



## Draft Technical Memorandum

Date: September 8, 2010  
To: Bill Bryant, SDOT  
From: Randy Hammond, HNTB Corporation  
Subject: Transit Corridor Improvement Project  
NW Market/45th Street  
Agreement No. T09-06  
**NW Market Street/24th Avenue NW**  
**Transit Priority Analysis**

### EXECUTIVE SUMMARY

A traffic technical analysis has been prepared to assess transit priority treatment at the NW Market Street/24<sup>th</sup> Avenue NW intersection in Ballard. Several channelization revisions were evaluated with respect to bus travel times, overall traffic operations, pedestrian and bicycle impacts, and neighborhood context. A preferred channelization concept would provide dedicated left-turn lanes and protected left-turn signalization with an actuated signal control system. It would improve travel times for east-west bus movements during peak-period conditions. Overall intersection performance also would be enhanced. Parking removal would be limited to NW Market Street west of 24<sup>th</sup> Avenue NW, where four spaces would be lost permanently on the north side of the street, and one permanent removal on the south side. Eight additional spaces on the south side would be subject to a morning prohibition only. The revised channelization also would accommodate north-south bike lanes on 24<sup>th</sup> Avenue NW, north of NW Market Street.

### INTRODUCTION

The corridor between Ballard and Montlake traveled by Metro Route 44 has been identified for potential travel time improvements that will benefit bus movement. Measures including traffic signal priority treatment for buses, bus queue jump lanes, bus bulbs, and intersection modifications are under design to improve bus operation in the NW Market, N 46<sup>th</sup>, and NE 45<sup>th</sup> Street corridors.

In the Ballard area, the NW Market Street/24<sup>th</sup> Avenue NW intersection was identified as a significant source of bus delay, during the AM, midday and PM peak periods. A concept to rechannelize the intersection with right-turn only lanes for eastbound and westbound movements would have provided a queue jump opportunity for buses. On closer examination, the concept to combine this feature with transit signal priority proved incompatible with the existing fixed-time traffic signal control currently in use at this location. The constraints associated with split-phase signal operation and fixed-time control were reviewed, and protected control of left turns was introduced as a possible basis for intersection modifications.

Additional channelization and signalization studies were conducted to investigate alternative approaches to providing improved bus travel times. New intersection turning movement counts were conducted on April 22, 2010 to obtain current traffic volumes, vehicle turning patterns, and pedestrian/bicycle activity. A field visit with SDOT staff was conducted on April 28, 2010.

## CONCEPT DESCRIPTION

A series of intersection analyses were conducted using the Synchro software package to assess channelization options for the NW Market Street/24th Avenue NW intersection. The channelization options build on the earlier work for the Transit Priority studies for Metro Route 44. Existing channelization at this intersection is shown on Figure 1.

The recent traffic counts confirmed the observed high volumes of eastbound traffic turning onto Shilshole Avenue during the AM peak period, and the northbound left turn reverse movement during the PM peak period. Vehicles making the eastbound right turn must yield to pedestrians, interrupting through movements by inbound buses during the morning.

Based on observations during our field visit, an alternative was introduced that would rechannelize the eastbound approach with a dedicated right-turn lane, a single through lane, and a dedicated left-turn lane. With two departing westbound lanes, this option would result in a total of five lanes on the west leg. Curb-to-curb width on this leg is 54 feet. For the westbound approach, we provided two through lanes and a dedicated left-turn lane to oppose the eastbound left-turn lane. Westbound right turns would be made from the curbside through lane. Because the curb-to-curb width on the east leg is only 46 feet, only one departing eastbound lane would be provided. The second eastbound through lane on NW Market Street would develop downstream of the westbound left-turn pocket.

Based on this concept, three alternatives were developed: 7a, 7b, and 7c. Alternative 7a included a shared through-right lane for the southbound approach (see Figure 2), and alternative 7b included separate left, through, and right lanes on the southbound approach (See Figure 3). Alternative 7c included overlaps for the eastbound and westbound right turns with the 7b geometry. All Alternatives 7 provided a single dedicated left-turn lane and single through-right lane for the northbound approach. These features allow protected left-turn movements in all directions.

Due to the different curb-to-curb widths east and west of the intersection, the proposed geometry will include offsets across the intersection ranging between three and seven feet, depending upon the selection of approach lane widths. These lane offsets could be mitigated with interrupted striping (“chicken tracks”) across the intersection.

As the design of the intersection channelization modifications advances, consideration will be given to outbound Route 18 and 75 buses turning north at this location. Sufficient lane widths will be provided for all turn movements.

## PARKING UTILIZATION ANALYSIS

Parking utilization along NW Market Street, west of 24<sup>th</sup> Avenue NW was observed on Thursday July 29, 2010. The amount of time each parking space was occupied was recorded to determine the occupancy rate of seven spaces on the south side and four spaces on the north side of the street.

