US 281/LOOP 1604 INTERCHANGE

OPERATIONAL ANALYSIS

US 281: From Bitters Road to Loop 1604

Loop 1604: From Bitters Road to Red Land Road

Submitted to:
The Alamo Regional Mobility Authority

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June 2009

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

The Alamo Regional Mobility Authority (RMA) requested Rodriguez Transportation Group, Inc. (RTG) perform a traffic analysis of the US 281 North/Loop 1604 interchange. Currently the interchange is a three-level diamond configuration that creates major traffic congestion during peak periods. The Alamo RMA has prepared a design schematic which will provide direct connection ramps to alleviate the congestion.

The interchange was analyzed as well as the effects of the direct connection ramps on US 281 and Loop 1604. The analysis on Loop 1604 began at Bitters Road and extended to Red Land Road. US 281 was analyzed from Bitters Road to Sonterra Boulevard. The study area is shown below in Figure 1.

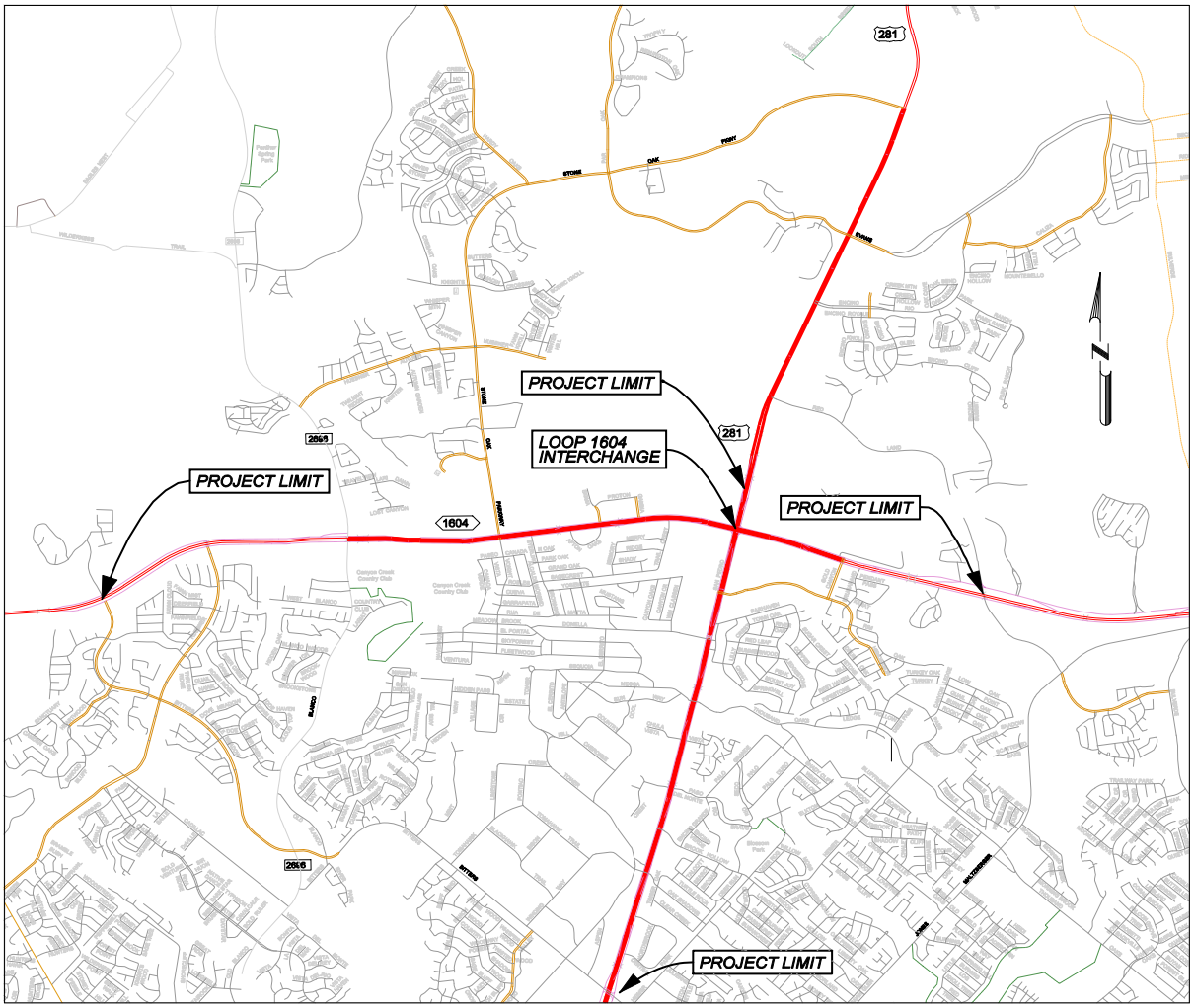


Figure 1: Study Area

DESCRIPTION

Existing Facility

The US 281 North/Loop 1604 interchange is located in a highly urbanized area of North Central San Antonio. The existing interchange operates as a three-level diamond arrangement between Loop 1604, which exists as a controlled-access four-lane freeway facility with continuous frontage roads, and US 281 North, which also operates as a controlled-access freeway with frontage roads. The number of mainlanes in each direction along US 281 varies from three to five, with the five-lane sections occurring where auxiliary lanes are provided between an entrance and exit ramps.

The congestion is most severe on Northbound (NB) US 281 at Loop 1604 in the PM peak period. The queue from the three-level diamond interchange extends to the main lanes of NB US 281, a distance of approximately one mile. The major cause of the queuing is the capacity constraints at the diamond interchange, where there were approximately 1,000 vehicles per hour (vph) making the left turn from NB US 281 to Westbound (WB) Loop 1604 (2005 counts). Not all of this congestion is due to the traffic signal delay, as roadway geometry has some effect on the traffic operations. Queuing also occurs in the AM peak period for this movement; however, it is not as severe as in the PM peak period.

