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INTERSECTION CONTROL EVALUATION TECHNICAL MEMORANDUM

DATE: June 08, 2022

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SUBJECT: Crystal Springs Road / Oak Ave/City Park Way Intersection Improvements Project #22051-000

INTRODUCTION

This memorandum provides a summary of the Intersection Control Evaluation (ICE) for the Crystal Springs Road and Oak Avenue/City Park Way intersection, including methodology, results and recommendations. The purpose of this study is to select the most cost effective intersection control strategy, based on delay, safety, and cost. The results of the intersection control evaluation was considered with a traffic signal warrant analysis, site observations and engineering judgment to form a basis for DKS's recommendations.

EXISTING CONDITIONS

ROADWAY NETWORK

The intersection of Crystal Springs Road and Oak Avenue/City Park Way is a four-legged intersection and is currently all-way stop controlled. There are marked high visibility crosswalks on all four legs of the intersection. The City's Walk-n-Bike plan identifies the intersection as a potential candidate for a mini-roundabout traffic control.

Crystal Springs Road runs east-west at the study intersection and is a two-lane roadway with curb-side parking on both sides. The City of San Bruno General Plan designates Crystal Springs Road as an arterial. The posted speed limit along Crystal Springs Road is 25 MPH. The City's Walk-n-Bike Plan recommends a Class III bikeway along Crystal Springs Road with bicyclists sharing the road with motorists.

North of the study intersection, Oak Avenue is a two-lane local roadway providing access to a residential neighborhood. South of the study intersection, City Park Way is a two-lane local roadway providing access to the proposed Recreation and Aquatics Center. The posted speed limit along City Park Way is 15 MPH near the study intersection. There is no posted speed limit along Oak Avenue, and is assumed to be 25 MPH. The City's Walk-n-Bike Plan recommends a Class III bikeway along Crystal Oak Avenue/City Park Way with bicyclists sharing the road with motorists.

EXISTING TRAFFIC VOLUMES

Pre pandemic traffic volume data for the analysis was obtained from the *San Bruno Recreation and Aquatics Center Transportation Impact Analysis* report (Hexagon Transportation Consultants, Inc., January 13, 2020). This study used AM and PM peak period turning movement counts collected on January 23rd, 2019 and added the estimated trips generated by the development to produce the intersection turning movement volumes shown in **Table 1**. These volumes were used in the Intersection Control Evaluation presented in this technical memorandum as existing traffic volumes. Because the traffic counts were collected prior to the COVID-19 pandemic, it is assumed that they provide a basis for a conservative operational analysis as compared to the current year's traffic demand near the project area. Therefore an additional growth factor was not applied.

TABLE 1: CRYSTAL SPRING ROAD/OAK AVENUE/CITY PARK WAY EXISTING TURNING MOVEMENT VOLUMES (OBTAINED FROM THE *SAN BRUNO RECREATION AND AQUATICS CENTER TRANSPORTATION IMPACT ANALYSIS* REPORT)

PEAK PERIOD	MOVEMENT											
	NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
AM	215	46	70	121	65	55	15	288	245	26	268	59
PM	123	52	63	37	48	22	20	327	189	78	304	45

The Intersection Control Evaluation also considered traffic operations 20 years after the intersection improvements are constructed. To obtain the Horizon Year (2042) turning movement counts, the existing traffic volumes were projected to the year 2042 based on an annual growth rate of 2%. The turning movement counts used for the Horizon Year (2042) delay analysis are provided in **Table 2**.

TABLE 2: CRYSTAL SPRING ROAD/OAK AVENUE/CITY PARK WAY HORIZON YEAR (2042) TURNING MOVEMENT VOLUMES

PEAK PERIOD	MOVEMENT											
	NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
AM	339	73	110	191	102	87	24	454	386	41	423	93
PM	194	82	99	58	76	35	32	516	298	123	479	71

INTERSECTION CONTROL EVALUATION METHODOLOGY

This study is based on guidelines set forth in the Caltrans ICE Process Informational Guide. The first step is to analyze the existing conditions, including level of service and crash data. An engineering analysis was performed to assess the changes in level of service and crashes that would result from an intersection control change, and a safety benefit-cost ratio (BCR) was calculated. Finally, an engineering review was completed, taking into account factors such as feasibility/constructability, footprint, the surrounding context, vulnerable road users, and cost, to determine the more effective control for the intersection.

The intersection controls evaluated are:

- All-way Stop (existing)
- Traffic signal
- Single lane or mini roundabout

LEVEL OF SERVICE

A key mobility metric is level of service (LOS), which is based on average vehicle delay. LOS is a quantitative stratification of performance that represents quality of service. There are six levels of service, ranging from A to F. LOS A represents the best operating conditions from the traveler's perspective and LOS F the worst. In accordance with the City of San Bruno General Plan's Policy T-B, the standard for acceptable operation of City intersections is LOS "D" or better.

AM and PM peak period conditions for the Crystal Springs Road and Oak Avenue/City Park Way intersection were modeled using both Synchro and SIDRA.

Synchro (Version 11) was used to assess the intersection operations with an all-way stop control and a traffic signal. Synchro is an industry standard analysis tool used for the analysis of signalized and unsignalized intersections. Synchro incorporates the Highway Capacity Manual (HCM) 2010 methodologies, which were used to calculate the control delay and LOS.

SIDRA (Version 9.0) was used to assess the intersection operations with a roundabout. SIDRA incorporates the HCM 2010 methodologies. HCM delay equations were used to determine the control delay and LOS. SIDRA Standard model was also reviewed as HCM delay equations do not include geometric delay.

SAFETY BENEFIT/COST ANALYSIS

Intersection Control Evaluations provide guidance on the type of control that is most appropriate. The improvement should result in a safer and more efficient intersection.

DKS developed a spreadsheet, consistent with the Caltrans' safety benefit and cost ratio (BCR) methodology, and used it to perform the ICE analysis. Modifying intersection control will change both the crash rate, as well as the average cost (due to change in severity) of crashes. The benefits are calculated as the annual value of crash savings from the control change. The costs are calculated as the annualized initial construction cost, plus annual costs for operating and maintaining the modified intersection. The planning-level construction costs of converting stop-controlled intersections to signal and roundabout control are shown in **TABLE 3**. These assumed costs are based on preliminary cost-estimates and improvements at similar intersections.

TABLE 3: CONSTRUCTION COST ESTIMATE FOR CONTROL TYPES

INTERSECTION TYPE	SIGNAL COST	MINI-ROUNDABOUT COST
4 – LEG (SINGLE LANE)	$400,000	$880,000[1]

[1]POTENTIAL RIGHT-OF-WAY COSTS ARE NOT INCLUDED IN ESTIMATED CONSTRUCTION COST

The initial construction cost was converted into an annualized cost based on a discount/interest rate of 3% and life cycle of 20 years, which are often applied to public works construction projects. In addition to the construction costs, **Table 4** provides a breakdown of the operations and maintenance costs for all control types (stop, signal and roundabout). These assumed costs are based off similar improvement projects.

TABLE 4: ANNUAL OPERATIONS & MAINTENANCE COST BREAKDOWN FOR CONTROL TYPES

TYPE OF COST	STOP	SIGNAL	ROUNDABOUT COST
LUMINAIRES – ELECTRICAL CONSUMPTION AND MAINTENANCE	$331	$663	$1,326
ELECTRICAL CONSUMPTION BY TRAFFIC SIGNALS	$0	$841	$0
SIGNAL RETIMING	$0	$1,667	$0
SIGNAL MAINTENANCE	$0	$4,500	$0
ROUNDABOUT LANDSCAPING MAINTENANCE	$0	$0	$2,000
ANNUAL COST	$331	$7,670	$3,326

Figure 1 shows the California Local Roadway Safety Manual's[1] recommended Crash Reduction Factors (CRF) for countermeasures at Non-Signalized Intersections. The countermeasure NS03 "Install Signals" provides a CRF of 30% (CMF 0.7) for signalizing an unsignalized intersection, and countermeasure NS04 provides varying CRF values (12-78%) for converting an intersection from all-way stop control to a roundabout.

[1] *Local Roadway Safety: A Manual for California's Local Road Owners*, Version 1.5, 2020

No.	Type	Countermeasure Name	Crash Type	CRF	Expected Life (Years)	HSIP Funding Eligibility	Systemic Approach Opportunity?
NS01	Lighting	Add intersection lighting (NS.I.)	Night	40%	20	100%	Medium
NS02	Control	Convert to all-way STOP control (from 2-way or Yield control)	All	50%	10	100%	High
NS03	Control	Install signals	All	30%	20	100%	Low
NS04	Control	Convert intersection to roundabout (from all way stop)	All	Varies	20	100%	Low
NS05	Control	Convert intersection to roundabout (from stop or yield control on minor road)	All	Varies	20	100%	Low

FIGURE 1: LRSM COUNTERMEASURES FOR NON-SIGNALIZED INTERSECTIONS

The crash reduction factor for converting an intersection to a roundabout is dependent on the ADT, project location, and roundabout type. DKS reviewed available sources in The Crash Modification Factors Clearinghouse to obtain the CMF for this study. CMF ID: 206 was used which sites a publication[2] that analyzed before and after crash rates at 23 intersections across 7 U.S. states. The results suggest a 72% reduction in all crash types (CMF 0.28) from converting a stop controlled intersection to a roundabout. However, it should be noted that the study primarily looked at side-street stop controlled intersections and thus the results of the actual safety benefits for the Oak Avenue and Crystal Spring Road intersection may be lower than calculated. Other available all-way stop control to roundabout conversion CMFs were found to have low quality ratings which indicate low quality or confidence in the results of the studies producing the CMFs.