During the AM peak hour of traffic, no vehicles parked on the north side of NW Market Street, and one vehicle parked on the south side, resulting in three-percent occupancy between 7:30 AM and 8:30 AM. During the remaining morning hours, 8:30 AM to 11:00 AM, the north side spaces had an occupancy rate of 33 percent, and the south side spaces had an occupancy rate of 28

percent. The south side occupancy rate was skewed higher by a single vehicle parked for four hours. The remaining five spaces averaged a 16 percent occupancy rate.

Parking utilization peaked during the midday hours (12:00 PM to 2:00 PM) with 65 percent occupancy on the north side and 69 percent occupancy on the south side. Vehicles parked for an average of 30 minutes on the north side and 60 minutes on the south side.

Parking utilization between the hours of 3:00 PM and 5:00 PM was 51 percent occupancy for the north side and 11 percent occupancy for the south side.

Three options for channelization of the west leg were reviewed for their operational performance and impacts to on-street parking, as shown in Appendix A. Option 0 would require permanent parking removal of up to nine spaces on the south side and four spaces on the north side, for a total loss of 13 spaces. This channelization option was rejected in favor of Option A. It would remove one space permanently from the south side and four spaces on the north side. Occupancy rates for this single space are comparable to the average on the south side: 10 percent in the morning, 85 percent in the midday and 8 percent in the afternoon.

With Option A, a temporary parking restriction would be implemented on the south side of NW Market Street, affecting an additional eight spaces during the morning peak period. Parking spaces on the south side of NW Market Street, west of those included in the study were not consistently occupied, indicating that there is currently an excess supply of parking spaces during the morning hours. Additional parking is also available on Shilshole Avenue NW to replace those affected by the morning restriction.

Option B channelization would narrow the approach roadway to a single lane, creating longer queue lengths on eastbound NW Market Street. It was not considered for further development.

## **COLLISION ANALYSIS**

Accident records for the nine-year period between 2001 – mid 2010 were reviewed for crashes at this intersection. A total of 16 crashes were reported, with three crashes involving injuries. No fatal crashes were reported. The average number of collisions is below two crashes annually, so this intersection would not be classified as a high-accident location.

The accident analysis covers a period when split-phase signal control was in effect at this intersection. Data from the previous operation with permissive turns is not available. A conversion to protected-only left turns would be equivalent to the split-phase control relative to potential safety characteristics.

## **TRAFFIC OPERATIONS**

Overall intersection operations and delays for bus operations are summarized on Table 1. Comparisons are provided to existing conditions for the AM, midday, and PM peak hours. All variants of Alternative 7 provide benefits for the east-west movements used by buses.

**Table 1 – Intersection Operation and Route 44 Bus Delays**

Intersection	Bus Movement Delay (sec)				Overall Intersection Delay (sec)		
	Inbound		Outbound		LOS	Delay	Δ
	Delay	Δ	Delay	Δ			
<b>AM Peak Hour</b>							
Existing	41.9		48.5		D	43.4	
Alternative 7a	31.7	-10.2	19.9	-28.6	D	41.4	-2.0
Alternative 7b	31.7	-10.2	19.9	-28.6	D	38.5	-4.9
Alternative 7c	31.7	-10.2	19.9	-28.6	D	36.6	-6.8
<b>Midday</b>							
Existing	40.3		38.3		D	41.3	
Alternative 7a	29.6	-10.7	27.8	-10.5	D	38.9	-2.4
Alternative 7b	29.6	-10.7	27.8	-10.5	D	36.3	-5.0
Alternative 7c	29.6	-10.7	27.8	-10.5	D	34.5	-6.8
<b>PM Peak Hour</b>							
Existing	63.5		67.8		E	58.7	
Alternative 7a	38.7	-24.8	32.4	-35.4	D	41.3	-17.4
Alternative 7b	34.9	-28.6	29.9	-37.9	D	38.0	-20.7
Alternative 7c	34.9	-28.6	29.9	-37.9	D	36.2	-22.5

Source: HNTB Corporation, 2010

Overall intersection delay for Alternative 7a would improve by two seconds per vehicle in the morning and midday peak hours, and would improve up to 17 seconds during PM peak conditions. More significantly, delays for the east-west through movements used by Route 44 would be reduced compared to the existing operation. Improvements up to 35 seconds per vehicle would be realized by outbound buses during the PM peak hour. More typically, improvements would range between ten and 28 seconds per vehicle for inbound and outbound bus movements.

In comparison to the proposed improvements in the *Traffic Alternatives Report* for the NW Market/NE 45<sup>th</sup> Street Transit Corridor Improvement Project, Alternative 7a would provide less outbound transit travel-time benefit in the AM and midday periods; 28.6 and 10.5 seconds in the AM and midday periods, respectively, compared to 42.0 and 28.1 in the earlier analysis. In the PM peak hour, Alternative 7a would provide significantly more transit travel-time benefit; 35.4 seconds, compared to 8.8 seconds in the outbound direction in the earlier analysis.

