Memorandum

Client:	Port of Seattle
Project:	Sustainable Airport Master Plan (SAMP) Environmental Document – Surface Transportation
Subject:	Preliminary Intersection Control Evaluation SR 518 EB Off-Ramp at 51st Avenue S (Network 4)
Submit to:	Christina Strandt, WSDOT
Submitted by:	Zach Wieben, Concord Engineering
Date:	January 30, 2024

1. Introduction and Overview

As part of the response to WSDOT's review of the Sustainable Airport Master Plan (SAMP) Traffic Analysis, Concord has completed a preliminary Intersection Control Evaluation (ICE) for the SR 518 EB Off-Ramp at 51st Avenue S intersection. The results of the preliminary ICEs performed for this phase of the SAMP are meant to confirm the feasibility of the recommended control.

Final selection of intersection control type will be determined when an updated ICE report is conducted at the time of building permit application, if needed. This will include updated transportation information and any changes to area context.

All steps required for ICE analysis from the WSDOT Design Manual 1300.05(3) will be completed as part of the Port of Seattle's permitting process at the time of development application, if needed. As required in DM 1300.05(3), a roundabout was assumed to be the default option and is the basis for which other alternatives are compared to.

1.1. Study Area and Intersections

Figure 1 shows the study intersection and surrounding area. The ICE analyses will include adjacent intersections to determine potential queue spillbacks or other network impacts. The extents of the network to be analyzed is identified below:

41. SR 518 EB On-Ramp @ 51st Ave S
42. SR 518 EB Off-Ramp @ 51st Ave S

1.2. Modeling and Analysis Assumptions

The modeling and analysis assumptions in this preliminary ICE were confirmed with WSDOT through a Methods and Assumptions document dated 11/02/2023. Study scenarios for the traffic operational analysis match those in the SAMP Traffic Analysis for the 2032/2037 No Action/Proposed Action PM peak hours.

