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Montana Department of Transportation

PO Box 201001
Helena, MT 59620-1001

Memorandum

To: Bob Vosen
District Administrator

From: Stan Brelin, PE SB
Traffic Operations Engineer

Date: July 20, 2022

Subject: Traffic Signal Warrant Study
US 93 & Bell Crossing – Victor MT

The Traffic Operations Section was requested by the Missoula District to complete a Traffic Signal Warrant Study for the intersection of US 93 & Bell Crossing located north of the City of Victor. Based on our observations and analysis **we recommend installing a roundabout at this intersection currently.**

Existing Conditions

The intersection of US 93 and Bell Crossing is a four-legged, two-way stopped controlled (TWSC) intersection north of the City of Victor in Ravalli County. US 93 is a north-south principal arterial (non-interstate) and is part of the National Highway System. This stretch of highway traverses the Bitterroot Valley connecting Missoula with multiple towns/cities to the south and eventually crosses into Idaho. Bell Crossing is an east-west minor collector that provides access to the Bitterroot River, residential properties, and ranches farther east. Bell Crossing also provides access to S-269 a north-south route roughly 2 miles east of the intersection. The Bitterroot Trail, a 50-mile-long recreational trail that connects Missoula to Hamilton, runs parallel to US 93 and crosses the west leg of the intersection. The Bitterroot Trail crossing is about 100ft long. There is no dedicated pedestrian access on any other leg of the intersection. The posted speed limit for US-93 is 70 mph and 60mph for Bell Crossing.

The northbound direction of US 93 consists of two through lanes and dedicated right and left-turn lanes. The northbound right-turn lane is an old design and does not have the desired offset to mitigate the moving sight distance concern. The southbound direction consists of a through lane, a shared through/right-turn lane, and a dedicated left-turn lane. US 93 has 11ft shoulders on either side. Both Bell Crossing approaches consist of a single shared movement lane. The westbound approach has a 3.5ft shoulder and since the eastbound leg is gravel up until the last 90ft to the intersection, there is no shoulder on this approach. Bell Crossing intersection is two-way-stop controlled with stop signs and augmented with red flashing beacons mounted on span wire located on the Bell Crossing approaches. Yellow flashing beacons are installed for the north/south

US 93 travel lanes.

Figure 1. Aerial of US 93 & Bell Crossing Intersection

Figure 2. Looking South from Bell Crossing WB at the Stop Ba

Vehicles approaching the intersection going westbound (WB) have two utility poles and some signs that are likely causing sight obstruction looking south for on coming northbound vehicles. There is similar sight obstruction for Bell Crossing eastbound (EB) looking north. Both sight obstructions can be alleviated with moving the stop bar closer to the intersection.

Figure 3. Looking South from Bell Crossing past the Stop Bar

Traffic Volumes

Automatic turning movement counts (TMCs) were taken at the intersection in June of 2020. The counts represent the three highest hourly volumes of traffic and were taken over a 12-hour period from 7AM to 7PM. The highest peak traffic volume occurred during the PM peak. Additionally, truck volumes were recorded as a percentage of the total volume with at an average of 4.6% for the intersection.