Movement-by-movement delays for all turning movements of Alternative 7a with the preferred Option A westbound approach are provided in Appendix B.

Estimates of queue lengths for Alternative 7a indicate that the southbound queue would extend up to about 500 feet on southbound 24<sup>th</sup> Avenue NW at NW Market St during morning peak conditions. A queue of this length would block the intersection of NW 56<sup>th</sup> Street, similar to existing conditions.

The Option A channelization would create a lane trap for eastbound traffic using the left lane. The fraction of vehicles turning left ranges between 3 and 17 percent at various times of day, suggesting that through vehicles will merge into the through lane on the intersection approach. During the morning peak period, most eastbound traffic (72 percent) would be shifting into the

right lane for the turn onto Shilshole Avenue NW. It is estimated that morning parking restrictions should extend about 210 feet from the intersection to accommodate the right-turning traffic, affecting about nine total parking spaces.

## **FREIGHT MOBILITY**

Freight activity in the vicinity of the NW Market Street/24<sup>th</sup> Avenue NW intersection is associated with the manufacturing and industrial center and with local deliveries. Shilshole Avenue NW is designated as a major truck street in the City's Transportation Plan. NW Market Street and 24<sup>th</sup> Avenue NW are designated as minor arterial streets, on which trucks are permitted to operate.

Benefits to freight mobility include increased lane widths at the intersection. Lane widths would be increased on the intersection approaches with the revised channelization. Curb lanes would range in width from 11 to 14 feet, with through and turning lanes at 10 to 11 feet.

The proposed signalization revisions would reduce overall intersection delays compared to the existing split-phase signal operation. Truck movements from eastbound NW Market Street onto Shilshole Avenue NW would experience reductions in delay of up to 30 percent. This right-turn movement also will turn into a single southbound lane on Shilshole Avenue NW, providing additional turning width.

The protected left-turn movements at the intersection would allow for lead-lag left-turns if necessary to manage turning conflicts by trucks in opposing left-turn lanes. Lead-lag signalization for left turns would provide identical operational and safety performance compared to the protected phasing with leading left turns.

The minor leg of 24<sup>th</sup> Avenue NW south of the intersection is used for freight access and egress. During the PM peak period, queues of left-turning vehicles on northbound Shilshole Avenue NW frequently block left turns from the minor leg. As a result, many motorists use NW 54<sup>th</sup> Street and 26<sup>th</sup> Avenue NW instead to exit the industrial area. With the intersection revisions, queues of left-turning vehicles will be reduced during the morning and midday periods, which may ease the exiting movement from the minor leg at these times of day. Otherwise, operations at the minor leg will be unchanged from existing conditions.

## **PEDESTRIAN AND BICYCLE FEATURES**

The intersection signalization revisions would preserve existing curbs, sidewalks and curb ramps. The revised traffic signal phasing would accommodate pedestrians with less delay than is currently experienced with the split-phase operation.

By reducing the number of through lanes for north-south traffic, opportunities are provided for enhancement of bicycle operations through this intersection. On the southbound approach, Alternative 7a would provide a single shared through-right lane and a dedicated left-turn lane. A single lane would be provided for northbound traffic on the north leg. This configuration would allow for a bike lane in each direction on 24<sup>th</sup> Avenue NW north of NW Market Street, connecting to a similar configuration north of NW 56<sup>th</sup> Street. New bicycle facilities would not be included on the south, east or west legs of the NW Market Street/24<sup>th</sup> Avenue NW intersection.

## **RECOMMENDATION**

We recommend pursuing Alternative 7a as being the best selection for improved bus movement. Alternative 7a also addresses the needs of pedestrians, bicyclists, freight mobility, and general traffic using the intersection. On the west leg of the intersection, Option A is recommended for advancement. It will require permanent removal of four spaces on the north side of the street, and one from the south side. Eight additional spaces on the south side would be restricted during the morning peak period to serve the heavy eastbound right-turn movement.

Protected phasing is recommended, with detection on all approaches. These modifications will require conversion from fixed-time to actuated control, necessitating a new controller and cabinet. The cabinet could be sized to allow future application of transit signal priority operation at this location.