In the AM peak period the heaviest delay occurs along Eastbound (EB) Loop 1604 at Southbound (SB) US 281. Traffic counts from 2005 indicate there were approximately 1,200 vph making this right turn in the AM peak period. Though there is a dedicated turn bay as well as optional turn (shared with a through movement) provided for the right turn, there is severe queuing for this movement. The congestion occurs throughout all hours of operations, though it is significantly worse during the AM peak period.

Proposed Facility

In order to relieve the congestion at the three level diamond interchange, direct connection ramps to and from US 281 and Loop 1604 are proposed. Due to financial constraints, not all of the direct connection ramps can be constructed in one project. This study will analyze only four direct connection ramps that are proposed for the initial project. It is clear that the heaviest movements are:

1. NB US 281 to WB Loop 1604 and
2. EB Loop 1604 to SB US 281.

With just these two movements removed from the three level diamond interchange the traffic operations will improve greatly. In addition to these two direct connection ramps, the proposed initial project also calls for the construction of the remaining two direct connection ramps on the south side of Loop 1604 (NB US 281 to EB Loop 1604 and WB Loop 1604 to SB US 281). These two ramps remove additional vehicles from the frontage road intersections and should provide improved operations at the three level diamond interchange and the frontage road as well.

TRAFFIC ANALYSIS

Traffic Projections

Traffic data was provided by the Texas Department of Transportation (TxDOT) Transportation Programming and Planning (TP&P) Division. The original data was presented to TxDOT's San Antonio District in 1998 and provided traffic volumes for years 2005 and 2025. This data was in the form of an Average Daily Traffic (ADT) on the main lanes, ramps and frontage roads. TP&P also provided a peak hour factor (K-factor), directional distribution, truck percentages and other data required for the analysis.

There were also field traffic counts performed along Loop 1604 in 2005 and 2006. A comparison was made between the field counts and the TP&P traffic projections, and it was discovered that the Year 2025 TP&P projections were relatively close to the field counts that were taken in 2006 (in some cases the field counts were higher then the TP&P projections). Therefore, the 2025 TP&P traffic projection data was considered to reflect existing demand and used for this analysis. Figure 2 depicts the volumes that were used for this analysis.