The average crash costs were obtained from Caltrans' Annual Collision Data on California State Highways as shown in **Figure 2**.

Table 5 includes the existing condition, to (signal or a single-lane roundabout), CMF, base average crash cost (cost of collision with existing control) and new average crash cost (cost of collision in proposed conditions). The crash cost calculations are described in the **Safety Benefit/Cost Ratio** section below. As can be seen, the crash cost with both a traffic signal and a roundabout are lower as compared with the existing AWSC.

The safety benefits are calculated based on the crash reduction savings. The conversion of a stop-controlled intersection into a signalized intersection, or roundabout, reduces the severity of the collision.

[2] *Observational Before-After Study Of The Safety Effect Of U.S. Roundabout Conversions Using The Empirical Bayes Method*, Persaud Et Al., 2001

10/19/2021

BASIC AVERAGE CRASH RATE TABLE FOR INTERSECTIONS

	RATE GROUP	BASE RATE	+ ADT FACTOR	PCT FAT	PCT INJ	PCT F+I	INTERSECTION TYPE*	CONTROL TYPE	AREA	CRASH COST ($1000) F+I	CRASH COST ($1000) ALL
I	01	0.130	0.00000	1.4	44.4	45.8	F, M and S	NO CONTROL	RURAL	542.4	256.2
I	02	0.250	0.00000	2.5	44.1	46.6	F, M and S	STOP & YIELD SIGNS (EXC 4WAY)	RURAL	822.4	390.9
I	03	0.490	0.00000	0.8	32.7	33.5	F, M and S	4 WAY STOP	RURAL	461.3	164.1
I	04	0.540	0.00000	1.0	37.0	38.0	F, M and S	SIGNALS	RURAL	490.9	195.4
I	05	0.460	0.00000	1.5	36.0	37.5	F, M and S	4 WAY FLASHERS	RURAL	656.8	255.2
I	06	0.160	0.00000	0.8	45.8	46.6	F, M and S	NO CONTROL	SUBURBAN	364.3	179.5
I	07	0.240	0.00000	1.7	41.2	42.9	F, M and S	STOP & YIELD SIGNS (EXC 4WAY)	SUBURBAN	623.3	277.9
I	08	0.430	0.00000	0.7	40.3	41.0	F, M and S	4 WAY STOP	SUBURBAN	363.2	159.7
I	09	0.420	0.00000	0.5	37.4	37.9	F, M and S	SIGNALS	SUBURBAN	318.5	132.1
I	10	0.340	0.00000	0.8	39.9	40.7	F, M and S	4 WAY FLASHERS	SUBURBAN	393.0	170.8
I	11	0.050	0.00000	2.6	44.9	47.5	F, M and S	NO CONTROL	URBAN	802.9	389.9
I	12	0.140	0.00000	1.1	46.2	47.3	F, M and S	STOP & YIELD SIGNS (EXC 4WAY)	URBAN	436.7	215.1
I	13	0.170	0.00000	0.4	26.8	27.2	F, M and S	4 WAY STOP	URBAN	337.2	103.5
I	14	0.240	0.00000	0.5	46.9	47.4	F, M and S	SIGNALS	URBAN	288.8	145.4
I	15	0.260	0.00000	1.5	41.4	42.9	F, M and S	4 WAY FLASHERS	URBAN	572.9	255.0
I	16	0.130	0.00000	1.4	41.0	42.4	T, Y and Z	NO CONTROL	RURAL	572.2	250.8
I	17	0.190	0.00000	1.7	39.8	41.5	T, Y and Z	STOP & YIELD SIGNS (EXC 4WAY)	RURAL	668.5	285.8
I	18	0.560	0.00000	2.0	35.7	37.7	T, Y and Z	4 WAY STOP	RURAL	815.1	316.2
I	19	0.450	0.00000	0.5	34.6	35.1	T, Y and Z	SIGNALS	RURAL	344.5	130.2
I	20	0.560	0.00000	2.0	35.7	37.7	T, Y and Z	4 WAY FLASHERS	RURAL	815.1	316.2
I	21	0.140	0.00000	0.6	39.1	39.7	T, Y and Z	NO CONTROL	SUBURBAN	340.6	146.3
I	22	0.170	0.00000	1.2	39.9	41.1	T, Y and Z	STOP & YIELD SIGNS (EXC 4WAY)	SUBURBAN	503.1	217.5
I	23	0.180	0.00000	1.7	25.5	27.2	T, Y and Z	4 WAY STOP	SUBURBAN	887.2	254.6
I	24	0.290	0.00000	0.5	37.7	38.2	T, Y and Z	SIGNALS	SUBURBAN	317.3	132.5
I	25	0.180	0.00000	2.9	25.5	28.4	T, Y and Z	4 WAY FLASHERS	SUBURBAN	1344.0	394.8
I	26	0.060	0.00000	1.9	41.7	43.6	T, Y and Z	NO CONTROL	URBAN	673.1	302.6
I	27	0.090	0.00000	1.2	46.9	48.1	T, Y and Z	STOP & YIELD SIGNS (EXC 4WAY)	URBAN	456.3	227.9
I	28	0.070	0.00000	1.1	38.6	39.7	T, Y and Z	4 WAY STOP	URBAN	488.4	203.7
I	29	0.200	0.00000	0.5	46.8	47.3	T, Y and Z	SIGNALS	URBAN	289.1	145.3
I	30	0.070	0.00000	2.6	38.6	41.2	T, Y and Z	4 WAY FLASHERS	URBAN	900.3	380.4
I	31	0.740	0.00000	0.8	19.1	19.9	R	YIELD ON ALL APPROACHES	ALL*	642.6	142.0

FIGURE 2: CALTRANS ANNUAL COLLISION DATA AVERAGE CRASH RATE TABLE FOR INTERECTIONS

TABLE 5: BREAKDOWN OF CRASH REDUCTION SAVINGS

EXISTING CONTROL	TO	CMF	BASE AVERAGE CRASH COST	NEW AVERAGE CRASH COST
AWSC	SIGNAL	0.7	$159,700	$132,100
AWSC	RAB-1	0.28	$159,700	$142,000

NOTE: RAB-1 = SINGLE LANE ROUNDABOUT, CMF = CRASH MODIFICATION FACTOR.

VOLUME DATA

To estimate the annual crash cost savings of the alternative intersection controls, planning-level 20-year projected entering volumes are needed. These were estimated from existing entering volumes, based on an annual growth rate of 2%, and at 11% ratio of PM peak hour volumes to average daily volumes. The entering volumes were used for the crash analysis.

CRASH DATA

Raw collision data was retrieved from the Statewide Integrated Traffic Records System (SWITRS) for the City of San Bruno for the most recent five years (01/01/2017-01/01/2022). The dataset includes a multitude of information for each collision: date, time, location, traffic control, weather, severity, primary collision factor, lighting and CHP notes. Per the Caltrans' methodology, the total number of collisions at an intersection for all types is used for the ICE analysis.

SAFETY BENEFIT /COST RATIO

The number of collisions in the most recent five-year period is converted to collision rate, based on the number of entering vehicles as follows:

$$R = \frac{C \times 100{,}000{,}000}{V \times 365 \times N \times L}$$

The variables in this equation are:

R = Roadway Departure crash rate for the road segment expressed as crashes per 100 million vehicle-miles of travel,
C = Total number of roadway departure crashes in the study period
V = Traffic volumes using Average Annual Daily Traffic (AADT) volumes
N = Number of years of data
L = Length of the roadway segment in miles

Next, the collision rate is used to determine the expected 20-year collisions (based on 20-year projected volume), assuming no change in control. The average annual collision frequency is calculated over the 20 years. The annual collision cost is calculated based on Caltrans' average crash cost data, which takes into account all severity types (property damage, injury, fatality). Lastly, the annual crash cost savings are calculated based on the crash costs of the proposed condition, minus the crash costs of the existing condition. The annual crash cost savings are counted as the "benefits" in the BCR calculation. The annual benefits are divided by the annual costs (construction, operations, and maintenance) to determine the safety benefit-cost ratio.

INTERSECTION CONTROL EVALUATION RESULTS

The intersection control evaluation worksheet is provided in Appendix A.

Table 6 summarizes the AM and PM peak LOS and control delay (seconds per vehicle) for the three intersection control types analyzed under both Existing (2022) and Horizon year (2042) traffic conditions. HCM LOS worksheets are provided in Appendix B.

TABLE 6: SUMMARY OF LOS AND CONTROL DELAY UNDER ALTERNATIVE INTERSECTION CONTROL CONDITIONS

MEASURE OF PERFORMANCE	EXISTING (AWSC)		TRAFFIC SIGNAL		ROUNDABOUT	
	AM	PM	AM	PM	AM	PM
EXISTING (2022) TRAFFIC VOLUMES						
LOS	**F**	**E**	B	B	B	B
CONTROL DELAY (SEC/VEH)	80.0	43.8	19.6	14.1	13.3	11.4
HORIZON YEAR (2042) TRAFFIC VOLUMES						
LOS	**F**	**F**	D	C	**F**	**F**
CONTROL DELAY (SEC/VEH)	389.4	284.2	54.0	26.3	80.0	52.8

NOTE: **BOLD** (UNACCEPTABLE LOS)

As shown in **Table 6**, under Existing Year traffic conditions, the intersection operates unacceptably at LOS E or worst. With a traffic signal or a roundabout, the intersection is expected to operate at an acceptable LOS B during both AM and PM peak periods under Existing Year traffic conditions. Under the Horizon Year traffic conditions, the intersection is expected to continue to operate unacceptably at LOS F. Installing a traffic signal is expected to operate the intersection at an acceptable LOS D or better while a single-lane roundabout is expected to operate at an unacceptable LOS F.

