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MEMORANDUM

Date: June 13, 2007 **Project #:** 7673.1K

To: Mike Niederhauser, Maryland State Highway Administration

From: Eric Waltman, P.E., Ed Myers, P.E., and Eric Hulme

Project: Intersection Feasibility Study

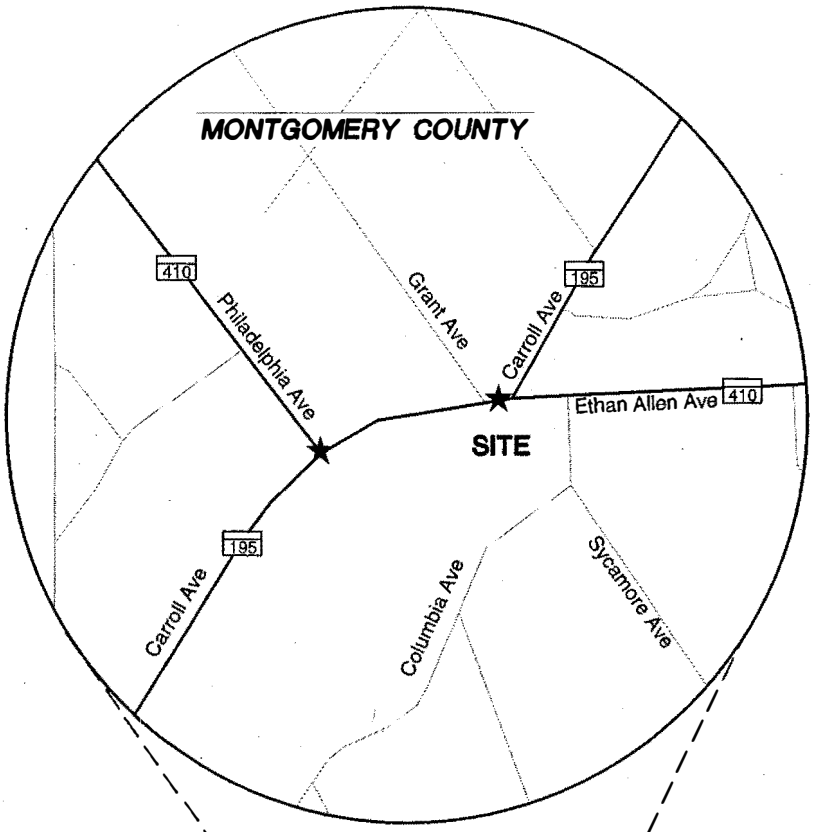
Subject: MD 410/MD 195/Sycamore/Grant Intersection – Takoma Park, MD

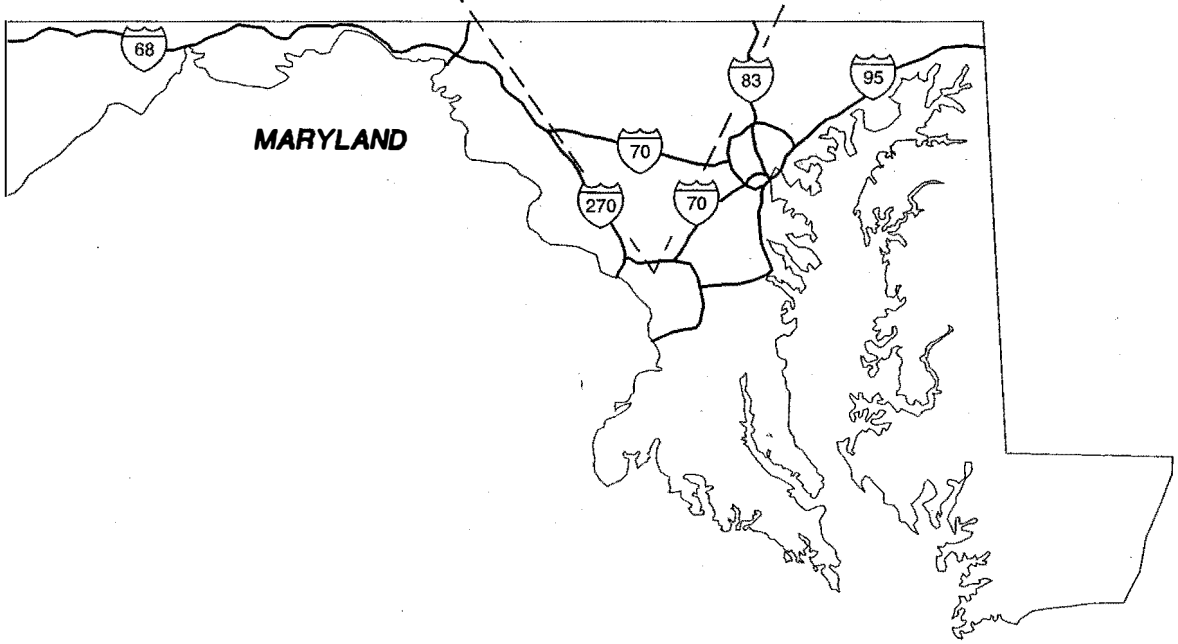
This memorandum documents Kittelson & Associates, Inc.'s (KAI) intersection feasibility analysis of the Ethan Allen Avenue (MD 410)/Carroll Avenue (MD 195)/Sycamore Avenue/Grant Avenue intersection located in Takoma Park, Montgomery County, Maryland. A site vicinity map is included as Figure 1. The feasibility of several intersection improvement scenarios were assessed as follows: (1) maintaining existing signalized intersection control, (2) realigning Carroll Avenue to form the north leg of the Ethan Allen Avenue/Sycamore Avenue intersection and replacing signalized control with a mini-roundabout, (3) realigning Columbia Avenue to form the south leg of the Ethan Allen Avenue/Grant Avenue/Carroll Avenue intersection and replacing signalized control with a mini-roundabout. Based on the results of the analysis a mini-roundabout is recommended because it is forecast to operate with less delay and shorter queues than the existing signalized intersection control, while also providing significant safety advantages.

