700.2

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING / PLANNING
610 SW Alder Street, Suite 700, Portland, OR 97205 503.228.5230 503.273.8169

MEMORANDUM

Date: May 27, 2009 Project #: 10120

To: William (Bill) J. Falconi
City of Nevada City
317 Broad Street
Nevada City, CA 95959

From: Hermanus Steyn, Lee Rodegerdts, P.E. and Rohit Rai

Project: Zion St/Gold Flat Rd & Nevada City Hwy/Ridge Rd Roundabout Reviews

Subject: Roundabout Feasibility Study

cc: Doug Hobbs

Kittelson & Associates, Inc. (KAI) has prepared an independent evaluation of the feasibility of proposed roundabouts at the Gold Flat Road/Zion Street and Nevada City Highway/Ridge Road intersections in Nevada City, California. In summary, the feasibility of two roundabouts at the subject intersections does not appear to be feasible due to right-of-way constraints. However, it may be possible to pursue other roundabout options, including a larger single roundabout at the Gold Flat Road/Zion Street intersection with a separate two-way stop-controlled intersection at Nevada City Highway/Ridge Road intersection.

Project Background and Objectives

Gold Flat Road/Zion Street and Nevada City Highway/Ridge Road are offset T-intersections that operate as all-way stopped control (AWSC) intersections today. These intersections are shown in Figure 1.

LSC Transportation Consultants (LSC) conducted traffic operations analysis and developed preliminary geometric layout for the potential implementation of two 115-foot inscribed diameter at the two subject intersections (illustrated in Figure 2). The intersection footprint would impact several properties as discussed in the *Gold Flat Road Corridor Study*. These roundabouts were developed based on a WB-50 tractor-trailer design vehicle. They also do not include pedestrian/bicycle facilities at the subject intersections due to right-of-way constraints and impacts to surrounding properties.

Therefore, the objectives of this feasibility study were:

- Confirm that traffic operations of roundabouts
- Reduce right-of-way impacts compared to LSC roundabouts

This review is based on traffic operations analysis and preliminary geometric layout prepared by LSC, as well as aerial photography and base maps provided by the City of Nevada City. For simplicity, this memorandum assumes the Nevada City Highway and Zion Street are running east-west.

Traffic Operations Analysis

KAI conducted an independent year 2030 operational analysis using the procedures identified in National Cooperative Highway Research Program (NCHRP) Report 572 (Reference 1), calibrated to California conditions (References 2 and 3). Table 1 (next page) summarizes the anticipated capacity, delay, and queue lengths for each approach at the roundabouts based on these California-calibrated equations. Attachment "A" contains a summary sheet of the roundabout calculations.

Assuming a target design threshold volume-to-capacity (v/c) ratio of 0.85, a review of the traffic operations results revealed that all the approaches at the two intersections would operate acceptably. Therefore, it is proposed that the roundabout has single-lane entries on all approaches with the exception of the eastbound Nevada City Highway approach at the eastern roundabout. A two-lane entry is introduced for this approach to manage queuing between the two roundabouts.

Conceptual Sketch-Level Roundabout Layout

Based on the traffic operations review, KAI developed a scaled, hand-sketched design concept at the study intersections to illustrate potential improvements. The following goals and assumptions were applied:

- Locate a roundabout (including pedestrian/bicycle facilities) within existing right-of-way to the extend possible
- Minimize right-of-way impacts
- Accommodate future anticipated queuing between two roundabouts

Figure 2 illustrates the proposed modified roundabouts. The geometric principles conveyed through the sketch are based on the Federal Highway Administration (FHWA) publication *Roundabouts: An Informational Guide* (FHWA Guide, Reference 4) and other current practice guides, research, and practical experience. The findings below highlight key geometric elements.

- Size, location, and geometric constraints
    - The modified roundabouts were developed with an objective of creating minimum impact to the surroundings (locating the sidewalks within public right-of-way). This resulted in an inscribed diameter of approximately 105 feet.

