Henderson Interchange Feasibility Study

HENDERSON INTERCHANGE

CA Group, Inc
CAVIOLA ANSON

in association with

JACOBS

RDV SYSTEMS

HORROCKS ENGINEERS

Ninyo & Moore

Henderson Interchange Feasibility Study
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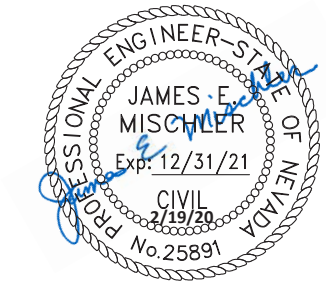

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Abbreviations and Acronyms

AASHTO	American Association of State Highway and Transportation Officials
AWSC	all-way stop controlled
BCA	benefit-cost analysis
CCRFCD	Clark County Regional Flood Control District
CD	collector-distributor
CE	Categorical Exclusion
CFR	code of federal regulations
CFS	cubic feet per second
DC	direct connect
DDI	diverging diamond interchange
EA	Environmental Assessment
EB	eastbound
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Map
HCM	Highway Capacity Manual
HOV	high-occupancy vehicle
I-11	Interstate 11
I-215	Interstate 215
I-515	Interstate 515
ITS	intelligent transportation system
LOMR	Letter of Map Revision
LOS	level-of-service
MOE	measure of effectiveness
mph	miles per hour
MSE	mechanically stabilized embankment
M-VMT	million vehicle miles traveled
N/A	not applicable
NB	northbound
NDOT	Nevada Department of Transportation
NEPA	National Environmental Policy Act
PEL	Planning and Environmental Linkages
Project	Henderson Interchange I-215/I-515/I-11 reconstruction project
RTC	Regional Transportation Commission of Southern Nevada
RTP	Regional Transportation Plan
RTIP	Regional Transportation Improvement Plan
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SB	southbound
SFHA	Special Flood Hazard Area
SNTS	Southern Nevada Traffic Study, NDOT
SPUI	single-point urban interchange
TDM	Traffic Demand Management
TSM	Transportation System Management
VA	value analysis
v/c	volume-to-capacity ratio
VHT	vehicle hours traveled
VMT	vehicle miles traveled
vph	vehicles per hour
WB	westbound
YOE	year of expenditure

Table of Contents

List of Tables

List of Figures

Appendices

1.0 Introduction

The Henderson Interchange connects I-515 from the north, I-215 from the west, I-11 from the south, and Lake Mead Parkway (SR-564) from the east. Each of the four routes begin or end at the interchange.

This Henderson Interchange Feasibility Study is prepared based on the Federal Highway Administration's (FHWA) guidance for Planning and Environmental Linkages (PEL) so that the study can be used as the basis for subsequent project development under the National Environmental Policy Act of 1969 (NEPA) and its implementing regulations, as contained in 23 Code of Federal Regulations (CFR) and 40 CFR. These regulations require that the NEPA process rigorously explores and objectively evaluates all reasonable alternatives to the proposed action. Reasonable alternatives are those that are practical or feasible from a technical and economic standpoint, achieve the purpose and need for the project, and do not create unacceptable environmental impacts when compared to other alternatives. This document summarizes the full range of ideas for transportation improvements considered for the study and the process used to identify and screen the ideas and to combine them into reasonable alternatives for further consideration.

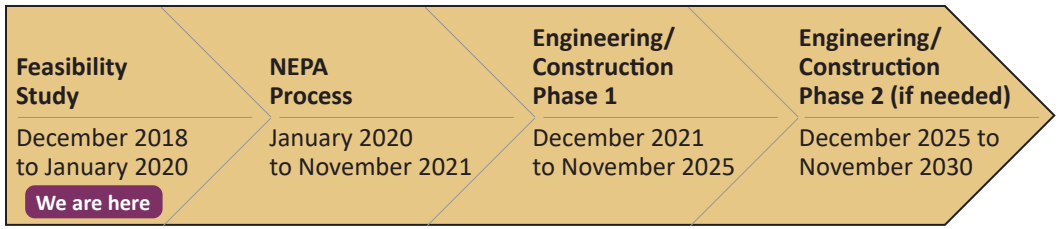


Figure 1. Schedule

After definition of the project's purpose and need, three levels of alternatives development and screening took take place during this feasibility study. Level 1 is an evaluation to eliminate ideas and alternatives that have fatal flaws. Level 2 is a comparative screening of ideas and alternatives based primarily on qualitative criteria to identify and rank ideas and alternatives that could satisfy the purpose and need. Level 3 is a detailed screening and refinement of alternatives to ascertain which alternative or alternatives best meet the purpose and need for the project.

This report includes additional detailed information about the alternatives development and evaluation process. It describes how alternatives were identified and how they were evaluated on their ability to meet the purpose and need for the project, their environmental impact, and their practicality. It also describes how ideas were combined to create build alternatives recommended for further evaluation in Level 3 detailed screening, and further refinement of alternatives for advancement to the NEPA process.

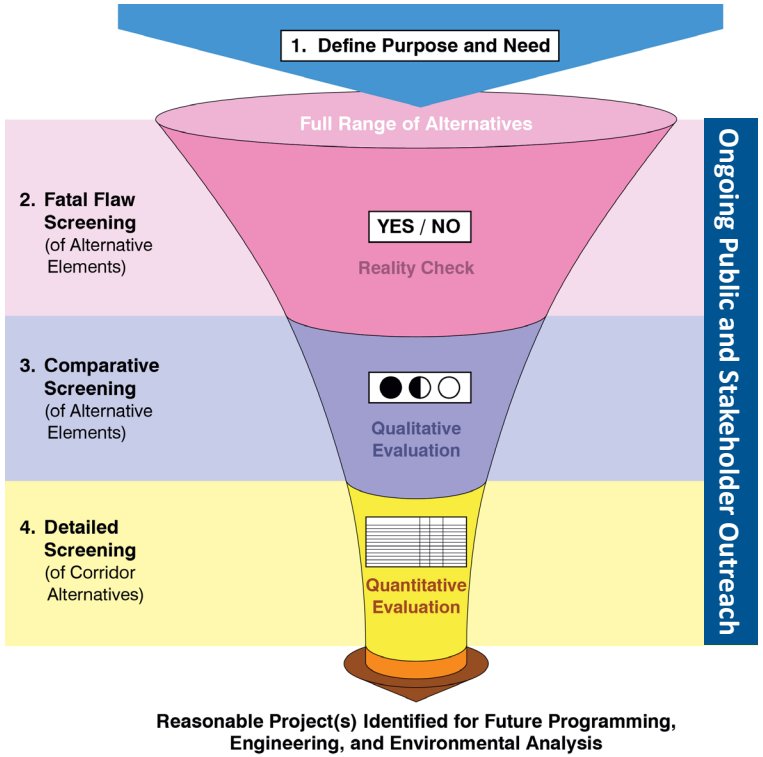


Figure 2. Alternatives Screening Process

1.1 Study Area and Logical Termini

This feasibility study covers an area between Galleria Drive (northern terminus) and Horizon Drive (southern terminus), and along Lake Mead Parkway and Interstate 215 (I-215) between Van Wagenen Street (eastern terminus) and Valle Verde Drive (western terminus).

These logical termini allow for development of a project that can be constructed alone, serving a significant purpose, addressing environmental impacts on a sufficient scale, without requiring implementation of other future projects or restricting consideration of other reasonably foreseeable transportation projects.

Figure 3. Henderson Interchange Study Area

1.2 Project Purpose

At the onset of this feasibility study, the transportation needs of the study area were identified and analyzed. From this effort, a purpose and need statement was developed and included in **Appendix 3**. The purpose and need statement will be refined following this feasibility study as the project is further developed through the NEPA process. Project needs are further discussed in **Section 2.2**.

The purpose of the proposed project is to:

Resolve existing roadway deficiencies, such as weaving and congestion areas pictured in **Figure 4** and areas of higher accident frequency and severity.

Figure 4. Existing Roadway Deficiencies

- Provide transportation improvements to serve existing and future growth areas to meet anticipated growth of the Las Vegas area, as forecast by RTC in **Figure 5**.

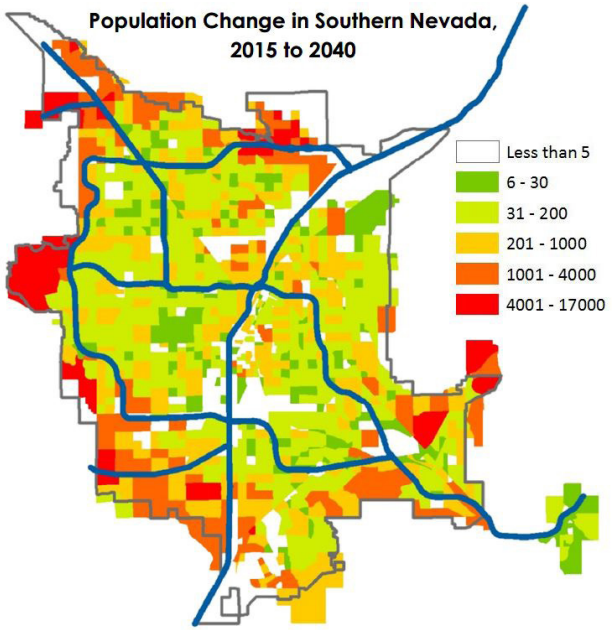


Figure 5. RTC's Anticipated Las Vegas Growth Forecast

- Restore local traffic connectivity such as access from Lake Mead Parkway to Gibson Road, as pictured below.

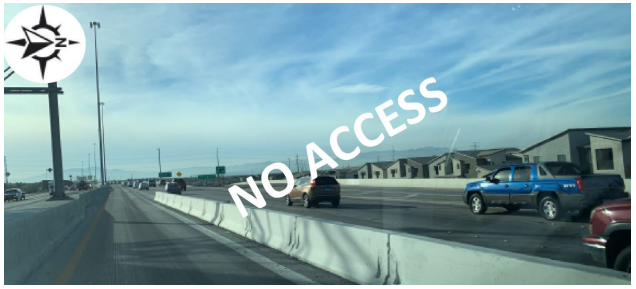


Figure 6. Lack of Lake Mead Parkway Access to Gibson Road

- Accommodate regional and local plans including future high-occupancy vehicle (HOV) lanes and a future Interstate 11.

Figure 7. Crash Locations

1.3 Study Process

As described in the Alternatives Selection Report in **Appendix 3**, the study team held a workshop that yielded 36 ideas. Four were found to have fatal flaws, three new ideas were generated, and the resulting 37 feasible ideas were evaluated and scored against evaluation criteria. Sixteen recommended ideas were bundled into three build alternatives for further analysis.

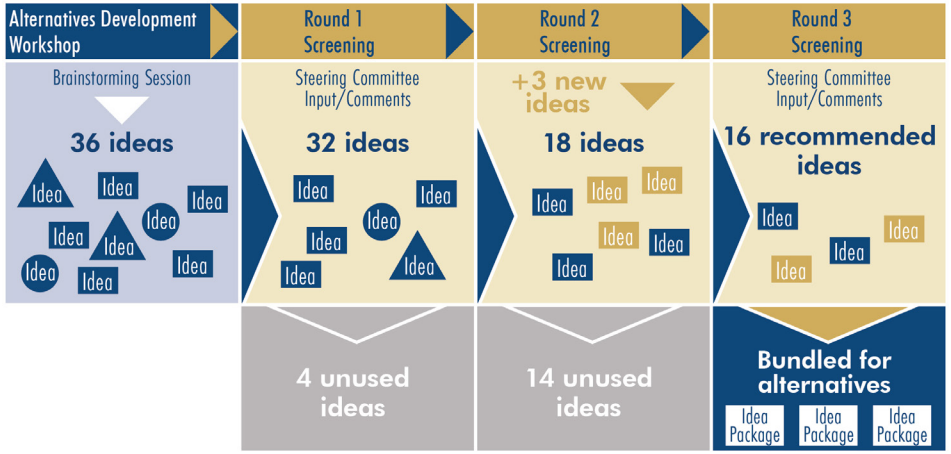


Figure 8. Alternatives Selection Process

Figure 9. Evaluation Criteria

Further qualitative and quantitative analyses based on ranking criteria and the degree to which each alternative met the purpose and need for the project were then used by the study team to arrive at two build alternatives, Build Option 1 and Build Option 2 for further consideration.