EXISTING CONDITIONS

Ethan Allen Avenue (MD 410) is an east-west two-lane roadway with a posted speed of 25 miles per hours (MPH) whose western terminus is at Carroll Avenue. Carroll Avenue (MD 195) is a northeast-southwest two-lane roadway with a posted speed of 25 MPH. Sycamore Avenue is a north-south two-lane roadway with a posted speed of 25 MPH. Grant Avenue is a one-lane roadway with a posted speed of 25 MPH. Sidewalks exist on every roadway in the site vicinity.

The Ethan Allen Avenue (MD 410)/Carroll Avenue (MD 195)/Sycamore Avenue/Grant Avenue intersection is actually combination of three closely spaced intersections. Carroll Avenue (MD 195)/Grant Avenue is the westernmost intersection and functions as an unsignalized intersection. Grant Avenue provides northbound travel away from Carroll Avenue. The remaining two intersections, Carroll Avenue (MD 195)/Ethan Allen Avenue (MD 410) and Ethan Allen Avenue (MD 410)/Sycamore Avenue form an offset pair of signalized intersections operated by a single controller.





(NO SCALE)

Vicinity Map
Takoma Park, MD

FIGURE 1

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The nearest signalized intersection is Carroll Avenue (MD 195)/Philadelphia Avenue (MD 410) which is located approximately 400 feet west of Grant Avenue.

Surrounding land uses in the site vicinity include, surface parking and a grocery market located in the southwest quadrant of the Ethan Allen Avenue/Sycamore Avenue intersection, single family residences located in the southeast and northeast quadrants of the Ethan Allen Avenue/Sycamore Avenue intersection, a public space (Takoma Junction) located in the northeast quadrant of the Carroll Avenue/Ethan Allen Avenue intersection, specialty retail stores located in the northwest quadrant of the Carroll Avenue/Ethan Allen Avenue intersection, and a gas station located in the northwest quadrant of the Carroll Avenue/grant Avenue intersection. A fire station is located along the south side of Carroll Avenue at Carroll Avenue/Philadelphia Avenue intersection.

TRAFFIC OPERATIONS ANALYSIS

An operational analysis was conducted for the off set pair of signalized intersections (Carroll Avenue/Ethan Allen Avenue/Sycamore Avenue) under existing traffic conditions during weekday a.m. and p.m. peak hour. Traffic volumes were provided by SHA and are summarized in Figure 2.