It is apparent upon examination of the field counts taken in 2006 that there was very little difference in the AM and PM peak period traffic volumes on Loop 1604. The main lanes were at or near capacity in both directions during both peak periods. This is due to the high demand in the corridor, coupled with the fact that the facility is a circumferential route providing only two mainlanes in each direction.

Within the interchange, the AM and PM volumes are also very close to each other with the exception of NB US 281 to WB Loop 1604. In the AM peak hour there were 1,007 vph making this left turn, with 506 vehicles continuing on the through movement. In the PM peak there were still 890 vehicles making the left turn; however, there were 1,058 continuing through the intersection. Therefore, the signals at the interchange at this location have to provide enough green time for both the left turning volume in the AM or the through movement in the PM.

After the comparisons made between the AM and PM peak hour it was determined that just one peak hour operational model could be created since the volumes are very similar between the two time periods. The CORridor SIMmulation (CORSIM) operational model was used in this analysis, which is approved by the Federal Highway Administration (FHWA) to perform traffic analysis on projects such as this one.

Alternatives

The CORSIM model was created in order to compare the operations of various alternatives. Several ideas were presented, but only two real alternatives emerged. Both of the alternatives were identical on NB and SB US 281. The alternatives differ on EB and WB Loop 1604. Figure 3 shows the number of lanes used in the analysis for each alternative, with the number of lanes circled.

Alternative I

Alternative I is the base alternative that provided the four new direct connection ramps. The description of the ramp and lane arrangement along each leg is described below.