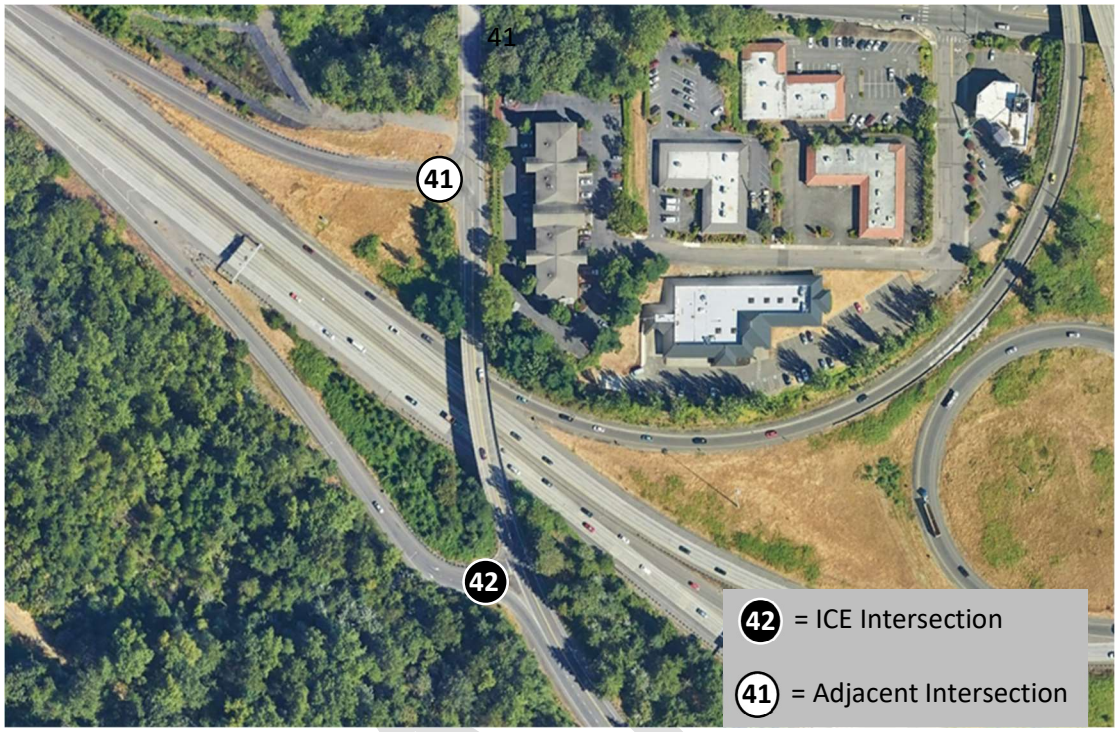

Figure 1 – Network 4 Study Intersections

2. Background and Project Needs

2.1. Background

The intersections included in this preliminary ICE were included in the SAMP Traffic Analysis supporting future SEA Airport expansion. The expansion/relocation of airport facilities identified in the SAMP are needed to serve expected future passenger demand. Increased vehicle volumes at intersections surrounding SEA Airport are expected as a result and improvements are being analyzed to keep intersection operations at LOS D or future baseline (without SAMP) levels of service.

2.2. Baseline and Contextual Needs

The intersection of SR 518 EB Off-Ramp and S 154th Street is expected to operate at acceptable LOS C in the 2032 No Action and LOS D in the 2037 No Action scenarios. The intersection is only expected to exceed LOS D in the 2037 Proposed Action scenario. This preliminary ICE attempts to identify the preferred improvement alternative that would mitigate LOS impacts while supporting other safety and mobility goals.

The baseline needs for the intersection analyzed are listed below. These needs occur at all WSDOT intersections and are required to be addressed when comparing intersection control alternatives:

- Reduce serious injury and fatality collisions
- Provide continuous pedestrian and non-motorized facilities
- Efficient and effective vehicle traffic operations

The contextual needs for the SR 518 and 51st Avenue S. Eastbound Off-ramp are developed based on specific site characteristics. These needs can vary depending from location to location. The contextual needs of all intersections studied for ICEs as part of the SAMP are listed below:

- Support mobility of road users/modes including freight and transit
- Reduce/minimize impact to critical areas
- Reduce/minimize need for additional right-of-way (ROW)

2.3. Existing conditions

The SR 518 Eastbound Off-Ramp and 51st Avenue S intersection currently serves 1680 vehicles in the PM peak hour and operates at LOS C. Existing PM peak hour volumes at the study intersections are shown in Figure 2. Table 1 summarizes the existing LOS of the study intersections.

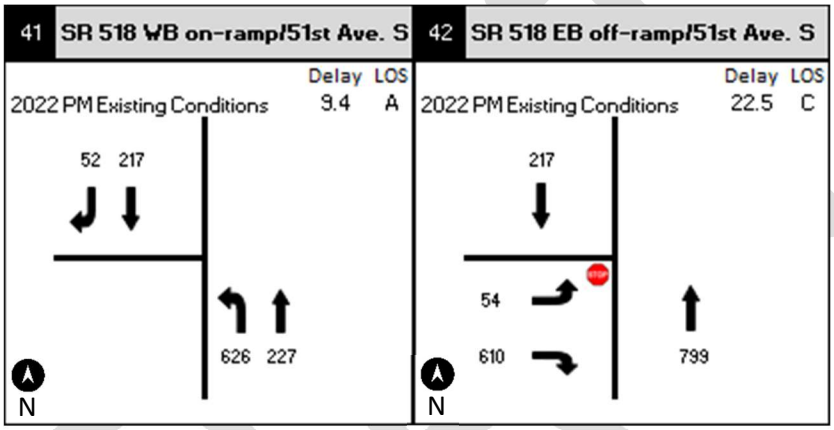

Figure 2 – Existing PM Peak Hour Volumes

Table 1: Existing Level of Service – PM Peak Hour

ID	Intersection	Jurisdiction	Control Type	LOS	Delay
41	SR 518 EB On-Ramp @ 51st Ave S	WSDOT	TWSC	B	9.4 sec (NB Left)
42	**SR 518 EB Off-Ramp @ 51st Ave S**	**WSDOT**	**OWSC**	**C**	**22.5 sec (EB Left)**

OSWC = One-Way Stop Control

TWSC = Two-Way Stop Control

51st Avenue S. is classified as a 2-3-lane Urban Major Collector with a posted speed limit of 30 mph. The roadway does not have pedestrian facilities. The site vicinity is not served by any transit services and is not used by any routes. The area does not have any significant pedestrian/non-motorized trip generators and is generally constrained by steep slopes on all sides.

The intersection of SR 518 EB Off Ramp and 51st Avenue S has an existing collision rate of 1.53 collisions per million entering vehicles (MEV). Front to rear collisions were the most common collision type reported at the intersection. There were no fatality collisions and three serious injury collisions reported in the five years of collision data review.