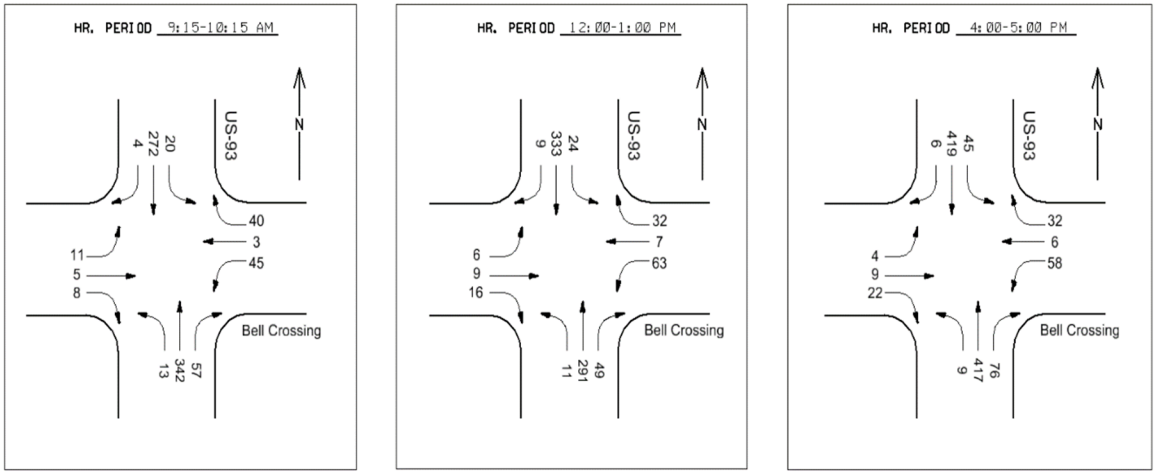

Figure 4. Peak Hour TMCs – US 93 & Bell Crossin

COVID-19 Impacts on Traffic Volumes

Data from Montana's continuous traffic counting cameras has shown that the COVID-19 pandemic has likely affected traffic volumes throughout the state. Below are two graphs of the traffic counts throughout the day at a site on US 93 10 miles south of Victor. The graph on the left is from June 3rd, 2019 and the one on the right is from June 3rd, 2020. Both dates are weekdays. The most notable difference between these two dates is the peak volumes. In 2019, the AM and PM peak 15-minute volumes were 342 and 411, respectively. In 2020, the AM and PM peak 15-minute volumes were 268 and 363, respectively. The AM peak volume decreased by 22% and the PM peak volume decreased by 12%. The total daily volume between the two dates is comparable, but their distributions are different. The 2019 graph shows a distribution with large AM and PM peaks and lower volumes in the middle of the day, while the 2020 graph shows volumes increasing throughout the day after the initial AM peak.

The differences between pre-COVID-19 and 2020 travel patterns may impact capacity analysis and volumes for the capacity analysis are adjusted accordingly as COVID-19 effects on traffic are expected to normalize back to pre-COVID-19 levels in the coming months. The volumes used in the capacity analysis will be the 2020 volumes with an adjustment factor for each peak. The AM peak will be increased by 22%, the afternoon peak will be increased by 9% and the PM peak at an increase of 12%.

