BROADMOOR INTERCHANGE PROJECT

ACCESS REVISION REPORT

DECEMBER 2022

PREPARED FOR:

THE CITY OF PASCO

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EXECUTIVE SUMMARY

The City of Pasco has experienced sustained growth west of US 395 and north of Argent Road for the last 15 years. As new commercial and residential developments continue to advance towards the Columbia River, formerly rural roadway corridors have become strained due incoming urban traffic patterns and uses. The City has continued to address these issues by expanding and modernizing rural facilities to support heavier traffic and increased bicycle and pedestrian usage, as well as construction new roadways that include amenities for all modes of travel. Broadmoor Blvd, also known as Road 100, is one of the formerly rural facilities that the City is rapidly upgrading to serve as a primary arterial corridor. Incoming growth in the Broadmoor Area (shown in Figure 1) will include further expansion and improvement to Broadmoor Blvd.

FIGURE 1: BROADMOOR INTERCHANGE LOCATION

The I-182 and Broadmoor Blvd interchange provides a critical connection between the regional freeway system and both current and planned land uses in western Pasco. In addition, this interchange currently provides one of the few north-south connections across I-182 for all modes of travel. The traffic safety, bicycle and pedestrian connectivity, and traffic operations of the Broadmoor Interchange are critical to sustaining the City's Comprehensive Plan Goals for western Pasco. To this end, an Access Revision Report (ARR) has been completed in accordance with

Washington Department of Transportation (WSDOT) requirements to determine the needed improvements to the Broadmoor Interchange.

The purpose of this project is to **reduce congestion** at the I-182 off-ramp diverges and terminals on Broadmoor Blvd, caused by the growth of the Broadmoor Area identified in the City of Pasco Comprehensive Plan. Additionally, this project is intended to **improve traffic safety** on the I-182 off-ramps and ramp terminals at Broadmoor Blvd. The project will also **improve the active transportation facilities** along Broadmoor Blvd through the I-182 interchange which currently is a critical gap in the City's active transportation network.

The project purpose is driven by the project need, which were determined through rigorous analysis of present day and estimated future conditions at the interchange. The project need includes:

- ***Traffic Operations:*** The eastbound exit from I-182 to Broadmoor Blvd is currently nearing capacity during the evening rush hour, leading to slowing and queuing on the freeway. In addition, the I-182 eastbound ramp terminal intersection at Broadmoor Blvd is nearing capacity and is expected to receive traffic volumes that will create heavy queuing and delay (Level of Service F) conditions by the year 2025. The westbound I-182 is also expected to experience Level of Service (LOS) F conditions, but in a longer time frame (15-20 years).
- ***Safety:*** Under present day conditions, evening rush hour vehicle queues on the I-182 eastbound off-ramp to Broadmoor Blvd create hazardous conditions on I-182 with slowing vehicles existing to Broadmoor Blvd mingling with high-speed traffic continuing on the freeway. In addition, the I-182 eastbound off-ramp and ramp terminal have a history of rear-end collisions.
- ***Active Transportation:*** The Broadmoor Blvd overpass currently presents a significant barrier to north/south bicycle and pedestrian movement. The nearest available crossing to the west is Court Street (near the Columbia River), and the nearest crossing to the east is located at Road 68, nearly two miles away. There are no sidewalks between the I-182 eastbound and westbound ramp terminals on Broadmoor Blvd, forcing pedestrians to use the shoulder. The limited facilities for bicycles and pedestrians create a high-stress active transportation environment on the Broadmoor Blvd corridor, discourage use of non-motorized modes of travel.

The performance gaps and needs at the Broadmoor interchange are displayed in Figure 2.

FIGURE 2: BROADMOOR INTERCHANGE PERFORMANCE GAPS AND NEEDS

To address the interchange performance gaps and needs and achieve the project purpose, a series of alternatives were developed through a rigorous screening and evaluation process to determine the best, most feasible and reasonable solution. The alternatives development process (outlined in Figure 3) was led by the City and included input from a Technical Advisory Team consisting of

representatives from effected local jurisdictions as well as input from the public, gathered through a series of public open houses.

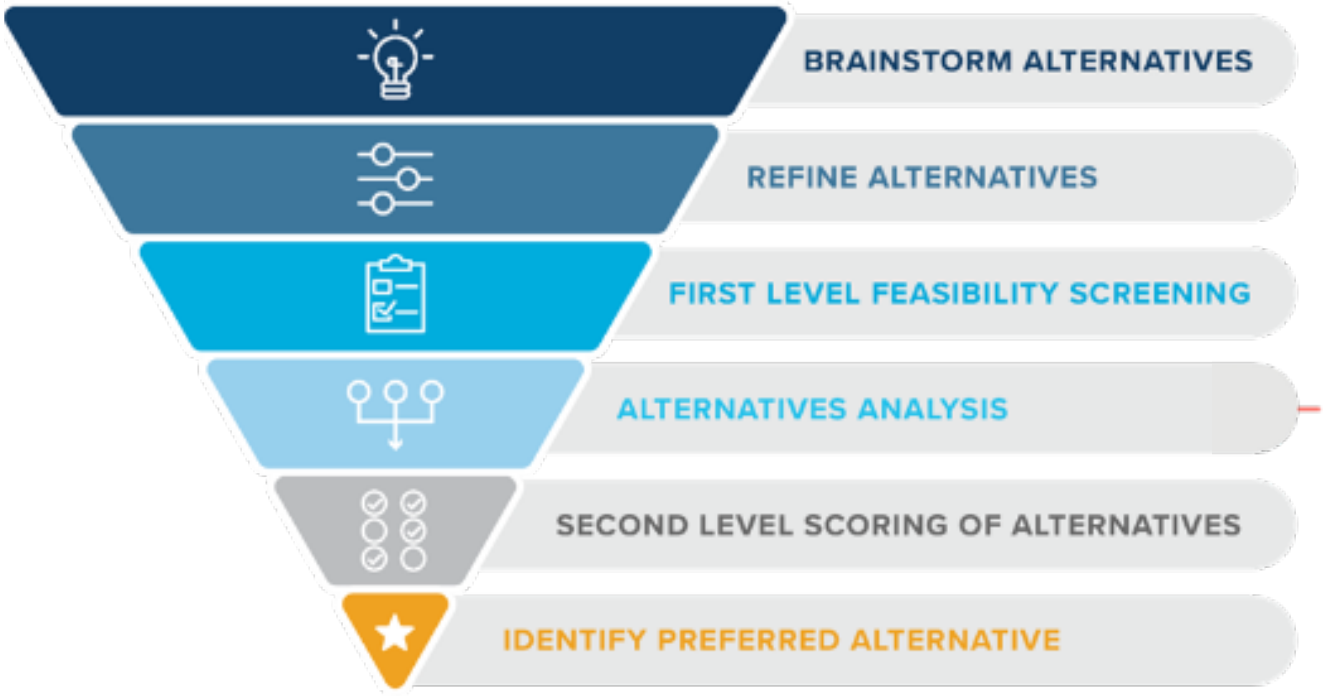

FIGURE 3: BROADMOOR INTERCHANGE ALTERNATIVES DEVELOPMENT PROCESS

As shown in Figure 3, the project development process included two levels of screening: a quantitative, First Level Feasibility Screening, and a quantitative, Second Level Evaluation and Scoring of Alternatives. The alternatives development process followed the WSDOT guidance for advancing practical solutions, aligning with the core principles of the Practical Decision-Making Process including:

- Starting with a clear purpose and need
- Consideration of resource constraints and lifecycle costs
- Engagement of stakeholders and partnership opportunities
- Consideration of overall system performance
- Consideration of incremental, phased solutions
- Application of innovation and creativity

The core principles guided the selection of feasibility criteria in the First Level Screening and performance metrics in the Second Level Evaluation and scoring.

To ensure all feasible and reasonable options were considered, alternatives were initially separated into the following five categories to better compare performance and avoid biasing analysis results:

- Freeway Alternatives – focused on the I-182 freeway on and off-ramps
- Westbound Ramp Terminal Alternatives – focused on the I-182 westbound ramp terminal on Broadmoor Blvd

- Eastbound Ramp Terminal Alternatives – focused on the I-182 eastbound ramp terminal on Broadmoor Blvd
- Active Transportation Alternatives – focused on bicycle and pedestrian improvements only through or near the interchange
- Comprehensive Alternatives – focused on complete interchange re-build or re-configuration

Alternatives deemed feasible and reasonable according to the project purpose and need were grouped into these categories and were evaluated against a wide array of performance measures capturing traffic operations, traffic safety, and active transportation impacts and benefits. The alternatives considered in this stage of the evaluation included the following:

- Existing off-ramp expansions and new off-ramp connections to Broadmoor Blvd
- Signal revisions and lane geometry changes and expansions at both ramp terminals
- Multi-lane roundabouts at both ramp terminals
- Bicycle and Pedestrian bridges across I-182
- Re-striping to add enhance existing bicycle and pedestrian facilities through the interchange
- Bicycle and Pedestrian grade separations at the interchange ramp terminals
- Diverging Diamond Interchange (DDI) configurations at the interchange

These alternatives were designed to a conceptual (two-dimensional) level to estimate right-of-way impacts and project cost and were then compared and scored against each other during the Level 2 Evaluation process. The highest scoring alternatives from each of the first four categories (freeway, westbound ramp terminal, eastbound ramp terminal, and active transportation) were combined to create a comprehensive alternative that was then evaluated against the DDI. The DDI did not perform well against the traffic operations performance measure, as any DDI configuration requires the closing of the existing northbound Broadmoor Blvd to westbound I-182 loop ramp. The queuing issues created by removing this connection showed that the DDI is not the right configuration for the traffic patterns at the Broadmoor Interchange. The combined alternative scored higher than the DDI, becoming the preferred alternative, which is summarized as follows and shown in Figure 4:

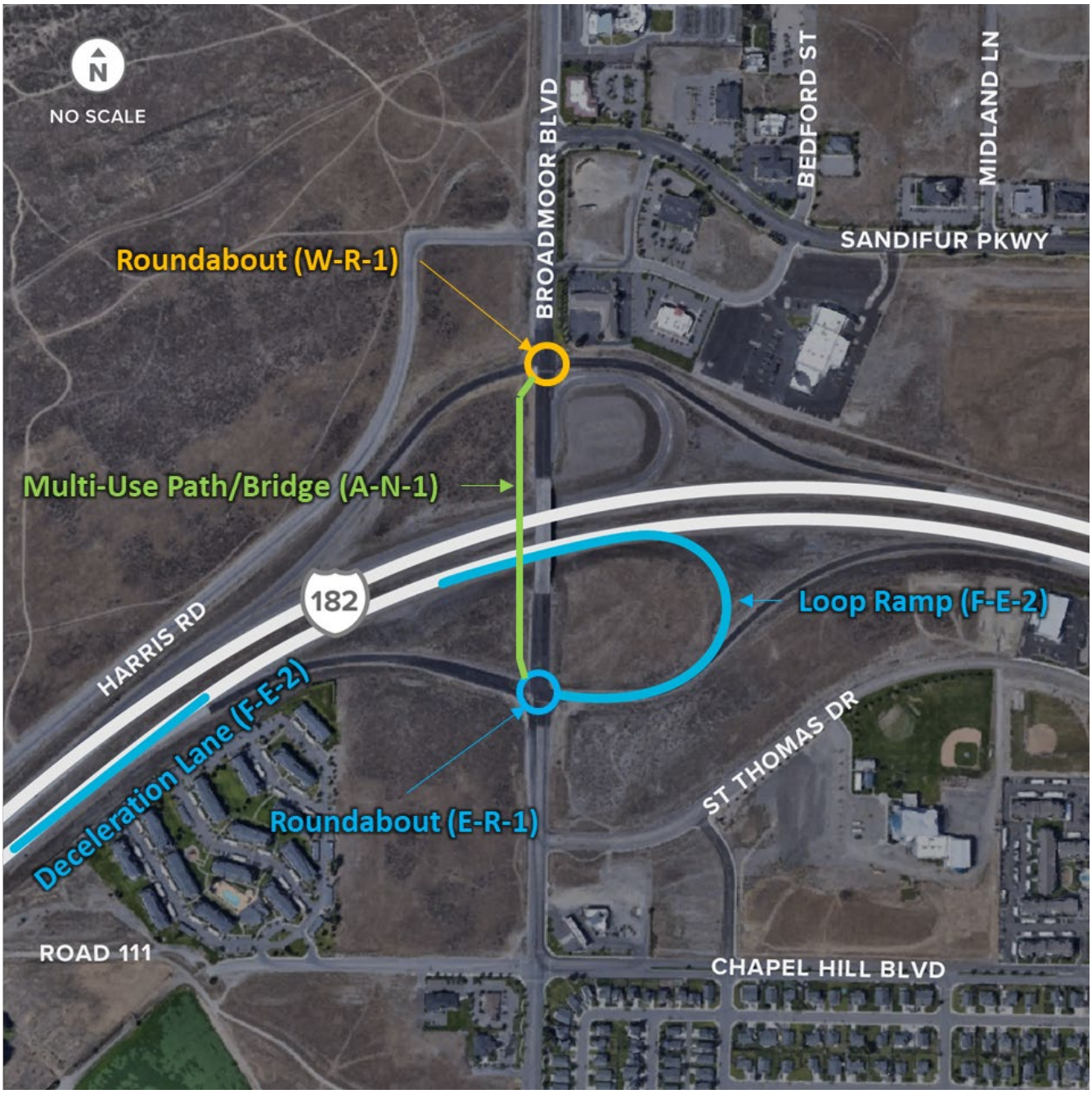

FIGURE 4: BROADMOOR INTERCHANGE PREFERRED ALTERNATIVE

- **Alternative F-E-2**: New I-182 eastbound exist loop ramp serving the eastbound I-182 to northbound Broadmoor Blvd Movement
  - Estimated Cost: **$3.3 Million**
- **Alternative E-R-1**: New multi-lane roundabout at the I-182 eastbound ramp terminal at Broadmoor Blvd, designed to accommodate the new loop ramp
  - Estimated Cost: **$2.3 Million**

- **Alternative W-R-1**: New multi-lane roundabout at the I-182 westbound ramp terminal at Broadmoor Blvd
  - Estimated Cost: **$1.7 Million**
- **Alternative A-N-1**: New multi-use path and I-182 overcrossing just west of Broadmoor Blvd between the interchange ramp terminals
  - Estimated Cost: **$7.5 Million**

This Preferred Alternative meets the project purpose by fulfilling the following needs at the Broadmoor Interchange:

- ***Traffic Operations:*** Meets mobility standards (LOS of D or better) at both the I-182 eastbound exit points and the interchange ramp terminals, under both morning and evening rush hour conditions for estimated year 2025 and 2045 traffic conditions.
- ***Safety:*** Under present day conditions, evening rush hour vehicle queues on the I-182 eastbound off-ramp to Broadmoor Blvd create hazardous conditions on I-182 with slowing vehicles existing to Broadmoor Blvd mingling with high-speed traffic continuing on the freeway. In addition, the I-182 eastbound off-ramp and ramp terminal have a history of rear-end collisions.
- ***Active Transportation:*** The Broadmoor Blvd overpass currently presents a significant barrier to north/south bicycle and pedestrian movement. The nearest available crossing to the west is Court Street (near the Columbia River), and the nearest crossing to the east is located at Road 68, nearly two miles away. There are no sidewalks between the I-182 eastbound and westbound ramp terminals on Broadmoor Blvd, forcing pedestrians to use the shoulder. The limited facilities for bicycles and pedestrians create a high-stress active transportation environment on the Broadmoor Blvd corridor, discourage use of non-motorized modes of travel.

The Preferred Alternative includes several components that do not necessarily need to be constructed at the same time, and do not have the same level of urgency. Based on the evaluation performed for multiple future years (2025 and 2045), the following phasing recommendations were made for the Preferred Alternative:

- **Phase 1A**: This phase includes the Loop Ramp (**F-E-2**) and Roundabout at the Eastbound Ramp Terminal (**E-R-1**). A third project, known as alternative **A-I-2**, which re-stripes the Broadmoor Blvd Bridge temporarily to add an enhanced mixed-use crossing on the west side, is also recommended for inclusion as a temporary solution until Phase 1B can be completed. Based on funding available to the City at this time, Phase 1A is recommended to advance through design and into construction immediately to address current and immediate needs at the interchange. This phase is shown in blue in Figure 4.
- **Phase 1B**: Includes the separated multi-use path and bridge over I-182 on the west side of Broadmoor Blvd (**A-N-1**). This phase is shown in green in Figure 4. The City will begin pursuing funding for this project, with the intent of constructing the project within the next five years.
- **Phase 2**: Includes the roundabout at the westbound ramp terminal (**W-R-1**), shown in yellow in Figure 4
- **Phase 3**: This phase could include projects beyond the Preferred Alternative, such as the pedestrian grade separations at the westbound on-ramp (**A-W-1a**) and the eastbound off-ramp (**A-E-2a**), and other projects targeting issues beyond the purpose and need of this project, such as capacity issues related to the westbound on-ramp merge onto I-182.

CHAPTER 1. INTRODUCTION AND BACKGROUND

The City of Pasco has continued to experience steady and substantial growth over the last 10-15 years, particularly in areas west of US 395. This growth has led to increased traffic on both the I-182 Columbia River bridge and along Broadmoor Blvd. Bridge volumes increased by 2.7% annually between 2010 and 2019, with average daily volumes exceeding 70,000 vehicles in 2019. While the COVID-19 pandemic reduced traffic throughout the state, traffic volumes in February 2021 on the bridge are back to 98% of 2019 (pre-pandemic) levels. Broadmoor Blvd has also experienced significant growth, with daily traffic volumes reaching 22,000 vehicles by 2018.

The Broadmoor Blvd interchange is a key connection between the regional system (I-182) and Broadmoor Blvd (Road 100), and arterial connection serving both commercial and residential traffic in west Pasco along with agricultural land uses in Franklin County. The Broadmoor Interchange location is shown in Figure 5.

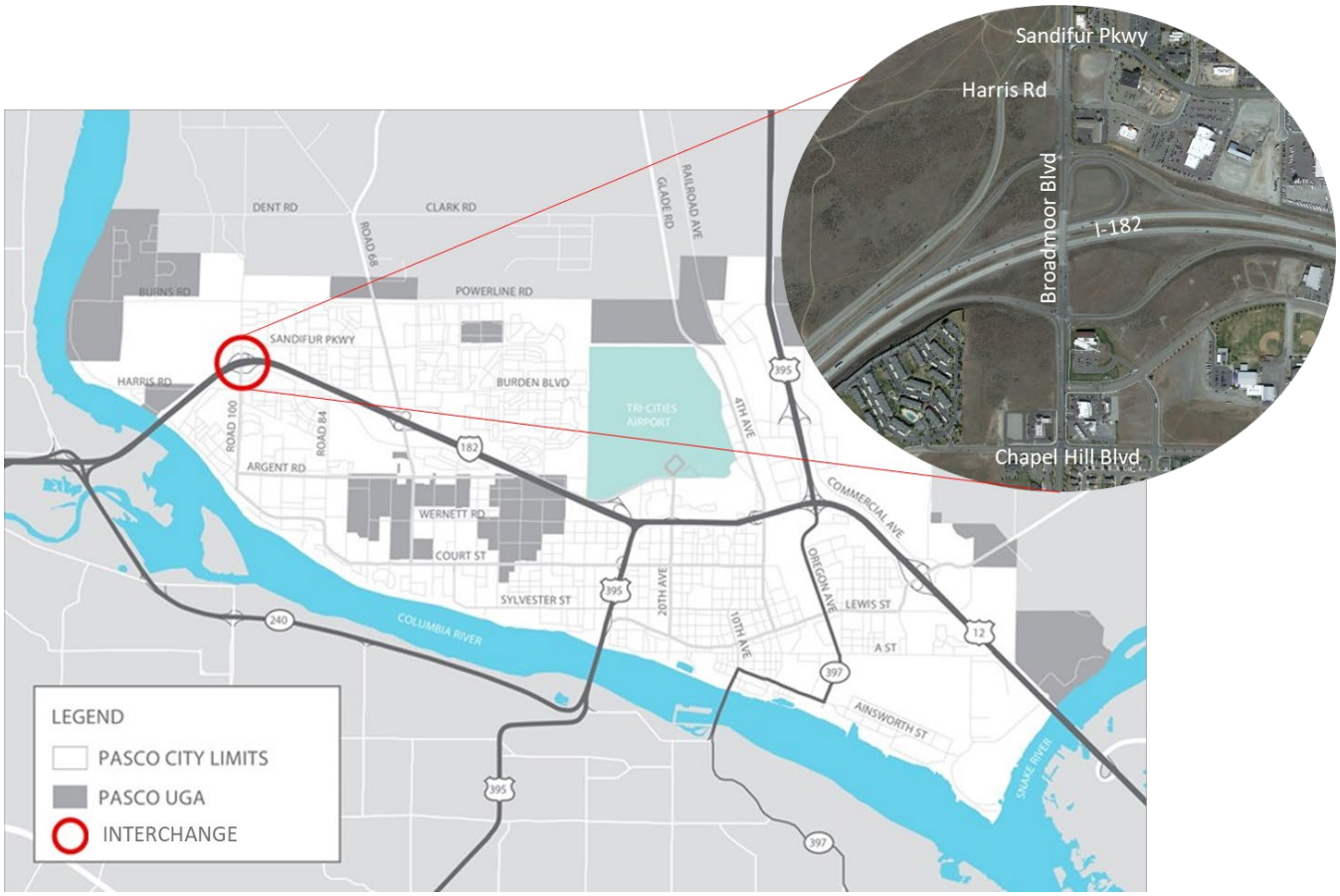

FIGURE 5: BROADMOOR INTERCHANGE VICINITY MAP

The Broadmoor Blvd and I-182 interchange was constructed in the early 1980's as a simple diamond interchange. The interchange was designed to accommodate loop ramps in the northeast and southeast quadrants, anticipated to be added at a future date to serve growth in the west side of Pasco. The loop ramp in the northeast quadrant of the interchange was constructed in 2009, providing additional capacity to the northbound Broadmoor Blvd to westbound I-182 movement.

The existing interchange configuration has provided sufficient capacity to serve growth to date. However, as currently constructed the interchange is fast approaching capacity, and more than 7,000 new dwelling units and 3,000 new jobs are planned for in the greater Broadmoor Area in the next 20 years in the City of Pasco's Comprehensive Plan. This is expected to further increase traffic on both Broadmoor Blvd and at the I-182 interchange, exceeding the current capacity of the system within the next five years.

Prior planning efforts have identified the Broadmoor Interchange as a location of critical need for the City to meet traffic safety and community growth goals. These prior studies have indicated a need for interchange revisions at Broadmoor Blvd, necessitating an Access Revision Report (ARR). This document will include a summary of the alternatives development and evaluation process performed by the City to determine the Preferred Alternative for the Broadmoor Interchange, while providing the documentation to support at an access revision to I-182.

The ARR study limits are shown in Figure 6.

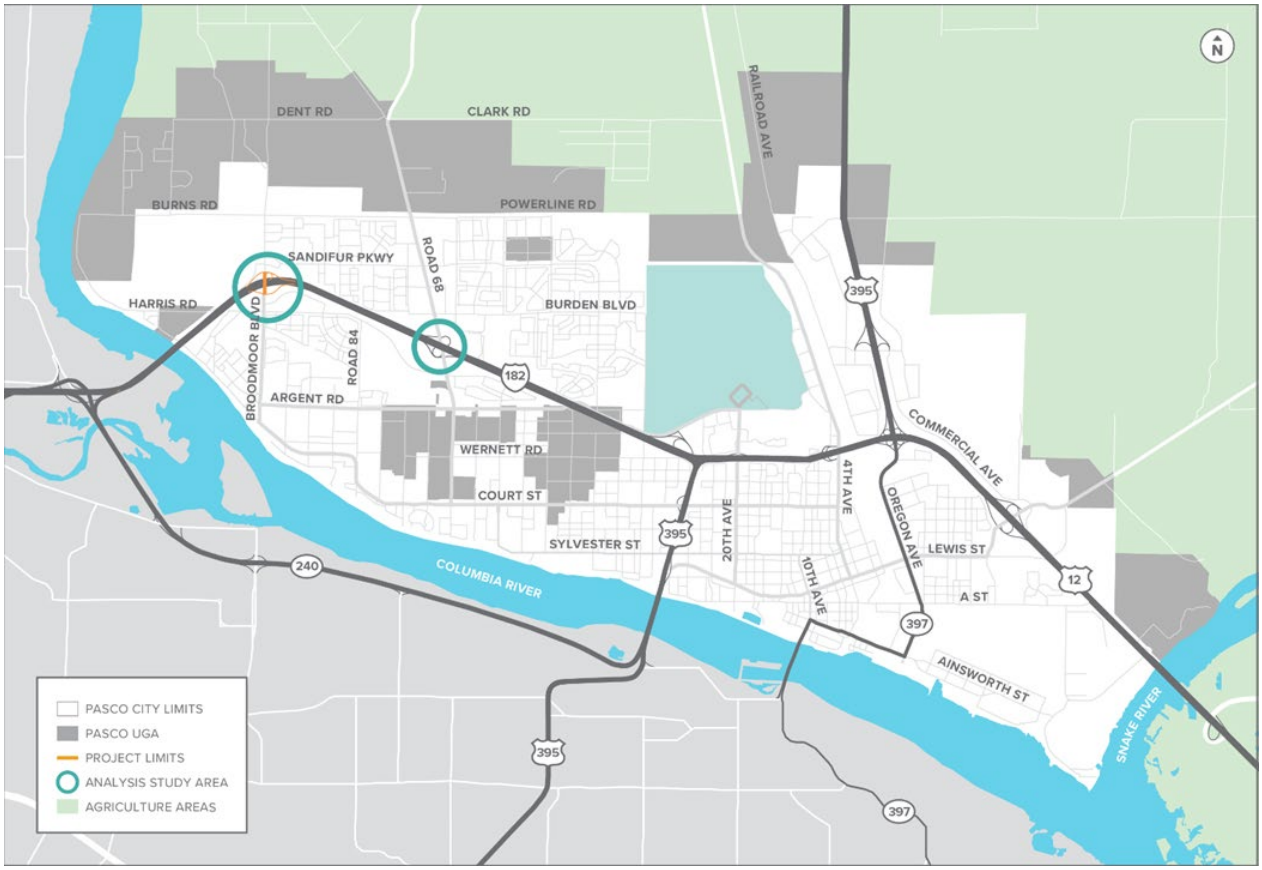

FIGURE 6: PROJECT STUDY LIMITS

PLANNING LINKAGE

Over the past six years, the City of Pasco has led several studies that included traffic analysis of the Broadmoor Interchange. A **Feasibility Study of Interchanges** conducted in 2015-2016 recommended capacity enhancements to the Broadmoor Blvd Interchange, predicting that the current interchange configuration would near capacity around the year 2020. More recently (in 2019), the City led traffic analysis efforts to support the **Preliminary Broadmoor Area Environmental Impact Statement (EIS)**, focusing on identifying future transportation needs and solutions on Broadmoor Blvd. This study identified the Broadmoor interchange as a location of needed improvement. Further transportation analysis performed during the City's **2018 Comprehensive Plan Update** and the **Transportation System Master Plan (TSMP)** projects also included a planned improvement to the Broadmoor Interchange. In 2021, the City led a traffic analysis study to determine the full scope of Broadmoor Blvd improvements needed to meet future growth needs over the next 20 years. This effort included a **Broadmoor Interchange Analysis** (which is included as an attachment to Appendix A), focusing on existing service and safety levels as well as near and long-term gaps and needs at the interchange, along with some preliminary interchange improvement concepts.

INTERSECTION CONTROL EVALUATION (ICE)

The WSDOT ARR policy is constructed to meet the national and state interest to preserve and enhance the Interstate and non-Interstate freeway system with an appropriate level of service in terms of safety and mobility performance for the movement of people and goods. As such the ARR is primary focused on changes to access points to Washington State freeway system. However, Design Manual (DM) 550 requires the ARR to fulfil the requirement of the intersection control evaluation (ICE) from DM Chapter 1300. Whereas the ICE is meant to screen and evaluate alternatives to determine the best possible intersection type and design and consideration of all modes. Merging these two policies into one document provides for a holistic evaluation of the interstate system but also the intersecting local network and that is what is provided herein. The structure of the report provides for existing conditions, developing, examining alternatives, and consideration of context/modal priorities to help guide discussion with working group, community outreach, and ultimately recommendations for the local and state transportation system. This approach satisfies both the ARR, and ICE polices within the WSDOT design manual.

COMPLETE STREETS LEGISLATION

The recently adopted Complete Streets legislation requires WSDOT to adhere to the guidelines of the legislation for all state projects commencing design on July 1, 2022. While the project identified in this ARR document will be led by the City of Pasco, consideration has still been given to the Complete Streets guidelines, namely, consideration of reduced speeds to 30 mph on roadways that do not provide physical separate for pedestrians and bicyclists, and prioritization of project elements that provide safe, ADA accessible, and physically separated facilities to vulnerable users. Consideration was also given to planned active transportation connections and facilities around the interchange, as well as planned and zoned land uses.

CHAPTER 2. EXISTING CONDITIONS ANALYSIS

This section summarizes the present-day conditions of the Broadmoor Blvd and I-182 interchange, including traffic operations, safety conditions, and pedestrian and bicycle facilities.

TRAFFIC COUNTS

The intersection turn movement counts were collected in March and December of 2019. The full count data is included in Appendix E. Figure 7 and Figure 8 list the existing conditions PM and AM peak hour turning movements at the project study intersections. Note that for the traffic analysis, the traffic counts were balanced between the interchange ramp terminals.