2.4. Alternatives Considered

The alternatives considered in this preliminary ICE were a signal or roundabout. WSDOT also requested a practical design concept of additional eastbound left turn queue storage on the off-ramp and enhanced pedestrian facilities at the intersection. A final ICE will be completed by the Port at the time of building permit application if required. This preliminary ICE is meant to inform future decisions about the ultimate intersection control chosen.

3. Feasibility

3.1. Alternatives

Baseline Design

Preliminary baseline design would maintain the existing intersection control and stop control on the eastbound leg of the SR 518 eastbound off-ramp to 51st Avenue S. The off-ramp is a single lane from the gore point until it approaches the intersection where the right turn separates into a free flow add lane which merges into a single southbound lane approximately 250 feet south of the intersection.

In addition to the existing stop-control intersection, an enhanced stop-controlled intersection was also considered as a potential improvement. This modification to the existing stop-control would extend queue storage for the critical eastbound left turn movement to prevent queue spill back that would block the higher volume eastbound right turn movement. Preliminary estimates from aerial imagery showed there could be approximately 380 feet of separated storage from the eastbound left turn stop bar back to where there was at least 28 feet of pavement width on the eastbound off-ramp.

Roundabout Design

Preliminary design for the roundabout alternative was developed based on the minimum lane configuration required for desired LOS and v/c. The intersection would operate acceptably according to WSDOT guidelines for LOS and volume-to-capacity ratios as a single circulating roundabout with single entering lanes on all approaches. The roundabout would accommodate up to a WB-67 design vehicle with a truck apron outer diameter of 88 feet and an inscribed circle diameter of 120 feet. The circulating lane width would be 16 feet and all entering lanes would be 16 feet in width.

Construction of the roundabout would be constrained by the 51st Avenue S overpass to the north. The placement of the roundabout was done so as not to require any changes to the 51st Avenue S overpass and to accommodate WB-67 design vehicle. This placement would require a 10’ cut wall on the southwest side of the intersection and a 10’ fill wall on the east side of the intersection. WSDOT also indicated a compact roundabout could be a practical design alternative to the regular single-lane roundabout that might reduce the intersection footprint required. The constructability for both roundabout options would need to be confirmed through an engineering evaluation that accounted for the slope stability around the intersection. A sketch of the preliminary design is shown in Figure 3.

Figure 3 – Network 4 Roundabout Concept

Signal Design

Preliminary design for the signal alternative was developed based on the minimum lane configuration required for desired LOS. The signal would operate with an 80-second uncoordinated signal. Removal of the eastbound right-turn slip lane was assumed to reduce vehicle speed and enhance pedestrian and non-motorized safety. The eastbound approach would only be activated by eastbound left vehicles and eastbound right turn vehicles would dwell in a protected green phase unless activated by conflicting pedestrian and vehicle movements. A sketch of the preliminary design is shown in Figure 4.

