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TECHNICAL MEMORANDUM 5

DATE: January 27, 2022

TO: Don Morehouse | ODOT

FROM: John Bosket, PE; Aaron Berger, PE (WA); Kayla Fleskes, PE | DKS Associates

SUBJECT: US 97 Baker Road IAMP Project #20020-006
Concept Development and Evaluation

This memorandum describes the development and evaluation of concepts for improving transportation conditions within the US 97 Baker Road Interchange Area Management Plan (IAMP) area of primary impact (API). Initial concepts were screened and discussed during a concept evaluation workshop with the Technical Advisory Committee (TAC). Based on direction received during the concept evaluation workshop, the top concepts were further refined and evaluated against the goals and evaluation criteria from Technical Memorandum #1. This memorandum includes a description of the top concepts and their performance relative to the evaluation criteria.

This memorandum is organized into the following sections:

- **Process for developing and evaluating concepts -** In this section, the process for developing and evaluating the initial interchange alternative concepts is discussed.
- **Improvements consistent between concepts -** In this section, improvements that are the basically the same in each concept, such as the framework for active transportation improvements, some access spacing, and Cinder Butte Road/Baker Road intersection improvements, are acknowledged to aid the comparison of alternatives.
- **Refined concept description and performance –** The top three alternative concepts are described in more detail and specific considerations related to active transportation, traffic operations and safety are discussed for each.
- **Refined concept evaluation –** Using the evaluation criteria, each refined alternative concept is qualitatively scored to help guide the discussion of the key opportunities and tradeoffs associated with each concept and ultimately select a preferred concept.

PROCESS FOR DEVELOPING AND EVALUATING CONCEPTS

Based on the needs identified in Technical Memoranda #1-4, the project team developed an initial set of eight alternative concepts. These alternatives targeted key deficiencies identified during the analysis and from public comments and included the following (for alternative concept figures and a more detailed description of the alternatives, see Appendix A):

- Alternative 1 – Enhance Existing Ramp Terminals
- Alternative 2 – Tight Urban Diamond Interchange
- Alternative 3 – Southbound On- and Off-Ramp Flyovers with Signalized Intersection
- Alternative 4 – Southbound On- and Off-Ramp Flyovers with Roundabout Intersection
- Alternative 5 – Southbound Off-Ramp Flyover with Signalized Intersection and Existing Southbound Loop On-Ramp
- Alternative 6 – Southbound Off-Ramp Flyover with Roundabout Intersection and Existing Southbound Loop On-Ramp
- Alternative 7 – Southbound Off-Ramp Flyover with Signalized Intersection and New Southbound Diamond On-Ramp
- Alternative 8 – Southbound Off-Ramp Flyover with Roundabout Intersection and New Southbound Diamond On-Ramp

Given that conflicts with the railroad were a primary concern identified with existing operations, grade separation of the railroad and Baker Road was also investigated - either raising the railroad over Baker Road or raising Baker Road over the railroad. Raising the railroad over Baker Road would be very costly as it would require the construction of a temporary parallel track for use during construction and a lengthy structure to bring the railroad over Baker Road at acceptable grades. Raising Baker Road over the railroad would also require a costly structure and may sever access to Baker Court, Cinder Butte Road, Pocahontas Lane, and several homes on Baker Road. Through discussion with the TAC and Community Advisory Committee (CAC), both options were deemed undesirable due to the costs, constructability challenges, and impacts to local circulation and property access in the vicinity.

The initial eight alternatives were presented virtually in an online open house from June 7 -20, 2021 and during a June 9 virtual public meeting. The comments received during the online open house and public meeting were considered during the refinement process and concept evaluation workshop held on June 28.

The four-hour concept evaluation workshop was held with members from the TAC to discuss the initial concepts. During the concept evaluation workshop, each of the initial alternatives were discussed and qualitatively scored relative to No-Build conditions and against each of the project goals. The highlights of this scoring and key considerations are documented in Appendix A. Based on the discussions at the concept evaluation workshop, three concepts were selected for further refinement:

- Alternative 2 – Tight Urban Diamond Interchange (with roundabouts)
- Alternative 4 – Southbound On- and Off-Ramp Flyovers with Roundabout Intersection
- Alternative 6 – Southbound Off-Ramp Flyover with Roundabout Intersection and Existing Southbound Loop On-Ramp

While each of these alternatives include roundabouts as part of the TAC-preferred concepts, any roundabouts on the state highway system would be subject to the stakeholder engagement process for approval outlined in ODOT Highway Directive DES 02. If during the stakeholder engagement process it was determined roundabouts would be infeasible at the US 97 ramp terminals, traffic

signals would be necessary instead. Therefore, intersection operations were analyzed for both roundabouts and traffic signals at the ramp terminals.

With each of the three refined concepts, an active transportation framework was discussed during the concept evaluation workshop to improve conditions for people walking, biking, and taking transit. The active transportation framework is compatible with all three alternatives and includes a multi-use path on the south side of Baker Road that connects to planned trails in the area. The active transportation framework is discussed in more detail in the following sections.

In addition to the eight initial alternatives for the interchange area, which were discussed during the concept evaluation workshop, four options were investigated by the project team to address the specific deficiencies identified at the Baker Road/Cinder Butte Road intersection. These options included:

- Option A: Adding short (less than 125 feet) westbound left and eastbound left turn lanes on Baker Road, with an optional northbound right turn lane to reduce delay on Cinder Butte Road. This would include a minor realignment of Cinder Butte Road to the east to provide as much turn lane storage as possible between the intersection and the railroad crossing and to reduce the intersection skew.
- Option B: Adding a traffic signal at the intersection, along with short (less than 125 feet) westbound left and eastbound left turn lanes on Baker Road. This would include a minor realignment of Cinder Butte Road to the east to provide as much left turn lane storage as possible between the intersection and the railroad crossing and to reduce the intersection skew.
- Option C: Adding a roundabout at the intersection.
- Option D: Realigning Baker Road so the major movements at the intersection are the northbound to eastbound and westbound to southbound movement, with the eastbound movement being stop-controlled.

While Option D mitigates the risk of queue spillbacks to the railroad, it would add significant delay to eastbound motor vehicle traffic on Baker Road and would negatively impact local access at Pocahontas Lane. Option C (adding a roundabout) would improve delay for the side-streets and address some of the crash risks, but it would be challenging to implement given the limited right-of-way and the need to provide sufficient distance between the entrance to the roundabout and railroad crossing. Given those constraints, Option C and Option D were removed from further consideration.

CONCEPT REFINEMENT

During the refinement process of the top three alternatives selected by the TAC, significant concerns were identified with Alternative 6 (Southbound Off-Ramp Flyover with Roundabout and Existing Southbound Loop On-Ramp). The initial concept for Alternative 6 showed a southbound off-ramp flyover connecting to a roundabout at the northbound ramp terminal. In this configuration, the southbound right turn movement was shown as a free movement to allow the approach lane to operate with an acceptable level of congestion. However, this creates a weave movement between the heavy southbound right turn movement merging to the left to continue through on Baker Road while westbound vehicles on Baker Road merge to the right to turn onto US

97 southbound, as shown in Figure 1. There would be limited distance available to make the weave movement (less than 700 feet), increasing the risk of collisions.

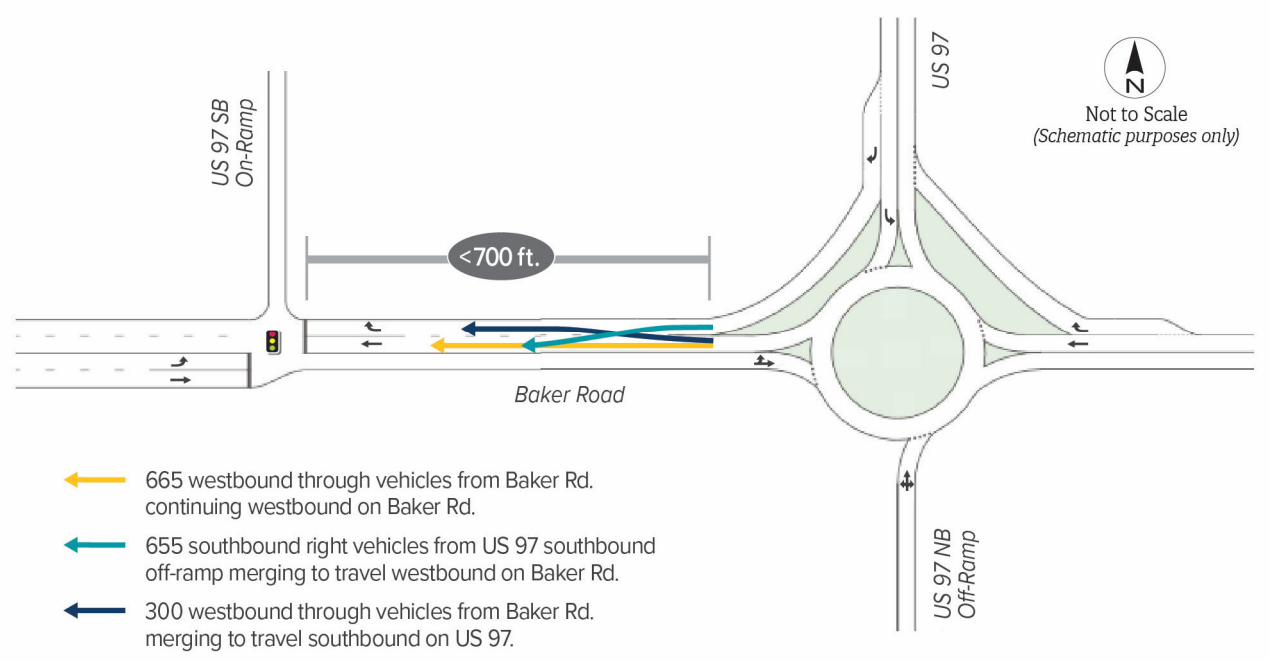

FIGURE 1. ALTERNATIVE 6 WESTBOUND WEAVING MOVEMENTS ON BAKER ROAD (2040 PM PEAK HOUR)

To mitigate the weaving problem, an additional westbound through lane would be necessary at both US 97 ramp terminals, allowing the southbound right turn movement to yield and then merge into the through lane as shown in Figure 2. However, this solution results in significant delay for the heavy southbound right turn movement, with the lane approaching capacity (volume-to-capacity ratio of 0.97).

In addition, because this alternative does not address the conflicts between the closely spaced intersections, side-by-side left turn lanes would be needed to access Baker Court and the US 97 southbound on-ramp (as shown in Figure 2). Even with side-by-side left turn lanes, which would require additional widening of Baker Road, not enough queue storage is provided between the US 97 southbound on-ramp and Baker Court. The lack of queue storage could likely only be mitigated by realigning the southbound loop ramp intersection to be opposite Baker Court.

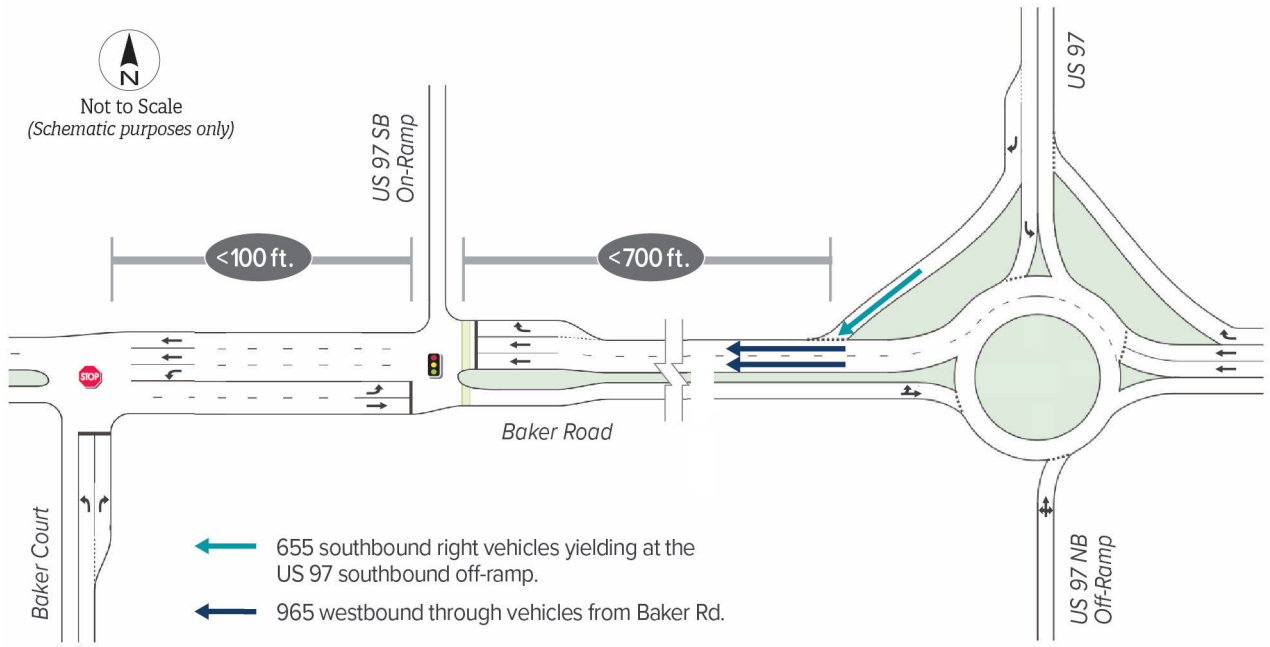

FIGURE 2. ALTERNATIVE 6 MITIGATED SOUTHBOUND LOOP RAMP CONFIGURATION

Given the capacity challenges associated with this alternative that required additional mitigation and the cost of a US 97 southbound off-ramp flyover, it was determined that Alternative 1 (Enhance Existing Ramp Terminals) would likely perform better than Alternative 6, with fewer tradeoffs. The southbound loop ramp could be realigned with Baker Court but there would not be the associated cost of a southbound off-ramp flyover. The refined concept for Alternative 1 is discussed below in more detail in the Refined Concepts Description and Performance section of this memo.

IMPROVEMENTS CONSISTENT BETWEEN CONCEPTS

While the three refined concept alternatives (discussed in more detail in the Refined Concepts Description and Performance section) provide examples of different configurations at the interchange, some elements of the concepts are consistent between all three alternatives, as described below.

ACTIVE TRANSPORTATION FRAMEWORK

In each of the alternatives, a similar framework for active transportation improvements has been applied. Each of the alternatives includes a 15-foot multi-use path on the south side of Baker Road/Knott Road, with sidewalk and an on-street buffered bicycle lane on the north side of the road (as shown in Figure 3). This would require widening the existing bridge structure. Note that depending on the alternative, a median or center travel lane may be included across the bridge. Curb-to-curb clear distances can be refined during design.

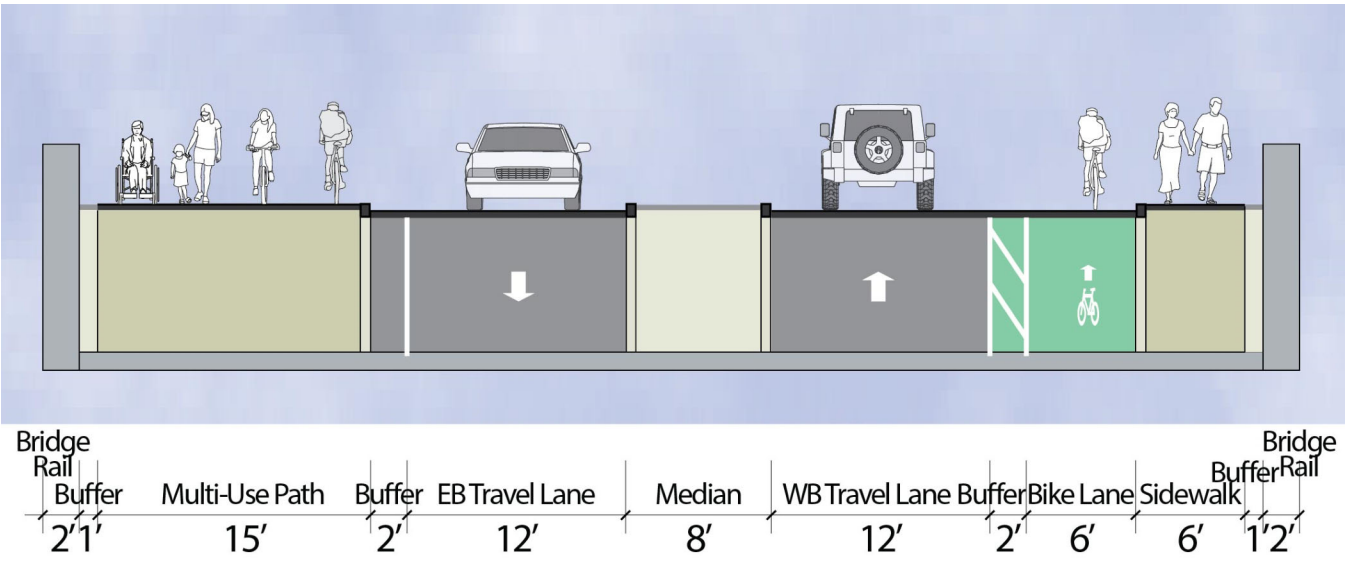

FIGURE 3. BAKER ROAD CROSS SECTION OVER US 97 WITH ACTIVE TRANSPORTATION IMPROVEMENTS

On the west end of the interchange, the multi-use path could connect to Cinder Butte Road or Baker Court, providing access to Riverwoods Country Store and Morning Star Christian School, as shown in Figure 4 below. It is anticipated that in the future the local transit stop will be relocated from River Woods Baptist Church on Cinder Butte Road to be closer to the interchange. The location is still unknown but could be near the Riverwoods Country Store or possibly in the northeast quadrant of the interchange.

The Bend to Lava Butte Multi-Use Path project, which would construct a path from Lava Lands Visitor Center to Baker Road, is still in the planning phase. The alignment of the path and location of an associated trailhead have not yet been determined and could be on the west or east side of US 97. This path and trailhead are currently shown in Figure 4 on the east side of US 97 for illustrative purposes only. It is anticipated that all interchange improvement concepts being considered would be compatible with path, trailhead, and transit stop locations on either side of US 97.

On the east end of the interchange, the multi-use path tunnels under the US 97 northbound off-ramp and Knott Road. Grade separation will improve safety for people walking and biking by eliminating conflicts with motor vehicles when crossing these roads. Crossing the multi-use path under Knott Road to the north allows the path to connect to the future Arnold Canal Trail. In each of the alternatives, an optional path on the north side of the interchange is shown under US 97 along the Arnold Canal. This path could be constructed if clearance under US 97 can be obtained. These elements are generally compatible with each of the refined alternatives, although minor modifications specific to each alternative are discussed in the following sections.

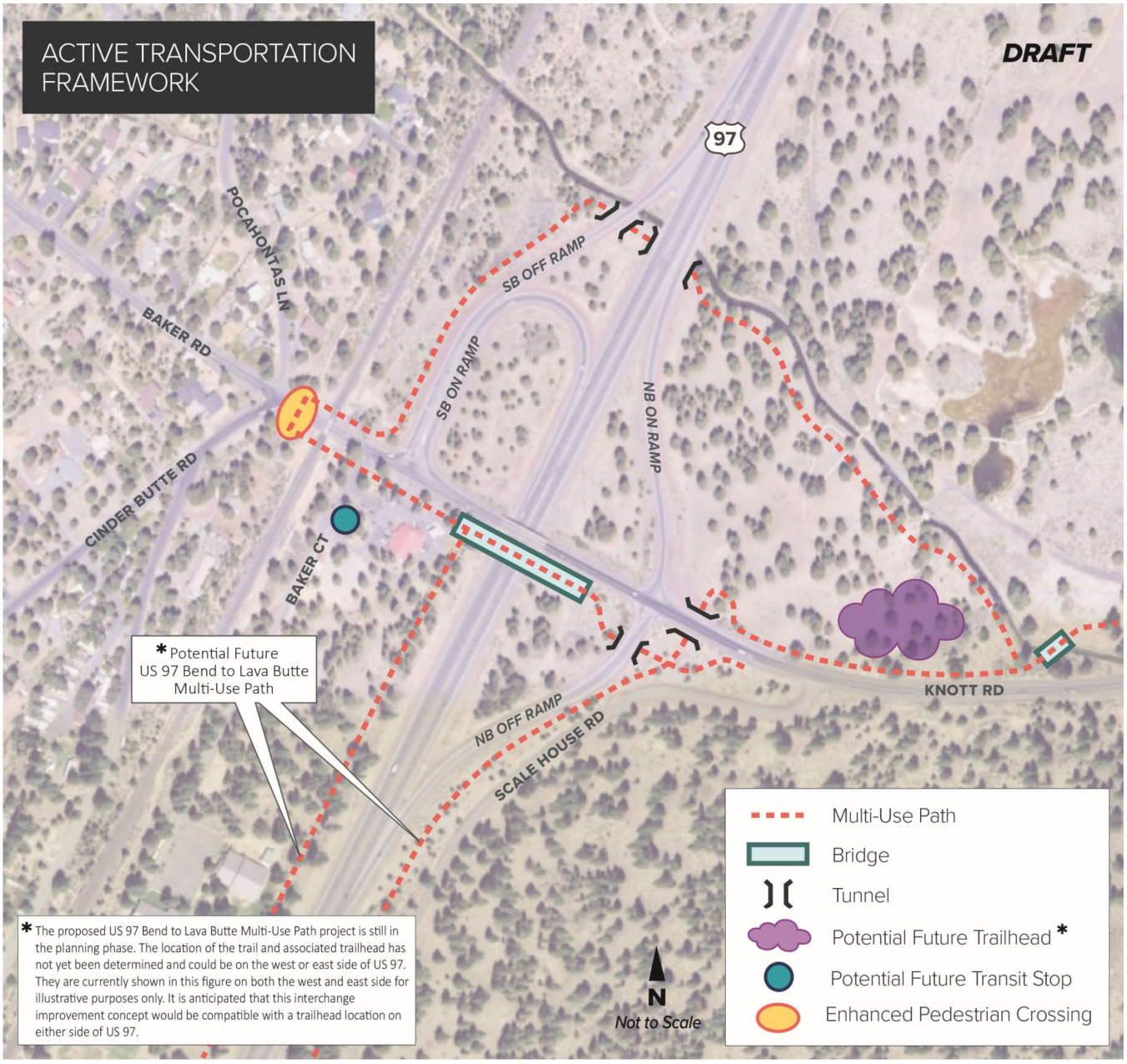

FIGURE 4. BAKER ROAD CROSS SECTION WITH ACTIVE TRANSPORTATION IMPROVEMENTS

MULTIMODAL LEVEL OF SERVICE (MMLOS) ANALYSIS

Multimodal level of service (MMLOS) analysis is used to evaluate conditions for people walking, biking, and taking transit. MMLOS scores are based on user perceptions of facilities and are graded from best (LOS A) to worst (LOS F). Pedestrian and bicycle facilities were analyzed using the ODOT modified version of MMLOS. Note that no significant changes to transit service are assumed between the alternatives and therefore transit MMLOS was not evaluated. Notably, all alternatives can accommodate the relocation of the local transit stop from River Woods Baptist Church on Cinder Butte Road to either the southwest or northeast quadrants of the interchange.

All the alternatives include a multi-use path on the south side of the interchange. This facility is a major improvement over existing conditions, where no sidewalk or bicycle facilities exist. In general, given the 15-foot width of the multi-use path, the path is expected to operate at LOS B or better for people walking and biking, indicating good conditions.

In the following sections describing each of the three refined concepts, any differences in conditions for people walking and biking (such as crossing locations or number of conflicts with motor vehicles) are discussed in more detail below.

ACCESS SPACING

ODOT has adopted interchange and access management spacing standards in the Oregon Highway Plan (OHP)[1] that specify the minimum separation required between interchange crossroads, adjacent interchange ramp tapers and access points along crossroads. As noted in *Technical Memorandum #2B: Existing Transportation System Inventory*, OHP standards indicate that a minimum of 1,320 feet (0.25 mi) be provided between the ramp terminals and the first intersection on the crossroad, a standard that is not met under existing conditions. Given the existing constraints (such as the numerous single-family home driveways located within 1,320 feet west of the interchange) it is infeasible for any of the alternatives to meet the OHP access spacing standards. However, some of the alternatives move in the direction of meeting access spacing standards by moving ramp terminals farther from existing access points or realigning the ramp terminals with public streets to avoid closely offset intersections (see Refined Concepts Description below for more details).

One improvement included in each of the alternatives is relocating Scale House Road. Scale House Road is located approximately 525 feet east of the existing northbound ramp terminal. It is recommended that Scale House Road be relocated farther east to provide additional spacing from the northbound ramp terminal. The relocation of this intersection must include an evaluation of safe intersection sight distance to ensure the horizontal and vertical curves are not obstructing needed sight lines.

[1] 1999 Oregon Highway Plan, as amended May 2015, Oregon Department of Transportation, Appendix C.

ROADWAY SYSTEM FUNCTIONAL CLASS

All of the three refined concepts include the same movements allowed today to/from Baker Road/Knott Road to/from US 97 and limited changes in travel patterns are anticipated with any of the alternatives compared to the future baseline No-Build conditions. Given this, no changes to functional classification within the API are recommended.

CINDER BUTTE ROAD AND BAKER ROAD INTERSECTION

Cinder Butte Road is located approximately 425 feet from the existing US 97 southbound ramp terminal. Traffic operations were evaluated at this intersection to determine the potential for westbound queue spillback to either the railroad or the US 97 southbound ramp terminal.

With the addition of short (less than 125 feet) eastbound and westbound left turn lanes on Baker Road at Cinder Butte Road, the intersection operates with minimal delay, as shown in Table 1 below, and has relatively minimal impact on the adjacent interchange operations. Adding left turn lanes also has the potential to address some of the existing crash patterns identified in *Technical Memorandum #3: Current Transportation System Operations*. Adding left turn lanes on Baker Road can reduce crashes by 33 to 47 percent[2]. An optional northbound right turn lane can be added to help reduce side-street delay and allow northbound left turning movements to bypass queues during a railroad crossing event.

However, in at least one of the refined interchange concepts, there is a need for a low-stress pedestrian crossing at Cinder Butte Road to allow for people walking and biking to access the shared use path on the south side of Baker Road. Given the traffic volumes on Baker Road and the proximity of Cinder Butte Road to the railroad (approximately 125 feet), a traffic signal would be necessary to allow people walking and biking to safely cross Baker Road while ensuring that queues could be cleared prior to a railroad crossing event.

Table 1 lists the intersection operations for a traffic signal at Cinder Butte Road/Baker Road (intersection operations and queueing reports are included in Appendix B). It should be noted that a traffic signal at this location will likely not meet *Manual on Uniform Traffic Control Devices* (MUTCD) traffic volume warrants[3]. Instead, a traffic signal would need to be warranted based on the need for a pedestrian crossing or proximity to the railroad.