Table 1
Roundabout Operations Analysis Results Year 2030 Traffic Conditions

	Volume/Capacity	Average Delay (sec)	95th Percentile Queue
Weekday A.M. Peak Hour			
Zion Street/Gold Flat Road Intersection: Eastern Roundabout			
Northbound Gold Flat Road	0.77	15	200
Westbound Zion Street	0.58	8	100
Eastbound Nevada City Highway			
• Two-lane entry, left lane	0.35	5	50
• Two-lane entry, right lane	0.25	4	25
Nevada City Highway/Ridge Road Intersection: Western Roundabout			
Eastbound Nevada City Highway	0.36	6	50
Westbound Nevada City Highway	0.49	5	75
Southbound Ridge Road	0.42	6	75
School Peak Hour			
Zion Street/Gold Flat Road Intersection: Eastern Roundabout			
Northbound Gold Flat Road	0.65	11	125
Westbound Zion Street	0.74	13	200
Eastbound Nevada City Highway			
• Two-lane entry, left lane	0.45	6	75
• Two-lane entry, right lane	0.39	6	50
Nevada City Highway/Ridge Road Intersection: Western Roundabout			
Eastbound Nevada City Highway	0.56	9	100
Westbound Nevada City Highway	0.58	6	100
Southbound Ridge Road	0.53	8	100
Weekday P.M. Peak Hour			
Zion Street/Gold Flat Road Intersection: Eastern Roundabout			
Northbound Gold Flat Road	0.54	8	100
Westbound Zion Street	0.67	10	150
Eastbound Nevada City Highway			
• Two-lane entry, left lane	0.44	6	75
• Two-lane entry, right lane	0.38	6	50
Nevada City Highway/Ridge Road Intersection: Western Roundabout			
Eastbound Nevada City Highway	0.56	8	100
Westbound Nevada City Highway	0.53	6	100
Southbound Ridge Road	0.44	7	75

- Alignment of approaches and number of lanes
    - To minimize right-of-way impact, the alignments of the approaching facilities were maintained with adjustments to the entries and exits to better facilitate maneuvers.
- Private Access Points to Approaching Roadways
    - Access to the Imaginarium is not provided at the western roundabout. There might be opportunities to explore shared access with neighboring properties.
    - Access to the fire station of Ridge Road will have to be relocated approximately 90 feet away from Nevada City Highway to allow full access.
    - As stated by LSC, the access to the Sierra Presbyterian Church parking lot off Gold Flat Road will have to be relocated by approximately 40 feet away from Zion Street.
- Design vehicle turning movements
    - The roundabouts have been designed to accommodate a tractor-trailer (WB-67) truck for all movements. Figure 3 shows critical truck turning templates for a WB-67 design vehicle.
- Design speed
    - Figure 4 illustrates the fastest paths through the roundabouts for the through eastbound and westbound movements. The speeds for these movements are higher than desired (25 mph is the desirable maximum speed) and are a consequence of designing the approaches to minimize right-of-way impact. Other movements are expected to have acceptable speeds. Nevada City Highway to the west is posted at 35 mph and Zion Street at 25 mph.
- Pedestrian facilities
    - No sidewalks are currently located along the study intersections. The proposed modified design includes sidewalks on either side of the roads with crosswalks to provide improved pedestrian circulation with minimum impact on the right-of-way.
- Bicycle facilities
    - There are currently no bike lanes along the existing roadway facilities, and cyclists will likely travel through the roundabout in the center of the travel lane. If bike lanes are provided, then bike ramps could be added in future if desired.
- Right-of-Way Impact
    - The property in the northwest corner to the western Nevada City Highway/Ridge Road roundabout will be impacted, but based on the aerial photograph base provided by the City of Nevada City, it appears unlikely that the on-site operation would be impacted.

- The vacant property in the southeast corner to the eastern Gold Flat Road/Zion Street roundabout will be impacted; however, the City might have opportunity to work with the property as that property develops.

Findings and Next Steps

Due to the right-of-way constraints and the resulting small diameters of the two proposed roundabouts, the entry speeds are higher than desired along some approaches. Based on the current project objectives, the feasibility of roundabouts at the subject intersections are questionable and would not be recommended at this stage.

However, the City might consider the following approach:

- If the property owner in the southeast corner to the eastern Gold Flat Road/Zion Street intersection is a willing participant, then investigate the design of a single-lane roundabout at the Gold Flat Road/Zion Street intersection with a larger, more typical, 125-foot inscribed diameter.
- The western Nevada City Highway/Ridge Road intersection can be converted to a side-street (Ridge Road) stopped controlled intersection. A preliminary traffic operations investigation indicates that if a wide median is introduced that provides the opportunity to complete the minor street left-turn in two stages (as might be possible in the design of the splitter island for the roundabout), this intersection would operate within capacity.

Thank you for the opportunity to review the feasibility of roundabouts at the subject intersections. Please feel free to call us if you have any questions or concerns with these comments.