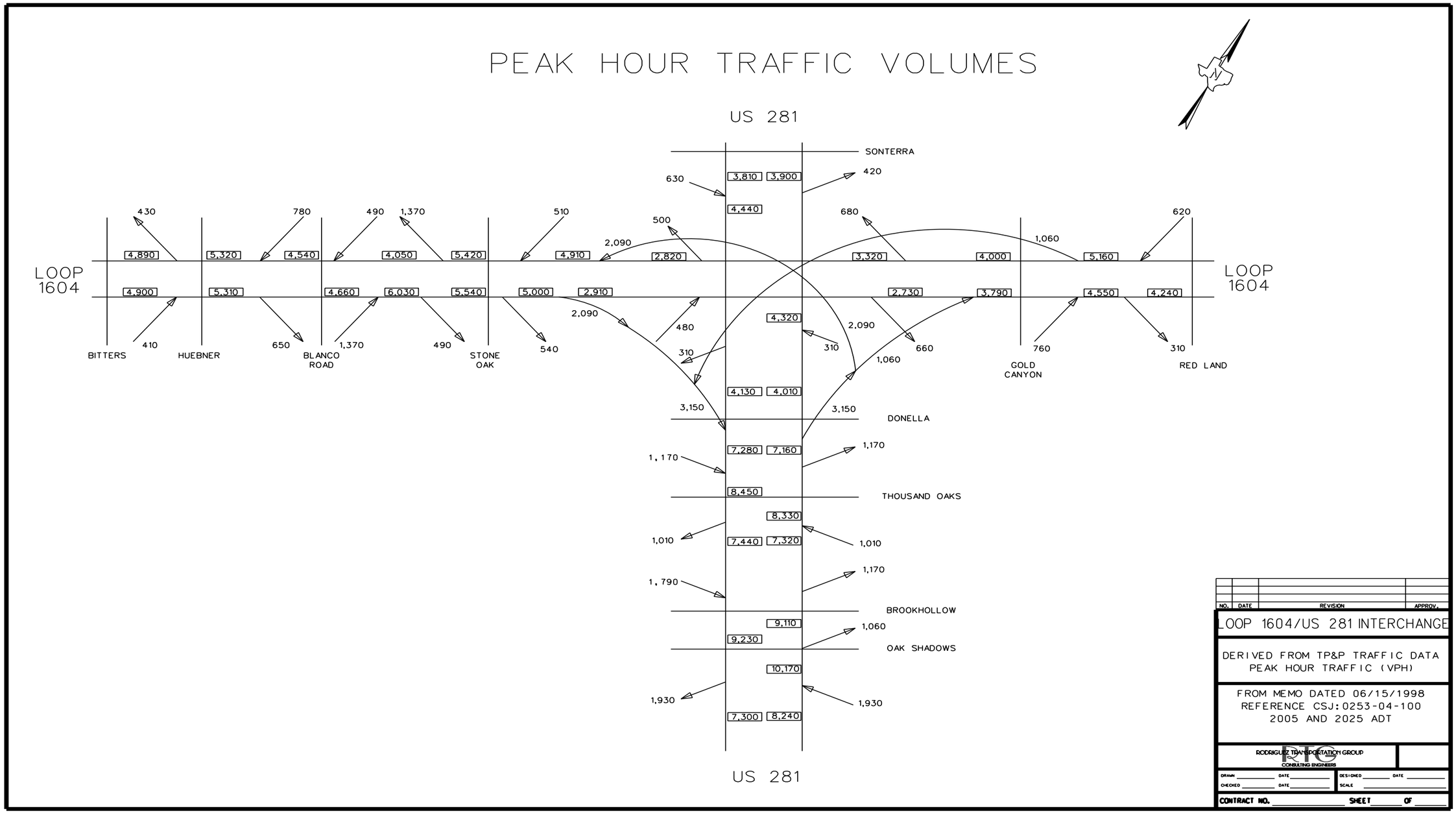


Figure 2: TP&P Traffic Volumes With K-Factor Applied

WB Loop 1604 (West of US 281)

The direct connection from NB US 281 would merge with WB Loop 1604 approximately 2,000 feet to the east of the existing frontage road entrance that services that movement. The direct connection ramp would receive its own lane thereby forming three mainlanes on WB 1604.The frontage road ramp would then merge with the third auxiliary lane created by the direct connection ramp. Downstream from this point, the Stone Oak entrance ramp would be replaced with an exit ramp to Blanco, with the third auxiliary lane added by the connector terminated at this point. The Stone Oak entrance ramp would be relocated west of the new Blanco exit ramp.

WB Loop 1604 (East of US 281)

The direct connection exit ramp to SB US 281 would exit from Loop 1604 at Gold Canyon interchange downstream from the existing Red Land Road entrance ramp and east of the existing exit servicing the US 281 frontage roads. The existing exit ramp to Gold Canyon must be removed due to merge conflicts with the direct connection exit.

EB Loop 1604 (West of US 281)

The direct connection exit ramp from EB Loop 1604 to SB US 281 would be located approximately 2000 feet to the west of the existing exit that services the US 281 frontage roads. It is necessary to revise the ramp pattern from Stone Oak to US 281 to create a space for the addition of the direct connection. A new exit ramp would be located approximately 1000 feet to the east of Stone Oak. The auxiliary lane that currently extends from the Blanco Road Entrance to the Stone Oak exit would then be extended to the direct connection ramp.

EB Loop 1604 (East of US 281)

The direct connection ramp from NB US 281 will enter EB Loop 1604 east of the current exit to Gold Canyon. The ramp will enter with as a merge condition, i.e., it will not form its own lane as it enters EB Loop 1604. No other changes will be made to Loop 1604.

Alternative II

Alternative II involved expanding the proposed study area to involve areas outside of the physical ingress and egress locations of the direct connection ramps. This alternative provides the same direct connector locations and is identical to Alternative I along NB and SB US 281, but differs along Loop 1604. The descriptions of the impacts to EB and WB Loop 1604 are described below.

WB Loop 1604 (West of US 281)

The direct connection entrance ramp from NB 281 will enter the freeway to form its own third auxiliary lane at the same location as Alterative I. The Blanco exit and Stone Oak entrance ramps are reversed as in Alternative I. The added third lane is dropped at the new Blanco exit. The Blanco entry will add a third auxiliary lane and is dropped further west at the Bitters exit.

WB Loop 1604 (East of US 281)

The direct connection ramp exiting to SB US 281 will be constructed at the same location as Alternative I. In Alternative II however, a third main lane is created at the Red Land Road entrance to WB Loop 1604. The added third auxiliary lane is then terminated at the direct connection ramp exit to SB US 281.

