be low. Areas designated as outlying areas with potential for TSP along each alignment are as follows:

- East Corridor – east of First Street, but not including intersections near Madison College
- West Corridor – south/west of Sheboygan Avenue/Whitney Way
- North Corridor – North of Johnson Street
- South Corridor – South of Badger Road/Fish Hatchery Road

A 10 percent extension of green time has been assumed at those intersections where TSP has been assumed. This results in an extra 7 seconds of green time for a 90 second cycle with 75% green time for the arterial through movement.

Finally, consideration was given to signal progression. This has been expressed as the probability that a bus is stopped at a signalized intersection. For arterial through movements, a 25% stop probability has been assumed (i.e., a bus could be stopped for the full red phase of a cycle one of every four signalized intersections). For the downtown and University area, a 33% delay probability has been assumed. For intersections where the bus must make a left turn, a 50% delay probability has been assumed.

Buses are also required to stop at all railroad crossings. Travel time estimates take into account the time to decelerate to a complete stop, and then accelerate at each of the following railroad crossings:

Table 4 presents resulting calculations of average signal delay at each signalized intersection and railroad crossing along proposed BRT alignments. Some delay has also been assumed at stop signs. It is important to note that this table is intended to reflect reasonable assumptions of traffic signal delay along each BRT alignment, and not anticipated actual delay, and that assumptions such as intersections with TSP will require much further analysis.

Travel Time Results

Tables 5 through 9 present resulting travel time estimates for each of the four corridors, including portions of the Central Corridor from Capitol Square. The travel time estimates follow the methodology described in this paper, and are based on the following formula for each station-to-station segment:

$$\text{Total Travel Time} = \text{bus time in motion (including acceleration and deceleration to the maximum defined speed)} + \text{traffic signal delay time} + \text{station dwell time}$$

Travel time estimates have only been calculated for one direction (outbound from downtown Madison). Travel times for the reverse direction are assumed to be similar. Layover/recovery time will be included in bus cycle time calculations that will account for potential variations. Run time (in-motion time) ranges from 57 to 66 percent of total travel time for all corridors.

Travel time estimates shown in the following tables do not specifically account for potential travel time differences on alignment segments where mixed runningway conditions are proposed. For example, on Whitney Way and Mineral Point Road (West Corridor), there are two alternative alignment configurations still under consideration – side running and median busway. Similarly, segments of the south corridor’s proposed alignment include options of a side running vs. median busway configuration. A median busway configuration would separate bus traffic from general vehicular traffic, and thus provide more reliable bus travel times. It may also provide slightly faster bus travel times, depending on the level of congestion in the general traffic lanes.