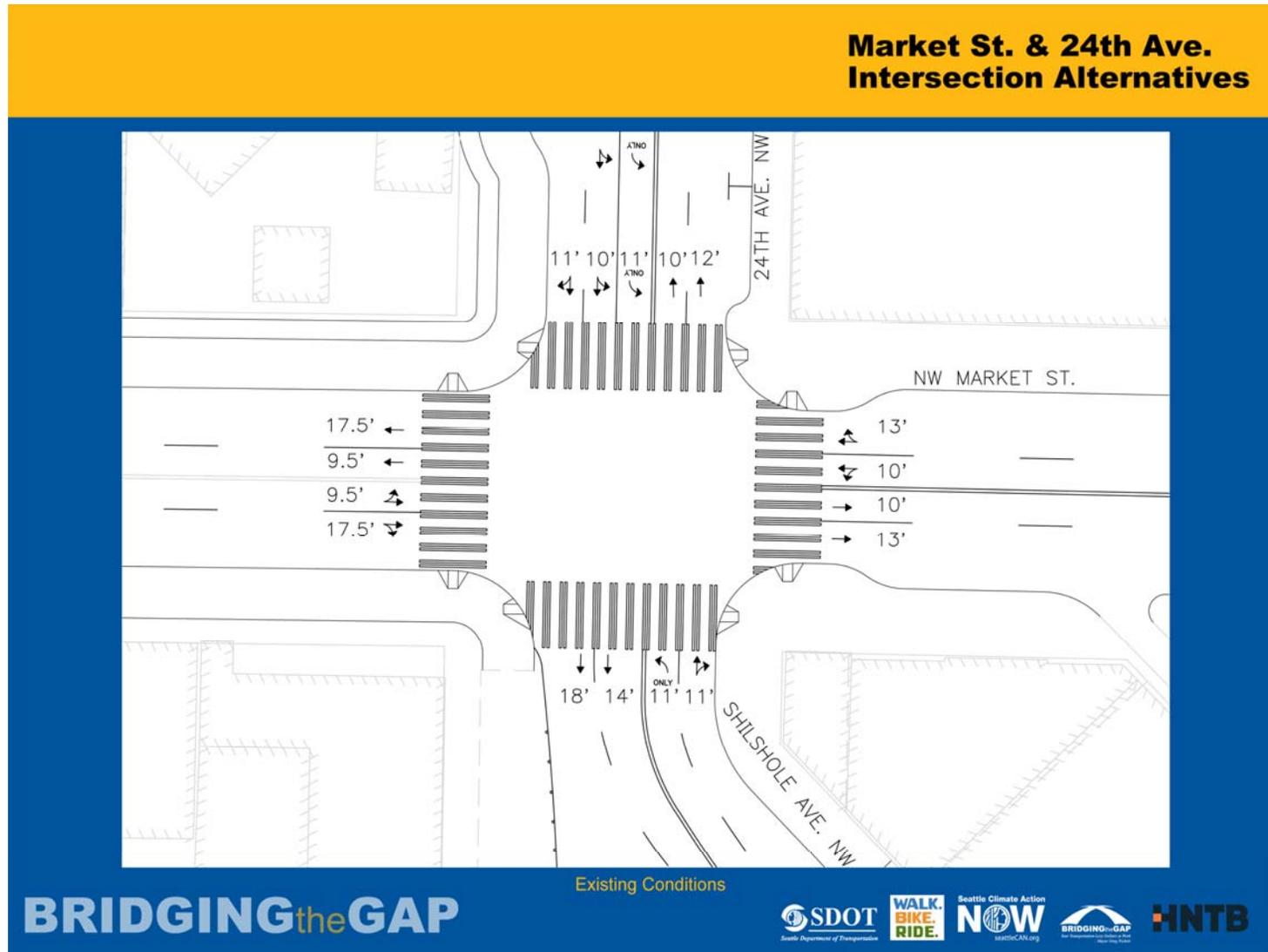


Figure 1