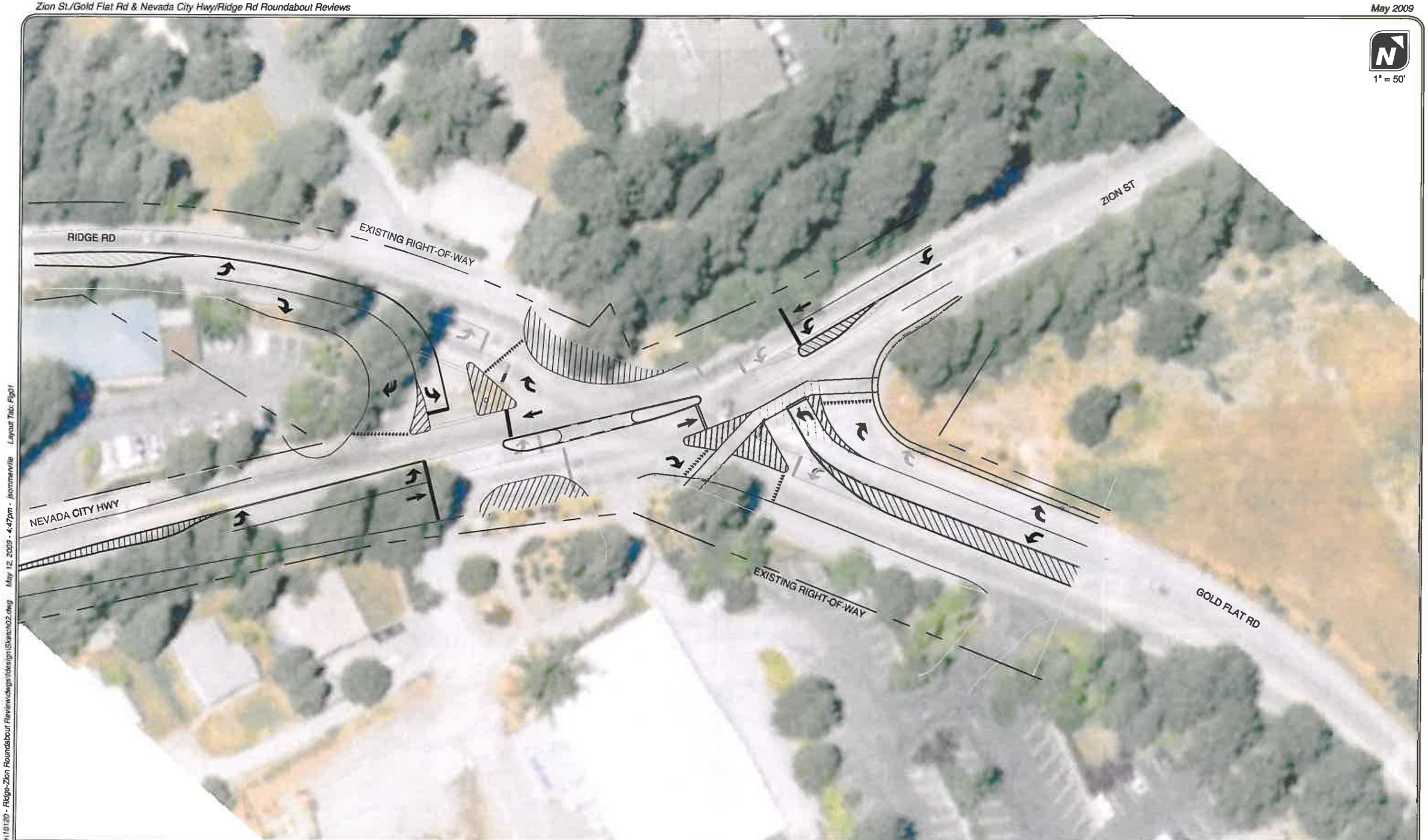
REFERENCES

1. Rodegerdts, L., M. Blogg, E. Wemple, E. Myers, M. Kyte, M. Dixon, G. List, A. Flannery, R. Troutbeck, W. Brilon, N. Wu, B. Persaud, C. Lyon, D. Harkey, and D. Carter. *NCHRP Report 572: Roundabouts in the United States*. National Cooperative Highway Research Program, Transportation Research Board, National Academy of Sciences, Washington, D.C., 2007.

2. Tian, Z. Z., F. Xu, L. A. Rodegerdts, W. E. Scarbrough, B. L. Ray, W. E. Bishop, T. C. Ferrara, and S. Mam. *Roundabout Geometric Design Guidance*. Report No. F/CA/RI-2006/13. California Department of Transportation, June 2007.

3. Xu, F., and Z. Z. Tian. "Driver Behavior and Gap-Acceptance Characteristics at Roundabouts in California." *Transportation Research Record: Journal of the Transportation Research Board, No. 2071*, Transportation Research Board of the National Academies, Washington, D.C., 2008, pp. 117–124.