1.4 Linking Planning and NEPA

The project purpose, need, and objectives were developed with stakeholder input and serve as a foundation for future action on the recommended alternatives. This is the initial step in linking the Planning and the NEPA processes. The objective is that the planning process and the environmental analysis required during the project development process through NEPA documentation work in tandem, with the results of the transportation planning process feeding into the NEPA process. See **Figure 10** showing the different steps involved in the planning process and how it is linked with NEPA.

Reasons for linking the Planning and NEPA processes include:

- Long-range planning develops the purpose and need and foundation for alternatives analysis. Both are required by NEPA.
- Process provides clarity for public input in framing purpose and need/criteria for local agencies, planning partners, and general public.
- Eliminates duplication of planning and NEPA processes by using environmental data acceptable in the NEPA process, documents decisions and processes, and engages agencies early.
- Develops a process for meeting the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) requirements for the planning process.
- Encourages environmental stewardship.
- Identifies fatal flaws early, improves project delivery, and improves transportation management's regional planning project-oriented process.

Identification of the Preferred Alternative will occur during the NEPA phase of the project and the responsibility for this task rests with the agencies with jurisdiction, including FHWA, NDOT, and the City of Henderson. The final authority to select the Preferred Alternative is the responsibility of FHWA and will occur with the approval of the NEPA decision document.

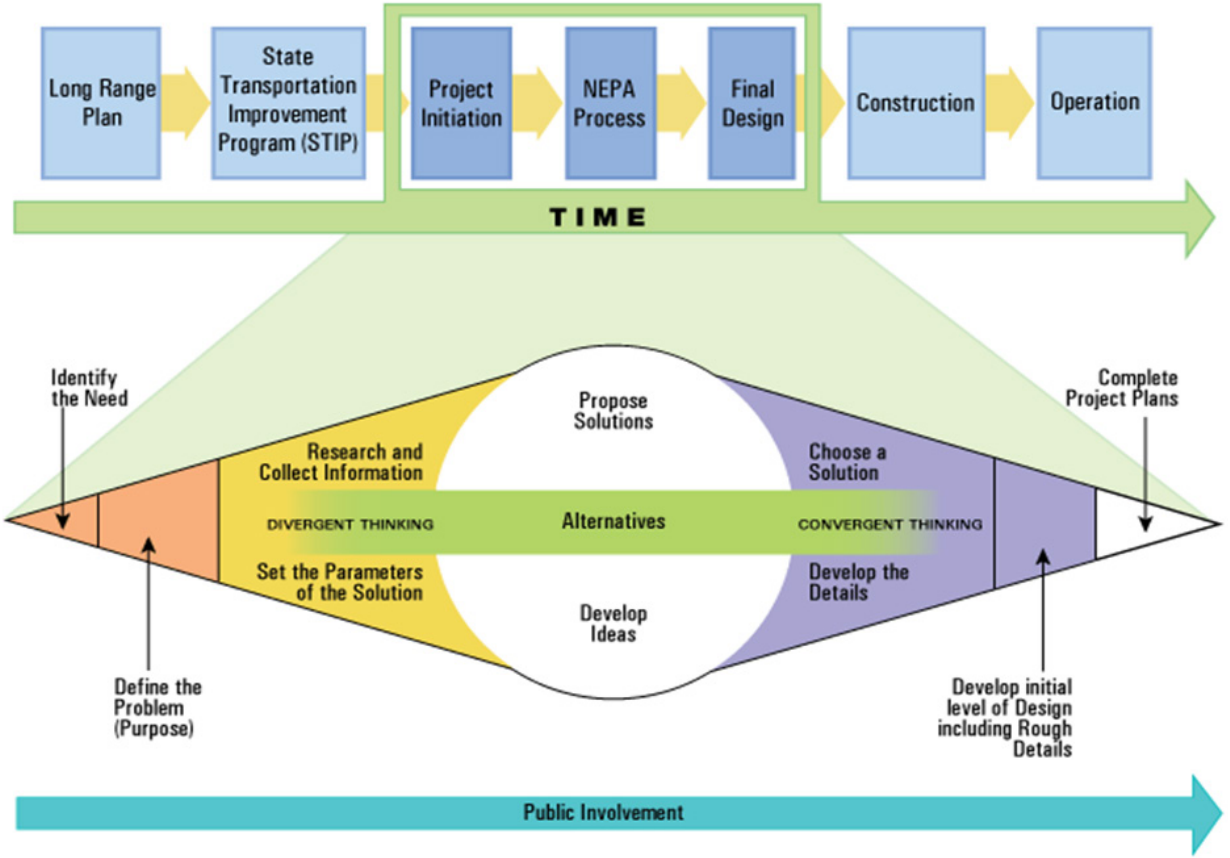


Figure 10. Link Between Planning and NEPA

2.0 Existing Conditions

2.1 Demographic Conditions and Travel Demand

According to RTC, Southern Nevada is home to more than two million residents and hosts more than 42 million visitors each year. The region continues to experience rapid growth in population and tourism that can strain the transportation system and make travel for residents and visitors more difficult.

This study developed and calibrated a "subarea" traffic model within the Southern Nevada Aimsun Next model, originally developed by the Nevada Department of Transportation's (NDOT) Southern Nevada Traffic Study (SNTS). The calibrated subarea model was then used to develop year 2040 traffic forecasts needed for future conditions analyses. NDOT developed the SNTS Aimsun Next traffic model based on socioeconomic and land use assumptions in the Access 2040 Regional Transportation Plan adopted by the Regional Transportation Commission of Southern Nevada (RTC) on February 9, 2017. No separate analysis of demographic conditions or travel demand was made as part of this feasibility study. As described in the Traffic Forecasting Memorandum contained in **Appendix 1**, extensive calibration work was undertaken by the study team to calibrate the excerpted Aimsun Next model to match observed year 2017 traffic operations. The calibrated model was then used to forecast year 2040 no-build and build alternative traffic operations performance.

A summary of traffic operations performance for the no-build, build Option 1, and build Option 2 configurations is provided in **Section 4.3**.

2.2 Existing Roadway Conditions

The Henderson Interchange exists as a directional system interchange with one low-volume movement carried as a low-speed loop ramp. Right-of-way limits at the interchange vary. The posted speed limits are 65 mph on I-515, I-215, and I-11; and 45 mph on Lake Mead Parkway. The functional classifications of roadways within the study corridor are:

- Interstate Highway for I-515, I-215, and I-11
- Principal Arterial for Lake Mead Parkway
- Minor Arterial for Sunset Road and Stephanie Street
- Minor Collector for Galleria Drive, Auto Show Drive, Horizon Drive, Gibson Road, and Valle Verde Drive

Interstate Highways

I-515, I-215, and I-11 are six-lane divided freeways. Lane widths are 12 feet and the shoulder widths vary from one foot to ten feet within the study area. I-11 has a service interchange within the study area at Horizon Drive. I-515 has service interchanges within the study area at Auto Show Drive, Sunset Road and Galleria Drive. I-215 has service interchanges within the study area at Valle Verde Drive, Stephanie Street and Gibson Road. I-215 begins at I-515 and the eastern extension from I-215 is State Route (SR) 564, Lake Mead Parkway. I-515 ends at I-215 and the southern extension from I-515 is I-11.

Local Roadways

Service interchange configurations within the study area include:

- I-11/Horizon Drive – Diverging diamond
- I-515/Auto Show Drive – Tight diamond
- I-515/Sunset Road – Diamond
- I-515/Galleria Drive – Tight diamond with southern ramps braided with northern ramps for Sunset Road
- I-215/Gibson Road – Diamond
- I-215/Stephanie Street – Diamond
- I-215/Valle Verde Drive – Diverging diamond

Signalized intersections within the study area are located at:

- All service interchange ramp termini
- Lake Mead Parkway intersection with Eastgate Road/Fiesta Henderson Boulevard
- Lake Mead Parkway intersection with Van Wagenen Street

Transit

RTC operates three bus routes within the study area, shown in **Figure 11**, on the following page. Existing bus stops would be maintained by the project.

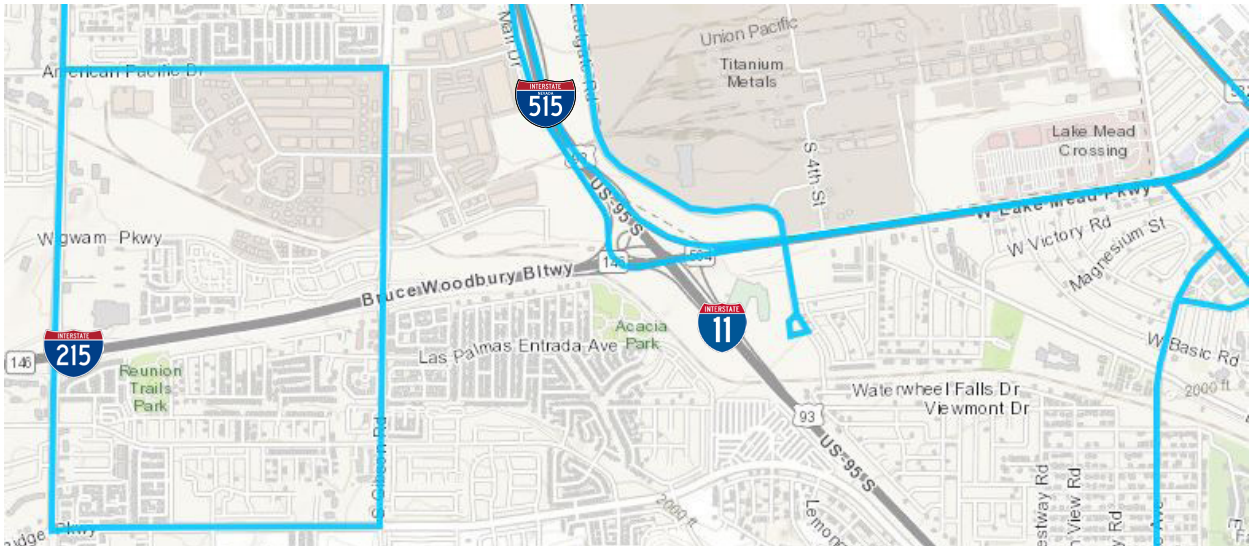


Figure 11. Transit Routes within Study Area

Route HDX provides express bus service between Henderson and downtown Las Vegas with a route along Lake Mead Parkway east of I-515 and on I-515 north of Lake Mead Parkway. The route includes a loop to a park and ride lot on Fiesta Henderson Boulevard south of Lake Mead Parkway.

Route 217 provides regular service along Lake Mead Parkway east of Eastgate Road and on Eastgate Road north of Lake Mead Parkway.

Route 115 provides regular service in a loop that circulates on Stephanie Street, Horizon Ridge Parkway, Gibson Road and American Pacific Drive.

Pedestrian and Bicycle Facilities

Existing pedestrian and bicycle facilities include sidewalks on both sides of Lake Mead Parkway, a combined path serving bicycles and pedestrians on the north side of Lake Mead Parkway, and a combined path along the south side of I-215 west of Acacia Park.

Pedestrian and bicycle facilities along Lake Mead Parkway terminate on the south side at the Fiesta Henderson Hotel/Casino, and on the north side at a dead end prior to the central interchange area. These facilities would be maintained or reconstructed in-kind by this project.

The combined path along the south side of I-215 is within NDOT right-of-way and connects through Acacia Park to the UPRR trail that leads to the Lake Mead Recreational Area. This path would be maintained or reconstructed in-kind by this project.