EB Loop 1604 (West of US 281)

As in the WB direction, an additional auxiliary lane is added upstream of the direct connection ramp to remove a portion of the ramp weaving traffic from the through lanes. On EB Loop 1604 a third auxiliary lane exists from the entrance ramp from Blanco Road and continues to Stone Oak exit ramp. The added third auxiliary lane continues past the Stone Oak Exit and is terminated at the direct connection exit ramp to SB US 281.

EB Loop 1604 (East of US 281)

The direct connection ramp from NB US 281 enters the facility to the east of the Gold Canyon exit ramp at the same point as in Alternative I; however, in Alternative II the direct connection ramp forms its own lane as it enters EB Loop 1604. The existing Gold Canyon entrance then enters Loop 1604 and creates a fourth auxiliary mainlane, which is terminated approximately 1200 feet downstream at the Red Land Road exit ramp. The main lanes are reduced to two lanes to the west of the Red Land Road exit.

US 281 SB

In order to accommodate the direct connection entrance ramp on SB US 281, the existing frontage road entrance that serviced the EB Loop 1604 to US 281 SB movement must be removed. The direct connection ramp will most likely provide service for a majority of these vehicles. The other vehicles that will not be able to use the direct connection ramp from Loop 1604 to SB US 281 will go through the interchange at Donella, and enter from the on-ramp south of there. The traffic volumes at Donella indicate that there is available capacity to handle additional throughput.

US 281 NB

As with the case on US 281 SB, the frontage road exit ramp from US 281 NB to Loop 1604 had to be eliminated to allow for the construction of the US 281 NB direct connection ramp to EB and WB Loop 1604. Once again, most of the vehicles using this ramp will now be on the direct connection ramps, and must no longer have to wait at the diamond interchange at US 281 North/Loop 1604. The other vehicles will exit south of Donella. The Donella interchange with US 281 appears to have the capacity to handle the additional traffic volumes.

STUDY RESULTS

Initial Results

Figure 3 also provides a comparison of speeds (in mph) across both alternatives. Typically a Level of Service (LOS) is reported for the alternatives; however, in this situation a LOS report would not be a proper basis for comparison. Since Alternative II provides for significantly more operational capacity than Alternative I does, the LOS would automatically be better since LOS is based on the traffic density on the roadway. The travel speeds along with the throughput volumes is the proper output data that can be reviewed to perform a true comparison between the alternatives.

On WB Loop 1604 at the start of the network near Red Land Road, there is a demand of nearly 4,600 vph entering the CORSIM network; however, they all do not enter due to the capacity constraint of the existing two lanes. Alternative II works better at this location also because the third auxiliary lane is added by the Red Land Road entrance versus being forced to merge in Alternative I. Downstream of this point the speeds show nearly identical in both alternatives, though the throughput volumes are greater in Alternative II.

Alternative I has slow speeds on WB Loop 1604 west of US 281 due to the high volume entering from the direct connection entry from NB US 281 combined with the downstream ramps having a forced merge condition. Due to additional weave capacity provided by Alternative II however, a breakdown in traffic operations does not occur until downstream of the Blanco entrance ramp. The question of why there is a speed of 25 mph when there are three lanes on the network in Alternative II compared to a speed of 31 mph when there are only two lanes in Alternatives I can be explained by the fact that the lane arrangement in Alternative II allow more demand on the facility. Thus the mainlanes are almost completely full with nearly 5,300 vehicles on the network when the 780 vph merge onto the main lanes from the Blanco entrance. In Alternative I with only two mainlanes on the network, there is severe congestion upstream of the Blanco entrance ramp with only a limited number of vehicles able to enter from the ramp.

The speeds on EB Loop 1604 are high due to the fact that the true demand never really enters the system from west of Bitters. There is a demand of nearly 4,900 vph upstream of the entrance ramp from Bitters, but this volume input into CORSIM doesn't enter the network due to capacity constraint of the existing two lanes. Alternative II does operate better at the Bitters entrance ramp because the ramp enters with its own lane versus having to merge on two saturated lanes as in Alternative I.