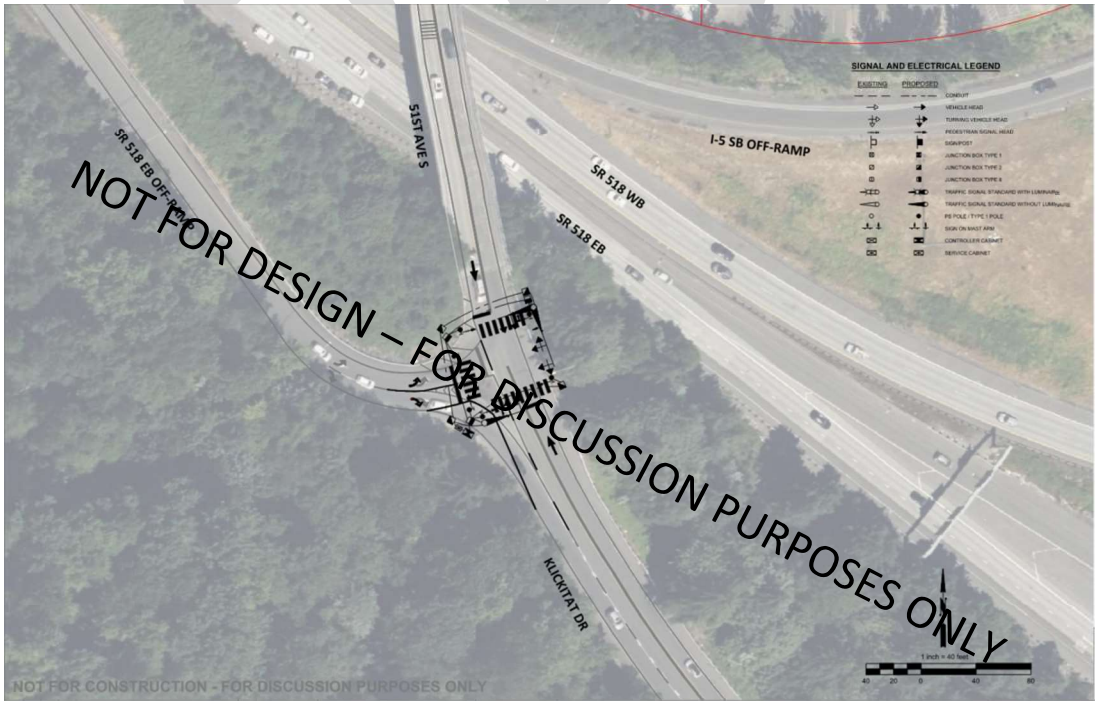

Figure 4 – Network 4 Signal Concept

3.2. Qualitative Assessment

Both the signal and roundabout would address the baseline needs identified. Each would improve safety for all users compared, provide non-motorized and pedestrian crossing facilities, and improve vehicular traffic operations. The existing intersection control would not address the baseline need of effective and efficient vehicle operations and was therefore not considered a viable future alternative. The enhanced stop-control alternative would only partially address the baseline needs of improved safety for all users and improve vehicular operations. This alternative still assumes the existing eastbound right-turn slip lane and only attempts to provide additional queue storage for the eastbound left turn movement rather than addressing the experienced delay of the movement at the intersection.

Contextual needs were evaluated for each of the alternatives. Both the signal and roundabout alternative would be able to provide marked pedestrian crossings. Both the signal and roundabout were designed to accommodate freight movements up to a WB-67 vehicle. The signal alternative is not expected to have any additional impact on critical areas or ROW. Both roundabout options (typical single-lane and compact) could require expanding the existing intersection footprint and/or cut and fill retaining walls. This potential impact to critical areas could increase construction costs depending on the stability of the hillside. All alternatives could be constructed within existing WSDOT ROW.

Table 2: Contextual Needs Qualitative Assessment

Contextual Need	Enhanced Stop-Control	Roundabout	Signal
Active Transportation Mobility	-	+	/
Freight Mobility	-	/	+
Minimizes Impact to Critical Areas	+	-	+
Minimize Need for Additional ROW	/	/	/

+ = Better
/ = Neutral
- = Worse

The estimated construction cost of each design alternative is summarized in Table 3. These planning level cost estimates for 2032 assuming a 5% annual inflation rate and will need to be verified during the final design process. The signal was shown to have the lower estimated construction cost of the two options that would address baseline needs. Costs for the practical design solution of extending the eastbound left turn pocket and additional pedestrian crossing enhancements are expected to be approximately $600,000.

Table 3: Design Alternatives Preliminary Construction Cost Estimates

ID	Intersection	Enhanced Stop-Control	Roundabout	Signal Design Cost
42	SR 518 EB Off-Ramp @ 51st Ave S.	$600,000	$7.6 Million	$1.5 Million

4. Operational and Safety Performance

4.1. Operational Analysis

Traffic operational analyses were conducted for the PM Peak hour using Synchro Version 11.1 Build 1 for signalized, stop controlled, and uncontrolled intersections and Sidra 9.0 for roundabouts. Results from Synchro follow WSDOT's *Synchro & SimTraffic Protocol (2018)*. Results from Sidra follow WSDOT's *Sidra Policy Settings*.

Level of service for the study intersections was determined using the overall intersection average delay per vehicle for signals, roundabouts, and all-way stop controlled intersections. Level of service for other unsignalized intersections was reported the movement/approach with the highest average delay per vehicle. The LOS standard for WSDOT intersections is LOS D. Additionally, volume-to-capacity (v/c) ratios for the roundabout alternatives were also calculated. WSDOT identifies a v/c ratio of 0.90 when additional analysis may be required. 95th-percentile queue lengths from SimTraffic and Sidra were also reported.