Traffic Operations

The existing conditions Aimsun Next model was developed to calibrate the traffic model to the year 2017 field traffic conditions. A calibrated model is necessary to evaluate future improvement alternatives. At the start of the traffic modeling (early 2019), NDOT was constructing changes to the system interchange (I-515/I-215 interim improvements restriping project). The most recent dataset available to calibrate the model (not influenced by construction) was from the year 2017 as available from the precursor SNTS. Therefore, the existing year traffic operations observations, as available from the calibrated Aimsun model, is from the year 2017. The following are the specific areas of the existing conditions (the year 2017) transportation network where deficient traffic operations were observed:

- The I-215 eastbound to I-11 southbound interchange ramp merges from two lanes to one lane and then joins the I-11 southbound mainline. This lane reduction and ramp-merge, insufficient capacity, results in upstream queues (on the ramp itself and upstream, along I-215 eastbound) during peak periods of traffic.
- The weaving movement along I-215 eastbound, between the Gibson Road on-ramp and the I-515/I-11 interchange ramps, results in congestion and queues. This weaving movement impacts the traffic that can reach and be served by the I-515/I-11 interchange ramps. Under existing conditions, the I-215 eastbound section between Gibson Road and the I-515/I-11 system ramps, experiences speeds as low as 50 mph and 40 mph during critical 15-minute peak periods of travel within the AM and the PM periods respectively. The weaving distance and associated weaving capacity and system ramp capacity are insufficient.

- The I-215 eastbound system ramp merges on to I-515 northbound, followed by the northbound Auto Show Drive on-ramp merging on to the freeway. These ramp merges occur within about 0.25 of a mile, and neither of these ramps includes an auxiliary lane or a parallel acceleration lane. These successive (closely spaced) merges result in a slowdown (to approximately 50 mph) along the freeway. This slowdown also results in upstream queues on the system ramp.
- Occasionally, southbound I-11 traffic exiting to Horizon Drive experiences queuing, resulting from deficiencies along Horizon Drive (at the Horizon Drive Interchange); these queues extend onto the mainline. When this queue spillback occurs, freeway speeds as low as approximately 30 mph in the PM peak period were observed along I-11 southbound just upstream of the Horizon Drive off-ramp. The Horizon Drive Interchange has poor operations resulting in queue spillback to I-11 southbound.
- The southbound I-515 to westbound I-215 system-to-system ramp experiences significant congestion and queuing. Long queues occur on southbound I-515 and block the southbound on-ramp from Auto Show. There is insufficient capacity on the system ramp.

Freeway and ramp traffic operational results (density, speed, flow, demand volume) from the Aimsun Next model for the existing conditions (the year 2017) for the two-hour AM (7:00 – 9:00 AM) and PM (4:00 – 6:00 PM) modeling periods are included in **Appendix 1**.

As noted earlier, NDOT constructed interim improvements at the system interchange in the year 2019. NDOT's I-515/I-215 Restriping Project provided two-lanes for the southbound I-515 to westbound I-215 movement increasing its capacity. Additionally, a second lane was provided for most of the length of the eastbound I-215 to northbound I-515 system ramp (moving the location of the merge to a single lane away from the existing weave section). Three compromises had to be made to accommodate these improvements:

1. Traffic on southbound Auto Show Drive to I-515 lost access to westbound I-215 and must use alternate routes (Gibson Road and Eastgate/Lake Mead Parkway) to access westbound I-215.
2. Traffic on Lake Mead Parkway can no longer access Gibson Road directly and must use Stephanie Street or Eastgate Road. Delineation and a physical barrier prevent this access to Gibson Road.
3. One lane instead of two lanes serve westbound Lake Mead Parkway traffic as it enters I-215 (one lane was repurposed to serve the southbound to westbound system ramp).

Since 2017, traffic volumes and congestion has worsened, with slower speeds and more queues experienced at all of the locations identified earlier. Additionally, queuing and slow traffic is also observed on:

- The northbound I-11 to westbound I-215 ramp behind the reduction from two to one lane (along the system ramp)
- At the Eastgate intersection on Lake Mead Parkway
- On I-215 (within the Study Area)

2.3 Existing Utilities

The study area contains an extensive amount of utility infrastructure, both above and below ground. This infrastructure consists of every type of utility conveyance found within the Las Vegas valley and services commercial, residential, and government enterprises. It is comprised of both transmission facilities as well as distribution services.

To identify corridor utilities, possible sources were identified to obtain data. The standard suite of agency contacts was assembled, and, through on-line research, past projects and development improvements were identified as possible sources for as-built information. These historical documents were mined for utility infrastructure improvements as well as for the existence of previously installed facilities.

As-built plans received through this effort were reviewed for accuracy (where applicable) and imported into the developing utility base map. Some of the data had to be converted to the common coordinate system so that it was vertically and horizontally positioned for use. In the case of public agencies, data received was depicted on a common map printed from their electronic system and was not from actual as-built drawings. These plans are the typical products issued by the agencies to developers or engineers upon request. As usual for these products, the agencies issue disclaimers directing customers to

field verify these locations prior to any actual design or construction. They do not guarantee the location accuracy of these provided products.

A utility matrix was created along with a CAD base map drawing to encompass the limits of the study area. Known utilities from past projects were incorporated where applicable. An attempt to identify possible utility owners and facilities was undertaken and updated with each new piece of information. Known existing utilities and potential impacts from build alternatives are summarized in **Appendix 4**.

2.4 Existing Drainage Facilities

The proposed improvements to the I-215/Lake Mead Parkway, I-515/I-11 and the Henderson Interchange will result in additional travel lanes, changes in shoulder width, relocation of existing shoulder and barrier rail, new HOV lanes and realignment of on- and off-ramps and flyovers. These improvements will require modifications to existing drainage facilities along the project corridor.

These drainage facilities include Clark County Regional Flood Control District (CCRFCD) Master Plan facilities, onsite and local facilities. The general impact to drainage facilities includes relocation of drop inlets and storm drain; extending/shortening storm drain laterals; relocating storm drain systems and channels.

The facilities and impacts to them from build alternatives are summarized in **Appendix 16**.

The project is located on Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) panels 2595, 2583 and 2615. The panels show that the majority of the project lies within Zone X defined by FEMA as areas determined to be outside the 0.2% annual change floodplain. The project from Auto Show Drive to Galleria Drive lies within Shaded Zone X, defined by FEMA as areas of 0.2% annual change flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

Portions of the project lie within a Special Flood Hazard Area (SFHA). SFHA are defined as the area that will be inundated by the base flood event having a 1% chance of being equaled or exceeded in any given year. Zone A is a SFHA for which no base flood elevations have been determined. Zone A lies within the following locations:

- Crossing I-215 west of Stephanie Street, contained in storm drain (CCRFCD facility PTMR 0050)
- Crossing I-215 east of Stephanie Street, contained in culvert (CCRFCD facility PTST 0051)
- Crossing I-215 west of Gibson Road, contained in storm drain (CCRFCD facility PTRE 0174)
- Crossing I-215 east of Gibson Road, contained in structure (CCRFCD facility PTHR 0049)
- Crossing I-11 south of the Henderson Interchange and Lake Mead Parkway east of the Henderson Interchange
- Along the north side of Lake Mead Parkway from the Henderson Interchange to beyond Eastgate Road, contained in structure
- Along the east side of I-515 from the Henderson Interchange to Auto Show Drive
- Crossing the I-515 at the UPRR Henderson Spur north of the Henderson Interchange, contained within channel (CCRFCD facility PTHR 0000)

It will be required to demonstrate that project improvements do not cause any adverse drainage impacts within these areas. The FIRM panels and Letters of Map Revision (LOMR) for this project are included in **Appendix 15**, FEMA Floodplain Documentation.

2.5 Previous Studies

The SNTS was published by NDOT in October 2018. The study included alternatives for improvements to the southern Nevada transportation network including I-215, I-515, and the Henderson Interchange. Alternatives presented in the SNTS for the system to system interchange are incorporated into ideas and alternatives considered for the current feasibility study. An SNTS alternative for ramp braiding along I-215 west of Stephanie Street is not considered in this study because it has not been adopted or programmed for development by a government entity. An SNTS alternative for auxiliary lanes on I-515 between Auto Show Drive and Sunset Road is included in this study.

The Southern Nevada HOV Plan was published by NDOT in July 2015 with an Addendum published in 2018. The plan calls for construction of a single median HOV lane in each direction on I-215 west of the Henderson Interchange and on I-515 north of the Henderson Interchange. Alternatives developed for this feasibility study include accommodation for future construction of HOV lanes. Where necessary and appropriate to avoid future re-work, alternatives developed for this feasibility study include portions of the HOV facility that would be constructed in advance of the HOV lanes, including bridges, retaining walls, grading, and drainage.

This study considers the potential siting of an I-11 corridor within the Las Vegas Valley. I-11 has been designated as a corridor from the Mexican border near Nogales, Arizona to the Canadian border. Planning is underway for the segment from Nogales to Reno, Nevada, and the I-11 corridor within Nevada is anticipated to be selected upon completion of the Tier 1 Environmental Impact Statement for I-11 in early 2022. While the segment of highway within Nevada between Hoover Dam and the Henderson Interchange has been designated as I-11 with signs installed along the highway, it is possible that the results of the I-11 planning efforts could lead to a different route being used. It is also possible that the route for I-11 may include portions of I-215 and/or I-515, as well as the current signed segment of I-11.

Traffic Demand Management (TDM) and Transportation System Management (TSM) alternatives are not considered as part of this study. They will be evaluated during the NEPA phase.

3.0 Future Conditions and Facilities

3.1 Demographic Forecasts

According to RTC, the population of Clark County is expected to grow from 2.3 million in 2020 to 2.9 million in the study horizon year of 2040. City of Henderson population is projected to grow from 320,000 in 2020 to 427,000 in 2040, a one-third increase.

3.2 2040 Regional Transportation Plan

Forecasts for this study are based on the Aimsun Next traffic model that was developed for the SNTS, which in turn was based on the Access 2040 Regional Transportation Plan for Southern Nevada 2017-2040 prepared by RTC.

3.3 Year 2040 Traffic Volume Forecasts

The calibrated existing conditions Aimsun Next model was used to develop the peak hour volume forecasts for the following forecast scenarios:

- Future Year 2040 No-Action Alternative
- Future Year 2040 Build Alternatives (Two options)

Within this Project's limits, the year 2040 No-Action Alternative network included the changes introduced as part of the I-515/I-215 Restriping Project. NDOT implemented the I-515/I-215 Restriping Project during the years 2018 and 2019; therefore, these changes were not part of the existing conditions year 2017 network. The schematics for the two Build Alternative options that were modeled are included in **Appendix 1**.

The assumptions and methodology used in developing the year 2040 peak hour volumes and the forecast peak hour volumes for the No-Action Alternative and the Build Alternatives (two options) are documented in the Traffic Forecasting Memorandum in **Appendix 1**.

3.4 Year 2040 No-Action Alternative – Traffic Operations

In addition to the deficiencies observed with the existing conditions, by the year 2040, the demand for the I-215 eastbound system ramp to I-515 northbound significantly exceeds the available capacity.

- In the year 2040 PM peak hour, a demand of more than 3,400 vehicles is projected along this existing one-lane ramp. This bottleneck is expected to result in extensive upstream queuing and congestion along I-215 eastbound.
- This bottleneck results in queues that spillback onto the weaving section along I-215 eastbound, between the Gibson Road on-ramp and the I-515/I-11 interchange ramps. The interaction between these two bottlenecks results in severe queuing and congestion.
- With the year 2040 No-Action Alternative, the I-215 eastbound section between Gibson Road and the I-515/I-11 system ramps is expected to experience speeds as low as 20 mph in the PM peak period.
- The impacts of this bottleneck and other adjacent upstream bottlenecks are expected to result in queues that extend for several miles upstream along I-215 eastbound.

Similarly, the year 2040 traffic demands exceed the existing capacity for some of the other system-to-system ramp movements between the I-215, I-515, and I-11 freeways.

- The I-215 eastbound system ramp to I-11 southbound is expected to have a year 2040 demand of approximately 3,000 vehicles per hour (vph) in the PM peak period. This demand significantly exceeds the available capacity of the existing one-lane ramp.
- The I-11 northbound system ramp to I-215 westbound and the I-515 southbound system ramp to I-215 westbound are expected to have a year 2040 demand of more than 2,000 vph. These demands exceed the available capacity of these existing one-lane ramps.
- Significant congestion and queuing are expected near the Henderson Interchange due to these ramps being overcapacity.
- Capacity improvements to the system interchange are needed to meet the projected year 2040 demand.

In the No-Action Alternative, westbound Lake Mead Parkway drops from two lanes to one lane at the Henderson Interchange. This reduction in the number of lanes results in upstream queues that may extend to the Lake Mead

Parkway/Eastgate Road intersection. This bottleneck severely limits the number of vehicles that can travel west of here and along I-215 westbound.