**Table 4
Traffic Signal Delay Calculations**

Corridor	Seg. ID	Intersection	Actual Cycle Lengths				% Green		Max.	Max.	Prob.	Avg.	
			AM PK	Off Pk	PM PK	USE	Time	TSP?	Green Time	Red Time	of Delay	Delay	
Central	C20w	Millin St.	Wisconsin Ave.	80	65	80	0:01:20	50%	No	0:00:40	0:00:40	33%	0:00:13
	C20w	Millin St.	Carroll St./State St. (RT)	80	65	80	0:01:20	50%	No	0:00:40	0:00:40	33%	0:00:13
	C20w	State St.	W. Dayton St.	80	65	80	0:01:20	50%	No	0:00:40	0:00:40	33%	0:00:13
	C30w	State Street	Johnson St.	90/100	80	90/100	0:01:40	50%	No	0:00:50	0:00:50	33%	0:00:17
	C30w	State Street	Gorham St. (LT)	90/100	80	90/100	0:01:40	50%	No	0:00:50	0:00:50	33%	0:00:17
	C30w	Gorham St.	N. Broom St.	90/100	80	90/100	0:01:40	50%	No	0:00:50	0:00:50	33%	0:00:17
	C30w	University Ave.	N. Frances St.	90/100	80	90/100	0:01:40	50%	No	0:00:50	0:00:50	33%	0:00:17
	C40w	University Ave.	N. Lake St.	90/100	80	90/100	0:01:40	50%	No	0:00:50	0:00:50	33%	0:00:17
	C40w	University Ave.	Campus Mall	90/100	80	90/100	0:01:40	50%	No	0:00:50	0:00:50	33%	0:00:17
	C40w	University Ave.	Park St. (LT)	90/100	80	90/100	0:01:40	50%	No	0:00:50	0:00:50	33%	0:00:17
	C20e	Main Street	Martin Luther King Blvd., Jr.	80	65	80	0:01:20	50%	No	0:00:40	0:00:40	33%	0:00:13
	C20e	Main Street	Pickney Street/King Street (LT)	80	65	80	0:01:20	50%	No	0:00:40	0:00:40	33%	0:00:13
	C20e	Pickney St.	Washington Ave. (RT)	80	65	80	0:01:20	50%	No	0:00:40	0:00:40	33%	0:00:13
	C20e	Washington Ave.	Webster St.	80	65	80	0:01:20	50%	No	0:00:40	0:00:40	33%	0:00:13
	C30e	Washington Ave.	Blair St.	90/100	80	90/100	0:01:40	75%	No	0:01:15	0:00:25	25%	0:00:06
South	S50	University Ave.	Park St. (LT)	90/100	80	90/100	0:01:40	50%	No	0:00:50	0:00:50	33%	0:00:17
	S50	Park St.	W. Johnson St.	90/100	80	90/100	0:01:40	50%	No	0:00:50	0:00:50	33%	0:00:17
	S50	Park Street	W. Dayton St.	95	85	90	0:01:30	75%	No	0:01:07	0:00:23	25%	0:00:06
	S50	Park Street	Regent St.	95	85	90	0:01:30	75%	No	0:01:07	0:00:23	25%	0:00:06
	S60	Park Street	Braxton Place	95	85	90	0:01:30	75%	No	0:01:07	0:00:23	25%	0:00:06
	S60	Park Street	W. Washington Ave.	95	85	90	0:01:30	75%	No	0:01:07	0:00:23	25%	0:00:06
	S70	Park Street	Erin St.	95	85	90	0:01:30	75%	No	0:01:07	0:00:23	25%	0:00:06
	S80	Park Street	Fish Hatchery Road	95	85	90	0:01:30	75%	No	0:01:07	0:00:23	25%	0:00:06
	S80	Park Street	W. Olin Ave.	95	85	90	0:01:30	75%	No	0:01:07	0:00:23	25%	0:00:06
	S90	Park Street	W. Wingra Dr.	95	85	90	0:01:30	75%	No	0:01:07	0:00:23	25%	0:00:06
	S100	Park Street	Plaenert Dr.	95	85	90	0:01:30	75%	No	0:01:07	0:00:23	25%	0:00:06
	S100	Park Street	Railroad Crossing	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0:00:10
	S110	Park Street	Buick St.	95	85	90	0:01:30	75%	No	0:01:07	0:00:23	25%	0:00:06
	S120	Park Street	Hughes Place	95	85	90	0:01:30	75%	No	0:01:07	0:00:23	25%	0:00:06
	S120	Park Street	Badger Road (RT)	95	85	90	0:01:30	75%	No	0:01:07	0:00:23	25%	0:00:06
	S130	W. Badger Road	Fish Hatchery Road (LT)	90	80	90/100	0:01:40	25%	No	0:00:25	0:01:15	50%	0:00:38
	S140	Fish Hatchery Road	Ann St./Emil St.	90	80	90/100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
	S140	Fish Hatchery Road	Beltline WB Ramps	90	80	90/100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
	S140	Fish Hatchery Road	Beltline EB Ramps	90	80	90/100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
	S140	Fish Hatchery Road	Greenway Cross	90	80	90/100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
	S150	Fish Hatchery Road	Post Road	90	80	90/100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
S160	Fish Hatchery Road	High Ridge Trail (RT)	n/a	n/a	n/a	Stop	n/a	n/a	n/a	n/a	n/a	0:00:10	
S160	Cahill Main	Caddis Bend	n/a	n/a	n/a	Stop	n/a	n/a	n/a	n/a	n/a	0:00:10	
S160	Caddis Bend	Fish Hatchery Road (LT)	90	80	90/100	0:01:40	25%	Yes	0:00:28	0:01:13	50%	0:00:36	