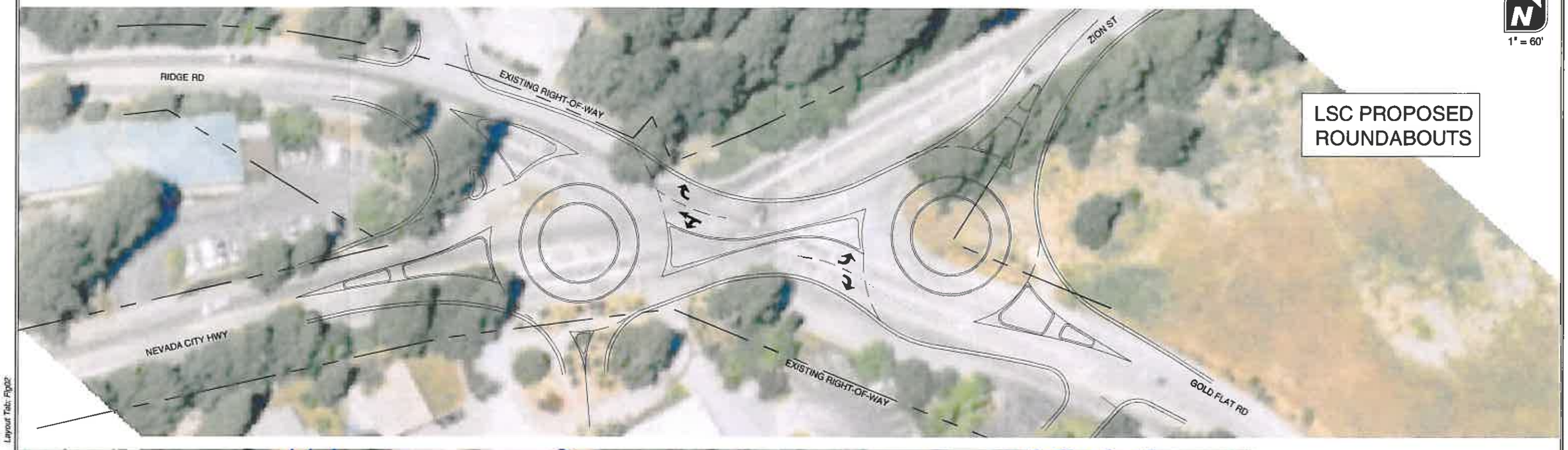
4. Robinson, B. W., L. Rodegerdts, W. Scarbrough, W. Kittelson, R. Troutbeck, W. Brilon, L. Bondzio, K. Courage, M. Kyte, J. Mason, A. Flannery, E. Myers, J. Bunker, and G. Jacquemart. *Roundabouts: An Informational Guide*. Report No. FHWA-RD-00-067, Federal Highway Administration, U. S. Department of Transportation, Washington, D.C., June 2000.