Along I-515 southbound, with the No-Action Alternative, the Galleria Drive on-ramp and the Sunset Road on-ramp merge successively within about 0.25 of a mile, and neither of these ramps includes an auxiliary lane or a parallel acceleration lane. Downstream of here, there are two closely spaced off-ramps to Auto Show Drive and I-215/Lake Mead Parkway. The interaction of these ramps, together with an increase in volumes by the year 2040, result in severe congestion along the freeway. The speeds along the freeway slow down to approximately 10 mph during certain critical 15-minute peak periods of travel within the PM period.

The year 2040 traffic demands at the Lake Mead Parkway/Eastgate Road intersection are expected to be significantly higher than the available capacity. This is expected to result in severe congestion and queuing at this intersection that prevents/delays vehicles in traveling through this intersection to the other parts of the network.

The I-11 northbound Horizon Drive on-ramp is forecast to have a demand of more than 2,000 vph in the AM peak hour. Under the No-Action Alternative, this is a one-lane ramp, and it has a short acceleration lane on the freeway. This results in excessive queuing upstream past the ramp terminal intersection and along Horizon Drive.

Freeway and ramp traffic operational results (density, speed, flow, demand volume) from the Aimsun Next model for the year 2040 No-Action Alternative for the two-hour AM (7:00 – 9:00 AM) and PM (4:00 – 6:00 PM) modeling periods are included in **Appendix 1**.

3.5 Year 2040 Build Option 1 – Traffic Operations

Traffic operations analysis and modeling were completed iteratively and in coordination with the design team to ensure that the proposed Build Option 1 provides a satisfactory level of operations (better than the No-Action Alternative) for the design year of 2040.

- With Build Option 1, the system ramps at the Henderson Interchange have sufficient capacity to handle the projected year 2040 demand. However, it is noted that the I-215 eastbound system ramp to I-515 northbound will likely be near or at capacity by the year 2040. With Build Option 1, this ramp has three lanes that drop down to two lanes that merge onto I-515 northbound.
- Build Option 1 includes braiding of the Gibson Road ramps along I-215 and the system interchange ramps. This significantly improves the operations along I-215 eastbound and westbound near the Henderson Interchange. Freeway speeds of approximately 60 mph or greater are expected along I-215 near the Henderson Interchange in both the AM and the PM peak periods. However, a segment leading into the interchange, on eastbound I-215, is near capacity by the year 2040.
- Build Option 1 also includes two lanes for westbound Lake Mead Parkway at the Henderson Interchange. This alleviates queuing upstream of here, expected with the No-Action Alternative.
- Along I-515 southbound, Build Option 1 includes auxiliary lanes for the Galleria Drive on-ramp and the Sunset Road on-ramp. The additional capacity on the freeway results in better operations and the freeway speeds are expected to be approximately 60 mph or greater in both the AM and the PM peak periods.
- Build Option 1 includes several improvements to the Lake Mead Parkway/Eastgate Road intersection. These improvements greatly alleviate the congestion issues at this intersection and adequately process the traffic to the rest of the network. However, it is noted that this intersection will likely be near or at capacity by the year 2040. Furthermore, accommodation of a pedestrian crosswalk, at-grade, across the widened Lake Mead Parkway could be of concern due to the length of the crossing and the extent of exposure to vehicles.
- Build Option 1 proposes to improve the I-11 northbound Horizon Drive on-ramp to be a two-lane ramp, with the I-11 northbound section between Horizon Drive and the Henderson Interchange proposed to be improved to a five-lane section. This results in better operations for the Horizon Drive on-ramp, with all the demand processed through the ramp, onto the freeway.

Freeway and ramp traffic operational results (density, speed, flow, demand volume) from the Aimsun Next model for the year 2040 Build Option (Option 1) for the two-hour AM (7:00 – 9:00 AM) and PM (4:00 – 6:00 PM) modeling periods are included in **Appendix 1**.

3.6 Year 2040 Build Option 2 – Traffic Operations

Traffic operations analysis and modeling were completed iteratively and in coordination with the design team to ensure that the proposed Build Option 2 provides a satisfactory level of operations (better than the No-Action Alternative).

- With Build Option 2, the system ramps at the Henderson Interchange have sufficient capacity to handle the projected year 2040 demand.
- Build Option 2 includes braiding of the Gibson Road ramps along I-215 and the system interchange ramps. This significantly improves the operations along I-215 eastbound and westbound near the Henderson Interchange. Freeway speeds of approximately 60 mph or greater are expected along I-215 near the Henderson Interchange in both the AM and the PM peak periods.
- Build Option 2 also includes two lanes for westbound Lake Mead Parkway at the Henderson Interchange. This alleviates the queuing upstream of here, expected with the No-Action Alternative.
- Along I-515 southbound, Build Option 2 includes auxiliary lanes for the Galleria Drive on-ramp and the Sunset Road on-ramp. The additional capacity on the freeway results in better operations and the freeway speeds are expected to be approximately 60 mph or greater in both the AM and the PM peak periods.
- Build Option 2 includes several improvements to the Lake Mead Parkway/ Eastgate Road intersection (identical to Build Option 1). These improvements greatly alleviate the congestion issues at this intersection and adequately process the traffic to the rest of the network. However, it is noted that this intersection will likely be near or at capacity by the year 2040. Additionally, as noted previously for Build Option 1, accommodation of a pedestrian crosswalk, at-grade, across the widened Lake Mead Parkway could be of concern due to the length of the crossing and exposure to vehicles.
- Build Option 2 proposes to improve the I-11 northbound Horizon Drive on-ramp to be a two-lane ramp, with the I-11 northbound section between Horizon Drive and the Henderson Interchange proposed to be improved to a five-lane section. This results in better operations for the Horizon Drive on-ramp, with all the demand processed through the ramp, onto the freeway.

Freeway and ramp traffic operational results (density, speed, flow, demand volume) from the Aimsun Next model for the year 2040 Build Option (Option 2) for the two-hour AM (7:00 – 9:00 AM) and PM (4:00 – 6:00 PM) modeling periods are included in **Appendix 1**.

3.7 Comparison of Alternatives Based on Traffic Model Results

Network/sub-area wide Measures of Effectiveness (MOE) were determined and evaluated from the Aimsun Next model for the modeled alternatives. The following is a brief description of some of the key MOE:

- **Latent Vehicles**: The number of vehicles that are expected to be processed in the traffic simulation but are not simulated because of the limited physical capacity of the roadway network to process vehicles. The vehicles are outside of the model, not always because the entire system is saturated. Bottleneck locations near the boundaries of the model do not allow vehicles to proceed, and in the absence of alternative routes, vehicles are backed up outside the model perimeter and unable to enter the network. If the bottleneck conditions are removed, the volume of the latent vehicles may see a significant reduction.

  Example: Consider a water distribution system where all the pipes are full, but there is still water in the reservoir trying to get into the pipe network for a given time. The water that is unable to enter due to inadequate capacity (and no alternate pipe available to satisfy the demand) is the latent demand (or latent vehicles for the roadway network).
- **Latent Delay Time**: The amount of time latent vehicles must wait to enter the network. In our water distribution system example, this would be how long the water in the reservoir would wait before entering the pipe system.

- **Total Network Delay**: This measures the amount of time each vehicle is delayed in the simulation and sums them all into a single delay time. The better the network operates, the lower the total network delay.
- **Average Network Delay**: This measures the average delay experienced by every vehicle in the simulation. The better the network operates, the lower the average network delay.

Appendix 1 includes a comparison of the network/sub-area MOE for the two-hour AM (7:00 – 9:00 AM) and PM (4:00 – 6:00 PM) modeling periods for the modeled alternatives (including the year 2040 No-Action Alternative and the Build Options).

Table 1 shows a summary comparison of the key MOE. From **Table 1** and **Appendix 1**, it can be seen that the No-Action Alternative is significantly worse than the existing conditions. Both the Build Options 1 and 2 greatly improve the traffic operations compared to the No-Action Alternative. Note that the (>4,000 vehicles) Latent Vehicles observed in the PM peak period for the Build Option are primarily because of bottlenecks along I-215 eastbound west of Stephanie Street. Improving the capacity of this stretch of I-215 eastbound is outside the scope of this project.

From **Table 1** and **Appendix 1**, it can also be seen that both Build Options operate comparably, within the margin of variance that is associated with microsimulation models. Microsimulation models are stochastic or statistical models that result in variance between runs to better match real-world conditions. **Figure 12** also illustrates the similar operation of the Build Option (even though they differ in geometric layout). **Figure 12** compares the two Build Options for one representative MOE (Total Network Delay). **Figure 12** shows the average and the standard deviation in Total Network Delay for both the AM and the PM modeling periods. The difference in operations between Build Option 1 and 2 is statistically insignificant.

3.8 Local Roadway Network Analysis

Synchro Intersection Operations Analysis Methodology

Intersection operation analysis was performed using Synchro 10 for 2040 No-Build and Build Options 1 and 2) scenarios. Traffic operations analysis was performed for both AM and PM peak-hours. The various traffic data were collected from existing topography and Google/Bing Maps and included the following:

- Intersection geometry (number of right/through/left lanes, unsignalized and unsignalized)
- Peak-hour volumes for AM and PM (vehicles, pedestrians and bicycles)
- Existing traffic signal timing (provided by RTC-FAST)
- Roadway segment length
- Percent Trucks and recreational vehicles
- Speed limit

Synchro Modeling and Analysis

Synchro 10 was used to model the project corridor that includes ramp terminal and respective adjacent intersections. Synchro modeling and analysis was performed for 2040 scenarios with 2040 geometry configuration and included the following 15 intersections. The existing traffic signal timings obtained from RTC-FAST were used as basis for analyzing the traffic operations. For each alternative considered, intersection splits were optimized at all signalized intersections. Existing cycle lengths were maintained unless an operation failure called for an improvement.

Level of Service (LOS) is a qualitative measure of traffic operation performance. Grades from A through F are assigned, where similar to grades in school, A is the best and F denotes failure.

The performance measure used to characterize the operation of an intersection is “control delay”. This is the delay that results when a traffic control device, such as a stoplight, causes traffic to reduce speed or stop.

For motorized vehicles at intersections, grades are assigned based on the average delay per vehicle, with grades assigned as follows:

A – less than 10 seconds per vehicle
B – more than 10 and less than 20 seconds per vehicle
C – more than 20 and less than 35 seconds per vehicle
D – more than 35 and less than 55 seconds per vehicle
E – more than 55 and less than 80 seconds per vehicle
F – more than 80 seconds per vehicle

Table 1. Comparison of Network/Sub-Area Wide Measures of Effectiveness

Network Performance AM Peak Period 7:00-9:00 AM

Parameter	2017 Existing Conditions	2040 No-Action Alternative	2040 Build Option 1	2040 Build Option 2	2040 No-Action Alternative vs. 2017 Existing Conditions: Absolute Difference	2040 No-Action Alternative vs. 2017 Existing Conditions: Percent Difference		2040 Build Alternative Option 1 vs. 2040 No-Action Alternative: Absolute Difference	2040 Build Alternative Option 1 vs. 2040 No-Action Alternative: Percent Difference		2040 Build Alternative Option 2 vs. 2040 No-Action Alternative: Absolute Difference	2040 Build Alternative Option 2 vs. 2040 No-Action Alternative: Percent Difference	
Total Traveled Distance (mi)	**181811**	**202409**	**256327**	**253602**	**20599**	**11%**		**53918**	**27%**		**51192**	**25%**	
Total Travel Time (hour)	**3656**	**8372**	**5899**	**5797**	**4716**	**129%**		**2473**	**30%**		**2575**	**31%**	
Latent Vehicles	1	11786	3	3	11786	-	▲	11783	100%	▼	11783	100%	▼
Total Network Vehicles	**56674**	**80171**	**79441**	**79430**	**23497**	**41%**		**730**	**1%**		**741**	**1%**	
Latent Delay Time (hour)	0	2408	0	0	2408	-	▲	2408	100%	▼	2408	100%	▼
Total Network Delay (hour)	**1522**	**7712**	**3299**	**3232**	**6190**	**407%**	▲	**4413**	**57%**	▼	**4480**	**58%**	▼
Average Network Delay (seconds/vehicle)	**97**	**346**	**150**	**146**	**250**	**258%**	▲	**197**	**57%**	▼	**200**	**58%**	▼