Table 7 summarizes the AM and PM peak 95th percentile queue for the three intersection control types analyzed under both Existing (2022) and Horizon year (2042) traffic conditions.

With a Stop-control, the available storage in the eastbound and westbound approaches is exceeded during both AM and PM peak periods under both Existing (2022) and Horizon year (2042) traffic conditions.

With a Traffic Signal, the available storage in the eastbound approach is exceeded during the AM Peak under Existing (2022), and during both AM and PM peak periods under Horizon year (2042) traffic conditions. Under the Horizon year traffic conditions, the available storage is also expected to be exceeded for the westbound left-turn movement (during the AM peak) and the westbound through movements (during both AM and PM peaks).

With a roundabout, the available storage is expected to be exceeded during both AM and PM peak periods under Horizon year (2042) traffic conditions

TABLE 7: SUMMARY OF 95TH PERCENTILE QUEUE LENGTHS UNDER ALTERNATIVE INTERSECTION CONTROL CONDITIONS

INTERSECTION CONTROL	MOVEMENT	AVAILABLE STORAGE (FT)	95TH PERCENTILE QUEUE LENGTH (FEET)			
			EXISTING (2022)		HORIZON (2042)	
			AM Peak	PM Peak	AM Peak	PM Peak
ALL-WAY STOP CONTROL	EB	315	615	382.5	1445	1327.5
	WB	180	200	232.5	602.5	832.5
	NB	950	130	57.5	385	140
	SB	680	100	27.5	275	57.5
TRAFFIC SIGNAL CONTROL	EBL	100	16	17	25	27
	EBT	315	367	254	816	632
	WBL	100	27	59	77	198
	WBT	180	180	161	354	338
	NBL/NBT	950	134	87	412	243
	SBL	100	88	38	202	83
	SBT	680	66	50	176	124
ROUNDABOUT CONTROL	EB	315	232.4	152.8	2096.5	1677.8
	WB	180	69.0	76.4	428.4	701.3
	NB	950	88.0	37.7	548.4	149.2
	SB	680	52.1	16.4	283.5	43.8

Table 8 summarizes the benefit-cost ratios for a traffic signal control versus a roundabout at the study intersection. This table also includes the number of collisions that were reported to have occurred within or near the intersection in the past five years. A total of four crashes occurred at the intersection during the study period. Three were broadside collisions and one involved a motor vehicle hitting an object. One resulted in injury/complaint of pain.

TABLE 8: SUMMARY OF SAFETY BENEFIT/COST RATIOS

SAFETY BENEFIT/COST RATIO		NUMBER OF COLLISIONS IN THE PAST FIVE YEARS
SIGNAL	ROUNDABOUT	
1.3	1.2	4

As shown in **Table 8**, the benefit/cost ratio is slightly higher for a traffic signal as compared to a roundabout for the Crystal Springs Road and Oak Avenue/City Park Way intersection. This is the result of the initial high cost of a roundabout.

FOOTPRINT DEVELOPMENT AND ASSESSMENT

TRAFFIC SIGNAL

Crystal Springs Road has a width of 55 feet curb-to-curb with two travel lanes and on-street parking on either side of the roadway. The eastbound and southbound approaches of the intersections could be restriped to add turn lanes to accommodate an increase in demand and provide protected phases for left-turning vehicles. Oak Avenue north of the intersection has a width of 40 feet curb-to-curb with two travel lanes and on-street parking on either side. The southbound approach of the intersection could also be restriped to add a turn lane and provide protected phases for left-turning vehicles. City Park Way currently has two lanes for the northbound approach striped as a shared left/thru lane and a right-turn only lane.

There are overhead electric and cable lines along the south side of Crystal Springs Road that may conflict with traffic signal poles and mast arms. Curb extensions may be needed for the placement of poles to avoid conflict with overhead utility lines and also reduce pedestrian crossing distances at the intersection.

ROUNDABOUT

A traditional single lane roundabout has a typical inscribed circle diameter of 90 feet to 180 feet, while a mini-roundabout has a typical inscribed circle diameter of 45 feet to 90 feet and is generally more compact than traditional single-lane roundabouts. The typical design vehicle for mini-roundabouts is a Single Unit (SU-30) truck. The central island and splitter islands will need to be fully mountable in order to accommodate larger vehicles. **Figure 3** summarizes fundamental design and operational elements for single-lane and mini roundabouts[3].

Design Element	Mini-Roundabout	Single-Lane Roundabout
Desirable maximum entry design speed	15 to 20 mph (25 to 30 km/h)	20 to 25 mph (30 to 40 km/h)
Maximum number of entering lanes per approach	1	1
Typical inscribed circle diameter	45 to 90 ft (13 to 27 m)	90 to 180 ft (27 to 55 m)
Central island treatment	Fully traversable	Raised (may have traversable apron)
Typical daily service volumes on 4-leg roundabout below which may be expected to operate without requiring a detailed capacity analysis (veh/day)*	Up to approximately 15,000	Up to approximately 25,000

FIGURE 3: ROUNABOUT CATEGORY COMPARISON

[3] National Cooperative Highway Research Program (NCHRP) Report 672: *Roundabouts: An Informational Guide, Second Edition, 2010*

A preliminary concept was developed for a small single-lane roundabout with an 84-foot inscribed circle. As shown in **Figure 4**, a single-lane roundabout would require additional right-of-way and will impact adjacent residential parcels.

A preliminary concept was developed for a mini-roundabout with a 75-foot inscribed circle. As shown in **Figure 5**, the footprint of a mini-roundabout would not likely impact adjacent parcels. Turn templates were checked for the preliminary concept plan which showed that passenger vehicles can be accommodated through a mini-roundabout. However, the design vehicle of SU-30 will need to traverse over the central and splitter islands to be able to maneuver the majority of the movements through the intersection. Turn template exhibits are provided in Appendix C. High volumes of vehicles larger than a passenger vehicle (buses, delivery trucks, maintenance trucks etc.) through the intersection may lead to increased delay at the intersection.