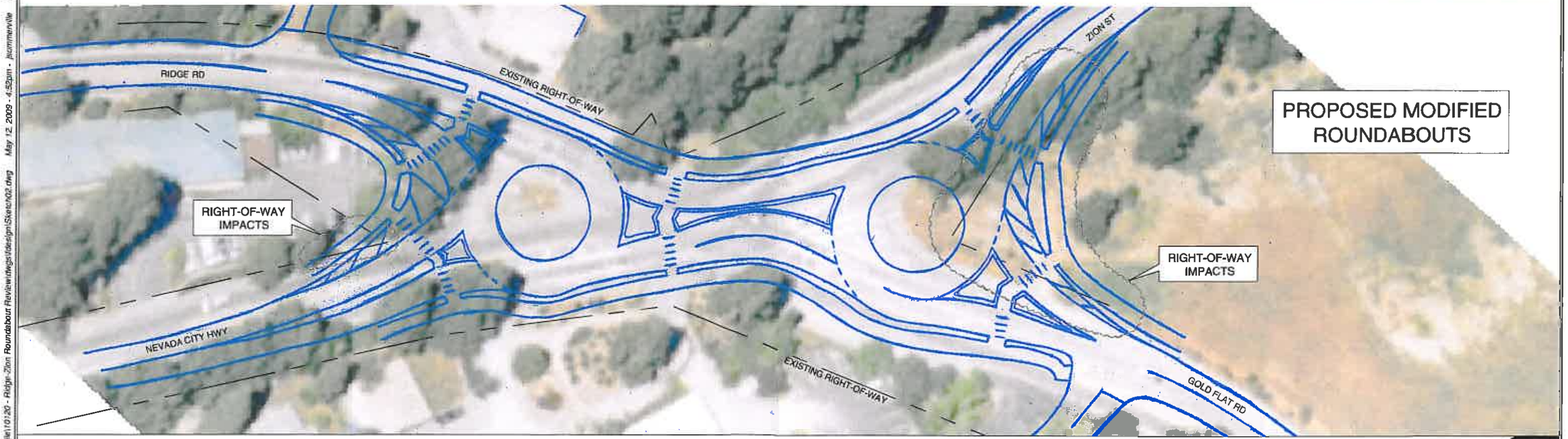


FOR DISCUSSION PURPOSES ONLY

EXISTING OFFSET T-INTERSECTIONS
NEVADA CITY, CA

FIGURE 1



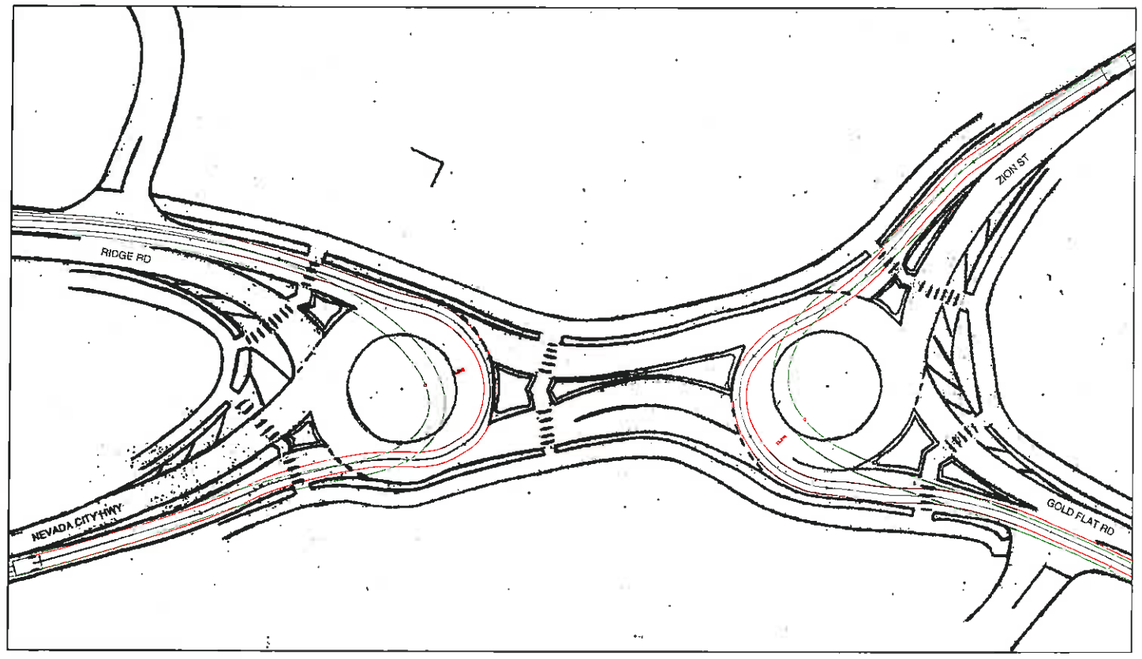


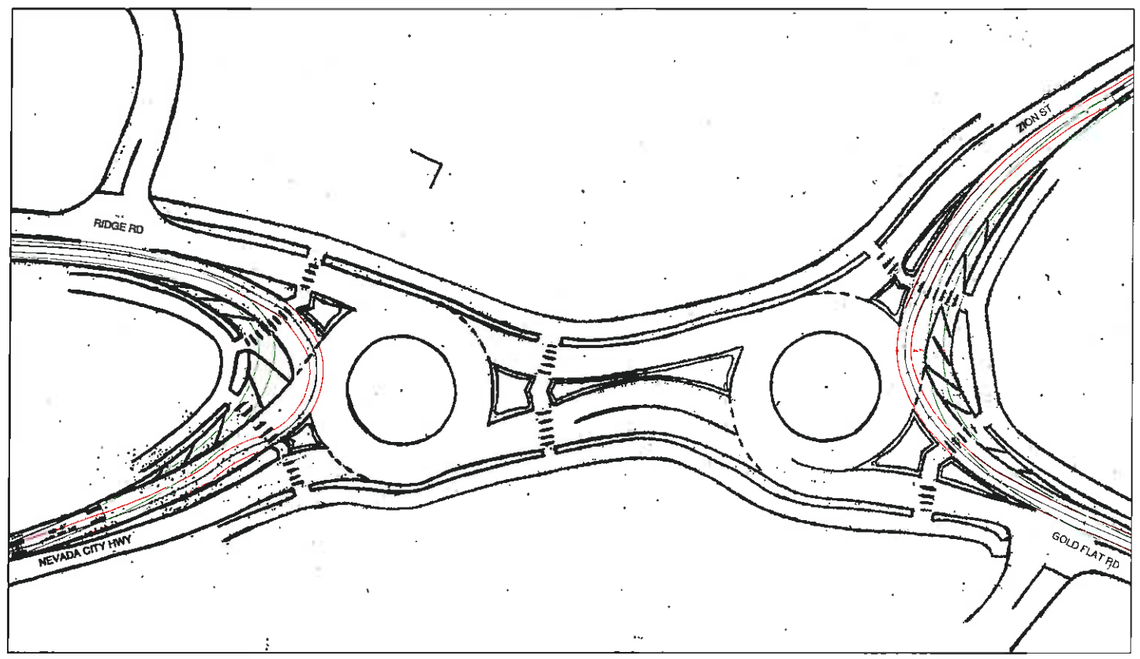
H:\proj\file1010\20 - Ridge-Zion Roundabout Reviews\dwgs\design\Sketch02.dwg May 12, 2009 - 4:52pm - jscommerville Layout Tab: Fig02