Table 4 (Continued)
Traffic Signal Delay Calculations

Corridor	Seg. ID	Intersection	Actual Cycle Lengths				% Green		TSP?	Max. Green Time	Max. Red Time	Prob. of Delay	Avg. Delay
			AM Pk	Off Pk	PM Pk	USE	Time						
North	N20	Main Street	Martin Luther King Blvd., Jr.	80	65	80	0:01:20	50%	No	0:00:40	0:00:40	33%	0:00:13
	N20	Main Street	Pinckney Street/King Street (LT)	80	65	80	0:01:20	50%	No	0:00:40	0:00:40	33%	0:00:13
	N20	Pinckney St.	Washington Ave. (RT)	80	65	80	0:01:20	50%	No	0:00:40	0:00:40	33%	0:00:13
	N20	Washington Ave.	Webster St.	80	65	80	0:01:20	50%	No	0:00:40	0:00:40	33%	0:00:13
	N30	Washington Ave.	Blair St.	90/100	80	90/100	0:01:40	75%	No	0:01:15	0:00:25	25%	0:00:06
	N40	Washington Ave.	Paterson St.	90/100	80	90/100	0:01:40	75%	No	0:01:15	0:00:25	25%	0:00:06
	N50	Washington Ave.	Ingersoll St.	90/100	80	90/100	0:01:40	75%	No	0:01:15	0:00:25	25%	0:00:06
	N50	Washington Ave.	Baldwin St.	90/100	80	90/100	0:01:40	75%	No	0:01:15	0:00:25	25%	0:00:06
	N60	Washington Ave.	Busway Connection (LT)	60	60	60	0:01:40	25%	No	0:00:25	0:01:15	50%	0:00:38
	N60	Busway Connection	Johnson Street	60	60	60	0:01:40	50%	No	0:00:50	0:00:50	33%	0:00:17
	N70	Sherman Ave.	Commercial Ave.	FREE			0:01:30	70%	Yes	0:01:09	0:00:21	33%	0:00:07
	N80	Sherman Ave.	Railroad Crossing	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0:00:10
	N80	Sherman Ave.	Aberg Ave.	FREE			0:01:30	70%	Yes	0:01:09	0:00:21	33%	0:00:07
	N90	Sherman Ave.	Schlingen Ave.	FREE			0:01:30	70%	Yes	0:01:09	0:00:21	33%	0:00:07
	East	E20	Main Street	Martin Luther King Blvd., Jr.	80	65	80	0:01:20	50%	No	0:00:40	0:00:40	33%
E20		Main Street	Pinckney Street/King Street (LT)	80	65	80	0:01:20	50%	No	0:00:40	0:00:40	33%	0:00:13
E20		Pinckney St.	Washington Ave. (RT)	80	65	80	0:01:20	50%	No	0:00:40	0:00:40	33%	0:00:13
E20		Washington Ave.	Webster St.	80	65	80	0:01:20	50%	No	0:00:40	0:00:40	33%	0:00:13
E30		Washington Ave.	Blair St.	90/100	80	90/100	0:01:40	75%	No	0:01:15	0:00:25	25%	0:00:06
E40		Washington Ave.	Paterson St.	90/100	80	90/100	0:01:40	75%	No	0:01:15	0:00:25	25%	0:00:06
E50		Washington Ave.	Ingersoll St.	90/100	80	90/100	0:01:40	75%	No	0:01:15	0:00:25	25%	0:00:06
E50		Washington Ave.	Baldwin St.	90/100	80	90/100	0:01:40	75%	No	0:01:15	0:00:25	25%	0:00:06
E60		Washington Ave.	RR Crossing #1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0:00:10
E60		Washington Ave.	RR Crossing #2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0:00:10
E60		Washington Ave.	First Street	90/100	80	90/100	0:01:40	75%	No	0:01:15	0:00:25	25%	0:00:06
E70		Washington Ave.	4th Street	90/100	80	90/100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
E80		Washington Ave.	North St./Milwaukee St.	90/100	80	90/100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
E90		Washington Ave.	Johnson St.	90/100	80	90/100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
E90		Washington Ave.	N. Marquette	90/100	80	90/100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
E100		Washington Ave.	Aberg Ave. SB Ramps	90/100	80	90/100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
E100		Washington Ave.	Aberg Ave. NB Ramps	90/100	80	90/100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
E120		Washington Ave.	Wright St. (LT)	90/100	80	90/100	0:01:40	25%	No	0:00:25	0:01:15	50%	0:00:38
E120		Wright St.	Anderson St. (RT)	FREE			0:01:30	75%	No	0:01:07	0:00:23	25%	0:00:06
E130		Anderson St.	Stoughton Road (RT)	FREE			0:02:00	75%	No	0:01:30	0:00:30	25%	0:00:08
E130		Stoughton Road	Washington Ave. (LT)	FREE			0:01:30	25%	No	0:00:23	0:01:07	50%	0:00:34
E130		Washington Ave.	Mendota St.	90	90	100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
E140		Washington Ave.	Lien Road	90	90	100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
E140	Washington Ave.	Thierer Road/Portage Road	90	90	100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04	
E150	Washington Ave.	Eagan Road (RT)	90	90	100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04	
E150	Eagan Road	E. Towne Blvd. (LT)	n/a	n/a	n/a	Stop	n/a	n/a	n/a	n/a	n/a	0:00:10	