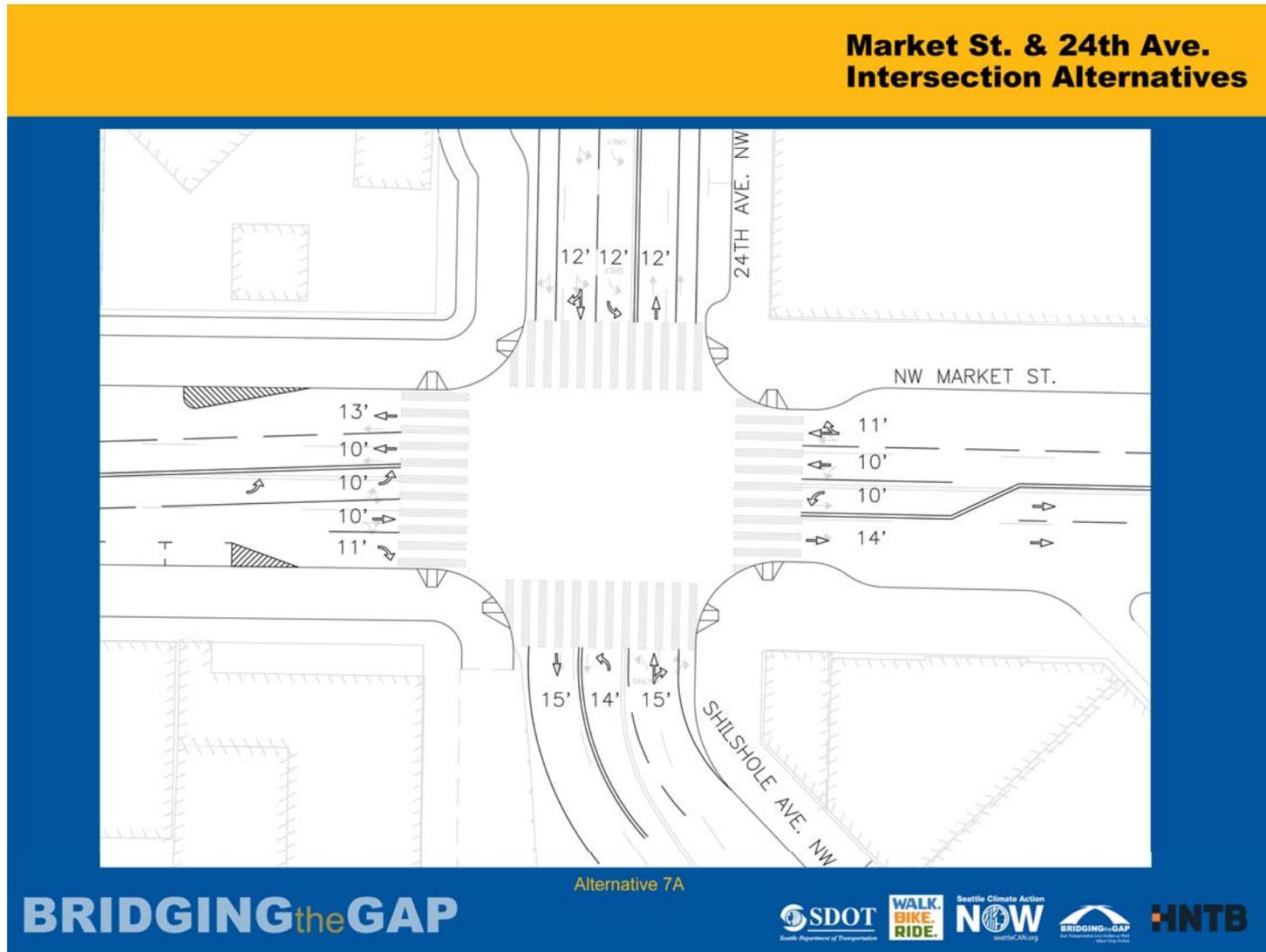


Figure 2

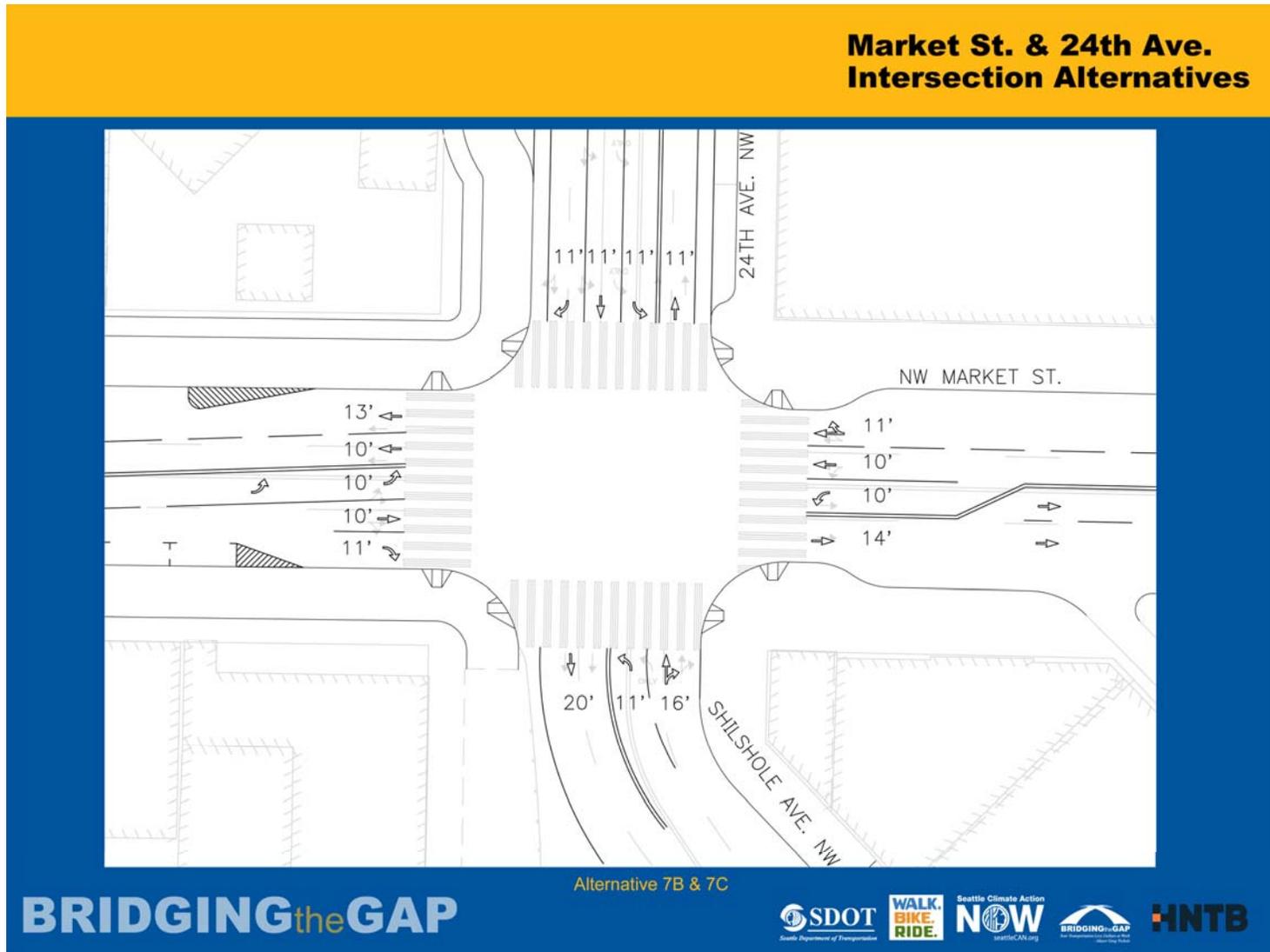