[2] ODOT Crash Reduction Factor List, 2020, CMF ID: 254, 269

[3] *Manual on Uniform Traffic Control Devices,* Chapter 4C, Federal Highway Administration, 2009

TABLE 1: CINDER BUTTE ROAD/BAKER ROAD FUTURE 2040 DESIGN HOUR TRAFFIC OPERATIONS

SCENARIO	CONTROL	MOBILITY TARGET	CINDER BUTTE ROAD/BAKER ROAD RESULTS		
			V/C [A]	LOS [A]	DELAY (SEC) [A]
NO-BUILD	Two-way stop-control	Average Delay ≤ 35 secs	0.71 / 0.66	A / F	9
BUILD OPTION A	Two-way stop-control w/ added turn lanes	Average Delay ≤ 35 secs	0.34 / 0.30	A / F	6
BUILD OPTION B	Signal w/ added turn lanes	Average Delay ≤ 55 secs	0.59	A	6

[A] V/C ratio and LOS reported as worst major street/minor street movement at two-way stop-controlled (TWSC) intersections. Major streets are those not stop-controlled at intersections, while minor streets are stop-controlled. Delay reported as worst major street/minor street movement for ODOT and City intersections and average for County intersections, to best match the existing mobility standards. For traffic signals, v/c ratio, LOS and delay are reported for the overall intersection.

Table 2 lists the impact of the Cinder Butte Road/Baker Road alternatives on intersection queueing. It is recommended that Cinder Butte Road be shifted slightly west to "tee" up the intersection, as shown in the concepts for each of the alternatives (discussed below). This would impact the corners of two parcels but would reduce the intersection skew and provide approximately 125 feet of westbound left turn storage. In Option B, signalization will result in longer westbound queues that would extend well beyond the railroad tracks and, depending on the alignment of the US 97 southbound ramp, into the southbound ramp terminal. Therefore, signalization of the Cinder Butte Road intersection should only be considered for alternatives that move the southbound ramp terminal much farther to the east and traffic signal preemption must be used to clear queues prior to a railroad crossing event.

TABLE 2: CINDER BUTTE ROAD/BAKER ROAD FUTURE 2040 DESIGN HOUR VEHICLE QUEUING

MOVEMENT	95TH PERCENTILE QUEUE (FT)			APPROXIMATE AVAILABLE STORAGE (FT) [A]
	NO-BUILD	BUILD OPTION A: TWO-WAY STOP-CONTROL W/ ADDED TURN LANES	BUILD OPTION B: SIGNAL W/ ADDED TURN LANES	
NB	**>400** *	75	100	250
WBL	-	125	100	125
WBT	**150** [B]	25	**250**	125

Bold and red queue exceeds approximate available storage.

*= Queuing significantly exceeds storage due to downstream queue spillback.

[A] Available storage reported as approximate turn bay length or approximate distance to nearest intersection/railroad crossing.

[B] Upstream congestion is metering the flow of arriving traffic, resulting in shorter queues.

REFINED CONCEPTS DESCRIPTION AND PERFORMANCE

The following sections describe the refined concepts and how each perform:

- Alternative 1: Enhance Existing Ramp Terminals
- Alternative 2: Tight Urban Diamond Interchange (TUDI)
- Alternative 4: Southbound On- And Off-Ramp Flyovers with Roundabout (Flyover Interchange)

While each of these alternatives include roundabouts as part of the preferred concepts, any roundabouts on the state highway system would be subject to the stakeholder engagement process for approval outlined in ODOT Highway Directive DES 02. If during the stakeholder engagement process it was determined roundabouts would be infeasible at the US 97 ramp terminals, traffic signals would be necessary instead. Therefore, intersection operations were analyzed for both roundabouts and traffic signals at the ramp terminals.

Intersection operations were analyzed using Synchro and Sidra software with Highway Capacity Manual 6th edition (HCM 6) methodologies (intersection operation and queueing reports are included in Appendix B). Performance measures used for this analysis include volume-to-capacity (v/c) ratios, seconds of control delay, and levels of service (LOS). To assess the adequacy of future performance for State facilities, ODOT's mobility standards from the Highway Design Manual[4] (HDM) were used, which rely on v/c ratios. These standards differ whether a roadway is located within a Metropolitan Planning Organization (MPO) boundary or not. Baker Road acts as the boundary for the MPO. Therefore, this interchange is assumed to fall within the MPO, and the v/c ratio mobility standard for State facilities (Statewide Highway and Expressway) is maximum of 0.75.

In addition, planning-level cost estimates were developed to provide an order of magnitude comparison for each alternative. A cost breakdown for each estimate is provided in Appendix C. The cost estimates do not include right-of-way, engineering, construction management or administration costs and a 50 percent contingency was included for each alternative given the conceptual nature of design. The preferred alternative layouts were utilized to develop projected quantities for the estimates.

[4] 2012 ODOT Highway Design Manual, Table 10-2, pg. 10-61

ALTERNATIVE 1: ENHANCE EXISTING RAMP TERMINALS (ENHANCE EXISTING)

This alternative focuses on enhancing the existing ramp terminals to address the operational deficiencies along Baker Road, reduce the potential for queue spillback onto US 97, and eliminate turning conflicts between closely spaced intersections. In this alternative, the southbound ramp terminal is realigned with Baker Court and a traffic signal is installed, as shown in Figure 5. While ODOT access spacing standards are not met in this alternative, realigning the US 97 southbound ramp opposite Baker Court eliminates the existing problem with the offset intersections. In addition, the US 97 southbound off-ramp is lengthened to prevent queue spillbacks onto the US 97 mainline and the US 97 southbound on-ramp is lengthened to meet current ODOT standards and improve the ability to accelerate to merging speeds.

To increase motor vehicle capacity at the northbound ramp terminal, a single lane roundabout with a westbound right turn slip lane is added. A roundabout at the US 97 ramp terminal would be subject to ODOT Highway Directive DES 02, therefore a traffic signal was also analyzed at the ramp terminal. A traffic signal would require dual westbound through lanes and an eastbound left turn lane at the US 97 northbound ramps, as shown in Figure 5. This configuration would also allow dual eastbound through lanes to provide additional queue storage at the US 97 southbound ramp terminal. However, this would require additional width on the bridge over the US 97 mainline to accommodate an additional lane for motor vehicle traffic.

At the intersection of Cinder Butte Road, eastbound and westbound left turn lanes are added on Baker Road, with the option to formalize a northbound right turn lane to reduce side street delay. The following sections discuss the performance of this alternative.

ACTIVE TRANSPORTATION CONSIDERATIONS

As shown in Figure 5, Alternative 1 is also compatible with the active transportation framework that connects regional multi-use paths and provides a low-stress crossing of US 97. Active transportation features unique to this alternative are listed below.

- The southbound ramp terminal is realigned with Baker Court and signalized, consolidating vehicle turning movements to one location. While this provides a signalized crossing for people walking and biking and connects the multi-use path on the south side with the north side of Baker Road, the crossing distance and pedestrian exposure time are relatively long, requiring people to cross up to five lanes of motor vehicle traffic (if the northbound ramp terminal is also signalized).

TRAFFIC OPERATIONS

Table 3 lists the intersection operations results for this alternative. At the northbound ramp terminal, the roundabout v/c ratio just fails to meet the mobility standard by 0.03, with only the westbound approach failing to meet the standard. A traffic signal meets the mobility standard with the lane configuration shown in Figure 5.

At the southbound ramp, two traffic signal options are shown, one with a single eastbound through lane (operating with a v/c of 0.81) and another with dual eastbound through lanes (operating with a v/c of 0.76). Note that the dual eastbound through lanes configuration is only recommended to be implemented with a traffic signal at the US 97 northbound ramp terminal, as providing only one eastbound approach lane at the roundabout is preferred.

Both traffic signal configurations at the southbound ramp terminal fail to meet the mobility standard. To meet standards, dual southbound right turn lanes would be required, which is not recommended for safety reasons. Dual southbound right turn lanes would require additional widening of Baker Road to Cinder Butte Road, resulting in a higher-stress crossing for people walking and biking and the potential for many lane changes in a short distance and through the railroad crossing.

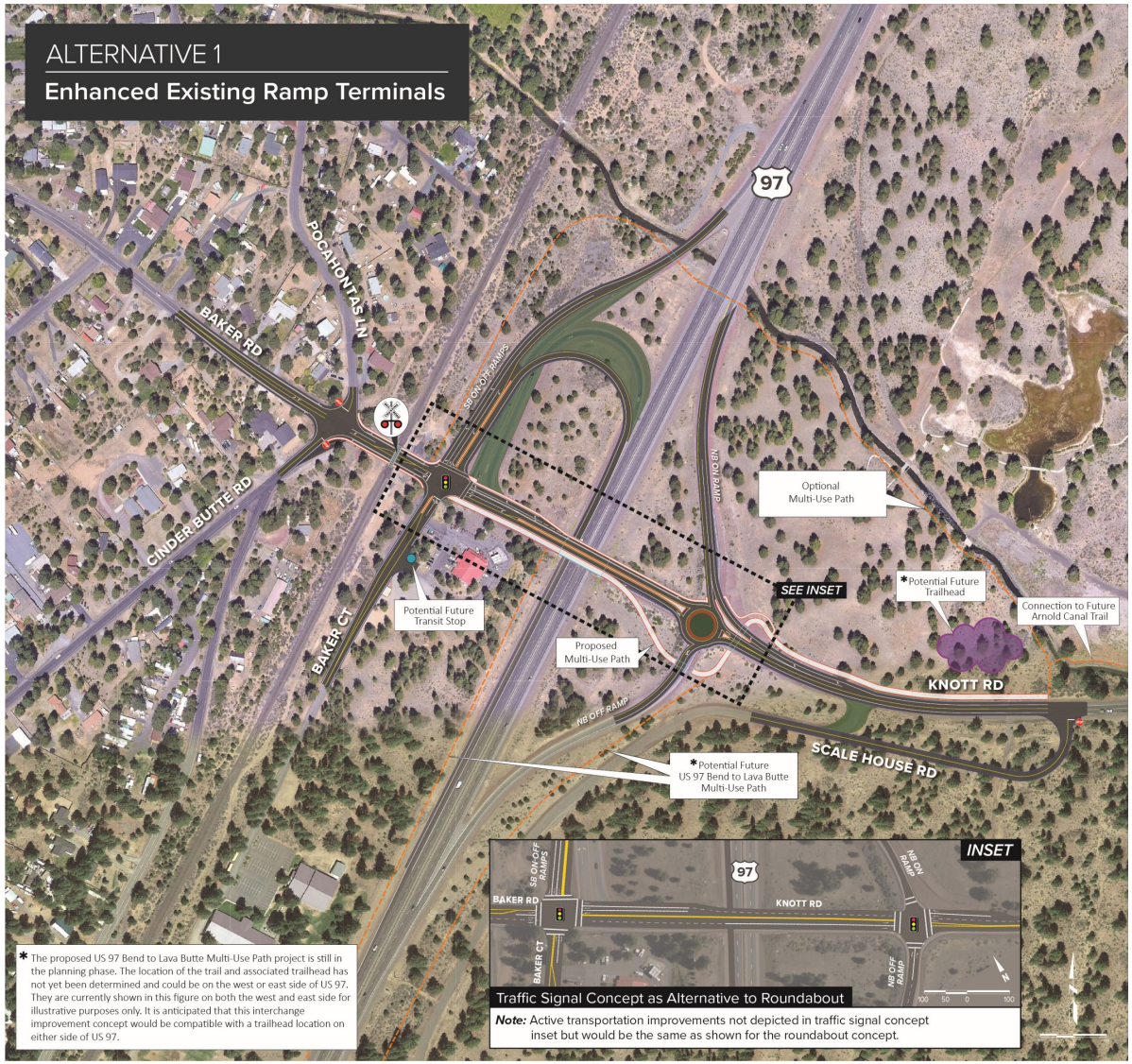

FIGURE 5. ALTERNATIVE 1 – ENHANCE EXISTING

TABLE 3: ALTERNATIVE 1 FUTURE 2040 DESIGN HOUR TRAFFIC OPERATIONS

ID	STUDY INTERSECTION (MAJOR STREET/ MINOR STREET)	MOBILITY STANDARD	NO-BUILD				ALTERNATIVE 1 - ENHANCE EXISTING (TRAFFIC SIGNAL AND ROUNDABOUT)				ALTERNATIVE 1 - ENHANCE EXISTING (TRAFFIC SIGNALS ONLY)			
			CONTROL	V/C [A]	LOS [A]	DELAY (SEC) [A]	CONTROL	V/C [A]	LOS [A]	DELAY (SEC) [A]	CONTROL	V/C [A]	LOS [A]	DELAY (SEC) [A]
3	BAKER RD/BAKER CT	Average Delay ≤ 35 secs	TWSC	0.68 / 0.79	A / F	6	Realigned (Signal)	-	-	-	Realigned (Signal)	-	-	-
4	BAKER RD/KNOTT RD/ US 97 SB RAMPS	v/c ≤ 0.75	TWSC	0.37 / **1.32**	A / F	9 / 220	Signal	**0.81**	C	32	Signal	**0.76**	C	31
5	KNOTT RD/US 97 NB RAMPS	v/c ≤ 0.75	TWSC	0.92 / **>3.0**	C / F	23 / >300	RAB	**0.78**	B	13	Signal	0.65	C	23

Bold and red indicates mobility target/standard is not met.

[A] V/C ratio and LOS reported as worst major street/minor street movement at two-way stop-controlled (TWSC) intersections. Major streets are those not stop-controlled at intersections, while minor streets are stop-controlled. Delay reported as worst major street/minor street movement for ODOT and City intersections and average for County intersections, to best match the existing mobility targets. For roundabouts (RAB), v/c ratio reported for the worst approach lane and LOS/delay reported for the overall intersection. For traffic signals, v/c ratio, LOS and delay are reported for the overall intersection.

Table 4 lists notable queuing near the interchange. Queueing is significantly improved under this alternative compared to No-Build conditions, particularly for queueing on the southbound and northbound ramp terminals.

TABLE 4: ALTERNATIVE 1 FUTURE 2040 DESIGN HOUR INTERSECTION VEHICLE QUEUING

ID	STUDY INTERSECTION	MOVEMENT	95TH PERCENTILE QUEUE (FT)			APPROXIMATE AVAILABLE STORAGE (FT) [A]
			NO-BUILD	ALT. 1 (SIGNAL AND ROUND-ABOUT)	ALT. 1 (SIGNALS ONLY)	
4	BAKER RD/ KNOTT RD/ US 97 SB RAMPS	SBL	**>1,500** *,[B]	**300**	250	275
		SBR	**>1,500** *	375	375	725 [C]
		EB	**>1,300** *	**300**	**175**	75
5	KNOTT RD/US 97 NB RAMPS	WBT	325	350	225	> 500
		NB	**>1,200** *	50	100	375 [C]
		EBL	**>775** *	< 25	350	500
		EBT	**>775** *	< 25	200	800

Bold and red queue exceeds approximate available storage.

*= Queuing significantly exceeds storage due to downstream queue spillback.

[A] Available storage reported as approximate turn bay length or approximate distance to nearest intersection/railroad crossing.

[B] Turn bay frequently blocked by southbound right queue.

[C] Distance represents distance to allow vehicles leaving the highway mainline to safely come to a stop. 820 feet is needed from the gore point for safe stopping distance, assuming a 75 mph design speed, based on *AASHTO A Policy on Geometric Design of Highways and Streets*.

At the US 97 southbound ramp terminal average and 95th percentile queues are still expected to spillback to the railroad crossing (which is now closer to the intersection due to the realignment of the ramp terminal) with either a single eastbound through lane or dual eastbound through lanes. However, a traffic signal at the ramp terminal allows for railroad preemption to clear queues across the tracks.

Both ramp terminals are able to queue without spilling back into the safe stopping distance on the off-ramps (segment of the ramp needed to allow vehicles leaving the highway mainline to safely come to a stop) as either traffic signals or with a roundabout at the US 97 northbound ramp terminal. However, it is recommended that the southbound off-ramp be lengthened to provide additional storage during a rail crossing event. A typical rail crossing event is assumed to cause the crossing gates to block Baker Road for approximately 110 seconds. If a rail crossing event occurred

during a 95th percentile queue on the southbound off-ramp, the southbound off-ramp would need to be extended to a total length of approximately 1,950 feet to accommodate the queue without impacting the safe stopping distance. This is approximately 400 feet longer than the existing ramp. Lengthening the off-ramp may require reconstructing the ramp bridge over the Arnold Canal.

In general, the traffic signal at the US 97 southbound ramps and Baker Court improves conditions for transit. If a transit stop is relocated to the Riverwoods Country Store, a traffic signal will provide direct access from US 97 to the transit stop for Route 30 buses. The traffic signal is also anticipated to improve conditions for freight vehicles, particularly accessing Baker Court. However, the roundabout at the US 97 northbound ramp would need to comply with ODOT Highway Directive DES-02 and be properly designed to accommodate large freight vehicles that use Knott Road to access US 20 and bypass US 97 through Bend. In this alternative, the increased radius on the US 97 southbound loop on-ramp and increased acceleration distance would improve conditions for freight vehicles.

SAFETY

In Alternative 1, a roundabout or traffic signal could be installed at the US 97 northbound ramp terminal in place of an existing two-way stop-controlled intersection. Installing a roundabout has the potential to reduce injury crashes by up to 82 percent[5]. Roundabouts also reduce vehicle speeds and in particular, the US 97 northbound ramps roundabout could help reduce speeds for westbound vehicles approaching from Knott Road, a concern identified in existing conditions. While not shown in the concept drawing, including a chicane in the westbound approach should be considered to further influence a reduction in speeds. The concept with the traffic signal includes additional lanes, which could encourage higher speeds, particularly during off-peak hours. If a traffic signal was installed at the US 97 northbound ramp terminal instead, it would have the potential to reduce angle crashes (which are typically higher severity crashes) by up to 77 percent but could increase rear end crashes (which are typically lower severity crashes) by 58 percent[6].

Alternative 1 realigns the US 97 southbound ramps with Baker Court to consolidate turning movements at a single location and reduce turning conflicts. As previously noted for the northbound ramp terminal, a traffic signal at the US 97 southbound ramp terminal has the potential to reduce angle crashes by up to 77 percent but could increase rear end crashes by 58 percent[7].

By realigning the US 97 southbound ramp terminal in Alternative 1, the ramp terminal is now closer to the railroad crossing. However, while the ramp terminal is closer to the railroad crossing, the new traffic signal would include railroad preemption to clear any standing queues prior to a railroad crossing event.

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[5] ODOT Crash Reduction Factor List, 2020, CMF ID: 228

[6] ODOT Crash Reduction Factor List, 2020, CMF ID: 323, 324

[7] ODOT Crash Reduction Factor List, 2020, CMF ID: 323, 324

Alternative 1 also lengthens the southbound off-ramp to reduce the potential for queue spillbacks towards the US 97 mainline while also lengthening the US 97 southbound on-ramp to increase the acceleration distance to meet ODOT standards and improve merging safety.

ADDITIONAL CONSIDERATIONS

For this alternative, the planning-level cost estimate is approximately $14 million dollars (based on alternative with a roundabout). This alternative is relatively cost effective as nearly half of the new interchange footprint utilizes the existing interchange configuration and it requires the least amount of retaining walls and excavation. This alternative is the only alternative that would require linear roadway work along US 97. Construction improvements to the US 97 southbound acceleration lane will likely require a temporary closure of the ramp. Placing temporary pavement in the existing median along US 97, reducing speeds, and shifting southbound travel lanes may provide the space needed to maintain the southbound on-ramp.

ALTERNATIVE 2: TIGHT URBAN DIAMOND INTERCHANGE (TUDI)

Alternative 2 reconstructs the interchange to use a more traditional "diamond" configuration, as shown in Figure 6. This is primarily done by replacing the existing US 97 southbound on- and off-ramps with a configuration similar to that used for the northbound ramps, but with the ramps much closer to the highway mainline to accommodate the new southbound on-ramp just east of the Riverwoods Country Store. Both ramp terminals are controlled by roundabouts. Roundabouts at the US 97 ramp terminals would be subject to ODOT Highway Directive DES 02, therefore traffic signals were also analyzed at the ramp terminal. This alternative requires minimal widening of the bridge structure over US 97 with roundabouts, with only two lanes for motor vehicle traffic needed across the bridge. However, with traffic signals four lanes for motor vehicle traffic would be needed across the bridge.

While ODOT access spacing standards are not met in this alternative, access spacing is improved slightly, with the southbound ramp terminal being moved to approximately 150 ft from Baker Court (compared to approximately 100 feet today). Baker Court can also be converted to right-out only, with the northbound left being served by a U-turn at the adjacent roundabout. A westbound left turn is still provided into Baker Court. Note that the northbound left turn would remain with traffic signals at the US 97 ramp terminals as there would be no opportunities for U-turns.

At the intersection of Cinder Butte Road, eastbound and westbound left turn lanes are added on Baker Road, with the option to formalize a northbound right turn lane to reduce side street delay. The following sections discuss the performance of this alternative.

ACTIVE TRANSPORTATION CONSIDERATIONS

As shown in Figure 6, Alternative 2 is also compatible with the active transportation framework that connects regional multi-use paths and provides a low-stress crossing of US 97. Active transportation features unique to this alternative are listed below.

- The replacement of the southbound loop on-ramp with a direct ramp east of the Riverwoods Country Store creates an at-grade crossing with the multi-use path running along the south side of Baker Road. This is the only alternative that includes an at-grade crossing of this path. While the crossing would only involve a single lane of low-speed traffic exiting the US 97 southbound ramp terminal roundabout (or traffic signal), this could be the only at-grade crossing for many miles of the path joining Lava Butte with the Arnold Canal Trail.
- On the west side of US 97, the crossing for people walking and biking to get between the north side of Baker Road and the multi-use path on the south side would be provided at the US 97 southbound ramp terminal roundabout.

TRAFFIC OPERATIONS

Table 5 lists the intersection operations results for this alternative. The TUDI performs significantly better than No-Build conditions and has lower v/c ratios than Alternative 1 as well. While neither ramp terminal would meet HDM mobility standards as roundabouts, they would be very close to doing so with only one approach lane on each roundabout failing to meet the standard (exceeding maximum v/c ratio by less than 0.03). Both ramp terminals would meet HDM mobility standards as traffic signals. However, more delay would be experienced by the northbound approach at Baker Court with traffic signals at the US 97 ramp terminals as the northbound left turn would need to remain open with no opportunity for a U-turn at an adjacent roundabout.

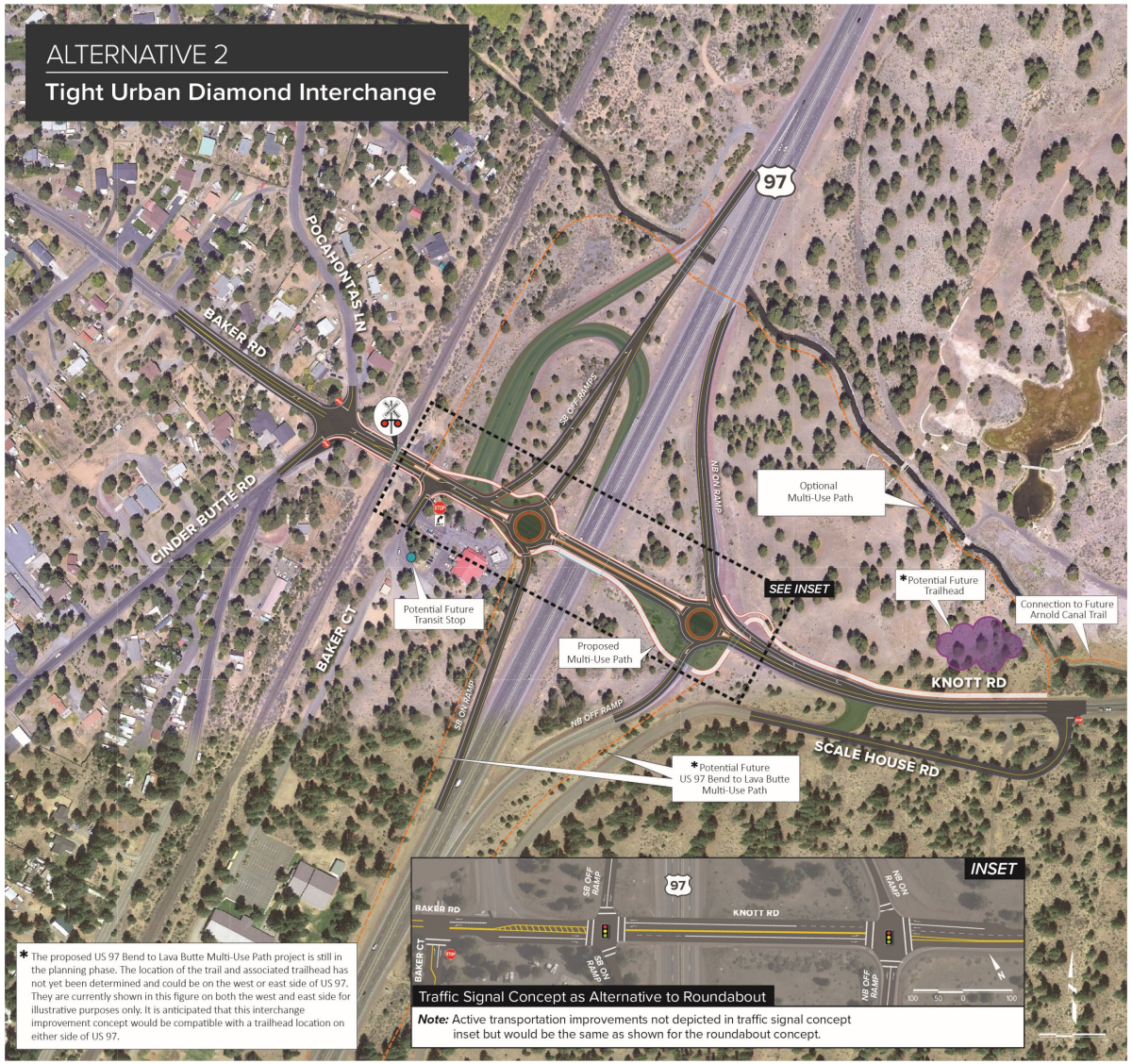

FIGURE 6. ALTERNATIVE 2 – TIGHT URBAN DIAMOND INTERCHANGE

TABLE 5: ALTERNATIVE 2 FUTURE 2040 DESIGN HOUR TRAFFIC OPERATIONS

ID	STUDY INTERSECTION (MAJOR STREET/ MINOR STREET)	MOBILITY STANDARD	NO-BUILD				ALTERNATIVE 2 - TUDI (ROUNDABOUTS)				ALTERNATIVE 2 - TUDI (TRAFFIC SIGNALS)			
			CONTROL	V/C [A]	LOS [A]	DELAY (SEC) [A]	CONTROL	V/C [A]	LOS [A]	DELAY (SEC) [A]	CONTROL	V/C [A]	LOS [A]	DELAY (SEC) [A]
3	BAKER RD/BAKER CT	Average Delay ≤ 35 secs	TWSC	0.68 / 0.79	A / F	6	TWSC (NB Left closed)	0.11 / 0.38	A / C	2	TWSC	0.11 / 0.33	A / D	3
4	BAKER RD/KNOTT RD/ US 97 SB RAMPS	v/c ≤ 0.75	TWSC	0.37 / **1.32**	A / F	9 / 220	RAB	**0.76**	B	15	Signal	0.70	C	33
5	KNOTT RD/US 97 NB RAMPS	v/c ≤ 0.75	TWSC	0.92 / **>3.0**	C / F	23 / >300	RAB	**0.78**	B	13	Signal	0.60	C	30

Bold and red indicates mobility target/standard is not met.