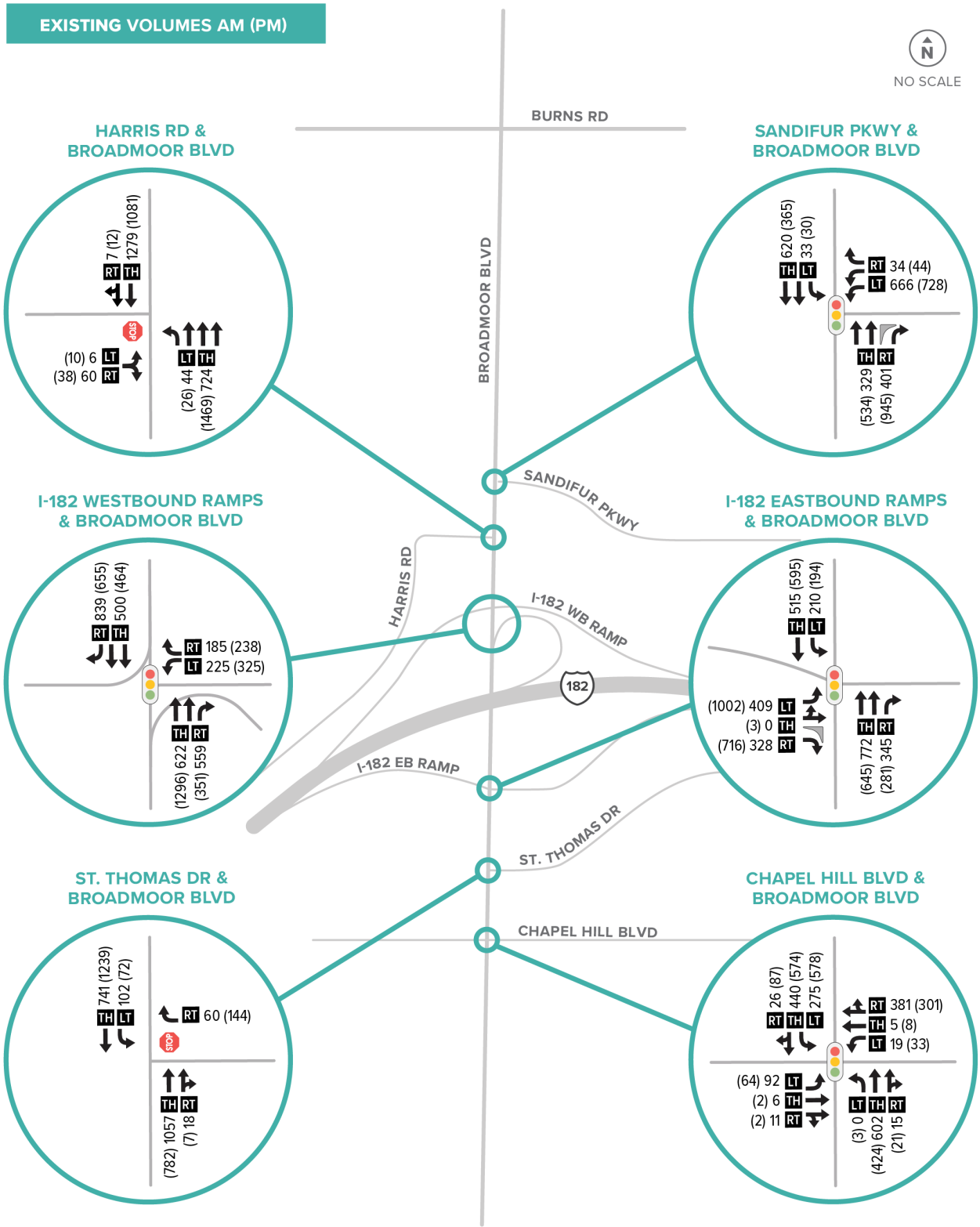

FIGURE 7: BROADMOOR INTERCHANGE EXISTING (2019) TRAFFIC VOLUMES

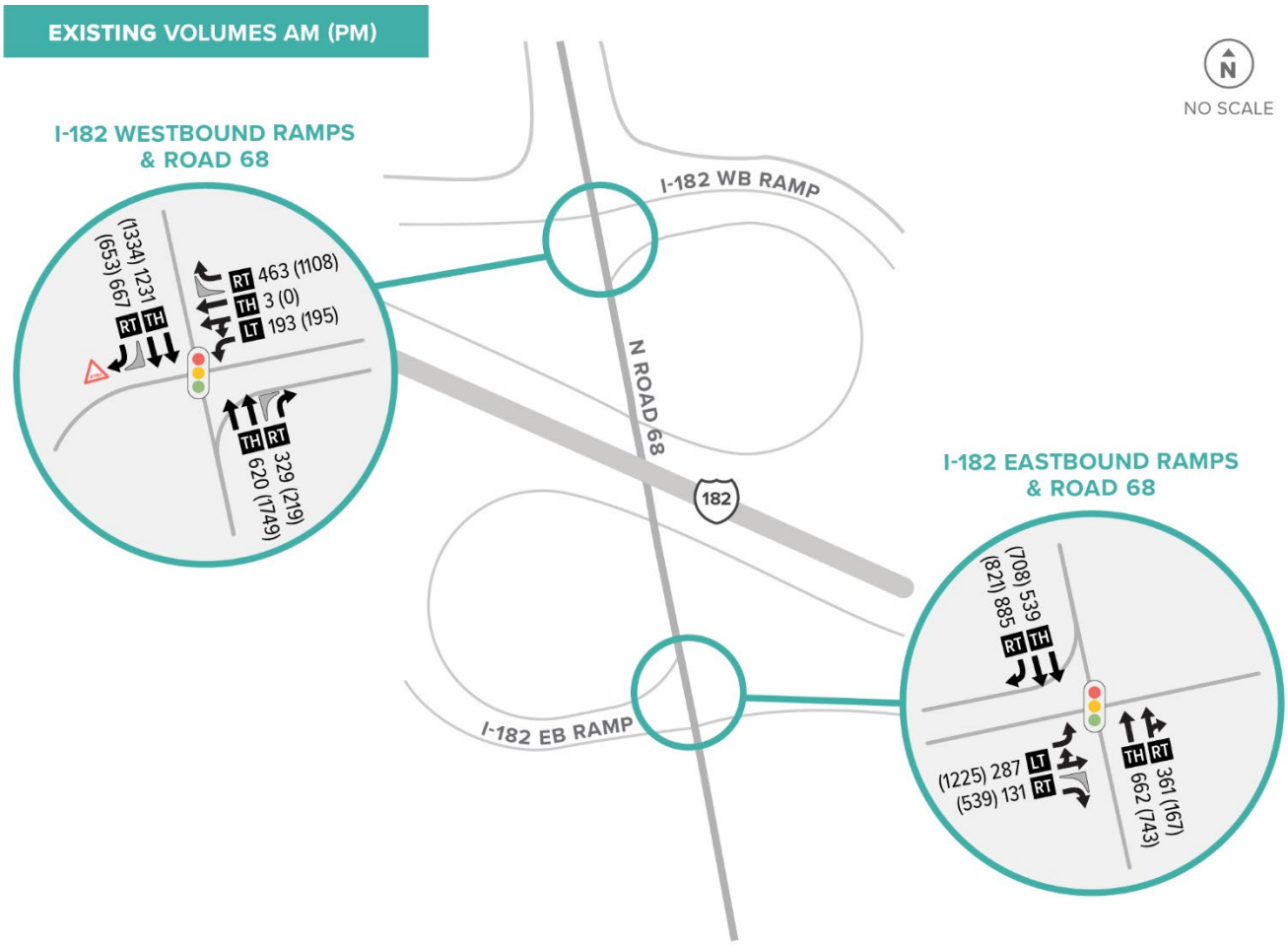

FIGURE 8: ROAD 68 INTERCHANGE EXISTING (2019) TRAFFIC VOLUMES

In addition to the peak hour counts shown in Figure 7 and Figure 8, I-182 mainline volumes were compiled from WSDOT I-182 Automatic Traffic Recorder Site R081 on the Columbia River Bridge. These volumes (summarized in Table 1) were used to determine the Peak Hour traffic volumes on I-182 to support the freeway analysis portions of the project.

TABLE 1: 2019 EXISTING CONDITIONS I-182 PEAK HOUR VOLUMES

LOCATION	DIRECTION	AM PEAK HOUR VOLUME	PM PEAK HOUR VOLUME
I-182 AT COLUMBIA RIVER	Eastbound	2,263	4,010
	Westbound	3,062	3,007

EXISTING CONDITIONS TRAFFIC OPERATIONS ANALYSIS

The following sections describe the results of the existing conditions traffic operational analysis focused on freeway performance and intersection operations, based on the methodology described in the project *Methods and Assumptions Memorandum* (included as Appendix B). Performance

measures for this analysis focus on delay, level of service (LOS), and queueing at and around interchange ramp terminals.

FREEWAY OPERATIONS

Freeway operational performance is typically measured with LOS (A through F), which is tied to vehicle density either on the freeway mainline or at merge/diverge/weave locations. Vehicle density is measured in vehicles per lane per mile, essentially providing a snapshot of the level of congestion on a given freeway segment. Once vehicle density reaches a certain intensity (i.e. vehicle flows near the facility capacity) travel speeds drop, and congestion builds, ultimately leading to queuing and stop and go traffic. LOS A represents low densities (11 or less vehicles per lane per mile), where vehicles may operate at or near free flow speed. LOS F represents densities of 45 or more, where vehicles are compressed into stop and go conditions. Density and the associated freeway LOS were used throughout this project to measure freeway traffic operations.

Table 2 lists the existing peak hour mainline I-182 eastbound and westbound Highway Capacity Manual (HCM) operations at the Broadmoor Blvd Interchange. The full Highway Capacity Software (HCS) outputs are included in Appendix F-1.

TABLE 2: EXISTING FREEWAY OPERATIONS RESULTS

DIRECTION	SEGMENT	MOVEMENT TYPE	MOBILITY TARGET	AM PEAK HOUR		PM PEAK HOUR	
				LOS	DENSITY (FWY/ RAMP)	LOS	DENSITY (FWY/ RAMP)
I-182 EASTBOUND	Before Broadmoor Blvd Off	Basic	D	B	12.2	C	21.8
	Broadmoor Blvd Off-Ramp	Diverge	D	C	13.0/20.8	D	23.2/32.6
	Between ramps	Basic	D	A	8.3	B	12.5
	Broadmoor Blvd On-Ramp	Merge	D	B	12.1/15.0	B	16.3/18.7
	After Broadmoor Blvd On	Basic	D	B	11.2	B	15.2
I-182 WESTBOUND	Before Broadmoor Blvd Off	Basic	D	B	11.4	B	13.5
	Broadmoor Blvd Off-Ramp	Diverge	D	B	11.8/18.2	C	14.0/20.9
	Between ramps	Basic	D	A	9.3	A	10.6
	Broadmoor Blvd On-Ramp	Merge	D	C	18.3/23.9	C	17.4/22.0
	After Broadmoor Blvd On	Basic	D	B	16.5	B	15.7

During field observations performed both in 2019 and 2021, slowing was observed during in the outside eastbound lane of I-182 between the off-ramp to Broadmoor Blvd and the west side of the Columbia River Bridge, with speeds ranging from 15 to 35 mph during the PM peak hour (4:35 to 5:35 PM). As shown in Table 2, the I-182 eastbound diverge to the Broadmoor Blvd eastbound off-ramp operates at LOS D under PM peak hour existing conditions.

INTERSECTION OPERATIONS

The existing conditions HCM intersection operations are summarized in Table 3, and the full HCM reports (from Synchro) are included in Appendix F-4.

TABLE 3: EXISTING (2019) INTERSECTION OPERATIONS RESULTS

INTERSECTION	MOBILITY STANDARD	AM PEAK HOUR		PM PEAK HOUR	
		LOS	DELAY (S)	LOS	DELAY (S)
BROADMOOR BLVD INTERCHANGE AREA					
SANDIFUR BLVD AND BROADMOOR BLVD	LOS D	B	11	B	16
HARRIS BLVD AND BROADMOOR BLVD	LOS D	B/C	13/22	B/B	10/14
I-182 WESTBOUND RAMPS AND BROADMOOR BLVD	LOS D	A	8	B	18
I-182 EASTBOUND RAMPS AND BROADMOOR BLVD	LOS D	B	14	A	9
ST THOMAS DR AND BROADMOOR BLVD	LOS D	B/B	13/15	B/D	12/26
CHAPEL HILL BLVD AND BROADMOOR BLVD	LOS D	B	15		B
ROAD 68 INTERCHANGE AREA					
I-182 WESTBOUND RAMPS AND ROAD 68	LOS D	A	5	A	8
I-182 EASTBOUND RAMPS AND ROAD 68	LOS D	A	7	C	24

As shown in Table 3, the ramp terminals currently meet WSDOT mobility targets of LOS D. However, the HCM operations do not fully capture the impacts of queues and spillback of turn storage bays, which lead to increased delay and congestion, particularly during the PM peak hour.

QUEUEING

For this project queue storage is defined as either turn bay length, distance to nearest upstream signal, or for an off-ramp, the distance from the ramp terminal stop bar to the safe stopping distance (SSD) from the gore point. Table 4 summarizes the I-182 off-ramp storage lengths applicable for this project.

TABLE 4: I-182 RAMP SAFE STOPPING AND QUEUEING DISTANCES AT BROADMOOR BLVD

RAMP	RAMP LENGTH (STRIPED GORE TO STOP BAR)	SAFE STOPPING DISTANCE[A]	SAFE QUEUE DISTANCE
I-182 EASTBOUND OFF-RAMP	1470 ft	570 ft (from 60 mph)	900 ft
I-182 WESTBOUND OFF-RAMP	1600 ft	570 ft (from 60 mph)	1,030 ft

[A] Assumes 10 mph reduction from mainline speed at gore point

Table 5 lists key 95th percentile queues at the Broadmoor Blvd interchange and along Broadmoor Blvd under existing conditions, based on the results from 10 simulation runs from SimTraffic. Figure 9 summarizes the critical queues by movement at the project study intersections. The full SimTraffic outputs are included in Appendix F-7.

TABLE 5: EXISTING CONDITIONS 95TH PERCENTILE QUEUES

INTERSECTION	MOVEMENT	APPROXIMATE STORAGE (FT)[A]	95TH PERCENTILE QUEUE (FT)	
			AM PEAK HOUR	PM PEAK HOUR
SANDIFUR PKWY AND BROADMOOR BLVD	NBT	720	130	210
	NBR	720	<25	90
	SBT	-	190	120
	SBL	100	70	60
	WBL	1,670	460	360
	WBR	1,670	450	50
I-182 WESTBOUND RAMPS AND BROADMOOR BLVD	NBT	1,100	170	360
	NBR	230	<25	110
	SBT	720	140	130
	SBR	720	40	<25
	WBL	1,030/1,600[B]	430	370
	WBR	350	160	230
I-182 EASTBOUND RAMPS AND BROADMOOR BLVD	NBT	900	750	650
	NBR	200	**>200**	**>200**

INTERSECTION	MOVEMENT	APPROXIMATE STORAGE (FT)[A]	95TH PERCENTILE QUEUE (FT)	
			AM PEAK HOUR	PM PEAK HOUR
	SBL	1,110	620	460
	SBT	1,110	850	880
	EBL	230	**>230**	**>230**
	EBR	900/1,470[B]	510	**>1,470**
ST THOMAS DR AND BROADMOOR BLVD	SBL	190	**>190**	90
	WBR	190	140	180
CHAPEL HILL BLVD AND BROADMOOR BLVD	NBL	80	<25	<25
	NBT	-	530	180
	NBTR	-	580	260
	SBL	300	280	**>900**
	SBTR	900	310	**>900**
	EBL	225	140	90
	EBT	-	70	<25
	EBTR	-	40	<25
	WBL	250	50	70
	WBT	-	150	40
	WBTR	-	750	180

[A] Approximate storage distance is determined by the length of existing turn bays or the distance to the next upstream signal if applicable.

[B] Ramp storage distance shown by Length to Safe Stopping Distance/Length to striped gore.

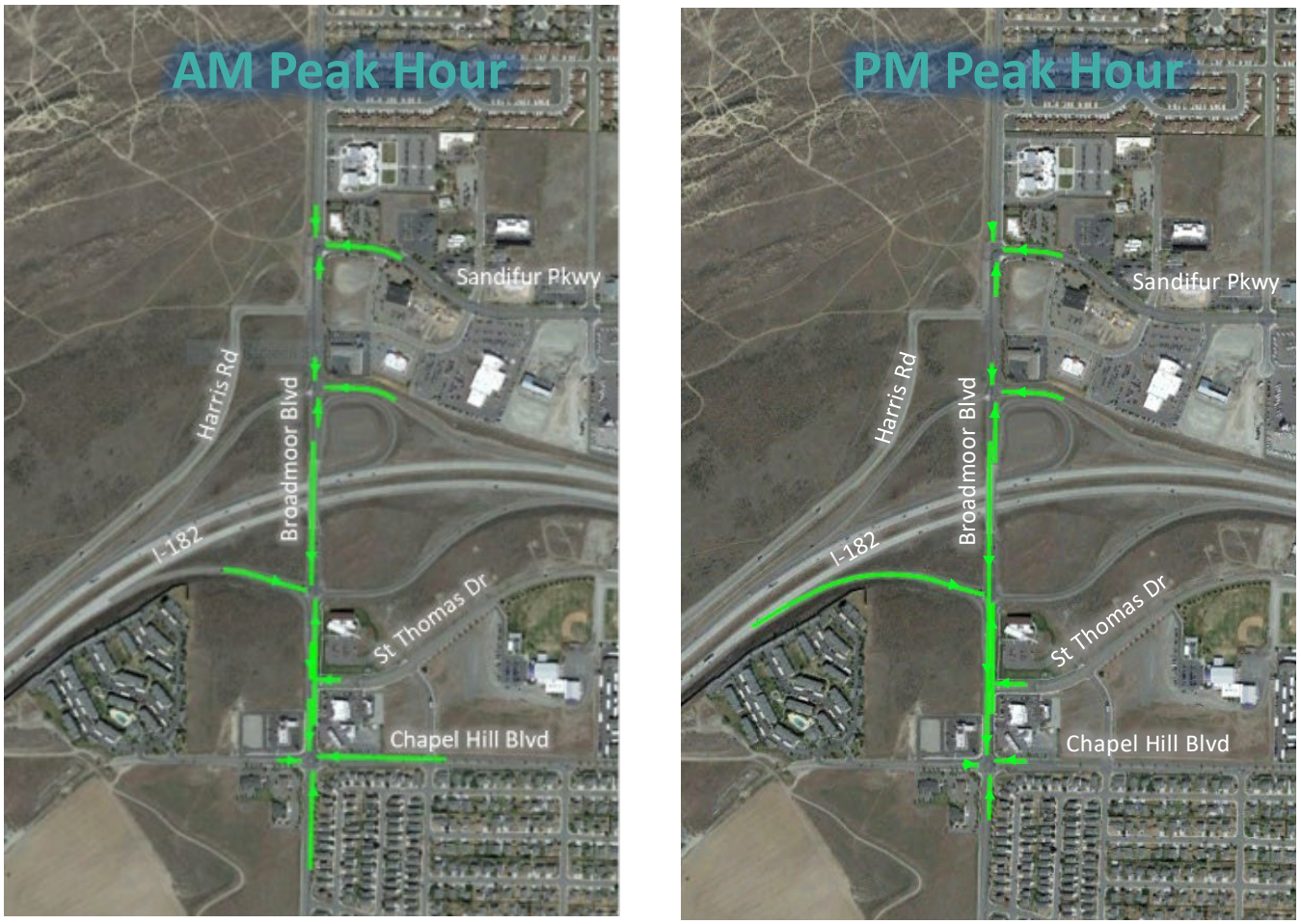

FIGURE 9: EXISTING CONDITIONS (2019) CRITICAL QUEUES

During the Pasco Transportation Master Plan (TMP) project field visit[1] in January of 2020, the project team noted queues of 15 to 25 vehicles on the eastbound I-182 off-ramp to Broadmoor Blvd, along with slowing on the off-ramp back to the I-182 mainline. A second field visit performed in October of 2021 included similar observations. Eastbound right turn queues on the I-182 eastbound off-ramp were caused by congestion spillback from the free right turn merge onto southbound Broadmoor Blvd, while eastbound left turn queues were caused by traffic spilling back beyond the left turn storage bays during the red phase of the ramp terminal signal. The left turn queue ultimately controlled the ramp queues, with vehicles destined for the eastbound right turn using the shoulder to get around the left turn queue spillback, sometimes as far down the ramp as the striped gore point.

[1] These observations were made during a peak hour of the lowest volume season (winter), as indicated by the PTR data on the I-182 Columbia River Bridge. City of Pasco staff have noted significantly longer queues during spring and summer peak hours, likely due to higher volumes caused seasonal workers traveling to and from the agricultural land uses to the north.

The queueing results summarized in Table 5 and shown in Figure 9 are consistent with the field observations. Key queueing findings are summarized as follows:

- PM Peak Hour
  - The I-182 eastbound off-ramp queues from the eastbound left turns spill back down the ramp, reaching the striped gore
  - The free eastbound right turn at the eastbound ramp terminal is forced into a short merge with southbound Broadmoor Blvd traffic. This issue is further complicated by vehicles entering and queuing in the southbound left turn onto St Thomas Dr, creating a crash risk on the Broadmoor corridor as well as queues in the eastbound right turn lane on the off-ramp.
  - Southbound queues from the Broadmoor Blvd/Chapel Hill Blvd intersection spill back through I-182 eastbound ramp terminal. These queues do not reach the westbound ramp terminal.
- AM Peak Hour
  - Northbound vehicle queues from the eastbound ramp terminal can extend back through the Chapel Hill Blvd intersection
  - Southbound queues from the eastbound ramp terminal do not quite reach the westbound ramp terminal
  - Southbound left turn queues at St Thomas Dr extend beyond the turn bay and impact southbound Broadmoor Blvd

MULTIMODAL CONDITIONS

The Broadmoor Blvd overpass currently presents a significant barrier to north/south bicycle and pedestrian movement. There are no sidewalks between the eastbound and westbound ramp terminals, forcing pedestrians to use the shoulder. The facilities and barriers through the interchange are summarized by direction as follows:

- **Northbound:** The shoulder narrows to about 5 feet on the interchange overpass structure. Pedestrians and bicyclists must cross the northbound Broadmoor Blvd to westbound I-182 movement only protected by a striped crosswalk without any signalization. At the westbound ramp terminal, bicyclists are forced into vehicle travel lanes north of the intersection as the should drops off completely and the parallel multi-use path is not readily accessible.
- **Southbound:** At the westbound ramp terminals, bicyclists and pedestrians must cross the southbound Broadmoor to westbound I-182 movement using a striped crosswalk without signalization. The southbound shoulder is slightly wider on the overpass than northbound, with approximately 6 feet on the structure. Southbound bicyclists have to cross the unsignalized free eastbound right turn at the eastbound ramp terminal using a striped crosswalk as well, with no downstream facilities.

FIGURE 10: PROTECTED PEDESTRIAN ROUTE THRU INTERCHANGE

Sidewalk exists on both sides of Broadmoor Blvd north of Chapel Hill Blvd, and the sidewalk on the west side of the street terminates south of St Thomas Drive. The sidewalk on the east side of the

street continues to the I-182 EB ramps. There is a shared use trail that meets Broadmoor Blvd north of the I-182 WB ramps. However, it is not accessible from Broadmoor Blvd due to a fence until north of Bedford Street.

Bicycle and pedestrian comfort were measured analytically using Level of Traffic Stress (LTS). LTS is a quantitative measurement on a scale 1-4, with 1 being the least stressful and 4 being the most stressful. LTS uses data related to the pedestrian/bicycle facility type (physical versus no separation, width, etc) and adjacent roadway or intersection volume and speed data.

Table 6 below shows the Level of Traffic Stress (LTS) under existing conditions in the study area.

TABLE 6: EXISTING CONDITIONS BIKE/PED LEVEL OF TRAFFIC STRESS

SEGEMENT	BIKE			PEDESTRIAN		
CROSS-STREET	SEGMENT BIKE LTS	CROSSING BIKE LTS	TOTAL BIKE LTS	SEGMENT PED LTS	CROSSING PED LTS	TOTAL PED LTS
CHAPEL HILL BLVD	4	4	4	4	4	4
ST THONMAS DR	4	4	4	4	4	4
I-182 WESTBOUND RAMP TERMINAL	4	4	4	4	4	4
I-182 EASTBOUND RAMP TERMINAL	4	4	4	4	4	4
SANDIFUR PARKWAY	4	4	4	4	4	4

In addition to the high stress bicycle and pedestrian environment at the Broadmoor Interchange, active transportation modes are forced to take an indirect route to simple traverse the interchange north/south. Figure 10 outlines the current best protected (with signalized crossings north/south route along Broadmoor Blvd through the interchange.

SAFETY PERFORMANCE ANALYSIS

The most recent five years of crash records January 1, 2015, to December 31, 2019, for the study area were obtained from the Washington State Department of Transportation Crash Portal. The crash records were summarized by study intersection for intersection-related crashes in Table 7 and non-intersection related crashes were summarized in Table 8. In total, 182 crashes were studied for this analysis and are mapped in Figure 11 by crash severity. The following key findings are summarized below:

- No fatal crashes were reported within the study period.

- The most common crash type throughout the study area is rear-end crashes. In particular, along Rd 100 from Sandifur Pkwy to Chapel Hill Blvd, 49% of all crashes resulted in a rear-end, which is likely related to intersection congestion along the study corridor.
- There are several run-off-the road crash reports located for the westbound on-ramp curve (entrance from northbound Rd 100).
- Nine crashes were reported near the diverge area of the eastbound off-ramp exit.

TABLE 7: STUDY INTERSECTION CRASH RECORDS (2016-2020)

INTERSECTION	TOTAL CRASHES [A]	SEVERITY		TYPE			CRASH RATE [D]
		INJURY	PDO	REAR END	TURNING [B] /ANGLE [C]	OTHER	
CHAPEL HILL BLVD	26	9	17	8	12 LT, 2 RT, 3 Angle	1 Linear Curb	0.679
ST THONMAS DR	6	2	4	3	3 LT	0	0.147
SANDIFUR PKWY	20	8	12	3	11 LT, 4 Angle	2 Sideswipe	0.414
I-182 WESTBOUND RAMP TERMINAL	9	2	7	6	3 Angle	0	0.148
I-182 EASTBOUND RAMP TERMINAL	58	17	41	39	2 LT, 9 Angle	6 Sideswipe 1 Fence 1 Overturned	0.925

[A] Intersection crashes were filtered to crashes that were only intersection related. Crashes that were "not intersection related" were omitted.

[B] Turning crashes are labelled as LT (Left Turning Vehicle Involved) and RT (Right Turning Vehicle Involved).

[C] Angle crashes are recorded as "entering at an angle".

[D] Crash rate is calculated based on FHWA intersection crash rate calculation using count data from WSDOT and BFCG: https://safety.fhwa.dot.gov/local_rural/training/fhwasa1210/s3.cfm

Source: WSDOT Crash Portal.

TABLE 8: STUDY AREA SEGMENT CRASH RECORDS (2016-2020)

SEGMENT	TOTAL CRASHES [A]	SEVERITY		TYPE			
		INJURY	PDO	REAR END	SIDE-SWIPE	OVER-TURNED	OTHER
EASTBOUND OFF-RAMP	9	2	7	0	2	3	4
EASTBOUND ON-RAMP	0						

SEGMENT	TOTAL CRASHES [A]	SEVERITY		TYPE			
		INJURY	PDO	REAR END	SIDE-SWIPE	OVER-TURNED	OTHER
WESTBOUND OFF-RAMP	9	4	5	2	2	1	4 [B]
WESTBOUND ON-RAMP (ENTRANCE FROM RD 100 NORTHBOUND)	8	3	5	0	0	2	3 Barrier 3 Ledge
WESTBOUND ON-RAMP (ENTRANCE FROM RD 100 TERMINAL WESTBOUND)	11	5	6	6	2	1	2
RD 100 (FROM SANDIFUR PKWY TO CHAPEL HILL BLVD)	26	7	18	16	6	0	4

[A] Total crashes that are non-intersection related.

[B] Three vehicles were involved in a collision with the light pole located at the entrance of the westbound off-ramp. It was also reported that these three drivers were exceeding reasonable safe speed.

Source: WSDOT Crash Portal.

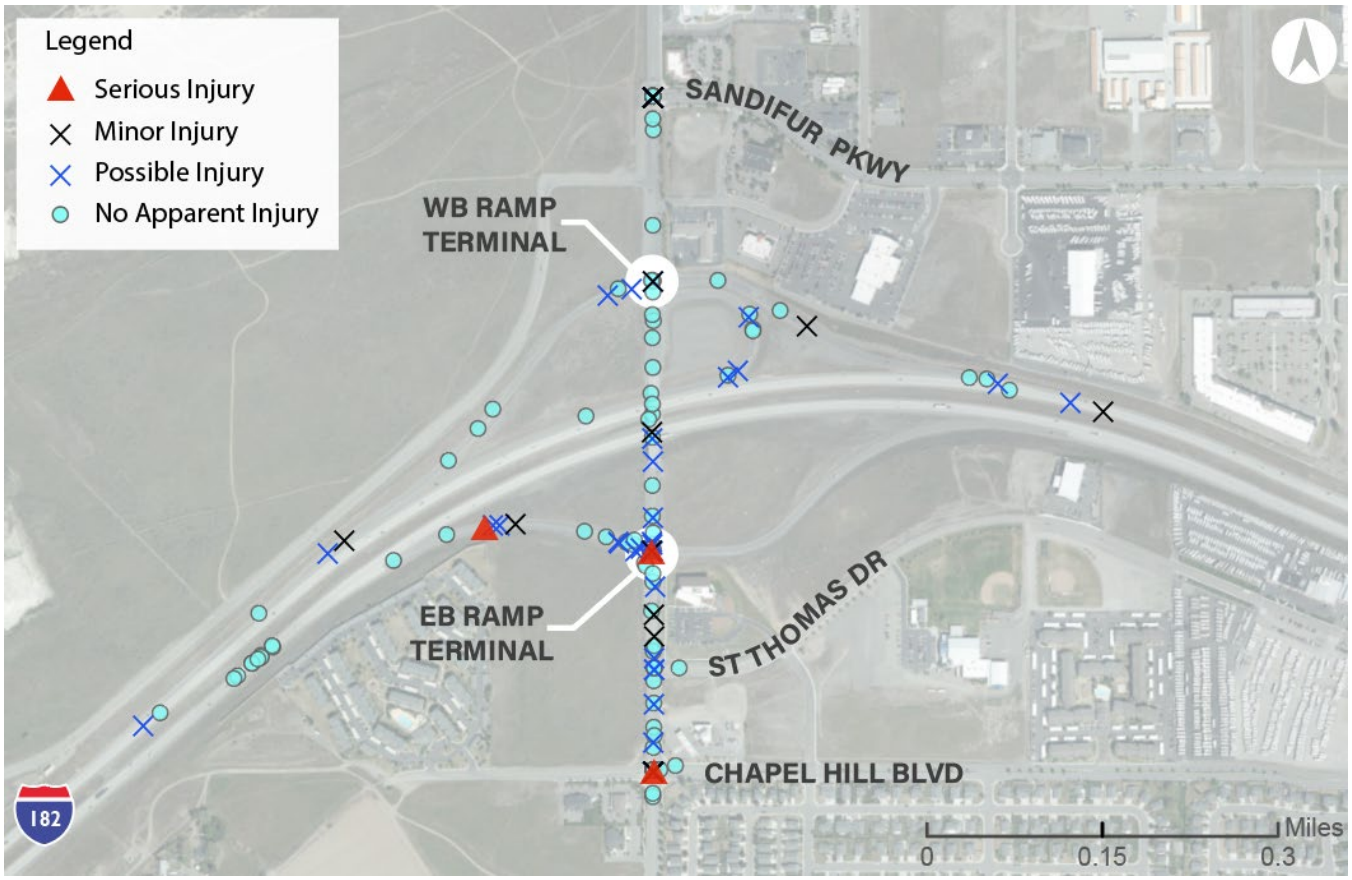

FIGURE 11: CRASH SEVERITY FOR ALL COLLISIONS ANALYZED ALONG STUDY CORRIDOR.

The following summarizes the main conclusions from the safety analysis:

- The westbound loop on-ramp (entrance from NB Rd 100) has horizontal curvature that has resulted in roadway departure collisions
- The westbound on-ramp (entrance from RD 100 terminal westbound) merging geometry contributes to sideswipe crashes
- The eastbound ramp terminal intersection existing conditions include both safety and operational concerns.
    - Based on Table 5, the existing eastbound ramp operations results indicate that there is queueing on the main line. This queueing on the main line leads to rear-end collisions on the eastbound ramp.
    - The eastbound ramp has horizontal curvature that results in roadway departure collisions.

EXISTING CONDITIONS SUMMARY

Based on the existing conditions analysis, the following key issues are present today at the Broadmoor Blvd 100 and I-182 interchange:

1. The eastbound ramp PM peak period vehicle queues extend into the safe stopping distance from the I-182 gore, leading to heightened rear end crash risk at this location.
2. The I-182 eastbound off-ramp and ramp terminal has a high crash frequency, driven mainly by rear-end collisions, highlighting the concern raised by the PM peak period vehicle queues.
3. The current pedestrian and bicycle facilities at the interchange create a north/south barrier to these modes for transportation, exacerbated by the free turn movements at the ramp terminals.

Based on these key findings, the current interchange is in need of traffic safety, active transportation, and operational upgrades.

CHAPTER 3. FUTURE BASELINE ANALYSIS

The Future Baseline (No-Build) Analysis discussion includes the following sections:

- Baseline Projects
- Future Land Use Summary
- Traffic Forecasts
- Traffic Operational Analysis
- Active Transportation Analysis
- Safety Performance Analysis

The Future Baseline Alternative analyzed in this chapter is the Local Solution alternative for this project, as it includes all planned local improvements around the interchange.

BASELINE PROJECTS

The Broadmoor Interchange project considers two future years, a year of opening/interim year of 2025, and a 20-year horizon year of 2045. The baseline projects with potential influence on the Broadmoor Interchange assumed to be constructed in 2025 are shown in Table 9 and in yellow on Figure 12.