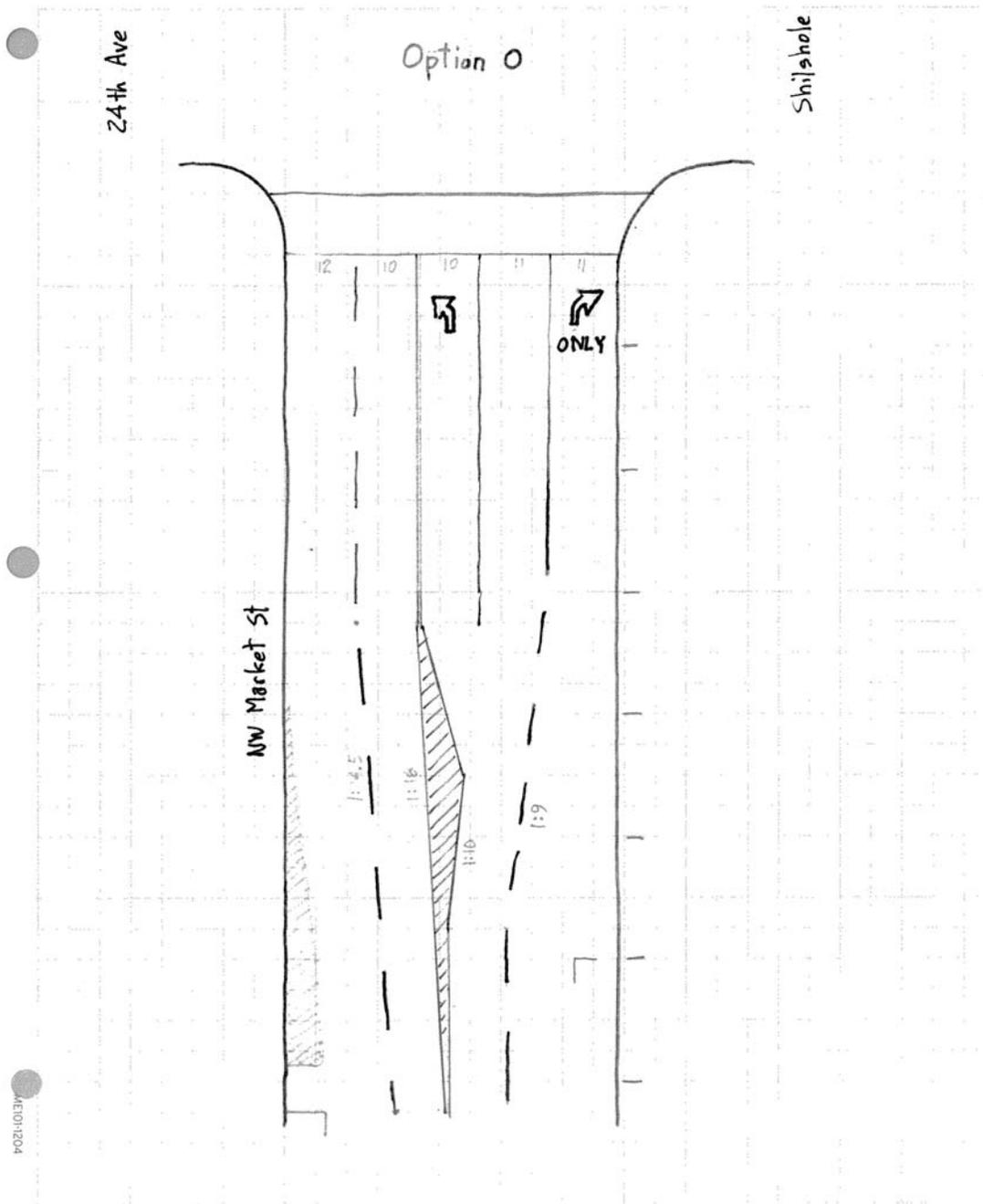