Table 4 (Continued)
Traffic Signal Delay Calculations

Corridor	Seg. ID	Intersection	Actual Cycle Lengths				% Green		TSP?	Max. Green Time	Max. Red Time	Prob. of Delay	Avg. Delay
			AM Pk	Off Pk	PM Pk	USE	Time						
West	W50	University Ave.	Park St	90/100	80	90/100	0:01:40	50%	No	0:00:50	0:00:50	33%	0:00:17
	W50	University Ave.	N. Brooks St.	90/100	80	90/100	0:01:40	50%	No	0:00:50	0:00:50	33%	0:00:17
	W50	University Ave.	N. Mills St.	90/100	80	90/100	0:01:40	50%	No	0:00:50	0:00:50	33%	0:00:17
	W60	University Ave.	N. Charter St.	90/100	80	90/100	0:01:40	50%	No	0:00:50	0:00:50	33%	0:00:17
	W60	University Ave.	N. Orchard St.	90/100	80	90/100	0:01:40	50%	No	0:00:50	0:00:50	33%	0:00:17
	W70	University Ave.	N. Randall Ave.	90/100	80	90/100	0:01:40	50%	No	0:00:50	0:00:50	33%	0:00:17
	W70	University Ave.	RR Xing/Ped Xing	90/100	80	90/100	0:01:40	50%	No	0:00:50	0:00:50	33%	0:00:17
	W70	University Ave.	Campus Drive	90/100	80	90/100	0:01:40	50%	No	0:00:50	0:00:50	33%	0:00:17
	W80	University Ave.	Fairley Ave.	100/115	85	100	0:01:40	75%	No	0:01:15	0:00:25	25%	0:00:06
	W80	University Ave.	Ridge Street	100/115	85	100	0:01:40	75%	No	0:01:15	0:00:25	25%	0:00:06
	W90	University Ave.	Shorewood Blvd.	100/115	85	100	0:01:40	75%	No	0:01:15	0:00:25	25%	0:00:06
	W100	University Ave.	Midvale Blvd.	100/115	85	100	0:01:40	75%	No	0:01:15	0:00:25	25%	0:00:06
	W100	University Ave.	Segoe Road (LT)	100/115	85	100	0:01:40	25%	No	0:00:25	0:01:15	50%	0:00:38
	W100	Segoe Road	Frey Road	100/115	85	100	0:01:40	75%	No	0:01:15	0:00:25	25%	0:00:06
	W100	Segoe Road	Sheboygan Ave. (future signal RT)	FREE			0:01:30	75%	No	0:01:07	0:00:23	25%	0:00:06
	W120	Sheboygan Ave.	Whitney Way (future signal LT)	FREE			0:01:30	25%	No	0:00:23	0:01:07	50%	0:00:34
	W120	Whitney Way	Regent St.	FREE			0:01:30	75%	Yes	0:01:14	0:00:16	25%	0:00:04
	W130	Whitney Way	Mineral Point Road (RT)	95	90	100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
	W140	Mineral Point Road	Rosa Rd.	95	90	100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
	W150	Mineral Point Road	Island Dr.	95	90	100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
	W160	Mineral Point Road	Yellowstone Dr. (future signal)	95	90	100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
	W160	Mineral Point Road	Grand Canyon Dr.	95	90	100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