[A] V/C ratio and LOS reported as worst major street/minor street movement at two-way stop-controlled (TWSC) intersections. Major streets are those not stop-controlled at intersections, while minor streets are stop-controlled. Delay reported as worst major street/minor street movement for ODOT and City intersections and average for County intersections, to best match the existing mobility targets. For roundabouts (RAB), v/c ratio reported for the worst approach lane and LOS/delay reported for the overall intersection. For traffic signals, v/c ratio, LOS and delay are reported for the overall intersection.

Table 6 shows notable queuing near the interchange. Queueing is significantly improved under this alternative compared to No-Build conditions, particularly for queueing on the southbound and northbound ramp terminals.

TABLE 6: ALTERNATIVE 2 FUTURE 2040 DESIGN HOUR INTERSECTION VEHICLE QUEUING

ID	STUDY INTERSECTION	MOVEMENT	95TH PERCENTILE QUEUE (FT)			APPROXIMATE AVAILABLE STORAGE (FT) [A]
			NO-BUILD	ALT. 2 (ROUND-ABOUTS)	ALT. 2 (TRAFFIC SIGNALS)	
3	BAKER RD/BAKER CT	WBL	NA	< 25	75	100
4	BAKER RD/ KNOTT RD/ US 97 SB RAMPS	SBL	**>1,500** *,[B]	50	175	275
		SBR	**>1,500** *	300	200	725 [C]
		EB	**>1,300** *	225	225	250
5	KNOTT RD/US 97 NB RAMPS	NB	**>1,200** *	50	100	375 [C]
		EBL	**>775** *	< 25	350	700

Bold and red queue exceeds approximate available storage.

*= Queuing significantly exceeds storage due to downstream queue spillback.

[A] Available storage reported as approximate turn bay length or approximate distance to nearest intersection/railroad crossing.

[B] Turn bay frequently blocked by southbound right queue.

[C] Distance represents distance to allow vehicles leaving the highway mainline to safely come to a stop. 820 feet is needed from the gore point for safe stopping distance, assuming a 75 mph design speed, based on *AASHTO A Policy on Geometric Design of Highways and Streets*.

With either a traffic signal or roundabout, eastbound queues are expected to approach Baker Court but would not spillback to the railroad crossing.

While the westbound left turn queuing entering Baker Court is expected to be minimal during future design hour (summer weekday p.m. peak hour) conditions, the design hour does not account for a.m. conditions when school is in session. During the a.m. conditions, queueing may have the potential to spillback towards the US 97 southbound ramp terminal roundabout, given the limited queue storage for the westbound left turn (approximately 100 feet). In addition, during a rail crossing event the westbound queue at the railroad crossing could spillback towards the US 97 southbound ramp terminal roundabout, blocking southbound and westbound movements at the intersection.

Both roundabouts would need to comply with ODOT Highway Directive DES-02 and be properly designed to accommodate large freight vehicles, particularly as freight vehicles use Knott Road to access US 20 and bypass US 97 through Bend.

SAFETY

In the TUDI alternative, roundabouts or traffic signals could be installed at both ramp terminals in place of existing two-way stop-controlled intersections. Installing roundabouts has the potential to reduce injury crashes by up to 82 percent[8]. Roundabouts also reduce vehicle speeds and in particular, the US 97 northbound ramps roundabout could help reduce speeds for westbound vehicles approaching from Knott Road, a concern identified in existing conditions. While not shown in the concept drawing, including a chicane in the westbound approach should be considered to further influence a reduction in speeds. The concept with the traffic signal includes additional lanes, which could encourage higher speeds, particularly during off-peak hours. If traffic signals were installed at the US 97 ramp terminals instead, it would have the potential to reduce angle crashes (which are typically higher severity crashes) by up to 77 percent but could increase rear end crashes (which are typically lower severity crashes) by 58 percent[9].

With the new southbound on-ramp, a new conflict has been added between people walking and biking on the multi-use path and people turning onto US 97 southbound. Although the multi-use path is only crossing one lane, it would be difficult for people walking/biking to tell if vehicles are proceeding straight across the roundabout or turning southbound onto US 97, as well as having the multiple threats of seeing eastbound cars stopping for cars headed south in the roundabout and not know if they are continuing southbound on US 97 or eastbound on Knott Road. However, people walking and biking on the path would only be required to cross a single lane of motor vehicle traffic, allowing for limited exposure to motor vehicles. In addition, vehicle speeds are reduced when exiting roundabouts, reducing the potential for high severity crashes.

By moving the US 97 southbound ramp terminal farther east, additional queue storage is provided between the intersection and the railroad, limiting the potential for queues to spill back to the railroad.

ADDITIONAL CONSIDERATIONS

The planning-level cost estimate for this alternative is approximately $18 million dollars (based on alternative with roundabouts). This alternative is relatively cost effective, with approximately a quarter of the proposed interchange falling within the existing roadway footprint. This alternative requires a new bridge over Arnold Canal and would require an additional retaining wall in the southwest quadrant of the US 97 southbound ramp terminal to mitigate right-of-way impacts. This alternative does not present any unique constructability challenges compared to the other alternatives.

[8] ODOT Crash Reduction Factor List, 2020

[9] ODOT Crash Reduction Factor List, 2020, CMF ID: 323, 324

ALTERNATIVE 4: SOUTHBOUND ON- AND OFF-RAMP FLYOVERS WITH ROUNDABOUT (FLYOVER)

Alternative 4 reconstructs the US 97 southbound on- and off-ramps by realigning them to a shared intersection with the northbound ramps on the east side of US 97, as shown in Figure 7. This would require new bridges over US 97 for the southbound on- and off-ramps and a new bridge over the Arnold Canal. In this alternative, all of the on- and off- ramps would connect at one partial multilane roundabout intersection. A roundabout at the US 97 ramp terminal would be subject to ODOT Highway Directive DES 02, therefore a traffic signal was also analyzed at the ramp terminal. A traffic signal would require dual eastbound left turn lanes at the US 97 ramps, as shown in Figure 7.

While ODOT access spacing standards are not met, this alternative moves in the direction of meeting those standards much better than the others, with approximately 900 feet of spacing between any access point and the ramp terminal. As shown, the southbound ramp terminal is moved significantly farther from Baker Court, Cinder Butte Road, and the railroad crossing (approximately 950 feet compared to less than 225 feet today), effectively mitigating conflicts with the ramp terminals.

At the intersection of Cinder Butte Road (a Deschutes County intersection), eastbound and westbound left turn lanes are added on Baker Road and the intersection is signalized to provide an enhanced crossing for people walking and biking along the multi-use path to cross back to the north side of the roadway while allowing preemption at the railroad crossing. It should be noted that it is unlikely that the intersection of Baker Road/Cinder Butte Road will meet MUTCD traffic signal volume warrants in the future. Instead, warrants would have to be met for pedestrian crossing or proximity to the railroad. If a traffic signal was not warranted at this location, a rectangular rapid flashing beacon (RRFB) or pedestrian hybrid beacon (PHB) could be considered along Baker Road east of Baker Court, with enough distance to ensure that when the enhanced crossing is activated for a pedestrian, eastbound queues would not spillback to the railroad.

ACTIVE TRANSPORTATION CONSIDERATIONS

As shown in Figure 7, Alternative 4 is compatible with the active transportation framework that connects regional multi-use paths and provides a low-stress crossing of US 97. Active transportation features unique to this alternative are listed below.

- There are limited conflicts between turning vehicles and people using the multi-use path on the south side of Baker Road (only crossing Baker Court). All of the ramp terminals are co-located at one intersection, which is grade-separated from the multi-use path.
- To cross people walking and biking on the multi-use path back to the north side of Baker Road, a traffic signal (if warranted) is provided at Cinder Butte Road to provide an enhanced crossing. An RRFB or PHB with a pedestrian refuge island could also be considered on Baker Road east of the railroad and Baker Court if a traffic signal is not warranted.

TRAFFIC OPERATIONS

Table 7 lists the intersection operations results for this alternative. The flyover interchange alternative performs significantly better than No-Build conditions and similar to Alternative 2. While the roundabout for the US 97 ramp terminals does not meet HDM mobility standards, it would be very close to doing so with only one approach lane failing meet the standard (exceeding the maximum v/c ratio by less than 0.01). A traffic signal would also not meet HDM mobility standards, although it would be close (exceeding the maximum v/c ratio by 0.03). Dual southbound right turn lanes at the traffic signal would be required to meet the standard, which is not recommended as it would require a downstream merge on Baker Road, which is otherwise a single westbound lane.

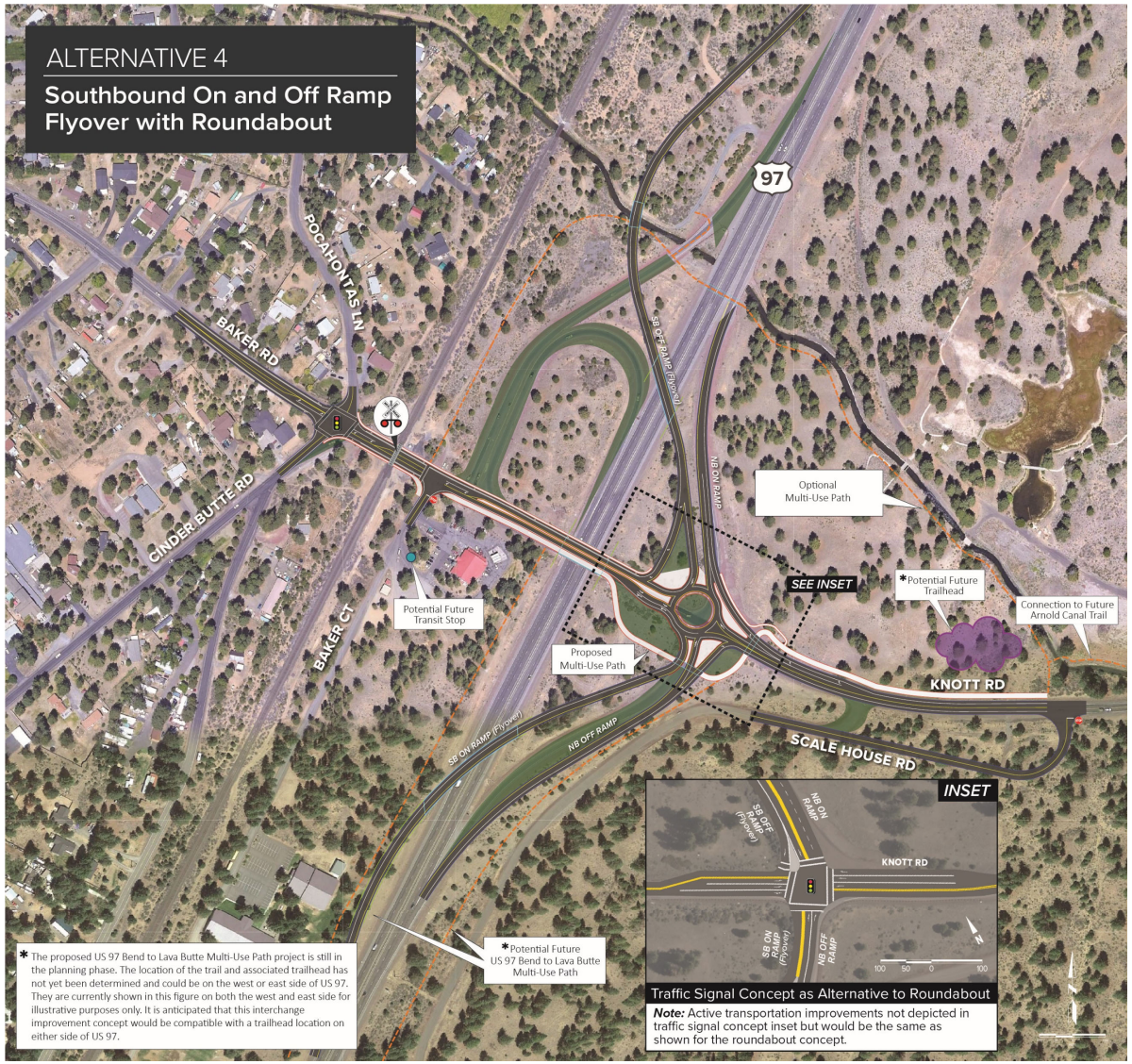

FIGURE 7. ALTERNATIVE 4 – FLYOVER INTERCHANGE

TABLE 7: ALTERNATIVE 4 FUTURE 2040 DESIGN HOUR TRAFFIC OPERATIONS

ID	STUDY INTERSECTION (MAJOR STREET/ MINOR STREET)	MOBILITY STANDARD	NO-BUILD				ALTERNATIVE 4 - FLYOVER (ROUNDABOUT)				ALTERNATIVE 4 - FLYOVER (TRAFFIC SIGNAL)			
			CONTROL	V/C [A]	LOS [A]	DELAY (SEC) [A]	CONTROL	V/C [A]	LOS [A]	DELAY (SEC) [A]	CONTROL	V/C [A]	LOS [A]	DELAY (SEC) [A]
3	BAKER RD/BAKER CT	Average Delay ≤ 35 secs	TWSC	0.68 / 0.79	A / F	6	TWSC (w/ WBL lane)	0.11 / 0.33	A / D	3	TWSC (w/ WBL lane)	0.11 / 0.33	A / D	3
4	BAKER RD/KNOTT RD/ US 97 SB RAMPS	v/c ≤ 0.75	TWSC	0.37 / **1.32**	A / F	9 / 220	Realigned	-	-	-	Realigned	-	-	-
5	KNOTT RD/US 97 NB RAMPS	v/c ≤ 0.75	TWSC	0.92 / **>3.0**	C / F	23 / >300	RAB	**0.76**	B	14	Signal	**0.78**	C	32

Bold and red indicates mobility target/standard is not met.

[A] V/C ratio and LOS reported as worst major street/minor street movement at two-way stop-controlled (TWSC) intersections. Major streets are those not stop-controlled at intersections, while minor streets are stop-controlled. Delay reported as worst major street/minor street movement for ODOT and City intersections and average for County intersections, to best match the existing mobility targets. For roundabouts (RAB), v/c ratio reported for the worst approach lane and LOS/delay reported for the overall intersection.

Table 8 lists notable queuing near the interchange. Queueing is significantly improved under this alternative with the roundabout, performing much better than the other alternatives with no queue spillback concerns.

TABLE 8: ALTERNATIVE 4 FUTURE 2040 DESIGN HOUR INTERSECTION VEHICLE QUEUING

ID	STUDY INTERSECTION	MOVEMENT	95TH PERCENTILE QUEUE (FT)			APPROXIMATE AVAILABLE STORAGE (FT) [A]
			NO-BUILD	ALT. 4 (ROUND-ABOUT)	ALT. 4 (TRAFFIC SIGNAL)	
3	BAKER RD/BAKER CT	WBL	NA	75	75	75
4/5	BAKER RD/ KNOTT RD/ US 97 SB RAMPS / US 97 NB RAMPS	SBTL	**>1,500** *,B	50	200	275
		SBR	**>1,500** *	300	475	725 [C]
		EBL	**>775** *	75	**250**	200
		EBTR	**>1,300** *	50	375	800
		WBL	NA	NA	225	300
		WBT	325	275	300	>1000
		WBR	325	100	175	300
		NBTL	**>1,200** *	<25	75	150
		NBR	**>1,200** *	25	100	375 [C]

Bold and red queue exceeds approximate available storage.

*= Queuing significantly exceeds storage due to downstream queue spillback.

[A] Available storage reported as approximate turn bay length or approximate distance to nearest intersection/railroad crossing.

[B] Turn bay frequently blocked by southbound right queue.

[C] Distance represents distance to allow vehicles leaving the highway mainline to safely come to a stop. 820 feet is needed from the gore point for safe stopping distance, assuming a 75 mph design speed, based on *AASHTO A Policy on Geometric Design of Highways and Streets*.

The longest queue in this alternative with the roundabout is the southbound right turn, at approximately 300 feet long. The additional capacity provided by the roundabout significantly limits any additional queuing. The traffic signal sees longer queues than the roundabout but none of the queues create any spillback concerns. Under signal control, the eastbound left turn queue storage was limited to 200 feet in an attempt to avoid further widening of the US 97 overcrossing structure. However, the 95th percentile eastbound left queue was estimated to be 250 feet, so some additional structure widening may be required.

In addition, while the concept only shows approximately 75 feet for westbound left turn queue storage at Baker Court to accommodate p.m. peak hour queues, the queue storage could easily be lengthened to better accommodate a.m. peak hour conditions when school is in session.

A roundabout would need to comply with ODOT Highway Directive DES-02 and be properly designed to accommodate large freight vehicles, particularly as freight vehicles use Knott Road to access US 20 and bypass US 97 through Bend.

SAFETY

In this alternative, a single roundabout or traffic signal is installed in place of the two existing two-way stop-controlled intersections. Installing roundabouts has the potential to reduce injury crashes by up to 82 percent[10]. Roundabouts also reduce vehicle speeds and in particular, this roundabout could help reduce speeds for westbound vehicles approaching from Knott Road, a concern identified in existing conditions. While not shown in the concept drawing, including a chicane in the westbound approach should be considered to further influence a reduction in speeds. The concept with the traffic signal includes additional lanes, which could encourage higher speeds, particularly during off-peak hours. If a traffic signal was installed at the US 97 ramp terminal instead, it would have the potential to reduce angle crashes (which are typically higher severity crashes) by up to 77 percent but could increase rear end crashes (which are typically lower severity crashes) by 58 percent[11].

In addition, consolidating turning movements at one intersection reduces the number of potential turning conflicts in the interchange area. Conflicts between people walking and biking on the multi-use path and motor vehicles are also limited to only at Baker Court by constructing grade separated crossings under the US 97 ramp terminal.

At Cinder Butte Road, a traffic signal has the potential to reduce angle crashes (typically higher severity crashes) by up to 77 percent but could increase rear end crashes (typically lower severity crashes) by 58 percent[12].

ADDITIONAL CONSIDERATIONS

The planning-level cost estimate for this alternative is approximately $34.5 million dollars (based on alternative with roundabout). This alternative is relatively costly due to the need for additional bridge structures over US 97 for the southbound ramp flyovers and the need for more retaining walls and fill. Temporary nighttime closures would be anticipated to construct the new flyover ramps. Phasing of improvements would be challenging with this alternative, as all ramp terminals travel through a single intersection and the final intersection may not be at the same grade as the existing roadway, making maintaining traffic flow during construction more difficult.

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[10] ODOT Crash Reduction Factor List, 2020, CMF ID: 228

[11] ODOT Crash Reduction Factor List, 2020, CMF ID: 323, 324

[12] ODOT Crash Reduction Factor List, 2020, CMF ID: 323, 324

REFINED CONCEPT EVALUATION

The alternatives were compared using the evaluation criteria in each of the eight project goal areas. The No-Build condition and each of the refined concepts were scored relative to each of the evaluation criteria to highlight the relative level of benefit that could be provided by implementing that solution. These qualitative scores will help guide the discussion of the key opportunities and tradeoffs associated with each alternative to ultimately select a preferred alternative. Each evaluation criterion is rated on the qualitative scale listed in Table 9; Table 13 summarizes the qualitative scoring for each alternative by each evaluation criterion and notes where there would be differences if roundabouts or traffic signals were installed at the US 97 ramp terminals. This section describes some of the key considerations under each goal that went into the scoring.

TABLE 9: ALTERNATIVE SCORING SCALE

QUALITATIVE SCORE	PERFORMANCE
	Excellent
	Good
	Fair
	Poor
	Very Poor

GOAL 1: EFFICIENT TRAVEL

The evaluation criteria under this alternative are tied to meeting intersection mobility targets. Tables 10 and 11 below summarize the intersection operations between the alternatives with either roundabouts or traffic signals, as previously discussed. While each of the alternatives perform significantly better than the No-Build conditions, most of the alternatives are close to but fail to meet ODOT's HDM mobility standards for the ramp terminals. However, both the TUDI and Flyover alternatives perform well with roundabouts, with only a single approach lane failing to meet the standard (operating within 0.03 v/c of the standard). The TUDI alternative also performs well with traffic signals, with both intersections meeting the mobility standard. The Enhance Existing and Flyover alternatives fail to meet the standard with traffic signals but still perform well (operating within 0.03 v/c of the standard).

TABLE 10: FUTURE 2040 DESIGN HOUR TRAFFIC OPERATIONS - ROUNDABOUTS

ID	STUDY INTERSECTION (MAJOR STREET/MINOR STREET)	MOBILITY TARGET	NO-BUILD			ALT 1 (ENHANCE EXISTING)			ALT 2 (TUDI)			ALT 4 (FLYOVER)		
			V/C [A]	LOS [A]	DELAY (SEC) [A]	V/C [A]	LOS [A]	DELAY (SEC) [A]	V/C [A]	LOS [A]	DELAY (SEC) [A]	V/C [A]	LOS [A]	DELAY (SEC) [A]
2	BAKER RD/ CINDER BUTTE RD	Average Delay ≤ 35 secs	0.71 / 0.66	A / F	9	0.34 / 0.30	A / F	6	0.34 / 0.30	A / F	6	0.59	A	6
3	BAKER RD/BAKER CT	Average Delay ≤ 35 secs	0.68 / 0.79	A / F	6	-	-	-	0.11 / 0.38	A / C	6	0.11 / 0.30	A / D	3
4	BAKER RD/ KNOTT RD/ US 97 SB RAMPS	v/c ≤ 0.75	0.37 / **1.32**	A / F	9 / 220	**0.81**	C	32	**0.76**	B	15	-	-	-
5	KNOTT RD/US 97 NB RAMPS	v/c ≤ 0.75	0.92 / **>3.0**	C / F	23 / >300	**0.78**	B	13	**0.78**	B	13	**0.76**	B	14

Bold and red indicates mobility target/standard is not met.

[A] V/C ratio and LOS reported as worst major street/minor street movement at two-way stop-controlled (TWSC) intersections. Major streets are those not stop-controlled at intersections, while minor streets are stop-controlled. Delay reported as worst major street/minor street movement for ODOT and City intersections and average for County intersections, to best match the existing mobility targets. For roundabouts (RAB), v/c ratio reported for the worst approach lane and LOS/delay reported for the overall intersection.

TABLE 11: FUTURE 2040 DESIGN HOUR TRAFFIC OPERATIONS – TRAFFIC SIGNALS

ID	STUDY INTERSECTION (MAJOR STREET/MINOR STREET)	MOBILITY TARGET	NO-BUILD			ALT 1 (ENHANCE EXISTING)			ALT 2 (TUDI)			ALT 4 (FLYOVER)		
			V/C [A]	LOS [A]	DELAY (SEC) [A]	V/C [A]	LOS [A]	DELAY (SEC) [A]	V/C [A]	LOS [A]	DELAY (SEC) [A]	V/C [A]	LOS [A]	DELAY (SEC) [A]
2	BAKER RD/ CINDER BUTTE RD	Average Delay ≤ 35 secs	0.71 / 0.66	A / F	9	0.34 / 0.30	A / F	6	0.34 / 0.30	A / F	6	0.59	A	6
3	BAKER RD/BAKER CT	Average Delay ≤ 35 secs	0.68 / 0.79	A / F	6	-	-	-	0.11 / 0.30	A / D	3	0.11 / 0.30	A / D	3
4	BAKER RD/ KNOTT RD/ US 97 SB RAMPS	v/c ≤ 0.75	0.37 / **1.32**	A / F	9 / 220	**0.76**	C	31	0.70	D	36	-	-	-
5	KNOTT RD/US 97 NB RAMPS	v/c ≤ 0.75	0.92 / **>3.0**	C / F	23 / >300	0.65	C	23	0.60	C	27	**0.78**	C	32

Bold and red indicates mobility target/standard is not met.

[A] V/C ratio and LOS reported as worst major street/minor street movement at two-way stop-controlled (TWSC) intersections. Major streets are those not stop-controlled at intersections, while minor streets are stop-controlled. Delay reported as worst major street/minor street movement for ODOT and City intersections and average for County intersections, to best match the existing mobility targets. For roundabouts (RAB), v/c ratio reported for the worst approach lane and LOS/delay reported for the overall intersection.

The intersections of Baker Road/Cinder Butte Road and Baker Road/Baker Court meet Deschutes County delay standards in each of the alternatives and conditions are improved relative to the No-Build scenario. As noted in *Technical Memorandum #4: Future Baseline (No-Build) Operational Conditions Current Transportation System Operations*, no mobility deficiencies were identified on the US 97 mainline at the merging and diverging connections with the ramps, so all the alternatives and the No-Build scenario continue to perform well for US 97 mainline mobility.

GOAL 2: SAFETY

Some of the risk factors influencing scoring for the safety criteria include:

- **Intersection control:** In general, roundabouts have great potential to reduce the severity of crashes at intersections and each alternative contains a roundabout. Traffic signals would improve safety compared to the existing two-way stop-control, but not as much as roundabouts.
- **US 97 ramp queueing:** Each of the alternatives also address the potential for queueing back into the safe stopping distance on US 97.
- **Need for left turn lanes on Baker Road:** All of the alternatives add left turn lanes on Baker Road where needed, addressing one of the crash risks identified in the existing conditions safety analysis.
- **Turning movement conflicts and access management:** While none of the alternatives meet ODOT access spacing standards given the numerous private driveways west of Cinder Butte Road, each of the alternatives improves upon existing access spacing. The Flyover alternative provides the greatest improvement in moving towards meeting ODOT access spacing standards. The Enhance Existing alternative consolidates turning movements at Baker Court but does not address any other access spacing challenges. The TUDI alternative creates additional separation between Baker Court and the US 97 southbound ramps, but the separation is relatively minor and there is still potential for queues from Baker Court to spillback to the US 97 southbound ramp terminal, particularly in the a.m. peak hour.
- **Exposure for people walking and biking:** The Flyover alternative has the fewest potential motor vehicle conflicts with people walking and biking as a grade separated crossing is provided at the only ramp terminal. The TUDI alternative creates an additional conflict with people walking and biking on the multi-use path on the south side of Baker Road.
- **Railroad conflicts:** The Flyover alternative most significantly reduces potential conflicts in the interchange area by creating additional distance between the railroad and Baker Court, while consolidating turning movements in to a single location. However, the Flyover alternative also includes a traffic signal at Cinder Butte Road to accommodate an enhanced pedestrian crossing. The westbound queues at the Cinder Butte Road traffic signal consistently extend beyond the railroad crossing (although signal preemptions would allow the tracks to clear prior to a railroad crossing event). The TUDI alternative provides additional separation between the US 97 southbound ramps and the railroad. The Enhance Existing alternative consolidates turning movements at Baker Court by realigning the US 97 southbound ramps. While realigning the ramps provides even less distance to the railroad, increasing the potential for conflicts at the railroad crossing, the traffic signal would allow for preemption and the ability to clear queues prior to a railroad crossing event.

GOAL 3: ECONOMIC DEVELOPMENT

Under No-Build conditions, the existing interchange would not be able to serve the traffic demand associated with future development, particularly in the "thumb" area. Each of the alternatives significantly improves access to the thumb area for all modes of travel and maintains access to adjacent properties. The Enhance Existing alternatives provides the most direct access to Baker Court, while the TUDI alternative with roundabouts requires some minor out-of-direction travel but still provides full access to Baker Court.

For all of the alternatives, roundabouts would need to comply with ODOT Highway Directive DES-02 and be properly designed to accommodate large freight trucks. Traffic signals are generally preferred by the freight community. However, roundabouts allow for over-height vehicles to bypass the Baker Road bridge over US 97, if needed, while traffic signals would impose a height limitation.