TABLE 9: YEAR 2025 RELEVANT BACKGROUND PROJECTS

#	PROJECT NAME	PROJECT LOCATION	PROJECT DESCRIPTION	PROJECT SOURCE
1	Pedestrian/Bicycle Access Rd 68 Int.	Road 68 through I-182 Interchange	Bike/Pedestrian Improvements along Road 68 through the I-182 Interchange	Pasco CIP
2	Burns Road Pedestrian/Bicycle Pathway	Burns Road (Road 100 to Road 68)	Bike/Pedestrian pathway along Burns Road	Pasco CIP
3	Crescent Rd Surface Improv.	Crescent Rd (Road 108 to Chapel Hill Blvd)	Three-lane formalized paved connection	Pasco CIP
4	Road 100 Pedestrian/Bicycle Improvements	Broadmoor Blvd (I-182 Interchange to Burns Road)	New multi-use path along Broadmoor Blvd	Pasco TIP
5	Sandifur Pkwy Extension – Phase 1	Sandifur Pkwy (Broadmoor Blvd to Road 108)	New 5-lane roadway extension	Pasco TIP
6	Harris Road Re-alignment	Harris Rd (new Road 108) to Sandifur Pkwy	Close existing Harris Rd access to Broadmoor Blvd, re-align Harris Rd northbound to connect to Sandifur Pkwy Extension as Road 108	Pasco TIP
7	Broadmoor Blvd Widening	Broadmoor Blvd (I-182 Interchange to Burns Road)	Widening to 6/7 lane cross section from the interchange to Sandifur Pkwy, 5-lane from Sandifur Pkwy to Burns Rd	On-going development planning
8	Broadmoor Blvd Widening	Broadmoor Blvd (I-182 Interchange to Chapel Hill Blvd)	Widening to two southbound lane, and close southbound left turn at St Thomas Drive	On-going development planning

The assumed year 2045 background projects (additive to the 2025 assumed project) with potential impacts to the ARR analysis are summarized in Table 10 and shown in purple in Figure 12.

TABLE 10: YEAR 2045 RELEVANT BACKGROUND PROJECTS

#	PROJECT NAME	PROJECT LOCATION	PROJECT DESCRIPTION	PROJECT SOURCE
9	Road 100 Widening	Road 100 (Chapel Hill Blvd to Court St)	Widen to 5-lanes as needed	Pasco TIP
10	Road 76 Overcrossing	Road 76 (Chapel Hill Blvd to Burden Blvd)	New roadway extension with I-182 overcrossing	Pasco TIP
11	Sandifur Pkwy Extension – Phase 2	Sandifur Pkwy (Road 108 to Shoreline Road)	New 3-lane roadway extension	Pasco TSMP
12	Road 108 Extension	Road 108 (Sandifur Pkwy to Clark Rd	New 3-lane roadway extension	Pasco TSMP
13	Road 116 Extension	Road 116 (Harris Rd to Burns Rd)	New 3-lane roadway extension	Pasco TSMP

FIGURE 12: 2025 AND 2045 RELEVANT BACKGROUND PROJECTS

In addition, Ben-Franklin Transit is planning for a new park and ride to be located near the future Road 108 and Sandifur Extension. This future transit expansion to the area will make the Broadmoor Area more accessible to all, while also providing an alternative to personal vehicle trips.

The projects with the most immediate operation impacts to the Broadmoor Interchange are shown in further detail in Figure 13. Note that the projects shown in this figure are all assumed for both 2025 and 2045 conditions.

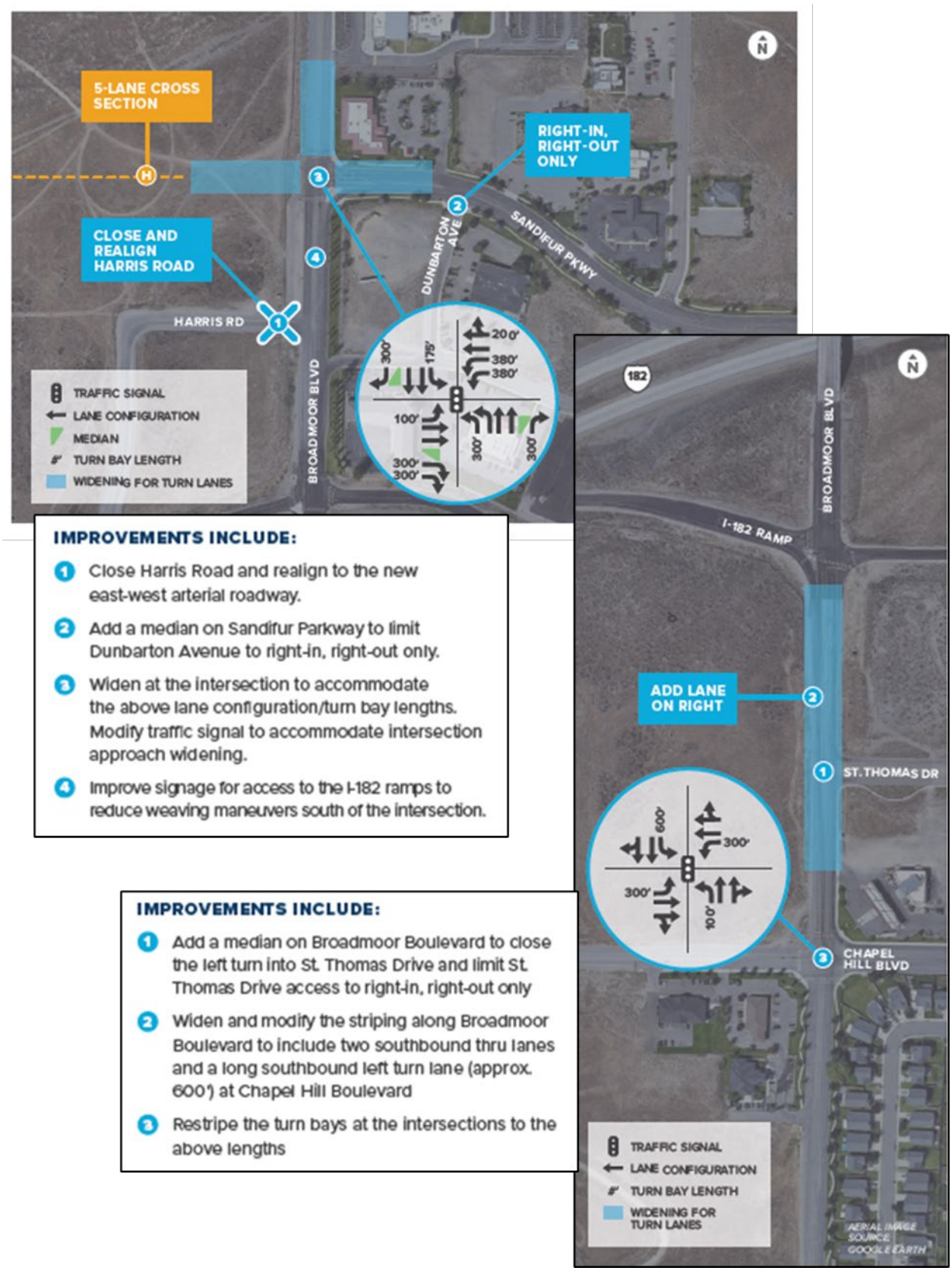

FIGURE 13: BASELINE PROJECTS DETAILS

FUTURE LAND USE SUMMARY

The land use assumptions for the year 2025 and 2045 conditions correspond to the land use forecasts developed for the most recent City of Pasco Comprehensive Plan Update. These assumptions include approximately 7,000 new homes and more than 3,000 new jobs in the area near the interchange.

TRAFFIC FORECASTS

The interim/opening year 2025 and horizon year 2045 forecasts were developed for the project study intersections using the BFCG 2019, 2025, and 2045 regional travel demand models, following the process described in the *Methods and Assumptions* memorandum (see Appendix B). The forecasts were constrained by the capacity of the I-182 bridge over the Columbia River, which is not planned for expansion. Constraining the future traffic on this bridge to match the expected capacity ensure that the Broadmoor Interchange volumes reflect only traffic that can feasibly reach the interchange from I-182. The additional traffic demand unable to use the I-182 bridge during the PM peak hour would either shift to different times (a phenomenon known as "peak spreading") or other modes, as driver would consider other commute and schedule options. As previously noted, Ben-Franklin Transit (BFT) has long term plans to expand transit access in the Broadmoor Area with a new park and ride. This new transit location point would provide people within the Tri-Cities with an alternate mode to access the Broadmoor Area and could reduce the impacts of peak spreading and over-capacity conditions on I-182 by shifting drivers to transit.

The 2025 forecasted turn movements are shown in Figure 14 and Figure 15, and the 2045 forecasts are shown in Figure 16 and Figure 17.

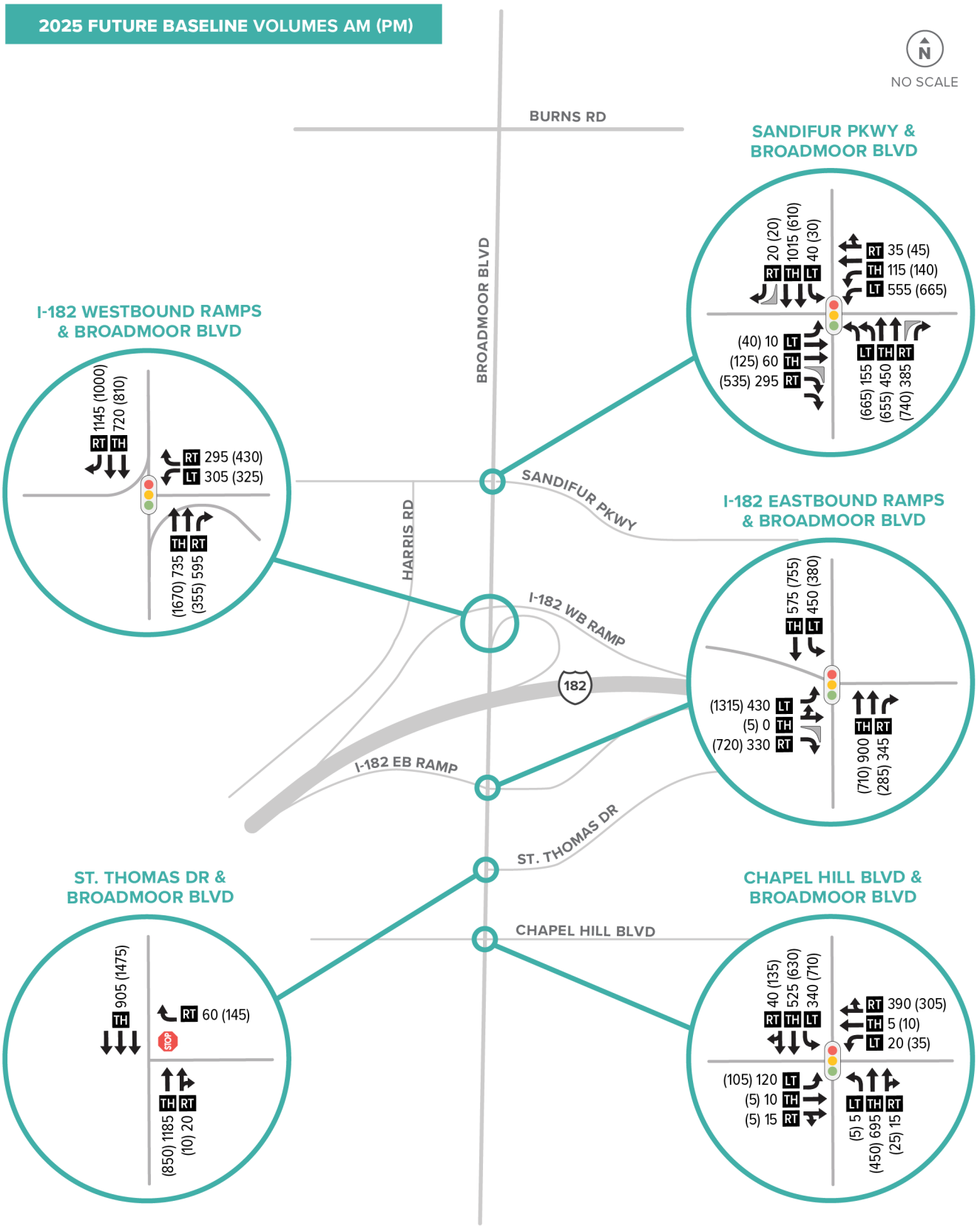

FIGURE 14: BROADMOOR INTERCHANGE INTERIM/OPENING YEAR 2025 FORECASTS

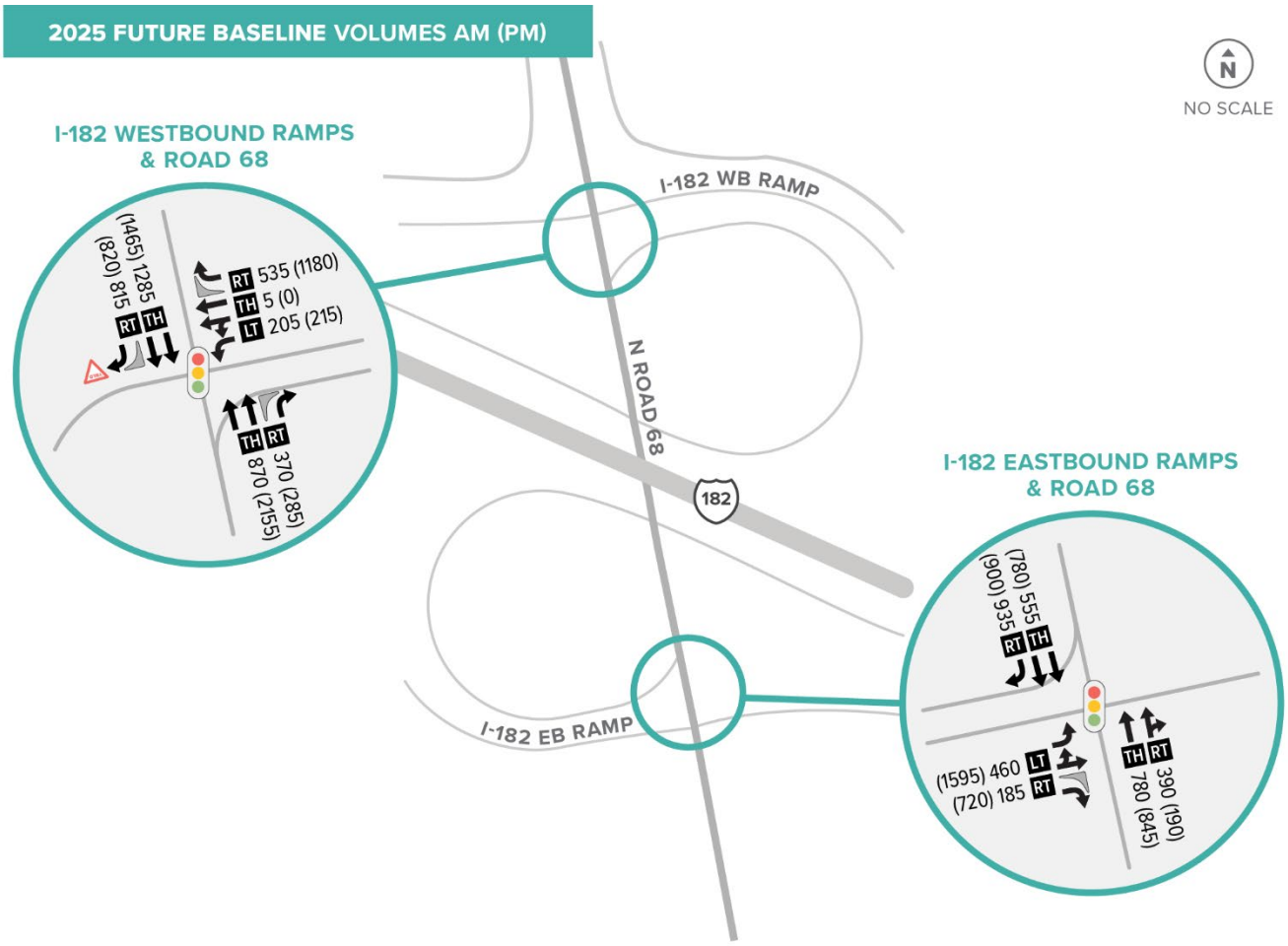

FIGURE 15: ROAD 68 INTERCHANGE INTERIM/OPENING YEAR 2025 FORECASTS

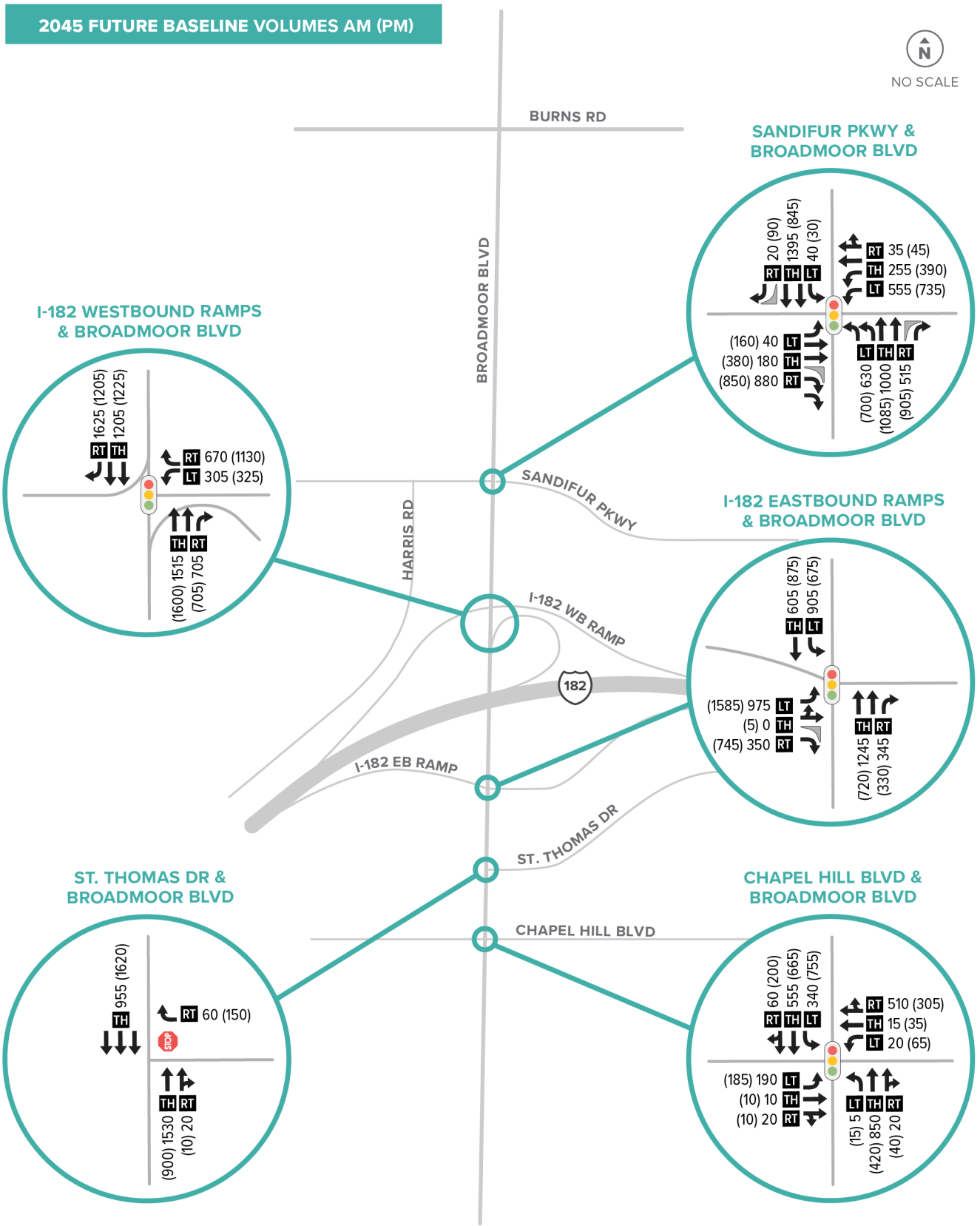

FIGURE 16: BROADMOOR INTERCHANGE HORIZON YEAR 2045 FORECASTS

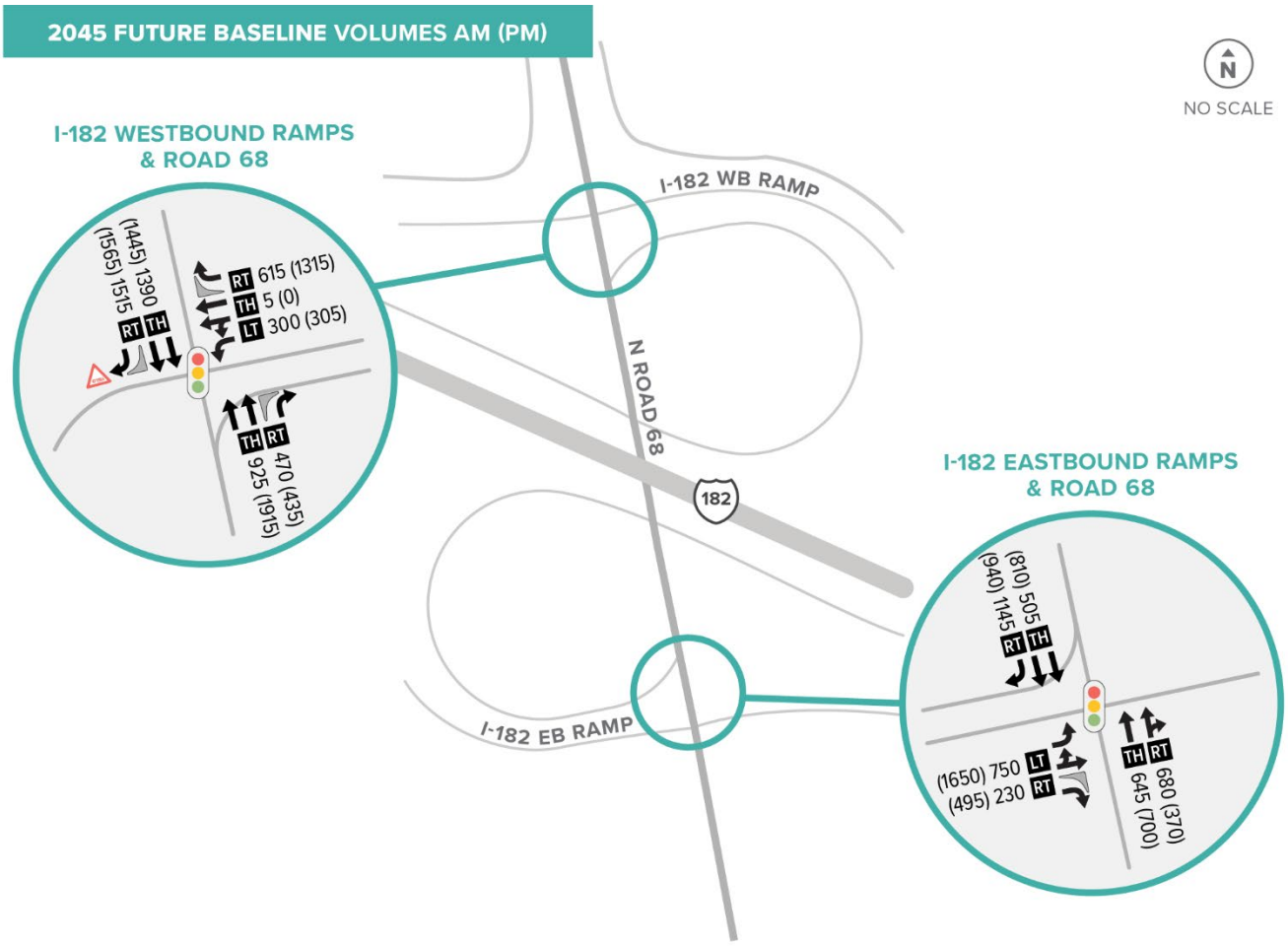

FIGURE 17: ROAD 68 INTERCHANGE HORIZON YEAR 2045 FORECASTS

In addition to the turn movement forecasts, the I-182 freeway volumes were forecast for 2025 and 2045, as summarized in Table 11, along with the percent growth over Existing (2019) conditions.

TABLE 11: I-182 FREEWAY FORECASTS

LOCATION	PEAK HOUR	2019 COUNT	2025		2045	
			Volume	% Growth	Volume	% Growth
I-182 EASTBOUND AT THE COLUMBIA RIVER	AM	2,263	2,490	10%	3,705	64%
	PM	4,010	4,470	11%	5,400	35%
I-182 WESTBOUND AT THE COLUMBIA RIVER	AM	3,062	3,405	11%	5,310	73%
	PM	3,007	3,425	14%	5,190	73%

As shown in the prior figures and tables, traffic demand is forecasted to grow significantly on the freeway, on the interchange ramps, and on Broadmoor Blvd. Some key growth locations are summarized as follows:

- Southbound Left Turn at Broadmoor Blvd and I-182 eastbound ramps – This movement doubles in both the AM and PM peak by 2025, and nearly doubles again from 2025 to 2045 due to primarily to growth in the Broadmoor Area, as well as expected development north of Burns Road.
- Eastbound Left Turn at Broadmoor Blvd and I-182 eastbound ramps – This movement grows by more than 300 trips during the PM peak hour by 2025, and by nearly 600 trips by 2045. It also more than doubles by 2045 during the AM peak hour. Most of this growth is driven by projected development of the Broadmoor Area, as well as expected development north of Burns Road.
- Southbound Right Turn at Broadmoor Blvd and I-182 westbound ramps – This movement grows by more than 300 trips in both the AM and PM peak hours by 2025, and nearly doubles in the AM peak hour between present day and 2045. This is due primarily to growth in the Broadmoor Area, as well as expected development north of Burns Road.
- Westbound Right Turn at Broadmoor Blvd and I-182 eastbound ramps – By 2045, this movement grows by nearly 500 trips during the AM peak hour, and by nearly 900 trips during the PM peak hour. Most of this growth is driven by projected development of the Broadmoor Area, as well as expected development north of Burns Road.

BASELINE TRAFFIC OPERATIONS ANALYSIS

The Baseline traffic operations analysis includes:

- Freeway Operations
- Intersection Operations
- Queuing

FREEWAY OPERATIONS

Table 12 and Table 13 lists the 2025 and 2045 peak hour mainline I-182 eastbound and westbound HCM operations at the Broadmoor Blvd Interchange. The full HCS outputs are included in Appendix F-2.

TABLE 12: INTERIM YEAR (2025) FREEWAY OPERATIONS RESULTS

DIRECTION	SEGMENT	MOVEMENT TYPE	MOBILITY TARGET	AM PEAK HOUR		PM PEAK HOUR	
				LOS	DENSITY (FWY/ RAMP)	LOS	DENSITY (FWY/ RAMP)
I-182 EASTBOUND	Before Broadmoor Blvd Off	Basic	D	B	13.5	C	25.0
	Broadmoor Blvd Off-Ramp	Diverge	D	C	14.2/22.1	**F**	**45.0/35.5**
	Between ramps	Basic	D	A	9.4	B	13.3

DIRECTION	SEGMENT	MOVEMENT TYPE	MOBILITY TARGET	AM PEAK HOUR		PM PEAK HOUR	
				LOS	DENSITY (FWY/ RAMP)	LOS	DENSITY (FWY/ RAMP)
	Broadmoor Blvd On-Ramp	Merge	D	B	14.5/17.7	B	15.8/18.6
	After Broadmoor Blvd On	Basic	D	B	13.6	B	14.9
I-182 WESTBOUND	Before Broadmoor Blvd Off	Basic	D	B	12.5	B	14.9
	Broadmoor Blvd Off-Ramp	Diverge	D	B	13.0/19.8	C	15.6/22.8
	Between ramps	Basic	D	A	9.3	B	11.1
	Broadmoor Blvd On-Ramp	Merge	D	C	20.2/26.2	C	19.6/24.7
	After Broadmoor Blvd On	Basic	D	C	18.4	B	18.1

TABLE 13: HORIZON YEAR (2045) FREEWAY OPERATIONS RESULTS

DIRECTION	SEGMENT	MOVEMENT TYPE	MOBILITY TARGET	AM PEAK HOUR		PM PEAK HOUR	
				LOS	Density (Fwy/ Ramp)	LOS	Density (Fwy/ Ramp)
I-182 EASTBOUND	Before Broadmoor Blvd Off	Basic	D	C	18.6	D	29.0
	Broadmoor Blvd Off-Ramp	Diverge	D	D	19.7/28.5	**F**	**45.0/38.0**
	Between ramps	Basic	D	B	12.0	B	15.3
	Broadmoor Blvd On-Ramp	Merge	D	C	19.5/23.2	C	18.3/21.5
	After Broadmoor Blvd On	Basic	D	B	18.1	B	17.1
I-182 WESTBOUND	Before Broadmoor Blvd Off	Basic	D	C	20.4	C	24.1
	Broadmoor Blvd Off-Ramp	Diverge	D	D	21.0/28.5	D	24.5/32.2
	Between ramps	Basic	D	B	15.3	B	16.2
	Broadmoor Blvd On-Ramp	Merge	D	**E**	**32.0/35.5**	D	29.2/33.1
	After Broadmoor Blvd On	Basic	D	D	29.1	D	27.1

As shown in Table 12 and Table 13, the I-182 eastbound diverge to the Broadmoor Blvd eastbound off-ramp continues to operate at LOS F under both 2025 and 2045 PM peak hour conditions. Increased demand during the AM peak hour causes the I-182 westbound on-ramp from Broadmoor Blvd to operate over capacity, resulting in LOS E operations at the merge.

INTERSECTION OPERATIONS

The 2025 and 2045 Future No-Build (Baseline) intersection operation results are summarized in Table 14, and the full Synchro reports are included in Appendix F-5. As listed in Table 14, the ramp terminals currently meet WSDOT mobility targets of LOS D.

TABLE 14: FUTURE NO-BUILD CONDITIONS INTERSECTION OPERATIONS RESULTS

Intersection	Mobility Standard	AM Peak Hour - LOS/Delay(s)		PM Peak Hour - LOS/Delay(s)	
		2025	2045	2025	2045
BROADMOOR BLVD INTERCHANGE AREA					
Sandifur Blvd and Broadmoor Blvd	LOS D	D / 38	**E / 68**	D / 44	D / 52
I-182 Westbound Ramps and Broadmoor Blvd	LOS D	B / 10	C / 30	B / 10	**F / 117**
I-182 Eastbound Ramps and Broadmoor Blvd	LOS D	B / 16	**F / 166**	**60 / E**	**F / 137**
Chapel Hill Blvd and Broadmoor Blvd	LOS D	D / 37	D / 49	C / 32	D / 38
ROAD 68 INTERCHANGE AREA					
I-182 Westbound Ramps and Road 68	LOS D	A / 5	A / 6	B / 10	A / 10
I-182 Eastbound Ramps and Road 68	LOS D	A / 9	B / 13	**E / 90**	**E / 77**

The following key intersection operations key findings are based on the results shown in Table 14:

- PM Peak Hour
  - Increased demand at the Broadmoor Blvd and I-182 eastbound ramps intersection causes at-capacity conditions (LOS E) by 2025, and over capacity conditions (LOS F) by 2045 during the PM peak hour. Growth to the eastbound left turn and southbound left turn at this intersection are the primary contributors to the increased congestion.
  - No additional eastbound capacity is available downstream of the Broadmoor Interchange as the Road 68 and I-182 eastbound ramps intersection also operates at capacity under 2025 and 2045 conditions, despite the benefits of the Road 76 overcrossing in 2045.
  - The Broadmoor Blvd and I-182 westbound ramps intersection operates over capacity under 2045 conditions due to growth in demand for the northbound through and westbound right turn movements.
- AM Peak Hour

- Under 2045 conditions, growth in demand for the southbound left turn movement at the Broadmoor Blvd and I-182 eastbound ramps intersection causes LOS F operations at this intersection.
- The Broadmoor Blvd and Sandifur Pkwy intersection operates at capacity (LOS E) under 2045 conditions. However, the LOS E condition is driven by growth to the eastbound right turn, southbound through, and westbound left turn movements, and as shown in the subsequent queuing section does not negatively impact operations at the interchange ramp terminals.

QUEUEING

Based on the SimTraffic queueing analysis, Table 15 lists key 95th percentile queues at the Broadmoor Blvd interchange and along Broadmoor Blvd under Future Interim Year (2025) and Horizon Year (2045) conditions. The full SimTraffic outputs are included in Appendix F-8.