Network Performance PM Peak Period 4:00-6:00 PM

Parameter	2017 Existing Conditions	2040 No-Action Alternative	2040 Build Option 1	2040 Build Option 2	2040 No-Action Alternative vs. 2017 Existing Conditions: Absolute Difference	2040 No-Action Alternative vs. 2017 Existing Conditions: Percent Difference		2040 Build Alternative Option 1 vs. 2040 No-Action Alternative: Absolute Difference	2040 Build Alternative Option 1 vs. 2040 No-Action Alternative: Percent Difference		2040 Build Alternative Option 2 vs. 2040 No-Action Alternative: Absolute Difference	2040 Build Alternative Option 2 vs. 2040 No-Action Alternative: Percent Difference	
Total Traveled Distance (mi)	**206663**	**195651**	**257959**	**249876**	**11012**	**5%**		**62308**	**32%**		**54225**	**28%**	
Total Travel Time (hour)	**4926**	**8636**	**7206**	**6957**	**3710**	**75%**		**1431**	**17%**		**1680**	**19%**	
Latent Vehicles	2	18220	4200	5504	18219	-	▲	14020	77%	▼	12716	70%	▼
Total Network Vehicles	**67499**	**90522**	**89521**	**89556**	**23023**	**34%**		**1001**	**1%**		**966**	**1%**	
Latent Delay Time (hour)	0	3981	752	1066	3981	-	▲	3229	81%	▼	2915	73%	▼
Total Network Delay (hour)	**2445**	**10002**	**6320**	**6607**	**7557**	**309%**	▲	**3682**	**37%**	▼	**3395**	**34%**	▼
Average Network Delay (seconds/vehicle)	**130**	**398**	**254**	**266**	**267**	**205%**	▲	**144**	**36%**	▼	**132**	**33%**	▼

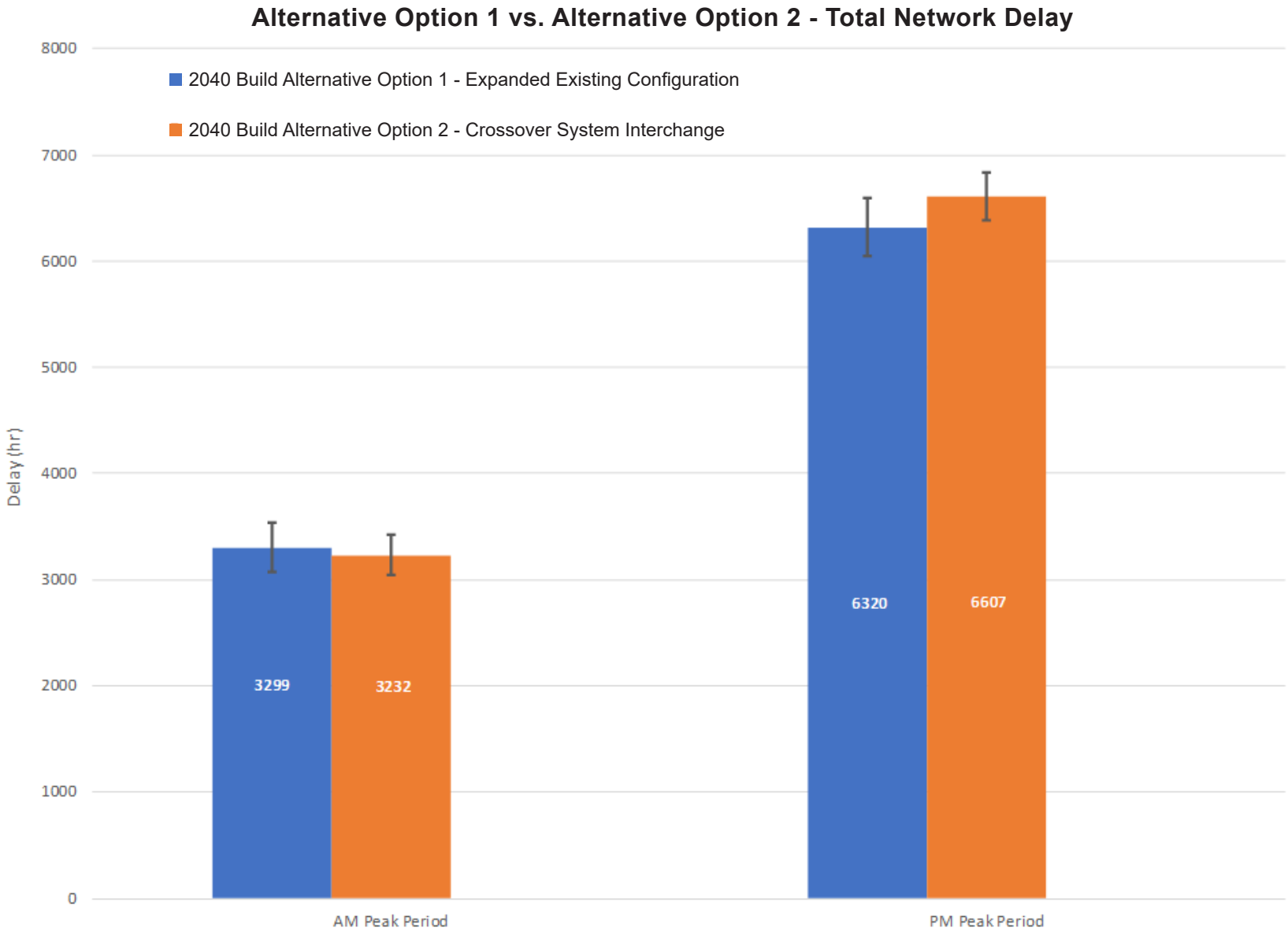


Figure 12. Comparison of Total Network Delay

Intersection performance results including intersection-wide delay (seconds/vehicle), approach delay and LOS for signalized and unsignalized intersections were extracted for the following intersections:

- I-515 SB/Sunset Road
- I-515 NB/Sunset Road
- Gibson Road/Auto Show Drive
- I-515 SB/Auto Show Drive
- I-515 NB/Auto Show Drive
- Eastgate Road/Auto Show Drive
- I-11 SB/Horizon Drive
- I-11 NB/Horizon Drive
- Stephanie Street/I-215 WB
- Stephanie Street/I-215 EB
- Gibson Road/Wigwam Parkway
- Gibson Road/I-215 WB
- Gibson Road/I-215 EB
- Gibson Road/Las Palmas Entrada Avenue
- Eastgate Road/Lake Mead Boulevard

Each of the project intersections are signalized except at Eastgate Road and Auto Show Drive, which is all-way stop controlled. Minor adjustments to splits were performed in order to achieve optimum LOS. Traffic operations from the 2040 No-Action alternative were used as the basis for evaluating the two Build alternatives, 2040 Build Option 1 and 2040 Build Option 2.

As part of the SNTS project, existing volumes were collected at all of the project intersections. The intersection approach volumes were collected from Aimsun Next models for 2040 No-Action, and the two 2040 Build Alternatives. The Aimsun Next model approach volumes and the exiting turning movement proportions were used to calculate the turning volumes used in Synchro analysis for all 2040 scenarios. 2040 Build Option 2 analysis were performed only at the intersections that has different traffic volumes when compared to the 2040 Build Option 1.

Synchro Analysis Results

Table 4 shows the comparison of the Synchro results at the project intersections for 2040 No-Action, 2040 Build Alternative and 2040 Build Option 2 for the AM and the PM peak hours. All of the results comply with HCM 6th edition, except the I-11/ Horizon Drive (DDI) where only HCM 2000 results were available.

Synchro results indicate that all the signalized project intersections perform satisfactorily with LOS E or better without failure (LOS F) in all the scenarios except at Eastgate Road/Lake Mead Parkway and the Diverging Diamond Interchange at I-11/Horizon Drive (DDI).

At Eastgate Road/Lake Mead Parkway, significantly higher delay with LOS F were noted for all the scenarios considering pedestrian crossing in all directions. An additional option was evaluated due to the LOS F as a result of pedestrian phase. The option excluded the north-south crosswalk at this intersection and provided an opportunity to eliminate the longer pedestrian clearance required in the north-south direction. This change allowed to provide longer splits in the east-west direction to accommodate the high traffic volumes. The delays thus obtained reduced considerably and the intersection operated with LOS E in both Build Alternatives when the north-south pedestrian phase was eliminated. Pedestrian movements are accommodated only when push buttons are actuated by pedestrians, and north-south pedestrian movements are currently infrequent. If and when north-south pedestrian movements become more frequent and result in degradation of signal LOS to F, a pedestrian bridge could improve LOS.

Results for the DDI service interchange at I-11/ Horizon Drive were calculated based on HCM 2000 since HCM 6th edition results are unavailable for DDI. The results indicate that the DDI operated with LOS F in the PM peak period in all scenarios. The poor LOS at Horizon Drive ramp termini results from geometric issues on the local roadway including proximity of the signalized intersection with Horizon Ridge Parkway to ramp termini intersections. Improvements to the local roadway network are beyond the scope of this study, and it has been determined by traffic operations analysis that degraded LOS on Horizon Drive would not result in queues extending back to the I-11 mainline.

The all-way stop controlled intersection at Eastgate Road/Auto Show Drive showed LOS F during the PM peak-hour. Installing a traffic signal at this intersection in the near future would provide better LOS.

Table 2. Synchro Results for Project Intersections

Intersection	2040 No Action		2040 Build Option 1		2040 Build Option 2	
	AM	PM	AM	PM	AM	PM
I-515 SB/Sunset Road	32.1 (C)	27.1 (C)	32.1 (C)	27.1 (C)	32.1 (C)	27.0 (C)
I-515 NB/Sunset Road	22.5 (C)	20.5 (C)	22.5 (C)	20.5 (C)	22.5 (C)	20.1 (C)
Gibson Road/Auto Show Drive	31.5 (C)	40.1 (D)	31.5 (C)	40.1 (D)	31.5 (C)	40.1 (D)
I-515 SB/Auto Show Drive	33.0 (C)	35.8 (D)	33.0 (C)	32.8 (D)	33.0 (C)	32.8 (D)
I-515 NB/Auto Show Drive	18.2 (B)	44.3 (D)	24.5 (C)	57.6 (E)	24.5 (C)	57.6 (E)
Eastgate Road/Auto Show Drive (all-way stop controlled)	25.9 (D)	71.3 (F)	25.9 (D)	71.3 (F)	25.9 (D)	71.3 (F)
I-11 SB/Horizon Drive	26.9 (D)	101.9 (F)	25.9 (D)	99.26 (F)	25.9 (D)	99.35 (F)
I-11 NB/Horizon Drive	28.9 (D)	111.4 (F)	26.6 (D)	125.2 (F)	26.6 (D)	105.7 (F)
Stephanie Street/I-215 WB	58.2 (E)	50.5 (D)	58.2 (E)	50.5 (D)	58.2 (E)	50.5 (D)
Stephanie Street/I-215 EB	78.9 (E)	57.3 (E)	78.9 (E)	57.3 (E)	78.9 (E)	57.3 (E)
Gibson Road/Wigwam Parkway	21.5 (C)	40.2 (D)	21.5 (C)	40.2 (D)	21.5 (C)	40.2 (D)
Gibson Road/I-215 WB	38.2 (D)	28.7 (C)	39.2 (D)	28.7 (C)	39.2 (D)	30.5 (C)
Gibson Road/I-215 EB	28.0 (C)	23.7 (C)	28.0 (C)	23.7 (C)	28.0 (C)	23.7 (C)
Gibson Road/Las Palmas Entrada Avenue	59.1 (E)	36.1 (D)	59.1 (E)	36.1 (D)	59.1 (E)	36.1 (D)
Eastgate Road/Lake Mead Parkway (No N-S Ped Phase)	256.8 (F)	212.5 (F)	64.0 (E)	69.7 (E)	64.0 (E)	72.5 (E)
Eastgate Road/Lake Mead Parkway *(With N-S Ped Phase)*	768.4 (F)	543.4 (F)	480.2 (F)	325.3 (F)	480.2 (F)	320.7 (F)

Numerical values in table represent the average delay in seconds for each motorist at the intersection.
Letters within parentheses indicate level of service (LOS) for the intersection.