Further downstream on EB Loop 1604, the direct connection ramp from NB US 281 to EB Loop 1604 ties in east of the Gold Canyon exit, but due to the bottleneck at the start of the network both alternatives worked well in this area even though the Gold Canyon entrance ramp is forced to merge with the main lanes. This is largely due to the fact that this direct connection has about half the volume than the WB direct connection entry has.

There are no differences in lane or ramp configuration on NB or SB US 281 between the two alternatives. SB US 281 operated very well due to the fact that the volumes on the main lanes are fairly low before the direct connection ramp enters the freeway. Though the direct connection is a two lane ramp at this point, an additional two lanes were provided on SB US 281 to accommodate the ramp, with the fifth lane dropped at the exit for Brookhollow.

There is a bottleneck at the Bitters entrance ramp on NB US 281. The main lanes have over 10,000 vph when this ramp enters the facility and there is only a 1,000 foot weaving distance downstream to the Brookhollow exit. The Brookhollow entrance ramp has a demand volume of over 1,900 vph and the Brookhollow exit ramp's volume is over 1,000 vph. The speed in this weaving section is only 25 mph and the bottleneck extends back to the beginning of the CORSIM model, a distance of approximately mile. The queue would be longer if the model were extended.

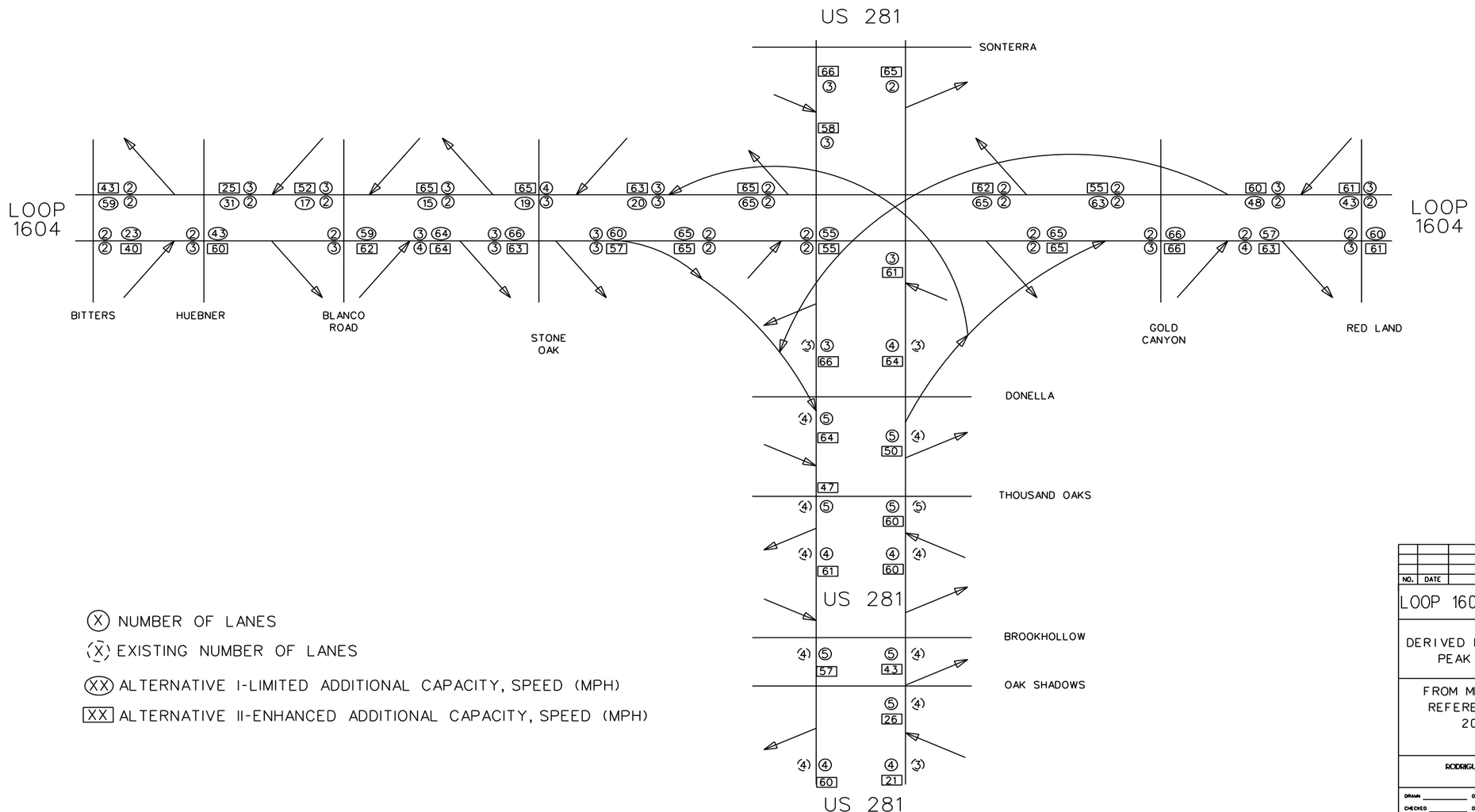
The final item that was analyzed was the determination of the need for either a two lane direct connection exit ramp from EB Loop 1604 to SB US 281. The demand volume for this movement is nearly 2,100 vph in the peak period, which is near the capacity for a one lane ramp. However, due to the bottleneck that occurs at the start of the network only approximately 1,800 vph are able to take the direct connector to SB US 281. CORSIM was used to model both one and two lane direct connection ramps, with a very minor difference in results. With a one lane exit, the speeds at the start of the direct connection ramp are nearly 43 mph, while with a two lane exit ramp the speeds were about 55 mph. However, this speed reduction occurs only at the gore point of the direct connection ramp, with no effects to the main lanes.