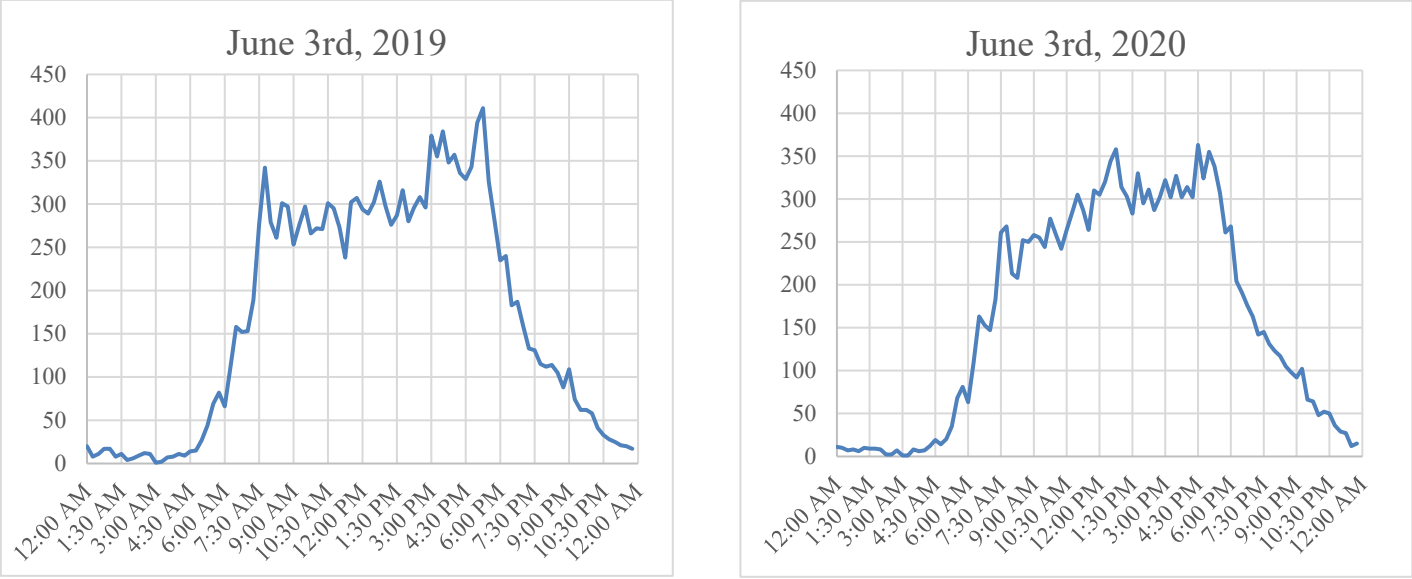

Figure 5. 2019 and 2020 Daily Traffic Volume Count

Crash History

A five-year crash history of the intersection was taken from June 15, 2015 through June 15, 2020. A total of six intersection-related crashes were recorded. Several types of crashes of different severities occurred here and are referred by their technical terms as: Property Damage Only (PDO), Possible Injury (PI), Suspected Serious Injury (SSI). Addressable crashes are highlighted in green on the table below.

Table 1. Crash Details – US 93 & Bell Crossing - Victor

Sequence	Date	Time	Weather	Road Condition	Light Condition	Crash Type	Severity
1	8/8/2016	13:50	Clear	Dry	Daylight	Sideswipe, Same Direction	PDO
2	5/24/2017	08:00	Blowing sand and dirt	Dry	Daylight	Right Angle	PDO
3	7/13/2017	15:05	Clear	Dry	Daylight	Right Angle	PI
4	12/16/2017	08:59	Fog, smog, smoke	Ice/Frost	Daylight	Roll Over	PDO
5	8/1/2018	18:39	Clear	Dry	Daylight	Right Angle	SSI
6	7/11/2019	08:50	Clear	Dry	Daylight	Right Angle	SSI

Three of the six crashes failed to see a northbound vehicle already in the intersection. The second reported crash also followed this trend, however there was significant amounts of dust in the air at the time which would degrade safety and operations regardless of choice in traffic control. This trend indicates that there may be a sight distance issue at the westbound approach that could be addressed with the addition of traffic signal control or a roundabout.

Capacity Analysis – Existing Conditions

Capacity analysis of the intersection was performed using HCS 2010 software. The AM, NOON, and PM peaks from the June 2020 count were used to calculate the v/c ratio, delay (seconds), and level of service (LOS). The growth rate was determined from data analysis of traffic volumes from the last 5 years. This allowed us to determine a projected traffic growth rate of 3.5% per year for the mainline and 1% for the minor street.

All movements originating from the northbound and southbound approaches, as well as the right-turn movements from the eastbound and westbound directions, have delays under 10 seconds, representing a LOS of 'A'. The delay for the through and left-turn movements from the eastbound and westbound approaches is between 17-25 seconds, representing a LOS of 'C'. Future analysis into the letting year for which a treatment option would be installed, showed the westbound approach with a LOS 'D'. Future analysis into the design year showed significant decreases across the minor street movement at a LOS 'F' for all peaks. The movements are not exceeding their capacity which is usually the cause for a poor LOS. The volume to capacity ratio is lower than would be acceptable at this LOS for these movements but due to the high mainline traffic they are unable to find gaps in order to complete their respective movements which increases delay and ultimately a poor LOS as a result. There are several treatment options that could address this issue.