	W160	Mineral Point Road	Ganmon Road	FREE			0:01:30	50%	Yes	0:00:49	0:00:41	33%	0:00:13
	W160	Mineral Point Road	Mall Entrance (LT)	n/a	n/a	n/a	Stop	n/a	n/a	n/a	n/a	n/a	0:00:30
	W170	Westfield Road	Mineral Point Road (LT)	95	90	100	0:01:40	25%	Yes	0:00:28	0:01:13	50%	0:00:36
	W170	Mineral Point Road	Randolph Drive	95	90	100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
	W170	Ganmon Road	High Point Road	95	90	100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
West Odana Road Alignment	W140a	Whitney Way	Mineral Point Road	95	90	100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
	W140a	Whitney Way	Tokay Blvd. (RT)	95	90	100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
	W180a	Tokay Blvd.	Odana Road (RT)	95	90	100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
	W180a	Odana Road	Research Park Blvd.	95	90	100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
	W190a	Odana Road	Potomac Lane	95	90	100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
	W200a	Odana Road	Grand Canyon Drive	95	90	100	0:01:40	75%	Yes	0:01:23	0:00:17	25%	0:00:04
	W200a	Odana Road	Ganmon Road	95	90	100	0:01:40	50%	Yes	0:00:55	0:00:45	33%	0:00:15
W200a	Odana Road	Mall Ring Road (RT)	n/a	n/a	n/a	Stop	n/a	n/a	n/a	n/a	n/a	0:00:10	

**Table 5
East Corridor Travel Time Estimate**

Station	Max Spd. [mph]	Distance [mi]	Total Distance	Run Time (hr:min:sec)	Delay Time (hr:min:sec)	Dwell Time (hr:min:sec)	Total Time (hr:min:sec)
Capitol Square	10	0.28	0.00	0:01:44	0:00:53	0:00:00	0:00:00
Webster Street	25	0.22	0.28	0:00:44	0:00:06	0:00:15	0:02:52
Blair Street	35	0.40	0.50	0:01:00	0:00:06	0:00:15	0:03:57
Paterson Street	35	0.50	0.89	0:01:10	0:00:12	0:00:15	0:05:18
Baldwin Street	35	0.46	1.39	0:01:06	0:00:26	0:00:15	0:06:56
First Street	35	0.38	1.86	0:00:58	0:00:04	0:00:15	0:08:43
Fourth Street	35	0.41	2.24	0:01:01	0:00:04	0:00:30	0:10:15
Milwaukee Street	35	0.46	2.65	0:01:06	0:00:09	0:00:15	0:11:36
Starkweather Creek	35	0.47	3.11	0:01:06	0:00:09	0:00:15	0:13:06
Melvin Court	35	0.37	3.58	0:00:57	0:00:00	0:00:15	0:14:35
Wright Street	25	0.49	3.95	0:01:23	0:00:43	0:00:15	0:15:47
Madison College	25	0.80	4.44	0:02:08	0:00:46	0:00:30	0:18:23
Mendota Street	40	0.47	5.24	0:01:04	0:00:09	0:00:15	0:21:32
Thierer Road	30	0.58	5.70	0:01:25	0:00:14	0:00:15	0:23:00
East Towne Mall			6.28			0:01:00	0:25:39
Totals			6.28	0:16:52	0:04:02	0:04:45	0:25:39
						Avg. Speed (mph):	14.69