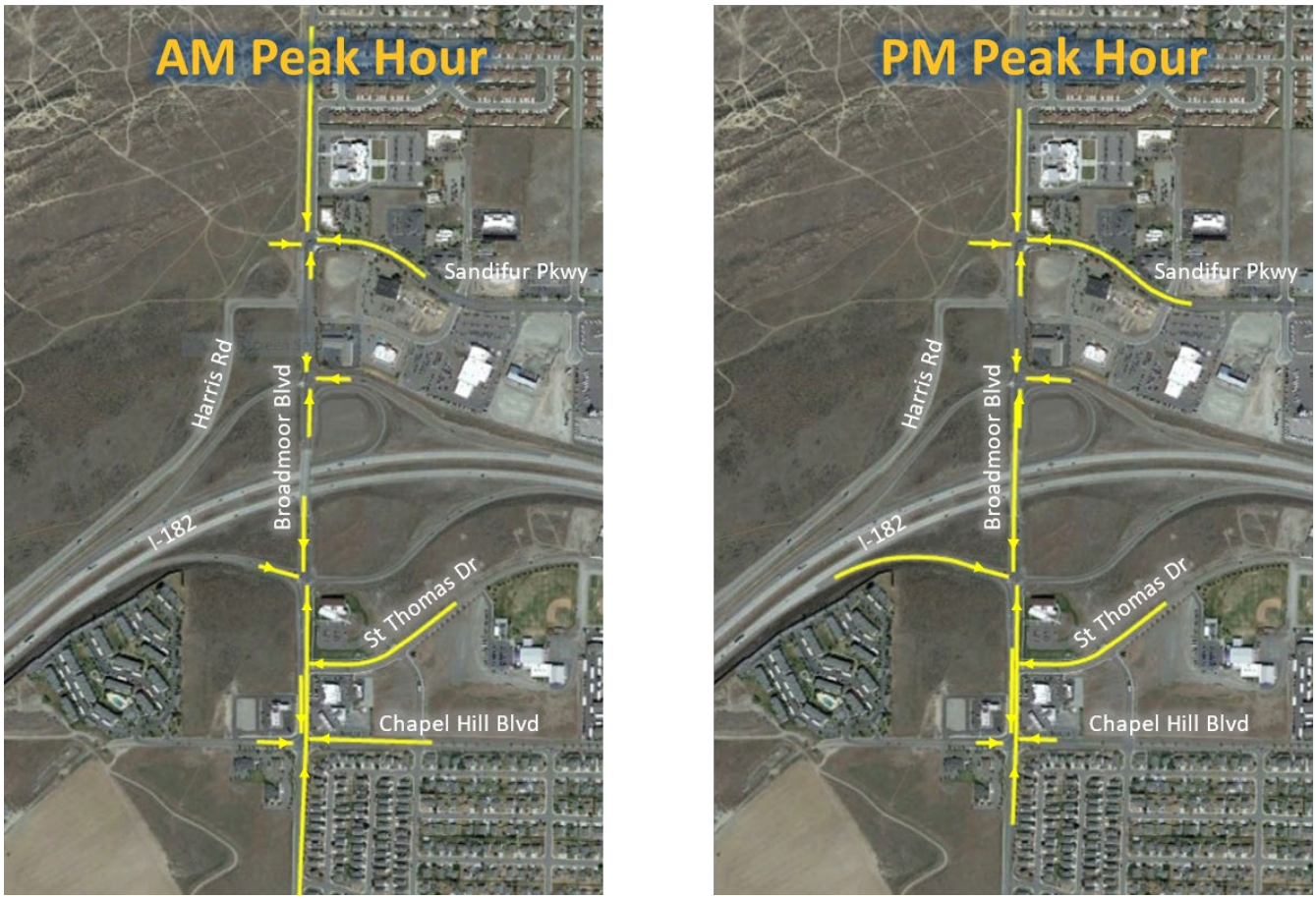

FIGURE 18: YEAR 2025 CONDITIONS CRITICAL QUEUES

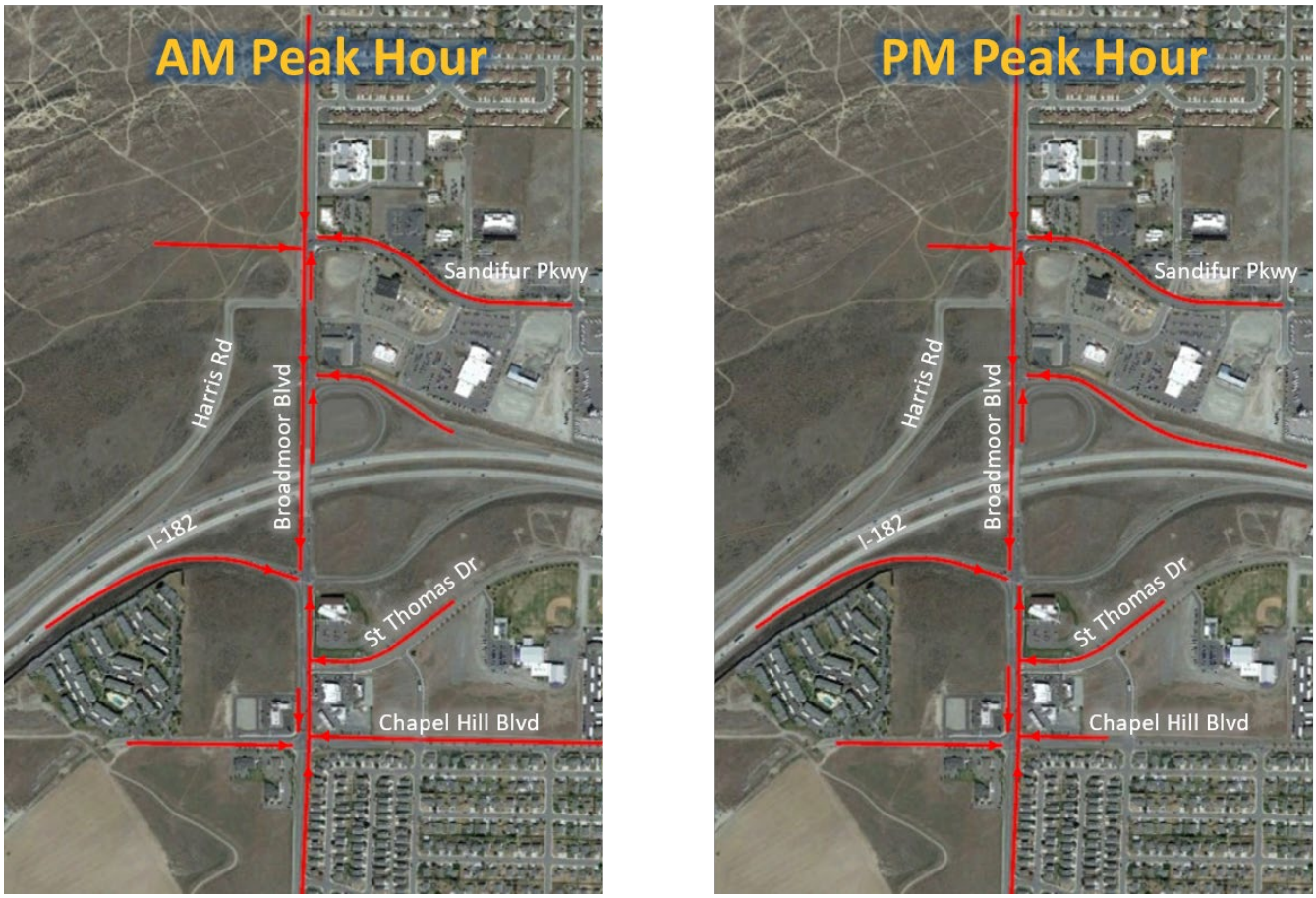

FIGURE 19: YEAR 2045 CONDITIONS CRITICAL QUEUES

TABLE 15: FUTURE NO-BUILD 95TH PERCENTILE QUEUES

INTERSECTION	MOVEMENT	APPROXIMATE STORAGE (FT)[A]	95TH PERCENTILE QUEUE (FT)			
			AM PEAK HOUR		PM PEAK HOUR	
			2025	2045	2025	2045
SANDIFUR PKWY AND BROADMOOR BLVD	NBL	720	140	300	270	220
	NBT	720	170	210	200	230
	NBR	350	60	70	120	160
	SBL	150	**>150**	**>150**	**>150**	**>150**
	SBT	1,310	1,250	**>1,310**	740	**>1,310**
	SBR	175	**>175**	**>175**	**>175**	**>175**

INTERSECTION	MOVEMENT	APPROXIMATE STORAGE (FT)[A]	95TH PERCENTILE QUEUE (FT)			
			AM PEAK HOUR		PM PEAK HOUR	
			2025	2045	2025	2045
	EBL	100	40	70	80	**>100**
	EBT	900	90	**>900**	130	510
	EBR	500	200	**>500**	250	**>500**
	WBL	1,670	720	**>1,670**	1,110	**>1,670**
	WBT	1,670	260	**>1,670**	760	**>1,670**
	WBR	250	80	170	90	200
I-182 WESTBOUND RAMPS AND BROADMOOR BLVD	NBT	1,100	290	450	230	320
	NBR	230	<25	50	<25	<25
	SBT	720	120	**>720**	140	**>720**
	SBR	720	<25	60	<25	50
	WBL	1,030/1,600[B]	210	930	260	**>1,600**
	WBR	350	130	**>350**	260	**>350**
I-182 EASTBOUND RAMPS AND BROADMOOR BLVD	NBT	900	**>900**	**>900**	**>900**	**>900**
	NBR	200	**>200**	**>200**	**>200**	**>200**
	SBL	1,110	460	**>1,110**	770	**>1,110**
	SBT	1,110	130	**>1,110**	1,030	**>1,110**
	EBL	230	**>230**	**>230**	**>230**	**>230**
	EBR	900/1,470[B]	110	**>1,470**	**1,080**	**>1,470**
ST THOMAS DR AND BROADMOOR BLVD	SBL	N/A	Movement Closed			
	WBR	-	**>1,000**	**>1,000**	**>1,000**	**>1,000**
CHAPEL HILL BLVD AND BROADMOOR BLVD	NBL	80	50	50	40	50
	NBT	-	1,030	**>2,000**	430	**>2,000**

INTERSECTION	MOVEMENT	APPROXIMATE STORAGE (FT)[A]	95TH PERCENTILE QUEUE (FT)			
			AM PEAK HOUR		PM PEAK HOUR	
			2025	2045	2025	2045
	NBTR	760	1,070	**>2,000**	490	**>2,000**
	SBL	640	350	270	510	400
	SBT	900	130	150	110	170
	SBTR	900	160	180	150	220
	EBL	225	220	**>225**	160	**>225**
	EBT	-	130	**>1,000**	60	**>1,000**
	EBTR	-	70	250	30	**>1,000**
	WBL	250	50	50	80	100
	WBT	-	80	**>3,000**	50	110
	WBTR	-	750	**>3,000**	200	550

[A] Approximate storage distance is determined by the length of existing or planned (2025 and 2045 conditions) turn bays or the distance to the next upstream signal if applicable.

[B] Ramp storage distance shown by Length to Safe Stopping Distance/Length to striped gore.

The queueing results summarized in Table 15 and shown in Figure 18 and Figure 19 show increased queuing over existing conditions under both 2025 and 2045 conditions. Key queueing findings are summarized as follows:

- PM Peak Hour
  - Under 2025 conditions, the I-182 eastbound off-ramp queues are limited by the number of vehicles actually able exit the freeway during the peak hour. By 2045, vehicle access to the ramp is still constrained, but the queueing on Broadmoor Blvd further restricts the capacity of the eastbound ramp terminal and causes queues to spill back to the freeway
  - The widening project on Broadmoor Blvd between the eastbound ramp terminal and Chapel Hill Blvd combined with the closure of the southbound left turn into St Thomas Dr effectively mitigates the existing merge issue caused by the eastbound right turn from the I-182 off-ramp. Southbound queues from the Broadmoor Blvd/Chapel Hill Blvd intersection no longer extend through the eastbound ramp terminal under both 2025 and 2045 conditions.
  - Under 2025 conditions, the northbound queues on Broadmoor Blvd extend back through Chapel Hill Blvd due to increased conflicting demand from the eastbound left turn at the I-182 eastbound off-ramp.
  - Under 2045 conditions, increased demand on the southbound left turn and eastbound left turn movements at the I-182 eastbound ramp terminal cause the southbound left turn and northbound through movements on Broadmoor Blvd to spill back through Sandifur Pkwy and

Chapel Hill Blvd, respectively. The southbound queues cause the westbound off-ramp to queue back to the I-182 mainline as well.

- AM Peak Hour
  - Under 2025 and 2045 conditions, the combined increases in demand on the northbound through and eastbound left turn movements at the eastbound ramp terminal cause northbound vehicle queues on Broadmoor Blvd to extend well beyond Chapel Hill Blvd.
  - Under 2045 conditions, the increased demand on the southbound left turn at the eastbound ramp terminal causes southbound queues on Broadmoor Blvd to extend back through Sandifur Pkwy.

MULTIMODAL CONDITIONS

There is a new multi-use trail planned on the west side of Broadmoor Blvd by 2025. Between Burns Road and the I-182 WB ramps, the trail will be 12 feet wide and buffered. Between the I-182 EB ramps and Chapel Hill Blvd, the trail will be 10 feet wide and curb tight. It will tie into the existing sidewalk north of Chapel Hill Blvd. There are no additional improvements planned between 2025 and 2045. The Table 16 below shows the LTS for bicycles and pedestrians in 2025 and 2045 in the baseline scenario.

TABLE 16: FUTURE NO-BUILD BLTS AND PLTS RESULTS

	BIKE			PEDESTRIAN		
CROSS-STREET	SEGMENT BIKE LTS	CROSSING BIKE LTS	TOTAL BIKE LTS	SEGMENT PED LTS	CROSSING PED LTS	TOTAL PED LTS
CHAPEL HILL BLVD	3	3	3	4	4	4
ST THONMAS DR	3	3	3	4	4	4
I-182 WESTBOUND RAMP TERMINAL	4	4	4	4	4	4
I-182 EASTBOUND RAMP TERMINAL	4	4	4	4	4	4
SANDIFUR PARKWAY	3	3	3	4	4	4

SAFETY PERFORMANCE ANALYSIS

The future conditions safety analysis was performed for the following segments and intersections:

- Broadmoor Blvd: Westbound Ramp Terminal to Eastbound Ramp Terminal
- Westbound Ramp Terminal

- Eastbound Ramp Terminal
- I-182 Freeway

The following section detail the Future No-Build conditions safety analysis results for each of these segments and intersections.

BROADMOOR BLVD SEGMENT NO-BUILD SAFETY RESULTS

The safety performance of this roadway segment was conducted with the HSM Smart spreadsheet tool for urban and suburban arterials. The results analysis was conducted for baseline years of 2025 and 2045. The analysis for this segment indicated that 2.784 predicted crashes per year will occur for the year 2025, and 3.064 crashes per year are predicted for 2045. Table 17 breaks down these crashes in two injury categories: fatal and injury collisions; and property damage only collisions.

TABLE 17: BROADMOOR BLVD INTERCHANGE SEGEMENT PREDICTED YEARLY CRASHES

YEAR	FATAL/INJURY	PDO	TOTAL
2025	0.759	1.994	2.754
2045	0.998	2.579	3.577

WESTBOUND RAMP TERMINAL NO-BUILD SAFETY RESULTS

The safety performance of this ramp terminal intersection was conducted using the HSM ISAT-e Spreadsheet tool for ramp terminals. The results analysis was conducted for baseline years of 2025 and 2045. The analysis for this intersection indicated that 6.715 predicted crashes per year will occur for the year 2025, and 4.306 predicted crashes per year for 2045. Table 18 breaks down these crashes in two injury categories: fatal and injury collisions; and property damage only collisions.

TABLE 18: WESTBOUND RAMP TERMINAL PREDICTED YEARLY CRASHES

YEAR	FATAL/INJURY	PDO	TOTAL
2025	2.836	3.879	6.715
2045	4.306	5.370	9.676

EASTBOUND RAMP TERMINAL NO-BUILD SAFETY RESULTS

The safety performance of this ramp terminal intersection was conducted using the HSM ISAT-e Spreadsheet tool for ramp terminals. The results analysis was conducted for baseline years of 2025 and 2045. The analysis for this intersection indicated that 16.098 predicted crashes a year will

occur for the year 2025, and 20.550 predicted crashes a year for 2045. Table 19 breaks down these crashes in two injury categories: fatal and injury collisions; and property damage only collisions.

TABLE 19: EASTBOUND RAMP TERMINAL PREDICTED YEARLY CRASHES

YEAR	FATAL/INJURY	PDO	TOTAL
2025	4.915	11.183	16.098
2045	6.435	14.115	20.550

I-182 FREEWAY SEGEMENT NO-BUILD SAFETY RESULTS

The safety performance for I-182 eastbound from 1500 feet west of the eastbound off-ramp to the eastbound on-ramp was conducted using the HSM ISAT-e Spreadsheet tool for freeways. The results analysis was conducted for baseline years of 2025 and 2045 and were compared against predicted (not observed) 2019 conditions. The analysis results are summarized in Table 20. Table 20 breaks down these crashes in two injury categories: fatal and injury collisions; and property damage only collisions.

TABLE 20: EASTBOUND RAMP TERMINAL PREDICTED YEARLY CRASHES

YEAR	FATAL/INJURY	PDO	TOTAL
I-182 EASTBOUND SEGMENT			
2019	6.797	12.345	19.142
2025	7.640	14.046	21.686
2045	12.401	23.255	35.656
I-182 EASTBOUND OFF-RAMP TO BROADMOOR BLVD			
2019	2.703	3.577	6.280
2025	3.234	4.290	7.524
2045	4.844	6.411	11.255

As shown in Table 20, crashes on the freeway and the eastbound off-ramp are predicted to increase steadily into the future, nearly doubling by the year 2045.

CHAPTER 4. ALTERNATIVES

This chapter focuses on the alternatives considered, and includes the following sections:

- Potential for Local Solutions – Discussion
- First Level (Preliminary) Alternatives – Overview of the alternatives brainstorming and quantitative initial screening process
- Reasonable Alternatives – Description of the alternatives advanced to the Level 2 Evaluation

POTENTIAL FOR LOCAL SOLUTIONS

Local solutions are typically identified and tested during the Non-Access Feasibility Study (NAFS) prior to the Access Revision Report. Prior traffic studies performed at this interchange clearly identified as deficiencies at the interchange that could not be solved by adding or enhancing the local system around the interchange. As noted in the project *Purpose and Need Memorandum,* these prior studies were used as a substitute for a NAFS. Local projects identified in the City of Pasco TSMP and the Comprehensive Plan were included in the baseline (No-Build) alternative, providing the local solution alternative as a background to any proposed interchange projects. These local projects are summarized in Table 9 and Table 10 in Chapter 3.

FIRST LEVEL (PRELMINARY) ALTERNATIVES

The alternatives development process is outlined in detail in the *Alternatives Screening Matrix Memorandum,* with is included in Appendix C. The alternatives development process is summarized in Figure 20.

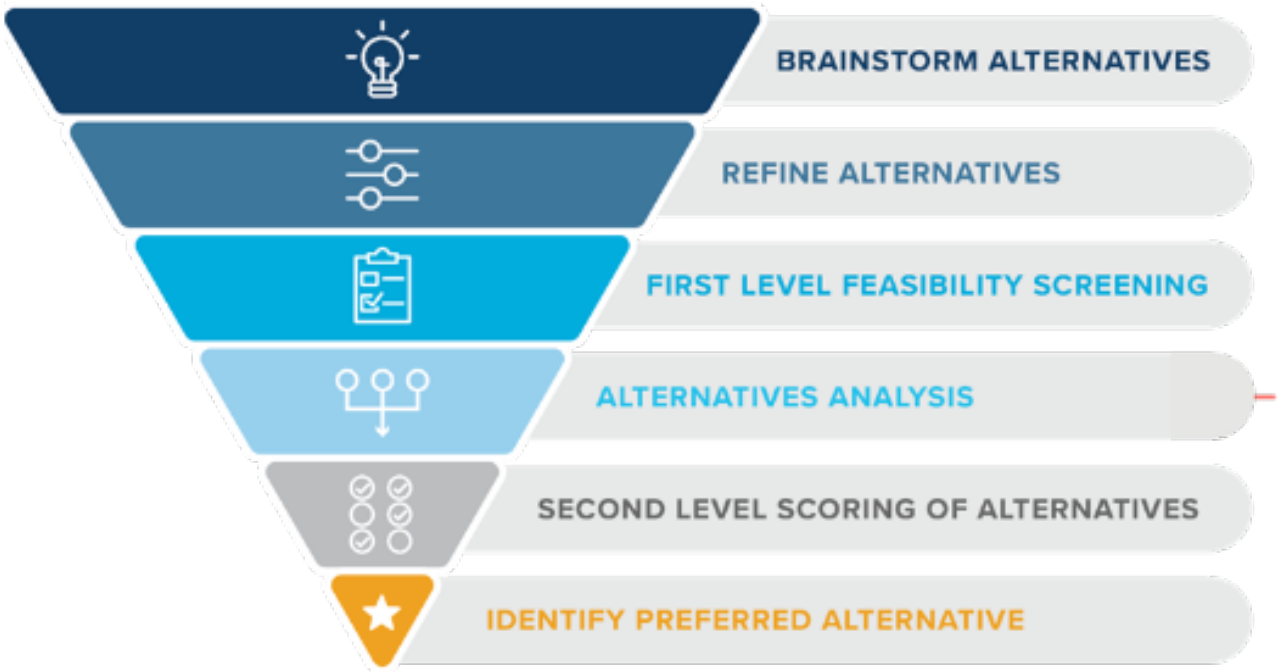

FIGURE 20: ALTERNATIVE DEVELOPMENT AND SCREENING PROCESS

The First Level Screening provided a qualitative, fatal flaw and reasonable feasibility assessment of the alternatives brainstormed by the TAC, public, and project team. Prior to the First Level screening, proposed alternatives were filtered against the project purpose and need and were then refined/combined to avoid redundancy. These alternatives were then grouped into the following categories:

- Freeway Alternatives – focused on the freeway on and off-ramps
- Westbound Ramp Terminal Alternatives – focused on the I-182 westbound ramp terminal on Broadmoor Blvd
- Eastbound Ramp Terminal Alternatives – focused on the I-182 eastbound ramp terminal on Broadmoor Blvd
- Active Transportation Alternatives – focused on active transportation improvements only through or near the interchange
- Comprehensive Alternatives – focused on complete interchange re-build or reconfiguration

The alternatives refined by the TAC for consideration in the First Level Screening are summarized in Table 21. High level conceptual outlines for these alternatives are included in Appendix D-1.

TABLE 21: FIRST LEVEL SCREENING ALTERNATIVES

#	TITLE	DESCRIPTION
	FREEWAY ALTERNATIVES	
F-E-1	Exist + Decel Loop	New eastbound loop off-ramp with decel lane
F-E-2	Decel + Decel Loop	New eastbound loop off-ramp, with decel lane + decel lane to existing EB off
F-E-4	Decel + Dual off	Dual EB off-ramp with decel lane
	WESTBOUND RAMP TERMINAL ALTERNATIVES	
W-S-1	Flying T	Flying T with dual WBR, single SBT, WBL add lane
W-S-2	Dual WBR	Signalized dual WBR
W-R-1	Roundabout	New roundabout at ramp terminal
	EASTBOUND RAMP TERMINAL ALTERNATIVES	
E-R-1	Roundabout + Loop	Roundabout with Loop Ramp - NB add lane
E-R-2	Roundabout + Exist	Roundabout with existing off-ramp
E-S-1	Signal + Loop 1	Signal with loop ramp - single SBL, dual WBR
E-S-2	Signal + Loop 2	Signal with loop ramp - dual SBL, dual WBR

#	TITLE	DESCRIPTION
E-S-3	Signal + Widening 1	Signal with existing - dual SBL
	ACTIVE TRANSPORTATION ALTERNATIVES	
A-N-1	Ped Bridge - West Side	New crossing on west side of Broadmoor
A-N-2	Ped Bridge - East Side	New ped crossing on east side of Broadmoor
A-N-3	Ped Bridge - Midland Ln	New ped crossing over I-182 aligned with Midland Ln
A-W-1A	WB on-ramp undercrossing	Ped undercrossing at WB on-ramp
A-W-2B	WB off-ramp overcrossing	Ped overcrossing at WB off-ramp
A-E-1A	EB on-ramp undercrossing	Ped undercrossing at EB on-ramp
A-E-2A	EB off-ramp undercrossing	Ped undercrossing at EB off-ramp
A-I-1	Cantilever Ped Crossing	Cantilever ped structure on west side of Broadmoor
A-I-2	West side path	Narrow vehicles lanes for multi-use path on west side of Broadmoor Overcrossing
A-I-3	East side path	Narrow vehicles lanes for multi-use path on East side of Broadmoor Overcrossing
A-P-2	EB on-ramp path	New path following EB on-ramp alignment
	COMPREHENSIVE ALTERNATIVES	
C-P-1	DDI full Signal + New Bridge	DDI with signals with new parallel structure
C-P-2	DDI Signal + Roundabout with New Bridge	DDI with roundabout at EB terminal, signal at WB terminal with new parallel structure
C-P-3	DDI with Roundabout with New Bridge	DDI with roundabouts at both ramp terminals with new parallel structure

The First Level Screening Matrix is shown in Table 22. The detailed assumptions behind each screening criteria are presented in the *Alternatives Screening Matrix Memorandum* included as Appendix C.

TABLE 22: FIRST LEVEL SCREENING MATRIX

#	PERFORMANCE MEASURE	SCORING CRITERIA
1	Significant Right-of-way Acquisition	Pass/Fail
2	Widening existing bridge structure	Pass/Fail
3	Replace existing bridge structure	Pass/Fail
4	Ability to meet reasonable and safe geometric standards	Pass/Fail
5	Does not add new access points on to the interstate	Pass/Fail
6	Active Transportation Connectivity and Safety Opportunities	Pass/Fail

The refined set of proposed alternatives were scored against the First Level Screening matrix shown in Table 22. All concepts with passing scores in all applicable criteria (measure #7 did not apply to many of the interchange concepts) were then advanced into the Level 2 evaluation and screening. Concepts with even a single "Fail" score were not advanced.

- Significant Right-of-way Acquisition
- Widening existing bridge structure
- Does not add new access points on to the interstate

The First Level Screening results are summarized in Table 23.

TABLE 23: FIRST LEVEL ALTERNATIVES SCREENING MATRIX

#	ALTERNATIVE DESCRIPTION	ROW AQU.	WIDEN BRDG.	REPLACE BRDG.	SAFE STRDS.	NO NEW ON-RAMPS	AT. CONN. & SAFETY
		1	2	3	4	5	6
FREEWAY ALTERNATIVES							
F-E-1	Exist + Decel Loop	Pass	Pass	Pass	Pass	Pass	N/A
F-E-2	Decel + Decel Loop	Pass	Pass	Pass	Pass	Pass	N/A
F-E-4	Decel + Dual off	Pass	Pass	Pass	Pass	Pass	N/A
WESTBOUND RAMP TERMINAL ALTERNATIVES							
W-S-1	Flying T	Pass	Pass	Pass	Pass	Pass	N/A
W-S-2	Dual WBR	Pass	Pass	Pass	Pass	Pass	N/A
W-R-1	Roundabout	Pass	Pass	Pass	Pass	Pass	N/A
EASTBOUND RAMP TERMINAL ALTERNATIVES							

#	ALTERNATIVE DESCRIPTION	ROW AQU.	WIDEN BRDG.	REPLACE BRDG.	SAFE STRDS.	NO NEW ON-RAMPS	AT. CONN. & SAFETY
		1	2	3	4	5	6
E-R-1	Roundabout + Loop	Pass	Pass	Pass	Pass	Pass	N/A
E-R-2	Roundabout + Exist	Pass	Pass	Pass	Pass	Pass	N/A
E-S-1	Signal + Loop 1	Pass	Pass	Pass	Pass	Pass	N/A
E-S-2	Signal + Loop 2	Pass	**Fail**	Pass	Pass	Pass	N/A
E-S-3	Signal + Widening 1	Pass	**Fail**	Pass	Pass	Pass	N/A
ACTIVE TRANSPORTATION ALTERNATIVES							
A-N-1	Ped Bridge - West Side	N/A	N/A	N/A	N/A	N/A	Pass
A-N-2	Ped Bridge - East Side	N/A	N/A	N/A	N/A	N/A	Pass
A-N-3	Ped Bridge - Midland Ln	N/A	N/A	N/A	N/A	N/A	Pass
A-W-1A	WB on-ramp undercrossing	N/A	N/A	N/A	N/A	N/A	Pass
A-W-2B	WB off-ramp overcrossing	N/A	N/A	N/A	N/A	N/A	Pass
A-E-1A	EB on-ramp undercrossing	N/A	N/A	N/A	N/A	N/A	Pass
A-E-2A	EB off-ramp undercrossing	N/A	N/A	N/A	N/A	N/A	Pass
A-I-1	Cantilever Ped Crossing	N/A	N/A	N/A	N/A	N/A	Pass
A-I-2	West side path	N/A	N/A	N/A	N/A	N/A	Pass
A-I-3	East side path	N/A	N/A	N/A	N/A	N/A	Pass
A-P-2	EB on-ramp path	N/A	N/A	N/A	N/A	N/A	Pass
COMPREHENSIVE ALTERNATIVES							

#	ALTERNATIVE DESCRIPTION	ROW AQU.	WIDEN BRDG.	REPLACE BRDG.	SAFE STRDS.	NO NEW ON-RAMPS	AT. CONN. & SAFETY
		1	2	3	4	5	6
C-P-1	DDI full Signal + New Bridge	Pass	**Fail**	Pass	Pass	Pass	Pass
C-P-2	DDI Signal + Roundabout with New Bridge	Pass	**Fail**	Pass	Pass	Pass	Pass
C-P-3	DDI with Roundabout with New Bridge	Pass	Pass	Pass	Pass	Pass	Pass

As shown in Table 23, the following alternatives did not pass the First Level Screening for the reasons summarized below:

- **E-S-2**: This alternative would require widening to the existing Broadmoor Bridge to accommodate dual southbound left turn lane at the eastbound ramp terminal.
- **E-S-3**: This alternative would require widening to the existing Broadmoor Bridge to accommodate dual southbound left turn lane at the eastbound ramp terminal.
- **C-P-1** and **C-P-2**: Technically, all three Diverging Diamond Interchange (DDI) alternatives considered could either be constructed using a parallel structure or by widening the existing bridge. As a DDI would be considered an ultimate, long-term solution for the interchange, the alternative (**C-P-3**) with the most promising configuration from a traffic operations and safety benefit perspective was selected to advance to the Level 2 Evaluation.

Of the remaining alternatives, some additional refinement was performed before advancing to the Level 2 Evaluation. Alternative **A-I-1** was determined to be infeasible as a cantilever structure and was therefore modified to a bridge widening alternative while still advanced to the Level 2 Evaluation to provide a cost comparison against the separated structure options. Alternatives **A-I-2** and **A-I-3** were combined to a single alternative for evaluation purposes, as the cost was not expected to differ substantially based on which side of Broadmoor Blvd received the re-striped mixed-use facility. These modified alternatives were included with the other alternatives passing the First Level Screening and were considered likely to provide improvements to the interchange in alignment with the project purpose and need. These "reasonable" alternatives were advanced to the Level 2 evaluation, and the conceptual designs for each alternative were refined to allow for cost estimates. The conceptual design descriptions and costs estimates for the reasonable alternatives are included in the following section.

REASONABLE ALTERNATIVES

This section describes the conceptual design and summarizes the cost estimates for each alternative advanced to the Level 2 Evaluation. The alternative descriptions are grouped by the

categories created in the First Level Screening process: Freeway, Westbound Ramp Terminal, Eastbound Ramp Terminal, Active Transportation, and Comprehensive.

FREEWAY ALTERNATIVE DESCRIPTIONS

Three alternatives involving improvements and modifications to the freeway facility passed through the First Level Screening. These alternatives are listed as follows:

- **F-E-1**: New Eastbound Loop Exit Ramp
- **F-E-2**: New Eastbound Loop Exit Ramp with New Deceleration Lane at Existing Off-Ramp
- **F-E-4**: Dual Eastbound Off-Ramp

Each of these alternatives is described in the following sections.