As noted under the Goal 2: Safety discussion above, the Flyover alternative reduces potential conflicts between motor vehicles and the railroad by moving the US 97 southbound ramps east of the bridge (although the Cinder Butte Road traffic signal increases the frequency of westbound queues extending across the railroad tracks). The TUDI alternative provides some additional separation from the railroad, while the Enhance Existing alternative moves the US 97 southbound ramps in closer proximity to the railroad (although traffic signal preemption could enhance the ability to clear queues extending towards the railroad).

GOAL 4: MULTIMODAL TRAVEL

Each of the alternatives significantly enhance the quality of walking and biking facilities on Knott Road/Baker Road in the interchange area by providing a complete network of separated walking and biking facilities and a low-stress multi-use path on the south side of Baker Road. The multi-use path also creates a low-stress opportunity to cross US 97, which was a priority carried over from the US 97 Parkway Plan.

Each of the alternatives includes grade separated crossings of Baker Road and the US 97 northbound off-ramp. However, the TUDI alternative adds an additional conflict between motor vehicles and people walking and biking the multi-use path at the US 97 southbound on-ramp. The Enhance Existing alternative increases pedestrian exposure to motor vehicle traffic with a wide crossing of Baker Road but does provide signalization, which will allow for protected crossings of Baker Road and Baker Court.

All of the alternatives can accommodate planned trail connections and the alignment of the proposed US 97 Baker/Knott Road to Lava Butte Multi-Use Path. All of the alternatives can accommodate planned transit service expansions while providing significantly safer access to a relocated transit stop, whether near the Riverwoods Country Store or east of the interchange. The TUDI was scored slightly lower with regard to supporting transit service because of the short left turn lane accessing Baker Court, resulting in possible spillback into Baker Road during morning periods when school traffic is heavier.

GOAL 5: EQUITY

All of the alternatives have relatively similar footprint and impact on existing properties near the interchange area. The TUDI alternative requires a retaining wall on the southwest corner of the US 97 southbound ramp to limit right-of-way impacts. However, it is anticipated that there will be little to no impacts to properties owned, used by, or accessed by historically underrepresented community members. Continued conversation during upcoming committee and public meetings will be used to explore potential impacts further.

GOAL 6: ENVIRONMENTAL STEWARDSHIP

Each of the alternatives is expected to have a similar impact as the existing interchange on resource lands and wildlife. However, the Flyover alternative will likely require additional noise analysis and mitigation as both of the US 97 southbound ramps are raised above the US 97 mainline. The TUDI may also require additional noise mitigation, particularly on the southwest corner of the US 97 southbound ramps.

Each of the alternatives will likely have a similar impact on the ability of people to walk, bike or take transit instead of driving personal vehicles. As there are no changes to US 97 accessibility between alternatives, no significant difference is expected to vehicle miles travelled between the alternatives. Therefore, the main driver of the ability to reduce vehicle emissions is related to the level of delay in the interchange alternatives, which is discussed in detail under Goal 1: Efficient Travel.

GOAL 7: CORRIDOR VISION

Each of the alternatives are consistent with the US 97 Parkway Plan and Bend to Lava Butte Refinement Plan in that they address safety and congestion, connect the trail network, and provide a low-stress crossing of US 97. Each alternative is also effective at accommodating planned growth, although the TUDI and Flyover alternatives perform better than the Enhance Existing alternative.

The Enhance Existing and TUDI alternatives are expected to be able to accommodate visual and physical gateway elements as an entry/exit to Bend. However, with the large flyover ramps, the Flyover alternative may limit options.

In general, roundabouts are simpler for emergency responders to control during an evacuation scenario, requiring fewer personnel, and are not vulnerable to power outages. As the Flyover alternative only has one intersection to control during an evacuation, it performs better than other alternatives. The Enhance Existing scenario includes a traffic signal at the US 97 southbound ramp and has the least excess capacity of the alternatives, lowering the potential for enhancing evacuation routes.

GOAL 8: IMPLEMENTABLE

Table 12 below lists the planning-level cost estimates for each alternative (based on alternatives with roundabouts). The planning-level cost estimates are intended to provide an order of magnitude comparison between alternatives. The cost estimates do not include right-of-way, engineering, construction management or administration costs and a 50 percent contingency was included for each alternative given the conceptual nature of design.

The Flyover alternative is the most expensive, as it requires two additional flyover bridges of US 97 and more of the proposed footprint falls outside of the existing roadway alignment. The Flyover alternatives also has the highest risk for cost increases due to constructability challenges associated with the flyover ramps (as noted below). The Enhance Existing alternative is the least costly alternative as the majority of the footprint utilizes the existing roadway and it requires the fewest retaining walls.

TABLE 12: PLANNING-LEVEL COSTS PER ALTERNATIVE

ALTERANTIVE	PLANNING-LEVEL COST ESTIMATE
ALT. 1 – ENHANCE EXISTING	$14.1 million
ALT. 2 – TUDI	$18.3 million
ALT. 4 – FLYOVER	$34.5 million

The constructability of each alternative was also considered. Opportunities and constructability challenges include:

- **Improvements along Baker Road**: The improvements along Baker Road for all three alternatives are relatively similar. Maintaining business access and coordination with the railroad will be required. Union Pacific Railroad/Burlington Northern Santa Fe approved flaggers are anticipated during any work in the vicinity of the railroad right-of-way. It is anticipated that one lane of traffic in each direction can be maintained during construction.
- **US 97 ramp and ramp terminal improvements:** While the proposed improvements at the US 97 ramp terminals vary between each alternative, all three alternatives provide similar opportunities since a majority of the proposed improvements are outside of the existing roadway. Proposed ramp improvements would be sequenced to maintain traffic while providing safe and sizeable work zones for the contractor. Work outside of the existing ramp alignments would be constructed first to minimize the need for temporary pavement or short-term closures.

  All three alternatives propose a roundabout at the northbound US 97 ramp terminal. The proposed roundabout would be constructed in phases to maintain traffic through the work zone. The proposed roundabout for the Flyover alternative may need to be higher than the existing grade, which will be controlled by the flyover profiles and vertical clearance over US 97. This will make maintaining traffic during the construction of this roundabout more challenging. Temporary pavement around the proposed improvements may be required to maintain traffic.
- **Improvements along US 97:** The Enhance Existing alternative is the only alternative that would require linear roadway work along US 97. Construction of the improvements to the US 97 southbound on-ramp acceleration lane will likely require a temporary closure of the ramp.

Placing temporary pavement in the existing median along US 97, reducing speeds, and shifting southbound travel lanes may provide the space needed to maintain the southbound on-ramp.

- **Bridges over US 97:** All three alternatives require bridge widening over US 97. The widening will require pile driving adjacent to US 97 and overhead bridge work over US 97. The Flyover alternative constructs two new bridges over US 97. Temporary nighttime closures are anticipated to place girders and pour the concrete deck for each bridge structure.

TABLE 13: ALTERNATIVE SCORING BY EVALUATION CRITERIA

GOALS	OBJECTIVES	EVALUATION CRITERIA	NO-BUILD	ALTERNATIVE 1 (ENHANCE EXISTING) (ROUNDABOUT/SIGNAL)	ALTERNATIVE 2 (TUDI) (ROUNDABOUT/SIGNAL)	ALTERNATIVE 4 (FLYOVER) (ROUNDABOUT/SIGNAL)
1. Provide for efficient travel through the interchange area based on existing and planned land uses in the area.	a. Provide for efficient travel for regional through traffic along US 97.	Meets ODOT's adopted mobility standards for US 97 through the planning horizon.	⏫	⏫	⏫	⏫
		Meets ODOT's adopted mobility standards at the US 97 ramp terminals with Baker Road and Knott Road through the planning horizon.	⏬	🔼 / 🔼	🔼 / ⏫	🔼 / 🔼
	b. Provide for efficient travel on the local roadway system in the interchange area.	Meets Deschutes County and City of Bend mobility standards for local system study intersections through the planning horizon.	🔽	🔼	🔼	⏫
2. Improve safety for all modes of travel.	a. Reduce the frequency and severity of crashes for all modes with an emphasis on severe and fatal injuries.	Reduces the frequency and severity of crashes, as assessed through analysis of crash data and use of Crash Modification Factors.	⏬	⏫ / 🔼	⏫ / 🔼	⏫ / 🔼
		Minimizes conflicts and risk factors that could lead to crashes.	⏬	🔼	🔼	⏫
		Enhances safety for vehicular and non-motorized modes of transportation at rail crossings.	⏬	🔽	🔼	🔼
	b. Move in the direction of meeting ODOT's adopted access spacing standards along US 97, Baker Road, and Knott Road, or meet the standards where feasible.	Meets or improves access spacing pursuant to ODOT's adopted access spacing standards.	⏬	🔼	➖	⏫
3. Support regional and local economic development.	a. Maintain access to properties along Baker Road and Knott Road in a manner that supports the economic development objectives of existing and future businesses consistent with the Deschutes County and Bend Comprehensive Plans.	Maintains accessibility to properties consistent with the documented needs of existing land uses and anticipated potential needs of future uses based on Comprehensive Plan designations.	🔽	⏫	🔼	⏫
	b. Develop an interchange design that facilitates truck freight movement along US 97 and to and from destinations to the east.	Proposed interchange geometry, such as curves, clearances, and grades, accommodates trucks and oversize vehicles.	➖	➖ / 🔼	➖ / 🔼	➖ / 🔼

GOALS	OBJECTIVES	EVALUATION CRITERIA	NO-BUILD	ALTERNATIVE 1 (ENHANCE EXISTING) (ROUNDABOUT/SIGNAL)	ALTERNATIVE 2 (TUDI) (ROUNDABOUT/SIGNAL)	ALTERNATIVE 4 (FLYOVER) (ROUNDABOUT/SIGNAL)
	c. Allow for safe and uninterrupted service on the Burlington Northern Santa Fe railroad.	Based on qualitative criteria, reduces potential conflicts with the rail crossing on Baker Road.				
4. Facilitate the use of multimodal travel options.	a. Provide low-stress walking and biking facilities that create east-west connectivity through the interchange area.	Based on qualitative criteria, enhances the quality of walking and biking facilities.				
		Reduces the level of traffic stress for people walking and biking.				
		Increases the number of grade-separated US 97 crossings provided in the Area of Potential Impact for people walking and biking.				
	b. Identify where planned trails in the interchange area can be safely connected and accessed.	Based on qualitative criteria, enhances trail system completeness and quality of connections.				
	c. Accommodate long-term connectivity to the south.	Incorporates the alignment of the proposed US 97: Baker/Knott Road to Lava Butte Multi-Use Path and connects it to the walking and biking network in the interchange area.				
	d. Support future enhancements to Cascades East Transit service.	Can accommodate planned transit service improvements and expansions.				
		Provides safe walking and biking access to transit.				
5. Develop the project to support the community's value of equity.	a. Provide an equitable decision-making process that encourages participation by all.	Historically underrepresented community members within the Area of Social Impact were invited to participate in the project. (This will be used to evaluate the project process, but not individual alternatives.)	NA	NA	NA	NA
		Feedback from historically underrepresented community members indicates they were able to participate in the process. (This will be used to evaluate the project process, but not individual alternatives.)	NA	NA	NA	NA

GOALS	OBJECTIVES	EVALUATION CRITERIA	NO-BUILD	ALTERNATIVE 1 (ENHANCE EXISTING) (ROUNDABOUT/SIGNAL)	ALTERNATIVE 2 (TUDI) (ROUNDABOUT/SIGNAL)	ALTERNATIVE 4 (FLYOVER) (ROUNDABOUT/SIGNAL)
	b. Achieve a just allocation of burdens and benefits among community members.	Impacts to properties owned, used by, or accessed by historically underrepresented community members are proportionate to those of other populations.	^	^	^	^
6. Practice good stewardship of the environment.	a. Reduce vehicle emissions through reduction of vehicular delay, improved connections in the local system, and the use of alternative travel modes.	Assessment of reductions in vehicular delay and vehicle-miles traveled, as well as improvements supporting walking, biking, and use of transit.	vv	^	^^ / ^	^^ / ^
	b. Minimize impacts on resource lands.	Minimizes impacts on land designated for natural resources, scenic and historic areas, and open spaces.	^	^	^	^
	c. Minimize adverse impacts on wildlife.	Recommendations minimize or avoid impacts to wildlife habitat and safety.	^	^	^	^
7. Develop solutions that are consistent with the established shared corridor vision and adopted state and local plans.	a. Create a US 97 corridor that is compatible with the recommendations from the US 97 Parkway Plan and Bend to Lava Butte Refinement Plan.	Recommendations are compatible with those from the US 97 Parkway Plan and Bend to Lava Butte Refinement Plan.	vv	^^	^^	^^
	b. Ensure compatibility with future planned growth in Bend's opportunity areas and expansion areas.	Traffic forecasts and connectivity improvements in the Area of Potential Impact account for the impact of housing and employment growth in Bend's opportunity areas and expansion areas.	vv	^^	^^	^^
	c. Consider the visual sequence of project elements as an entry/exit node to the City of Bend.	Can accommodate or does not compete with visual and physical gateway elements to south Bend.	-	^	^	v
	d. Support the action plan in the Greater Bend Community Wildfire Protection Plan to enhance community safety.	Recommendations maintain or enhance access and evacuation routes for the Southwest and Southeast Communities.	vv	^	^	^^
8. Develop implementable solutions for the interchange area.	a. Minimize impacts on resource lands.	Minimizes impacts on land designated for natural resources, scenic and historic areas, and open spaces.	^	^	^	^
	b. Ensure public funds are invested efficiently and effectively, and solutions are fiscally responsible.	Based on qualitative criteria, solutions are effective at addressing goals and objectives compared to costs and would reasonably fit within funding expectations for project partners.	NA	^	^	v

GOALS	OBJECTIVES	EVALUATION CRITERIA	NO-BUILD	ALTERNATIVE 1 (ENHANCE EXISTING) (ROUNDABOUT/SIGNAL)	ALTERNATIVE 2 (TUDI) (ROUNDABOUT/SIGNAL)	ALTERNATIVE 4 (FLYOVER) (ROUNDABOUT/SIGNAL)
	c. Develop solutions that can be implemented in phases.	Solutions can be implemented incrementally in functional phases.	NA			
	d. Develop a design that is constructable and could be reasonably maintained.	Minimizes the number of potential design exceptions.	NA			
		Is easily constructable with regard to rail impacts and ability to maintain traffic.	NA			
		Does not create maintenance challenges.	NA			

Based on the detailed scoring for the evaluation criteria, Table 14 below summarizes the results for each alternative by goal. Each of the alternatives perform significantly better than the No-Build scenario. In general, the Flyover alternative performs well for nearly all of the goals, but it is the most expensive solution and will likely be the most difficult to implement. The TUDI alternative performs similarly to the Enhance Existing alternative, although each has various tradeoffs. For example, the TUDI alternative is closer to meeting motor vehicle mobility standards but increases conflicts between motor vehicles and people walking and biking on the multi-use path on the south side of Baker Road.

TABLE 14: SUMMARY OF ALTERNATIVE SCORING BY GOAL

GOALS	NO-BUILD	ALT. 1 (ENHANCE EXISTING)	ALT. 2 (TUDI)	ALT. 4 (FLYOVER)
1. Provide for efficient travel through the interchange area based on existing and planned land uses in the area.				
2. Improve safety for all modes of travel.				
3. Support regional and local economic development.				
4. Facilitate the use of multimodal travel options.				
5. Develop the project to support the community's value of equity.				
6. Practice good stewardship of the environment.				
7. Develop solutions that are consistent with the established shared corridor vision and adopted state and local plans.				
8. Develop implementable solutions for the interchange area.	NA			

NEXT STEPS

The assessment of the three refined alternative concepts described in this memorandum will help guide the discussion of the key opportunities and tradeoffs associated with each alternative to ultimately select a preferred concept. These refined concepts will be discussed with the project Technical Advisory Committee and Community Advisory Committee and will be presented at an online open house for additional public input. Based on the feedback received and direction from the Bend MPO Policy Board, a preferred concept will be selected for additional refinement and inclusion in the Interchange Area Management Plan.

APPENDIX A: INITIAL CONCEPT DESCRIPTIONS AND SCORING

Alternative Name: ALTERNATIVE 1 – LOW BUILD	Ranking: 2

Description

Maintain existing interchange configuration with improvements at ramp terminals to add capacity

Advantages	Disadvantages
• Can be built in phases with low impacts • Most cost effective	• Will need additional lanes to handle the operations • Queuing will go beyond the railroad • Will still have congestion at the intersection due to the heavy SB right and WB right, EB left (at NB ramp terminal) • Added exposure to bikers • Not the best alternative for transit

Scoring Options

Very Poor	*Poor*	*Fair*	*Good*	*Excellent*
-2	-1	0	1	2

Discussion/Sketches/Photos/Calculations

Comments:

- One option for this alternative is a roundabout at Baker Court.
- A traffic signal may fix some issues but would not fix the queuing at the railroad.
- Bikers will still need to cross ramps; this adds exposure for multi-modal travel. However, having a roundabout or signal would create a somewhat protected crossing for Baker Road compared to the No Build options.
- One solution to make this alternative more feasible would be to increase ramp length as a mitigation.

Alternative Name: ALTERNATIVE 1 – LOW BUILD	Ranking: 2

- This does not address all of the challenges of the area, it is relatively inexpensive, and there are not significant impacts, so it scores well for solutions for the interchange area.
- This alternative is consistent with the planned 3-lane section elsewhere on Baker/Knott.
- Safety can improve (particularly if roundabouts are installed), but there is not a significant improvement, and it still conflicts with the railroad. This is also why this alternative does not score high for economic development.
- The structure is in a good shape and the bridge/structure type lends itself to widening. The new bridge would likely be added to the north, and there could be some minor shifts in the horizontal alignment of the roadway. There may need to be some nighttime closures.

Estimate Cost: Low

Alternative Name: ALTERNATIVE 2- TIGHT URBAN DIAMOND INTERCHANGE	Ranking: 3

Description

Reconstruct the southbound (SB) on and off ramp by removing the existing loop ramp and realigning the existing southbound off ramp.

Reconstruct southbound ramp terminal:

- Remove loop ramp
- New southbound on ramp and retaining walls

Intersection improvements at northbound ramp terminal to add capacity.

Advantages	Disadvantages
• Pedestrians and bikes are no longer crossing the railroad tracks. • Can be built in phases with low impacts • Cost effective	• Queuing extends beyond the railroad • Traffic performance is similar to Low Build • Queuing will be more of an issue on western side • For active transportation, the new SB ramp adds a new conflict point for bikes and pedestrians

Scoring Options

Very Poor	*Poor*	*Fair*	*Good*	*Excellent*
-2	-1	0	1	2

Alternative Name: ALTERNATIVE 2- TIGHT URBAN DIAMOND INTERCHANGE	Ranking: 3

Discussion/Sketches/Photos/Calculations

Comments:

- The SB exit and SB entrance loop would be eliminated in this alternative that would include an offset tight diamond with a similar crossing of the Arnold Canal. However, the deceleration lane length would likely need to be lengthened.
- The performance of this alternative will be evaluated in more detail if it moves forward.
- If the roundabout moves forward, we would need a deeper dive into the alignment of the roundabouts and the placement of the SB ramp terminals.
- A cantilever likely is not an option but a separate bike/pedestrian bridge is possible, it might not have a strong impact on cost.

Estimate Cost: Low

Alternative Name: ALTERNATIVE 3- SOUTHBOUND ON AND OFF RAMP FLYOVERS WITH SIGNALIZED INTERSECTION	Ranking: 7

Description

Reconstruct the southbound on and off ramp by removing the existing loop ramp and realigning the existing southbound off ramp.

Construct the new southbound on and off flyover ramps:

- Remove the existing southbound on and off ramp
- New bridges over US 97
- New bridge over channel

Construct the new intersection on the east side of US 97.

All on and off ramps will go through one **signalized** intersection.

Advantages	Disadvantages
• Eliminates the potential for ramp queueing at the railroad • Improves the existing access spacing at Baker Court • Creates only one intersection to cross on the east side of US97 • Moving ramps to the east side helps with safety and access management • Serve more years for the expected traffic • Less conflict points for bikers/walkers • Better V/C with Signal versus the roundabout due to running directions at the same time • One intersection is better than two for the pedestrian and bike facility	• Not as easy to construct • Is very expensive

Scoring Options

Very Poor	*Poor*	*Fair*	*Good*	*Excellent*
-2	-1	0	1	2

Alternative Name: ALTERNATIVE 3- SOUTHBOUND ON AND OFF RAMP FLYOVERS WITH SIGNALIZED INTERSECTION	Ranking: 7

Discussion/Sketches/Photos/Calculations

Comments:

- Consider pulling the intersection further to the north.
- This may be different to drivers since the ramp is on a different side and drivers are not as use to the offset.
- The structure would still be widened for turn lanes and bike/pedestrian improvements.
- This alternative concentrates volumes at one intersection and works well. It may be more costly in the short term, but it may work better in the long term.

Estimate Cost: High

Alternative Name: ALTERNATIVE 4 – SOUTHBOUND ON AND OFF RAMP FLYOVERS WITH ROUNDABOUT INTERSECTION	Ranking: 8

Description

Reconstruct the southbound on and off ramp by removing the existing loop ramp and realigning the existing southbound off ramp.

Construct the new southbound on and off flyover ramps

- Remove the existing southbound on and off ramp
- New bridges over US 97
- New bridge over channel

Construct the new intersection on east side of US 97

All on and off ramps will go through one **roundabout** intersection

Advantages	Disadvantages
• Eliminates the potential for ramp queueing at the railroad • Improves the existing access spacing at Baker Court • Creates only one intersection to cross on the east side of US97 • Moving ramps to the east side helps with safety and access management • Serve more years for the expected traffic • Less conflict points for bikers/walkers • One intersection is better than two for the pedestrian and bike facility • When evacuating people out of Deschutes River Woods, it is much easier to shut down a leg of a roundabout versus a signal	• Not as easy to construct • Is very expensive • Might be more of a challenge to have a roundabout off US97 for the freight component • Roundabout will be larger

Scoring Options

Very Poor	*Poor*	*Fair*	*Good*	*Excellent*
-2	-1	0	1	2

Alternative Name: ALTERNATIVE 4 – SOUTHBOUND ON AND OFF RAMP FLYOVERS WITH ROUNDABOUT INTERSECTION	Ranking: 8

Discussion/Sketches/Photos/Calculations

Alternative Name: ALTERNATIVE 4 – SOUTHBOUND ON AND OFF RAMP FLYOVERS WITH ROUNDABOUT INTERSECTION	Ranking: 8

Comments

Comments:

- This maybe different to drivers since the ramp is on a different side, and drivers are not as used to the offset.
- Roundabouts could be a challenge for the freight community on US 97. The roundabout would have to be large to accommodate the over-dimension loads.
- There are high travel speeds coming into the area from the east, and sight distance is a little bit limited. A roundabout could have a calming effect, and if tunnels cannot be built for walking and biking, crossings are little bit better with this alternative.
- We will need to consider what this would look like for bikes/pedestrians if we do not have the money to construct grade-separated crossings here at the beginning.
- There may be fewer lanes for the roundabout, and that could be a less expensive option for the vehicle bridge, which may allow for grade separation of the bike/pedestrian facilities.
- Access for Baker Court will be much better in this alternative. Freight could be differentiated between signal and roundabout, but this assumes a larger roundabout to accommodate it.

Estimate Cost: High

Alternative Name: ALTERNATIVE 5 – SOUTHBOUND OFF RAMP FLYOVER WITH SIGNALIZED INTERSECTION	Ranking: 6

Description

Construct the new southbound off flyover ramps.

- Remove the existing southbound off ramp
- New bridge over US 97
- New bridge over channel

Construct the new intersection on the eastside of US 97.

- All off ramps will go through one **signalized** intersection.

Maintain the existing southbound loop ramp.

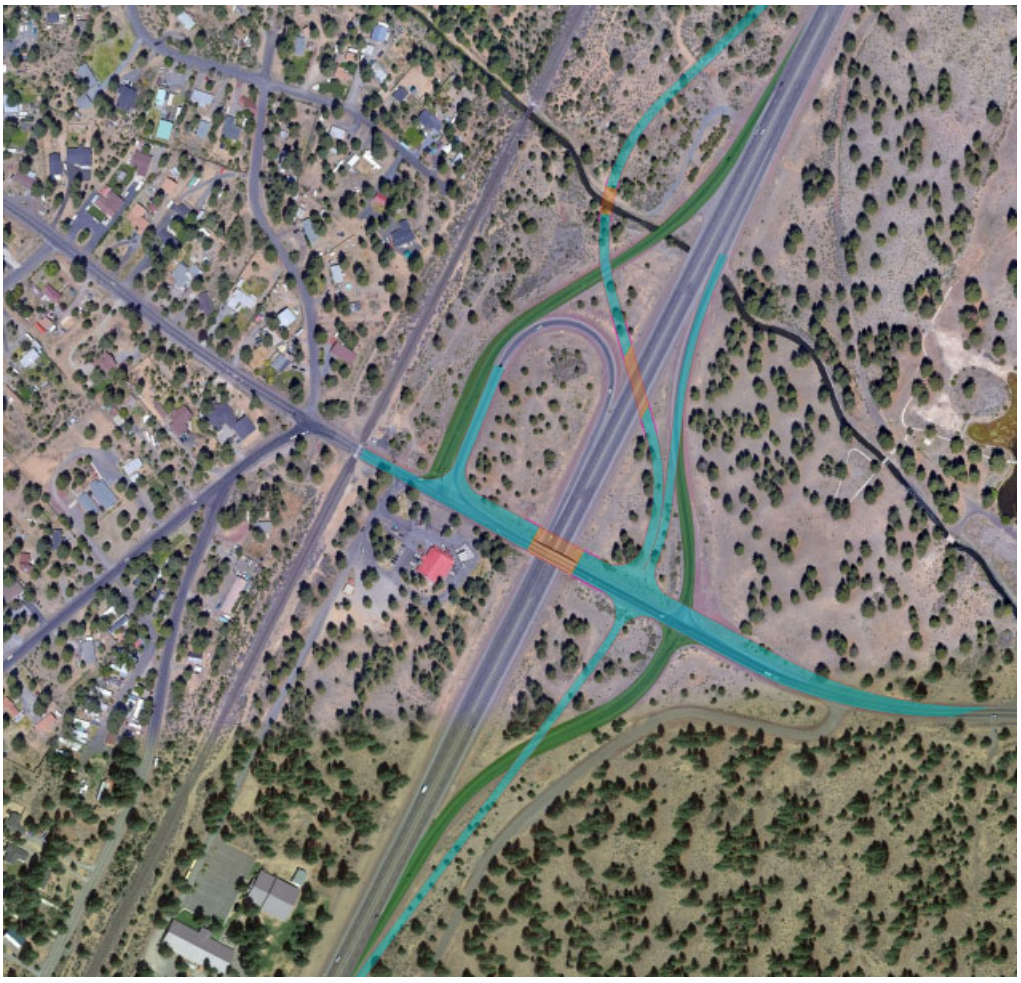
Advantages	Disadvantages
• Eliminates the potential for ramp queueing at the railroad • Improves the existing access spacing at Baker Court • Creates only one intersection to cross on the east side of US97 • Moving the ramps to the east side helps with safety and access management • Serve more years for the expected traffic • Less conflict points for bikers/walkers • One intersection is better than two for the pedestrian and bike facility • When evacuating people out of Deschutes River Woods, it is much easier to shut down a leg of a roundabout versus a signal	• Not as easy to construct • Is very expensive • A-typical configuration and may be confusing for drivers

Scoring Options

Very Poor	*Poor*	*Fair*	*Good*	*Excellent*
-2	-1	0	1	2

Alternative Name: ALTERNATIVE 5 – SOUTHBOUND OFF RAMP FLYOVER WITH SIGNALIZED INTERSECTION	Ranking: 6

Discussion/Sketches/Photos/Calculations



Alternative Name: ALTERNATIVE 5 – SOUTHBOUND OFF RAMP FLYOVER WITH SIGNALIZED INTERSECTION	Ranking: 6

Comments

Comments:

- This option may not meet drivers' expectations.
- The loop ramp brings conflicts with people walking and biking along the north side.
- We will still have constructability challenges on the north side

Estimate Cost: Medium/High

Alternative Name: ALTERNATIVE 6 – SOUTHBOUND OFF RAMP FLYOVER WITH ROUNDABOUT INTERSECTION	Ranking: 6.5

Description

Construct the new southbound off flyover ramps:

- Remove the existing southbound off ramp
- New bridge over US 97
- New bridge over channel

Construct the new intersection on the eastside of US 97.