Preliminary LOS analysis for the different design alternatives were analyzed for the 2032 and 2037 analysis years even though the intersection is not expected to exceed a LOS D until 2037. PM peak hour turning movement volumes for the 2032 and 2037 analysis years came directly from the SAMP Traffic Analysis Proposed Action alternative. Traffic volumes are shown in graphic form in Figure 5. Table 4 summarizes the 2032 and 2037 PM peak hour LOS analysis.

The level of service analysis shows the SR 518 EB Off-Ramp at 51st Avenue S intersection would operate at LOS E in the 2037 Planned Action scenario under baseline conditions. The roundabout would improve the intersection LOS to LOS A and the signal would improve intersection LOS to LOS B when analyzed as an isolated intersection. It should be noted however queue spillback from the northbound lanes at the SR 518 WB On-Ramp intersection are expected to result in a 17.2% reduction in capacity for the northbound leg and a 1.6% reduction in capacity for the eastbound leg when the roundabout is modeled as part of a Sidra Network system. The roundabout would operate at LOS C overall when modeled in a network setting with a critical v/c of 0.93 and the intersection would operate at a LOS D when analyzed as a signal in SimTraffic. Delay, v/c, and queue results reported in Table 4 and 5 represent isolated roundabout analysis. Figure 6 shows the lane blockage probability of the roundabout concept.

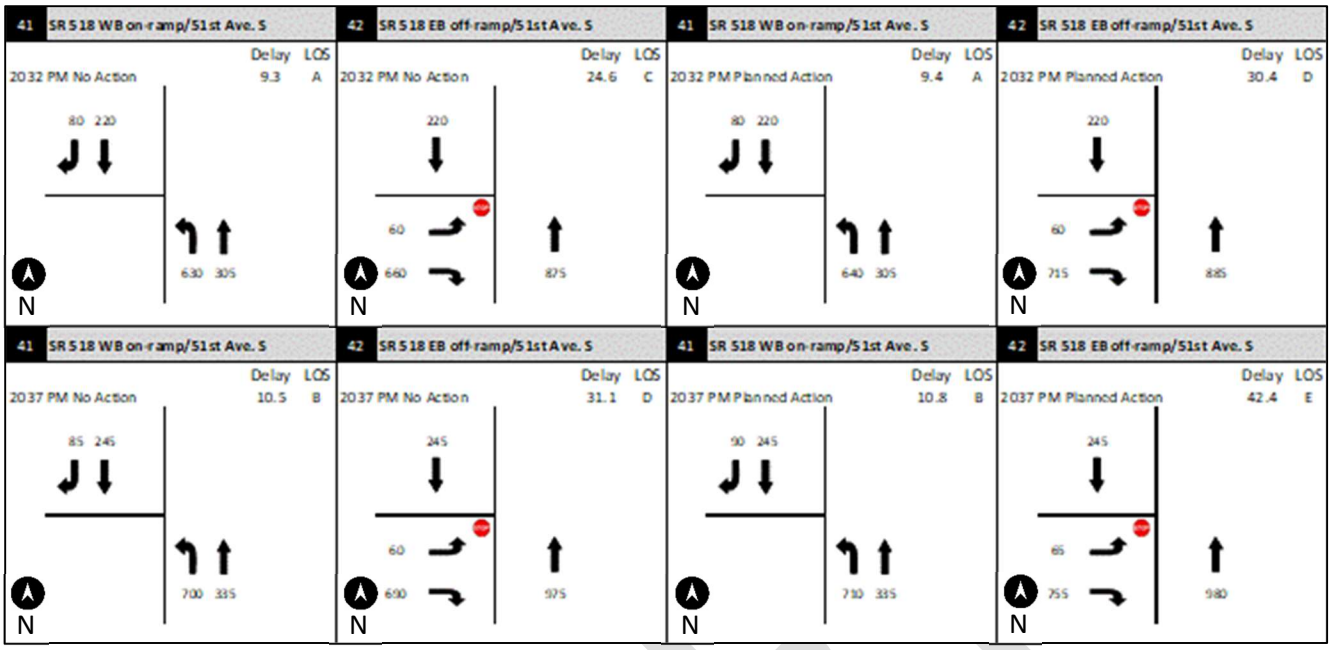

Figure 5 – 2032 and 2037 PM Peak Hour Volumes

Table 4: PM Peak Hour Preliminary LOS Results – Network[1]