Alternative F-E-1

Alternative **F-E-1** is a new eastbound loop exit ramp at Broadmoor Blvd, as shown in Figure 21. This exit ramp is initially identified as a tapered diverge from I-182, beginning just west of the Broadmoor Blvd overcrossing, 1500 feet east of the existing eastbound off-ramp gore to meet WSDOT and FHWA spacing standards. The treatment of the loop ramp at the terminal intersection on Broadmoor Blvd is addressed in the Eastbound Ramp Terminal category. This design is anticipated to easily fit within the existing freeway right-of-way. A small retaining wall will likely be needed at the toe of the Broadmoor Blvd overcrossing. The loop ram design speed is anticipated to be approximately 30 mph. This alternative reflects the original long term ramp configuration planned for the interchange.

FIGURE 21: ALTERNATIVE F-E-1 (LOOP RAMP) CONCEPTUAL LAYOUT

The new loop ramp would separate traffic exiting I-182 eastbound into two different locations, eliminating the queuing caused by the diverge failure at the existing exit ramp. The existing ramp would remain but would only serve eastbound right turns (I-182 eastbound to Broadmoor Blvd southbound). The loop ramp would serve the high volume eastbound left turn at the eastbound ramp terminal, converting the left turns to westbound right turns.

The estimated cost for this alternative is **$2.8 Million**, with the detailed cost estimate breakdown included in Appendix I.

Alternative F-E-2

Alternative **F-E-2** builds off **F-E-1**, including the same new eastbound loop exit ramp at Broadmoor Blvd, as shown in Figure 22. In addition, this alternative includes a new 600 to 700-foot deceleration lane at the existing eastbound off-ramp. The deceleration lane is anticipated to include a small retaining wall near the existing ramp diverge but is not anticipated to require any right-of-way acquisition.

FIGURE 22: ALTERNATIVE F-E-2 (LOOP RAMP WITH DECEL. LANE) CONCEPTUAL LAYOUT

The existing diverge was identified as a high crash occurrence location with a preponderance towards rear-end collisions under existing conditions. This new deceleration lane is intended to improve safety at the existing diverge location, pulling existing vehicles out of the freeway main lanes earlier to give them more time to slow down.

The estimated cost for this alternative is **$3.3 Million**, with the detailed cost estimate breakdown included in Appendix I. Note that this is the combined cost for the loop ramp (**F-E-1**) plus the deceleration lane.

Alternative F-E-4

Alternative **F-E-4** widens the existing eastbound off-ramp to a two-lane exit, as shown in Figure 23. To achieve this, a 800 to 900 foot deceleration lane would be added in advance of the existing eastbound off-ramp. Vehicles would have the option to exit from both the deceleration lane and the outside through lane on I-182, which would become a through/option exit lane. This alternative is anticipated to include multiple retaining walls, one along the deceleration lane and another along the widened portion of the off-ramp. No right-of-way acquisition is anticipated for the alternative.

FIGURE 23: ALTERNATIVE F-E-4 (TWO-LANE EXIT RAMP) CONCEPTUAL LAYOUT

The dual lane exit ramp is intended to address the diverge failure at the existing off-ramp by adding capacity. The added capacity would decrease slowing on at the freeway exit, improving freeway queuing conditions.

The estimated cost for this alternative is **$3.2 Million**, with the detailed cost estimate breakdown included in Appendix I.

WESTBOUND RAMP TERMINAL DESCRIPTIONS

Three alternatives directly involving the I-182 westbound ramp terminal at Broadmoor Blvd passed the First Level Screening. These alternatives are listed as follows:

- **W-S-1**: "Flying T" Signal Configuration
- **W-S-2**: Dual Westbound Right Turn Lane
- **W-R-1**: Roundabout

Each of these alternatives is described in the following sections.

Alternative W-S-1

Alternative **W-S-1** reconfigures the existing signal at the westbound ramp terminal to a "Flying T" design with a dual lane westbound right turn lane, as shown in Figure 24. The "Flying T" component of the design involves separating the westbound left turn from conflict with the southbound through movement. Southbound Broadmoor Blvd would be reconfigured to a single southbound through lane and a drop lane to the southbound right turn. The westbound left turn

would have its own receiving lane on Broadmoor Blvd, separated from the southbound through with a curb median barrier. No right-of-way acquisition is anticipated for this alternative.

FIGURE 24: ALTERNATIVE W-S-1 ("FYLING T") CONCEPTUAL LAYOUT

This alternative is intended to address some of the queuing and capacity issues noted under the long term (2045) No-Build traffic operations, namely excessive queuing on the westbound off-ramp. The dual westbound right turn lanes add capacity to an expected heavy growth movement. Separating the westbound left turn from the southbound through movement simplifies signal operations with the westbound off-ramp movements no longer conflicting in any way with traffic on southbound Broadmoor Blvd.

The estimated cost for this alternative is **$0.83 Million**, with the detailed cost estimate breakdown included in Appendix I.

Alternative W-S-2

As shown in Figure 25, Alternative **W-S-2** is a simplified version of alternative **W-S-1**, only including the second westbound right turn lane but maintain the westbound left turn as it operates today.

FIGURE 25: ALTERNATIVE W-S-2 (DUAL RIGHT TURN) CONCEPTUAL LAYOUT

Similar to alternative **W-S-1**, this alternative provides additional storage and capacity for the westbound right turn movement to better serve increased traffic demand in the future. The dual westbound right also provides the opportunity to prohibit right turn on red movements while maintaining reasonable queue lengths. Prohibiting westbound right turn on red movements would better protect pedestrians crossing the westbound off-ramp crosswalk.

The estimated cost for this alternative is **$0.49 Million**, with the detailed cost estimate breakdown included in Appendix I.

Alternative W-R-1

Alternative **W-R-1** replaces the existing signal at the westbound ramp terminal with a multi-lane roundabout, as shown in Figure 26. This roundabout would include a southbound right turn slip lane to the westbound on-ramp, a northbound right turn slip lane to the westbound loop on-ramp, a two-lane westbound off-ramp approach, and dual circulating lanes. This design would be further refined if advanced as a preferred alternative, but the conceptual design includes a large enough radius to accommodate WB-67 truck turn movements. The roundabout footprint is anticipated to fit within the existing available right-of way.

FIGURE 26: ALTERNATIVE W-R-1 (ROUNDABOUT) CONCEPTUAL LAYOUT

Roundabouts can simplify and improve traffic operations by reducing conflicts while simultaneously improving safety by slowing vehicle speeds. This roundabout is intended to address long term traffic queuing needs on the westbound off-ramp, as well as improve both traffic and pedestrian

safety at the ramp terminal by reducing vehicle speeds and decreasing pedestrian crossing distances.

The estimated cost for this alternative is **$1.7 Million**, with the detailed cost estimate breakdown included in Appendix I.

EASTBOUND RAMP TERMINAL DESCRIPTIONS

Three alternatives directly involving the I-182 eastbound ramp terminal at Broadmoor Blvd passed the First Level Screening. These alternatives are listed as follows:

- **E-R-1**: Roundabout with Loop Ramp
- **E-R-2**: Roundabout without Loop Ramp
- **E-S-1**: Signal Modifications with Loop Ramp

Each of these alternatives is described in the following sections.

Alternative E-R-1

Alternative **E-R-1** replaces the existing signal at the eastbound ramp terminal with a multi-lane roundabout while also connecting the new loop ramp from alternatives **F-E-1** and **F-E-2** into the intersection, as shown in Figure 27. This roundabout would include a northbound right turn slip lane to the eastbound on-ramp, a two-lane westbound right turn from the new loop ramp, a two-lane eastbound right turn, and dual circulating lanes. This design would be further refined if advanced as a preferred alternative, but the conceptual design includes a maximum anticipated footprint, including a large enough radius to accommodate WB-67 truck turn movements. The roundabout footprint is anticipated to fit within the existing available right-of way.

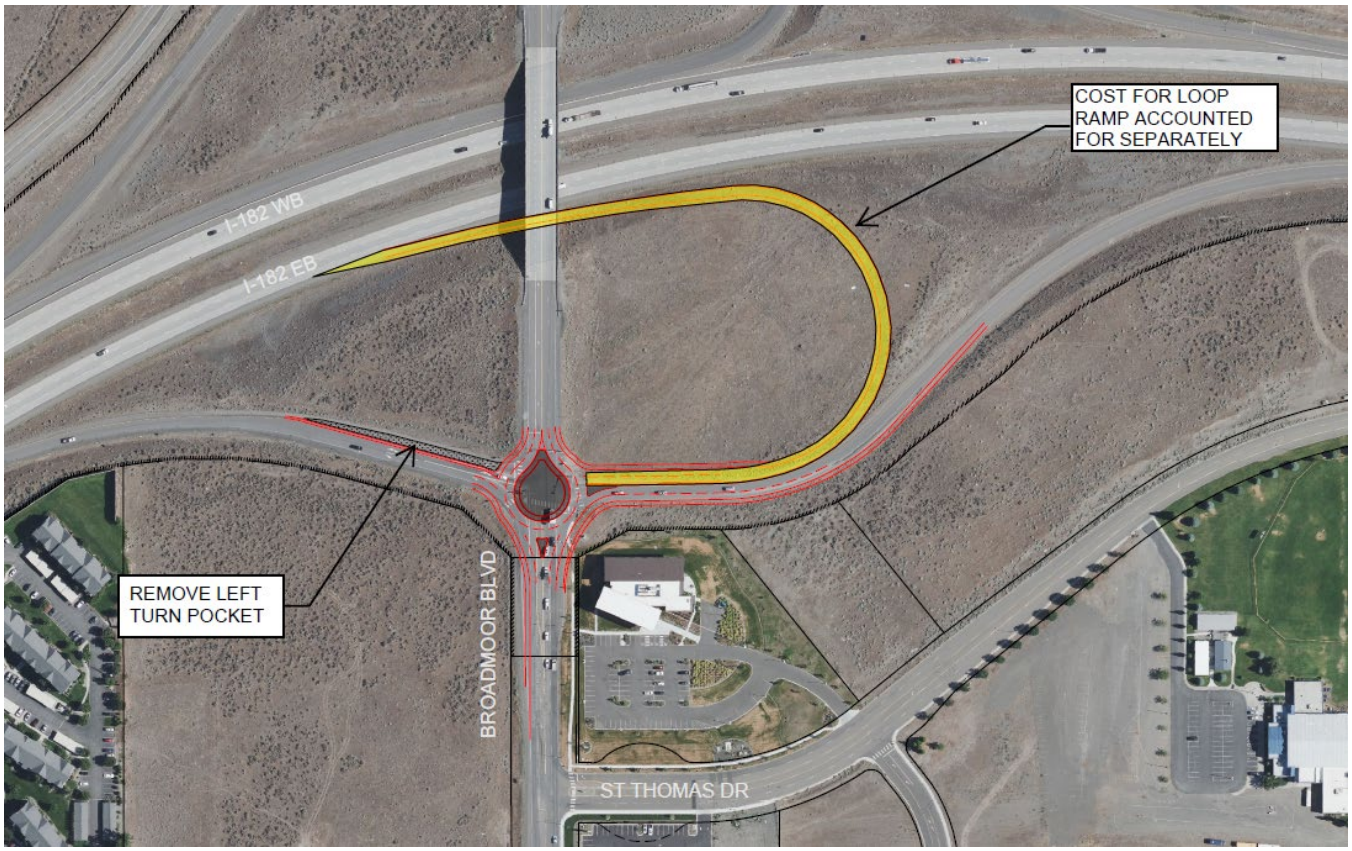

FIGURE 27: ALTERNATIVE E-R-1 (ROUNDABOUT + LOOP RAMP) CONCEPTUAL LAYOUT

Roundabouts can simplify and improve traffic operations by reducing conflicts while simultaneously improving safety by slowing vehicle speeds. This roundabout is intended to address long term traffic queuing needs on the eastbound off-ramp(s), limiting queueing and eliminating all conflicts between the heavy southbound left turn and the eastbound off-ramp movements. This alternative is also intended to pedestrian safety at the ramp terminal by reducing vehicle speeds and decreasing pedestrian crossing distances.

The estimated cost for this alternative is **$2.3 Million**, with the detailed cost estimate breakdown included in Appendix I. The cost of the loop ramp is not included in this estimate but is tied to the freeway alternatives.

Alternative E-R-2

Alternative **E-R-2** replaces the existing signal at the eastbound ramp terminal with a multi-lane roundabout, as shown in Figure 28. This roundabout would include a northbound right turn slip lane to the eastbound on-ramp, a two-lane eastbound approach, and dual circulating lanes. This design would be further refined if advanced as a preferred alternative, but the conceptual design includes a maximum anticipated footprint, including a large enough radius to accommodate WB-67 truck turn movements. The roundabout footprint is anticipated to fit within the existing available right-of way.

FIGURE 28: ALTERNATIVE E-R-2 (ROUNDABOUT) CONCEPTUAL LAYOUT

Roundabouts can simplify and improve traffic operations by reducing conflicts while simultaneously improving safety by slowing vehicle speeds. This roundabout would primarily address safety needs by slowing traffic speeds and improve traffic operations by reducing conflicts. This alternative is also intended to pedestrian safety at the ramp terminal by reducing vehicle speeds and decreasing pedestrian crossing distances.

The estimated cost for this alternative is **$1.8 Million**, with the detailed cost estimate breakdown included in Appendix I.

Alternative E-S-1

Alternative **E-S-1** modifies the existing signal at the eastbound ramp terminal to include the new eastbound loop off-ramp from alternatives **F-E-1** and **F-E-2**, as shown in Figure 29. This configuration would eliminate the eastbound left turn movement and replace it with a signalized, dual lane westbound right turn. The eastbound right turn could also be modified to a dual lane, signalized movement through further design refinement. The footprint of this alternative is anticipated to fit within the existing available right-of way.

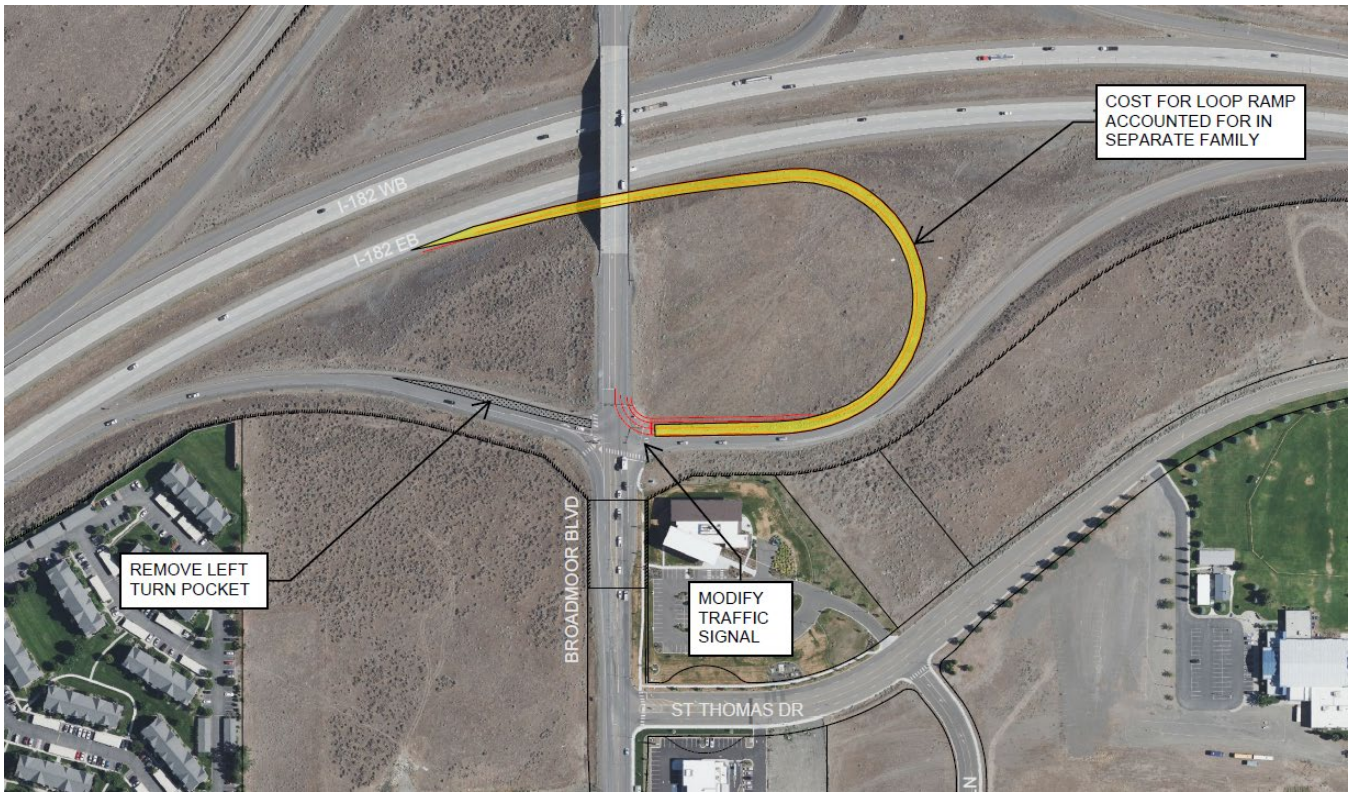

FIGURE 29: ALTERNATIVE E-S-1 (SIGNAL + LOOP RAMP) CONCEPTUAL LAYOUT

This alternative is intended to address long term traffic queuing needs on the eastbound off-ramp(s), limiting queueing and eliminating all conflicts between the heavy southbound left turn and the eastbound off-ramp movements. The signal timing would be simplified by eliminated the eastbound left turn, which is currently a critical movement within the signal phasing. The new westbound right turn movement would run concurrently with the heavy volume southbound left turn. In addition, vehicle demand on the existing eastbound off ramp would be reduced by more than 50%, allowing for better pedestrian crossing opportunities along the west side of Broadmoor Blvd.

The estimated cost for this alternative is **$1.1 Million**, with the detailed cost estimate breakdown included in Appendix I. The cost of the loop ramp is not included in this estimate but is tied to the freeway alternatives.

ACTIVE TRANSPORTATION ALTERNATIVE DESCRIPTIONS

The active transportation alternatives include a variety of different types of solutions. There are three new crossings of I-182 alternatives, two modifications to the existing Broadmoor Blvd bridge, and a series of supporting alternatives at the ramp terminal intersections intended to match with the various I-182 crossing options. These alternatives are described as follows in the subsequent sections:

Three alternatives directly involving the I-182 eastbound ramp terminal at Broadmoor Blvd passed the First Level Screening. These alternatives are listed as follows:

- **A-N-1, A-W-1a, A-E-2a**: New I-182 ped/bike bridge on the west side of Broadmoor Blvd and grade separations at the ramps on the west side
- **A-N-2, A-W-2b, A-E-1a**: New I-182 ped/bike bridge on the east side of Broadmoor Blvd and grade separations at the ramps on the east side
- **A-N-3, A-P-1**: New I-182 ped/bike bridge aligning with Midland Lane (east of Broadmoor Blvd) and trail connection along the eastbound on-ramp between the new crossing and Broadmoor Blvd
- **A-I-1**: Widening the Broadmoor Blvd bridge over I-182 to accommodate a protected bike/ped facility
- **A-I-2**: Re-striping Broadmoor Blvd to provide a semi-protected bike/ped facility

Each of these alternatives is described further in the following sections.

Alternatives A-N-1, A-W-1a, A-E-2a

Alternative **A-N-1** is a new 16-foot-wide bike/ped bridge over I-182, located just west of Broadmoor Blvd. This alternative also includes a new separate multi-use path along Broadmoor Blvd on the west side over the non-bridge segments between the eastbound and westbound ramp terminals. This alternative does not require any right-of-way acquisition.

Alternative **A-W-1a** is a bike/ped undercrossing at westbound slip on-ramp, and Alternative **A-E-2a** is a bike/ped undercrossing at the eastbound off-ramp. Both these alternatives would require retaining walls to both keep within the existing right-of-way and meet ADA slop standards. Alternatives **A-N-1**, **A-W-1a**, and **A-E-2a** are shown together in Figure 30.

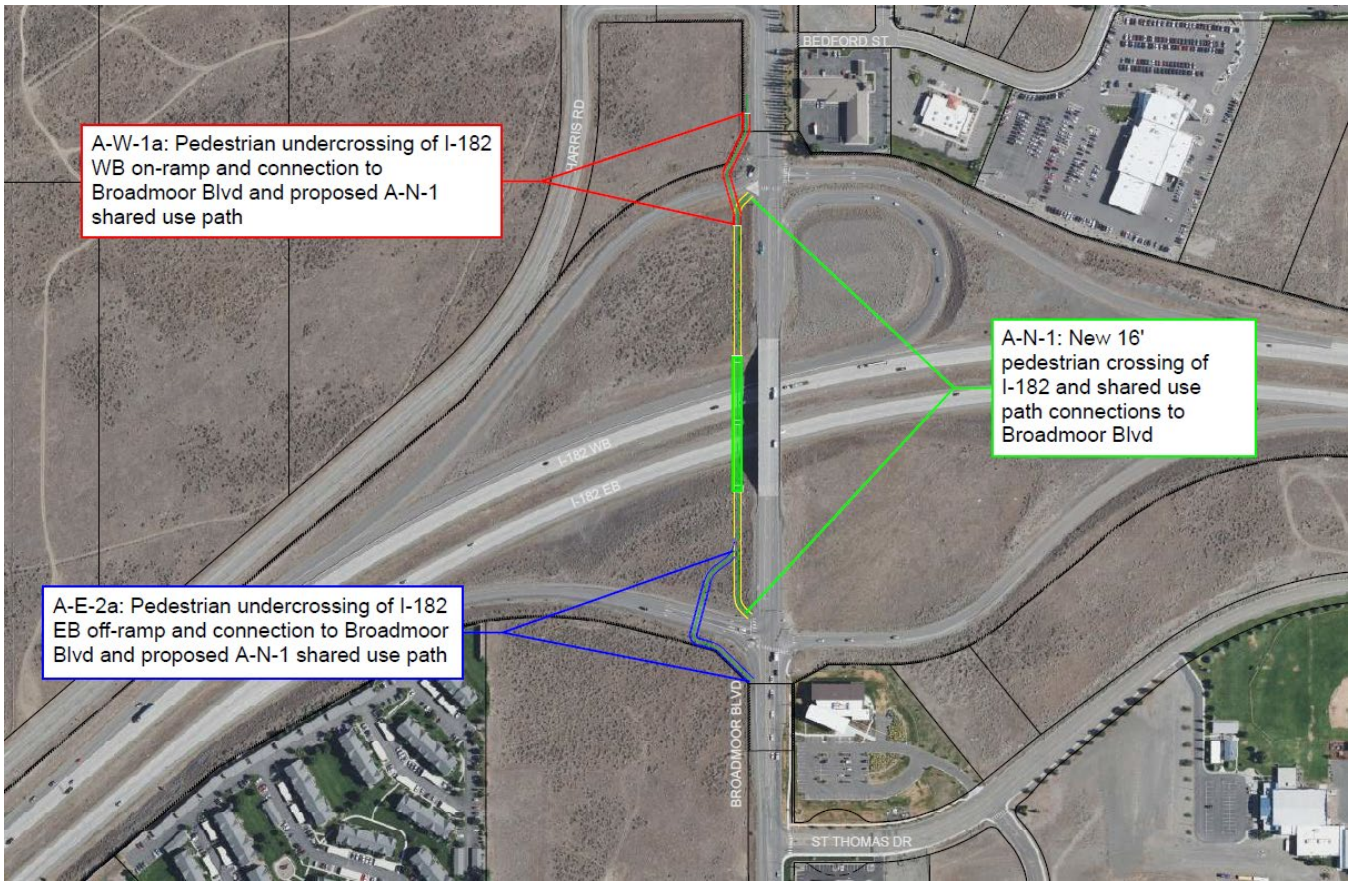

FIGURE 30: ALTERNATIVES A-N-1, A-W-1A, AND A-E-2A CONCEPTUAL LAYOUTS

The purpose of Alternative **A-N-1** is to separate bicycles and pedestrians from heavy traffic on Broadmoor Blvd, providing a grade friendly, low stress traveling environment. This alternative could either tie into the ramp terminal intersections or connect to alternatives **A-W-1a** and **A-E-2a**, forming a complete prioritized route for bikes and ped on the west side of Broadmoor Blvd. In addition, **A-N-1** would tie into the planned multi-use path planned for the near term along the west side of Broadmoor Blvd north of I-182, as well as the planned wide sidewalk facilities south of the interchange.

The grade separations at the ramps would separate bicycles and pedestrians from traffic conflicts along the west side of the ramp terminal intersections, prioritizing a north/south active transportation corridor.

The detailed cost estimates for these alternatives are included in Appendix I and are summarized as follows:

- **A-N-1**: **$7.5 Million**
- **A-W-1a**: **$2.3 Million**
- **A-E-2a**: **$2.2 Million**

While Alternative **A-N-1** is independent of **A-W-1a** and **A-E-2a**, the ramp grade separation alternatives should only be considered in conjunction with a focused active transportation improvement along the west side of Broadmoor Blvd.

Alternatives A-N-2. A-W-2b, A-E-1a

Alternative **A-N-2** is a new 16-foot-wide bike/ped bridge over I-182, located just east of Broadmoor Blvd. This alternative also includes a new separate multi-use path along Broadmoor Blvd on the east side over the non-bridge segments between the eastbound and westbound ramp terminals. This alternative does not require any right-of-way acquisition.

Alternative **A-W-2b** is a bike/ped overcrossing at the westbound off-ramp and westbound loop on-ramp and would tie into the existing mixed-use path that runs along the north side of I-182. Alternative **A-E-1a** is a bike/ped undercrossing at the eastbound on-ramp and the potential eastbound loop off-ramp. Both these alternatives would require retaining walls to both keep within the existing right-of-way and meet ADA slop standards. Alternatives **A-N-2**, **A-W-2b**, and **A-E-1a** are shown together in Figure 31.

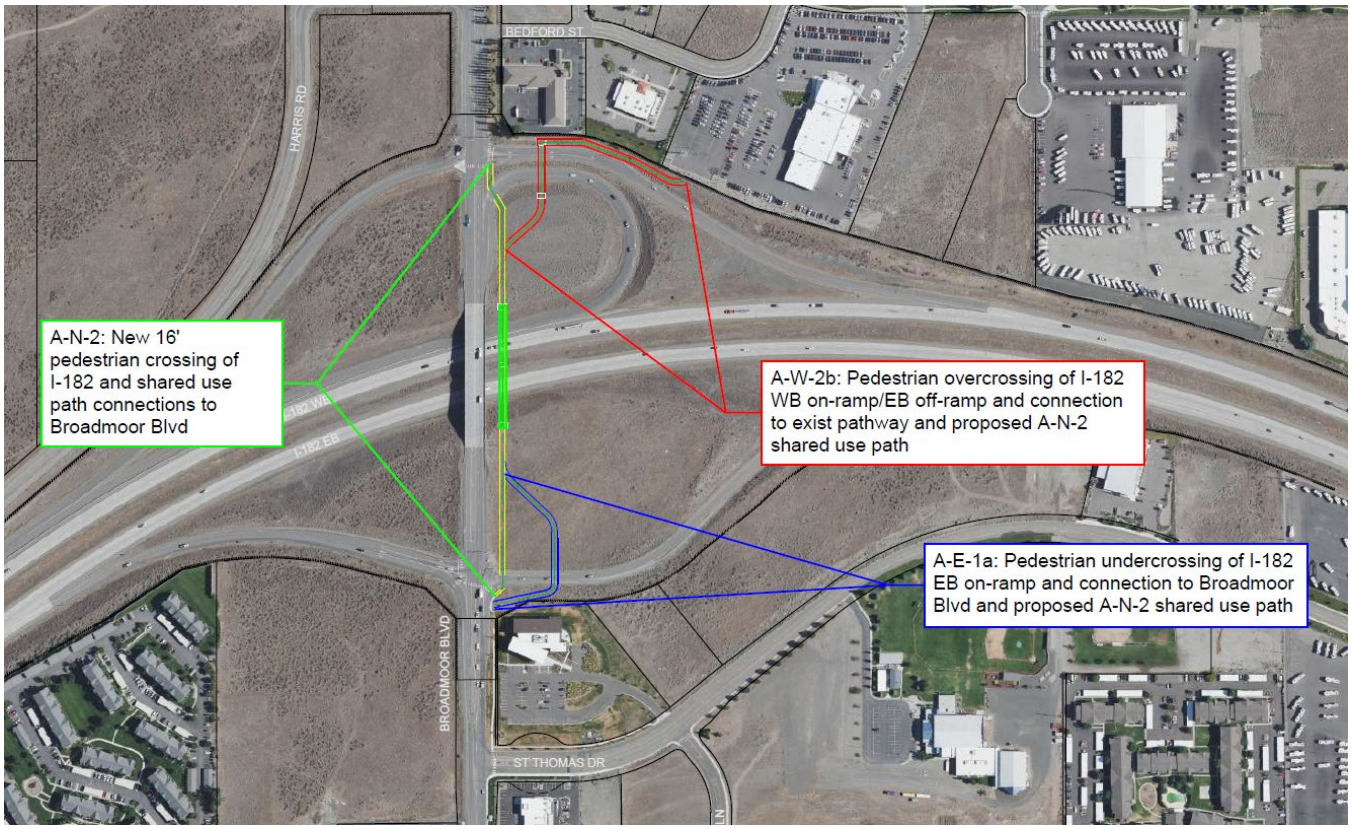

FIGURE 31: ALTERNATIVES A-N-2, A-W-2B, AND A-E-1A CONCEPTUAL LAYOUTS

The purpose of Alternative **A-N-2** is to separate bicycles and pedestrians from heavy traffic on Broadmoor Blvd, providing a grade friendly, low stress traveling environment. This alternative could either tie into the ramp terminal intersections or connect to alternatives **A-W-2b** and **A-E-1a**, forming a complete prioritized route for bikes and ped on the east side of Broadmoor Blvd. **A-**

N-2 would tie into the existing multi-use path running along the east side of Broadmoor Blvd from the interchange to Sandifur Parkway.

The grade separations at the ramps would separate bicycles and pedestrians from traffic conflicts along the east side of the ramp terminal intersections, prioritizing a north/south active transportation corridor. The overcrossing at the westbound ramps (**A-W-2b**) better matches the existing grades than an undercrossing would at the same location, but also requires significant re-grading of the existing I-182 mixed use path to complete the tie-in. Both crossing would be longer than their counterparts on the west side of the ramp terminals due to the need to cross multiple facilities (i.e. both on and off ramps).

The detailed cost estimates for these alternatives are included in Appendix I and are summarized as follows:

- **A-N-2**: **$8.8 Million**
- **A-W-2b**: **$7.2 Million**
- **A-E-1a**: **$2.9 Million**

While Alternative **A-N-2** is independent of **A-W-2b** and **A-E-1a**, the ramp grade separation alternatives should only be considered in conjunction with a focused active transportation improvement along the east side of Broadmoor Blvd.

Alternatives A-N-3, A-P-1

Alternative **A-N-3** is a new 16-foot-wide bike/ped bridge over I-182, aligning with Midland Lane east of Broadmoor Blvd. This crossing would tie into the existing I-182 mixed use trail on the north side of the freeway. Alternative **A-P-1** is a mixed-use trail connection parallel to the I-182 eastbound on-ramp, running from Broadmoor Blvd to the **A-N-3** bridge. Both alternatives would be built within existing right-of-way but retaining walls would be needed to reach the appropriate I-182 clearance height while maintaining ADA slopes. Both alternatives are shown together in Figure 32.