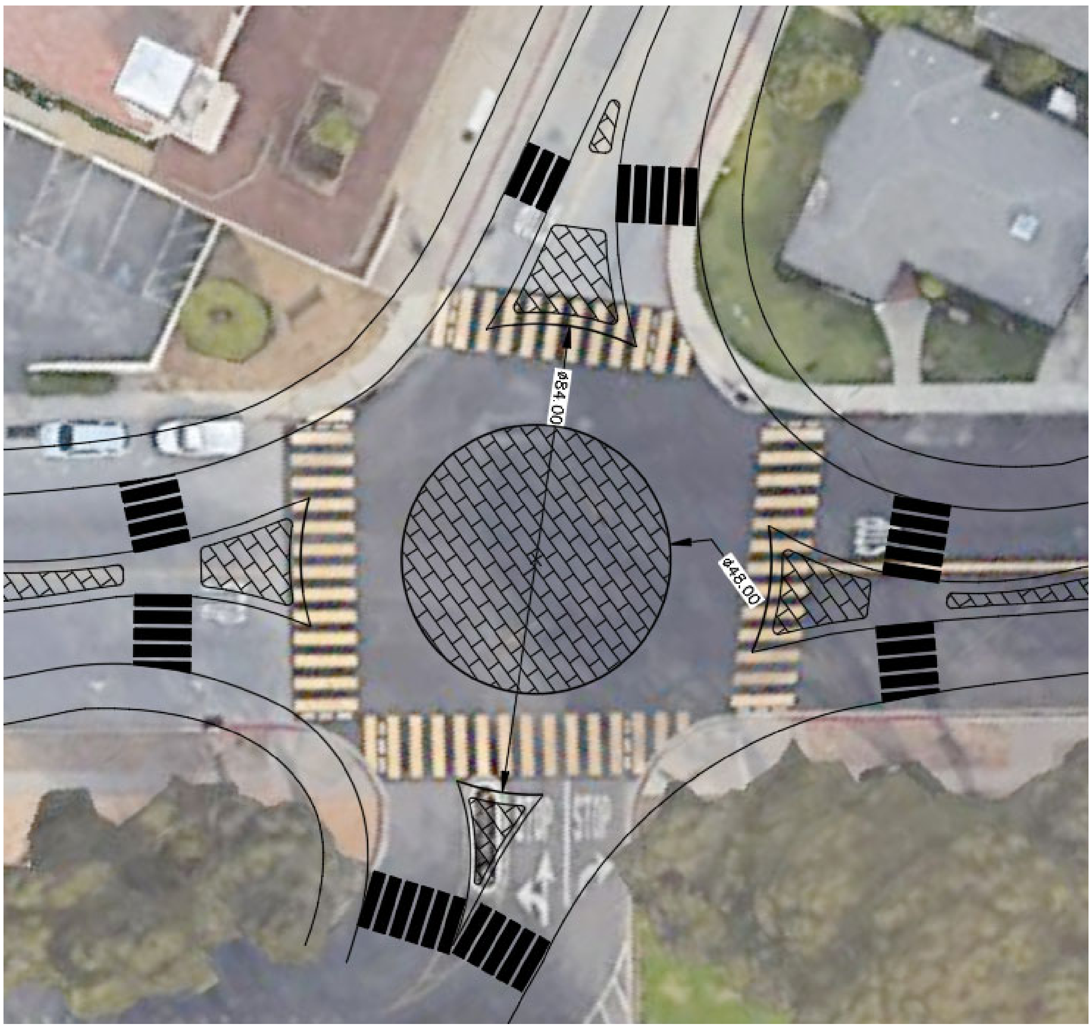

FIGURE 4: CRYSTAL SPRING ROAD/OAK AVENUE/CITY SINGLE-LANE ROUNDABOUT CONCEPT PLAN

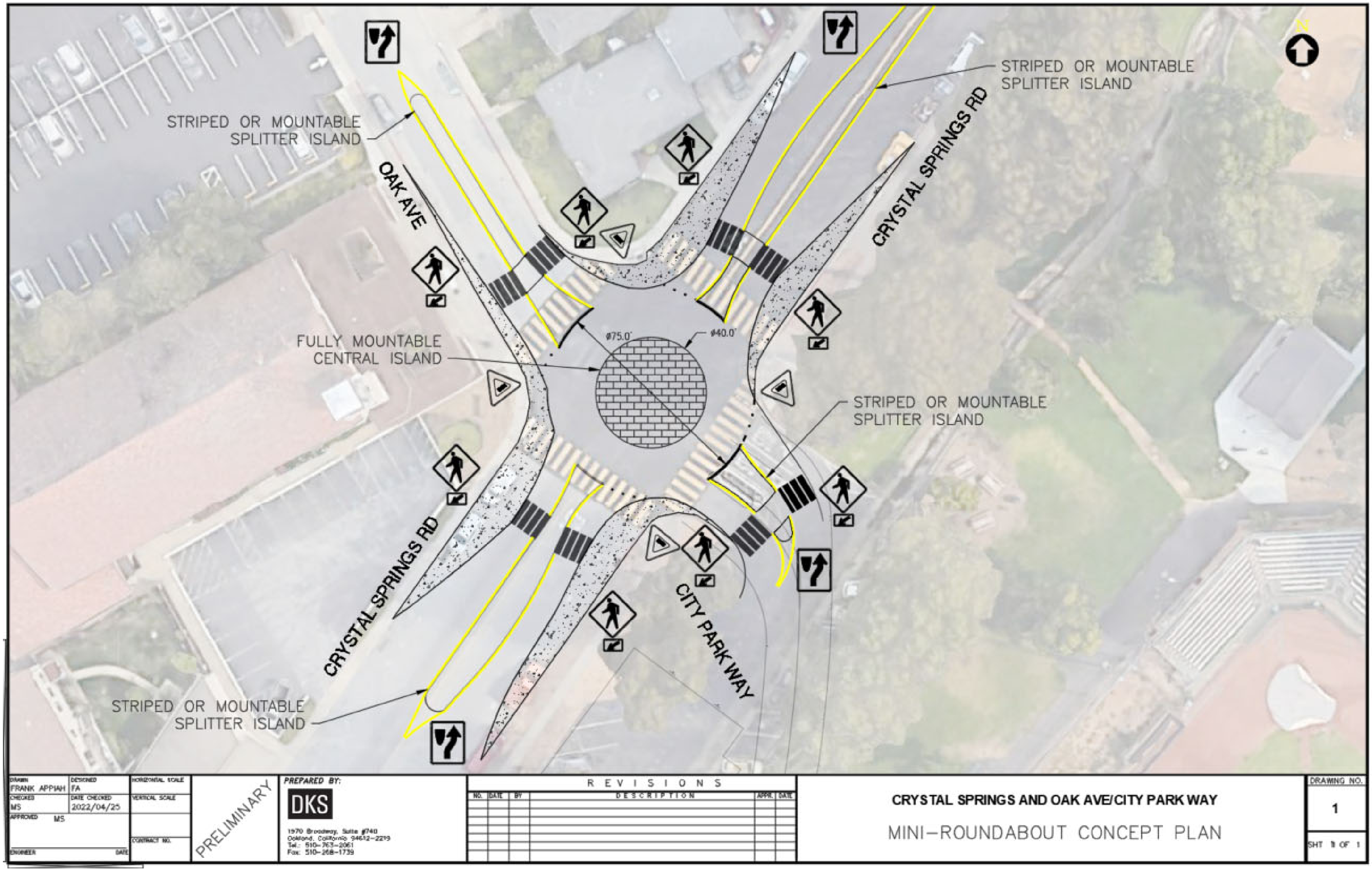

FIGURE 5: CRYSTAL SPRING ROAD/OAK AVENUE/CITY MINI-ROUNDABOUT CONCEPT PLAN

PEDESTRIAN AND BICYCLE ACCOMMODATION

PEDESTRIAN ACCOMMODATION

Crosswalks at roundabouts are generally set-back 20-25 feet from the entry point to accommodate storage of one vehicle length. This reduces the crossing distance for pedestrians; separates vehicle-vehicle and vehicle-pedestrian conflict points and improves visibility of pedestrians to entering vehicles upstream of the crosswalk as they wait for drivers ahead to enter the roundabout[4]. Splitter islands should be cut through to accommodate wheelchair users, and where possible, should be wide enough to be used as refuge areas for pedestrians. The design of mini-roundabouts typically does not allow for wide splitter islands, thus requiring pedestrians to pay attention to on-coming traffic from two approaches to cross the road in one stage.

Unlike traffic signals, roundabouts do not provide audible cues and thus pose a unique safety challenge in accommodating visually impaired pedestrians.

BICYCLE ACCOMODATION

Given the low speed along the project's roadways, and the lack of designated bike lanes, bicyclists can generally navigate through the intersection by sharing the road with motor vehicles, or dismount and use marked crosswalks.

KEY FINDINGS

- The benefit/cost ratio is higher for a traffic signal as compared to a roundabout for the Crystal Springs Road and Oak Avenue/City Park Way intersection. This is the result of the initial high cost of a roundabout.
- A mini-roundabout may be accommodated within the existing footprint of the intersection and is feasible under near-term traffic conditions. Turn templates showed that vehicles larger than a passenger car will need to traverse over the mountable central and splitter islands when navigating through the mini-roundabout.
- Under Existing traffic volume conditions, the Crystal Springs Road and Oak Avenue/City Park Way intersection operates unacceptably at LOS E or worse with the existing all-way stop control. With the installation of a traffic signal or a roundabout, the intersection is expected to operate at an acceptable LOS B during both AM and PM peak periods.
- Under Horizon Year (2042) traffic volume conditions, the Crystal Springs Road and Oak Avenue/City Park Way intersection is expected to operate unacceptably at LOS F with the existing all-way stop control. With the installation of a traffic signal, the intersection is expected to operate at an acceptable LOS D during the AM peak and LOS C during the PM Peak. The intersection is expected to operate at an unacceptable LOS F with a roundabout.

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[4] National Cooperative Highway Research Program (NCHRP) Report 672: *Roundabouts: An Informational Guide, Second Edition, 2010*

CONCLUSIONS AND RECOMMENDATIONS

The estimated construction cost of a traffic signal is $400,000 which is lower as compared with the estimated construction cost of $800,000 for a mini-roundabout. Under Horizon Year (2042) traffic conditions, a traffic signal would operate acceptably while a mini-roundabout is expected to operate unacceptably under both AM and PM peak periods. The City should consider the high initial cost of a roundabout and the future costs of mitigation measures when the capacity of the roundabout is exceeded by demand. Potential future improvements are:

- Replace the roundabout with a traffic signal, or
- Replace the mini-roundabout with a multi-lane roundabout which would have significant right-of-way cost and displacement implications as the adjacent tracts are currently developed.

A traffic signal will have a higher maintenance and operations cost as compared with a roundabout. The ongoing maintenance costs for roundabouts are typically associated with lighting and landscaping.

A roundabout is expected to have lower crash costs than a traffic signal. Pedestrians and bicyclists can safely be accommodated with both a traffic signal and a roundabout. However, roundabouts pose a unique challenge to visually impaired pedestrians who may not be familiar with the area because they lack audible cues.

Taking all of the measures of performance into consideration (delay, operations and maintenance, safety, and initial capital cost), a traffic signal shows a higher benefit-cost ratio (1.3) as compared with a roundabout (1.2). Based on these results, the intersection of Crystal Springs Road and Oak Avenue/City Park Way is a candidate for a traffic signal.