4.0 Alternatives Development and Evaluation

4.1 Improvements to Local Roads

Traffic projections for Lake Mead Parkway indicated a need for four lanes in each direction between Eastgate Road/Fiesta Henderson Boulevard and Van Wagenen Street. Proposed improvements are identical for both Options 1 and 2, with the existing northern curb line retained in place and widening taking place to the south where there is sufficient existing right-of-way. Medians and the south side sidewalk would be reconstructed, and bus stop pockets and bus stops would be reconstructed. Westbound Lake Mead Parkway would widen to five lanes approaching the Eastgate Road/Fiesta Henderson Boulevard intersection with the outside lane striped as a through/right lane.

Figure 13. Proposed Lake Mead Parkway Intersection at Eastgate

Eastgate Road would be retained in its current configuration. Fiesta Henderson Boulevard would be widened at the approach to Lake Mead Parkway to accommodate a triple left turn storage bay.

This project would not make improvements to Valle Verde Drive, Stephanie Street, Gibson Road, Galleria Drive, Sunset Road, Auto Show Drive or Horizon Drive except for reconstruction made necessary by ramp terminal improvements or signal timing adjustments.

4.2 Potential Right-of-Way Impacts

Options 1 and 2 as configured for this project can be constructed within existing right-of-way. There are several areas for both Options 1 and 2 where proposed improvements are close to the right-of-way boundary, and NDOT District 1 maintenance staff accommodated a lesser maintenance access clearance to allow the project to be constructed within existing right-of-way. If implementation of the project is delayed such that consideration of traffic projections for a design year later than 2040 would be warranted, a possibility exists that right-of-way might become needed if additional lanes beyond the needs of year 2040 traffic projections become warranted.

4.3 Proposed Freeway Improvements

Although the configurations of Options 1 and 2 differ greatly, traffic operations performance as predicted by Aimsun Next modeling shows that they provide comparable performance. Both serve all of the forecast travel demand at speeds that are considered to be satisfactory. Comparison of traffic operations performance is therefore not a differentiating factor for comparing Options 1 and 2. **Table 3** on the following page shows predicted operating speeds for various segments for the no-build alternative and for Options 1 and 2.

Table 3. Forecast Year 2040 Travel Speed

Segment			No-Build		Option 1		Option 2	
			AM	PM	AM	PM	AM	PM
I-215 & Lake Mead Pkwy	Valle Verde Drive to Stephanie	EB	58*	45*	44	44	44	44
		WB	28	9	60	29	60	51
	Stephanie Street to Gibson Road	EB	50*	60*	31	22	35	24
		WB	18	21	66	63	64	65
	Gibson Road to Eastgate Road	EB	25	23	65	64	63	62
		WB	23	19	70	71	60	65
I-515 & I-11	Galleria Drive to Sunset Road	NB	66	67	66	68	69	70
		SB	7	7	66	67	66	67
	Sunset Road to Auto Show Drive	NB	57	55	67	65	63	64
		SB	32	31	66	64	69	68
	Auto Show to I-215/ Lake Mead	NB	67	66	64	66	67	67
		SB	71*	71*	70	70	69	68
	Lake Mead/I-215 to Horizon	NB	66	57	68	64	70	69
		SB	64*	63*	68	65	69	67

*Options 1 and 2 serve all of the traffic demand within the study area. The No-Build alternative serves less than half of the traffic demand, and bottleneck traffic jams within the interchange area result in higher departing speeds for motorists who have waited through the long delay and are now departing from the interchange area.

4.4 Drainage Design Elements

Impacted drainage facilities are summarized in **Appendix 16**. Most impacts are common to both Options 1 and 2, with Option 1 having an impact to Drainage ID No. 78 that is not impacted by Option 2. Option 2 has impacts to Drainage ID Nos. 27, 28, 43, 44, 45 and 64 that are not impacted by Option 1. A full list of utilities is provided in **Appendix 4**.

4.5 Structure Design Elements

Bridges

There are 27 existing bridges within the study area, including five that cross over UPRR rail spurs and two that cross over drainage channels. The remainder serve as grade separation structures for service and system interchanges. Bridges represent the largest single element of construction cost for both Option 1 (51%) and Option 2 (38%). Disposition of the existing bridges is shown in **Appendix 5**.

The existing interchange includes four long, curved steel girder flyover structures. Other bridges within the interchanges are constructed with concrete superstructures. Current construction economic conditions favor concrete over steel, therefore the study team based preliminary plans, vertical profiles, and cost estimates on use of concrete for new bridge structures. Existing Bridge G-1958 would be retained and widened for both Options 1 and 2, and the superstructure type would therefore remain as steel girders.

Option 2 would construct four crossover structures, one each to the north, south, east and west of the central interchange. The crossing structures would be highly skewed because opposing directions of travel are adjacent to each other. The study team evaluated several structure types in an effort to yield a structure that is functionally skewed, but not structurally skewed. Structure types considered included post-tensioned concrete boxes supported by straddle bents and a concrete deck supported by transverse precast concrete bulb-tee girders. Final structure type would be determined during the detailed design phase. Unit costs for various bridge types include:

- High, curved flyover post tensioned box - $170/SF
- Traditional concrete bridge - $150/SF
- Widened steel bridge - $240/SF
- Concrete crossover bridge - $125/SF over entire area

As depicted in **Figure 14**, the crossover bridge decks cover only about one-half of the total bridge area comprised of abutment walls, bents, and bulb-tee girders, and the unit price applied to the entire area was therefore discounted from the unit price for a traditional concrete bridge.

Figure 14. Artist's Rendering of the Southern Crossover Bridge

The Bridge Type Selection Study in **Appendix 5** presents information for a representative sampling of bridges, including a long flyover bridge, a short bridge and widening of both existing steel and concrete bridges.

Retaining Walls

Both Options 1 and 2 would require construction of retaining walls to accommodate grade differentials between adjacent roadways or adjacent properties. Retaining walls could be cast in place or mechanically stabilized embankments (MSE) available from various proprietary wall providers. A decision on which wall type would be made during the detailed design phase based on cost and other constraints.

Both Options 1 and 2 would construct roadway improvements closer to the right-of-way than existing conditions. In consultation with NDOT District 1 maintenance staff, it was determined that retaining walls adjacent and parallel to the right-of-way would need to be at least 12' from the right-of-way line in order to accommodate maintenance access. This is less than NDOT's desired distance of 15', and this reduced distance is proposed for only those areas where achieving the desired 15' would result in the need to acquire additional right-of-way. Further, NDOT District 1 maintenance staff indicated that for locations where the walls are at least 10' high, the roadway including barrier and noise wall could be cantilevered beyond the retaining wall to a point at least 10' from the right-of-way line. Retaining walls and roadway sleeper slabs above the walls would be designed to accommodate the resulting cantilever. Both cast in place and MSE walls could accommodate cantilevered roadways above.

4.6 Geotechnical Design Elements

A limited geotechnical assessment is included in **Appendix 17**. The interchange area has been disturbed by previous uses and by construction of the existing interchange.

Based on findings of the geotechnical assessment, it appears to the study team that development of the project is feasible from a geotechnical and geologic perspective. Subsequent development phases would include performance of exploratory borings to evaluate subsurface conditions in areas of proposed structures and improvements.

Figure 15. Artist's Rendering of Cantilever over Bike Path

The following geotechnical, geological, groundwater, and construction considerations should be considered during planning and development of the project.

- **Anticipated Subsurface Soil**: Native soils along the project corridor would consist primarily of granular material (sandy and gravelly) with a few, relatively thin layers of fine-grained soil (clay and silt). The layers of fine-grained soil generally increase in thickness in the northern portion of 1-515 corridor and the eastern portion of the 1-215 corridor. Significant amounts of cobbles and small boulders would also likely be encountered, primarily along the southern portion of the 1-11 corridor and along the western portion of the 1-215 corridor, particularly in alluvial fan areas near the base of the McCullough Range.
- **Caliche**: Significant layers of cemented soil, or caliche, were encountered during previous geotechnical evaluations performed in the project area. Caliche layers may likely range from a few inches to several feet thick. Based on previous project experience, heavy ripping and rock excavation techniques should be anticipated. The presence of caliche layers may impede drilled shaft, trenching, and other excavations.
- **Oversize Materials**: Significant amounts of oversize material, including cobbles, boulders, and rocks or hard chunks greater than 3 to 4 inches in nominal diameter, may be generated during grading operations. It should be anticipated that some oversize material would also be generated during excavation of caliche.
- **Potential Burn Pit Debris**: The study team understands that the remnants of multiple "burn pits", may be located in the vacant area southwest of the Henderson Interchange. Debris-laden fill associated with these former burn pits may be encountered during excavation activities in this area. If encountered, these materials would need to be removed and properly disposed.
- **Groundwater**: Review of referenced groundwater-related data and the study team's previous professional experience in the area indicate that the depth to static groundwater is relatively shallow (less than 5 feet in low-lying areas) in the northern portion of the 1-515 corridor. Groundwater depths are generally deeper (30 feet or more) in the central and southern portions of the 1-11 corridor and significantly deeper beneath the 1-215 corridor.
- **Moisture-Sensitive Soils**: Numerous layers of moderately to highly gypsiferous soil may be present along the project corridors. These gypsiferous soils should be considered potentially water-soluble.
- **Corrosive Soils**: Based on the study team's previous professional experience, soils with relatively high sulfate contents, relatively low resistivities, and other potentially corrosive characteristics may be encountered along the project corridors.
- **Geologic Faults and Ground Fissures**: Review of referenced published geologic maps and observations during our site reconnaissance indicate that the project corridors are not traversed by faults or ground fissures. Nearby "compaction" faults that extend generally parallel to and west of the 1-515/I-11 corridor should not significantly affect design or construction of the project.
- **Foundation System**s: Based on the study team's previous professional experience in the project area and anticipated subsurface soil conditions, conventional spread footings and drilled shaft foundations would be appropriate for support for proposed structures and improvements.

4.7 Potential Utility Impacts

A list of existing utilities identified within the study area is included in **Appendix 4**, along with a summary of anticipated impacts by either Option 1 or Option 2.

Utilities encountered within the study area include Southwest Gas, sanitary sewer, water, electric, telephone, CATV and steam pipe. Four unknown facilities were identified, and further research is needed to ascertain the nature and owner of these facilities. It appears that only one of the unknown facilities would be impacted by the project, by both Options 1 and 2.

4.8 Alternative Renderings

Artist renderings of proposed improvements are provided on Pages 28 through 30. Renderings are based on a digital three-dimensional model created for this project representing existing conditions, Option 1 and Option 2.

4.9 Qualitative Comparison of Build Alternatives

Both Options 1 and Option 2 provide comparable traffic operations performance improvements over the no-build alternative. **Table 4** illustrates areas of differences between the options that may be considered in the subsequent NEPA phase to identify a Preferred Alternative.