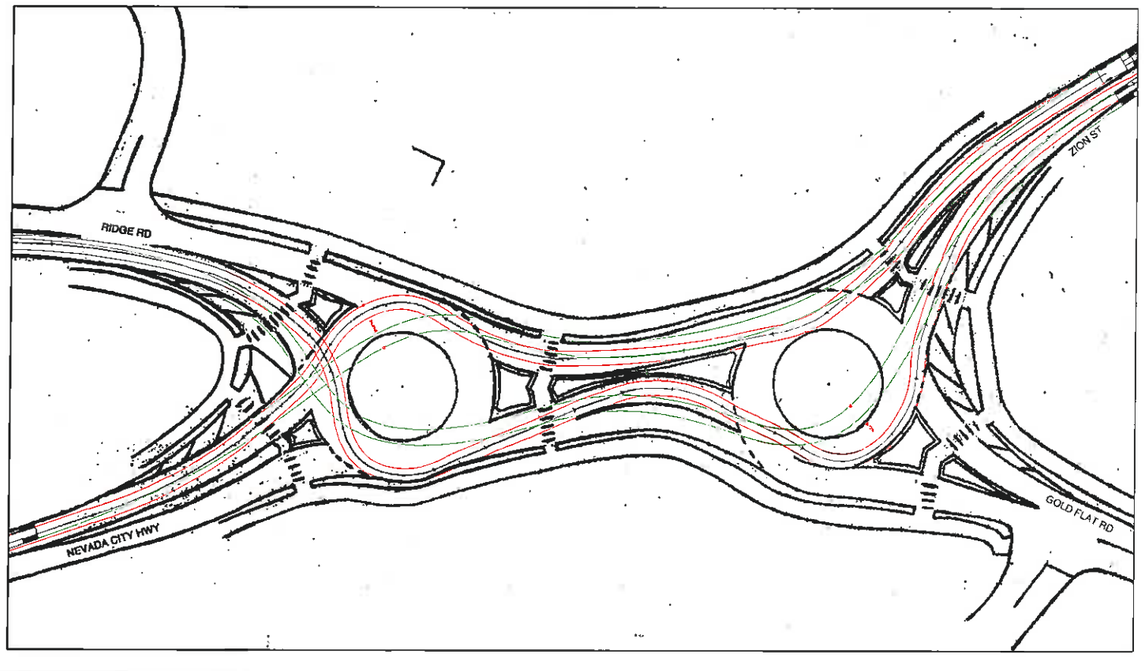
FOR DISCUSSION PURPOSES ONLY

PROPOSED ROUNDABOUTS
NEVADA CITY, CA

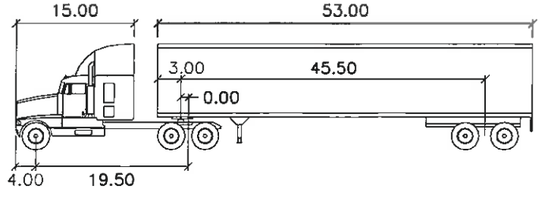
FIGURE 2







1" = 80'