Intersection	2032 No Action						2032 Proposed Action					
	Baseline		Roundabout		Signal		Baseline		Roundabout		Signal	
	LOS	Delay (sec)	LOS	Delay (sec)	LOS	Delay (sec)	LOS	Delay (sec)	LOS	Delay (sec)	LOS	Delay (sec)
SR 518 EB Off-Ramp @ 51st Ave S.	C (EBL)	24.6	B	11.7	B	12.0	D (EBL)	30.4	B	12.8	B	13.0
Intersection	**2037 No Action**						**2037 Proposed Action**					
	Baseline		**Roundabout**		**Signal**		**Baseline**		**Roundabout**		**Signal**	
	LOS	**Delay (sec)**	**LOS**	**Delay (sec)**	**LOS**	**Delay (sec)**	**LOS**	**Delay (sec)**	**LOS**	**Delay (sec)**	**LOS**	**Delay (sec)**
SR 518 EB Off-Ramp @ 51st Ave S.	D (EBL)	31.1	C	20.0	D	43.2	E (EBL)	42.4	C	23.0	D	47.9

[1]Baseline delays are same as reported from HCM results. Roundabout and signal delays are reported from SimTraffic/Sidra Network analysis.

Table 5: PM Peak Hour 95th-Percentile Queues and v/c Results [ft] – Network[1]

Intersection	Scenario	Baseline				Roundabout				Signal			
		EB	WB	NB	SB	EB	WB	NB	SB	EB	WB	NB	SB
SR 518 EB Off-Ramp @ 51st Ave S.	2032 No Action	219 0.80	-	0 0.51	0 0.13	174 0.65	-	238 0.71	0 0.17	162 0.51 (EBR)	-	277 0.67	168 0.64
SR 518 EB Off-Ramp @ 51st Ave S.	2032 Proposed Action	282 0.87	-	0 0.52	0 0.13	250 0.70	-	248 0.73	0 0.17	262 0.56 (EBR)	-	291 0.67	166 0.64
SR 518 EB Off-Ramp @ 51st Ave S.	2037 No Action	276 0.87	-	0 0.57	0 0.14	256 0.70	-	328 0.91	0 0.19	250 0.56 (EBR)	-	1602 0.74	180 0.68
SR 518 EB Off-Ramp @ 51st Ave S.	2037 Proposed Action	374 0.95	-	0 0.58	0 0.14	380 0.76	-	340 0.93	0 0.19	439 0.62 (EBR)	-	1560 0.75	172 0.69

[1]Baseline queues and baseline/signal v/c's are same as reported from HCM results. Roundabout and queues and v/c's are reported from Sidra Network analysis. Signal queues are reported from SimTraffic.

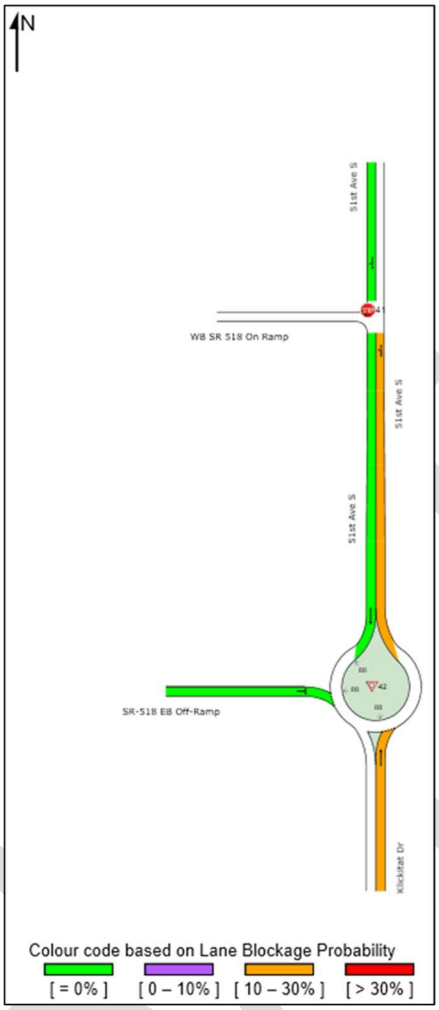

Figure 6 – Network 4 Lane Blockage Probability

4.2. Safety Analysis

A review of the existing collision data for the SR 518 EB Off-Ramp at 51st Avenue S intersection was performed for the five-year period from 2018 through 2022. The intersection had a collision rate of 1.53 per million entering vehicles and a collision frequency of 9.4 collisions per year. There were zero fatality and two severe injury collisions reported over the five years of data reported. Of the 47 collisions reported in that time, 17 involved a vehicle from the off-ramp attempting to make a left turn on 51st Avenue S. These types of collisions could be reduced by installing intersection control.