Table 4. Qualitative Comparison of Build Alternatives

Option 1	Option 2
The I-215 EB to I-515 NB ramp has three lanes that reduce to two lanes	EB 215 to SB 515 has less traffic weave with the EB traffic exiting to the frontage road prior to Gibson
Sharing an off ramp from I-11 to both EB Lake Mead Parkway and WB I-215 could leave some drivers confused and making last-minute changes, similar to the existing condition	NB I-11 to EB Lake Mead Pkwy has its own off ramp.
Proposed configuration is similar to the existing configuration with which most local residents are familiar	A crossover interchange would be the first of its type in Nevada
I-215 EB motorists cannot exit at Auto Show Drive. SB motorists entering from Auto Show Drive cannot access Lake Mead Parkway or I-215	Accommodates access to and from Auto Show Drive and I-215/Lake Mead Parkway
Motorists from the I-215/Gibson Road on-ramp destined to I-11 SB need to complete three lane changes within approximately 800’	I-215 EB motorists wishing to exit at Auto Show Drive need to complete two lane changes within approximately one-half mile
Motorists from Lake Mead Parkway WB destined to the Horizon Drive exit from I-11 would complete a merging maneuver and two-lane changes within approximately 1.8 miles	Motorists from Lake Mead Parkway destined to the Horizon Drive exit from I-11 would complete a merging maneuver and four lane changes within approximately 1.4 miles
No left-hand entrances or exits on mainline roadways	Crossover interchange employs left-hand entrances and exits that are discouraged by AASHTO
The I-215 EB to I-11 SB and I-515 NB have a counter-intuitive configuration with the SB exit on the left and NB exit on the right	Movements are intuitive – move left to go left, move right to go right
Cost is approximately $32M more	Cost is approximately $32M less

5.0 Costs and Benefits of Alternatives

5.1 Cost Estimates

Project costs were estimated based on use of NDOT's WIZARD spreadsheet for construction year 2019 that are presented in **Appendix 7**. Quantities were estimated based on preliminary plans for each option and separate files were developed for segments of the project so that like elements of work could be combined and so that interchangeable elements could be common to each build alternative. Separate costs were estimated for improvements to:

- I-515/I-11 south of Auto Show Drive
- I-515 north of Auto Show Drive
- I-215 west of Eastgate Road
- Lake Mead Parkway east of Eastgate Road

Project costs were further analyzed using Cost Risk Assessment methodology. A Cost Risk Assessment workshop was held in November 2019 to identify threats and opportunities that could have an effect on project costs, followed by cost modeling based on acceptance of risks (pre-response) and proactive mitigation of risks (post-response). The predicted 70th percentile post-response project costs are $327.7 million for Option 1 and $297.9 million for Option 2.

Life cycle costs were determined by adding estimated costs for future maintenance and rehabilitation to initial capital costs for each option in **Appendix 7**.

Future HOV improvements are not included with this current project or in the estimated project costs, risk assessment or benefit-cost analysis (BCA). Conceptual estimates of costs for future HOV improvements in current year dollars would be approximately $25 million for Option 1 and $4 million for Option 2.

5.2 Benefits Estimates

BCA is a systematic approach used to compare the benefits and costs of alternatives to determine sound investment decisions. BCA was performed following the Cal-B/C-Corridor methodology and tools used by Southern Nevada Traffic Study (SNTS), to evaluate and compare the relative net benefits of alternatives for the project area. The benefit-cost ratios of the two Build alternatives were analyzed and compared with that of the No-Action alternative. For the detailed BCA methodology, refer to **Appendix 8** Benefit-Cost Analysis of Southern Nevada Traffic Study Final Report, October 2018.

As detailed in **Appendix 8,** the user and non-user benefits were quantified and compared to the total capital costs in 2018 dollars using a 20-year analysis with 7% real discount rate. As part of the quantitative analysis of benefits, traffic operations analysis performed using Aimsun Next traffic model were utilized. Vehicle miles traveled (VMT) and vehicle hours traveled (VHT) for the No-Action and two Build alternatives were utilized from the Aimsun Output to estimate travel time savings, emissions savings, and vehicle operating cost savings. Crash cost savings yet (work in progress) to be quantified as part of this analysis and will be included in the final report.

The overall benefit-cost ratio of 3.78 for Build Option 1, and 4.18 for Build Option 2 denote that both build alternatives are cost-effective projects. The proposed improvements for Build Option 1 showed savings of more than $954.2 million in travel time, crash cost, vehicle operating cost, and emission reductions for Option 1; and $948.5 million for Option 2. These savings are the result of the additional capacity and improvement in traffic operations. Solely based on quantitative benefit-cost ratio, the better investment is Build Option 2 compared to Build Option 1. **Table 5** shows the summary of the BCA results in 2018 dollars.

Table 5. Benefit-Cost

	Option 1	Option 2
Life-Cycle Costs (mil. $)	$252.2	$226.9
Life-Cycle Benefits (mil. $)	$954.2	$948.5
Net Present Value (mil. $)	$702.0	$721.6
Benefit/Cost Ratio	3.78	4.18

The BCA described in **Table 5** is based on a real discount rate of 7% as recommended by the Office of Management and Budget (OMB) Circular A-94.[1] A real discount rate is a discount rate that reflects the opportunity cost of money net of the rate of inflation.[2] The same reference also encourages a sensitivity analysis using a discount rate of 3%.

[1] *Office of Management and Budget (OMB) Circular A-94: "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs." October 29, 1992.*
[2] *"TIGER Discretionary Grants; Appendix A: Additional Information on Benefit-Cost Analysis; Discounting." Federal Register 76:156, August 12, 2011, pp 50305.*

6.0 Implementation

6.1 Funding

Funding for preliminary development including environmental clearance and preliminary design is programmed for the current fiscal year. NDOT anticipates entering into an agreement with an engineering consultant to provide those services in early 2020. NDOT is working to identify funding for this project at the earliest possible date.

6.2 Environmental Clearance

NDOT anticipates that environmental clearance would be obtained in early 2022, based on preparation of an Environmental Assessment (EA).

6.3 Development of Construction Documents

NDOT anticipates that preliminary design of interchange improvements would be completed in early 2020. They have not yet determined whether the Henderson Interchange would move forward as a design-bid-build project with final plans prepared by an engineering consultant, a design-build project with final plans prepared by a design-builder, or another construction method.

6.4 Construction Phasing

If the full cost of project improvements cannot be allocated by NDOT for a particular fiscal year, it would be possible to phase the construction of either Option 1 or 2 so that the improvements could be spread over multiple years. For example, it would be possible to construct improvements to Lake Mead Parkway east of Eastgate Road, widening of I-515 north of and I-11 south of the core interchange, and widening of I-215 west of Gibson Road as a separate project prior to improvements to the core interchange area.

6.5 Maintenance of Traffic During Construction

Reconstruction of a major interchange while maintaining traffic operations is feasible but challenging. Based on construction year traffic, the study team recommends that a minimum of two lanes in each direction should be maintained for I-515, I-11, and I-215 mainlines, and that at least one lane in each direction should be maintained for Lake Mead Parkway within the interchange area. Construction phasing plans showing how the project can be constructed under traffic would be developed during a subsequent development phase for the Preferred Alternative. Phasing would be similar for both Options 1 and 2, with the following broad phases:

Phase 1: Construct proposed external ramps that are outside the footprint of the existing interchange, such as Ramps ES (eastbound to southbound), NE (northbound to eastbound), WN (westbound to northbound) and SW (southbound to westbound).

Phase 2: Detour traffic from internal ramps to adjacent service interchanges so that the internal ramps can be reconstructed without conveying traffic. For example, traffic wishing to use Ramp EN (eastbound to northbound) would travel south on I-11 to Horizon Drive, use the interchange to turn around and head north to the destination on I-515.

7.0 Public Involvement

The study team provided public involvement activities based on the approved Public Involvement Plan for the project, included with the summary of public involvement activities in **Appendix 10**. Study team efforts to involve the public included the following elements:

Project Branding. The study team developed and implemented project branding to provide the project with an identifiable representation to stakeholders and the public, with a goal of ensuring consistency and recognition of documents.

Internet and Social Media. A project website (www.hendersoninterchange.com) was established, and links were provided for statewide agencies to post. The website contained background/overview information on the project, reference materials, and public information meeting presentations/handouts, among other information. The website was used to provide stakeholders and the public ready access to project schedule, reference materials, public meeting information, and contact information—including a feedback function for comments and concerns. It was also referenced in numerous social media posts from the City of Henderson and partner agencies (NDOT, RTC, etc.) to help keep the public informed of the study throughout the process.

Public Meetings. Two public meetings were conducted with the first on March 27, 2019, to inform the public about the study and to seek input from the public on issues that could contribute to the purpose and need for the project. The second was held December 5, 2019 where the project purpose and need was shared with the public along with two build options that meet the purpose and need.

The meetings included full notification services for the project area:

- E-blasts to internal project team and agency distribution lists (NDOT and City of Henderson).
- Direct mail postcard printed and distributed to approximately 18,000 homes/businesses in the project area.
- Meeting notification posting on local agency websites and on NDOT's public information web page.
- Notices in the Las Vegas Review-Journal main news section (three dates for each public meeting) and a Spanish version of the notice in El Tiempo approximately one week before each meeting.
- Press release and associated social media coverage.

The public meetings included comprehensive information for the public, from detailed display boards on 36-inch by 48-inch boards to an interactive video animation of project options to a multimedia presentation on the project, with handouts for all attendees. The video animation was a three-dimensional digital model for existing conditions and the two build options that allowed the public to view the project from any vantage point at the second public meeting.

According to the sign-in sheets included in the Public Meeting Summary, a total of 160 people attended the meetings.

Documentation. A comprehensive contact database of project correspondence from the public—with detailed information on questions/concerns and resolution. The final correspondence document was a 33-page interactive PDF showing all comments/resolutions from members of the public.

Non-General Public Entities. The study team also reached out to non-general public entities to seek their input through project communications such as e-mail blasts for public meetings. Entities are shown in **Table 6**, on the following page.

Table 6. Non-General Public Entities		
Federal Highway Administration - Carson City	Reg. Transportation Commission of Southern NV (Las Vegas)	Thatcher Company of Nevada
US Dept of Agriculture - Natural Resources Conservation Services	Nevada Energy - Environmental Services (Reno)	Core-Mark International
US Dept of Agriculture - Forest Service Region 4	CenturyLink (aka Central Telephone - Las Vegas)	High Impact Sign & Design
US Forest Service - Humboldt-Toiyabe National Forest (Sparks)	Las Vegas Valley Water District	Good Spirits Distributing
BLM - State Office	Dept of Housing and Urban Development, Las Vegas Field Office	Aurora LED Systems
BLM - Southern NV District Office - District Office	NV Division of Water Resources - NFIP Coordinator (Carson City)	Xtreme Manufacturing
BLM - Southern NV District Office - Las Vegas Field Office Manager	Dept of Public Safety - Office of Traffic Safety	Touro University
US Army Corp of Engineers - Section Chief/Sacramento (NV Office)	Colorado River Commission of Nevada	Valley Automall
Federal Emergency Management Agency - Region IX Oakland	Southwest Gas - Southern Nevada Division HQ - Las Vegas	Sunset Station Hotel-Casino
US Dept of the Interior - Office of Environmental Policy & Compliance	Nevada Bell/AT&T (Reno)	Vista Landscape Center
US Fish & Wildlife Service, Southern Nevada Field Office (District 8)	Sierra Club - Southern Nevada Group	Nevada Environmental Resource Trust
US EPA Region 9	AGC Las Vegas (Associated General Contractors)	Union Pacific Railroad
USGS - Nevada Water Science Center (Carson City)	NV Chapter of Associated General Contractors (AGC) - Reno	Henderson Chamber of Commerce
National Park Service, Pacific West Region (San Francisco)	Nevada Environmental Coalition Inc.	Dept of Motor Vehicles
Bureau of Indian Affairs - Western Regional Office (Phoenix)	Eleventh Coast Guard District (Alameda)	Zero Fatalities
US Forest Service - Spring Mtn. Nat. Recreation Area (Mt. Charleston)	US Dept of the Interior - Bureau of Reclamation - Lower Colorado Region	Nevada Highway Patrol
US Dept of Energy - NV Site Office (Las Vegas)	USGS Western Ecological Research Center (WERC) - Las Vegas Field Station	City of Henderson Police Dept
FAA Western-Pacific Reg.(AWP-600), Airports Div., Los Angeles	Las Vegas Valley Water District	Nevada Dept of Transportation
NV Dept of Wildlife - Southern Region (Las Vegas)	FAA - Phoenix Airport District Office	WAZE
NV Dept of Conservation & Natural Res. - NV Heritage Program	Colfin 2018-5 Industrial Owner (Subsidiary of Colony Industrial)	District Attorney's Office
Nevada State Clearinghouse - State Land Use Agency	Fiesta Henderson Hotel-Casino	

8.0 Planning and Environmental Linkages

PEL is a collaborative approach to transportation decision-making that considers benefits and impacts of proposed transportation system improvements to the environment, community, and economy during the transportation planning process. The PEL process uses the information, analysis, or products developed during planning to inform that environmental review process, including preparing documentation for NEPA.