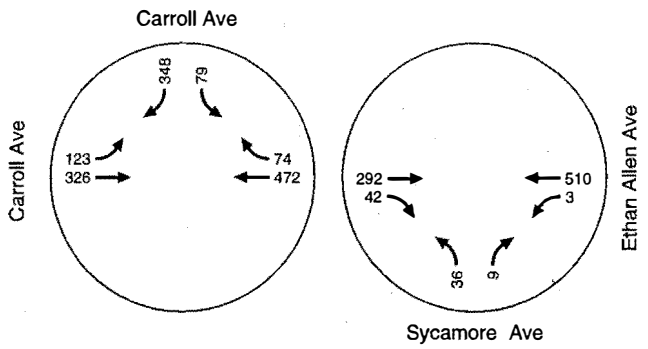
Figure 2 also provides a summary of the existing traffic volumes as they would apply to the two roundabout alternatives:

> **Concept "A"**: realignment of Carroll Avenue to form the north leg of the Ethan Allen Avenue/Sycamore Avenue intersection and replacement of signalized control with a mini-roundabout; and
>
> **Concept "B":** realignment and extension of Columbia Avenue to form the south leg of the Ethan Allen Avenue/Grant Avenue/Carroll Avenue intersection and replacement of signalized control with a mini-roundabout. The existing Ethan Allen Avenue/Sycamore Avenue intersection would be converted to stop control on the Sycamore Avenue approach and left-turn s to and from Sycamore Avenue would be restricted.

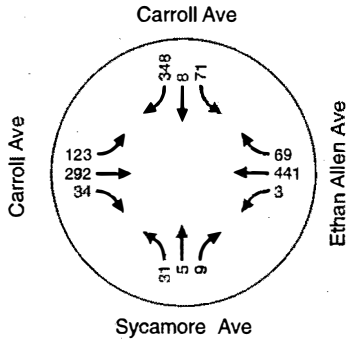
Signalized Intersection Operations

Signalized intersection operations were evaluated using the Synchro 6 software application. In the vicinity of Ethan Allen Avenue, Carroll Avenue has been widened to provide an exclusive left-turn lane and an exclusive through lane on the eastbound approach, and an exclusive left-turn lane and an exclusive right-turn lane on the southbound approach. All other approaches to the offset pair of signalized intersections maintain a single, shared lane. Table 1 provides a summary of traffic signal operations for the offset Carroll Avenue/Ethan Allen Avenue/Sycamore Avenue intersection under 2006 traffic conditions.