**Table 6
North Corridor Travel Time Estimate**

Station	Max Spd. [mph]	Distance [mi]	Total Distance	Run Time (hr:min:sec)	Delay Time (hr:min:sec)	Dwell Time (hr:min:sec)	Total Time (hr:min:sec)
Capitol Square	10	0.28	0.00	0:01:44	0:00:53	0:00:00	0:00:00
Webster Street	25	0.22	0.28	0:00:44	0:00:06	0:00:15	0:02:52
Blair Street	35	0.40	0.50	0:01:00	0:00:06	0:00:15	0:03:57
Paterson Street	35	0.50	0.89	0:01:10	0:00:12	0:00:15	0:05:18
Baldwin Street	30	0.60	1.39	0:01:27	0:00:54	0:00:15	0:06:56
Sherman Terrace	30	0.79	1.99	0:01:50	0:00:07	0:00:15	0:09:32
Commercial Avenue	30	0.50	2.78	0:01:15	0:00:17	0:00:15	0:11:44
Aberg	30	0.55	3.28	0:01:21	0:00:07	0:01:00	0:14:15
Vahlen Street	30	0.27	3.83	0:00:48	0:00:00	0:00:15	0:15:58
Trailsway	30	0.21	4.10	0:00:40	0:00:00	0:00:15	0:17:01
Wamer Park			4.31			0:00:30	0:18:11
Totals			4.31	0:11:59	0:02:42	0:03:30	0:18:11
						Avg. Speed (mph):	14.22

**Table 7
South Corridor Travel Time Estimate**

Station	Max Spd. [mph]	Distance [mi]	Total Distance	Run Time (hr:min:sec)	Delay Time (hr:min:sec)	Dwell Time (hr:min:sec)	Total Time (hr:min:sec)
Capitol Square	10	0.17	0.00	0:01:06	0:00:40	0:00:00	0:00:00
State Street	10	0.33	0.17	0:02:04	0:01:06	0:00:30	0:02:16
Bassett Street	20	0.36	0.50	0:01:15	0:00:50	0:00:30	0:05:56
Park Street	25	0.38	0.86	0:01:08	0:00:44	0:00:30	0:08:30
Regent Street	30	0.31	1.24	0:00:53	0:00:11	0:00:15	0:10:37
W. Washington Avenue	30	0.23	1.55	0:00:43	0:00:06	0:00:15	0:11:57
Erin Street	30	0.46	1.78	0:01:11	0:00:11	0:00:15	0:13:00
W. Olin Avenue	30	0.37	2.24	0:01:00	0:00:06	0:00:15	0:14:37
Wingra Creek	30	0.22	2.61	0:00:42	0:00:16	0:00:15	0:15:58
Bram Street	30	0.28	2.83	0:00:49	0:00:06	0:00:15	0:17:11
Villager Mall	25	0.25	3.11	0:00:49	0:00:11	0:00:15	0:18:20
South Transfer Point	30	0.45	3.36	0:01:09	0:00:38	0:02:00	0:21:21
Badger Road	30	0.58	3.81	0:01:25	0:00:17	0:00:15	0:23:22
Greenway Cross	30	0.39	4.39	0:01:02	0:00:04	0:00:15	0:25:20
Post Road	40	0.72	4.78	0:01:27	0:00:56	0:00:15	0:26:41
Caddis Bend			5.50			0:00:15	0:29:19
Totals			5.50	0:16:43	0:06:21	0:06:15 Avg. Speed (mph):	0:29:19 11.25