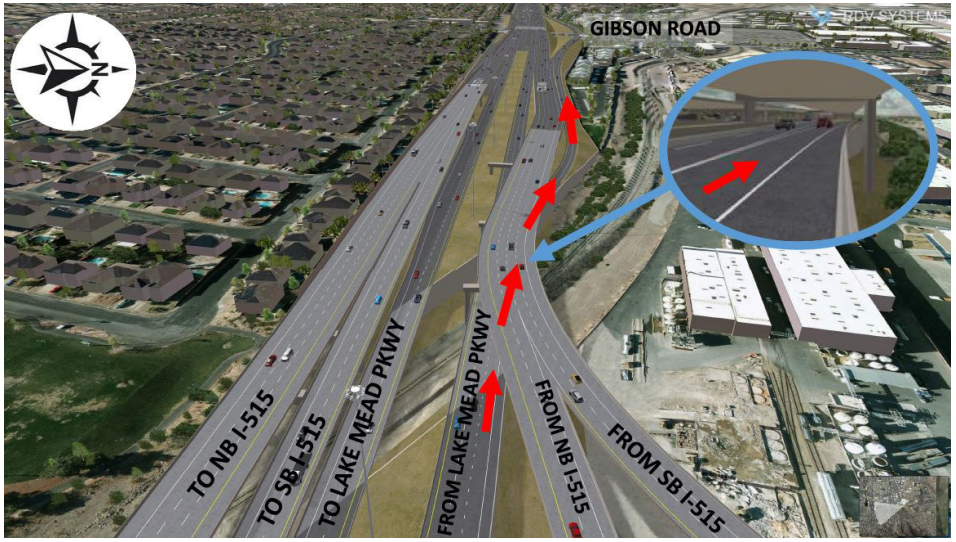
This Feasibility Study was conducted following the FHWA Planning and Environmental Linkages program guidelines. An NDOT Planning and Environmental Linkages Questionnaire and Checklist was prepared and is included in **Appendix 11**.

Option 1. Central Interchange Looking Northeast

Option 2. Central Interchange Looking Northeast

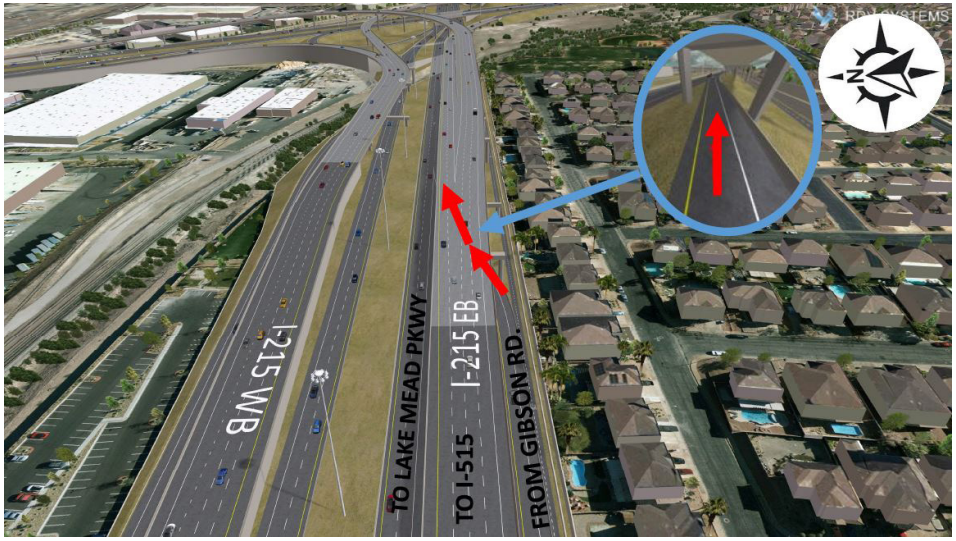
Option 1. Central Interchange Looking Southwest

Option 2. Central Interchange Looking Southwest



Option 1. Access to Gibson Road

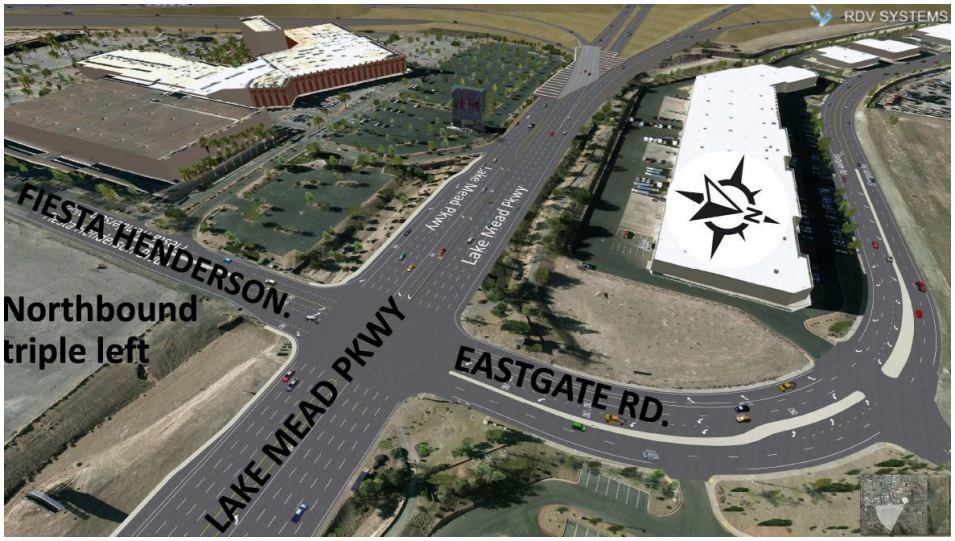
Option 2. Access to Gibson Road



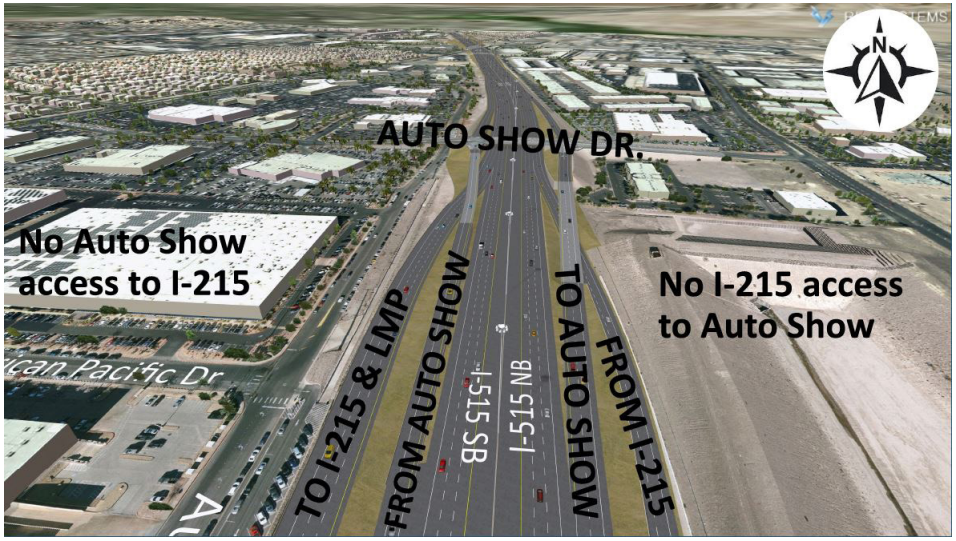
Option 1. Access from Gibson Road

Option 2. Access from Gibson Road

Option 1. Intersection with Eastgate Road/Fiesta Henderson Boulevard



Option 2. Intersection with Eastgate Road/Fiesta Henderson Boulevard



Option 1. Access to and from Auto Show Drive

Option 2. Access to and from Auto Show Drive

Appendix 1

Traffic Forecasting Memorandum

Appendix 2

Synchro Output

Appendix 3

Alternatives Screening Report

Appendix 4

Utilities

Appendix 5

Bridge Type Selection Study

Appendix 6

Conceptual Plans

Appendix 7

Cost Estimate Worksheets

Appendix 8

Benefit-Cost Analysis

Appendix 9

Cost Risk Assessment

Appendix 10

Public Involvement Activities

Appendix 11

Planning and Environmental Linkages Questionnaire and Checklist

Appendix 12

Summary of Hazardous Materials Reports

Appendix 13

UPRR Coordination

Appendix 14

TAC Meeting Minutes

Appendix 15

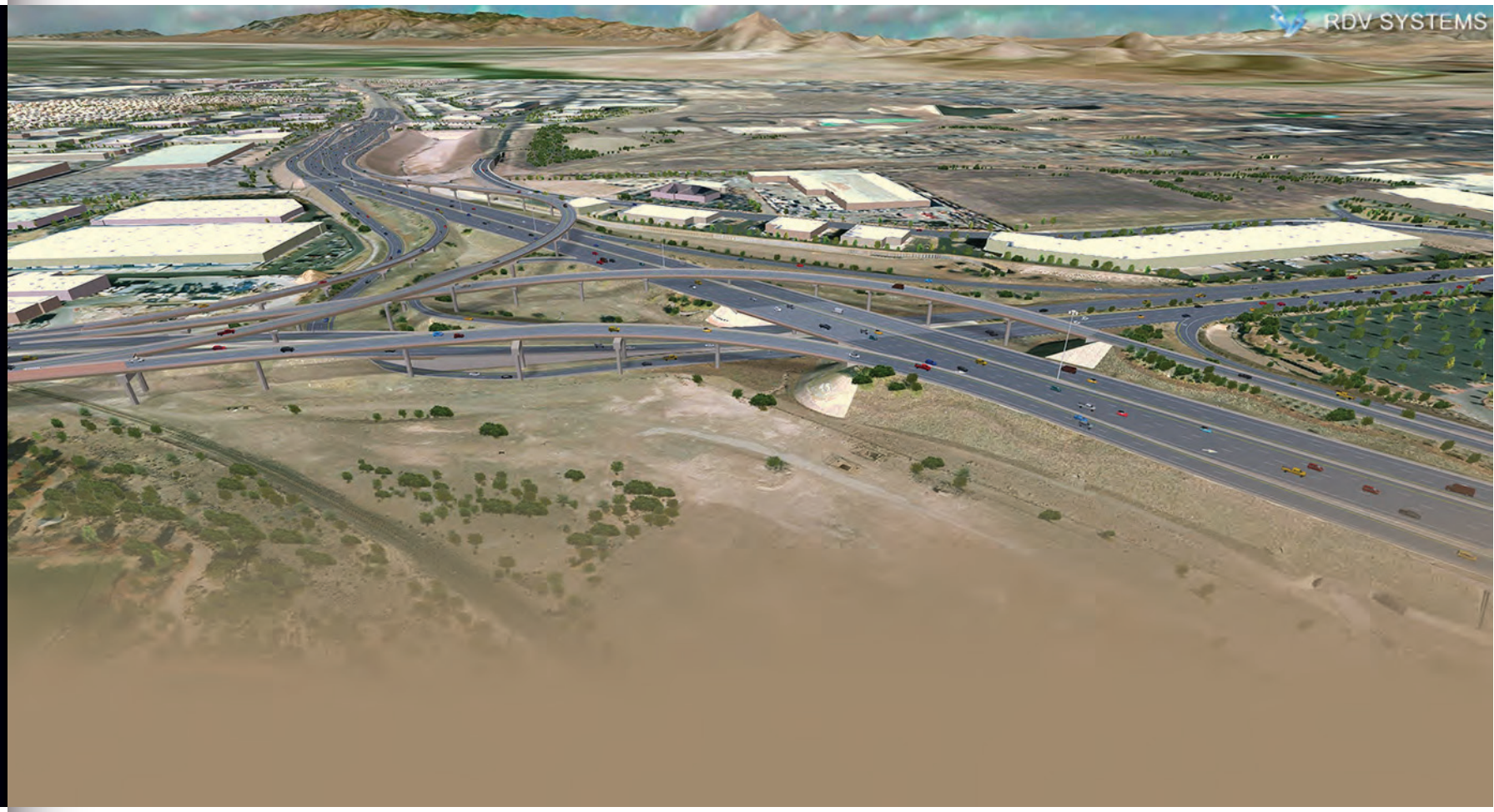
FEMA Floodplain Documentation

Appendix 16

Drainage Facilities

Appendix 17

Limited Geotechnical Assessment



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