Changing the intersection control from stop-control to a roundabout could change the existing collision patterns through the following crash modification factors: 32.8% reduction in fatal and injury collisions[1] and a 24.4% reduction in total crashes[2]. The crash modification factors are specific to ramp terminal intersections. A roundabout is an intersection with a circular configuration that safely and efficiently

[1] https://www.cmfclearinghouse.org/detail.cfm?facid=9449
[2] https://www.cmfclearinghouse.org/detail.cfm?facid=9445

moves traffic. Roundabouts feature channelized, curved approaches that reduce vehicle speed, entry yield control that gives right-of-way to circulating traffic, and counterclockwise flow around a central island that minimizes conflict points. The net result of lower speeds and reduced conflicts at roundabouts is an environment where crashes that cause injury or fatality are substantially reduced.

Changing the intersection control from stop-control to a signal could change the existing collision patterns through the following crash modification factors: 21.8% reduction in fatal and injury collisions[3] and a 16% reduction in total crashes[4]. These crash modification factors are not specific to ramp terminals and apply to general intersections converted from stop control to signal control.

5. Alternatives Evaluation

WSDOT's default assumption for an ICE is a roundabout due to their greater sustainability. The greater sustainability results from lower maintenance costs, reduced crashes and severity, improved vehicular delay, and natural traffic calming for increased safety of non-motorized modes.

A qualitative comparison of the roundabout and signal alternatives to the existing intersection control was performed based on the analysis documented in this report. Both the roundabout and signal would provide improved LOS operations, however the roundabout is expected to experience some capacity reduction because of queues spilling back from the westbound on-ramp intersection. Queue spillback could impact operations within the circulating lane of the roundabout. The roundabout is expected to perform better from a safety perspective. The signal is expected to cost $6.1 million less than the roundabout option with a smaller footprint in a steep slope area. Evaluation of practical solutions for the intersection, such as a compact roundabout or extending the eastbound left turn queue storage, could achieve some or all of the baseline and contextual needs at a cheaper cost. This evaluation would need to occur simultaneously as evaluation of steep slopes in the area that could provide further insight if a roundabout or signal is feasible. Neither the roundabout nor signal would impact adjacent intersections with queues. Table 6 summarizes the qualitative comparison of the design alternatives.

[3] https://www.cmfclearinghouse.org/detail.cfm?facid=9146
[4] https://www.cmfclearinghouse.org/detail.cfm?facid=9144

Table 6: Qualitative Assessment

Intersection	Unsignalized (Baseline)	Unsignalized (Extended Storage)	Roundabout	Signal
Operations	-	-	/	+
Safety	-	-	+	+
Active Transportation	-	+	+	/
Resiliency	/	/	+	-
Financial Stewardship	/	/	+	-
Freight Mobility	-	-	/	+
Minimizes Impact to Critical Areas	+	+	-	+
Minimizes Need for Additional ROW	/	/	/	/

+ = Better

/ = Neutral

- = Worse

6. Selection

Based upon preliminary evaluation the signal will be advanced as the preferred alternative in the future final ICE documentation due to the expected lower construction cost compared to constructing a roundabout in the steep slope area. WSDOT noted during initial review of the roundabout concept that a compact roundabout may be feasible for the intersection and should be evaluated in the future after an evaluation of the steep slopes in the area has been conducted. Additionally, the practical solution concept of extending the eastbound queue storage could improve interactions between eastbound vehicles if eastbound left turns are experiencing high levels of delay. This alternative should also be evaluated further in the future to understand if incremental improvements such as this may achieve the desirable baseline and contextual needs. It should be noted that the selection of this report does not constitute the final decision for future intersection control. This report only confirmed the feasibility of both the roundabout or signal alternative to mitigate future impact of the SAMP Planned Action. Final selection of intersection control type will be determined when a final ICE report is conducted at the time of building permit application, if needed.

Note: The intersection control concepts or drawings are only intended to determine basic intersection feasibility and are not considered approved geometric or lane configurations. Once the traffic control decision is finalized during building permit application the geometric design and lane configuration will be optimized to meet the site context, current practices, and WSDOT Design Policy.

Appendix A – Preliminary Roundabout and Signal Concepts

Appendix B – Delay and Queuing Results