**Table 8
West Corridor Travel Time Estimate – Mineral Point Road Alignment**

Station	Max Spd. [mph]	Distance [mi]	Total Distance	Run Time (hr:min:sec)	Delay Time (hr:min:sec)	Dwell Time (hr:min:sec)	Total Time (hr:min:sec)
Capitol Square	10	0.17	0.00	0:01:06	0:00:40	0:00:00	0:00:00
State Street	10	0.33	0.17	0:02:04	0:01:06	0:00:30	0:02:16
Bassett Street	20	0.36	0.50	0:01:15	0:00:50	0:00:30	0:05:56
Park Street	30	0.22	0.86	0:00:42	0:00:50	0:00:30	0:08:30
Mills/Charter Street	25	0.16	1.08	0:00:36	0:00:33	0:00:30	0:10:32
Randall Avenue	40	1.26	1.24	0:02:16	0:00:50	0:00:30	0:12:11
Farley Avenue	35	0.52	2.50	0:01:12	0:00:12	0:00:15	0:15:31
Shorewood Boulevard	35	0.37	3.02	0:00:57	0:00:06	0:00:15	0:17:11
Midvale Boulevard	30	0.46	3.39	0:01:11	0:00:56	0:00:15	0:18:29
Sheboygan Avenue	30	0.36	3.85	0:00:58	0:00:00	0:00:15	0:20:50
Eau Claire Avenue	30	0.56	4.21	0:01:23	0:00:38	0:00:15	0:22:03
Regent Street	30	0.55	4.77	0:01:21	0:00:04	0:00:15	0:24:19
Mineral Point Road (MPR align)	35	0.31	5.32	0:00:51	0:00:04	0:02:00	0:27:45
Rosa Road	40	0.69	5.63	0:01:24	0:00:04	0:00:15	0:28:55
Yellow Stone Drive	30	0.79	6.32	0:01:50	0:00:52	0:00:15	0:30:38
Westfield Road	40	0.65	7.11	0:01:21	0:00:45	0:00:30	0:33:50
High Point			7.76			0:00:30	0:36:26
Totals			7.76	0:20:27	0:08:29	0:07:30 Avg. Speed (mph):	0:36:26 12.78

**Table 9
West Corridor Travel Time Estimate – Odana Road Alignment**

Station	Max Spd. [mph]	Distance [mi]	Total Distance	Run Time (hr:min:sec)	Delay Time (hr:min:sec)	Dwell Time (hr:min:sec)	Total Time (hr:min:sec)
Capitol Square	10	0.17	0.00	0:01:06	0:00:40	0:00:00	0:00:00
State Street	10	0.33	0.17	0:02:04	0:01:06	0:00:30	0:02:16
Bassett Street	20	0.36	0.50	0:01:15	0:00:50	0:00:30	0:05:56
Park Street	30	0.22	0.86	0:00:42	0:00:50	0:00:30	0:08:30
Mills/Charter Street	25	0.16	1.08	0:00:36	0:00:33	0:00:30	0:10:32
Randall Avenue	40	1.26	1.24	0:02:16	0:00:50	0:00:30	0:12:11
Farley Avenue	35	0.52	2.50	0:01:12	0:00:12	0:00:15	0:15:31
Shorewood Boulevard	35	0.37	3.02	0:00:57	0:00:06	0:00:15	0:17:11
Midvale Boulevard	30	0.46	3.39	0:01:11	0:00:56	0:00:15	0:18:29
Sheboygan Avenue	30	0.36	3.85	0:00:58	0:00:00	0:00:15	0:20:50
Eau Claire Avenue	30	0.56	4.21	0:01:23	0:00:38	0:00:15	0:22:03
Regent Street	30	0.55	4.77	0:01:21	0:00:04	0:00:15	0:24:19
Mineral Point Rod (Odana Rd align)	35	0.60	5.32	0:01:20	0:00:09	0:00:15	0:26:00
West Transfer Point	35	0.71	5.92	0:01:32	0:00:09	0:02:00	0:29:28
Research Park Boulevard	30	0.60	6.63	0:01:27	0:00:04	0:00:15	0:31:24
Grand Canyon Drive	25	0.45	7.23	0:01:17	0:00:29	0:00:15	0:33:10
West Towne Mall	25	0.28	7.68	0:00:53	0:00:00	0:00:30	0:35:27
Westfield Road	40	0.65	7.96	0:01:21	0:00:45	0:00:30	0:36:50
High Point			8.61			0:00:30	0:39:26
Totals			8.61	0:22:51	0:08:20	0:08:15 Avg. Speed (mph):	0:39:26 13.10