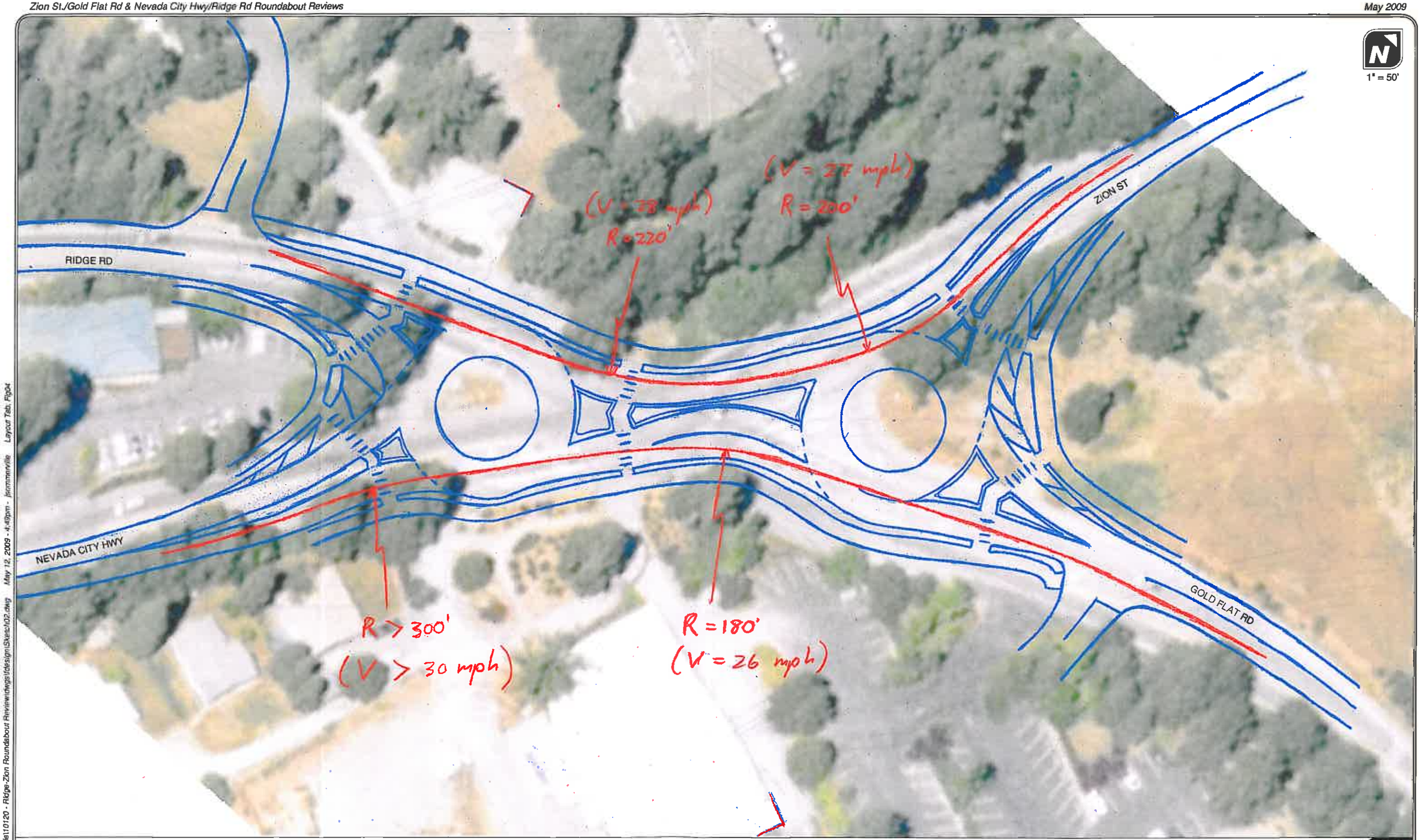
WB–67 feet

Tractor Width	: 8.00	Lock to Lock Time	: 6.00
Trailer Width	: 8.50	Steering Angle	: 28.40
Tractor Track	: 8.00	Articulating Angle	: 75.00
Trailer Track	: 8.50		