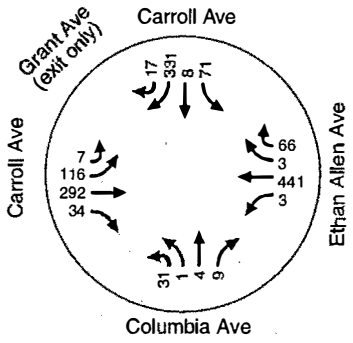
AM Conditions



Existing Intersection



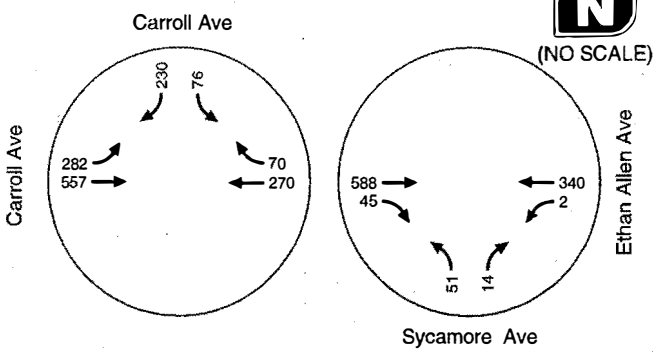
Roundabout Concept A



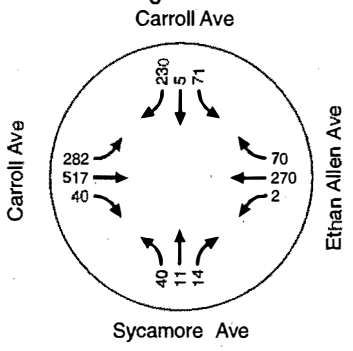
Roundabout Concept B

Philadelphia Ave

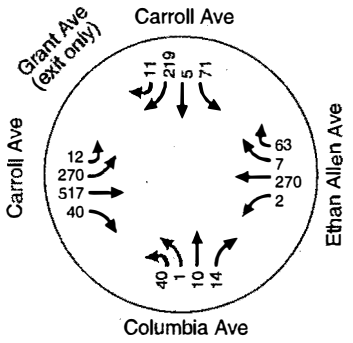
PM Conditions



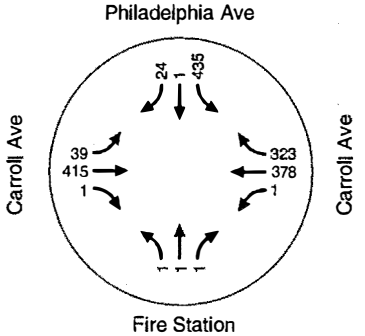
Existing Intersection



Roundabout Concept A



Roundabout Concept B



Philadelphia Ave

Traffic Volumes
Takoma Park, MD

FIGURE 2

Table 1 2006 Signalized Intersection Operations

Approach	Lane Configuration	95th Percentile Queue (# of veh)*	Volume to Capacity Ratio (v/c)	Average Delay (sec/veh)	Intersection Volume to Capacity Ratio (v/c)	Intersection Average Delay (sec/veh)
WEEKDAY AM PEAK HOUR						
Eastbound Carroll Ave	L, T	5, 7	0.52, 0.33	44.7, 12.2	0.68	22.7
Southbound Carroll Ave	L, R	4, 8	0.33, 0.81	42.2, 45.6		
Westbound Ethan Allen Ave	TR	24	0.76	32.7		
Northbound Sycamore Ave	LR	2	0.16	42.4		
WEEKDAY PM PEAK HOUR						
Eastbound Carroll Ave	L, T	13, 14	0.86, 0.57	59.9, 15.2	0.59	23.9
Southbound Carroll Ave	L, R	4, 5	0.34, 0.47	42.8, 28.0		
Westbound Ethan Allen Ave	TR	13	0.59	30.0		
Northbound Sycamore Ave	LR	3	0.25	43.3		

* Represents the 95% queue for the lane on each approach with the longest projected queue

As shown in Table 1, the offset pair of signalized intersections currently operates under capacity during the weekday a.m. peak hour, with an average delay of 22.7 seconds per vehicle and a maximum queue of 24 vehicles on the westbound Ethan Allen Avenue approach. The offset pair of signalized intersections also currently operates under capacity during the weekday p.m. peak hour, with an average delay of 23.9 seconds per vehicle and a maximum queue of 14 vehicles on the eastbound Carroll Avenue approach. Signalized operations worksheets are provided as Attachment "A".

Roundabout Operations

Roundabout operations were evaluated using the Sidra Intersection 3.1 software application. Tables 2 and 3 summarize the forecast operations for both roundabout alternatives under existing traffic conditions during the weekday a.m. and p.m. peak hours.

Table 2 2006 Roundabout Operations - Concept "A"

Approach	Number of Entry/Exit Lanes	Volume to Capacity Ratio (v/c)	Average Delay (sec/veh)	95th Percentile Queue (# of veh)	Intersection Volume to Capacity Ratio (v/c)	Intersection Average Delay (sec/veh)
WEEKDAY AM PEAK HOUR						
Eastbound Carroll Ave	1 / 1	0.47	0.5	5	0.80	14.0
Southbound Carroll Ave	1 / 1	0.80	2.0	12		
Westbound Ethan Allen Ave	1 / 1	0.60	1.5	6		
Northbound Sycamore Ave	1 / 1	0.09	14.6	1		
WEEKDAY PM PEAK HOUR						
Eastbound Carroll Ave	L, T	0.82	0.6	15	0.82	11.9
Southbound Carroll Ave	L, R	0.49	3.0	4		
Westbound Ethan Allen Ave	TR	0.56	2.3	6		
Northbound Sycamore Ave	LR	0.24	11.3	2		

As shown in Table 2, concept "A" is forecast to operate under capacity during the weekday a.m. peak hour, with an average delay of 14.0 seconds per vehicle and a maximum queue of 12 vehicles on the southbound Carroll Avenue approach. Concept "A" is also forecast to operate under capacity during the weekday p.m. peak hour, with an average delay of 11.9 seconds per vehicle and a maximum queue of 15 vehicles on the eastbound Carroll Avenue approach. Concept "A" roundabout operations worksheets are provided as Attachment "B".

Table 3 2006 Roundabout Operations - Concept "B"

Approach	Number of Entry/Exit Lanes	Volume to Capacity Ratio (v/c)	Average Delay (sec/veh)	95th Percentile Queue (# of veh)	Intersection Volume to Capacity Ratio (v/c)	Intersection Average Delay (sec/veh)
WEEKDAY AM PEAK HOUR						
Eastbound Carroll Ave	1 / 1	0.47	1.9	5	0.81	14.3
Southbound Carroll Ave	1 / 1	0.81	1.9	13		
Westbound Ethan Allen Ave	1 / 1	0.60	1.5	6		
Northbound Columbia Ave	1 / 1	0.09	14.7	1		
Northbound Grant Ave	0 / 1	-	-	-		
WEEKDAY PM PEAK HOUR						
Eastbound Carroll Ave	L, T	0.82	0.6	15	0.82	12.0
Southbound Carroll Ave	L, R	0.45	2.9	5		
Westbound Ethan Allen Ave	TR	0.56	2.2	6		
Northbound Columbia Ave	LR	0.24	11.3	2		
Northbound Grant Ave	0 / 1	-	-	-		