Table 2. Capacity Analysis
US 93 & Bell Crossing – Existing Conditions – Current 2020
AM Peak Hour

AM Peak	Southbound			Westbound			Northbound			Eastbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
v/c ratio	0.04	-	-		0.15		0.02	-	-		0.09	
Delay	8.6	-	-		14.8		8.1	-	-		15.4	
LOS	A	-	-		B		A	-	-		C	

NOON Peak Hour

AM Peak	Southbound			Westbound			Northbound			Eastbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
v/c ratio	0.02	-	-		0.28		0.01	-	-		0.15	
Delay	8.2	-	-		17.6		8.1	-	-		16.0	
LOS	A	-	-		C		A	-	-		C	

PM Peak Hour

AM Peak	Southbound			Westbound			Northbound			Eastbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
v/c ratio	0.08	-	-		0.38		0.01	-	-		0.10	
Delay	8.8	-	-		22.6		8.4	-	-		16.0	
LOS	A	-	-		C		A	-	-		C	

Table 2. Capacity Analysis
US 93 & Bell Crossing – Projected Conditions – Letting 2025
AM Peak Hour

	Southbound			Westbound			Northbound			Eastbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
v/c ratio	0.05	-	-		0.20		0.03	-	-		0.12	
Delay	8.9	-	-		17.8		8.3	-	-		18.3	
LOS	A	-	-		C		A	-	-		C	

NOON Peak Hour

	Southbound			Westbound			Northbound			Eastbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
v/c ratio	0.02	-	-		0.37		0.02	-	-		0.19	
Delay	8.5	-	-		22.3		8.4	-	-		19.1	
LOS	A	-	-		C		A	-	-		C	

	Southbound			Westbound			Northbound			Eastbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
v/c ratio	0.10	-	-		0.51		0.01	-	-		0.13	
Delay	9.2	-	-		33.8		8.7	-	-		19.3	
LOS	A	-	-		D		A	-	-		C	

Table 3. Capacity Analysis
US 93 & Bell Crossing – Projected Conditions – Design 2045
AM Peak Hour

	Southbound			Westbound			Northbound			Eastbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
v/c ratio	0.18	-	-		1.04		0.08	-	-		0.66	
Delay	12.5	-	-		203		10.1	-	-		130	
LOS	B	-	-		F		B	-	-		F	

NOON Peak Hour

	Southbound			Westbound			Northbound			Eastbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
v/c ratio	0.07	-	-		0.76		0.06	-	-		0.38	
Delay	10.6	-	-		85.0		10.1	-	-		53.7	
LOS	B	-	-		F		B	-	-		F	

PM Peak Hour

	Southbound			Westbound			Northbound			Eastbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
v/c ratio	0.33	-	-		8.02		0.01	-	-		1.05	
Delay	14.7	-	-		3500		11.3	-	-		307.7	
LOS	B	-	-		F		B	-	-		F	

Traffic Signal Warrants

The 2009 edition of the Manual on Uniform Traffic Control Devices (MUTCD) states that traffic signal control may be considered if one or more of the nine traffic signal warrants are met. Due to the approach speed of US 93 and being in a rural area the 70% volume criteria was used for the warrant study.

Warrant 1 – Eight Hour Vehicular Volume – Satisfied
Condition A or B must be fulfilled for this warrant to be satisfied.
Condition A – Minimum Vehicular Volume - Not Satisfied. 5 hours met thresholds.
Condition B – Interruption of Continuous Traffic - Satisfied. 11 hours met thresholds and after discounting 75% of minor approach right-turn volume, there were still 9 satisfying hours.
Warrant 2 – Four Hour Vehicular Volume – Satisfied
This warrant had 3 satisfying hours. *Will be met in 5 years with projected traffic growth.*
Warrant 3 – Peak Hour Vehicular Volume – Not Applicable
Warrant 4 – Pedestrian Volume – Not Applicable
Warrant 5 – School Crossing – Not Applicable
Warrant 6 – Coordinated Signal System – Not Applicable
Warrant 7 – Crash Experience – Not Satisfied
This warrant requires that three criteria be fulfilled for the warrant to be met. The three criteria are as follows:

- Warrant 1, Conditions A or B must be satisfied (fulfilled)
- Remedial measures have failed to reduce crash frequency (not fulfilled)
- Five or more reported crashes, of types susceptible to correction by a signal, have occurred within a 12-month period (not fulfilled)

Warrant 8 – Roadway Network – Not Applicable
Warrant 9 – Intersection Near a Grade Crossing – Not Applicable

Improvement Options

Three intersection treatment options were considered viable for further inspection and are listed below:

Alternative 1: Traffic Signal Control
Alternative 2: Roundabout
Alternative 3: Restricted Crossing U-Turn (RCUT)

Alternative 1: Traffic Signal Control

The implementation of a traffic signal at the intersection was modeled using Synchro 11 software. A capacity analysis was then performed, again using HCM software. The same AM, midday, and PM peaks from the June 2020 count were used to calculate the v/c ratio, delay, and level of service.

A protected left-turn phase evaluation was done at the intersection. The Left-Turn Treatment Worksheet from the Highway Capacity Manual 2010 recommends protected left-turn phasing if the cross product exceeds 50,000 or if the left-turn volume exceeds 240vph for left-turns that must cross one opposing lanes. This intersection did not meet the volume thresholds or cross products to justify a protected left-turn and was modeled as permissive only. Additionally, dedicated left-turn bays were added to the westbound and eastbound approaches to improve capacity and are recommended. Without these lanes, capacity in the design year has a LOS 'D' for both left-turn movements.

Finally, the westbound and eastbound approaches are currently offset by roughly 25 feet. The approaches would need to be realigned in order to eliminate the left-turn conflict that currently exists. The westbound approach could be moved to the south by roughly 12 feet and the eastbound moved north by roughly the same distance and this should fix the offset. A conceptual drawing is attached in the appendix for these modifications.

Nearly every movement during all peak hours have a LOS 'A' or 'B' for the letting year, showing improvement over the current TWSC layout. The design year yielded decreases in LOS but still maintained a LOS 'C' or better for all movements on all peaks.

Table 5. Capacity Analysis
US 93 & Bell Crossing – Signal Implementation – Design 2045
AM Peak Hour

	Southbound			Westbound			Northbound			Eastbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
v/c ratio	0.27	0.45	0.45	0.13	0.30		0.14	0.53	0.18	0.10	0.12	
Delay	9.9	5.2	5.2	16.8	17.4		7.3	5.4	4.1	17.2	16.3	
LOS	A	A	A	B	B		A	A	A	B	B	

NOON Peak Hour

	Southbound			Westbound			Northbound			Eastbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
v/c ratio	0.11	0.47	0.47	0.15	0.35		0.10	0.46	0.14	0.07	0.15	
Delay	7.5	5.5	5.5	16.1	16.8		7.6	5.3	4.2	16.3	15.6	
LOS	A	A	A	B	B		A	A	A	B	B	

PM Peak Hour

	Southbound			Westbound			Northbound			Eastbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
v/c ratio	0.46	0.66	0.66	0.27	0.42		0.02	0.70	0.25	0.02	0.72	
Delay	9.4	9.5	9.5	21.4	21.3		8.4	11.8	8.9	20.8	19.7	
LOS	A	A	A	C	C		A	B	A	C	B	

The traffic signal control option also allows for improved pedestrian and cyclist accessibility/connectivity. The Bitterroot trail is located adjacent to westside of the intersection and has a crossing on the eastbound approach. Bell Crossing crosses the Bitterroot River 3000 feet east of the US-93/Bell Crossing intersection and has a popular river access site at this crossing. Due to the lack of enhanced crossing opportunities for pedestrians and cyclists nearby, this traffic signal would provide an improved crossing location that is not available until the next traffic signal, which is in Victor roughly 2 miles away.