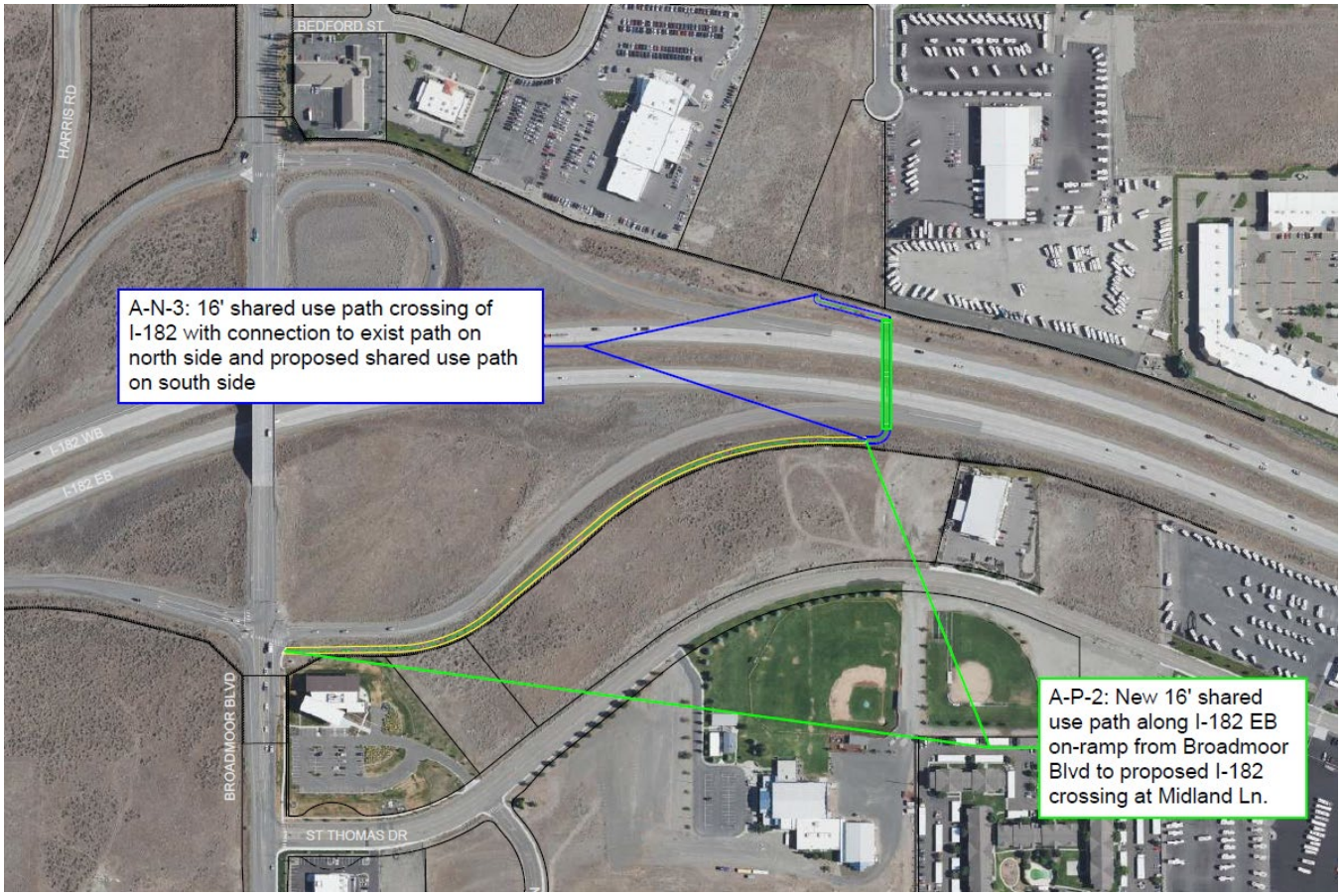

FIGURE 32: ALTERNATIVES A-N-3 AND A-P-1 CONCEPTUAL LAYOUTS

These alternatives target the existing pedestrian and bicycle movements and desire lines near Broadmoor Blvd, focusing on drawing active transportation modes away from the vehicle traffic at the interchange. Long-term, Midland Lane could include a direct connection to the new overcrossing, although such a trail connection is not currently included in any adopted plan.

The detailed cost estimates for these alternatives are included in Appendix I and are summarized as follows:

- **A-N-3**: **$8.8 Million**
- **A-P-1**: **$0.48 Million**

These two alternatives are dependent, and both would need to be constructed to complete an active transportation connection.

Alternative A-I-1

Alternative **A-I-1** would widen the Broadmoor Blvd bridge over I-182 to accommodate a 16-foot mixed use facility on the west side, as shown in Figure 33. The facility could be separated from traffic by a raised concrete barrier on the bridge and physically separated from Broadmoor Blvd as

a mixed-use path on the non-bridge segments. This alternative is not anticipated to require any right-of-way acquisition.

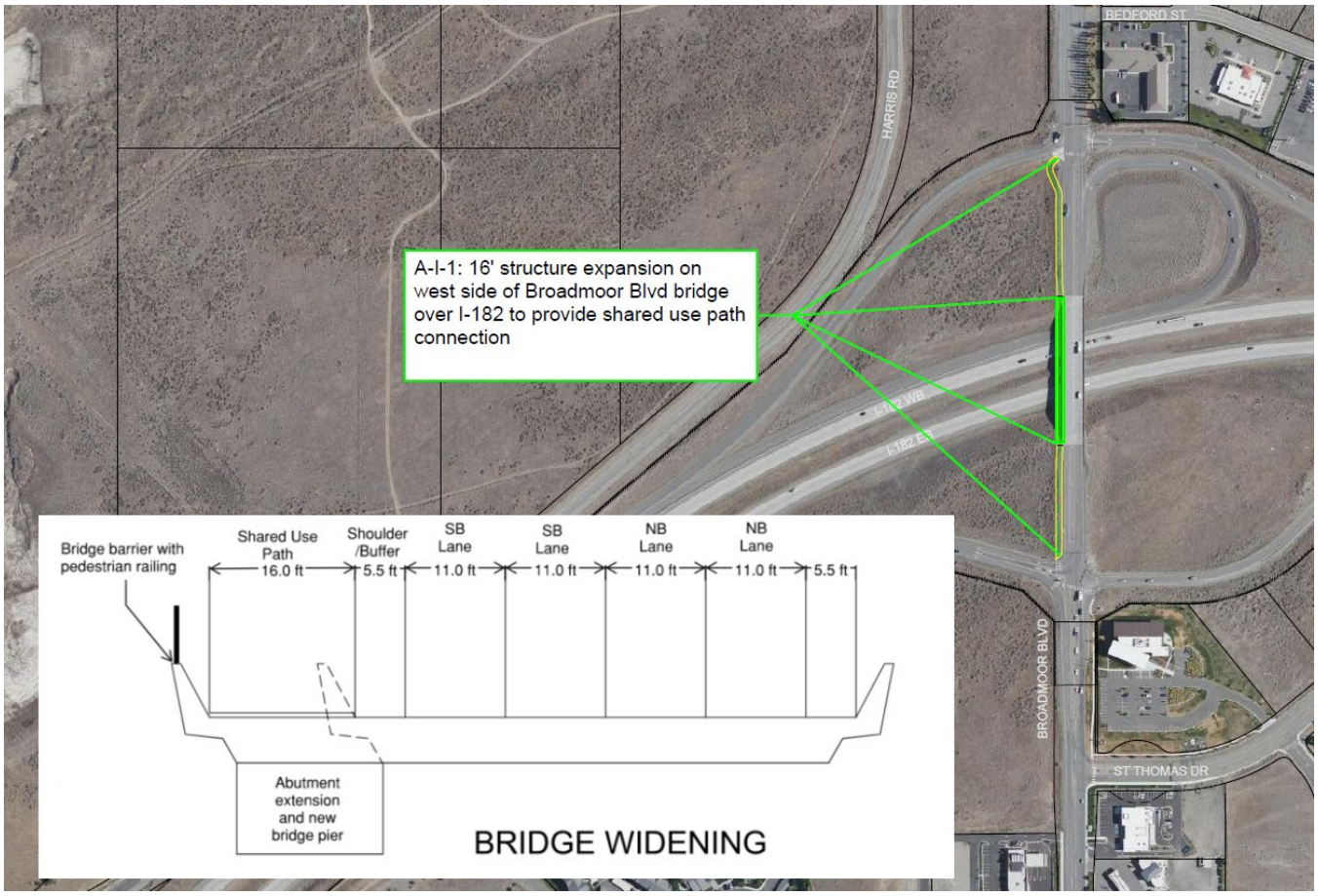

FIGURE 33: ALTERNATIVE A-I-1 (BROADMOOR BRIDGE WIDENING) CONCEPTUAL LAYOUT

The amount of width needed for the mixed-use path and the existing bridge girder design make a cantilever design infeasible. Therefore, this alternative would include an abutment extension and new bridge pier. This Alternative is intended to provide the same benefits as Alternative **A-N-1** and is also compatible with Alternatives **A-W-1a** and **A-E-2a**.

The estimated cost for this alternative is **$10.6 Million**, with the detailed cost estimate breakdown included in Appendix I.

Alternative A-I-2

Alternative **A-I-2** would re-stripe the Broadmoor Blvd bridge over I-182 to a temporary mixed-use facility on the west side, as shown in Figure 34. The mixed-use facilities could either be a 6-inch concrete sidewalk or a curb and flexible delineator protected facility. The travel lanes would be shifted to the east and striped to 11-feet apiece, with a 2-foot shoulder. This alternative is not anticipated to require any right-of-way acquisition.

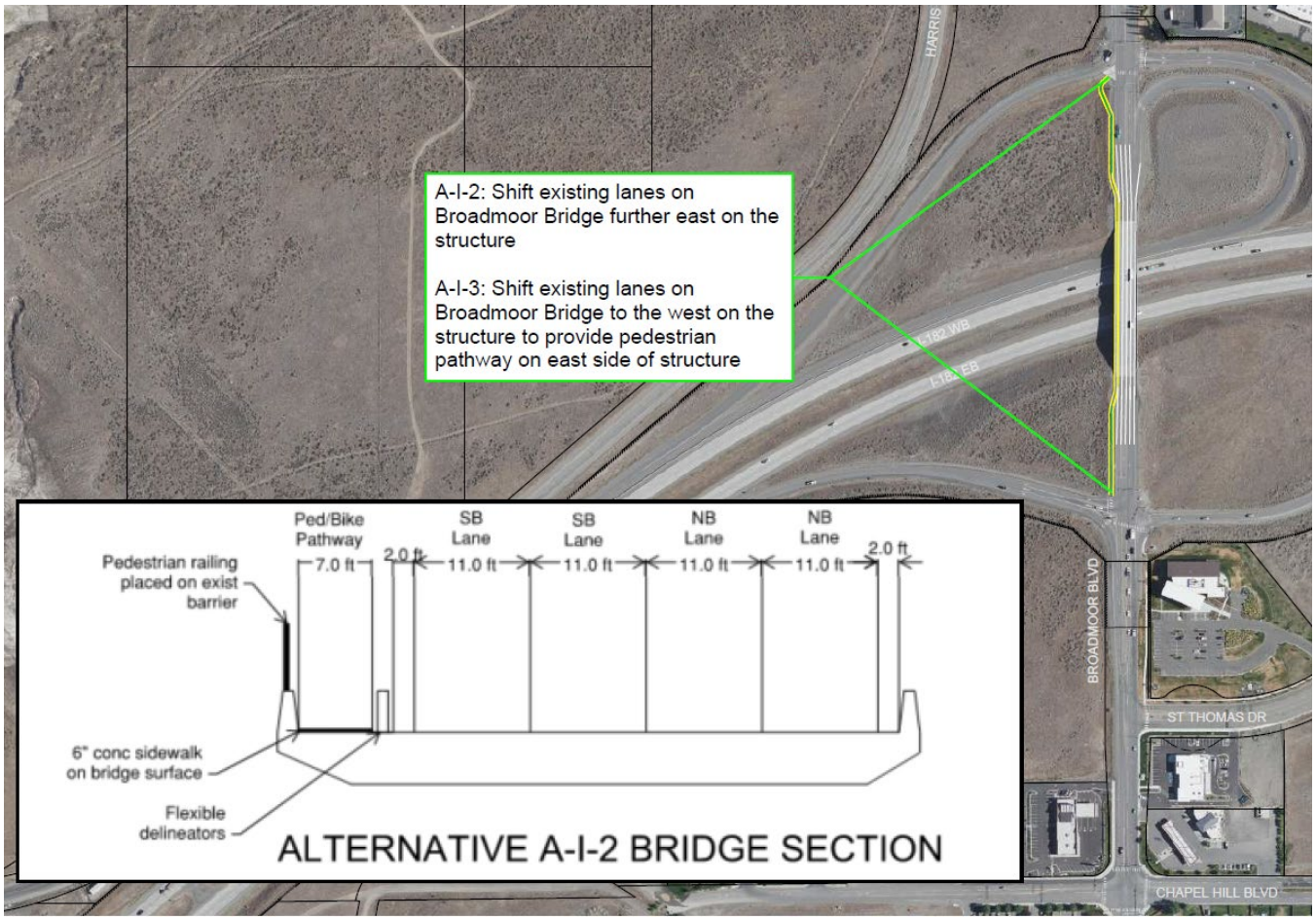

FIGURE 34: ALTERNATIVE A-I-2 (BROADMOOR RE-STRIPING) CONCEPTUAL LAYOUT

This alternative is intended to be a temporary solution to the existing active transportation deficiency on Broadmoor Blvd between the interchange ramp terminals. Long-term, a more substantial investment and improvement would be needed to meet the City's active transportation needs. This alternative could also be located on the west side of the bridge, better tying into the existing active transportation infrastructure along Broadmoor Blvd, rather than planned facilities.

The estimated cost for this alternative is **$0.24 Million**, with the detailed cost estimate breakdown included in Appendix I.

COMPREHENSIVE INTERCHANGE ALTERNATIVE DESCRIPTIONS

Only one standalone comprehensive interchange improvement alternative, **C-P-3** (the Diverging Diamond Interchange) passed through the First Level Screening. The design for **C-P-3** is described in in the following section.

Alternative C-P-3

Alternative **C-P-3** re-configures the Broadmoor Blvd and I-182 interchange into a Diverging Diamond Interchange (DDI). The DDI alternative carried forward into the Level 2 Evaluation

includes roundabouts at the ramp terminals rather than signals. The roundabout option was selected for further analysis due to the safety and active transportation benefits gained from slowing traffic at the ramp terminals. If the DDI alternative becomes the preferred alternative, further analysis would be performed to determine the best combination of traffic control (signals, roundabouts, yield).

Alternative **C-P-3** is shown in Figure 35. The alternative includes multi-lane roundabouts at each ramp terminal, a two-lane westbound on-ramp and eastbound on-ramp, both of which would merge quickly to a single lane, a barrier protected median mixed-use path, two southbound lanes, and three northbound lanes across I-182. The existing westbound loop on-ramp serving the northbound Broadmoor Blvd to westbound I-182 movement would be closed. Either a new structure would be constructed next to Broadmoor Blvd, or the Broadmoor Blvd bridge over I-182 would be substantially expanded to include the median and extra travel lane needed for the DDI to function.

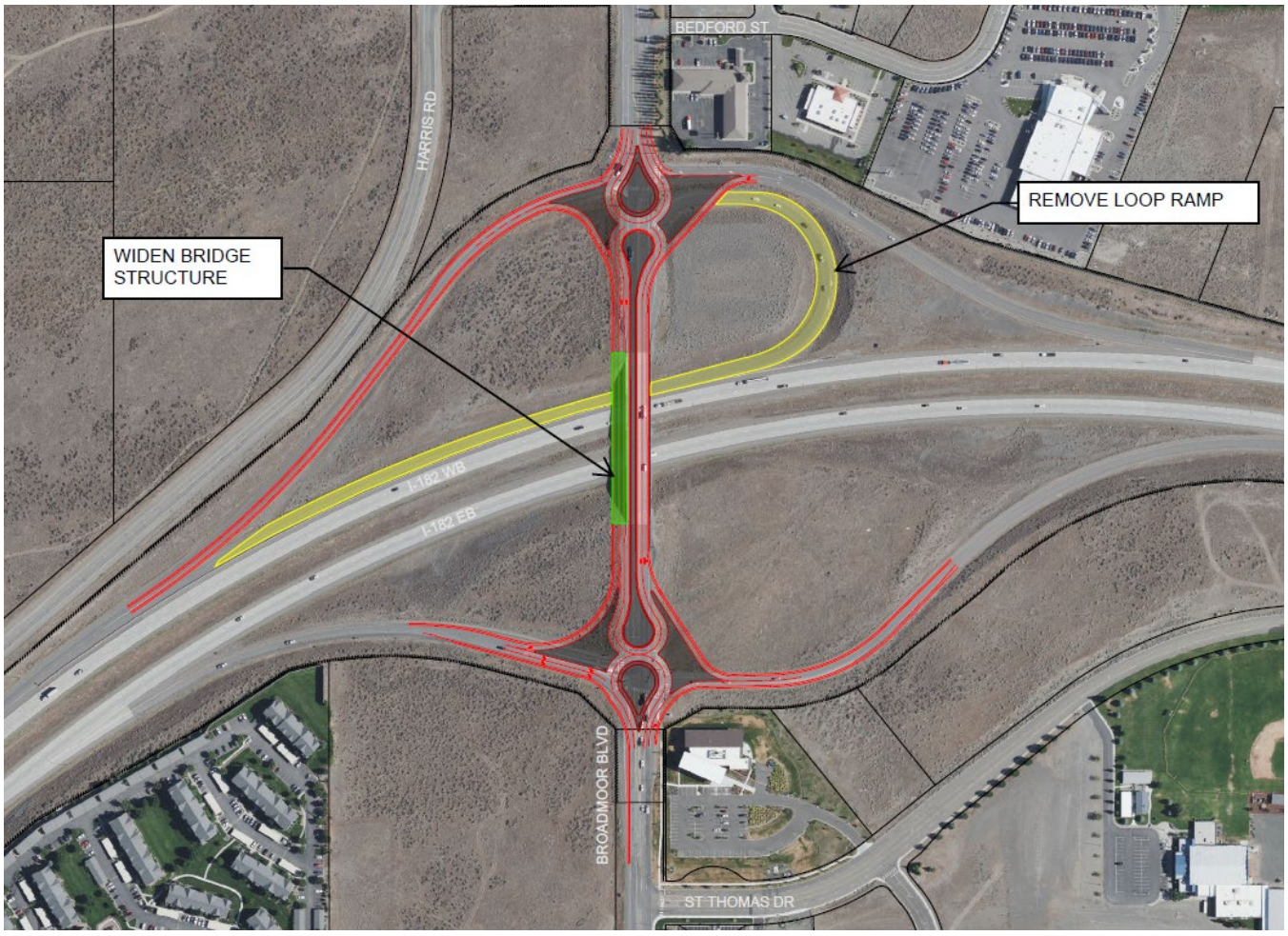

FIGURE 35: ALTERNATIVE C-P-3 (DDI WITH ROUNDABOUTS) CONCEPTUAL LAYOUT

Preliminary traffic analysis indicated that a signalized DDI would encounter significant traffic operations issues under future conditions, even with three northbound lanes on Broadmoor Blvd.

Therefore, the roundabout option was advanced into the Level 2 Evaluation, as this alternative showed more promise from a traffic operations and safety perspective. Overall, the intent of the DDI is to reduce traffic conflict points within the interchange, particularly left turn conflicts. Figure 36 highlights the traffic movements served by the DDI, showing interchange circulation patterns for drivers arriving from different directions.

FIGURE 36: DDI WITH ROUNDABOUTS CIRCULATION DIAGRAM

As shown in Figure 36, the DDI reduces conflicts in the interchange, providing optimized traffic flow. The roundabouts would be designed to clearly indicate and protect against wrong way

movements, which are the most common concern on a DDI due to the reverse nature of traffic between the ramp terminals. The physical barriers in the median would provide additional separate and comfort for drivers between the ramp terminals.

The estimated cost for this alternative is **$25.0 Million**, with the detailed cost estimate breakdown included in Appendix I.

CHAPTER 5. ALTERNATIVES ANALYSIS – LEVEL 2 EVALUATION

This section summarizes the results of the Level 2 Evaluation, and scores competing alternatives against each other. The project scoring is based on the performance measures presented in the Screening Matrix Memorandum (attached as Appendix C) and in the Methods and Assumptions Memorandum (attached as Appendix B).

As noted in the prior section, many of the alternatives identified for the interchange do not compete against one another, with most alternatives targeting specific portions of the project Purpose and Need (included in Appendix A). Therefore, for purposes of determine the optimal bundle of alternatives, for purposes of the Level 2 Evaluation and scoring the alternatives were separated into the following categories, as previously noted in Chapter 4:

- Freeway Alternatives
- Westbound Ramp Terminal Alternatives
- Eastbound Ramp Terminal Alternatives
- Active Transportation Alternatives
- Comprehensive Alternatives

Proposed alternatives were evaluated under the appropriate group. Only applicable performance measures were used to compare alternatives under each category. For example, the freeway specific alternatives were not evaluated for active transportation performance measures as the proposed improvements did not have an active transportation component or interface. The Comprehensive Alternatives included a project bundle for the highest-ranking projects from the prior categories (freeway, ramp terminals, active transportation), which were then compared against a comprehensive interchange re-construction alternative.

FREEWAY ALTERNATIVES

Three alternatives involving improvements and modifications to the freeway facility passed through the First Level Screening. These alternatives are described in detail in Chapter 4. The alternatives evaluated are listed as follows:

- **F-E-1**: New Eastbound Loop Exit Ramp
- **F-E-2**: New Eastbound Loop Exit Ramp with New Deceleration Lane at Existing Off-Ramp
- **F-E-4**: Dual Eastbound Off-Ramp

The Operations and Safety evaluation results along with the alternatives scoring is summarized in the following sections.

OPERATIONS RESULTS

The traffic analysis performed to support the Level 2 Evaluation used the HCS to estimate the future LOS for the portions of I-182 effected by the alternatives. Note that the 2025 and 2045 forecasted No-Build volumes were used to evaluate the proposed freeway alternatives, as larger system constraints will ultimately limit the volumes that can actually reach the Broadmoor Interchange.

Table 24 summarizes the effected I-182 freeway LOS conditions for AM and PM peak hours under 2025 and 2045 conditions for the three proposed alternatives along with No-Build.

TABLE 24: FREEWAY ALTERNATIVES- TRAFFIC OPERATIONS

ALTERNATIVE	SEGMENT	MOVEMENT TYPE	MOBILITY TARGET	AM PEAK HOUR		PM PEAK HOUR	
				2025	2045	2025	2045
NO BUILD	Broadmoor Blvd Off-Ramp	Diverge	D	C	D	F	F
F-E-1	Broadmoor Blvd Slip-Ramp	Diverge	D	C	C	D	D
	Broadmoor Blvd Loop-Ramp	Diverge	D	C	C	C	C
F-E-2	Broadmoor Blvd Slip-Ramp	Diverge	D	B	C	B	C
	Broadmoor Blvd Loop-Ramp	Diverge	D	B	C	C	C
F-E-4	Broadmoor Blvd Off-Ramp	Diverge	D	A	C	B	C

As shown in Table 24 and discussed in detail in Chapter 3, the diverge to the eastbound off-ramp fails under both 2025 and 2045 PM peak hour conditions with the existing ramp configuration. The new loop ramp in alternatives **F-E-1** and **F-E-2** creates a second diverge segment, but both the existing and new diverge segments operate at an acceptable LOS under future conditions. The added deceleration lane in alternative **F-E-2** provides additional improvement, bringing the existing off-ramp location to LOS C. Alternative **F-E-4** also improves operations at the existing eastbound off-ramp diverge location. However, HCS does not fully capture the impacts of the eastbound off-ramp up stream of the diverge. Approaching the added deceleration lane for the eastbound off-ramp, the capacity of the diverge will be limited to a single effective lane attempting to serve more than 2,000 peak hour trips. While an improvement over No-Build conditions, this location would still experience slowing and queuing more reflective of LOS F conditions.

SAFETY RESULTS

The ISAT-e tool was initially used to attempt to estimate the safety benefit of the freeway alternatives. However, this tool is not sensitive to expected operational improvements such as reduced/eliminated queuing and freeway speed differential (speed change between lanes on the freeway), the two area where the proposed alternatives are expected to provide the most significant benefits. Therefore, the safety evaluation for the freeway alternatives remained qualitative, focusing on the identified mobility benefits from the operations analysis. These expected safety benefits are summarized by freeway alternatives as follows:

- **F-E-1**: This alternative is expected to provide reduction in crashes at the combined two diverge locations (existing off-ramp and new loop ramp) as the LOS improves from LOS F to a worst case of LOS D at the off-ramps. The improved LOS is expected to reduce the freeway lane speed differential as well as slowing due to the diverges.
- **F-E-2**: This alternative is expected to provide additional safety benefit compared to F-E-1 due to further improved LOS and geometry at the existing eastbound off-ramp location due to the added deceleration lane.
- **F-E-4**: This alternative is expected to provide some benefit over No-Build conditions due to some improvement to LOS and improved geometry from an added deceleration lane. However, the benefits of these improvements will be limited by the outside lane capacity on I-182, as described in the traffic operations section. Speed differential and queuing conditions are still expected to occur, particularly under 2045 traffic conditions.

SCORING SUMMARY

The freeway alternatives were scored against No-Build conditions and each other, as shown in Table 25. The scoring ranges from -2 to +2, as described in Appendix C. The cost estimate for each alternative is included in Table 25 as well but is only used as a tiebreaker for scoring purposes.

TABLE 25: FREEWAY ALTERNATIVES – LEVEL 2 EVALUATION SCORING

PERFORMANCE MEASURES	SCORE		
	LOOP	LOOP + DECEL	DUAL OFF
	F-E-1	F-E-2	F-E-4
FREEWAY LEVEL OF SERVICE-DIVERGE EB	+1	+2	+1
FORWARD COMPATIBILITY	+2	+2	+2
PREDICTED CRASHES PER YEAR	0	+1	+1
PREDICTED CRASH SEVERITY (PERCENT FATAL/INJURY)	0	0	0
FREEWAY LOS AT EB DIVERGE	+1	+2	+1
TOTAL SCORE	**+4**	**+7**	**+5**
COST	$2.6-$3M	$3.7-$4.1M	$3-$3.4M

As shown in Table 25, all three alternatives improve traffic operations and safety on I-182 approaching and at the eastbound off-ramp diverge(s). The key differences in scoring for the three alternatives are summarized as follows:

- Traffic Operations
  - **F-E-2** scores highest due to the combined benefits of the new loop ramp and added deceleration lane. **F-E-1** improves operations over No-Build, but not to the extent of **F-E-2** absent the new deceleration lane at the existing eastbound off-ramp. **F-E-4** also improves over No-Build but score lower than **F-E-2** due to the single lane off effective exit capacity discussed in the freeway operations section.
- Safety
  - The added loop ramp in alternative **F-E-1** involves a new facility, which creates new conflicts and new opportunities for collisions. However, the loop ramp also reduces the speed differential and freeway queuing, provides a significant safety benefit, lead to a negligible score across all the applicable safety performance measures with the exception of the Freeway LOS at the ramp diverge. Alternative **F-E-2** scores higher due to the added safety benefit of the deceleration lane. And alternative **F-E-4** also higher due to improved operations and deceleration lane benefits.

Overall, **Alternative F-E-2 (New Eastbound Loop Exit Ramp with New Deceleration Lane at Existing Off-Ramp)** is the highest scoring alternative in the Freeway category. Note that Alternative **F-E-1** could potentially become an initial phase of **F-E-2**, as this alternative also

provides benefits over No-Build conditions and is really just one of the components of Alternative **F-E-2**.

WESTBOUND RAMP TERMINAL ALTERNATIVES

Three alternatives involving improvements and modifications to the westbound ramp terminal of I-182 and Broadmoor Blvd passed through the First Level Screening. These alternatives are described in detail in Chapter 4. The alternatives evaluated are listed as follows:

- **W-S-1**: "Flying T" Signal Configuration
- **W-S-2**: Dual Westbound Right Turn Lane
- **W-R-1**: Roundabout

The Operations, Safety, and Active Transportation evaluation results along with the alternatives scoring is summarized in the following sections.

OPERATIONS RESULTS

The traffic analysis performed to support the Level 2 Evaluation used Sidra and Synchro to estimate the Highway Capacity Manual (HCM) LOS at the I-182 Westbound Ramp Terminal at Broadmoor Blvd. The 2025 and 2045 AM and PM peak hour analysis results are summarized in Table 26.

TABLE 26: WESTBOUND RAMP TERMINAL ALTERNATIVES – HCM RESULTS

ALTERNATIVES	MOBILITY STANDARD	AM PEAK HOUR LOS		PM PEAK HOUR LOS	
		2025	2045	2025	2045
NO BUILD	LOS D	B/(C-WBR)	C/**(F-NBT)**	B/(D-WBR)	**F/(F-WBR)**
W-S-1 (FLYING T – SIG)	LOS D	A/(C-WBL)	C/**(F-SBR)**	A/(D-WBL)	B/**(E-WBR)**
W-S-2 (DUAL WBR – SIG)	LOS D	A/(C-WBL)	C/**(F-SBR)**	B/(D-WBL)	C/**(E-WBR)**
W-R-1 (RAB)	LOS D	A/(B-WBL)	A/**(F-SBR)**	A/(B-WBL)	A/(D-WBR)

INTERSECTION LOS/ (MOVEMENT LOS-WORST CASE MOVEMENT)

To supplement the HCM analysis and provide additional traffic operations performance measures, SimTraffic was run for the signalized alternatives (**W-S-1** and **W-S-2**). The best performing signalized option was assumed at the eastbound ramp terminal to prevent other deficiencies within the interchange from biasing the westbound ramp terminal queuing results. Sidra queues were used to estimate the ramp terminal queuing under the roundabout alternative (**W-R-1**). The key queuing results related to the I-182 Westbound Off-Ramp and the corresponding northbound and southbound queues on Broadmoor Blvd are summarized in Table 27.

TABLE 27: WESTBOUND RAMP TERMINAL ALTERNATIVES – QUEUING RESULTS

ALTERNATIVE	AVAILABLE STORAGE (FT)	AM PEAK HOUR 95TH PERCENTILE QUEUES (FT)		PM PEAK HOUR 95TH PERCENTILE QUEUES (FT)	
		2025	2045	2025	2045
WESTBOUND OFF-RAMP QUEUES[A]					
NO BUILD	1,030	210	930	1,080	**>1,600**
W-S-1 (FLYING T – SIG)	1,030	200	710	590	280
W-S-2 (DUAL WBR – SIG)	1,030	220	230	780	630
W-R-1 (RAB)	1,030	<50	160	80	300
NORTHBOUND/SOUTHBOUND BROADMOOR BLVD QUEUES					
NO BUILD	1,100/720	290/120	450/**>720**	230/140	320/**>1,110**
W-S-1 (FLYING T – SIG)	1,100/720	340/<50	**>1,100**/160	**>1,100**/160	**>1,100**/100
W-S-2 (DUAL WBR – SIG)	1,100/720	200/110	1,000/170	**>1,100**/130	**>1,100**/250
W-R-1 (RAB)	1,100/720	<50/<50	<50/110	<50/70	<50/110

[A] Off-Ramp Queue storage measured from terminal intersection to SSD from striped gore

As detailed in Chapter 3, by the year 2045 under No-Build conditions the westbound ramp terminal intersection operates at LOS F during the PM peak hour. The LOS F condition is driven both by the northbound through movement and the westbound right turn movement both exceed capacity. The key traffic operations findings for the Westbound Ramp Terminal Alternatives are summarized as follows:

- **W-S-1:** This alternative provides significant LOS improvement over No-Build conditions, particularly in the year 2045 PM peak hour. The dual westbound right turn maintains the off-ramp queues to within the SSD of the off-ramp under future conditions. However, the limited conflict westbound left turn (the "Flying T") creates coordination issue with the eastbound off-ramp, particularly related to managing westbound left turns weaving against southbound through movements. The coordination issues ultimately result in northbound queue spillback from the westbound ramp terminal through the eastbound ramp terminal, even during 2025 PM peak hour conditions. Note that the southbound right turn movement operates at LOS F. This is actually a free movement, aside from conflicts from ped crossings. The LOS F condition at this location could potentially be mitigated by grade separating pedestrians.

- **W-S-2:** This alternative provides similar LOS at the ramp terminal, but without the coordination and weaving issues caused by the Flying T. This results in better AM queuing conditions, although during the PM peak period, northbound queues still spill back to the eastbound ramp terminal in both 2025 and 2045.
- **W-R-1:** Of the three alternatives evaluated at the westbound ramp terminal, the roundabout provides the best LOS and shortest queues due to limited conflicts at the intersection.

It is important to note that the No-Build traffic operations issues at the westbound ramp terminal only arise under 2045 conditions. Under existing and near-term growth conditions, the ramp terminal is expected to continue to operate under acceptable LOS and queue conditions.

SAFETY RESULTS

The traffic safety analysis performed to support the Level 2 Evaluation used Highway Safety Manual (HSM) methodology and Crash Modification Factors (CMF) to estimate predicted crash frequency and severity at the I-182 Westbound Ramp Terminal at Broadmoor Blvd. The safety analysis results for 2045 conditions are summarized in Table 28.