- All off ramps will go through one **roundabout** intersection

Maintain the existing southbound loop ramp.

Advantages	Disadvantages
• Eliminates the potential for ramp queueing at the railroad • Improves the existing access spacing at Baker Court • Creates only one intersection to cross on the east side of US97 • Moving the ramps to the east side helps with safety and access management • Serve more years for the expected traffic • Less conflict points for bikers/walkers • One intersection is better than two for the pedestrian and bike facility • When evacuating people out of Deschutes River Woods, it is much easier to shut down a leg of a roundabout versus a signal	• Not as easy to construct • Is very expensive • A-typical configuration and may be confusing for drivers • Roundabout will be a large footprint • Short weave movement on bridge with this configuration • Loop ramp for bikes and peds is not as easy

Scoring Options

Very Poor	*Poor*	*Fair*	*Good*	*Excellent*
-2	-1	0	1	2

Alternative Name: ALTERNATIVE 6 – SOUTHBOUND OFF RAMP FLYOVER WITH ROUNDABOUT INTERSECTION	Ranking: 6.5

Discussion/Sketches/Photos/Calculations

Alternative Name: ALTERNATIVE 6 – SOUTHBOUND OFF RAMP FLYOVER WITH ROUNDABOUT INTERSECTION	Ranking: 6.5

Comments

Comments:

- This option may not meet drivers' expectations.
- The loop ramp brings conflicts with people walking and biking along the north side.
- We will still have constructability challenges on the north side.

Estimate Cost: Medium/High

Alternative Name: ALTERNATIVE 7– SOUTHBOUND OFF RAMP FLYOVER WITH SIGNALIZED INTERSECTION AND NEW SOUTHBOUND DIAMOND ON RAMP	Ranking: 5.5

Description

Construct the new southbound off flyover ramps:

- Remove the existing southbound off ramp
- New bridge over US 97
- New bridge over channel

Construct the new intersection on the east side of US 97.

- All off ramps will go through one **signalized** intersection.

Construct the new southbound diamond on ramp.

Mitigates concern for vehicles queuing back to the existing railroad intersection.

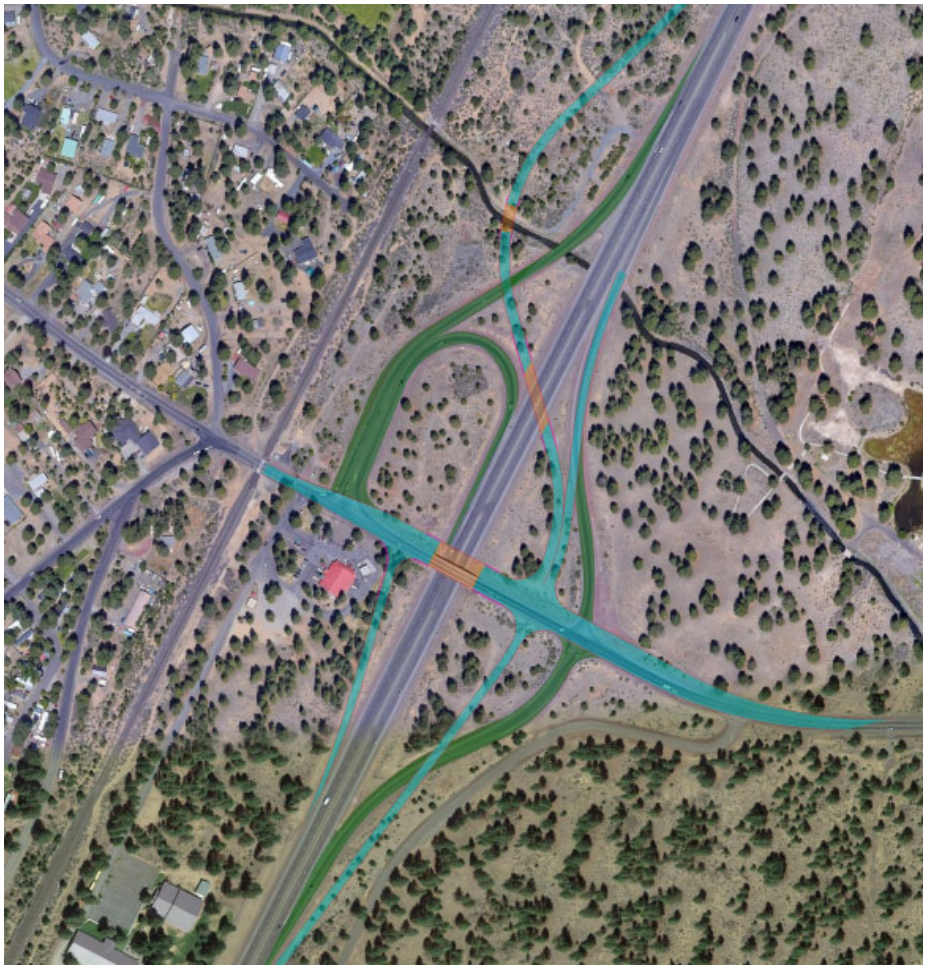
Advantages	Disadvantages
• Eliminates the potential for ramp queueing at the railroad • Improves the existing access spacing at Baker Court • Creates only one intersection to cross on the east side of US97 • Moving the ramps to the east side helps with safety and access management • Serve more years for the expected traffic • Less conflict points for bikers/walkers • One intersection is better than two for the pedestrian and bike facility	• Not as easy to construct • Is very expensive • A-typical configuration and may be confusing for drivers

Scoring Options

Very Poor	*Poor*	*Fair*	*Good*	*Excellent*
-2	-1	0	1	2

Alternative Name: ALTERNATIVE 7– SOUTHBOUND OFF RAMP FLYOVER WITH SIGNALIZED INTERSECTION AND NEW SOUTHBOUND DIAMOND ON RAMP	Ranking: 5.5

Discussion/Sketches/Photos/Calculations



Alternative Name: ALTERNATIVE 7– SOUTHBOUND OFF RAMP FLYOVER WITH SIGNALIZED INTERSECTION AND NEW SOUTHBOUND DIAMOND ON RAMP	Ranking: 5.5

Comments

Comments:

- It cleans up the overlapping left turn lanes at Baker Court and improves queueing towards the railroad compared to other alternatives (like the tight diamond). We would need to look at queueing back between the intersections as the entire lane would be for left turn lanes.
- From a phasing perspective, this could be upgraded to alternatives 5 & 6 eventually.
- The slip ramp cleans up access management better than the loop ramp, but it could be considered as a phasing option, assuming it still addresses the existing issues.
- From a multimodal perspective, the loop is better since it keeps the south side multiuse path clear of motor vehicle conflicts.

Estimate Cost: Medium/High

Alternative Name: ALTERNATIVE 8 – SOUTHBOUND OFF-RAMP FLYOVER WITH ROUNDABOUT INTERSECTION AND NEW SOUTHBOUND DIAMOND ON RAMP	Ranking: 6

Description

Construct the new southbound off flyover ramps:

- Remove the existing southbound off ramp
- New bridge over US 97
- New bridge over channel

Construct the new intersection on the east side of US 97.

- All off ramps will go through one **roundabout** intersection.

Construct the new southbound diamond on ramp.

Mitigates concern for vehicles queuing back to the existing railroad intersection.

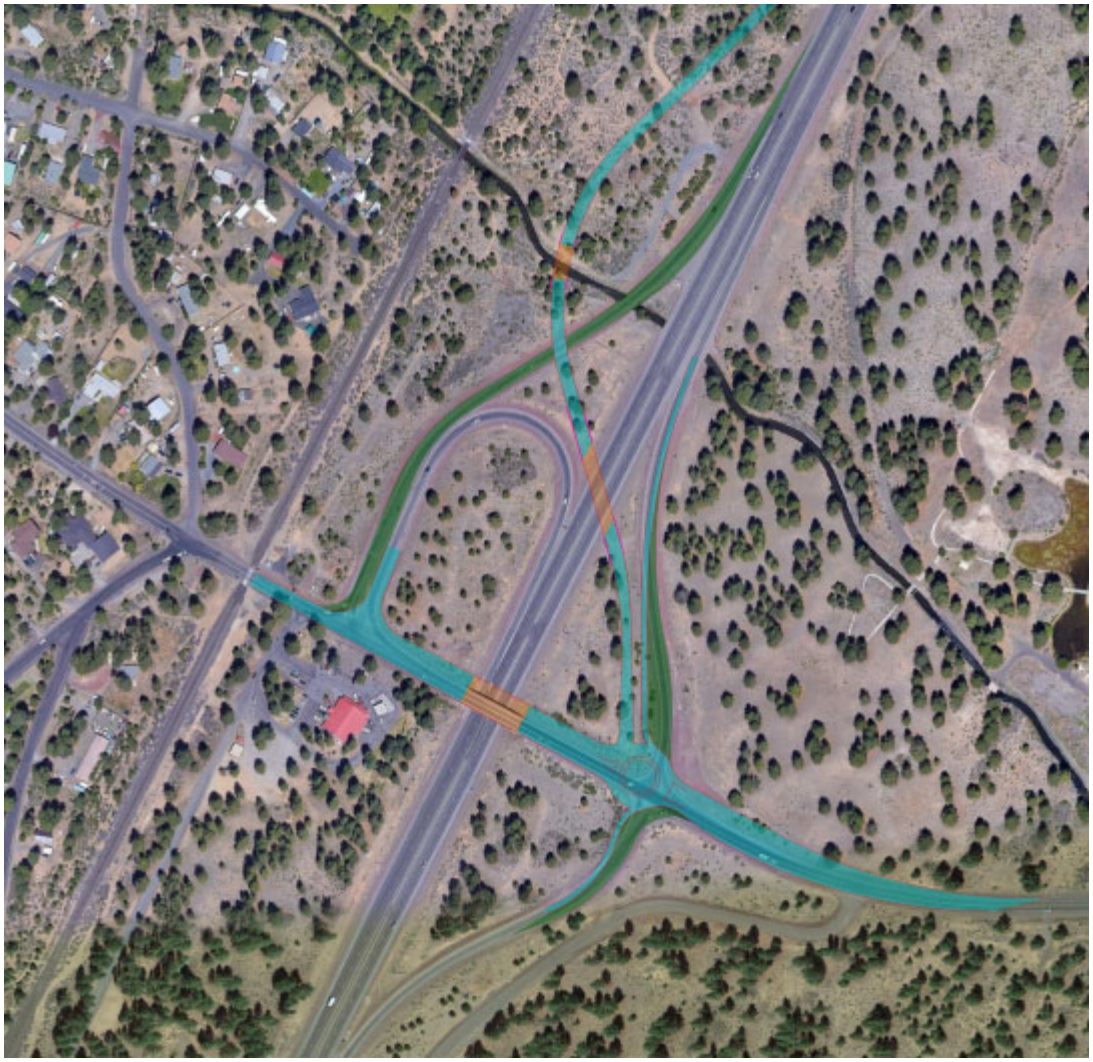
Advantages	Disadvantages
• Eliminates the potential for ramp queueing at the railroad • Improves the existing access spacing at Baker Court • Creates only one intersection to cross on the east side of US97 • Moving the ramps to the east side helps with safety and access management • Serve more years for the expected traffic • Less conflict points for bikers/walkers • One intersection is better than two for the pedestrian and bike facility	• Not as easy to construct • Is very expensive • Atypical configuration and may be confusing for drivers • Loop ramp for bikes and pedestrians is not as easy. • Roundabout will be a larger footprint • Requires two westbound lanes over the bridge

Scoring Options

Very Poor	*Poor*	*Fair*	*Good*	*Excellent*
-2	-1	0	1	2

Alternative Name: ALTERNATIVE 8 – SOUTHBOUND OFF-RAMP FLYOVER WITH ROUNDABOUT INTERSECTION AND NEW SOUTHBOUND DIAMOND ON RAMP	Ranking: 6

Discussion/Sketches/Photos/Calculations



Alternative Name: ALTERNATIVE 8 – SOUTHBOUND OFF-RAMP FLYOVER WITH ROUNDABOUT INTERSECTION AND NEW SOUTHBOUND DIAMOND ON RAMP	Ranking: 6

Comments

Comments:

- It cleans up the overlapping left turn lanes at Baker Court and improves queueing towards railroad compared to other alternatives (like tight diamond). We would need to look at queueing back between the intersections as the entire lane would be for left turn lanes.
- From a phasing perspective, this could be upgraded to alternatives 5 & 6 eventually.
- The slip ramp cleans up access management better than the loop ramp, but it could be considered as a phasing option, assuming it still addresses the existing issues.
- From a multimodal perspective, the loop is better since it keeps the south side multiuse path clear of motor vehicle conflicts.

Estimate Cost: Medium/High

APPENDIX B: INTERSECTION OPERATIONS AND QUEUEING REPORTS

APPENDIX B1: CINDER BUTTE ROAD/BAKER ROAD INTERSECTION OPERATIONS AND QUEUEING REPORTS

Intersection	
Int Delay, s/veh	5.9

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	10	340	20	355	640	30	10	0	145	10	0	5
Future Vol, veh/h	10	340	20	355	640	30	10	0	145	10	0	5
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	50	-	-	100	-	-	-	-	100	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	90	90	90	90	90	90	90	90	90	90	90	90
Heavy Vehicles, %	0	0	0	0	0	0	0	0	0	0	0	0
Mvmt Flow	11	378	22	394	711	33	11	0	161	11	0	6

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	744	0	0	400	0	0	1930	1943	389	2008	1938	728
Stage 1	-	-	-	-	-	-	411	411	-	1516	1516	-
Stage 2	-	-	-	-	-	-	1519	1532	-	492	422	-
Critical Hdwy	4.1	-	-	4.1	-	-	7.1	6.5	6.2	7.1	6.5	6.2
Critical Hdwy Stg 1	-	-	-	-	-	-	6.1	5.5	-	6.1	5.5	-
Critical Hdwy Stg 2	-	-	-	-	-	-	6.1	5.5	-	6.1	5.5	-
Follow-up Hdwy	2.2	-	-	2.2	-	-	3.5	4	3.3	3.5	4	3.3
Pot Cap-1 Maneuver	873	-	-	1170	-	-	51	66	664	45	66	427
Stage 1	-	-	-	-	-	-	622	598	-	151	184	-
Stage 2	-	-	-	-	-	-	150	180	-	562	592	-
Platoon blocked, %		-	-		-	-						
Mov Cap-1 Maneuver	873	-	-	1170	-	-	37	43	664	25	43	427
Mov Cap-2 Maneuver	-	-	-	-	-	-	37	43	-	25	43	-
Stage 1	-	-	-	-	-	-	614	590	-	149	122	-
Stage 2	-	-	-	-	-	-	98	119	-	420	584	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0.2	3.3	20.4	172.4
HCM LOS			C	F

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1
Capacity (veh/h)	37	664	873	-	-	1170	-	-	36
HCM Lane V/C Ratio	0.3	0.243	0.013	-	-	0.337	-	-	0.463
HCM Control Delay (s)	139.6	12.2	9.2	-	-	9.6	-	-	172.4
HCM Lane LOS	F	B	A	-	-	A	-	-	F
HCM 95th %tile Q(veh)	1	0.9	0	-	-	1.5	-	-	1.6

Intersection: 1: Apache Rd & Baker Rd

Movement	WB	NB
Directions Served	LT	LR
Maximum Queue (ft)	144	51
Average Queue (ft)	32	14
95th Queue (ft)	96	38
Link Distance (ft)	792	362
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (ft)		
Storage Blk Time (%)		
Queuing Penalty (veh)		

Intersection: 2: Cinder Butte Rd/Pocahontas Ln & Baker Rd

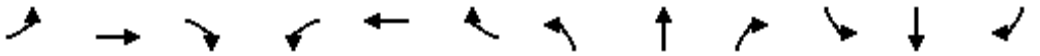
Movement	EB	EB	WB	WB	NB	NB	SB
Directions Served	L	TR	L	TR	LT	R	LTR
Maximum Queue (ft)	31	5	149	64	57	80	66
Average Queue (ft)	5	0	62	2	13	41	17
95th Queue (ft)	22	4	114	38	42	66	50
Link Distance (ft)		792		332	1094		314
Upstream Blk Time (%)							
Queuing Penalty (veh)							
Storage Bay Dist (ft)	50		150			100	
Storage Blk Time (%)	0		0			0	
Queuing Penalty (veh)	0		2			0	

Intersection: 4: Baker Rd/Knott Rd & US 97 SB Ramp

Movement	EB	EB	EB	WB	WB	WB	NB	NB	SB	SB	SB
Directions Served	L	T	TR	L	T	R	L	TR	L	T	R
Maximum Queue (ft)	105	195	195	140	485	226	120	198	284	159	397
Average Queue (ft)	30	88	78	26	201	25	56	81	165	59	225
95th Queue (ft)	83	164	157	85	401	140	109	157	258	117	363
Link Distance (ft)		332	332		818	818		192		551	551
Upstream Blk Time (%)								1			
Queuing Penalty (veh)								0			
Storage Bay Dist (ft)	100			150			100		275		
Storage Blk Time (%)	0	6		0	16		1	6	1	0	
Queuing Penalty (veh)	0	2		0	3		2	3	1	0	

HCM 6th Signalized Intersection Summary
2: Cinder Butte Rd/Pocahontas Ln & Baker Rd

09/24/2021



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	10	340	20	355	640	30	10	0	145	10	0	5
Future Volume (veh/h)	10	340	20	355	640	30	10	0	145	10	0	5
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
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
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
Adj Flow Rate, veh/h	11	378	22	394	711	33	11	0	32	11	0	6
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Percent Heavy Veh, %	0	0	0	0	0	0	0	0	0	0	0	0
Cap, veh/h	531	1055	61	836	1248	58	81	9	77	136	15	37
Arrive On Green	0.01	0.64	0.64	0.12	0.75	0.75	0.07	0.00	0.07	0.07	0.00	0.07
Sat Flow, veh/h	1667	1638	95	1667	1659	77	256	126	1111	769	215	537
Grp Volume(v), veh/h	11	0	400	394	0	744	43	0	0	17	0	0
Grp Sat Flow(s),veh/h/ln	1667	0	1733	1667	0	1736	1493	0	0	1521	0	0
Q Serve(g_s), s	0.2	0.0	7.7	4.6	0.0	13.3	0.3	0.0	0.0	0.0	0.0	0.0
Cycle Q Clear(g_c), s	0.2	0.0	7.7	4.6	0.0	13.3	1.9	0.0	0.0	0.7	0.0	0.0
Prop In Lane	1.00		0.05	1.00		0.04	0.26		0.74	0.65		0.35
Lane Grp Cap(c), veh/h	531	0	1117	836	0	1306	167	0	0	189	0	0
V/C Ratio(X)	0.02	0.00	0.36	0.47	0.00	0.57	0.26	0.00	0.00	0.09	0.00	0.00
Avail Cap(c_a), veh/h	605	0	1117	1195	0	1306	474	0	0	487	0	0
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	0.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	4.5	0.0	5.9	3.1	0.0	3.9	32.0	0.0	0.0	31.4	0.0	0.0
Incr Delay (d2), s/veh	0.0	0.0	0.2	0.4	0.0	1.8	0.8	0.0	0.0	0.2	0.0	0.0
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	0.0	0.0	2.1	0.6	0.0	3.0	0.7	0.0	0.0	0.3	0.0	0.0
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	4.5	0.0	6.1	3.5	0.0	5.7	32.8	0.0	0.0	31.6	0.0	0.0
LnGrp LOS	A	A	A	A	A	A	C	A	A	C	A	A
Approach Vol, veh/h		411			1138			43			17	
Approach Delay, s/veh		6.1			4.9			32.8			31.6	
Approach LOS		A			A			C			C	

Timer - Assigned Phs		2	3	4		6	7	8				
Phs Duration (G+Y+Rc), s		9.0	12.5	50.3		9.0	4.8	58.0				
Change Period (Y+Rc), s		4.0	4.0	4.0		4.0	4.0	4.0				
Max Green Setting (Gmax), s		20.0	24.0	34.0		20.0	4.0	54.0				
Max Q Clear Time (g_c+I1), s		3.9	6.6	9.7		2.7	2.2	15.3				
Green Ext Time (p_c), s		0.1	1.9	4.9		0.0	0.0	13.3				

Intersection Summary	
HCM 6th Ctrl Delay	6.2
HCM 6th LOS	A

Intersection: 1: Apache Rd & Baker Rd

Movement	WB	NB
Directions Served	LT	LR
Maximum Queue (ft)	132	42
Average Queue (ft)	33	14
95th Queue (ft)	98	36
Link Distance (ft)	793	362
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (ft)		
Storage Blk Time (%)		
Queuing Penalty (veh)		

Intersection: 2: Cinder Butte Rd/Pocahontas Ln & Baker Rd

Movement	EB	EB	WB	WB	NB	SB
Directions Served	L	TR	L	TR	LTR	LTR
Maximum Queue (ft)	47	233	150	302	131	54
Average Queue (ft)	7	101	102	127	54	13
95th Queue (ft)	31	193	163	254	103	40
Link Distance (ft)		793		308	1092	314
Upstream Blk Time (%)				0		
Queuing Penalty (veh)				2		
Storage Bay Dist (ft)	150		125			
Storage Blk Time (%)		3	3	4		
Queuing Penalty (veh)		0	23	13		

Intersection: 3: Baker Ct & Baker Rd

Movement	EB	WB	WB	NB	NB
Directions Served	TR	L	T	L	R
Maximum Queue (ft)	31	112	113	469	290
Average Queue (ft)	2	40	7	276	92
95th Queue (ft)	16	80	69	631	368
Link Distance (ft)	308		342	926	926
Upstream Blk Time (%)				2	1
Queuing Penalty (veh)				0	0
Storage Bay Dist (ft)		250			
Storage Blk Time (%)			0		
Queuing Penalty (veh)			0		

APPENDIX B2: ALTERNATIVE 1 (ENHANCE EXISTING) OPERATIONS AND QUEUEING REPORTS

HCM 6th Signalized Intersection Summary
4: Baker Rd/Knott Rd & US 97 SB Ramp

09/24/2021

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	30	415	50	20	400	300	55	35	105	250	85	570
Future Volume (veh/h)	30	415	50	20	400	300	55	35	105	250	85	570
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
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
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1641	1709	1723	1723	1709	1736	1723	1723	1723	1723	1723	1723
Adj Flow Rate, veh/h	32	441	54	22	426	153	60	38	27	266	92	471
Peak Hour Factor	0.94	0.94	0.92	0.92	0.94	0.94	0.92	0.92	0.92	0.94	0.92	0.94
Percent Heavy Veh, %	8	3	2	2	3	1	2	2	2	2	2	2
Cap, veh/h	38	631	77	31	713	875	75	190	135	292	577	525
Arrive On Green	0.02	0.42	0.42	0.04	0.83	0.83	0.05	0.20	0.20	0.18	0.34	0.34
Sat Flow, veh/h	1563	1493	183	1641	1709	1471	1641	937	666	1641	1723	1460
Grp Volume(v), veh/h	32	0	495	22	426	153	60	0	65	266	92	471
Grp Sat Flow(s),veh/h/ln	1563	0	1676	1641	1709	1471	1641	0	1603	1641	1723	1460
Q Serve(g_s), s	1.8	0.0	21.8	1.2	7.4	1.4	3.3	0.0	3.0	14.3	3.4	27.5
Cycle Q Clear(g_c), s	1.8	0.0	21.8	1.2	7.4	1.4	3.3	0.0	3.0	14.3	3.4	27.5
Prop In Lane	1.00		0.11	1.00		1.00	1.00		0.42	1.00		1.00
Lane Grp Cap(c), veh/h	38	0	708	31	713	875	75	0	325	292	577	525
V/C Ratio(X)	0.84	0.00	0.70	0.71	0.60	0.17	0.80	0.00	0.20	0.91	0.16	0.90
Avail Cap(c_a), veh/h	122	0	708	73	713	875	164	0	445	292	613	555
HCM Platoon Ratio	1.00	1.00	1.00	2.00	2.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	0.89	0.89	0.89	1.00	0.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	43.7	0.0	21.3	43.1	5.0	2.2	42.5	0.0	29.8	36.3	21.0	27.3
Incr Delay (d2), s/veh	35.2	0.0	5.7	23.6	3.3	0.4	17.2	0.0	0.3	30.9	0.1	16.8
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	1.1	0.0	9.1	0.7	2.1	0.4	1.7	0.0	1.2	7.9	1.3	11.4
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	78.9	0.0	27.0	66.7	8.3	2.6	59.7	0.0	30.1	67.3	21.1	44.0
LnGrp LOS	E	A	C	E	A	A	E	A	C	E	C	D
Approach Vol, veh/h		527			601			125			829	
Approach Delay, s/veh		30.1			9.0			44.3			48.9	
Approach LOS		C			A			D			D	

Timer - Assigned Phs	1	2	3	4	5	6	7	8
Phs Duration (G+Y+Rc), s	20.0	22.3	5.7	42.0	8.1	34.2	6.2	41.5
Change Period (Y+Rc), s	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Max Green Setting (Gmax), s	16.0	25.0	4.0	29.0	9.0	32.0	7.0	26.0
Max Q Clear Time (g_c+I1), s	16.3	5.0	3.2	23.8	5.3	29.5	3.8	9.4
Green Ext Time (p_c), s	0.0	0.4	0.0	1.4	0.0	0.7	0.0	2.8