As shown in Table 3, Concept "B" is forecast to operate under capacity during the weekday a.m. peak hour, with an average delay of 14.3 seconds per vehicle and a maximum queue of 13 vehicles on the southbound Carroll Avenue approach. Concept "B" is also forecast to operate under capacity during the weekday p.m. peak hour, with an average delay of 12.0 seconds per vehicle and a maximum queue of 15 vehicles on the eastbound Carroll Avenue approach. Concept "B" roundabout operations worksheets are provided as Attachment "C".

Operations Comparison

The operational analyses of the existing signalized control the roundabout alternatives are summarized in Table 4 below.

Table 4 MD 410/MD 195 Alternatives Comparison

Alternative	Intersection Volume to Capacity Ratio (v/c)	Intersection Average Delay (sec/veh)*	95th Percentile Queue (# of veh)**
WEEKDAY AM PEAK HOUR			
Existing Signal	0.68	22.7	24
Concept "A"	0.80	14.0	12
Concept "B"	0.81	14.3	13
WEEKDAY PM PEAK HOUR			
Existing Signal	0.59	23.9	14
Concept "A"	0.82	11.9	15
Concept "B"	0.82	12.0	15

* Reflects average delay for all entering vehicles for Roundabout and Signal
** Reflects approach with longest queue

As shown in Table 4, all alternatives are forecast to operate under capacity; however both roundabout alternatives are forecast to operate with less delay and shorter queues than the signalized alternative.

It was recognized during this feasibility study that the existing intersection is close to capacity. Growth in the area was also recognized to be minimal without roadway improvements to Ethan Allen Avenue, Carroll Avenue, and Philadelphia Avenue

DESIGN RECOMMENDATION

Based on the operational assessment, as well as inherent safety advantages associated with roundabouts (e.g. low speed environment, reduction of conflict points, elimination of high severity crash types), we recommend further consideration of either roundabout alternative as a potential intersection improvement.

Given the right-of-way constraints of the site and the pedestrian nature of the area, a mini-roundabout was considered to be the most appropriate roundabout application. Mini-roundabouts are small roundabouts used in low-speed urban environments, with average operating speeds of 35mph or less. In retrofit applications, mini-roundabouts are relatively inexpensive because they typically require minimal additional pavement at the intersecting roads. Because they are small, mini-roundabouts are perceived as pedestrian-friendly with short crossing distances and very low vehicle speeds on approaches and exits.