APPENDIX

CONTENTS

APPENDIX A. INTERSECTION CONTROL EVALUATION WORKSHEET

Intersection Performance Measures
Intersection #1: Crystal Springs and Oak Ave/City Park Way

Intersection Data			
ID:	1		**AM Entering Volume**
Geometry:	4-Leg Intersection	**F**	1,473
Existing Control:	All-Way Stop Control	**AWSC**	**PM Entering Volume**
Proposed Control #1:	Signal	**Signal**	1,308
Proposed Control #2:	Single Lane Roundabout	**RAB-1**	

Major Roadway Data		Minor Roadway Data	
Street:	Crystal Springs	**Street:**	Oak Ave/City Park Way
Direction:	E/W	**Direction:**	N/S

Measures of Performance: Delay		Existing	Signal	Roundabout
Operations		**Exisiting**	**Signal**	**Roundabout**
AM Peak Hour	**AM LOS**	F	B	B
	AM Average Delay (secs/veh)	80	19.6	13.3
PM Peak Hour	**PM LOS**	E	B	B
	PM Average Delay (secs/veh)	43.8	14.1	11.4

Measures of Performance: Operations & Maintenance		Signal	Roundabout
Luminaires - Annual Electrical Consumption and Maintenance	$ 331	$ 663	$ 1,326
Electrical Consumption (Traffic Signal Equipment)	-	$ 841	-
Signal Retiming and Maintenance	-	$ 6,167	-
Roundabout Landscaping Cost	-	-	$ 2,000
Roundabout CCTV Maintenance	-	-	$ -
Total	**$ 331**	**$ 7,670**	**$ 3,326**

Measures of Performance: Safety	Existing	Signal	Roundabout
Entering Volume (veh/day)	14,533	14,533	14,533
20-Year Projected Entering Volume (veh/day)	21,596	21,596	21,596
Base Collisions (5 year period)	4	-	-
Collision Rate (collisions/MV)	0.151	-	-
Expected 20-Year Collisions	20	14	6
Annual Collision Frequency (collisions/year)	0.99	0.70	0.28
Average Collision Cost	$ 159,700	$ 132,100	$ 142,000
Annual Collision Cost	$ 158,802	$ 91,950	$ 39,537
Annual Crash Cost Savings[1]	-	$ 66,852	$ 119,266

Measures of Performance: Capital Outlay	Existing	Signal	Roundabout
Initial Construction Cost	-	**$ 400,000**	**$ 880,000**
Right-of-Way Costs	-	**$ -**	**$ -**
Annualized Present Capital Cost (i=0.03, N=20)	-	**$ 44,810**	**$ 98,583.04**

Benefit/Cost Ratio Calculation			Signal	Roundabout
Annual Costs	Capital Costs		$ 44,810	$ 98,583
	Operations & Maintenance		$ 7,670	$ 3,326
	Total		**$ 52,481**	**$ 101,909**
Annual Benefits	Collision Savings		$ 66,852	$ 119,266
	Total		**$ 66,852**	**$ 119,266**
Benefit/Cost Ratio			**1.3**	**1.2**

APPENDIX B. LEVEL OF SERVICE AND DELAY WORKSHEETS

Intersection	
Intersection Delay, s/veh	80
Intersection LOS	F

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	15	288	245	26	268	59	215	46	70	121	64	55
Future Vol, veh/h	15	288	245	26	268	59	215	46	70	121	64	55
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	16	313	266	28	291	64	234	50	76	132	70	60
Number of Lanes	0	1	0	0	1	0	0	1	1	0	1	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	1	1	1	2
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	1	2	1	1
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	2	1	1	1
HCM Control Delay	157.9	43.1	28.8	27
HCM LOS	F	E	D	D

Lane	NBLn1	NBLn2	EBLn1	WBLn1	SBLn1
Vol Left, %	82%	0%	3%	7%	50%
Vol Thru, %	18%	0%	53%	76%	27%
Vol Right, %	0%	100%	45%	17%	23%
Sign Control	Stop	Stop	Stop	Stop	Stop
Traffic Vol by Lane	261	70	548	353	240
LT Vol	215	0	15	26	121
Through Vol	46	0	288	268	64
RT Vol	0	70	245	59	55
Lane Flow Rate	284	76	596	384	261
Geometry Grp	7	7	2	2	5
Degree of Util (X)	0.708	0.167	1.262	0.84	0.623
Departure Headway (Hd)	9.778	8.618	7.628	8.614	9.516
Convergence, Y/N	Yes	Yes	Yes	Yes	Yes
Cap	372	419	482	422	383
Service Time	7.478	6.318	5.628	6.614	7.516
HCM Lane V/C Ratio	0.763	0.181	1.237	0.91	0.681
HCM Control Delay	33	13	157.9	43.1	27
HCM Lane LOS	D	B	F	E	D
HCM 95th-tile Q	5.2	0.6	24.6	8	4

Intersection	
Intersection Delay, s/veh	43.8
Intersection LOS	E

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	20	327	187	78	304	45	123	52	63	37	48	22
Future Vol, veh/h	20	327	187	78	304	45	123	52	63	37	48	22
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	22	355	203	85	330	49	134	57	68	40	52	24
Number of Lanes	0	1	0	0	1	0	0	1	1	0	1	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	1	1	1	2
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	1	2	1	1
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	2	1	1	1
HCM Control Delay	66.5	38.2	16.3	14.4
HCM LOS	F	E	C	B

Lane	NBLn1	NBLn2	EBLn1	WBLn1	SBLn1
Vol Left, %	70%	0%	4%	18%	35%
Vol Thru, %	30%	0%	61%	71%	45%
Vol Right, %	0%	100%	35%	11%	21%
Sign Control	Stop	Stop	Stop	Stop	Stop
Traffic Vol by Lane	175	63	534	427	107
LT Vol	123	0	20	78	37
Through Vol	52	0	327	304	48
RT Vol	0	63	187	45	22
Lane Flow Rate	190	68	580	464	116
Geometry Grp	7	7	2	2	5
Degree of Util (X)	0.448	0.141	1.015	0.861	0.269
Departure Headway (Hd)	8.484	7.397	6.298	6.68	8.312
Convergence, Y/N	Yes	Yes	Yes	Yes	Yes
Cap	424	484	580	543	430
Service Time	6.245	5.156	4.318	4.703	6.39
HCM Lane V/C Ratio	0.448	0.14	1	0.855	0.27
HCM Control Delay	18	11.4	66.5	38.2	14.4
HCM Lane LOS	C	B	F	E	B
HCM 95th-tile Q	2.3	0.5	15.3	9.3	1.1

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	15	288	245	26	268	59	215	46	70	121	64	55
Future Volume (veh/h)	15	288	245	26	268	59	215	46	70	121	64	55
Number	5	2	12	1	6	16	7	4	14	3	8	18
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	0.99		0.98	0.99		0.98	1.00		0.97	1.00		0.96
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1937	1937	1976	1937	1937	1976	1863	1863	1900	1863	1863	1900
Adj Flow Rate, veh/h	16	313	266	28	291	64	234	50	76	132	70	60
Adj No. of Lanes	1	1	0	1	1	0	1	1	0	1	1	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	398	366	311	219	586	129	312	146	222	208	150	128
Arrive On Green	0.38	0.38	0.38	0.38	0.38	0.38	0.18	0.22	0.22	0.12	0.16	0.16
Sat Flow, veh/h	1051	957	813	860	1531	337	1774	655	995	1774	907	778
Grp Volume(v), veh/h	16	0	579	28	0	355	234	0	126	132	0	130
Grp Sat Flow(s),veh/h/ln	1051	0	1771	860	0	1868	1774	0	1649	1774	0	1685
Q Serve(g_s), s	0.6	0.0	14.6	1.5	0.0	7.1	6.1	0.0	3.1	3.5	0.0	3.4
Cycle Q Clear(g_c), s	7.6	0.0	14.6	16.1	0.0	7.1	6.1	0.0	3.1	3.5	0.0	3.4
Prop In Lane	1.00		0.46	1.00		0.18	1.00		0.60	1.00		0.46
Lane Grp Cap(c), veh/h	398	0	678	219	0	715	312	0	369	208	0	278
V/C Ratio(X)	0.04	0.00	0.85	0.13	0.00	0.50	0.75	0.00	0.34	0.64	0.00	0.47
Avail Cap(c_a), veh/h	434	0	740	249	0	781	658	0	608	658	0	621
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	14.4	0.0	13.8	21.2	0.0	11.5	19.1	0.0	15.9	20.6	0.0	18.4
Incr Delay (d2), s/veh	0.0	0.0	9.0	0.3	0.0	0.5	3.6	0.0	0.5	3.2	0.0	1.2
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.2	0.0	8.8	0.4	0.0	3.8	3.3	0.0	1.5	1.9	0.0	1.7
LnGrp Delay(d),s/veh	14.4	0.0	22.8	21.5	0.0	12.0	22.7	0.0	16.5	23.8	0.0	19.7
LnGrp LOS	B		C	C		B	C		B	C		B
Approach Vol, veh/h		595			383			360			262	
Approach Delay, s/veh		22.6			12.7			20.5			21.7	
Approach LOS		C			B			C			C	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2	3	4		6	7	8
Phs Duration (G+Y+Rc), s		23.2	10.2	15.4		23.2	13.1	12.6
Change Period (Y+Rc), s		4.5	4.5	4.5		4.5	4.5	4.5
Max Green Setting (Gmax), s		20.4	18.1	18.0		20.4	18.1	18.0
Max Q Clear Time (g_c+I1), s		16.6	5.5	5.1		18.1	8.1	5.4
Green Ext Time (p_c), s		1.5	0.3	0.5		0.5	0.5	0.5