TABLE 28: WESTBOUND RAMP TERMINAL ALTERNATIVES – YEAR 2045 SAFETY RESULTS

ALTERNATIVE	METHOD OF ANALYSIS	TOTAL PREDICTED CRASHES	PERCENT FATAL + INJURY
NO BUILD	ISAT-e	9.7	45%
W-S-1 (FLYING T – SIG)	ISAT-e	8.2	40%
W-S-2 (DUAL WBR – SIG)	ISAT-e	9.3	42%
W-R-1 (RAB)	Baseline ISAT-e *CMF	5.6	22%

*CMF: 0.29 applied to injury and fatal crashes, 0.81 for PDO crashes.

The key traffic safety findings for the Westbound Ramp Terminal Alternatives are summarized as follows:

- **W-S-1:** This alternative provides some improvement in crash frequency and severity as the westbound left turn no longer conflicts with the southbound through movement under the "Flying T" configuration. The dual right turn reduces queuing and provides some additional safety benefit.
- **W-S-2:** This alternative provides minor improvement in crash frequency and severity due to the queue reduction and safety benefits of the dual westbound right turn.
- **W-R-1:** Converting a standard signalized intersection to a roundabout terminal reduces the number of conflict points and changes the types of conflicts. A roundabout ramp terminal prevents the entering-at-angle and left turn movements, as vehicles are only permitted to turn right when entering and exiting the roundabout. Crossing related crashes are associated with a higher risk of severe injury. The presence of a roundabout also encourages vehicles to reduce operating speed when approaching and while in the roundabout, which is also shown to reduce crash severity. The tear drop shape of the roundabout encourages drivers to not enter ramps

the wrong way. These safety benefits result in a significant reduction in crash frequency and severity, as shown in Table 28.

Overall, alternative **W-R-1** provides the greatest safety benefit at this location relative to crash frequency and severity. It is important to note that the observed and predicted crash frequencies at this ramp terminal are not particularly high, so the potential benefits are lower than might typically be expect for a roundabout to signal conversion. Alternative **W-R-1** also provides the largest safety benefits due to lower queue lengths on Broadmoor Blvd, as shown in Table 27 in the traffic operations results.

ACTIVE TRANSPORTATION RESULTS

The active transportation analysis performed to support the Level 2 Evaluation used Synchro to estimate pedestrian delay, the WSDOT Level of Traffic Stress Methodology for bikes and pedestrians, and the conceptual designs for the alternatives to determine crossing distances. The active transportation evaluation results are summarized in Table 29.

TABLE 29: WESTBOUND RAMP TERMINAL ALTERNATIVES - ACTIVE TRANSPORTATION

PERFORMANCE MEASURES	2025-2045 CONDITIONS			
	NO-BUILD	FLYING T (SIG)	DUAL WBR (SIG)	RAB
		W-S-1	W-S-2	W-R-1
BIKE LTS	4	4	4	2
PEDESTRIAN LTS	4	4	4	2
CHANGE IN PEDESTRIAN TRAVEL TIME (SECONDS)	-	+12	+12	-19
MAXIMUM CROSSING DISTANCE (FT)	60’	36’	36’	24’
CROSSING CONTROL	SIGNAL	SIGNAL	SIGNAL	YIELD

The westbound ramp terminal alternatives impact active transportation of the westbound ramp terminal crossing. Under No Build Conditions, the crossing is LTS 4 for bicycles and pedestrians. Due to lower speeds, the crossing improves to LTS 3 for the roundabout alternative. The signal alternatives have no impact on the LTS compared to No Build.

The crossing time is expected to decrease for the roundabout alternative and increase for the signal alternatives compared to No Build. In the roundabout alternative, motor vehicles should yield to bicycles and pedestrians, which will save time compared to waiting for the walk or through

phase on the existing traffic signal. The signal alternatives are expected to have longer cycle lengths, and therefore will increase overall pedestrian delay at the intersection compared to No Build. The maximum crossing distance is lower in the alternatives compared to the No Build. This is because the medians included in the proposed design of the alternatives reduce the number of lanes being crossed at a time.

SCORING SUMMARY

The westbound ramp terminal alternatives were scored against No-Build conditions and each other, as shown in Table 30. The scoring ranges from -2 to +2, as described in Appendix C. The cost estimate for each alternative is included in Table 30 as well but is only used as a tiebreaker for scoring purposes.

TABLE 30: WESTBOUND RAMP TERMINAL ALTERNATIVES – LEVEL 2 EVALUATION SCORING

PROJECT OBJECTIVE	PERFORMANCE MEASURES	SCORE		
		FLYING T (SIG)	DUAL WBR (SIG)	RAB
		W-S-1	W-S-2	W-R-1
IMPROVE TRAFFIC OPERATIONS	WB Ramp Terminal Intersection LOS	+2	+2	+2
	WB Ramp Terminal 95th Percentile Off-Ramp Queue Lengths	+2	+2	+2
IMPROVE TRAFFIC SAFETY	Predicted Crashes Per Year	+1	0	+2
	Predicted Crashes Severity	+1	0	+2
	95th Percentile Queue Lengths Broadmoor NB/SB	-2	-2	+2
	WB Ramp Terminal 95th Percentile Off-Ramp Queue Lengths	+2	+2	+2
IMPROVE ACTIVE TRANSPORTATION SYSTEM	Bike LTS	0	0	+1
	Pedestrian LTS	0	0	+1
	Active Transportation Travel Time	-1	-1	+1
	Maximum Crossing Distance	+1	+1	+2
	Crossing Control	0	0	+1
	TOTAL SCORE	**+6**	**+4**	**+17**
SCALABILITY	**COST**	**$0.7-$0.9M**	**$0.4-$0.6M**	**$1.5-$1.9M**

As shown in Table 30, all three alternatives improve traffic operations and queuing at the Westbound Ramp Terminal, meeting mobility targets under 2025 and 2045 AM and PM peak hour conditions and keeping ramp queues within the acceptable storage area. The key performance differences between the three alternatives are caused by safety and active transportation measures and are summarized as follows:

- Safety
  - As discussed in the safety results section, Alternative **W-R-1** provides the largest safety benefit related to crash frequency and severity due to replacing the signal with a roundabout. Alternative **W-S-2** provides minimal change to crash frequency and severity.
  - From a queuing standpoint, the signal alternatives (**W-S-1** and **W-S-2**) actually create new issues on Broadmoor Blvd, particularly northbound, as noted in the traffic result section. This results in negative scores for these alternatives under the Broadmoor Blvd queuing performance measure. All three alternatives significantly improve the westbound off-ramp queues, maintain 95th Percentile queues within the available storage.
- Active Transportation
  - Alternatives **W-S-1** and **W-S-2** do not provide appreciable improvement to the Bike or Pedestrian LTS at the ramp terminal intersection. The roundabout configuration of Alternative **W-R-1** improves the LTS, leading to a positive score.
  - Alternatives **W-S-1** and **W-S-2** increase pedestrian delay due to signal timing changes, leading to negative scores. Alternative W-R-1 eliminates signalized delay for pedestrians, providing significant improvement over the No-Build condition.
  - All three alternatives provide opportunities to reduce crossing distances, with **W-R-1** providing the shortest distances. Alternative **W-R-1** provides a better crossing control option than the signalized alternative (including No-Build) with low-speed yield crossings.

Overall, **Alternative W-R-1 (New Roundabout)** is the highest scoring alternative in the Westbound Ramp Terminal category. Note that from an existing crash occurrence and near-term traffic operations perspective, the No-Build alternative is sufficient.

EASTBOUND RAMP TERMINAL ALTERNATIVES

Three alternatives involving improvements and modifications to the Eastbound ramp terminal of I-182 and Broadmoor Blvd passed through the First Level Screening. These alternatives are described in detail in Chapter 4. The alternatives evaluated are listed as follows:

- **E-R-1**: Roundabout with Loop Ramp
- **E-R-2**: Roundabout without Loop Ramp
- **E-S-1**: Signal Modifications with Loop Ramp

The Operations, Safety, and Active Transportation evaluation results along with the alternatives scoring is summarized in the following sections.

OPERATIONS RESULTS

The traffic analysis performed to support the Level 2 Evaluation used Sidra and Synchro to estimate the Highway Capacity Manual (HCM) LOS at the I-182 Eastbound Ramp Terminal at

Broadmoor Blvd. The 2025 and 2045 AM and PM peak hour analysis results are summarized in Table 31.

TABLE 31: EASTBOUND RAMP TERMINAL ALTERNATIVES – HCM RESULTS

ALTERNATIVES	MOBILITY STANDARD	AM PEAK HOUR LOS		PM PEAK HOUR LOS	
		2025	2045	2025	2045
NO BUILD	LOS D	B/(C-EBL)	**F/(F-SBL)**	**E/(F-EBL)**	**F/(F-EBL)**
E-R-1 (RAB W/ LOOP)	LOS D	A/(A-SBL)	B/(D-WBR)	A/(A-SBL)	B/(D-WBR)
E-R-2 (RAB W/ EXIST)	LOS D	A/(B-EBL)	**F/(F-NBT)**	A/(B-EBL)	B/(D-NBT)
E-S-1 (SIGNAL W/ LOOP)	LOS D	A/(D-WBR)	B/**(E-SBL)**	B/(D-WBR)	B/(D-WBR)

To supplement the HCM analysis and provide additional traffic operations performance measures, SimTraffic was run for the signalized alternative (**E-S-1**). The best performing signalized option was assumed at the westbound ramp terminal (**W-S-2**) to prevent other deficiencies within the interchange from biasing the eastbound ramp terminal queuing results. Sidra queues were used to estimate the ramp terminal queuing under the roundabout alternatives (**E-R-1** and **E-R-2**). The key queuing results related to the I-182 Eastbound Off-Ramp and the corresponding northbound and southbound queues on Broadmoor Blvd are summarized in Table 32.

TABLE 32: EASTBOUND RAMP TERMINAL ALTERNATIVES – QUEUING RESULTS

ALTERNATIVE	AVAILABLE STORAGE (FT)	AM PEAK HOUR 95TH PERCENTILE QUEUES (FT)		PM PEAK HOUR 95TH PERCENTILE QUEUES (FT)	
		2025	2045	2025	2045
EASTBOUND OFF-RAMP QUEUES[A]					
NO BUILD	900	110	**>1,470**	**1,080**	**>1,470**
E-R-1 (RAB W/ LOOP)	900/1,100[A]	<50/<50	<50/270	<50/160	70/370
E-R-2 (RAB W/O LOOP)	900	<50	300	100	240
E-S-1 (SIGNAL W/ LOOP)	900/1,100[A]	<50/150	<50/310	420/300	160/290
NORTHBOUND/SOUTHBOUND BROADMOOR BLVD QUEUES					
NO BUILD	900/1,100	**>900**/130	**>900/>1,100**	**>900**/1,030	**>900/>1,100**
E-R-1 (RAB W/ LOOP)	900/1,100	60/<50	240/<50	<50/<50	70/<50
E-R-2 (RAB W/O LOOP)	900/1,100	90/<50	**>900**/<50	110/<50	410/<50
E-S-1 (SIGNAL W/ LOOP)	900/1,100	350/<320	**>900**/500	**>900**/1,000	**>900**/620

[A] Off-Ramp Queue storage measured from terminal intersection to SSD from striped gore

As detailed in Chapter 3, by the year 2025 under No-Build conditions the eastbound ramp terminal intersection operates at LOS E during the PM peak hour. The LOS E condition is driven primarily by growth in demand for the eastbound left turn and southbound left turn movements. The key traffic operations findings for the Eastbound Ramp Terminal Alternatives are summarized as follows:

- **E-R-1:** This alternative provides significant LOS improvement over No-Build conditions, particularly in the year 2045 PM peak hour. The loop ramp reduces conflicts within the roundabout, with the heavy eastbound left turn movement becoming a westbound right turn that no longer conflicts with the heavy southbound left turn. This alternative operates within acceptable LOS standards under both AM and PM 2025 and 2045 conditions. The off-ramp and Broadmoor Blvd queues maintain within the available storage.
- **E-R-2:** This alternative provides some improvement over No-Build conditions, but still reaches LOS F conditions AM 2045 conditions. The conflict between the eastbound left turn and the southbound left turn creates a significant capacity constraint, leading to oversaturated conditions and lengthening queues, particularly on northbound Broadmoor Blvd.
- **E-S-1:** Similar to alternative **E-R-1**, this alternative improves the LOS for the eastbound ramp terminal by reducing the critical movements at the intersection by replacing the eastbound left

turn with a westbound right turn, which can run concurrently with the heavy southbound left turn movement. The signal option queues further than the roundabout options, with the northbound through movement in particular spilling back to Chapel Hill Blvd under 2025 PM peak hour conditions.

Overall, **Alternative E-R-1** (Roundabout with Loop Ramp) is the only eastbound ramp terminal that fully meets the mobility target (LOS D) for the ramp terminal while also maintaining acceptable queue lengths under 2025 and 2045 conditions.

SAFETY RESULTS

The traffic safety analysis performed to support the Level 2 Evaluation used Highway Safety Manual (HSM) methodology and Crash Modification Factors (CMF) to estimate predicted crash frequency and severity at the I-182 Eastbound Ramp Terminal at Broadmoor Blvd. The safety analysis results for 2045 conditions are summarized in Table 33.

TABLE 33: EASTBOUND RAMP TERMINAL ALTERNATIVES – YEAR 2045 SAFETY RESULTS

ALTERNATIVE	METHOD OF ANALYSIS	TOTAL PREDICTED CRASHES	PERCENT FATAL + INJURY
NO BUILD	ISAT-e	20.6	31%
E-S-1 (SIGNAL W/ LOOP)	ISAT-e	7.8	48%
E-R-1 (RAB W/ LOOP)	Baseline ISAT-e *CMF	13.3	14%
E-R-2 (RAB W/O LOOP)	Baseline ISAT-e *CMF	13.3	14%

*CMF: 0.29 applied to injury and fatal crashes, 0.81 for PDO crashes.

The key traffic safety findings for the Eastbound Ramp Terminal Alternatives are summarized as follows:

- **E-S-1:** This alternative provides some improvement in crash frequency over No-Build conditions due to the significantly reduced left turn conflicts, as the heavy volume eastbound left turn becomes a westbound right turn. The severity percentage increases, but this increase is more than balanced out by the total reduction in crashes, meaning that injury and fatal crashes are expected to decrease from No-Build conditions under this alternative.
- **E-R-1:** Converting a standard signalized intersection to a roundabout terminal reduces the number of conflict points and changes the types of conflicts. A roundabout ramp terminal prevents the entering-at-angle and left turn movements, as vehicles are only permitted to turn right when entering and exiting the roundabout. Crossing related crashes are associated with a higher risk of severe injury. The presence of a roundabout also encourages vehicles to reduce operating speed when approaching and while in the roundabout, which is also shown to reduce crash severity. The tear drop shape of the roundabout encourages drivers to not enter ramps the wrong way. The added eastbound loop off-ramp allows eastbound off ramp volumes to avoid conflicts points at the west and south leg, as they head to northbound Broadmoor Blvd. This loop off-ramp does however create a new set of conflict points, ultimately performing similar to **E-R-2**.
- **E-R-2:** This alternative provides the same estimated safety benefits as alternative **E-R-1**.

Overall, alternatives **E-R-1** and **E-R-2** provide the greatest safety benefit at this location relative to crash frequency and severity. Alternative **E-R-1** ultimately provides the largest safety benefits due to lower queue lengths on Broadmoor Blvd, as shown in Table 32 in the traffic operations results.

ACTIVE TRANSPORTATION RESULTS

The active transportation analysis performed to support the Level 2 Evaluation used Synchro to estimate pedestrian delay, the WSDOT Level of Traffic Stress Methodology for bikes and pedestrians, and the conceptual designs for the alternatives to determine crossing distances. The active transportation evaluation results are summarized in Table 34.

TABLE 34: EB RAMP TERMINAL ALTERNATIVE - ACTIVE TRANSPORTATION RESULTS

PERFORMANCE MEASURES	2025-2045 CONDITIONS			
	NO-BUILD	RAB W/ LOOP	RAB W/O LOOP	SIGNAL W/ LOOP
		E-R-1	E-R-2	E-S-1
BIKE LTS	4	2	2	4
PEDESTRIAN LTS	4	2	2	4
CHANGE IN PEDESTRIAN TRAVEL TIME (SECONDS)	-	-17	-24	-10
MAXIMUM CROSSING DISTANCE (FT)	45	24	24	36
CROSSING CONTROL	SIGNAL	YIELD	YIELD	SIGNAL

The eastbound ramp terminal alternatives impact active transportation of the eastbound ramp terminal crossing. Under No Build Conditions, the crossing is LTS 4 for bicycles and pedestrians. Due to lower speeds, the crossing improves to LTS 3 for the roundabout alternatives. The signal alternative has no impact on the LTS compared to No Build.

The crossing time is expected to decrease for each alternative compared to No Build. In the roundabout alternatives, motor vehicles should yield to bicycles and pedestrians, which will save time compared to waiting for the walk or through phase on the existing traffic signal. The signal with loop is expected to have a shorter cycle length, and therefore will decrease overall pedestrian delay at the intersection compared to No Build.

The maximum crossing distance is lower in the alternatives compared to the No Build. This is because the medians included in the proposed design of the alternatives reduce the number of lanes at the pedestrian crossing.

SCORING SUMMARY

The eastbound ramp terminal alternatives were scored against No-Build conditions and each other, as shown in Table 35. The scoring ranges from -2 to +2, as described in Appendix C. The cost estimate for each alternative is included in Table 35 as well but is only used as a tiebreaker for scoring purposes.

TABLE 35: EASTBOUND RAMP TERMINAL ALTERNATIVES – LEVEL 2 EVALUATION SCORING

PROJECT OBJECTIVE	PERFORMANCE MEASURES	SCORE		
		RAB W/ LOOP	RAB W/O LOOP	SIGNAL W/ LOOP
		E-R-1	E-R-2	E-S-1
IMPROVE TRAFFIC OPERATIONS	EB Ramp Terminal Intersection LOS	+2	+1	+2
	EB Ramp Terminal 95th Percentile Off-Ramp Queue Lengths	+2	+2	+2
IMPROVE TRAFFIC SAFETY	Predicted Crashes Per Year	+1	+1	+2
	Predicted Crashes Severity	+2	+2	+1
	95th Percentile Queue Lengths Broadmoor NB/SB	+2	+1	+1
	EB Ramp Terminal 95th Percentile Off-Ramp Queue Lengths	+2	+2	+2
IMPROVE ACTIVE TRANSPORTATION SYSTEM	Bike LTS	+1	+1	0
	Pedestrian LTS	+1	+1	0
	Active Transportation Travel Time	+2	+2	+2
	Maximum Crossing Distance	+2	+2	+1
	Crossing Control	+1	+1	0
	TOTAL SCORE	**+17**	**+15**	**+13**
SCALABILITY	**COST**	**$2.1-$2.5M**	**$1.6-$2.0M**	**$0.9-$1.3M**

As shown in Table 35, all three alternatives improve traffic operations, safety, and active transportation at the eastbound ramp terminal. The key performance differences between the three alternatives are summarized as follows:

- Traffic Operations

- Alternatives **E-R-1** and **E-S-1** meet mobility targets for 2025 and 2045, while Alternative **E-R-2** fails to meet mobility targets in 2045, leading to a lower score. All three alternatives meet the queue length goals for the I-182 eastbound off-ramp.

- Safety
  - As discussed in the safety results section, Alternative **E-S-1** provides the largest safety benefit related to crash frequency due to reduced conflicts from the loop ramp, while Alternatives **E-R-1** and **E-R-1** also provide reduction. **E-R-1** and **E-R-2** provide a greater benefit than **E-S-1** related to severe crashes due to the speed slowing benefits for roundabouts.
  - From a queuing standpoint, Alternative **E-R-1** provides the most benefit, containing all queues within the desired storage areas. Alternatives **E-R-2** and **E-S-1** improve over No-Build but still have Broadmoor Blvd queues that extend beyond available storage.
- Active Transportation
  - Alternatives **E-S-1** does provide appreciable improvement to the Bike or Pedestrian LTS at the ramp terminal intersection. The roundabout configurations of Alternatives **E-R-1** and **E-R-2** improve the LTS, leading to positive scores.
  - All here alternatives reduce pedestrian delay either through shorter crossing distances and more efficient pedestrian signal phasing (**E-S-1**) or by removing signal delay (**E-R-1** and **E-R-2**).
  - All three alternatives provide opportunities to reduce crossing distances, with **E-R-1** and **E-R-2** providing the shortest distances. Alternatives **E-R-1** and **E-R-2** also provide a better crossing control option than the signalized alternative (**E-S-1**) with low-speed yield crossings.

Overall, **Alternative E-R-1 (New Roundabout with Loop Ramp)** is the highest scoring alternative in the Eastbound Ramp Terminal category. Note that this alternative is also compatible with the highest scoring westbound ramp terminal alternative (**W-R-1**) and freeway alternative (**F-E-2**).

ACTIVE TRANSPORTATION ALTERNATIVES

The active transportation alternatives are separated into three subcategories: Westbound Ramp Terminal Crossings, Eastbound Ramp Terminal Crossings, and I-182 crossings. The highest scoring alternatives from the eastbound and westbound ramp terminals were included with the active transportation alternatives for the evaluation. The alternatives are described in detail in Chapter 4, and are summarized as follows:

- I-182 Crossings
  - **A-N-1**: Bridge and path on the west side of Broadmoor Blvd
  - **A-N-2**: Bridge and path on the east side of Broadmoor Blvd
  - **A-N-3** and **A-P-2**: Bridge across I-182 aligning with Midland Ln (**A-N-3**) with new path along the eastbound on-ramp (**A-P-3**)
  - **A-I-1**: Widen Broadmoor Blvd bridge to the west to protected mixed use path
  - **A-I-2**: Re-stripe Broadmoor Blvd to include curb protected mixed use path on west side
- Westbound Ramp Terminal Crossings
  - **A-W-1a**: Pedestrian undercrossing at westbound slip on-ramp

- **A-W-2b**: Pedestrian overcrossing at westbound off-ramp
- **W-R-1**: Roundabout at westbound ramp terminal

- Eastbound Ramp Terminal Crossings
  - **A-E-1a**: Pedestrian undercrossing at the existing eastbound off-ramp
  - **A-E-2a**: Pedestrian undercrossing
  - **E-R-1**: Roundabout with loop ramp at westbound ramp terminal

The Active Transportation evaluation results and alternatives scoring is summarized in the following sections.

ACTIVE TRANSPORTATION RESULTS

I-182 Bike/Ped Crossing Results

The first subcategory of active transportation alternatives are the I-182 crossings. This includes the five alternatives that provide a multi-modal crossing of I-182. The Broadmoor roadway segment between the I-182 eastbound ramps and westbound ramps for each alternative is compared for in Table 36.

TABLE 36: I-182 BIKE/PED CROSSINGS - EVALUATION RESULTS

PERFORMANCE MEASURES	2025-2045 CONDITIONS					
	NO-BUILD	PED BRIDGE W	PED BRIDGE E	PED BRIDGE MDL	WIDEN W SIDE	RE-STRIPE W
		A-N-1	A-N-2	A-N-3/A-P-2	A-I-1	A-I-2
BIKE LTS	4	1	1	1	1	4
PEDESTRIAN LTS	4	1	1	1	1	4
CHANGE IN PEDESTRIAN TRAVEL TIME (SECONDS)	-	+17	+17	+701	0	0

Under No Build conditions, the segment is LTS 4 for both bicycles and pedestrians. The only alternative that fails to improve the LTS is the re-striping alternative. However, this alternative is still expected to provide at least some level of improved safety and comfort for pedestrians and bicyclists due to a wider facility and the protection offered by a curb and delineator treatment. The alternatives that separate the bicycle and pedestrians from the traffic with a separate bridge or physical barrier are LTS 1. The separated structure alternatives increase the pedestrian travel time from a fixed point on either side of the bridge, with the Midland crossing adding more than 11 minutes of travel time. It should be noted that depending on the origin and destination, the

pedestrian travel will change. While the table shows an increase in pedestrian travel time for a specific origin and destination, some alternatives will decrease travel time for specific routes.

Westbound Ramp Terminal Bike/Ped Crossing Results

The second subcategory of active transportation alternatives are the westbound ramp terminal crossing treatments. These alternatives were selected in part to determine which side of the intersection (west side vs east side) works best for grade separations. Therefore, the grade separations on each side of the intersection are compared against No-Build, each other, and the highest performing intersection improvement, which at this location is a new roundabout at the ramp terminal (**W-R-1**). The westbound ramp terminal bike/pedestrian crossing alternatives evaluation results are summarized in Table 37.

TABLE 37: BIKE/PED WESTBOUND RAMP TERMINAL CROSSING - EVALUATION RESULTS

WESTBOUND RAMP TERMINAL				
PERFORMANCE MEASURES	MEASURE			
	NO-BUILD	WB ON U-XING	WB OFF O-XING	RAB
		A-W-1a	A-W-2b	W-R-1
BIKE LTS	4	1	1	2
PEDESTRIAN LTS	4	1	1	2
CHANGE IN PEDESTRIAN TRAVEL TIME (SECONDS)	-	-4	+235	-19
MAXIMUM CROSSING DISTANCE	60’	0	0	24’
CROSSING CONTROL	UNPROTECTED	PROTECTED	PROTECTED	YIELD

Under No Build conditions, the ramp terminal is LTS 4 for bicycles and pedestrians, and LTS 2 for the roundabout alternative (**W-R-1**). The undercrossing and overcrossing alternatives eliminate the conflict with vehicles at the intersection and are therefore LTS 1. They also have no crossing distance associated with them.

While the undercrossing and overcrossing have no delay at the intersection, the pedestrian must travel away from the intersection to get to the crossing. Therefore, an increase in pedestrian travel time is seen in the overcrossing alternative and only a slight decrease is seen in the undercrossing alternative. The travel time shown is assuming the pedestrian has an origin and destination close to the intersection. However, the travel time may differ depending on the pedestrian’s specific origin and destination.

Eastbound Ramp Terminal Bike/Ped Crossing Results

The third subcategory of active transportation alternatives are the eastbound ramp terminal crossing treatments. These alternatives were selected in part to determine which side of the intersection (west side vs east side) works best for grade separations. Therefore, the grade separations on each side of the intersection are compared against No-Build, each other, and the highest performing intersection improvement, which at this location is a new roundabout at the ramp terminal with a new loop ramp connection (**E-R-1**). The eastbound ramp terminal bike/pedestrian crossing alternatives evaluation results are summarized in Table 38.

TABLE 38: BIKE/PED EASTBOUND RAMP TERMINAL CROSSING- EVALUATION RESULTS

EASTBOUND RAMP TERMINAL				
PERFORMANCE MEASURES	MEASURE			
	NO-BUILD	EB ON U-XING	EB OFF U-XING	RAB W/ LOOP
		A-E-1a	A-E-2a	E-R-1
BIKE LTS	4	1	1	2
PEDESTRIAN LTS	4	1	1	2
CHANGE IN PEDESTRIAN TRAVEL TIME (SECONDS)	-	+21	+3	-17
MAXIMUM CROSSING DISTANCE	60’	0	0	24’
CROSSING CONTROL	UNPROTECTED	PROTECTED	PROTECTED	YIELD

The No Build is LTS 4 for bicycles and pedestrians, and the roundabout alternative is LTS 2 for bicycles and pedestrians. The undercrossing alternatives eliminate the conflict with vehicles at the intersection and are therefore LTS 1. They also have no crossing distance associated with them.

While the undercrossing alternatives have no delay at the intersection, they increase the pedestrian travel time due moving away from the intersection. However, the travel time may differ depending on the pedestrian’s specific origin and destination,

SCORING SUMMARY

The active transportation alternatives were scored against each other within the previously defined subcategories:

- I-182 Crossings
- Westbound Ramp Terminal Crossings
- Eastbound Ramp Terminal Crossings

The scoring results for each of these subcategories are summarized in the following sections.

I-182 Bike/Ped Crossing Scoring

The I-182 bike/pedestrian alternatives were scored against No-Build conditions and each other, as shown in Table 39. The scoring ranges from -2 to +2, as described in Appendix C. The cost estimate for each alternative is included in Table 39 as well but is only used as a tiebreaker for scoring purposes.

TABLE 39: I-182 BIKE/PED CROSSINGS – LEVEL 2 EVALUATION SCORES

PERFORMANCE MEASURES	SCORE				
	PED BRIDGE W	PED BRIDGE E	PED BRIDGE MDL	WIDEN W SIDE	RE-STRIPE
	A-N-1	A-N-2	A-N-3/A-P-2	A-I-1	A-I-2
BIKE LTS	+2	+2	+2	+2	+1
PEDESTRIAN LTS	+2	+2	+2	+2	+1
ACTIVE TRANSPORTATION TRAVEL TIME	0	0	-2	0	0
TOTAL SCORE	**+4**	**+4**	**+2**	**+4**	**+2**
COST	$7-$8M	$8.3-$9.3M	$8.1-$9.1M	$10.1-$11.1M	$0.7-$0.9M

As shown in Table 39, all four alternatives providing physical separation score well against the bike and ped LTS measures. The re-striping alternative (**A-I-2**) is also assumed to provide some improvement for bikes and pedestrians, even though the LTS remains 4, per the WSDOT methodology. Alternative **A-N-3/A-P-2** (the Midland crossing) scores poorly against the active transportation travel time measure due to significantly increased interchange crossing time.

Alternative **A-N-1** (new bridge on the east side) is the recommended alternative for this sub-category, as this alternative has the lowest estimated cost while providing the same LTS and travel time as the east side bridge and the widening alternative. Alternative **A-I-2** is also recommended as a low cost, temporary solution while funding opportunities for the preferred alternative are pursued.

Westbound Ramp Terminal Bike/Ped Crossing Scoring

The westbound ramp terminal bike/pedestrian crossing alternatives were scored against No-Build conditions and each other, as shown in Table 40. The scoring ranges from -2 to +2, as described in Appendix C. The cost estimate for each alternative is included in Table 40 as well. Note that the cost for the roundabout alternative (**W-R-1**) is not included in the table, as the grade separation alternatives are additive to the roundabout, which is already costed out in the Westbound Ramp Terminal Alternatives section.

TABLE 40: WESTBOUND RAMP TERMINAL BIKE/PED CROSSINGS – LEVEL 2 EVALUATION SCORES

PERFORMANCE MEASURES	SCORE		
	WB ON U-XING	WB OFF O-XING	RAB
	A-W-1a	A-W-2b	W-R-1
BIKE LTS	+2	+2	+1
PEDESTRIAN LTS	+2	+2	+1
ACTIVE TRANSPORTATION TRAVEL TIME	0	-2	+2
MAXIMUM CROSSING DISTANCE	+2	+2	+1
CROSSING CONTROL	+2	+2	+1
TOTAL SCORE	**8**	**6**	**6**
COST	**$2.1-$2.5 M**	**$6.6-$7.6M**	**-**

As shown in Table 40, the grade separation alternatives provide the best bike and pedestrian LTS scores and have an intersection crossing distance of zero. The overcrossing on the westbound off-ramp (**A-W-2b**) adds significant out of direction travel to meet ADA grade requirements, leading to a lower score for transportation travel time.

Overall, alternative **A-W-1a** is the highest scoring alternative. This undercrossing has a significant cost, and marginal benefit compared against the roundabout condition. Long-term, the grade separation may become a more desirable option, especially as the traffic volumes on the southbound right turns from Broadmoor Blvd onto the I-182 westbound slip on-ramp continue to increase. But for the purposes of this project, the pedestrian improvements associated with the roundabout (**W-R-1**) the recommended solution at the westbound ramp terminal.

Eastbound Ramp Terminal Bike/Ped Crossing Scoring

The eastbound ramp terminal bike/pedestrian crossing alternatives were scored against No-Build conditions and each other, as shown in Table 41. The scoring ranges from -2 to +2, as described in Appendix C. The cost estimate for each alternative is included in Table 41 as well. Note that the cost for the roundabout with loop ramp alternative (**E-R-1**) is not included in the table, as the grade separation alternatives are additive to the roundabout, which is already costed out in the Eastbound Ramp Terminal Alternatives section.