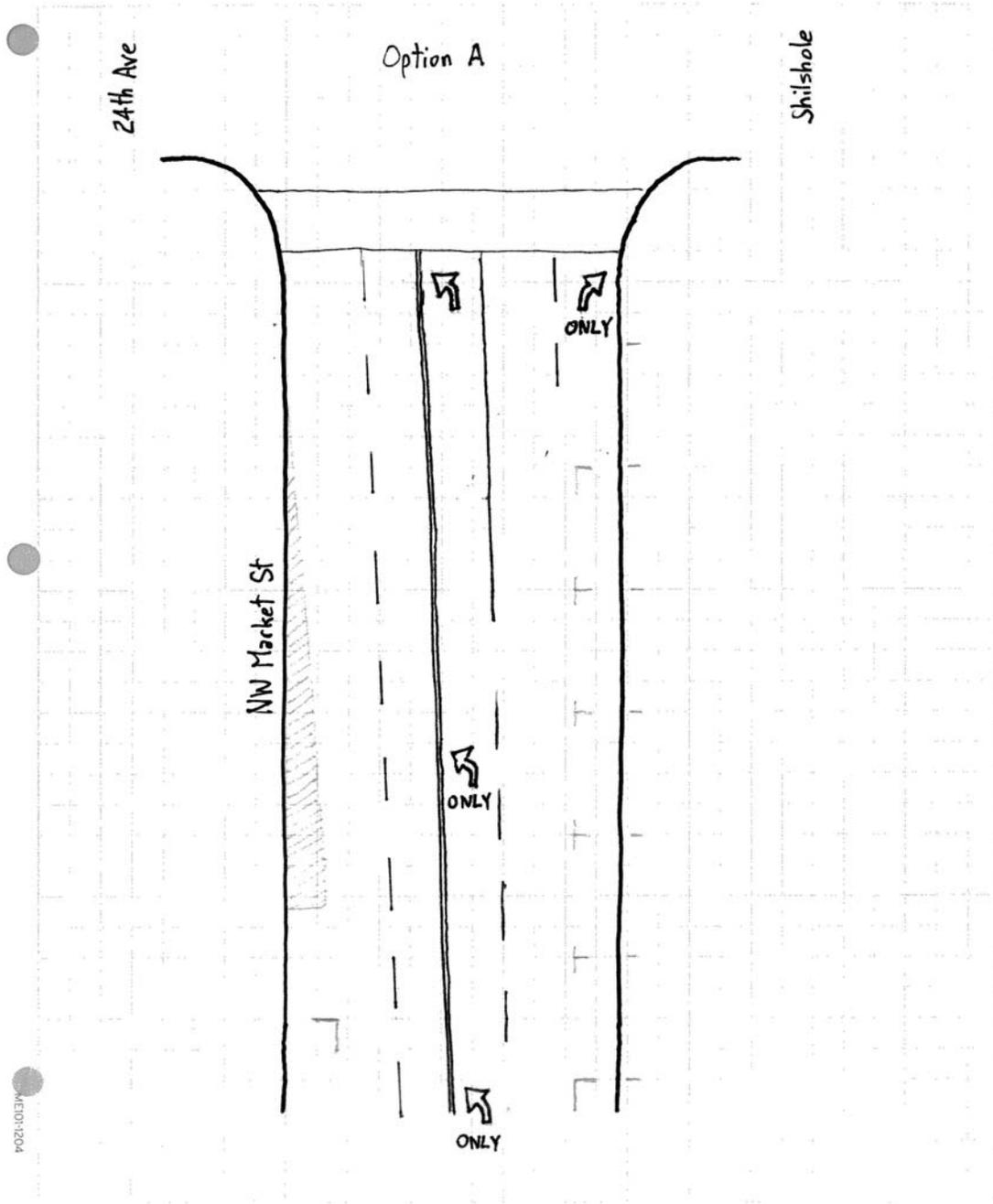
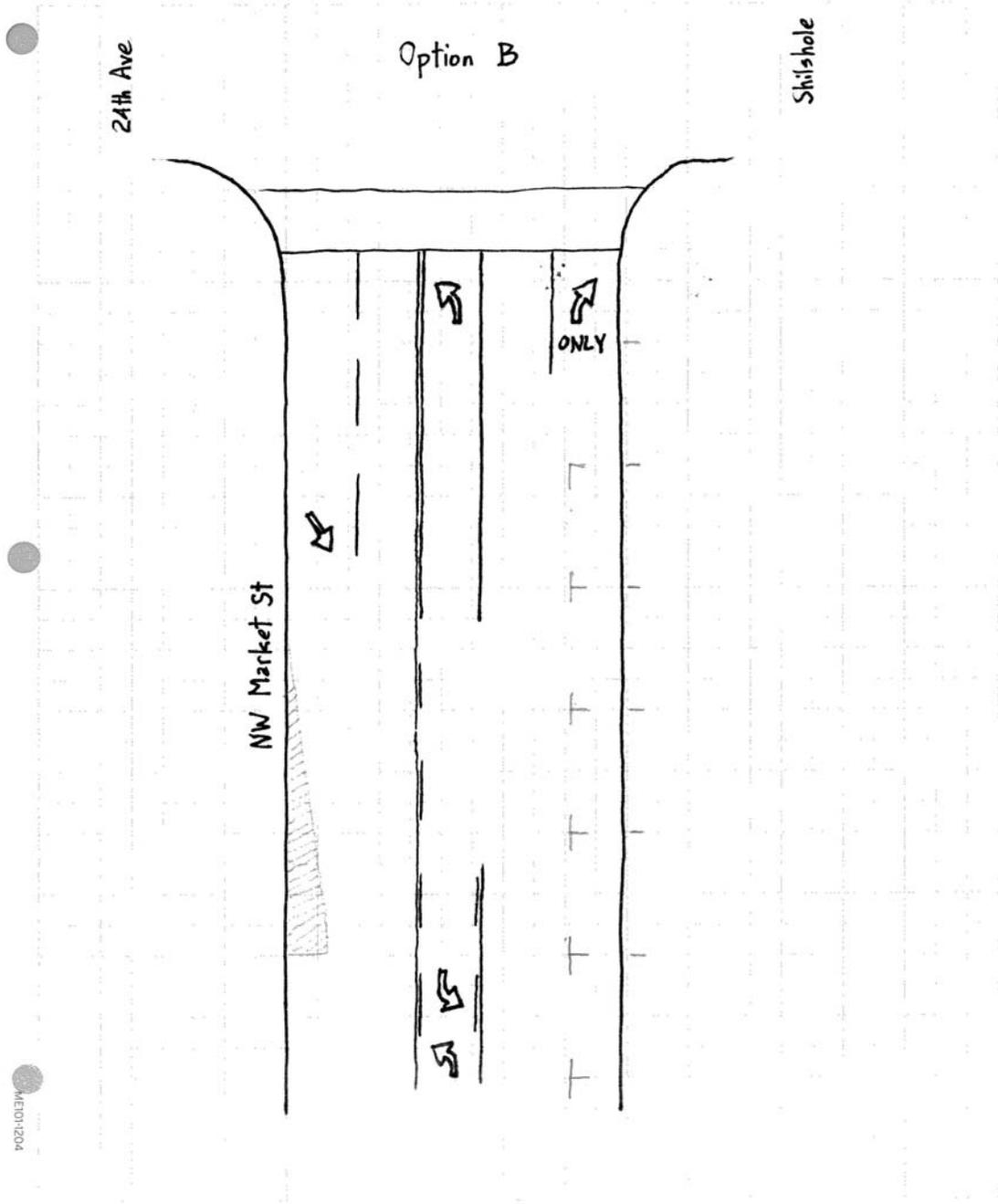