Intersection Summary	
HCM 2010 Ctrl Delay	19.6
HCM 2010 LOS	B

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	20	327	189	78	304	45	123	52	63	37	48	22
Future Volume (veh/h)	20	327	189	78	304	45	123	52	63	37	48	22
Number	5	2	12	1	6	16	7	4	14	3	8	18
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	0.99		0.98	0.99		0.98	1.00		0.96	1.00		0.96
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1937	1937	1976	1937	1937	1976	1863	1863	1900	1863	1863	1900
Adj Flow Rate, veh/h	22	355	205	85	330	49	134	57	68	40	52	24
Adj No. of Lanes	1	1	0	1	1	0	1	1	0	1	1	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	450	490	283	307	704	105	215	127	152	194	186	86
Arrive On Green	0.43	0.43	0.43	0.43	0.43	0.43	0.12	0.17	0.17	0.11	0.16	0.16
Sat Flow, veh/h	1030	1144	660	875	1644	244	1774	756	902	1774	1188	548
Grp Volume(v), veh/h	22	0	560	85	0	379	134	0	125	40	0	76
Grp Sat Flow(s),veh/h/ln	1030	0	1804	875	0	1888	1774	0	1658	1774	0	1736
Q Serve(g_s), s	0.7	0.0	11.8	4.1	0.0	6.6	3.3	0.0	3.1	0.9	0.0	1.8
Cycle Q Clear(g_c), s	7.3	0.0	11.8	15.9	0.0	6.6	3.3	0.0	3.1	0.9	0.0	1.8
Prop In Lane	1.00		0.37	1.00		0.13	1.00		0.54	1.00		0.32
Lane Grp Cap(c), veh/h	450	0	772	307	0	808	215	0	279	194	0	271
V/C Ratio(X)	0.05	0.00	0.72	0.28	0.00	0.47	0.62	0.00	0.45	0.21	0.00	0.28
Avail Cap(c_a), veh/h	578	0	996	415	0	1042	701	0	655	701	0	685
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	12.0	0.0	10.9	17.5	0.0	9.4	19.2	0.0	17.2	18.6	0.0	17.1
Incr Delay (d2), s/veh	0.0	0.0	1.9	0.5	0.0	0.4	3.0	0.0	1.1	0.5	0.0	0.6
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.2	0.0	6.2	1.0	0.0	3.5	1.8	0.0	1.5	0.5	0.0	0.9
LnGrp Delay(d),s/veh	12.0	0.0	12.8	17.9	0.0	9.8	22.1	0.0	18.3	19.1	0.0	17.6
LnGrp LOS	B		B	B		A	C		B	B		B
Approach Vol, veh/h		582			464			259			116	
Approach Delay, s/veh		12.7			11.3			20.3			18.1	
Approach LOS		B			B			C			B	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2	3	4		6	7	8
Phs Duration (G+Y+Rc), s		24.1	9.5	12.2		24.1	10.0	11.7
Change Period (Y+Rc), s		4.5	4.5	4.5		4.5	4.5	4.5
Max Green Setting (Gmax), s		25.3	18.1	18.1		25.3	18.1	18.1
Max Q Clear Time (g_c+I1), s		13.8	2.9	5.1		17.9	5.3	3.8
Green Ext Time (p_c), s		3.2	0.1	0.5		1.7	0.3	0.3

Intersection Summary	
HCM 2010 Ctrl Delay	14.1
HCM 2010 LOS	B

Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	16	579	28	355	234	126	132	130
v/c Ratio	0.05	0.78	0.18	0.47	0.58	0.32	0.43	0.43
Control Delay	14.1	24.5	17.7	16.3	25.2	11.7	25.5	18.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	14.1	24.5	17.7	16.3	25.2	11.7	25.5	18.3
Queue Length 50th (ft)	3	137	6	78	67	13	38	21
Queue Length 95th (ft)	16	#367	27	180	134	52	88	66
Internal Link Dist (ft)		294		342		259		398
Turn Bay Length (ft)	100		100				100	
Base Capacity (vph)	354	783	165	795	606	611	606	623
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.05	0.74	0.17	0.45	0.39	0.21	0.22	0.21

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	22	560	85	379	134	125	40	76
v/c Ratio	0.06	0.69	0.41	0.46	0.41	0.33	0.17	0.28
Control Delay	10.8	17.4	18.9	13.4	24.5	13.3	24.5	19.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	10.8	17.4	18.9	13.4	24.5	13.3	24.5	19.5
Queue Length 50th (ft)	4	118	17	75	39	16	12	15
Queue Length 95th (ft)	17	254	59	161	87	55	38	50
Internal Link Dist (ft)		294		342		259		398
Turn Bay Length (ft)	100		100				100	
Base Capacity (vph)	472	1030	269	1062	650	655	650	663
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.05	0.54	0.32	0.36	0.21	0.19	0.06	0.11

Intersection Summary

MOVEMENT SUMMARY

Site: 101 [AM Existing Conditions Roundabout (Site Folder: General)]

New Site
Site Category: (None)
Roundabout

Vehicle Movement Performance															
Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] ft	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed mph
South: City Park Way														
3	L2	215	2.0	234	2.0	0.520	13.3	LOS B	3.5	88.0	0.66	0.83	1.00	11.5
8	T1	46	2.0	50	2.0	0.520	13.3	LOS B	3.5	88.0	0.66	0.83	1.00	14.9
18	R2	70	2.0	76	2.0	0.520	13.3	LOS B	3.5	88.0	0.66	0.83	1.00	12.0
Approach		331	2.0	360	2.0	0.520	13.3	LOS B	3.5	88.0	0.66	0.83	1.00	12.1
East: Crystal Springs Rd														
1	L2	26	2.0	28	2.0	0.471	10.7	LOS B	2.7	69.0	0.55	0.55	0.65	15.1
6	T1	268	2.0	291	2.0	0.471	10.7	LOS B	2.7	69.0	0.55	0.55	0.65	8.7
16	R2	59	2.0	64	2.0	0.471	10.7	LOS B	2.7	69.0	0.55	0.55	0.65	13.1
Approach		353	2.0	384	2.0	0.471	10.7	LOS B	2.7	69.0	0.55	0.55	0.65	10.0
North: Oak Ave														
7	L2	121	2.0	132	2.0	0.415	11.8	LOS B	2.0	52.1	0.63	0.73	0.83	9.5
4	T1	64	2.0	70	2.0	0.415	11.8	LOS B	2.0	52.1	0.63	0.73	0.83	15.6
14	R2	55	2.0	60	2.0	0.415	11.8	LOS B	2.0	52.1	0.63	0.73	0.83	12.5
Approach		240	2.0	261	2.0	0.415	11.8	LOS B	2.0	52.1	0.63	0.73	0.83	11.8
West: Crystal Springs Rd														
5	L2	15	2.0	16	2.0	0.680	15.7	LOS C	9.1	232.4	0.67	0.86	1.11	11.9
2	T1	288	2.0	313	2.0	0.680	15.7	LOS C	9.1	232.4	0.67	0.86	1.11	6.2
12	R2	245	2.0	266	2.0	0.680	15.7	LOS C	9.1	232.4	0.67	0.86	1.11	12.5
Approach		548	2.0	596	2.0	0.680	15.7	LOS C	9.1	232.4	0.67	0.86	1.11	9.3
All Vehicles		1472	2.0	1600	2.0	0.680	13.3	LOS B	9.1	232.4	0.63	0.76	0.93	10.6

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
Delay Model: HCM Delay Formula (Geometric Delay is not included).
Queue Model: HCM Queue Formula.
Gap-Acceptance Capacity: Traditional M1.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: 101 [PM Existing Conditions Roundabout (Site Folder: General)]

New Site
Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] ft	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed mph
South: City Park Way														
3	L2	123	2.0	134	2.0	0.358	9.5	LOS A	1.5	37.7	0.56	0.54	0.56	12.8
8	T1	52	2.0	57	2.0	0.358	9.5	LOS A	1.5	37.7	0.56	0.54	0.56	16.6
18	R2	63	2.0	68	2.0	0.358	9.5	LOS A	1.5	37.7	0.56	0.54	0.56	13.6
Approach		238	2.0	259	2.0	0.358	9.5	LOS A	1.5	37.7	0.56	0.54	0.56	13.8
East: Crystal Springs Rd														
1	L2	78	2.0	85	2.0	0.521	10.9	LOS B	3.0	76.4	0.52	0.43	0.53	14.8
6	T1	304	2.0	330	2.0	0.521	10.9	LOS B	3.0	76.4	0.52	0.43	0.53	8.6
16	R2	45	2.0	49	2.0	0.521	10.9	LOS B	3.0	76.4	0.52	0.43	0.53	12.8
Approach		427	2.0	464	2.0	0.521	10.9	LOS B	3.0	76.4	0.52	0.43	0.53	10.3
North: Oak Ave														
7	L2	37	2.0	40	2.0	0.184	7.9	LOS A	0.6	16.4	0.54	0.54	0.54	10.7
4	T1	48	2.0	52	2.0	0.184	7.9	LOS A	0.6	16.4	0.54	0.54	0.54	17.7
14	R2	22	2.0	24	2.0	0.184	7.9	LOS A	0.6	16.4	0.54	0.54	0.54	14.5
Approach		107	2.0	116	2.0	0.184	7.9	LOS A	0.6	16.4	0.54	0.54	0.54	14.7
West: Crystal Springs Rd														
5	L2	20	2.0	22	2.0	0.628	13.4	LOS B	6.0	152.8	0.57	0.53	0.71	12.9
2	T1	327	2.0	355	2.0	0.628	13.4	LOS B	6.0	152.8	0.57	0.53	0.71	6.8
12	R2	187	2.0	203	2.0	0.628	13.4	LOS B	6.0	152.8	0.57	0.53	0.71	13.4
Approach		534	2.0	580	2.0	0.628	13.4	LOS B	6.0	152.8	0.57	0.53	0.71	9.5
All Vehicles		1306	2.0	1420	2.0	0.628	11.4	LOS B	6.0	152.8	0.55	0.50	0.61	11.1