TABLE 41: EASTBOUND RAMP TERMINAL BIKE/PED CROSSINGS – LEVEL 2 EVALUATION SCORES

PERFORMANCE MEASURES	SCORE		
	EB ON U-XING	EB OFF U-XING	RAB W/ LOOP
	A-E-1a	A-E-2a	E-R-1
BIKE LTS	+2	+2	+1
PEDESTRIAN LTS	+2	+2	+1
ACTIVE TRANSPORTATION TRAVEL TIME	-1	0	+1
MAXIMUM CROSSING DISTANCE	+2	+2	+1
CROSSING CONTROL	+2	+2	+1
TOTAL SCORE	**7**	**8**	**5**
COST	**$2.7-$3.1 M**	**$2-$2.4M**	**-**

As shown in Table 41, the grade separation alternatives provide the best bike and pedestrian LTS scores and have an intersection crossing distance of zero. The undercrossing on the eastbound on-ramp (**A-E-1a**) adds some out of direction travel to meet ADA grade requirements, leading to a lower score for transportation travel time.

Overall, alternative **A-E-2a** is the highest scoring alternative. This undercrossing has a significant cost, and marginal benefit compared against the roundabout condition. Long-term, the grade separation may become a more desirable option, especially as the traffic volumes on the eastbound off-ramp, which are only eastbound right turns with the loop ramp, continue to increase. But for the purposes of this project, the pedestrian improvements associated with the roundabout with loop ramp (**E-R-1**) is the recommended solution at the eastbound ramp terminal.

Note that with **A-N-1** as the recommended I-182 crossing alternative, both the roundabout options and the highest scoring intersection crossing alternatives (**A-W-1a** and **A-E-2a**) are compatible, as this alternative prioritizes the west side of Broadmoor Blvd for active transportation travel. The design of any project at both ramp terminals should consider geometry and grading that make these grade separations feasible in the future.

COMPREHENSIVE INTERCHANGE ALTERNATIVES

Only one standalone comprehensive interchange improvement alternative (the Diverging Diamond Interchange) passed through the First Level Screening. However, a second comprehensive alternative was developed by combining the highest scoring alternative from each category (Freeway, Westbound Ramp Terminal, Eastbound Ramp Terminal, and Active Transportation). These alternatives are described in detail in Chapter 4, along with the DDI. The DDI alternative was

combined with Alternative **F-E-4** (Eastbound off-ramp widening), as this was the only freeway improvement alternative compatible with the DDI. The comprehensive alternatives evaluated are listed as follows:

- **Combined Alternative:** New eastbound loop off-ramp with deceleration lane (**F-E-2**), Roundabouts at both ramp terminals (**W-R-1** and **E-R-1**), and a new ped bridge on the west side of Broadmoor Blvd (**A-N-1**)
- **Diverging Diamond Interchange (DDI)**: DDI with roundabouts (**C-P-3**) and eastbound off-ramp widening (**F-E-4**)

The cumulative Operations, Safety, and Active Transportation performance measures from this combined alternative are compared against from the DDI in the following sections.

OPERATIONS RESULTS

The Level 2 Evaluation results for the Comprehensive Alternatives include freeway analysis, ramp terminal LOS and queueing. The HCS calculated freeway analysis results are shown in Table 42 in the Freeway Alternatives Operations Results section of this document. The DDI alternative has the same freeway evaluation results as Alternative **F-E-4**, and the Combined Alternative has the same results as Alternative **F-E-2**.

The intersection traffic analysis performed to support the Level 2 Evaluation used Sidra to estimate the Highway Capacity Manual (HCM) LOS at the interchange ramp terminals on Broadmoor Blvd. The DDI is compared to alternative **E-R-1** (roundabout with loop ramp) at the eastbound ramp terminal and alternative **W-R-1** (roundabout) at the westbound ramp terminal. The 2025 and 2045 AM and PM peak hour analysis results are summarized in Table 42.

TABLE 42: COMPREHENSIVE ALTERNATIVES – RAMP TERMINAL HCM RESULTS

ALTERNATIVE	MOBILITY STANDARD	AM PEAK HOUR LOS		PM PEAK HOUR LOS	
		2025	2045	2025	2045
EASTBOUND RAMP TERMINAL					
NO-BUILD	LOS D	B/(C-EBL)	**F/(F-SBL)**	**E/(F-EBL)**	**F/(F-SBL)**
E-R-1	LOS D	A/(A-SBL)	B/(D-WBR)	A/(A-SBL)	B/(D-WBR)
C-P-3	LOS D	A/(B-SBT)	B/(D-SBT)	A/(B-SBT)	A/(B-SBT)
WESTBOUND RAMP TERMINAL					
NO-BUILD	LOS D	B/(C-WBR)	B/**(F-NBT)**	B/(D-WBR)	**F/(F-WBR)**
W-R-1	LOS D	A/(B-WBL)	A/**(F-SBR)**	A/(B-WBL)	A/(D-WBL)
C-P-3	LOS D	A/(B-NBT)	**F/(F-NBT)**	D**/(F-NBT)**	**F/(F-NBT)**

Sidra queues were used to estimate and compare the ramp terminal queuing between the roundabout alternatives (**E-R-1** and **W-R-1**) and the DDI (**C-P-3**). The key queuing results at the eastbound ramp terminal are shown in Table 43, and the queues for the westbound terminal are shown in Table 44.

TABLE 43: COMPREHENSIVE ALTERNATIVES – EASTBOUND RAMP TERMINAL QUEUING RESULTS

EASTBOUND RAMP TERMINAL QUEUING RESULTS					
ALTERNATIVE	AVAILABLE STORAGE (FT)	AM PEAK HOUR 95TH PERCENTILE QUEUES (FT)		PM PEAK HOUR 95TH PERCENTILE QUEUES (FT)	
		2025	2045	2025	2045
EASTBOUND OFF-RAMP TERMINAL					
NO-BUILD	900	110	**>1,470**	**1,080**	**>1,470**
E-R-1	900/1,100[A]	<50/<50	<50/270	<50/160	70/370
C-P-3	900	<50	<50	70	80
NORTHBOUND/SOUTHBOUND BROADMOOR BLVD QUEUES					
NO-BUILD	900/1,100	**>900**/130	**>900/>1,100**	**>900**/1,030	**>900/>1,100**
W-R-1	900/1,100	60/<50	240/<50	<50/<50	70/<50
C-P-3	900/1,100	<50/90	<50/300	<50/90	<50/100

[A]Slip Ramp/Loop Ramp

TABLE 44: COMPREHENSIVE ALTERNATIVES – WESTBOUND RAMP TERMINAL QUEUING RESULTS

WESTBOUND RAMP TERMINAL QUEUING RESULTS					
ALTERNATIVE	AVAILABLE STORAGE (FT)	AM PEAK HOUR 95TH PERCENTILE QUEUES (FT)		PM PEAK HOUR 95TH PERCENTILE QUEUES (FT)	
		2025	2045	2025	2045
WESTBOUND OFF-RAMP TERMINAL					
NO-BUILD	1,030	210	930	260	**>1,470**
E-R-1	1,030	<50	160	80	300
C-P-3	900	<50	<50	<50	<50
NORTHBOUND/SOUTHBOUND BROADMOOR BLVD QUEUES					
NO-BUILD	1,100/720	290/120	450/**>720**	230/140	320/**>720**
W-R-1	1,100/720	<50/<50	<50/110	<50/70	<50/110
C-P-3	1,100/720	90/<50	**>1,100**/<50	**>1,100**/<50	**>1,100**/<50

The key traffic operations findings for the alternatives **E-R-1** and **W-R-1** are discussed in the prior ramp terminal sections. The key findings for alternative **C-P-3** (the DDI) are summarized as follows:

- **Eastbound Ramp Terminal:** The DDI functions acceptable at this ramp terminal, with acceptable LOS. The only movement of concern is the southbound through movement, which would operate near capacity and at LOS D under AM peak hour 2045 conditions. The estimated queues at this ramp terminal remain within the available storage areas.
- **Westbound Ramp Terminal:** The DDI does not function effectively at this ramp terminal. As shown in Figure 37, the DDI creates a conflict that was previously eliminated by the northbound Broadmoor to westbound I-182 loop ramp. This movement now creates a weave conflict with the heavy eastbound left turn movement coming from the eastbound ramp terminal. In addition, the heavy northbound through movement conflicts with the heavy southbound through

movement, resulting in LOS F conditions during both the AM and PM peak in 2045, ultimately providing worse LOS than No-Build conditions at this location. This results in northbound queues that spill back to the eastbound ramp terminal.

Overall, **Alternative C-P-3** (DDI with roundabouts) combined with alternative **F-E-4** underperforms the combined **F-E-2**, **E-R-1**, and **W-R-2** alternatives at the interchange. The DDI would start to experience capacity and queuing issues even by the year 2025, and from a traffic operations perspective is not the best long-term configuration for this interchange.

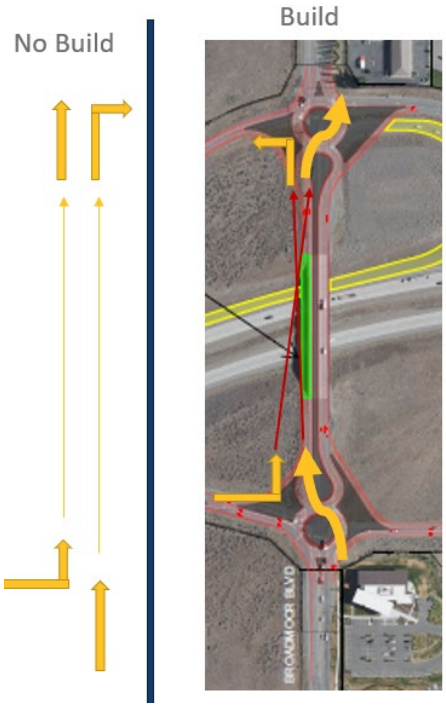

FIGURE 37: DDI WEAVE

SAFETY RESULTS

The safety evaluation 2 Evaluation used a combination of ISAT-e and HSM analysis to estimate the 2045 crash frequency and severity for the interchange ramp terminals and Broadmoor Blvd segments. For comparison, the combined predicted crash frequencies and severity for Alternatives **E-R-1**, **W-R-1**, and No-Build (where appropriate) were calculate. These results were all compared against 2045 No-Build conditions, as shown in Table 45.

TABLE 45: CUMULATIVE ALTERNATIVES – YEAR 2045 SAFETY RESULTS

ALTERNATIVE	METHOD OF ANALYSIS	TOTAL PREDICTED CRASHES	PERCENT FATAL + INJURY
NO BUILD	Combination	48.4	42%
E-R-1 + W-R-1 (RAB + LOOP RAMP)	Combination	37.1	35%
C-P-3 (DDI WITH RAB)	Combination	21.8	17%

Alternative **C-P-3** requires removal of the WB loop on-ramp, which will provide a ramp safety improvement according to ISAT-e analysis. The existing westbound loop on-ramp has a tight geometric curve, which can lead to increased crash frequency. The removal of the westbound loop on-ramp and having traffic merge with the non-loop westbound on-ramp showed a reduction in predicted collisions per year in the ISAT-e tool.

Converting a standard diamond interchange to a DDI reduces the frequency of conflict points and changes the types of conflicts, shown in Figure 38. All ramp to ramp through movements are removed, as well a left turns from off ramp and to the on ramp. The geometric design promotes slower speeds, which reduces crash severity.

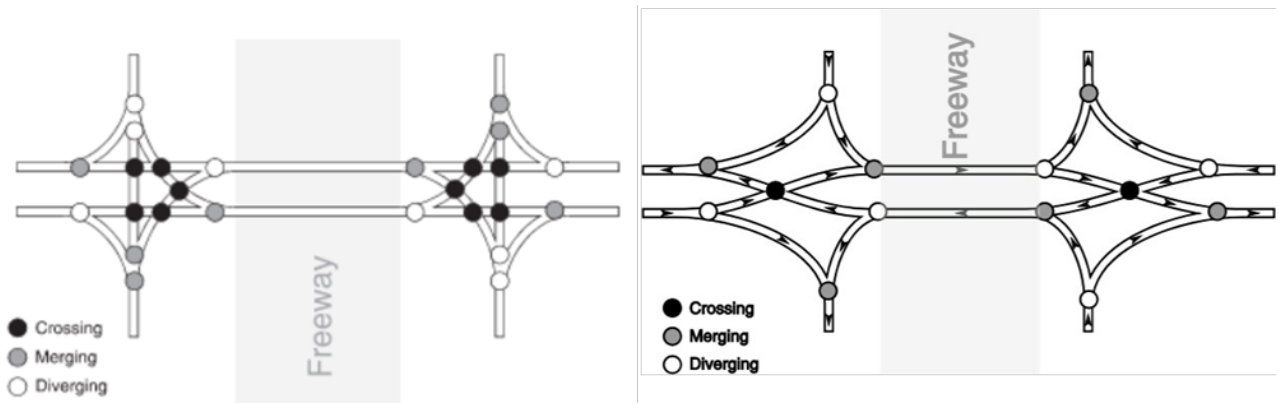

FIGURE 38: STANDARD DIAMOND VS DDI INTERCHANGE CONFLICT POINTS

However, the uncommon design of a DDI can lead to driver confusion. When a vehicle traveling on an off-ramp approaches the interchange, the driver may not know which side of the road to watch for traffic, as the traffic is crossed over. Driver sight distance could also be reduced from obstacles in between the exit ramps and the interchange. A study from 2021[2] found that converting an diamond interchange to a DDI resulted in a reduction of 44% to injury crashes, with an overall reduction of 8% to all crashes. This reduction was combined with the predicated roundabout crash reductions at the ramp terminals to estimate the future crash severity and frequency for 2045 conditions, as summarized in Table 45.

Alternative **C-P-3** shows further reductions in predicted crashes at the interchange. However, the traffic operations analysis shows significant queuing issues through the interchange for this alternative, along with heavy weaving conflicts that are not capture in the quantitative safety evaluation. The roundabout alternatives could include some form of a median curb barrier between the ramp terminals to further improve traffic safety. Overall, the combined **E-R-1** and **W-R-1** alternatives provide the best overall safety improvement to the interchange as these alternatives do not degrade the existing queuing condition.

ACTIVE TRANSPORTATION RESULTS

Active transportation analysis for the cumulative options includes the performance measures discussed in the active transportation section above and adds route directness index. The route directness index is the number of roadway crossings necessary to get from one end of the corridor to the other.

For the cumulative options, the entire corridor is considered. In Table 46, the worst LTS for the corridor is reported. The pedestrian travel time from one end of the corridor to the other is comparted to No Build. The maximum distance for a single crossing is reported.

[2] Study Citation: Abdelrahman, A., M. Abdel-Aty, J. Yuan, and M. Al-Omari. "Systematic Safety Evaluation of Diverging Diamond Interchanges Based on Nationwide Implementation Data". Presented at the 100th Annual Meeting of the Transportation Research Board, Paper No. 21-00026, Washington, D.C., (2021).

The DDI alternative improves bicycle and pedestrian from LTS 4 to LTS 2. The LTS is improved because of the protected movements at each intersection and the wide shared path on the overpass. The DDI alternative includes a shorter cycle length at intersections, which results in a shorter travel time.

TABLE 46: CUMULATIVE INTERCHANGE ALTERNATIVES – EVALIUATION RESULTS

PERFORMANCE MEASURES	MEASURE		
	NO-BUILD	LOOP+RAB+W SLIDE PED BRIDGE	DDI
		COMBO	C-P-3
BIKE LTS	4	2	2
PEDESTRIAN LTS	4	2	2
CHANGE IN PEDESTRIAN TRAVEL TIME (SECONDS)	-	-70	-41
MAXIMUM CROSSING DISTANCE	60	24	24
CROSSING CONTROL	SIGNAL	YIELD	YIELD
ROUTE DIRECTNESS INDEX	+3	+2	+4

As shown in Table 46, both the DDI and the Combined alternative provide improved LTS over No-Build conditions, as well as decreased pedestrian travel time, and decreased crossing distance. The DDI requires a minimum of four crossings for a pedestrian to traverse the interchange, which is one more than No-Build, while the Combined alternative only requires two.

SCORING SUMMARY

The comprehensive alternatives were scored against No-Build conditions and each other, as shown in Table 47. The scoring ranges from -2 to +2, as described in Appendix C. The cost estimate for each alternative is included in Table 47 as well but is only used as a tiebreaker for scoring purposes. Note that the cost estimate for the DDI alternative includes Alternative **F-E-4**, as this is the only freeway alternative compatible with **C-P-3**.

TABLE 47: COMPREHENSIVE ALTERNATIVES – LEVEL 2 EVALUATION SCORING

PERFORMANCE MEASURES	PERFORMANCE MEASURES	SCORE	
		LOOP+ RAB + W PED BRIDGE	DDI + DUAL OFF RAMP
		F-E-2/W-R-1/ E-R-1/A-N-1	C-P-3/F-E-4
IMPROVE TRAFFIC OPERATIONS	Freeway Level of Service-Diverge EB	+2	+1
	Forward Compatibility	+2	-1
	WB Ramp Terminal Intersection LOS	+2	-1
	EB Ramp Terminal Intersection LOS	+2	+2
	WB Ramp Terminal Off-Ramp Queue Lengths	+2	+2
	EB Ramp Terminal Off-Ramp Queue Lengths	+2	+2
IMPROVE TRAFFIC SAFETY	Predicted Crashes Per Year	+1	+2
	Predicted Crashes Severity (Percent Fatal)	+1	+2
	95th Percentile Queue Lengths Broadmoor NB/SB	+2	-1
	WB Ramp Terminal Off-Ramp Queue Lengths	+2	+2
	EB Ramp Terminal Off-Ramp Queue Lengths	+2	+2
	Freeway LOS at EB Diverge	+2	+1
IMPROVE ACTIVE TRANSPORTATION SYSTEM	Bike LTS	+1	+1
	Pedestrian LTS	+1	+1
	Active Transportation Travel Time	+2	+1
	Maximum Crossing Distance	+2	+2
	Crossing Control	+1	+1
	Route Directness Index	+1	-1
	TOTAL SCORE	**+29**	**+19**
SCALABILITY	**COST**	**$14-$16 M**	**$24-$32 M**

As shown in Table 47, both alternatives improve traffic operations, safety, and active transportation throughout the interchange. The key performance differences between the three alternatives are summarized as follows:

- Traffic Operations
  - As discussed in the traffic operations sections, Alternative **F-E-2** outperforms **F-E-4** due to better distributed exit ramp traffic volumes. This results in a higher score for the combined alternative compared to the DDI.
  - The DDI is not compatible with many other alternatives, given its unique lane configuration. This alternative would be particularly problematic if the westbound on-ramp connection onto I-182 reaches capacity in the future, as the opportunities provided by the existing loop ramp would be eliminated. Therefore, the DDI alternative received a forward compatibility score of -1.
  - The DDI alternative fails to meet the intersection mobility standard at the westbound ramp terminal under 2045 conditions. The DDI performance is actually worse than No-Build at this location due to increased traffic conflicts caused by closing the existing loop ramp. This result in a negative score at this location.
  - Both the DDI and combined alternatives meet mobility standards at the eastbound ramp terminal and improve off-ramp queuing operations.
- Safety
  - Both alternatives provide at worst LTS of 2 through the ramp terminals and along Broadmoor Blvd through the interchange. As discussed in the safety results section, the DDI alternative provides the largest crash reduction through the interchange, leading to a higher score that the combined alternative.
  - The queuing issues created on Broadmoor Blvd and throughout the interchange by the DDI, combined with the heavy northbound weaving conflict leads to a negative score under the Broadmoor queuing safety performance measure.
  - As discussed in the Freeway Alternatives section, from safety alternative **F-E-2** outperforms **F-E-4** on the freeway due to improved LOS at the freeway diverge to the eastbound off-ramps.
- Active Transportation
  - The combination of alternatives **E-R-1**, **A-N-1**, and **W-R-1** provides a faster pedestrian route through the interchange than the DDI, which also improves over No-Build conditions. Both alternatives have similar maximum crossing distances and crossing control.
  - The DDI requires a pedestrian to make a minimum of four roadway crossings to traverse the interchange in either direction. The combination of the **E-R-1**, **A-N-1**, and **W-R-1** require only two crossings for the optimal route (located on the west side), while No-Build requires three crossings. Therefore, the DDI alternative received a negative score for the route directness index, while the combined alternative received a positive score.

Overall, the combined alternative of **F-E-2** (New Loop Ramp with deceleration lane), **E-R-1** (roundabout with loop ramp at eastbound ramp terminal), **W-R-1** (roundabout at westbound ramp terminal), and **A-N-1** (new bike/ped bridge over I-182 on the west side of Broadmoor Blvd) provide the best performance relative to the project purpose and need. These combined alternatives (shown in Figure 39) are recommended as the Preferred Alternative for this Access Revision Report.

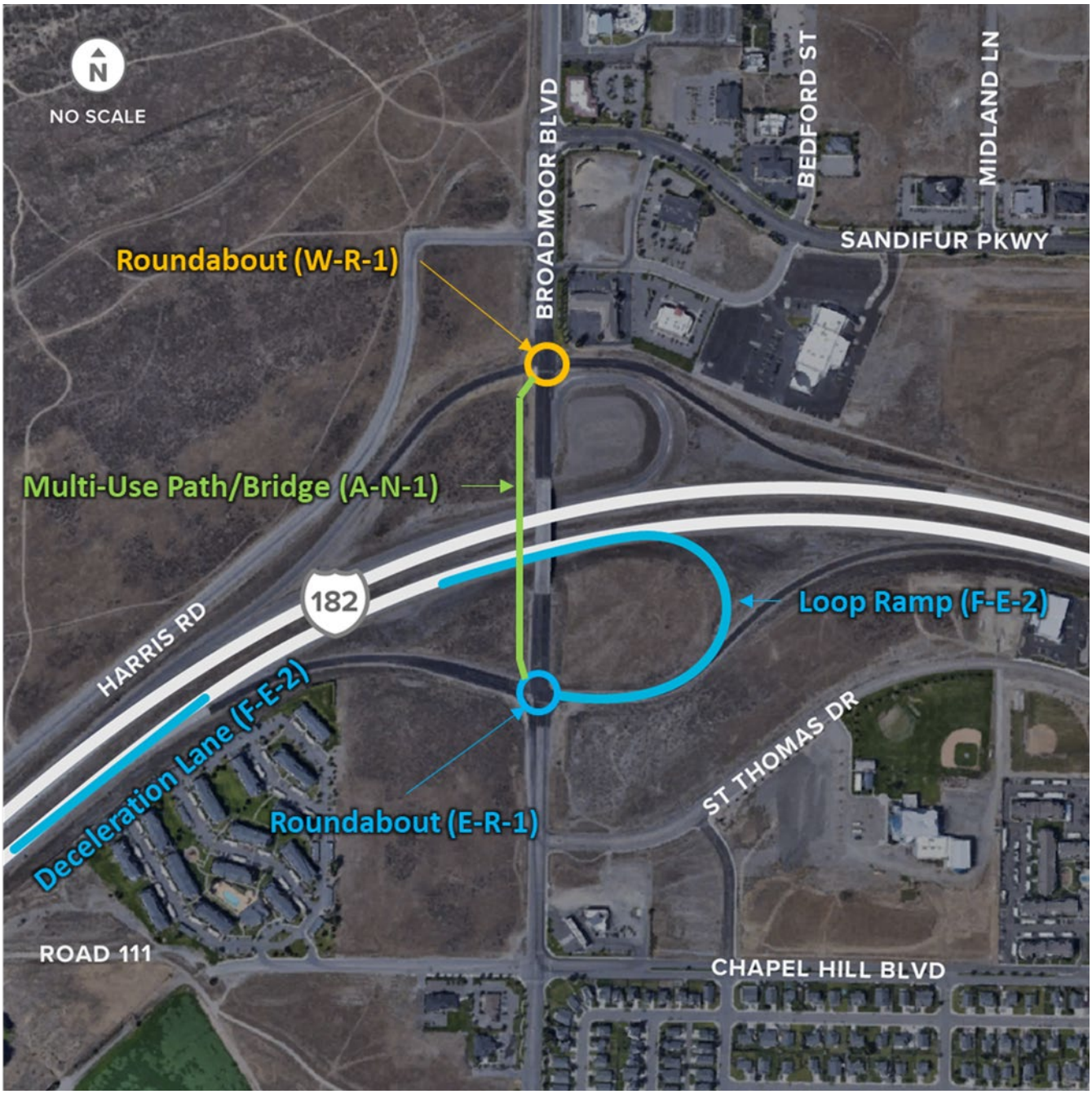

FIGURE 39: BROADMOOR INTERCHANGE PREFERRED ALTERNATIVE

CHAPTER 6. CONCEPTUAL SIGNING PLAN

The conceptual signing plan for the Preferred Alternative is included in Appendix K. The key takeaways from the signing plan are summarized as follows:

- The new interchange configuration will require a total of 18 new signs

- The main guide sign for the new loop ramp will require a sign bridge, located approximately at the existing eastbound off-ramp striped gore
- The signing plan assumes that the existing eastbound off-ramp will now be guide signed as "Exit 7A, Broadmoor Blvd South". The new loop ramp will be signed as "Exit 7B, Broadmoor Blvd North"
- All current Exit 7 signs will need to be replaced with the appropriate Exit 7A or Exit 7B signs

CHAPTER 7. PHASING RECOMMENDATIONS

While all the projects identified in the Preferred Alternative have both present and future utility, the City has the ability to fund a portion of these improvements immediately. Therefore, the projects have been prioritized based on the most immediate current needs as well as the cost for each improvement. Based on the results of the Level 2 Evaluation, the following project prioritization and phasing is recommended for the interchange improvements:

- **Phase 1A**: This phase includes the Loop Ramp and Deceleration Lane (**F-E-2**) and Roundabout with Loop Ramp at Eastbound Ramp Terminal (**E-R-1**). A refined version of Project **A-I-2**, which re-stripes the Broadmoor Blvd Bridge temporarily to add an enhanced mixed-use crossing on the west side, is also recommended for inclusion as a temporary solution until Phase 1B can be completed. This element of the project is described in more detail in the subsequent section. Based on funding available to the City at this time, Phase 1A is recommended to advance through design and into construction immediately to address current and immediate needs at the interchange.
- **Phase 1B**: This phase includes the separated mixed-use path and bridge over I-182 on the west side of Broadmoor Blvd (**A-N-1**). The City will immediately begin pursuing funding for this project, with the intent of constructing the project within the next five years.
- **Phase 2**: This phase would include the roundabout at the westbound ramp terminal (**W-R-1**). This project is not immediately needed, as shown in Level 2 Evaluation. Waiting to construct this project will give the City time to gather funding from a wider variety of sources.
- **Phase 3**: This phase could include projects beyond the Preferred Alternative, such as the pedestrian grade separations at the westbound on-ramp (**A-W-1a**) and the eastbound off-ramp (**A-E-2a**), and other projects targeting issues beyond the purpose and need of this Access Revision Report, such as capacity issues related to the westbound on-ramp merge onto I-182.

PHASE 1A ACTIVE TRANSPORTATION ELEMENT

This section describes the recommended interim (Phase 1A) active transportation elements and routing through the interchange. Project **A-I-2** was refined to align with the roundabout and loop ramp connection at the eastbound ramp terminal, resulting in the proposed active transportation routes and facilities shown in Figure 40.

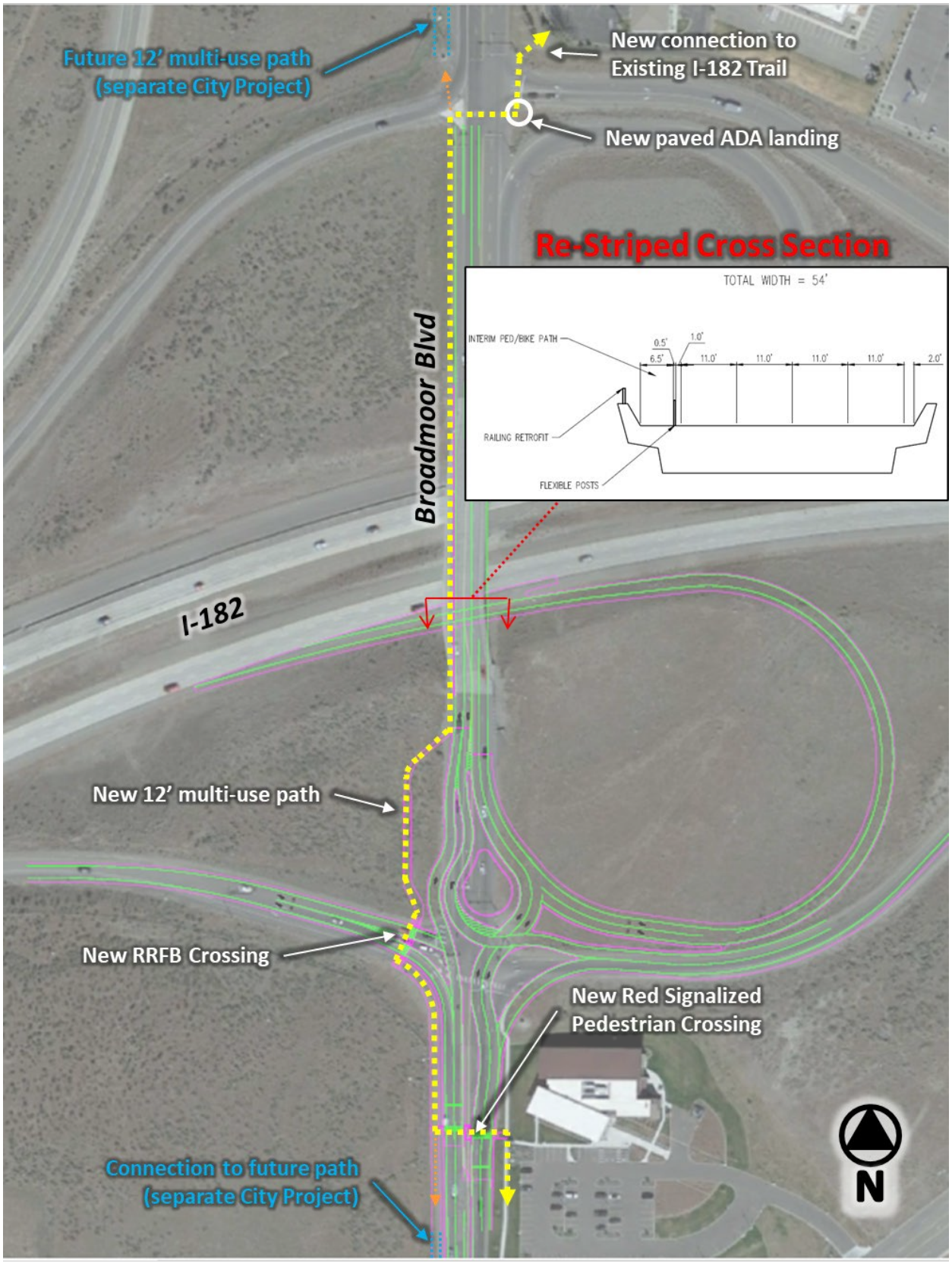

FIGURE 40: PHASE 1A ACTIVE TRANSPORTATION ELEMENTS

As shown in Figure 40, the active transportation crossings at the eastbound ramp terminal will be significantly simplified under Phase 1A. The east-west crossing of Broadmoor Boulevard will move south and become either an RRFB or red-protected type crossing with a median displacement for added safety. Active transportation uses will be consolidated to the west side of Broadmoor Boulevard, and the existing crosswalk over the eastbound on-ramp will be removed. The southern portion of the new 12’ mixed use path will be constructed, aligning with the future Phase 1B bridge. Broadmoor Boulevard will be re-striped from the south end of the existing bridge up to the westbound ramp terminal intersection, allocating a 6.5’ (on the bridge) to 9’ (north of the bridge) delineated area to active transportation users. A throw fence will also be added to the west side of the existing bridge to provide further pedestrian protection. ADA landing areas will be added to the south-east and north-east quadrants of the westbound ramp terminal intersection, and a new connection will be made from the north-east quadrant to the existing I-182 path. These improvements will improve safety for active transportation users through the interchange over the existing condition until Phase 1B is funded and constructed.

Appendix L includes the Broadmoor Interchange 30% Design ADA memo, which outlines the pedestrian routes and added design features throughout the interchange under the Phase 1A condition.

APPENDIX

APPENDICES

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APPENDIX I: COST ESTIMATES

APPENDIX J: PUBLIC INVOLVEMENT PLAN

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