Preliminary Roundabout Design

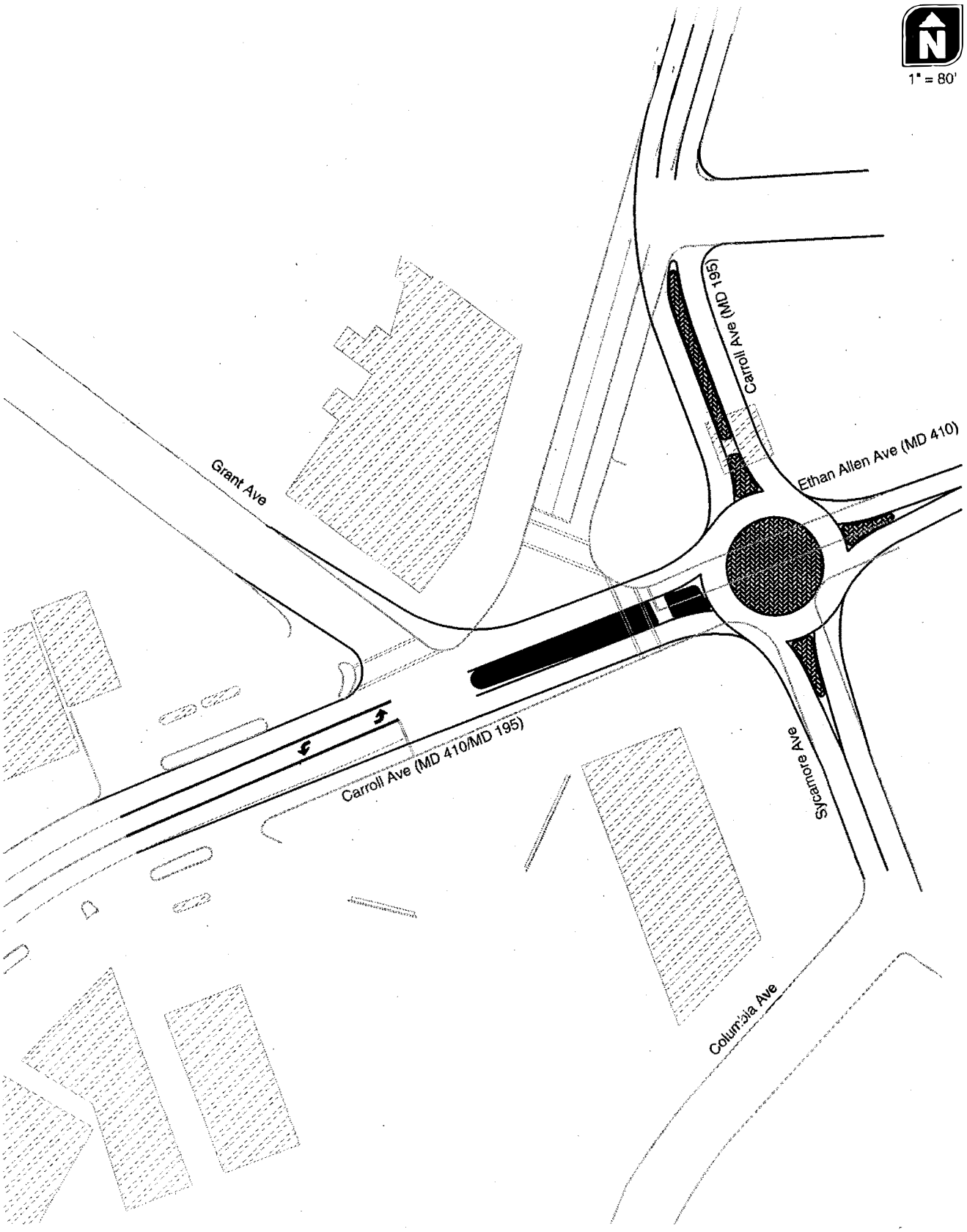
KAI developed roundabout Concept "A" with an inscribed circle diameter of 90 feet. Each approach would have one 16-foot entry lane and one 16-foot exit lane. Within the roundabout, there would be a 16-foot circulatory roadway with a 58-foot diameter central island that would be fully mountable to accommodate off-tracking of large vehicles. This layout should be sufficient to identify local access implications and the approximate extent of roadway widening.

This concept will result in the relocation of the existing Takoma Junction park to accommodate the realignment of Carroll Avenue. Figure 3 illustrates roundabout Concept "A".

KAI developed roundabout Concept "B" with one 16-foot entry lane and one 16-foot exit lane on all approaches, with the exception of Grant Avenue, which is only an exit lane. Concept "B" also employs a 16-foot circulatory roadway; however, the central island forms an ellipse to help create additional space in which to join a fifth leg. The elliptic central island of roundabout concept B has a major radius of 50 feet and a minor radius of 35 feet. This concept involves a property impact with the rerouting of Columbia Avenue through an existing parking lot west of the grocery store. A new intersection would be created to the southwest of the grocery store with stop control placed on the extension to Columbia Avenue (southbound approach).

The junction of Ethan Allen Avenue and Sycamore Avenue would be restricted to prohibit left-turns to and from Sycamore Avenue. Figure 4 illustrates roundabout Concept "B".

The roundabout designs are centered on the existing intersection to minimize realignment and right-of-way impacts. There is flexibility to adjust either concept's alignment, location, and/or size if appropriate based on historic or environmental features or other local concerns.