FOR DISCUSSION PURPOSES ONLY

TRUCK TURNING TEMPLATES FOR CRITICAL MOVEMENTS
NEVADA CITY, CA

FIGURE 3

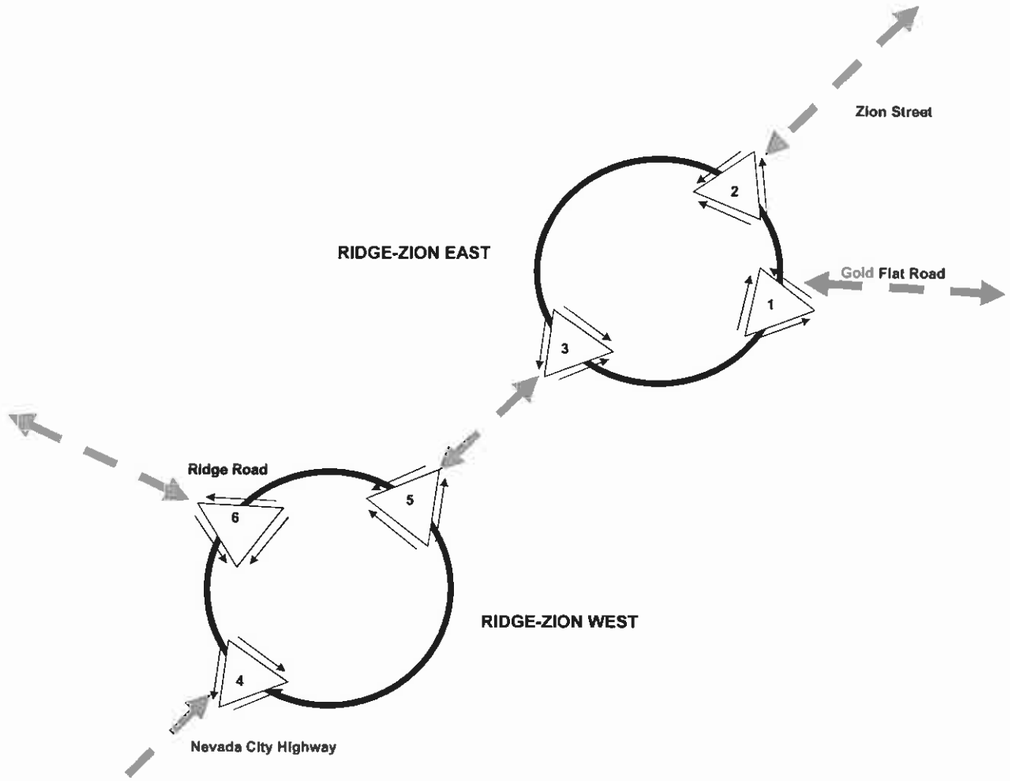


FOR DISCUSSION PURPOSES ONLY

FASTEST PATHS FOR CRITICAL MOVEMENTS
NEVADA CITY, CA

FIGURE 4

H:\prodfile\10120 - Ridge-Zion Roundabout Reviews\dwgs\design\Sketch02.dwg May 12, 2009 - 4:49pm - jscrimmerville Layout Tab: Fig04



ATTACHMENT "A"

Calibrated CalTrans Equations based on NCHRP Report 572 Methodology and Procedures																							
	Approaches for Weekday AM Peak Hour							Approaches for School Peak Hour							Approaches for Weekday PM Peak Hour								
	Ridge-Zion East				Ridge-Zion West			Ridge-Zion East				Ridge-Zion West			Ridge-Zion East				Ridge-Zion West				
	#1	#2	#3		#4	#5	#6	#1	#2	#3		#4	#5	#6	#1	#2	#3		#4	#5	#6		
Year 2030 Traffic Volumes																							
Exit	531	837	632		402	646	327	729	707	661		463	833	459	722	603	661		322	817	465		
Circulatory	377	275	262		359	53	358	452	323	338		397	81	358	439	325	342		349	73	382		
Entry	735	619	646		340	632	403	578	752	843		517	736	502	489	678	819		541	661	402		
Capacity																							
Single-lane Eq.	980	1087	1103		992	1363	993	908	1036	1020		953	1324	993	920	1033	1016		1002	1335	956		
Multilane Eq.	1116	1238	1256		1129	1552	1131	1034	1180	1161		1085	1508	1131	1048	1177	1157		1141	1520	1091		
Volume-to-Capacity																							
Single-lane circulatory w/ single-lane entries	0.77	0.58	[illegible]		0.36	0.49	0.42	0.65	0.74	[illegible]		0.56	0.58	0.53	0.54	0.67	[illegible]		0.56	0.53	0.44		
Single-lane circulatory w/ two-lane entry at #3 **(inside lane)**	[illegible]	[illegible]	0.35		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.45		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.44		[illegible]	[illegible]	[illegible]		
Single-lane circulatory w/ two-lane entry at #3 **(outside lane)**	[illegible]	[illegible]	0.25		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.39		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.38		[illegible]	[illegible]	[illegible]		
Delay (seconds)																							
Single-lane circulatory w/ single-lane entries	15	8	[illegible]		6	5	6	11	13	[illegible]		9	6	8	8	10	[illegible]		8	6	7		
Single-lane circulatory w/ two-lane entry at #3 **(inside lane)**	[illegible]	[illegible]	5		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6		[illegible]	[illegible]	[illegible]		
Single-lane circulatory w/ two-lane entry at #3 **(outside lane)**	[illegible]	[illegible]	4		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6		[illegible]	[illegible]	[illegible]		
95% Queuing (feet)																							
Single-lane circulatory w/ single-lane entries	193	97	[illegible]		41	70	53	123	177	[illegible]		91	97	79	84	135	[illegible]		90	81	56		
Single-lane circulatory w/ two-lane entry at #3 **(inside lane)**	[illegible]	[illegible]	40		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	60		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	57		[illegible]	[illegible]	[illegible]		
Single-lane circulatory w/ two-lane entry at #3 **(outside lane)**	[illegible]	[illegible]	25		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	45		[illegible]	[illegible]	[illegible]		