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
Delay Model: HCM Delay Formula (Geometric Delay is not included).
Queue Model: HCM Queue Formula.
Gap-Acceptance Capacity: Traditional M1.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Intersection	
Intersection Delay, s/veh	389.4
Intersection LOS	F

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	24	454	386	41	423	93	339	73	110	191	102	87
Future Vol, veh/h	24	454	386	41	423	93	339	73	110	191	102	87
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	26	493	420	45	460	101	368	79	120	208	111	95
Number of Lanes	0	1	0	0	1	0	0	1	1	0	1	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	1	1	1	2
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	1	2	1	1
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	2	1	1	1
HCM Control Delay	684.7	325.5	151.1	139.2
HCM LOS	F	F	F	F

Lane	NBLn1	NBLn2	EBLn1	WBLn1	SBLn1
Vol Left, %	82%	0%	3%	7%	50%
Vol Thru, %	18%	0%	53%	76%	27%
Vol Right, %	0%	100%	45%	17%	23%
Sign Control	Stop	Stop	Stop	Stop	Stop
Traffic Vol by Lane	412	110	864	557	380
LT Vol	339	0	24	41	191
Through Vol	73	0	454	423	102
RT Vol	0	110	386	93	87
Lane Flow Rate	448	120	939	605	413
Geometry Grp	7	7	2	2	5
Degree of Util (X)	1.262	0.3	2.443	1.605	1.109
Departure Headway (Hd)	14.812	13.627	12.226	15.012	16.825
Convergence, Y/N	Yes	Yes	Yes	Yes	Yes
Cap	251	265	310	248	219
Service Time	12.512	11.327	10.226	13.012	14.825
HCM Lane V/C Ratio	1.785	0.453	3.029	2.44	1.886
HCM Control Delay	185.5	22.1	684.7	325.5	139.2
HCM Lane LOS	F	C	F	F	F
HCM 95th-tile Q	15.4	1.2	57.8	24.1	11

Intersection	
Intersection Delay, s/veh	284.2
Intersection LOS	F

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	32	516	298	123	479	71	194	82	99	58	76	35
Future Vol, veh/h	32	516	298	123	479	71	194	82	99	58	76	35
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	35	561	324	134	521	77	211	89	108	63	83	38
Number of Lanes	0	1	0	0	1	0	0	1	1	0	1	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	1	1	1	2
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	1	2	1	1
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	2	1	1	1
HCM Control Delay	442.2	289.5	34.4	26.8
HCM LOS	F	F	D	D

Lane	NBLn1	NBLn2	EBLn1	WBLn1	SBLn1
Vol Left, %	70%	0%	4%	18%	34%
Vol Thru, %	30%	0%	61%	71%	45%
Vol Right, %	0%	100%	35%	11%	21%
Sign Control	Stop	Stop	Stop	Stop	Stop
Traffic Vol by Lane	276	99	846	673	169
LT Vol	194	0	32	123	58
Through Vol	82	0	516	479	76
RT Vol	0	99	298	71	35
Lane Flow Rate	300	108	920	732	184
Geometry Grp	7	7	2	2	5
Degree of Util (X)	0.745	0.236	1.918	1.562	0.466
Departure Headway (Hd)	11.355	10.242	8.696	9.509	12.988
Convergence, Y/N	Yes	Yes	Yes	Yes	Yes
Cap	321	353	432	388	279
Service Time	9.055	7.942	6.696	7.509	10.988
HCM Lane V/C Ratio	0.935	0.306	2.13	1.887	0.659
HCM Control Delay	40.9	16.1	442.2	289.5	26.8
HCM Lane LOS	E	C	F	F	D
HCM 95th-tile Q	5.6	0.9	53.1	33.3	2.3

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	24	454	386	41	423	93	339	73	110	191	102	87
Future Volume (veh/h)	24	454	386	41	423	93	339	73	110	191	102	87
Number	5	2	12	1	6	16	7	4	14	3	8	18
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		0.98	1.00		0.98	1.00		0.97	1.00		0.96
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1937	1937	1976	1937	1937	1976	1863	1863	1900	1863	1863	1900
Adj Flow Rate, veh/h	26	493	420	45	460	101	368	79	120	208	111	95
Adj No. of Lanes	1	1	0	1	1	0	1	1	0	1	1	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	302	461	393	74	738	162	396	159	241	244	142	121
Arrive On Green	0.48	0.48	0.48	0.48	0.48	0.48	0.22	0.24	0.24	0.14	0.16	0.16
Sat Flow, veh/h	879	958	816	633	1534	337	1774	656	996	1774	907	776
Grp Volume(v), veh/h	26	0	913	45	0	561	368	0	199	208	0	206
Grp Sat Flow(s),veh/h/ln	879	0	1775	633	0	1870	1774	0	1652	1774	0	1683
Q Serve(g_s), s	2.2	0.0	46.8	0.0	0.0	21.6	19.8	0.0	10.1	11.1	0.0	11.4
Cycle Q Clear(g_c), s	23.8	0.0	46.8	46.8	0.0	21.6	19.8	0.0	10.1	11.1	0.0	11.4
Prop In Lane	1.00		0.46	1.00		0.18	1.00		0.60	1.00		0.46
Lane Grp Cap(c), veh/h	302	0	854	74	0	900	396	0	400	244	0	263
V/C Ratio(X)	0.09	0.00	1.07	0.61	0.00	0.62	0.93	0.00	0.50	0.85	0.00	0.78
Avail Cap(c_a), veh/h	302	0	854	74	0	900	396	0	400	330	0	312
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	27.5	0.0	25.2	48.6	0.0	18.7	37.0	0.0	31.8	40.9	0.0	39.4
Incr Delay (d2), s/veh	0.1	0.0	50.8	13.4	0.0	1.3	28.2	0.0	1.0	14.5	0.0	10.4
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.5	0.0	34.8	1.5	0.0	11.4	12.8	0.0	4.7	6.4	0.0	6.1
LnGrp Delay(d),s/veh	27.6	0.0	76.0	62.1	0.0	20.0	65.2	0.0	32.7	55.5	0.0	49.8
LnGrp LOS	C		F	E		C	E		C	E		D
Approach Vol, veh/h		939			606			567			414	
Approach Delay, s/veh		74.6			23.1			53.8			52.7	
Approach LOS		E			C			D			D	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2	3	4		6	7	8
Phs Duration (G+Y+Rc), s		51.3	17.9	28.0		51.3	26.2	19.7
Change Period (Y+Rc), s		4.5	4.5	4.5		4.5	4.5	4.5
Max Green Setting (Gmax), s		46.8	18.1	21.6		46.8	21.7	18.0
Max Q Clear Time (g_c+I1), s		48.8	13.1	12.1		48.8	21.8	13.4
Green Ext Time (p_c), s		0.0	0.3	0.7		0.0	0.0	0.5

Intersection Summary	
HCM 2010 Ctrl Delay	54.0
HCM 2010 LOS	D

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	32	516	298	123	479	71	194	82	99	58	76	35
Future Volume (veh/h)	32	516	298	123	479	71	194	82	99	58	76	35
Number	5	2	12	1	6	16	7	4	14	3	8	18
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		0.99	1.00		0.99	1.00		0.97	1.00		0.94
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1937	1937	1976	1937	1937	1976	1863	1863	1900	1863	1863	1900
Adj Flow Rate, veh/h	35	561	324	134	521	77	211	89	108	63	83	38
Adj No. of Lanes	1	1	0	1	1	0	1	1	0	1	1	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	431	694	401	220	996	147	246	152	185	99	142	65
Arrive On Green	0.61	0.61	0.61	0.61	0.61	0.61	0.14	0.20	0.20	0.06	0.12	0.12
Sat Flow, veh/h	850	1146	662	650	1647	243	1774	752	912	1774	1185	543
Grp Volume(v), veh/h	35	0	885	134	0	598	211	0	197	63	0	121
Grp Sat Flow(s),veh/h/ln	850	0	1809	650	0	1890	1774	0	1663	1774	0	1727
Q Serve(g_s), s	2.5	0.0	37.5	19.9	0.0	18.1	11.5	0.0	10.6	3.4	0.0	6.6
Cycle Q Clear(g_c), s	20.6	0.0	37.5	57.4	0.0	18.1	11.5	0.0	10.6	3.4	0.0	6.6
Prop In Lane	1.00		0.37	1.00		0.13	1.00		0.55	1.00		0.31
Lane Grp Cap(c), veh/h	431	0	1094	220	0	1144	246	0	338	99	0	207
V/C Ratio(X)	0.08	0.00	0.81	0.61	0.00	0.52	0.86	0.00	0.58	0.64	0.00	0.58
Avail Cap(c_a), veh/h	436	0	1104	223	0	1153	322	0	338	322	0	314
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	17.3	0.0	15.1	37.3	0.0	11.3	41.7	0.0	35.7	45.8	0.0	41.3
Incr Delay (d2), s/veh	0.1	0.0	4.6	4.6	0.0	0.4	16.1	0.0	2.6	6.6	0.0	2.6
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.6	0.0	19.8	3.9	0.0	9.4	6.7	0.0	5.1	1.9	0.0	3.3
LnGrp Delay(d),s/veh	17.3	0.0	19.7	42.0	0.0	11.7	57.8	0.0	38.3	52.4	0.0	43.9
LnGrp LOS	B		B	D		B	E		D	D		D
Approach Vol, veh/h		920			732			408			184	
Approach Delay, s/veh		19.6			17.3			48.4			46.8	
Approach LOS		B			B			D			D	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2	3	4		6	7	8
Phs Duration (G+Y+Rc), s		64.5	10.0	24.6		64.5	18.3	16.4
Change Period (Y+Rc), s		4.5	4.5	4.5		4.5	4.5	4.5
Max Green Setting (Gmax), s		60.5	18.0	18.0		60.5	18.0	18.0
Max Q Clear Time (g_c+I1), s		39.5	5.4	12.6		59.4	13.5	8.6
Green Ext Time (p_c), s		8.0	0.1	0.5		0.6	0.2	0.4