Roundabout Concept A
Takoma Park, MD

FIGURE 3

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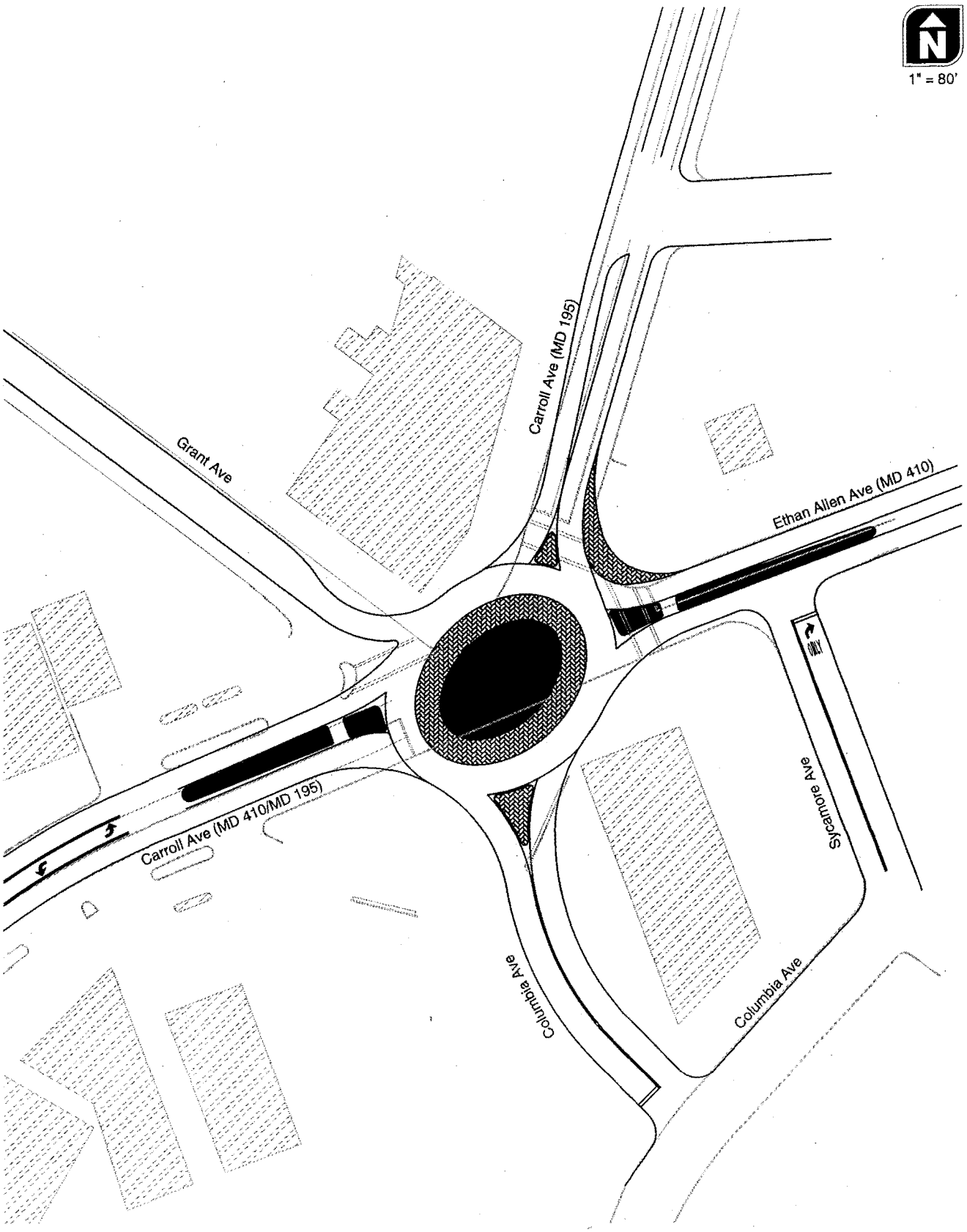

Roundabout Concept B
Takoma Park, MD

FIGURE 4

FUNCTIONAL DESIGN

This section provides a summary of key geometric design elements considered in the development of the roundabout concepts for the Ethan Allen Avenue (MD 410)/Carroll Avenue (MD 195)/Sycamore Avenue/Grant Avenue intersection to enhance safety and guidance at the intersection.

Fastest Path Checks

KAI conducted a check of fastest paths for the proposed roundabout concepts illustrated in Figures 3 and 4. The analysis was performed according to guidelines set firth in FHWA's *ROUNDABOUTS: An Informational Guide*. For reference, the five fastest path radii are defined in Figure 5.

Figure 5
Vehicle Path Radii at a Roundabout

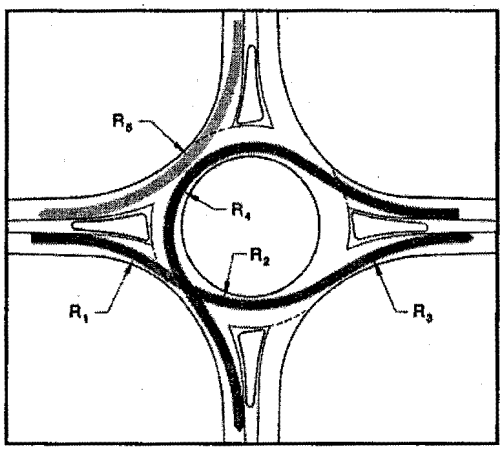

Table 5 summarizes the five fastest path radii measured for each approach and the corresponding travel speeds at the intersection.