Additionally, traffic signal control would need advanced warning flashers since this is a high-speed location. The advanced warning flashers would have to either favor truck or car traffic since both have different stop distances. These advanced warnings will cause some confusion/grievances due to only one vehicle type being accommodated.

Roundabout Option

While considering signalization, installation of a roundabout was also explored. The chart below summarizes the capacity analysis of the intersection if a roundabout were to be implemented. A roundabout offers similar LOS improvements compared to traffic control but does better than traffic signal control during the design year. The roundabout was designed with two circulating lanes on the minor legs in order to accommodate the two through lanes on US-93. Singular circulating lanes are located on the US-93 legs. Bell Crossing's approaches will be a single lane shared with all three movements. US-93 will have a shared left-through and a shared right-through lane. A layout of the proposed roundabout is given below:

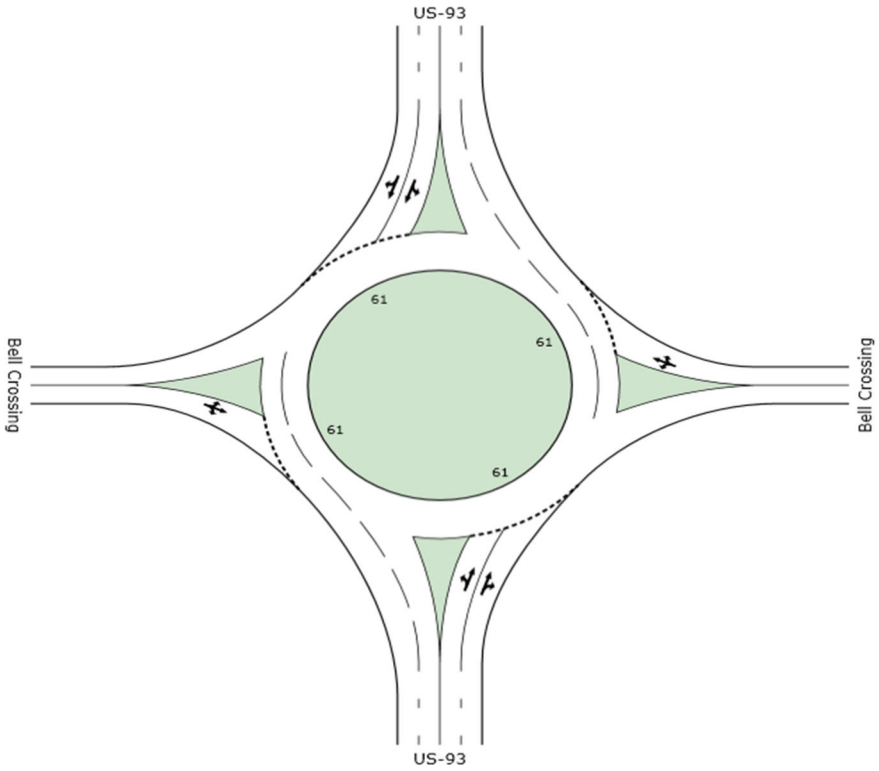

Figure 6. Proposed roundabout layout

Construction is likely to be more complicated at the current intersection's location due to the proximity of the electrical substation located immediately in the northeast quadrant of the intersection. This roundabout would have to be shifted from its currently location to the southwest quadrant in order to avoid impacting the substation. However, unlike traffic signal control the eastbound/westbound legs do not have to be offset in order to line up with the roundabout. Installation of a roundabout would include a splitter island on the east leg approach, this splitter island would have to be opened to allow access to the electrical substation unless the approach could be relocated.

The better capacity outcomes for the roundabout into the design year allows us to recommend it over traffic signal control.