Intersection Summary	
HCM 6th Ctrl Delay	32.4
HCM 6th LOS	C

USER REPORT FOR SITE

All Movement Classes

Project: Baker IAMP - Future RAB Tests

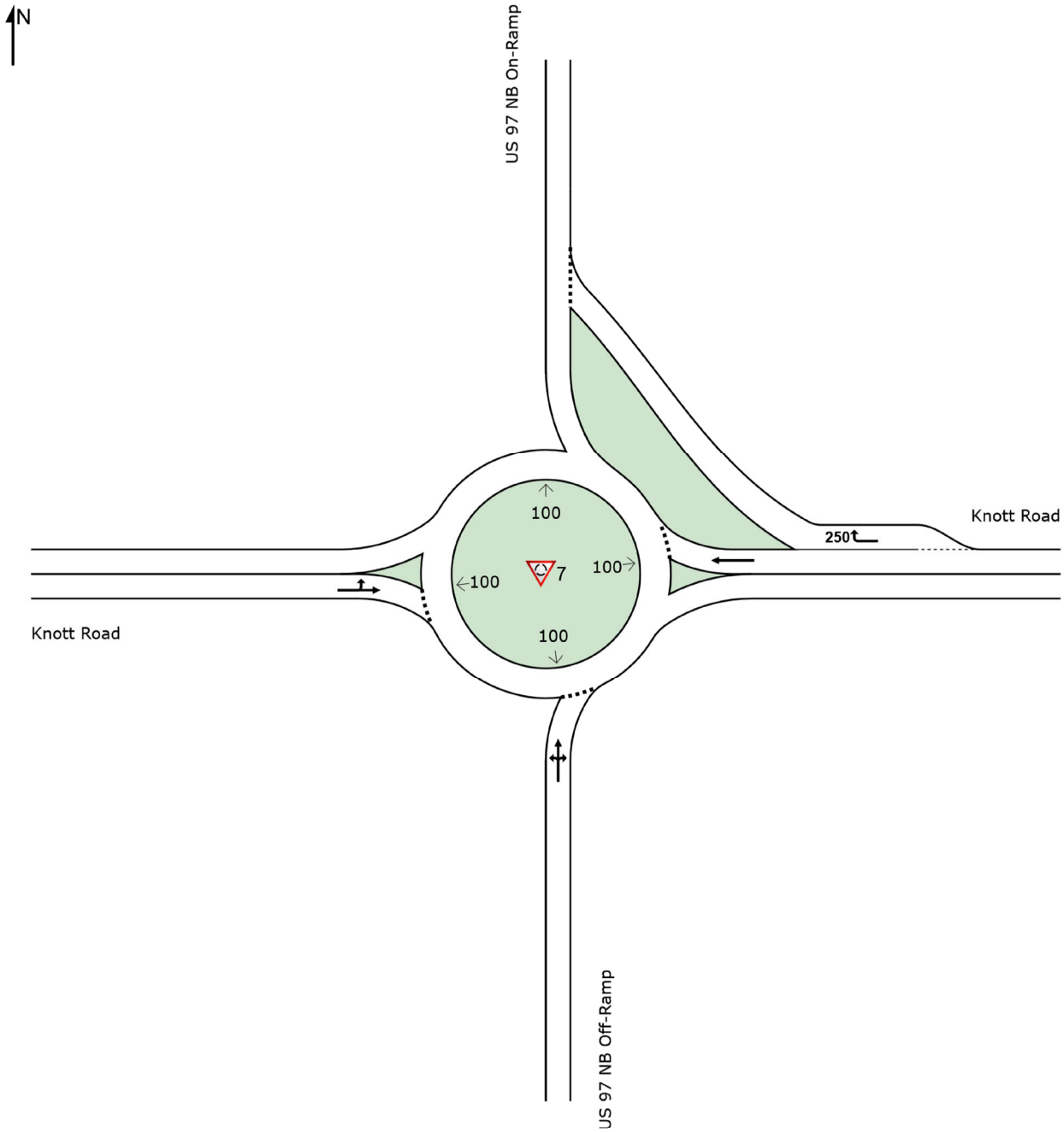
Template: Default Site User Report

Site: 7 [Refined - 01/02 - US 97 NB Ramp (Site Folder: General)]

New Site
Site Category: (None)
Roundabout

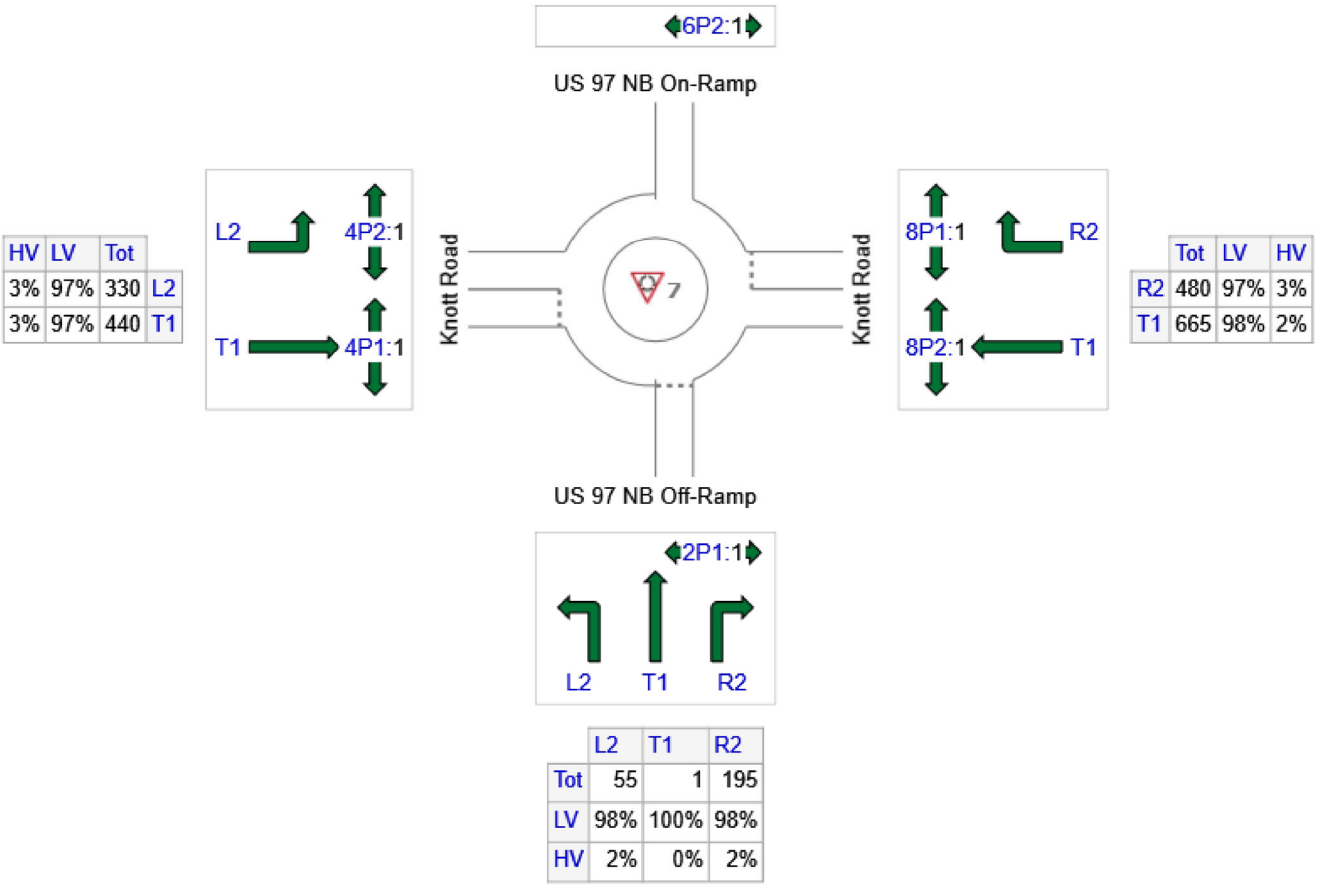
Site Layout

Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.


N
US 97 NB On-Ramp
Knott Road
250
100
100
100
100
7
Knott Road
US 97 NB Off-Ramp

Input Volumes

Volume Display Method: Total and %



HV	LV	Tot	
3%	97%	330	L2
3%	97%	440	T1

	Tot	LV	HV
R2	480	97%	3%
T1	665	98%	2%

	L2	T1	R2
Tot	55	1	195
LV	98%	100%	98%
HV	2%	0%	2%

	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
S: US 97 NB Off-Ramp	251	246	5
E: Knott Road	1145	1117	28
W: Knott Road	770	747	23
Total	2166	2110	56

Lane Use and Performance													
	DEMAND FLOWS [Total veh/h	HV] %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh	Dist] ft	Lane Config	Lane Length ft	Cap. Adj. %	Prob. Block. %
South: US 97 NB Off-Ramp													
Lane 1[d]	276	2.0	674	0.409	100	11.0	LOS B	1.9	47.9	Full	1600	0.0	0.0
Approach	276	2.0		0.409		11.0	LOS B	1.9	47.9				
East: Knott Road													
Lane 1[d]	731	2.0	935	0.781	100	20.0	LOS C	13.4	340.1	Full	1600	0.0	0.0
Lane 2	527	3.0	980	0.538	100	10.6	LOS B	4.3	108.9	Short	250	0.0	NA
Approach	1258	2.4		0.781		16.0	LOS C	13.4	340.1				
West: Knott Road													
Lane 1[d]	846	3.0	1340	0.632	100	10.3	LOS B	0.0	0.0	Full	1600	0.0	0.0
Approach	846	3.0		0.632		10.3	LOS B	0.0	0.0				
Intersection	2380	2.6		0.781		13.4	LOS B	13.4	340.1				

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 6).
Roundabout Capacity Model: US HCM 6.
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.

d Dominant lane on roundabout approach

Intersection: 1: Apache Rd & Baker Rd

Movement	WB	NB
Directions Served	LT	LR
Maximum Queue (ft)	124	44
Average Queue (ft)	28	15
95th Queue (ft)	84	38
Link Distance (ft)	792	362
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (ft)		
Storage Blk Time (%)		
Queuing Penalty (veh)		

Intersection: 2: Cinder Butte Rd/Pocahontas Ln & Baker Rd

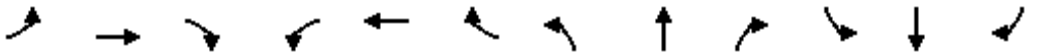
Movement	EB	EB	WB	WB	NB	NB	SB
Directions Served	L	TR	L	TR	LT	R	LTR
Maximum Queue (ft)	26	59	156	95	79	102	90
Average Queue (ft)	4	5	68	4	14	43	22
95th Queue (ft)	19	39	126	56	55	84	71
Link Distance (ft)		792		325	1093		314
Upstream Blk Time (%)				0			
Queuing Penalty (veh)				0			
Storage Bay Dist (ft)	50		150			100	
Storage Blk Time (%)		0	1		1	1	
Queuing Penalty (veh)		0	4		1	0	

Intersection: 4: Baker Rd/Knott Rd & US 97 SB Ramp

Movement	EB	EB	WB	WB	WB	NB	NB	SB	SB	SB
Directions Served	L	TR	L	T	R	L	TR	L	T	R
Maximum Queue (ft)	117	323	159	427	130	123	205	330	256	438
Average Queue (ft)	32	175	28	187	16	51	86	189	65	232
95th Queue (ft)	95	306	91	373	74	108	165	309	176	378
Link Distance (ft)		325		818	818		204		551	551
Upstream Blk Time (%)		1					0		0	0
Queuing Penalty (veh)		4					0		0	0
Storage Bay Dist (ft)	100		150			100		275		
Storage Blk Time (%)	0	20	0	13		1	6	4	0	
Queuing Penalty (veh)	1	6	0	3		2	4	3	0	

HCM 6th Signalized Intersection Summary
4: Baker Rd/Knott Rd & US 97 SB Ramp

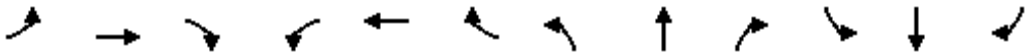
09/24/2021



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	30	415	50	20	400	300	55	35	105	250	85	570
Future Volume (veh/h)	30	415	50	20	400	300	55	35	105	250	85	570
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
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
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1641	1709	1723	1723	1709	1736	1723	1723	1723	1723	1723	1723
Adj Flow Rate, veh/h	32	441	54	22	426	153	60	38	27	266	92	471
Peak Hour Factor	0.94	0.94	0.92	0.92	0.94	0.94	0.92	0.92	0.92	0.94	0.92	0.94
Percent Heavy Veh, %	8	3	2	2	3	1	2	2	2	2	2	2
Cap, veh/h	38	1231	150	31	713	875	75	190	135	292	577	525
Arrive On Green	0.02	0.42	0.42	0.04	0.83	0.83	0.05	0.20	0.20	0.18	0.34	0.34
Sat Flow, veh/h	1563	2914	355	1641	1709	1471	1641	937	666	1641	1723	1460
Grp Volume(v), veh/h	32	245	250	22	426	153	60	0	65	266	92	471
Grp Sat Flow(s),veh/h/ln	1563	1624	1645	1641	1709	1471	1641	0	1603	1641	1723	1460
Q Serve(g_s), s	1.8	9.2	9.3	1.2	7.4	1.4	3.3	0.0	3.0	14.3	3.4	27.5
Cycle Q Clear(g_c), s	1.8	9.2	9.3	1.2	7.4	1.4	3.3	0.0	3.0	14.3	3.4	27.5
Prop In Lane	1.00		0.22	1.00		1.00	1.00		0.42	1.00		1.00
Lane Grp Cap(c), veh/h	38	686	695	31	713	875	75	0	325	292	577	525
V/C Ratio(X)	0.84	0.36	0.36	0.71	0.60	0.17	0.80	0.00	0.20	0.91	0.16	0.90
Avail Cap(c_a), veh/h	122	686	695	91	713	875	164	0	445	292	613	555
HCM Platoon Ratio	1.00	1.00	1.00	2.00	2.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	0.89	0.89	0.89	1.00	0.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	43.7	17.7	17.7	43.1	5.0	2.2	42.5	0.0	29.8	36.3	21.0	27.3
Incr Delay (d2), s/veh	35.2	1.4	1.4	23.6	3.3	0.4	17.2	0.0	0.3	30.9	0.1	16.8
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	1.1	3.5	3.6	0.7	2.1	0.4	1.7	0.0	1.2	7.9	1.3	11.4
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	78.9	19.1	19.1	66.7	8.3	2.6	59.7	0.0	30.1	67.3	21.1	44.0
LnGrp LOS	E	B	B	E	A	A	E	A	C	E	C	D
Approach Vol, veh/h		527			601			125			829	
Approach Delay, s/veh		22.8			9.0			44.3			48.9	
Approach LOS		C			A			D			D	

Timer - Assigned Phs	1	2	3	4	5	6	7	8
Phs Duration (G+Y+Rc), s	20.0	22.3	5.7	42.0	8.1	34.2	6.2	41.5
Change Period (Y+Rc), s	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Max Green Setting (Gmax), s	16.0	25.0	5.0	28.0	9.0	32.0	7.0	26.0
Max Q Clear Time (g_c+I1), s	16.3	5.0	3.2	11.3	5.3	29.5	3.8	9.4
Green Ext Time (p_c), s	0.0	0.4	0.0	2.6	0.0	0.7	0.0	2.8

Intersection Summary	
HCM 6th Ctrl Delay	30.5
HCM 6th LOS	C



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	330	440	0	0	665	480	55	0	195	0	0	0
Future Volume (veh/h)	330	440	0	0	665	480	55	0	195	0	0	0
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0			
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		0.98	1.00		1.00			
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00			
Work Zone On Approach		No			No			No				
Adj Sat Flow, veh/h/ln	1709	1709	0	0	1723	1723	502	529	502			
Adj Flow Rate, veh/h	363	484	0	0	731	160	60	0	34			
Peak Hour Factor	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91			
Percent Heavy Veh, %	3	3	0	0	2	2	2	0	2			
Cap, veh/h	752	1317	0	0	863	376	71	0	60			
Arrive On Green	0.92	1.00	0.00	0.00	0.26	0.26	0.14	0.00	0.14			
Sat Flow, veh/h	1628	1709	0	0	3359	1425	504	0	425			
Grp Volume(v), veh/h	363	484	0	0	731	160	60	0	34			
Grp Sat Flow(s),veh/h/ln	1628	1709	0	0	1637	1425	504	0	425			
Q Serve(g_s), s	2.7	0.0	0.0	0.0	19.1	8.4	10.4	0.0	6.7			
Cycle Q Clear(g_c), s	2.7	0.0	0.0	0.0	19.1	8.4	10.4	0.0	6.7			
Prop In Lane	1.00		0.00	0.00		1.00	1.00		1.00			
Lane Grp Cap(c), veh/h	752	1317	0	0	863	376	71	0	60			
V/C Ratio(X)	0.48	0.37	0.00	0.00	0.85	0.43	0.85	0.00	0.57			
Avail Cap(c_a), veh/h	752	1317	0	0	982	427	129	0	109			
HCM Platoon Ratio	2.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00			
Upstream Filter(I)	0.86	0.86	0.00	0.00	1.00	1.00	1.00	0.00	1.00			
Uniform Delay (d), s/veh	1.9	0.0	0.0	0.0	31.4	27.5	37.7	0.0	36.1			
Incr Delay (d2), s/veh	0.4	0.7	0.0	0.0	10.0	3.5	22.8	0.0	8.2			
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
%ile BackOfQ(50%),veh/ln	0.6	0.2	0.0	0.0	8.4	3.1	1.7	0.0	0.8			
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	2.3	0.7	0.0	0.0	41.4	31.0	60.5	0.0	44.3			
LnGrp LOS	A	A	A	A	D	C	E	A	D			
Approach Vol, veh/h		847			891			94				
Approach Delay, s/veh		1.4			39.6			54.7				
Approach LOS		A			D			D				

Timer - Assigned Phs		2		4			7	8				
Phs Duration (G+Y+Rc), s		16.7		73.3			45.6	27.7				
Change Period (Y+Rc), s		4.0		4.0			4.0	4.0				
Max Green Setting (Gmax), s		23.0		59.0			28.0	27.0				
Max Q Clear Time (g_c+I1), s		12.4		2.0			4.7	21.1				
Green Ext Time (p_c), s		0.2		3.4			1.1	2.7				

Intersection Summary												
HCM 6th Ctrl Delay			22.7									
HCM 6th LOS			C									

Intersection: 1: Apache Rd & Baker Rd

Movement	WB	NB
Directions Served	LT	LR
Maximum Queue (ft)	144	51
Average Queue (ft)	32	14
95th Queue (ft)	96	38
Link Distance (ft)	792	362
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (ft)		
Storage Blk Time (%)		
Queuing Penalty (veh)		

Intersection: 2: Cinder Butte Rd/Pocahontas Ln & Baker Rd

Movement	EB	EB	WB	WB	NB	NB	SB
Directions Served	L	TR	L	TR	LT	R	LTR
Maximum Queue (ft)	31	5	149	64	57	80	66
Average Queue (ft)	5	0	62	2	13	41	17
95th Queue (ft)	22	4	114	38	42	66	50
Link Distance (ft)		792		332	1094		314
Upstream Blk Time (%)							
Queuing Penalty (veh)							
Storage Bay Dist (ft)	50		150			100	
Storage Blk Time (%)	0		0			0	
Queuing Penalty (veh)	0		2			0	

Intersection: 4: Baker Rd/Knott Rd & US 97 SB Ramp

Movement	EB	EB	EB	WB	WB	WB	NB	NB	SB	SB	SB
Directions Served	L	T	TR	L	T	R	L	TR	L	T	R
Maximum Queue (ft)	105	195	195	140	485	226	120	198	284	159	397
Average Queue (ft)	30	88	78	26	201	25	56	81	165	59	225
95th Queue (ft)	83	164	157	85	401	140	109	157	258	117	363
Link Distance (ft)		332	332		818	818		192		551	551
Upstream Blk Time (%)								1			
Queuing Penalty (veh)								0			
Storage Bay Dist (ft)	100			150			100		275		
Storage Blk Time (%)	0	6		0	16		1	6	1	0	
Queuing Penalty (veh)	0	2		0	3		2	3	1	0	

Intersection: 5: Knott Rd & US 97 NB On Ramp

Movement	EB	EB	WB	WB	WB	NB	NB
Directions Served	L	T	T	T	R	LT	R
Maximum Queue (ft)	389	221	258	251	315	103	115
Average Queue (ft)	204	88	137	127	136	43	32
95th Queue (ft)	336	184	223	214	261	88	94
Link Distance (ft)	818	818	450	450		564	
Upstream Blk Time (%)							
Queuing Penalty (veh)							
Storage Bay Dist (ft)					400		300
Storage Blk Time (%)							
Queuing Penalty (veh)							

Intersection: 6: Scale House Rd & Knott Rd

Movement	NB
Directions Served	LR
Maximum Queue (ft)	67
Average Queue (ft)	14
95th Queue (ft)	52
Link Distance (ft)	196
Upstream Blk Time (%)	
Queuing Penalty (veh)	
Storage Bay Dist (ft)	
Storage Blk Time (%)	
Queuing Penalty (veh)	

Intersection: 7: China Hat Rd & Knott Rd

Movement	EB	WB	NB	SB
Directions Served	LTR	LTR	LTR	LTR
Maximum Queue (ft)	172	348	59	352
Average Queue (ft)	60	132	19	123
95th Queue (ft)	123	349	50	288
Link Distance (ft)	1848	325	227	1110
Upstream Blk Time (%)		8		
Queuing Penalty (veh)		0		
Storage Bay Dist (ft)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 8: Parrell Rd & China Hat Rd

Movement	EB	WB	NB	NB
Directions Served	TR	L	L	R
Maximum Queue (ft)	62	94	54	156
Average Queue (ft)	6	38	19	70
95th Queue (ft)	33	76	45	121
Link Distance (ft)				285
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)		250	150	
Storage Blk Time (%)				0
Queuing Penalty (veh)				0

Intersection: 9: US 97 & Ponderosa St/China Hat Rd

Movement
Directions Served
Maximum Queue (ft)
Average Queue (ft)
95th Queue (ft)
Link Distance (ft)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (ft)
Storage Blk Time (%)
Queuing Penalty (veh)

Intersection: 10: US 97 & Rocking Horse Ct

Movement
Directions Served
Maximum Queue (ft)
Average Queue (ft)
95th Queue (ft)
Link Distance (ft)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (ft)
Storage Blk Time (%)
Queuing Penalty (veh)

Intersection: 60: China Hat Rd & Stonegate Dr

Movement	SW
Directions Served	LR
Maximum Queue (ft)	84
Average Queue (ft)	34
95th Queue (ft)	66
Link Distance (ft)	379
Upstream Blk Time (%)	
Queuing Penalty (veh)	
Storage Bay Dist (ft)	
Storage Blk Time (%)	
Queuing Penalty (veh)	

Intersection: 90: US 97 SB Ramp/US 97 SB Off Ramp & US 97 On Ramp

Movement
Directions Served
Maximum Queue (ft)
Average Queue (ft)
95th Queue (ft)
Link Distance (ft)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (ft)
Storage Blk Time (%)
Queuing Penalty (veh)

Intersection: 118: US 97

Movement	NB	NW
Directions Served	T	R
Maximum Queue (ft)	20	129
Average Queue (ft)	2	12
95th Queue (ft)	18	64
Link Distance (ft)	1151	438
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (ft)		
Storage Blk Time (%)		
Queuing Penalty (veh)		

Intersection: 119: US 97 & US 97 On Ramp

Movement
Directions Served
Maximum Queue (ft)
Average Queue (ft)
95th Queue (ft)
Link Distance (ft)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (ft)
Storage Blk Time (%)
Queuing Penalty (veh)

Intersection: 120: US 97 & US 97 NB Off Ramp

Movement	NB
Directions Served	R
Maximum Queue (ft)	50
Average Queue (ft)	4
95th Queue (ft)	25
Link Distance (ft)	
Upstream Blk Time (%)	
Queuing Penalty (veh)	
Storage Bay Dist (ft)	10
Storage Blk Time (%)	0
Queuing Penalty (veh)	1

Intersection: 153: US 97 & US 97 SB Off Ramp

Movement	NB	NB	NB	SB	SB
Directions Served	T	T	T	T	TR
Maximum Queue (ft)	67	100	82	791	834
Average Queue (ft)	3	14	10	53	86
95th Queue (ft)	28	61	47	527	679
Link Distance (ft)	274	274	274	3444	3444
Upstream Blk Time (%)					
Queuing Penalty (veh)					
Storage Bay Dist (ft)					
Storage Blk Time (%)					
Queuing Penalty (veh)					

Network Summary

Network wide Queuing Penalty: 15

APPENDIX B3: ALTERNATIVE 2 (TUDI) OPERATIONS AND QUEUEING REPORTS

Intersection	
Int Delay, s/veh	2.2

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	445	50	105	970	0	195
Future Vol, veh/h	445	50	105	970	0	195
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	100	-	-	0
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	484	54	114	1054	0	212

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	538	0	-	511
Stage 1	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-
Critical Hdwy	-	-	4.12	-	-	6.22
Critical Hdwy Stg 1	-	-	-	-	-	-
Critical Hdwy Stg 2	-	-	-	-	-	-
Follow-up Hdwy	-	-	2.218	-	-	3.318
Pot Cap-1 Maneuver	-	-	1030	-	0	563
Stage 1	-	-	-	-	0	-
Stage 2	-	-	-	-	0	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	1030	-	-	563
Mov Cap-2 Maneuver	-	-	-	-	-	-
Stage 1	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0.9	15.2
HCM LOS			C

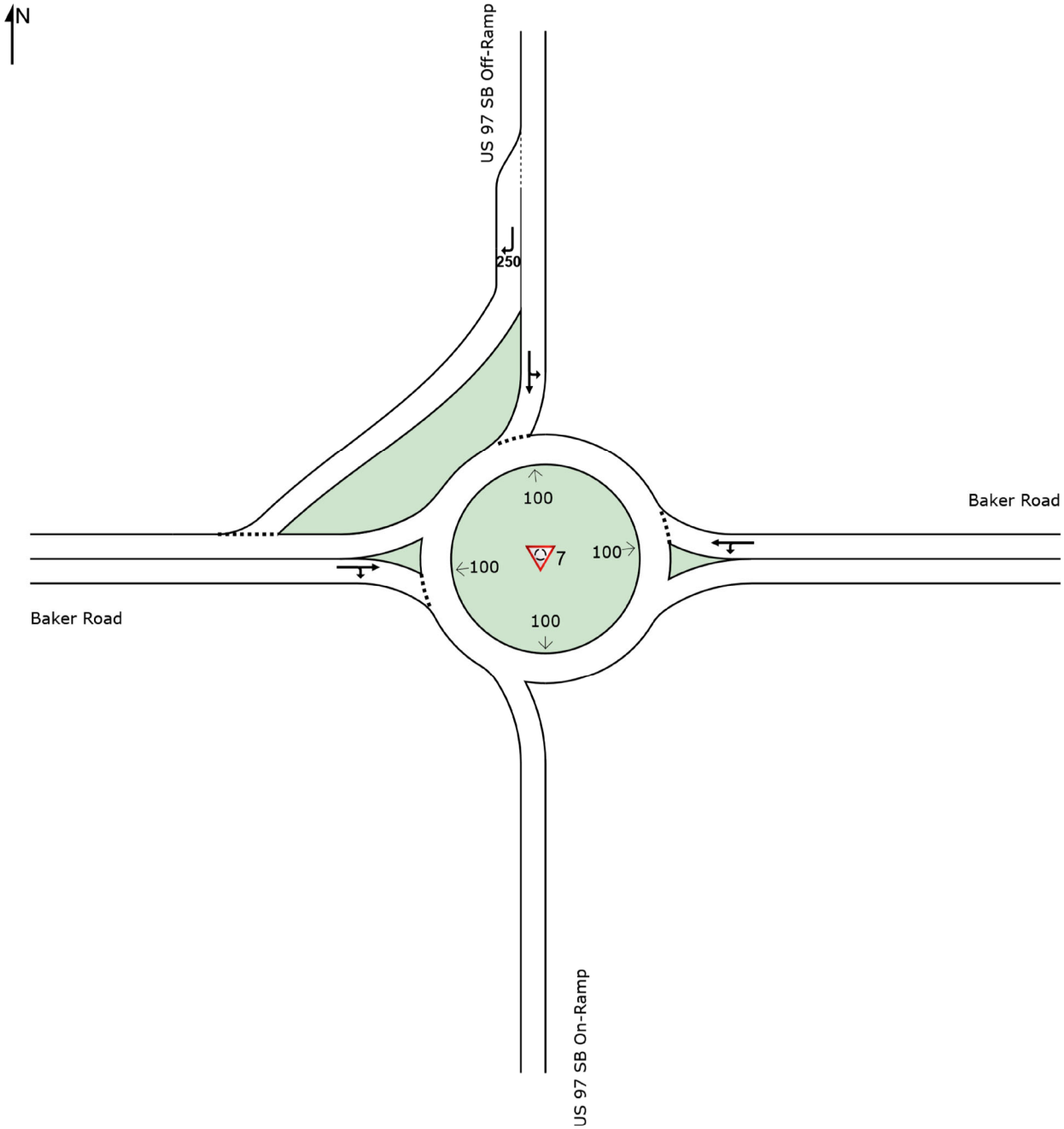
Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT
Capacity (veh/h)	563	-	-	1030	-
HCM Lane V/C Ratio	0.376	-	-	0.111	-
HCM Control Delay (s)	15.2	-	-	8.9	-
HCM Lane LOS	C	-	-	A	-
HCM 95th %tile Q(veh)	1.7	-	-	0.4	-