Figure 3

**APPENDIX A**







## APPENDIX B

Alternative 7a with the preferred eastbound approach configuration (Option A)

<b>AM Peak Hour</b>														
Scenario	Description	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Total
	2010 Turn Movement Count (vph)	17	170	499	29	144	62	110	63	23	166	492	38	
<b>Existing</b>	Average Vehicle Delay (s/veh)	41.9	41.9	41.9	42.7	42.7	42.7	46.4	46.4	46.4	34.9	44.3	44.3	42.7
<b>Preferred</b>	Average Vehicle Delay (s/veh)	55.9	28.1	36.2	57.2	33.1	33.1	63.1	24.5	24.5	49.7	51.0	51.0	42.3

<b>Midday Peak Hour</b>														
Scenario	Description	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Total
	2010 Turn Movement Count (vph)	68	228	206	47	316	191	204	133	19	157	163	99	
<b>Existing</b>	Average Vehicle Delay (s/veh)	40.3	40.3	40.3	39.9	39.9	39.9	47.5	47.5	47.5	43.7	39.2	39.2	41.7
<b>Preferred</b>	Average Vehicle Delay (s/veh)	48.1	29.6	26.0	58.6	28.5	28.5	53.1	38.4	38.4	49.4	55.8	55.8	39.2

<b>PM Peak Hour</b>														
Scenario	Description	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Total
	2010 Turn Movement Count (vph)	85	210	202	76	394	222	282	244	19	137	204	55	
<b>Existing</b>	Average Vehicle Delay (s/veh)	63.5	63.5	63.5	67.8	67.8	67.8	46.3	46.3	46.3	55.5	54.0	54.0	58.7
<b>Preferred</b>	Average Vehicle Delay (s/veh)	48.3	38.7	33.2	44.0	33.0	33.0	50.1	45.1	45.1	42.2	55.3	55.3	41.7