Table 6. Capacity Analysis
US 93 & Bell Crossing – Roundabout – Design 2045
AM Peak Hour

	Southbound			Westbound			Northbound			Eastbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
v/c ratio	0.26			0.10			0.34			0.05		
Delay	3.9			8.9			3.7			9.7		
LOS	A			A			A			A		

PM Peak Hour

	Southbound			Westbound			Northbound			Eastbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
v/c ratio	0.41			0.16			0.35			0.05		
Delay	4.0			9.3			3.5			7.5		
LOS	A			A			A			A		

Alternative Intersections - RCUT

This location was assessed for the feasibility of installing a Restricted Crossing U-Turn (RCUT) also called superstreet intersection. RCUT directs minor road traffic to a right turn only unto the mainline and in order to make a left-turn the user must drive a short distance downstream after making a right-turn where a dedicated U-turn is located. This occurs on both approaches on for minor street while the mainline can either be a free movement or signalized. The U-turn movements can also be either yield controlled, stop controlled or signalized. The benefits of a RCUT include a reduction in intersection conflict points, and a reduction in crash rates and crash severity. RCUT's do add more delay to the minor left-turn due to the longer distance and more movements required in order to complete the turn. All other movements are not impacted from the existing two way stop control. For the intersection of study, adding more delay to the left-turn is not preferrable as this movement will experience significant delay in the future from traffic growth. Additionally, just south of the intersection the road changes from the current five-lane typical to a four-lane typical. This lack of a median means significant right-of-way acquisition in order to create enough median space for a U-turn. There were no operational or safety issues identified that would justify an RCUT over traffic signal control.

The RCUT treatment option is not carried forward.

Summary

An advantage/disadvantage matrix was created in order to summarize the available information on both traffic signal control and roundabout treatment options. The RCUT was omitted from the matrix due to not being practical or feasible at this location. The matrix weighs the possible advantages and disadvantages of each treatment option for this location specifically. The roundabout was chosen as the preferred option over traffic signal control due to a reduction of speed at this location which will reduce the likelihood of high-speed crashes, its capacity outcomes were the best and will not require advanced warning flashers which have some shortcomings.

Traffic Signal Control		**Roundabout**	
Advantage	Disadvantage	Advantage	Disadvantage
Fastest construction time of all options	Minor street realignment	Speed reduction at a high-speed location	Intersection will need shifting
Smaller R/W acquisition	Requires advanced warning flashers	Minor street alignments preserved	Likely more expensive option
Future flexibility in lane/phase changes	Minor street requires turn bays	Best capacity out of all options	
	Does not inherently reduce speed at location. Right angle crashes may still be severe	No advanced warning flashers required	

Conclusions

- Traffic Signal Warrant 1 is met, even after discounting 75% of the minor approach right-turn volumes.
- Traffic Signal Warrant 2 is not currently met but will be met in five years.
- Three reported crashes that could be addressed with either roundabout or traffic signal control were recorded over the last five years.
- Existing conditions has both Bell Crossing approaches at a LOS ‘C’ or better and US-93 approaches at a LOS ‘A’.
- Projected capacity at the intersection in five years has Bell Crossing westbound approach at a LOS ‘D’ or better.
- Design year capacity at the intersection has both Bell Crossing approaches at a LOS ‘F’ or better.
- RCUT is valid option but due to a lack of addressable crashes and right-of-way constraints is not feasible at this location.
- The roundabout offers superior LOS improvements over traffic signal control, however, both yield acceptable results.
- Roundabout and traffic signal control have similar safety enhancements.
- Traffic signal control offers the greater flexibility, acceptable LOS and pedestrian access.
- Roundabout offers the best capacity outcomes, a great safety profile and will not require additional safety features like advanced warning flashers.

Recommendation

The roundabout option was determined to provide the best operations and safety performance at this location, and we recommend that should be installed at this location.

Please call Joe Zody at 444-7295 if you have any questions

cc: Bob Vosen - Missoula District Administrator
Glen Cameron – District Traffic Engineer
Patricia Burke – Safety Management Engineer
Joe Zody – Traffic & Safety
Brenden Borges – Traffic & Safety