Site: 7 [Refined - 02 - US 97 SB Ramp - Tight Diamond (Site Folder: General)]

New Site
Site Category: (None)
Roundabout

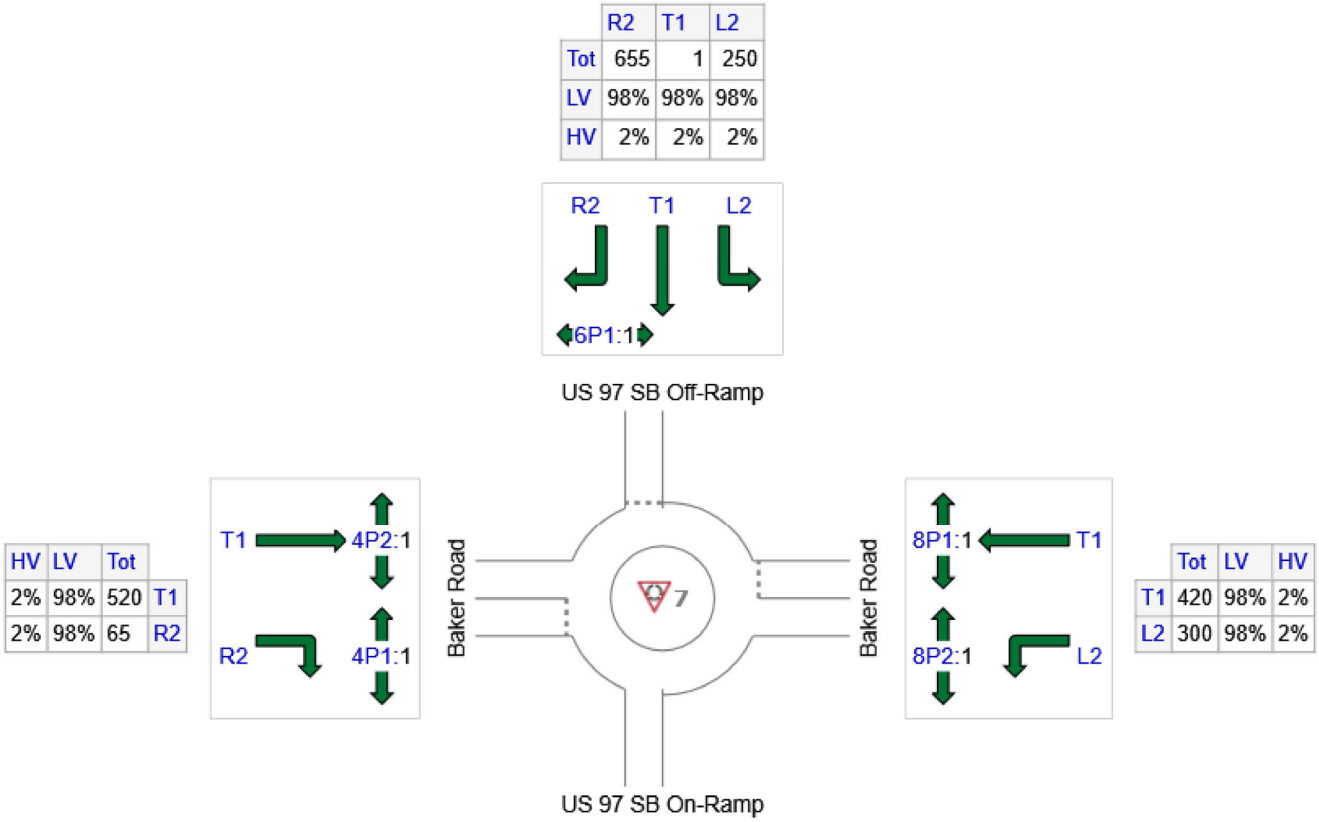
Site Layout

Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.



Input Volumes

Volume Display Method: Total and %



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
E: Baker Road	720	706	14
N: US 97 SB Off-Ramp	906	888	18
W: Baker Road	585	573	12
Total	2211	2167	44

Lane Use and Performance													
	DEMAND FLOWS [Total veh/h	HV] %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh	Dist] ft	Lane Config	Lane Length ft	Cap. Adj. %	Prob. Block. %
East: Baker Road													
Lane 1[d]	766	2.0	1353	0.566	100	8.9	LOS A	0.0	0.0	Full	1600	0.0	0.0
Approach	766	2.0		0.566		8.9	LOS A	0.0	0.0				
North: US 97 SB Off-Ramp													
Lane 1[d]	267	2.0	684	0.391	100	10.6	LOS B	1.9	48.5	Full	1600	0.0	0.0
Lane 2	697	2.0	919	0.758	100	18.9	LOS C	11.7	296.3	Short	250	0.0	NA
Approach	964	2.0		0.758		16.6	LOS C	11.7	296.3				
West: Baker Road													
Lane 1[d]	622	2.0	838	0.742	100	19.3	LOS C	8.8	222.6	Full	1600	0.0	0.0
Approach	622	2.0		0.742		19.3	LOS C	8.8	222.6				
Intersection	2352	2.0		0.758		14.8	LOS B	11.7	296.3				

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 6).
Roundabout Capacity Model: US HCM 6.
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.

d Dominant lane on roundabout approach

USER REPORT FOR SITE

All Movement Classes

Project: Baker IAMP - Future RAB Tests

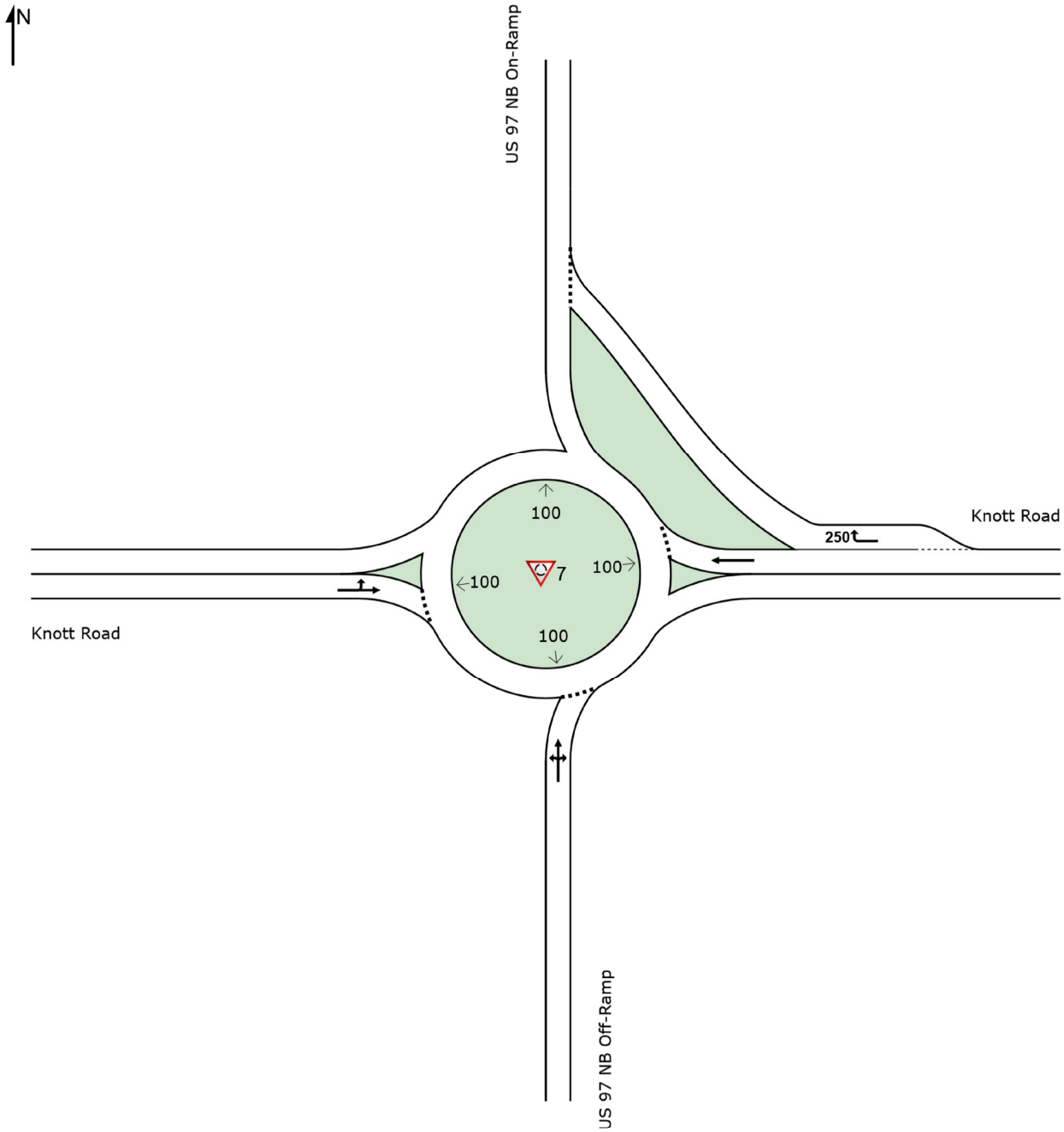
Template: Default Site User Report

Site: 7 [Refined - 01/02 - US 97 NB Ramp (Site Folder: General)]

New Site
Site Category: (None)
Roundabout

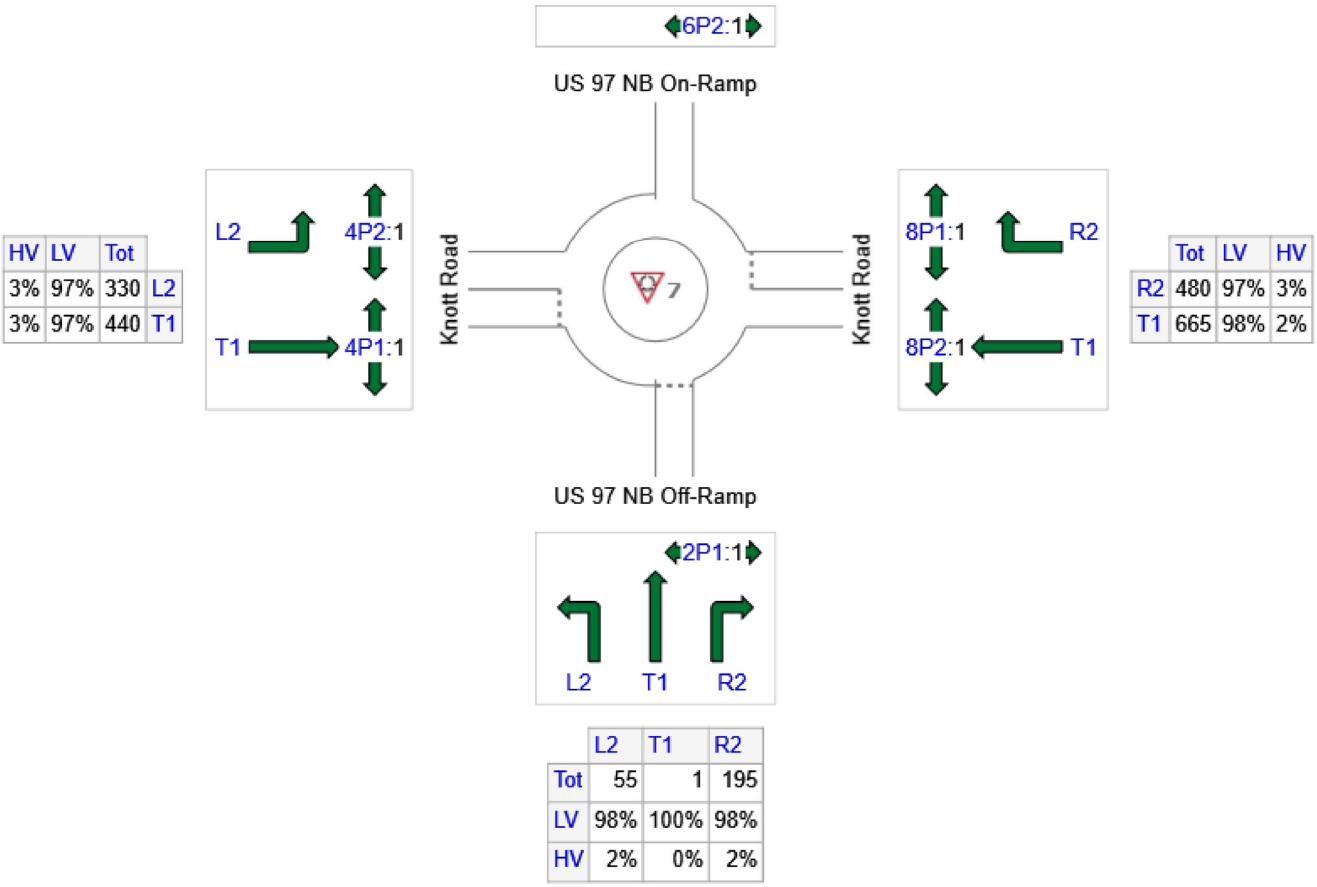
Site Layout

Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.


N
US 97 NB On-Ramp
Knott Road
250
100
100
100
100
7
Knott Road
US 97 NB Off-Ramp

Input Volumes

Volume Display Method: Total and %



HV	LV	Tot	
3%	97%	330	L2
3%	97%	440	T1

	Tot	LV	HV
R2	480	97%	3%
T1	665	98%	2%

	L2	T1	R2
Tot	55	1	195
LV	98%	100%	98%
HV	2%	0%	2%

	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
S: US 97 NB Off-Ramp	251	246	5
E: Knott Road	1145	1117	28
W: Knott Road	770	747	23
Total	2166	2110	56

Lane Use and Performance													
	DEMAND FLOWS [Total veh/h	HV] %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh	Dist] ft	Lane Config	Lane Length ft	Cap. Adj. %	Prob. Block. %
South: US 97 NB Off-Ramp													
Lane 1[d]	276	2.0	674	0.409	100	11.0	LOS B	1.9	47.9	Full	1600	0.0	0.0
Approach	276	2.0		0.409		11.0	LOS B	1.9	47.9				
East: Knott Road													
Lane 1[d]	731	2.0	935	0.781	100	20.0	LOS C	13.4	340.1	Full	1600	0.0	0.0
Lane 2	527	3.0	980	0.538	100	10.6	LOS B	4.3	108.9	Short	250	0.0	NA
Approach	1258	2.4		0.781		16.0	LOS C	13.4	340.1				
West: Knott Road													
Lane 1[d]	846	3.0	1340	0.632	100	10.3	LOS B	0.0	0.0	Full	1600	0.0	0.0
Approach	846	3.0		0.632		10.3	LOS B	0.0	0.0				
Intersection	2380	2.6		0.781		13.4	LOS B	13.4	340.1				

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 6).
Roundabout Capacity Model: US HCM 6.
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.

d Dominant lane on roundabout approach

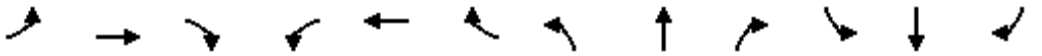
Intersection	
Int Delay, s/veh	2.7

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	445	50	105	970	55	140
Future Vol, veh/h	445	50	105	970	55	140
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	250	-	0	0
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	484	54	114	1054	60	152

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	538	0	1793	511
Stage 1	-	-	-	-	511	-
Stage 2	-	-	-	-	1282	-
Critical Hdwy	-	-	4.12	-	6.42	6.22
Critical Hdwy Stg 1	-	-	-	-	5.42	-
Critical Hdwy Stg 2	-	-	-	-	5.42	-
Follow-up Hdwy	-	-	2.218	-	3.518	3.318
Pot Cap-1 Maneuver	-	-	1030	-	89	563
Stage 1	-	-	-	-	602	-
Stage 2	-	-	-	-	260	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	1030	-	79	563
Mov Cap-2 Maneuver	-	-	-	-	180	-
Stage 1	-	-	-	-	602	-
Stage 2	-	-	-	-	231	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0.9	19.6
HCM LOS			C

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBT	EBR	WBL	WBT
Capacity (veh/h)	180	563	-	-	1030	-
HCM Lane V/C Ratio	0.332	0.27	-	-	0.111	-
HCM Control Delay (s)	34.6	13.7	-	-	8.9	-
HCM Lane LOS	D	B	-	-	A	-
HCM 95th %tile Q(veh)	1.4	1.1	-	-	0.4	-



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	520	65	300	420	0	0	0	0	250	0	655
Future Volume (veh/h)	0	520	65	300	420	0	0	0	0	250	0	655
Initial Q (Qb), veh	0	0	0	0	0	0				0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00				1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00				1.00	1.00	1.00
Work Zone On Approach		No			No						No	
Adj Sat Flow, veh/h/ln	0	1709	1723	1723	1709	0				1723	1723	1723
Adj Flow Rate, veh/h	0	553	69	319	447	0				266	0	362
Peak Hour Factor	0.94	0.94	0.94	0.94	0.94	0.94				0.94	0.94	0.94
Percent Heavy Veh, %	0	3	2	2	3	0				2	2	2
Cap, veh/h	0	1197	538	360	1081	0				457	480	407
Arrive On Green	0.00	0.37	0.37	0.07	0.21	0.00				0.28	0.00	0.28
Sat Flow, veh/h	0	3333	1460	1641	1709	0				1641	1723	1460
Grp Volume(v), veh/h	0	553	69	319	447	0				266	0	362
Grp Sat Flow(s),veh/h/ln	0	1624	1460	1641	1709	0				1641	1723	1460
Q Serve(g_s), s	0.0	11.7	2.8	17.3	20.4	0.0				12.6	0.0	21.4
Cycle Q Clear(g_c), s	0.0	11.7	2.8	17.3	20.4	0.0				12.6	0.0	21.4
Prop In Lane	0.00		1.00	1.00		0.00				1.00		1.00
Lane Grp Cap(c), veh/h	0	1197	538	360	1081	0				457	480	407
V/C Ratio(X)	0.00	0.46	0.13	0.89	0.41	0.00				0.58	0.00	0.89
Avail Cap(c_a), veh/h	0	1197	538	401	1081	0				638	670	568
HCM Platoon Ratio	1.00	1.00	1.00	0.33	0.33	1.00				1.00	1.00	1.00
Upstream Filter(I)	0.00	1.00	1.00	0.89	0.89	0.00				1.00	0.00	1.00
Uniform Delay (d), s/veh	0.0	21.6	18.8	40.6	21.2	0.0				27.9	0.0	31.1
Incr Delay (d2), s/veh	0.0	1.3	0.5	17.5	1.0	0.0				1.2	0.0	12.3
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0				0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	4.4	1.0	9.3	9.5	0.0				4.8	0.0	8.4
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	0.0	22.9	19.3	58.1	22.2	0.0				29.1	0.0	43.5
LnGrp LOS	A	C	B	E	C	A				C	A	D
Approach Vol, veh/h		622			766						628	
Approach Delay, s/veh		22.5			37.2						37.4	
Approach LOS		C			D						D	

Timer - Assigned Phs		3	4		6		8					
Phs Duration (G+Y+Rc), s		23.7	37.2		29.1		60.9					
Change Period (Y+Rc), s		4.0	4.0		4.0		4.0					
Max Green Setting (Gmax), s		22.0	21.0		35.0		47.0					
Max Q Clear Time (g_c+I1), s		19.3	13.7		23.4		22.4					
Green Ext Time (p_c), s		0.4	2.4		1.7		2.8					

Intersection Summary	
HCM 6th Ctrl Delay	32.7
HCM 6th LOS	C

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	330	440	0	0	665	480	55	0	195	0	0	0
Future Volume (veh/h)	330	440	0	0	665	480	55	0	195	0	0	0
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0			
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		0.98	1.00		1.00			
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00			
Work Zone On Approach		No			No			No				
Adj Sat Flow, veh/h/ln	1709	1709	0	0	1723	1654	502	-836	502			
Adj Flow Rate, veh/h	363	484	0	0	731	160	60	0	34			
Peak Hour Factor	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91			
Percent Heavy Veh, %	3	3	0	0	2	7	2	100	2			
Cap, veh/h	565	1120	0	0	863	361	0	0	109			
Arrive On Green	0.23	0.44	0.00	0.00	0.26	0.26	0.26	0.00	0.26			
Sat Flow, veh/h	1628	1709	0	0	3359	1368	-796	0	425			
Grp Volume(v), veh/h	363	484	0	0	731	160	60	0	34			
Grp Sat Flow(s),veh/h/ln	1628	1709	0	0	1637	1368	-796	0	425			
Q Serve(g_s), s	18.1	17.6	0.0	0.0	19.1	8.8	23.0	0.0	5.8			
Cycle Q Clear(g_c), s	18.1	17.6	0.0	0.0	19.1	8.8	23.0	0.0	5.8			
Prop In Lane	1.00		0.00	0.00		1.00	1.00		1.00			
Lane Grp Cap(c), veh/h	565	1120	0	0	863	361	-203	0	109			
V/C Ratio(X)	0.64	0.43	0.00	0.00	0.85	0.44	-0.30	0.00	0.31			
Avail Cap(c_a), veh/h	565	1120	0	0	982	410	-203	0	109			
HCM Platoon Ratio	0.67	0.67	1.00	1.00	1.00	1.00	1.00	1.00	1.00			
Upstream Filter(I)	0.82	0.82	0.00	0.00	1.00	1.00	1.00	0.00	1.00			
Uniform Delay (d), s/veh	29.5	13.6	0.0	0.0	31.4	27.6	0.0	0.0	27.1			
Incr Delay (d2), s/veh	2.0	1.0	0.0	0.0	10.0	3.9	0.0	0.0	1.6			
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
%ile BackOfQ(50%),veh/ln	7.6	7.4	0.0	0.0	8.4	3.2	0.0	0.0	0.6			
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	31.5	14.6	0.0	0.0	41.4	31.5	0.0	0.0	28.7			
LnGrp LOS	C	B	A	A	D	C	A	A	C			
Approach Vol, veh/h		847			891			94				
Approach Delay, s/veh		21.9			39.7			10.4				
Approach LOS		C			D			B				

Timer - Assigned Phs	2	4	7	8
Phs Duration (G+Y+Rc), s	27.0	63.0	35.3	27.7
Change Period (Y+Rc), s	4.0	4.0	4.0	4.0
Max Green Setting (Gmax), s	23.0	59.0	28.0	27.0
Max Q Clear Time (g_c+I1), s	25.0	19.6	20.1	21.1
Green Ext Time (p_c), s	0.0	3.3	0.7	2.7

Intersection Summary	
HCM 6th Ctrl Delay	29.9
HCM 6th LOS	C

Intersection: 1: Apache Rd & Baker Rd

Movement	WB	NB
Directions Served	LT	LR
Maximum Queue (ft)	101	36
Average Queue (ft)	23	15
95th Queue (ft)	71	36
Link Distance (ft)	796	362
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (ft)		
Storage Blk Time (%)		
Queuing Penalty (veh)		

Intersection: 2: Cinder Butte Rd/Pocahontas Ln & Baker Rd

Movement	EB	EB	WB	WB	NB	NB	SB
Directions Served	L	TR	L	TR	LT	R	LTR
Maximum Queue (ft)	24	6	131	1	47	77	57
Average Queue (ft)	4	0	49	0	9	35	14
95th Queue (ft)	18	2	93	1	34	61	42
Link Distance (ft)		796		296	1093		314
Upstream Blk Time (%)							
Queuing Penalty (veh)							
Storage Bay Dist (ft)	100		150			100	
Storage Blk Time (%)			0			0	
Queuing Penalty (veh)			0			0	

Intersection: 3: Baker Ct & Baker Rd

Movement	EB	WB	NB	NB
Directions Served	TR	L	L	R
Maximum Queue (ft)	37	84	194	117
Average Queue (ft)	2	32	71	52
95th Queue (ft)	16	67	177	94
Link Distance (ft)	296		925	925
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)		250		
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 4: Baker Rd/Knott Rd & US 97 SB Ramp

Movement	EB	EB	EB	WB	WB	SB	SB
Directions Served	T	T	R	L	T	L	R
Maximum Queue (ft)	257	253	105	389	395	198	222
Average Queue (ft)	155	119	24	208	187	95	105
95th Queue (ft)	237	221	68	333	342	166	189
Link Distance (ft)	298	298		499	499		
Upstream Blk Time (%)	0	0			0		
Queuing Penalty (veh)	0	1			0		
Storage Bay Dist (ft)			250			325	450
Storage Blk Time (%)		0	0				
Queuing Penalty (veh)		0	0				

Intersection: 5: Knott Rd & US 97 NB On Ramp

Movement	EB	EB	WB	WB	WB	NB	NB
Directions Served	L	T	T	T	R	LT	R
Maximum Queue (ft)	384	188	255	299	332	120	140
Average Queue (ft)	244	32	125	137	139	47	23
95th Queue (ft)	354	114	216	242	272	96	90
Link Distance (ft)	499	499	450	450		567	
Upstream Blk Time (%)	0						
Queuing Penalty (veh)	1						
Storage Bay Dist (ft)					400		300
Storage Blk Time (%)				0	0		
Queuing Penalty (veh)				0	0		

Intersection: 6: Scale House Rd & Knott Rd

Movement	NB
Directions Served	LR
Maximum Queue (ft)	44
Average Queue (ft)	10
95th Queue (ft)	36
Link Distance (ft)	196
Upstream Blk Time (%)	
Queuing Penalty (veh)	
Storage Bay Dist (ft)	
Storage Blk Time (%)	
Queuing Penalty (veh)	

Intersection: 7: China Hat Rd & Knott Rd

Movement	EB	WB	NB	SB
Directions Served	LTR	LTR	LTR	LTR
Maximum Queue (ft)	135	337	51	292
Average Queue (ft)	52	117	18	118
95th Queue (ft)	109	315	48	245
Link Distance (ft)	1848	325	227	1110
Upstream Blk Time (%)		7		
Queuing Penalty (veh)		0		
Storage Bay Dist (ft)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 8: Parrell Rd & China Hat Rd