Table 5
Fastest Path Curves and Travel Speed Summary

	Roundabout Concept A			Roundabout Concept B		
Approach	**Curve**	**Radius (feet)**	**Speed (mph)**	**Curve**	**Radius (feet)**	**Speed (mph)**
Carroll Ave (Eastbound)	**R1**	155	24	**R1**	135	23
	R2	60	16	**R2**	165	23
	R3	175	25	**R3**	175	25
	R4	45	14	**R4**	50	15
	R5	70	18	**R5**	105	21
Carroll Ave (Southbound)	**R1**	165	25	**R1**	135	23
	R2	60	16	**R2**	250	26
	R3	245	29	**R3**	265	29
	R4	45	14	**R4**	50	15
	R5	70	18	**R5**	100	20
Ethan Allen Ave (Westbound)	**R1**	160	24	**R1**	155	24
	R2	65	16	**R2**	125	21
	R3	225	28	**R3**	85	19
	R4	45	14	**R4**	75	17
	R5	75	18	**R5**	55	16
Sycamore/Columbia Ave (Northbound)	**R1**	175	25	**R1**	155	24
	R2	60	16	**R2**	100	19
	R3	185	26	**R3**	180	26
	R4	45	14	**R4**	65	16
	R5	85	19	**R5**	155	24

All the calculated approach speeds are within the desirable speed differential of 6-12 miles per hour for entry (R1) and circulating (R4) flows. All of these characteristics are consistent with recommendations made in the FHWA Roundabout Guide.

Truck Accommodation

Based on an evaluation of truck movements using the AutoTURN software application, the proposed roundabout designs can accommodate the turning movements of a WB-67 traveling to and from each state highway approach. The 16-foot circulatory roadway can accommodate the turning movements of a city bus without encroachment upon the central island. Illustrations of the analyzed truck movements are provided as Attachment "D".

In order to accommodate the truck movements the central islands of both roundabout concepts are fully-mountable and the splitter islands are fully-mountable where truck movements would otherwise be restricted by a raised splitter island.

Bicycle and Pedestrian Accommodation

The roundabout designs do not incorporate bicycle lanes, but do account for pedestrian crossings. We recommend that the roundabout Concept "A" be designed with a raised splitter island on the eastbound Ethan Allen Avenue approach to provide a pedestrian refuge as this approach has the widest cross-section. For roundabout Concept "B", we recommend that pedestrian refuges be provided in the splitter islands on both eastbound and westbound Ethan Allen Avenue.

Transit Accommodation

Under either roundabout alternative, we recommend eliminating existing pullout areas and replace them with stops on the entry approaches to the roundabout. By providing bus stops, rather than pullouts, buses will not need to merge back into traffic. Locating the bus stop on entry, rather than exit, eliminates the potential spillback of queues behind the bus blocking roundabout operations.

CONCLUSION AND RECOMMENDATION

KAI evaluated potential intersection improvements including maintaining existing signalized control and the feasibility of installing a mini-roundabout at the Ethan Allen Avenue (MD 410)/Carroll Avenue (MD 195)/Sycamore Avenue/Grant Avenue intersection. The study resulted in the following conclusions and recommendations:

- Both a traffic signal and a mini-roundabout are forecast to provide acceptable operations; however, the roundabout alternative will result in less overall delay and queuing.
- A roundabout will provide enhanced safety benefits as compared to the existing signalized control.
- A mini-roundabout is a recommended improvement as it strikes the best balance between operations, safety, and right-of-way impacts.
- Both roundabout Concept "A" and Concept "B" are feasible alternatives. However, both alternatives result in new roadway alignments that will impact local property owners. We recommend a developing a public involvement process to address the concerns of local stakeholders and to solicit additional comments or ideas for improvements.
- If a roundabout concept is selected as a preferred alternative, consideration should also be given to (1) modifying the Carroll Avenue cross-section between Grant Avenue and Philadelphia Avenue to a three-lane section with one lane of travel in each direction and a center median/left-turn lane, and (2) replacing the signalized Carroll Avenue/Philadelphia Avenue intersection with a roundabout.

- A detailed survey of the area should be obtained before final roundabout design plans are prepared.

Please contact us at 410-347-9610, if you have any questions regarding our study and recommendations.