Travel Time Validation

The last step consists of a comparison of estimated BRT travel times to current bus travel times, as reflected in bus schedules. Existing travel times and average speeds have been determined for key routes in each BRT corridor. The route comparisons provided below do not necessarily follow the exact alignment of proposed BRT routes, but they do provide an indication of typical bus travel times and operating speeds within each corridor.

- East Corridor – Route 6 via MATC has a p.m. peak travel time of 32 minutes and an average speed of 13.5 mph from Capitol Square to East Towne Mall, with a similar alignment. The estimated BRT travel time estimate is 25:39, with an average speed of 14.7 mph, a 9 percent improvement in average speed.
- West Corridor – There is no single existing route that currently operates between Capitol Square and High Point Road along an alignment similar to the proposed BRT alignment. Route 14 comes close, with service to Mineral Point Road and Westfield Road. Existing Metro schedules indicate Route 14 has a p.m. peak travel time of 39 minutes from Capitol Square to Gammon Road and Tree Lane. The route's outbound travel time would be slightly longer to Westfield Road and Mineral Point Road. The estimated BRT travel time estimate to Westfield Road and Mineral Point Road is 33:50. Thus, BRT p.m. peak outbound travel times reflect an improvement of approximately 13 percent.

The alternative Odana Road West Corridor alignment serves the existing West Transfer Point. There are multiple existing route options from Capitol Square to the West Transfer Point that can be used in a comparison to BRT times. Route 2 provides the most comparable local route service with a 38 minute p.m. peak period travel time. The proposed BRT travel time estimate is 29:28, a 22 percent improvement over Route 2. Routes 56 and 57 provide a quicker p.m. peak travel time of 28 minutes to the West Transfer Point. However, Routes 56 and 57 are peak period limited stop routes and do not continue to the West Towne Mall area. A transfer to either Routes 67 or 73 would be required.

- North Corridor – There is no single route that currently operates from Capitol Square to the North Town Center. A combination of Routes 2 and 22 are required to make this trip, resulting in a total travel time of about 31 minutes (including a transfer at the North Transfer Point). The estimated one-seat ride travel time for BRT is 18:11, with a 14.2 mph average speed. As a comparison, the average operating speed for Route 2 from Capitol Square to the existing North Transfer Point is 13.1 mph.
- South Corridor – There is no single route that currently operates from Capitol Square to Caddis Bend/Fish Hatchery Road along the same alignment that is proposed for BRT. Route 47 provides somewhat comparable service, with a 38 minute p.m. peak travel time. The estimated BRT travel time is 29:19 (23% faster) with an 11.25 mph average speed. For comparison purposes, the average operating speed for Routes 4 and 5 from Capitol Square to the South Transfer Point is 9.7 mph.

Finally, it is once again important to note that BRT travel times calculated for this study are intended represent reasonable estimates of anticipated travel times, and do not specifically take into account possible travel time impacts related to factors such as ADA boardings/alightings, weather impacts, road construction and traffic incident impacts. BRT route cycle times will be established that provide a reasonable time for recovery of such occurrences.