Movement	EB	WB	NB	NB
Directions Served	TR	L	L	R
Maximum Queue (ft)	53	100	72	189
Average Queue (ft)	6	35	17	76
95th Queue (ft)	30	76	46	138
Link Distance (ft)				285
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)		250	150	
Storage Blk Time (%)				1
Queuing Penalty (veh)				0

Intersection: 9: US 97 & Ponderosa St/China Hat Rd

Movement	SB	SB
Directions Served	T	T
Maximum Queue (ft)	1032	1031
Average Queue (ft)	858	857
95th Queue (ft)	1407	1403
Link Distance (ft)	958	958
Upstream Blk Time (%)	78	79
Queuing Penalty (veh)	0	0
Storage Bay Dist (ft)		
Storage Blk Time (%)		71
Queuing Penalty (veh)		0

Intersection: 10: US 97 & Rocking Horse Ct

Movement	B24	B24	B24	SB	SB
Directions Served	T	T		T	T
Maximum Queue (ft)	4	14	6	1139	1156
Average Queue (ft)	0	1	0	1000	1006
95th Queue (ft)	4	9	7	1487	1491
Link Distance (ft)	156	156	156	1104	1104
Upstream Blk Time (%)				4	6
Queuing Penalty (veh)				56	71
Storage Bay Dist (ft)					
Storage Blk Time (%)					83
Queuing Penalty (veh)					0

Intersection: 60: China Hat Rd & Stonegate Dr

Movement	SW
Directions Served	LR
Maximum Queue (ft)	80
Average Queue (ft)	34
95th Queue (ft)	65
Link Distance (ft)	379
Upstream Blk Time (%)	
Queuing Penalty (veh)	
Storage Bay Dist (ft)	
Storage Blk Time (%)	
Queuing Penalty (veh)	

Intersection: 118: US 97

Movement	NW
Directions Served	R
Maximum Queue (ft)	82
Average Queue (ft)	8
95th Queue (ft)	41
Link Distance (ft)	438
Upstream Blk Time (%)	
Queuing Penalty (veh)	
Storage Bay Dist (ft)	
Storage Blk Time (%)	
Queuing Penalty (veh)	

Intersection: 120: US 97 & US 97 NB Off Ramp

Movement	NB	SB
Directions Served	R	T
Maximum Queue (ft)	43	2
Average Queue (ft)	3	0
95th Queue (ft)	22	2
Link Distance (ft)		838
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (ft)	10	
Storage Blk Time (%)	0	
Queuing Penalty (veh)	1	

Intersection: 153: US 97 SB Off Ramp & US 97

Movement	NB	NB	SB	SB	B24	B24
Directions Served	T	T	T	TR	T	T
Maximum Queue (ft)	60	72	28	279	3250	3262
Average Queue (ft)	13	11	1	238	3173	3182
95th Queue (ft)	45	47	21	260	3527	3512
Link Distance (ft)	58	58	156	156	3220	3220
Upstream Blk Time (%)	0	0	0	98	4	6
Queuing Penalty (veh)	1	0	0	1243	52	74
Storage Bay Dist (ft)						
Storage Blk Time (%)						
Queuing Penalty (veh)						

Network Summary

Network wide Queuing Penalty: 1501

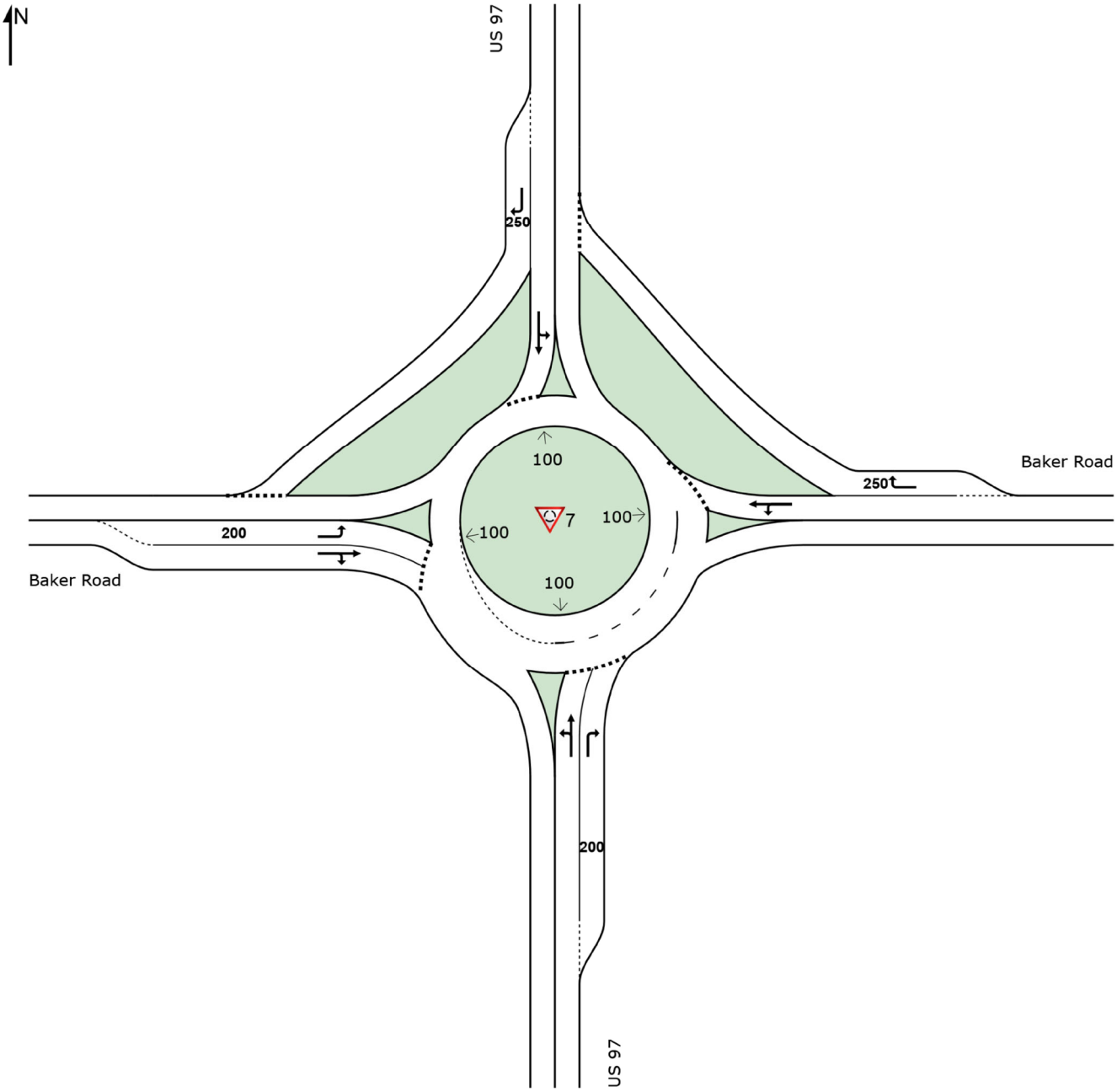
APPENDIX B4: ALTERNATIVE 4 (FLYOVER) OPERATIONS AND QUEUEING REPORTS

Site: 7 [Refined - 04 - US 97 Ramps - Full Flyover (Site Folder: General)]

New Site
Site Category: (None)
Roundabout

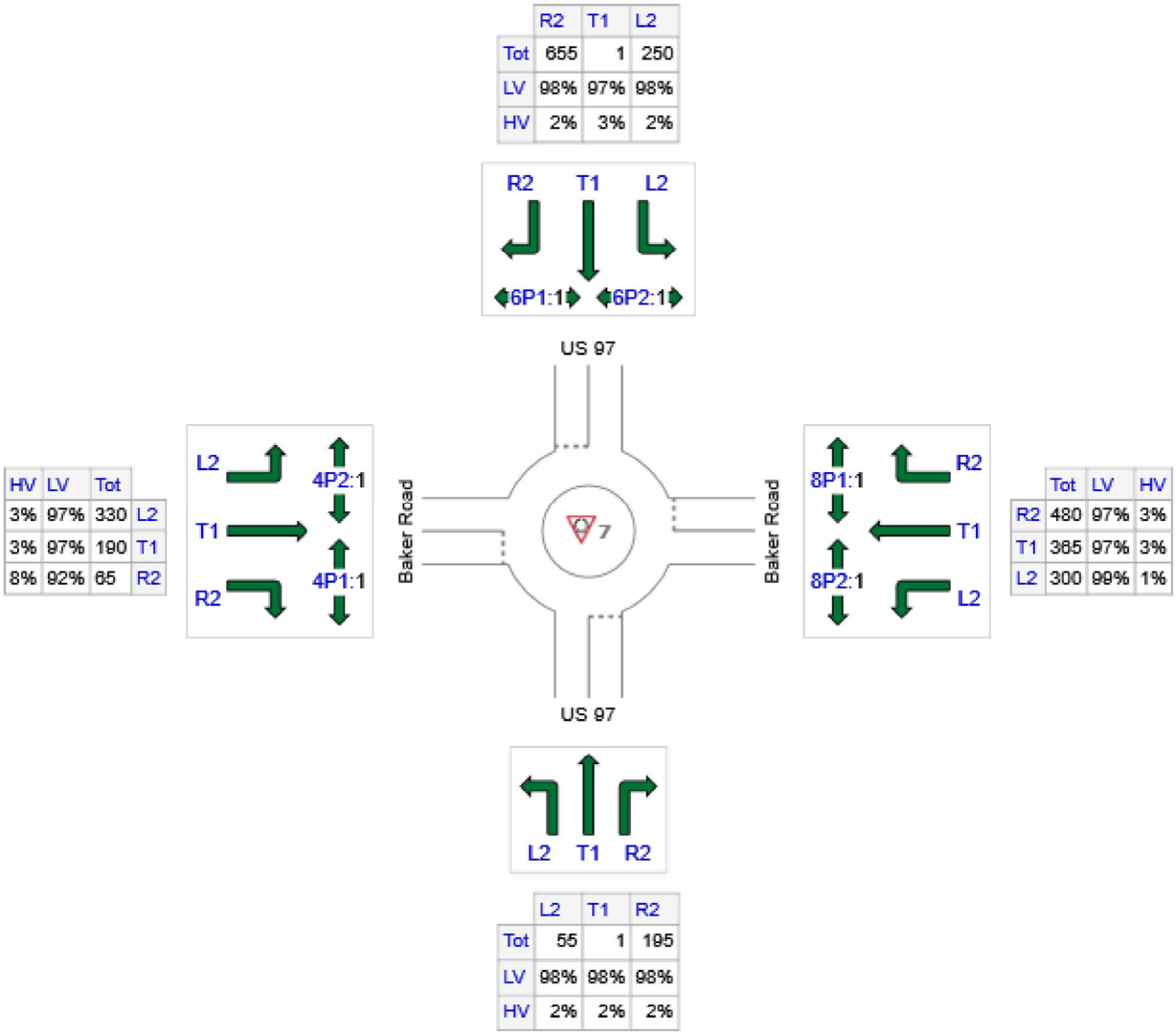
Site Layout

Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.



Input Volumes

Volume Display Method: Total and %



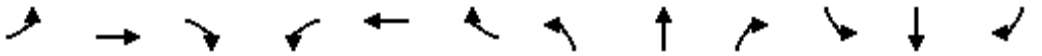
	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
S: US 97	251	246	5
E: Baker Road	1145	1117	28
N: US 97	906	888	18
W: Baker Road	585	564	21
Total	2887	2815	72

Lane Use and Performance

	DEMAND FLOWS [Total veh/h	HV] %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh	Dist] ft	Lane Config	Lane Length ft	Cap. Adj. %	Prob. Block. %
South: US 97													
Lane 1	62	2.0	600	0.103	100	7.2	LOS A	0.4	9.0	Full	1600	0.0	0.0
Lane 2[d]	214	2.0	670	0.320	100	9.5	LOS A	1.3	33.0	Short	200	0.0	NA
Approach	276	2.0		0.320		9.0	LOS A	1.3	33.0				
East: Baker Road													
Lane 1[d]	707	2.1	959	0.738	100	17.2	LOS C	10.8	273.7	Full	1600	0.0	0.0
Lane 2	511	3.0	1002	0.510	100	9.8	LOS A	3.5	89.6	Short	250	0.0	NA
Approach	1218	2.5		0.738		14.1	LOS B	10.8	273.7				
North: US 97													
Lane 1[d]	267	2.0	682	0.392	100	10.6	LOS B	1.9	48.7	Full	1600	0.0	0.0
Lane 2	697	2.0	914	0.762	100	19.2	LOS C	11.8	299.5	Short	250	0.0	NA
Approach	964	2.0		0.762		16.8	LOS C	11.8	299.5				
West: Baker Road													
Lane 1[d]	363	3.0	802	0.452	100	10.4	LOS B	2.6	67.6	Short	200	0.0	NA
Lane 2	280	4.3	792	0.354	100	8.8	LOS A	1.6	40.6	Full	1600	0.0	0.0
Approach	643	3.6		0.452		9.7	LOS A	2.6	67.6				
Intersection	3101	2.5		0.762		13.6	LOS B	11.8	299.5				

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 6).
Roundabout Capacity Model: US HCM 6.
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.

d Dominant lane on roundabout approach



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	330	190	65	300	365	480	55	0	195	250	0	655
Future Volume (veh/h)	330	190	65	300	365	480	55	0	195	250	0	655
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		0.99	1.00		1.00	1.00		1.00
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
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1709	1709	1723	1736	1709	1723	502	502	502	1723	1723	1723
Adj Flow Rate, veh/h	351	202	69	319	388	265	59	0	59	266	0	421
Peak Hour Factor	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Percent Heavy Veh, %	3	3	2	1	3	2	2	2	2	2	2	2
Cap, veh/h	438	248	85	356	478	726	66	0	150	364	0	526
Arrive On Green	0.14	0.20	0.20	0.22	0.28	0.28	0.14	0.00	0.14	0.22	0.00	0.22
Sat Flow, veh/h	3158	1218	416	1654	1709	1439	478	0	425	1641	0	1460
Grp Volume(v), veh/h	351	0	271	319	388	265	59	0	59	266	0	421
Grp Sat Flow(s),veh/h/ln	1579	0	1634	1654	1709	1439	478	0	425	1641	0	1460
Q Serve(g_s), s	7.8	0.0	11.4	13.5	15.3	8.1	8.8	0.0	7.5	10.9	0.0	16.0
Cycle Q Clear(g_c), s	7.8	0.0	11.4	13.5	15.3	8.1	8.8	0.0	7.5	10.9	0.0	16.0
Prop In Lane	1.00		0.25	1.00		1.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	438	0	332	356	478	726	66	0	150	364	0	526
V/C Ratio(X)	0.80	0.00	0.82	0.90	0.81	0.36	0.89	0.00	0.39	0.73	0.00	0.80
Avail Cap(c_a), veh/h	569	0	475	367	568	802	139	0	215	364	0	526
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	1.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	30.1	0.0	27.5	27.5	24.2	11.0	30.6	0.0	17.5	26.1	0.0	20.7
Incr Delay (d2), s/veh	4.6	0.0	4.8	22.4	6.3	0.1	14.1	0.0	0.6	6.5	0.0	7.9
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	3.1	0.0	4.6	7.2	6.5	3.7	1.2	0.0	0.7	4.5	0.0	6.9
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	34.7	0.0	32.2	49.9	30.5	11.1	44.7	0.0	18.1	32.6	0.0	28.7
LnGrp LOS	C	A	C	D	C	B	D	A	B	C	A	C
Approach Vol, veh/h		622			972			118			687	
Approach Delay, s/veh		33.6			31.6			31.4			30.2	
Approach LOS		C			C			C			C	

Timer - Assigned Phs		2	3	4		6	7	8				
Phs Duration (G+Y+Rc), s		14.0	19.5	18.7		20.0	14.0	24.2				
Change Period (Y+Rc), s		4.0	4.0	4.0		4.0	4.0	4.0				
Max Green Setting (Gmax), s		21.0	16.0	21.0		16.0	13.0	24.0				
Max Q Clear Time (g_c+I1), s		10.8	15.5	13.4		18.0	9.8	17.3				
Green Ext Time (p_c), s		0.2	0.0	1.2		0.0	0.2	2.1				

Intersection Summary												
HCM 6th Ctrl Delay			31.7									
HCM 6th LOS			C									

Intersection: 1: Apache Rd & Baker Rd

Movement	WB	NB
Directions Served	LT	LR
Maximum Queue (ft)	132	42
Average Queue (ft)	33	14
95th Queue (ft)	98	36
Link Distance (ft)	793	362
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (ft)		
Storage Blk Time (%)		
Queuing Penalty (veh)		

Intersection: 2: Cinder Butte Rd/Pocahontas Ln & Baker Rd

Movement	EB	EB	WB	WB	NB	SB
Directions Served	L	TR	L	TR	LTR	LTR
Maximum Queue (ft)	47	233	150	302	131	54
Average Queue (ft)	7	101	102	127	54	13
95th Queue (ft)	31	193	163	254	103	40
Link Distance (ft)		793		308	1092	314
Upstream Blk Time (%)				0		
Queuing Penalty (veh)				2		
Storage Bay Dist (ft)	150		125			
Storage Blk Time (%)		3	3	4		
Queuing Penalty (veh)		0	23	13		

Intersection: 3: Baker Ct & Baker Rd

Movement	EB	WB	WB	NB	NB
Directions Served	TR	L	T	L	R
Maximum Queue (ft)	31	112	113	469	290
Average Queue (ft)	2	40	7	276	92
95th Queue (ft)	16	80	69	631	368
Link Distance (ft)	308		342	926	926
Upstream Blk Time (%)				2	1
Queuing Penalty (veh)				0	0
Storage Bay Dist (ft)		250			
Storage Blk Time (%)			0		
Queuing Penalty (veh)			0		

Intersection: 5: Knott Rd & US 97 NB On Ramp

Movement	EB	EB	EB	B4	WB	WB	WB	NB	NB	SB	SB
Directions Served	L	L	TR	T	L	T	R	LT	R	LT	R
Maximum Queue (ft)	170	225	448	20	280	330	224	95	129	239	414
Average Queue (ft)	90	129	209	0	140	181	87	33	44	126	246
95th Queue (ft)	147	242	369	9	231	290	170	74	103	209	468
Link Distance (ft)			442	342		450		284		402	402
Upstream Blk Time (%)			0			0					3
Queuing Penalty (veh)			2			0					13
Storage Bay Dist (ft)	200	200			375		375		200		
Storage Blk Time (%)	0	0	9			0	0				
Queuing Penalty (veh)	0	0	29			1	0				

Intersection: 6: Scale House Rd & Knott Rd

Movement	WB	NB
Directions Served	LT	LR
Maximum Queue (ft)	17	56
Average Queue (ft)	1	12
95th Queue (ft)	22	40
Link Distance (ft)	1197	190
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (ft)		
Storage Blk Time (%)		
Queuing Penalty (veh)		

Intersection: 7: China Hat Rd & Knott Rd

Movement	EB	WB	NB	SB
Directions Served	LTR	LTR	LTR	LTR
Maximum Queue (ft)	162	362	55	265
Average Queue (ft)	58	140	20	107
95th Queue (ft)	119	354	52	207
Link Distance (ft)	1848	325	227	1110
Upstream Blk Time (%)		9		
Queuing Penalty (veh)		0		
Storage Bay Dist (ft)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 8: Parrell Rd & China Hat Rd

Movement	EB	WB	NB	NB
Directions Served	TR	L	L	R
Maximum Queue (ft)	54	86	53	162
Average Queue (ft)	6	35	19	70
95th Queue (ft)	32	74	46	127
Link Distance (ft)				285
Upstream Blk Time (%)				0
Queuing Penalty (veh)				0
Storage Bay Dist (ft)		250	150	
Storage Blk Time (%)				1
Queuing Penalty (veh)				0

Intersection: 9: US 97 & Ponderosa St/China Hat Rd

Movement
Directions Served
Maximum Queue (ft)
Average Queue (ft)
95th Queue (ft)
Link Distance (ft)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (ft)
Storage Blk Time (%)
Queuing Penalty (veh)

Intersection: 10: US 97 & Rocking Horse Ct

Movement
Directions Served
Maximum Queue (ft)
Average Queue (ft)
95th Queue (ft)
Link Distance (ft)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (ft)
Storage Blk Time (%)
Queuing Penalty (veh)

Intersection: 23: US 97 NB On Ramp

Movement	NB	NB	SB	B90
Directions Served	R	R	T	T
Maximum Queue (ft)	80	72	286	83
Average Queue (ft)	13	13	48	22
95th Queue (ft)	52	51	264	205
Link Distance (ft)	402	402	499	910
Upstream Blk Time (%)			2	
Queuing Penalty (veh)			18	
Storage Bay Dist (ft)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 25:

Movement
Directions Served
Maximum Queue (ft)
Average Queue (ft)
95th Queue (ft)
Link Distance (ft)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (ft)
Storage Blk Time (%)
Queuing Penalty (veh)

Intersection: 30: US 97

Movement	SE
Directions Served	R
Maximum Queue (ft)	142
Average Queue (ft)	81
95th Queue (ft)	123
Link Distance (ft)	308
Upstream Blk Time (%)	
Queuing Penalty (veh)	
Storage Bay Dist (ft)	
Storage Blk Time (%)	
Queuing Penalty (veh)	

Intersection: 60: China Hat Rd & Stonegate Dr

Movement	SW
Directions Served	LR
Maximum Queue (ft)	69
Average Queue (ft)	32
95th Queue (ft)	61
Link Distance (ft)	379
Upstream Blk Time (%)	
Queuing Penalty (veh)	
Storage Bay Dist (ft)	
Storage Blk Time (%)	
Queuing Penalty (veh)	

Intersection: 118: US 97

Movement	NB	NW
Directions Served	T	R
Maximum Queue (ft)	49	120
Average Queue (ft)	4	16
95th Queue (ft)	24	71
Link Distance (ft)	1148	438
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (ft)		
Storage Blk Time (%)		
Queuing Penalty (veh)		

Intersection: 120: US 97 & US 97 NB Off Ramp

Movement	SB	SB
Directions Served	T	T
Maximum Queue (ft)	25	53
Average Queue (ft)	1	4
95th Queue (ft)	13	26
Link Distance (ft)	316	316
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (ft)		
Storage Blk Time (%)		
Queuing Penalty (veh)		

Intersection: 153: US 97 & US 97 SB Off Ramp

Movement	NB	NB	NB	SB	SB
Directions Served	T	T	T	T	TR
Maximum Queue (ft)	65	130	101	551	643
Average Queue (ft)	5	30	21	26	27
95th Queue (ft)	38	97	76	331	363
Link Distance (ft)	274	274	274	3444	3444
Upstream Blk Time (%)					
Queuing Penalty (veh)					
Storage Bay Dist (ft)					
Storage Blk Time (%)					
Queuing Penalty (veh)					

Network Summary

Network wide Queuing Penalty: 103

APPENDIX C: COST ESTIMATE BREAKDOWN

Low Build

Item	Unit	Unit Price	Quantity	Cost
Asphalt Concrete Pavement	TON	$ 90	10,400	$ 936,000
Aggregate Base	TON	$ 40	18,800	$ 752,000
Concrete Sidewalk	SF	$ 20	34,600	$ 692,000
Concrete Curb	LF	$ 45	1,600	$ 72,000
Earthwork	CY	$ 10	17,800	$ 178,000
Retaining Walls	SF	$ 150	2,500	$ 375,000
Structures	LS	$ 2,150,000	1	$ 2,150,000
Signalization	LS	$ 500,000	1	$ 500,000
Drainage	5%	$ 283,000	1	$ 283,000
Illumination	5%	$ 283,000	1	$ 283,000
Signing & Striping	3%	$ 170,000	1	$ 170,000
Contingency	50%	$ 3,196,000	1	$ 3,196,000
Mobilization	10%	$ 959,000	1	$ 959,000
Maintenance of Traffic	5%	$ 479,000	1	$ 479,000
Erosion Control	2%	$ 192,000	1	$ 192,000
PE Cost	20%	$ 1,917,000	1	$ 1,917,000
CE Cost	10%	$ 959,000	1	$ 959,000
			Total	**$ 14,100,000**

Tight Urban Diamond Interchnage

Item	Unit	Unit Price	Quantity	Cost
Asphalt Concrete Pavement	TON	$ 90	15,600	$ 1,404,000
Aggregate Base	TON	$ 40	28,200	$ 1,128,000
Concrete Sidewalk	SF	$ 20	39,100	$ 782,000
Concrete Curb	LF	$ 45	2,000	$ 90,000
Earthwork	CY	$ 10	27,600	$ 276,000
Retaining Walls	SF	$ 150	5,100	$ 765,000
Structures	LS	$ 2,910,000	1	$ 2,910,000
Drainage	5%	$ 368,000	1	$ 368,000
Illumination	5%	$ 368,000	1	$ 368,000
Signing & Striping	3%	$ 221,000	1	$ 221,000
Contingency	50%	$ 4,156,000	1	$ 4,156,000
Mobilization	10%	$ 1,247,000	1	$ 1,247,000
Maintenance of Traffic	5%	$ 623,000	1	$ 623,000
Erosion Control	2%	$ 249,000	1	$ 249,000
PE Cost	20%	$ 2,494,000	1	$ 2,494,000
CE Cost	10%	$ 1,247,000	1	$ 1,247,000
			Total	**$ 18,300,000**

Southbound On/Off Ramp Flyovers with Roundabout

Item	Unit	Unit Price	Quantity	Cost
Asphalt Concrete Pavement	TON	$ 90	18,700	$ 1,683,000
Aggregate Base	TON	$ 40	33,800	$ 1,352,000
Concrete Sidewalk	SF	$ 20	34,600	$ 692,000
Concrete Curb	LF	$ 45	1,600	$ 72,000
Earthwork	CY	$ 10	81,100	$ 811,000
Retaining Walls	SF	$ 150	16,400	$ 2,460,000
Structures	LS	$ 6,790,000	1	$ 6,790,000
Drainage	5%	$ 693,000	1	$ 693,000
Illumination	5%	$ 693,000	1	$ 693,000
Signing & Striping	3%	$ 416,000	1	$ 416,000
Contingency	50%	$ 7,831,000	1	$ 7,831,000
Mobilization	10%	$ 2,349,000	1	$ 2,349,000
Maintenance of Traffic	5%	$ 1,175,000	1	$ 1,175,000
Erosion Control	2%	$ 470,000	1	$ 470,000
PE Cost	20%	$ 4,699,000	1	$ 4,699,000
CE Cost	10%	$ 2,349,000	1	$ 2,349,000
			Total	**$ 34,500,000**

Assumptions and Exclusions

1. Construction estimate represents 2021 dollars
2. ODOT bid history tabs were used to determine unit prices
3. End area method was used to estimate general excavation quantities and retaining walls. Existing topography and elevations and proposed structure depths were assumed to provide required vertical clearance
4. A 50% contingency was placed on all bid items listed, excluding Mobilization, Maintenance of Traffic, and Erosion Control
5. Mobilization, Maintenance of Traffic, and Erosion Control includes the 50% contingency for these percentage based items
6. Estimates do not include Right-of-way, engineering, construction management, or administrative costs