Intersection Summary	
HCM 2010 Ctrl Delay	26.3
HCM 2010 LOS	C

Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	26	913	45	561	368	199	208	206
v/c Ratio	0.09	0.95	0.51	0.57	0.92	0.49	0.74	0.72
Control Delay	15.6	43.2	43.8	20.4	67.2	26.3	54.8	46.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	15.6	43.2	43.8	20.4	67.2	26.3	54.8	46.5
Queue Length 50th (ft)	8	494	18	230	223	69	122	99
Queue Length 95th (ft)	25	#816	#77	354	#412	141	202	176
Internal Link Dist (ft)		294		342		259		398
Turn Bay Length (ft)	100		100				100	
Base Capacity (vph)	290	974	89	1004	403	425	336	354
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.09	0.94	0.51	0.56	0.91	0.47	0.62	0.58

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	35	885	134	598	211	197	63	121
v/c Ratio	0.09	0.74	0.74	0.49	0.76	0.59	0.40	0.57
Control Delay	11.0	20.1	45.4	13.9	60.1	36.7	52.3	47.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	11.0	20.1	45.4	13.9	60.1	36.7	52.3	47.4
Queue Length 50th (ft)	10	390	62	211	132	89	40	65
Queue Length 95th (ft)	27	632	#198	338	#243	168	83	124
Internal Link Dist (ft)		294		342		259		398
Turn Bay Length (ft)	100		100				100	
Base Capacity (vph)	410	1189	180	1231	315	360	315	328
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.09	0.74	0.74	0.49	0.67	0.55	0.20	0.37

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

MOVEMENT SUMMARY

Site: 101 [AM Horizon Year Conditions Roundabout (Site Folder: General)]

New Site
Site Category: (None)
Roundabout

Vehicle Movement Performance															
Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] ft	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed mph
South: City Park Way														
3	L2	339	2.0	368	2.0	0.982	59.6	LOS F	21.6	548.4	1.00	2.40	4.00	5.4
8	T1	73	2.0	79	2.0	0.982	59.6	LOS F	21.6	548.4	1.00	2.40	4.00	6.9
18	R2	110	2.0	120	2.0	0.982	59.6	LOS F	21.6	548.4	1.00	2.40	4.00	5.2
Approach		522	2.0	567	2.0	0.982	59.6	LOS F	21.6	548.4	1.00	2.40	4.00	5.6
East: Crystal Springs Rd														
1	L2	41	2.0	45	2.0	0.881	35.7	LOS E	16.9	428.4	0.97	1.87	2.72	7.9
6	T1	423	2.0	460	2.0	0.881	35.7	LOS E	16.9	428.4	0.97	1.87	2.72	4.3
16	R2	93	2.0	101	2.0	0.881	35.7	LOS E	16.9	428.4	0.97	1.87	2.72	6.7
Approach		557	2.0	605	2.0	0.881	35.7	LOS E	16.9	428.4	0.97	1.87	2.72	5.0
North: Oak Ave														
7	L2	191	2.0	208	2.0	0.906	51.8	LOS F	11.2	283.5	0.93	1.81	3.03	4.5
4	T1	102	2.0	111	2.0	0.906	51.8	LOS F	11.2	283.5	0.93	1.81	3.03	7.6
14	R2	87	2.0	95	2.0	0.906	51.8	LOS F	11.2	283.5	0.93	1.81	3.03	5.5
Approach		380	2.0	413	2.0	0.906	51.8	LOS F	11.2	283.5	0.93	1.81	3.03	5.6
West: Crystal Springs Rd														
5	L2	24	2.0	26	2.0	1.228	133.3	LOS F	82.5	2096.5	1.00	4.57	7.30	2.5
2	T1	454	2.0	493	2.0	1.228	133.3	LOS F	82.5	2096.5	1.00	4.57	7.30	1.4
12	R2	386	2.0	420	2.0	1.228	133.3	LOS F	82.5	2096.5	1.00	4.57	7.30	2.9
Approach		864	2.0	939	2.0	1.228	133.3	LOS F	82.5	2096.5	1.00	4.57	7.30	2.1
All Vehicles		2323	2.0	2525	2.0	1.228	80.0	LOS F	82.5	2096.5	0.98	2.98	4.76	3.5

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
Delay Model: HCM Delay Formula (Geometric Delay is not included).
Queue Model: HCM Queue Formula.
Gap-Acceptance Capacity: Traditional M1.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: 101 [PM Horizon Year Conditions Roundabout (Site Folder: General)]

New Site
Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] ft	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed mph
South: City Park Way														
3	L2	194	2.0	211	2.0	0.685	21.6	LOS C	5.9	149.2	0.79	1.16	1.58	9.6
8	T1	82	2.0	89	2.0	0.685	21.6	LOS C	5.9	149.2	0.79	1.16	1.58	12.4
18	R2	99	2.0	108	2.0	0.685	21.6	LOS C	5.9	149.2	0.79	1.16	1.58	9.8
Approach		375	2.0	408	2.0	0.685	21.6	LOS C	5.9	149.2	0.79	1.16	1.58	10.3
East: Crystal Springs Rd														
1	L2	123	2.0	134	2.0	0.928	39.5	LOS E	27.6	701.3	1.00	2.16	2.98	7.4
6	T1	479	2.0	521	2.0	0.928	39.5	LOS E	27.6	701.3	1.00	2.16	2.98	4.0
16	R2	71	2.0	77	2.0	0.928	39.5	LOS E	27.6	701.3	1.00	2.16	2.98	6.2
Approach		673	2.0	732	2.0	0.928	39.5	LOS E	27.6	701.3	1.00	2.16	2.98	4.9
North: Oak Ave														
7	L2	58	2.0	63	2.0	0.401	15.0	LOS C	1.7	43.8	0.70	0.81	0.97	8.8
4	T1	76	2.0	83	2.0	0.401	15.0	LOS C	1.7	43.8	0.70	0.81	0.97	14.6
14	R2	35	2.0	38	2.0	0.401	15.0	LOS C	1.7	43.8	0.70	0.81	0.97	11.5
Approach		169	2.0	184	2.0	0.401	15.0	LOS C	1.7	43.8	0.70	0.81	0.97	12.0
West: Crystal Springs Rd														
5	L2	32	2.0	35	2.0	1.104	84.7	LOS F	66.1	1677.8	1.00	3.41	4.93	3.8
2	T1	516	2.0	561	2.0	1.104	84.7	LOS F	66.1	1677.8	1.00	3.41	4.93	2.0
12	R2	298	2.0	324	2.0	1.104	84.7	LOS F	66.1	1677.8	1.00	3.41	4.93	4.3
Approach		846	2.0	920	2.0	1.104	84.7	LOS F	66.1	1677.8	1.00	3.41	4.93	2.9
All Vehicles		2063	2.0	2242	2.0	1.104	52.8	LOS F	66.1	1677.8	0.94	2.38	3.36	4.7

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
Delay Model: HCM Delay Formula (Geometric Delay is not included).
Queue Model: HCM Queue Formula.
Gap-Acceptance Capacity: Traditional M1.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

APPENDIX C. MINI-ROUNDABOUT TURN TEMPLATE EXHIBITS

30% SUBMITTAL
NOT FOR CONSTRUCTION

DRAWN	DESIGNED	HORIZONTAL SCALE
FRANK APPIAH	FA	
CHECKED	DATE CHECKED	VERTICAL SCALE
MS	2022/04/25	
APPROVED MS		CONTRACT NO.
ENGINEER	DATE	

PRELIMINARY

PREPARED BY:

DKS

1970 Broadway, Suite #740
Oakland, California 94612–2219
Tel.: 510–763–2061
Fax: 510–268–1739

REVISIONS

NO.	DATE	BY	DESCRIPTION	APPR.	DATE

CRYSTAL SPRINGS AND OAK AVE/CITY PARK WAY

SU-30 TRUCK AUTOTURN

DRAWING NO.
-

SHT 1 OF 1

Last Saved By: benjamin.tinklenberg 5-06-22 03:10pm

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30% SUBMITTAL
NOT FOR CONSTRUCTION

DRAWN	DESIGNED	HORIZONTAL SCALE
FRANK APPIAH	FA	
CHECKED	DATE CHECKED	VERTICAL SCALE
MS	2022/04/25	
APPROVED MS		
ENGINEER	DATE	CONTRACT NO.

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NOT FOR CONSTRUCTION

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FRANK APPIAH	FA	
CHECKED	DATE CHECKED	VERTICAL SCALE
MS	2022/04/25	
APPROVED MS		CONTRACT NO.
ENGINEER	DATE	

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CRYSTAL SPRINGS AND OAK AVE/CITY PARK WAY

PASSENGER VEHICLE AUTOTURN

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APPROVED: MS		
ENGINEER	DATE	CONTRACT NO.

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PASSENGER VEHICLE AUTOTURN

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