Final Results

The results that emerged out the alternative analysis and modeling effort indicated that three lanes were not needed in each direction on EB and WB Loop 1604, because there are two lanes that will either enter or exit at Bitters and Red Land Road. However, it did improve traffic operations to add additional auxiliary lanes to accommodate the additional volumes that would enter EB and WB Loop 1604 because these vehicles will no longer be metered by the traffic signals at the interchange. The resulting preferred alternative that emerged out of the comparative analysis between the two alternatives is shown in Figure 4.

On EB Loop 1604 it was determined that the third auxiliary lane should be added with the addition of the Blanco entrance ramp with the lane terminated at the direct connection exit ramp to SB US 281. Furthermore on EB Loop 1604, a third auxiliary lane would be added with the addition of the NB US 281 direct connection entrance ramp. The Gold Canyon entrance ramp would enter and form a fourth lane. The fourth lane would be terminated at the Red Land Road exit ramp. The third main lane will then be terminated 1,500 feet after the exit to Red Land Road. Due to the low demand volumes this scenario did not appear to cause any type of operational problems; however, further study might be required by taking traffic counts in this area to confirm the traffic operations model. Again, the true demand volumes never reached this area of EB Loop 1604 thus making this section of roadway operate very well.

ALTERNATIVES I AND II
AVERAGE SPEED ACROSS NETWORK



(X) NUMBER OF LANES

(X) EXISTING NUMBER OF LANES

(XX) ALTERNATIVE I-LIMITED ADDITIONAL CAPACITY, SPEED (MPH)

[XX] ALTERNATIVE II-ENHANCED ADDITIONAL CAPACITY, SPEED (MPH)

NO.	DATE	REVISION	APPROV.

LOOP 1604/US 281 INTERCHANGE

DERIVED FROM TP&P TRAFFIC DATA
PEAK HOUR TRAFFIC (VPH)

FROM MEMO DATED 06/15/1998
REFERENCE CSJ: 0253-04-100
2005 AND 2025 ADT

RODRIGUEZ TRANSPORTATION GROUP
CONSULTING ENGINEERS

DRAWN _____ DATE _____ DESIGNED _____ DATE _____
CHECKED _____ DATE _____ SCALE _____

CONTRACT NO. _____ SHEET _____ OF _____

Figure 3: Number of Lanes and Speeds Between Alternatives I & II

The third auxiliary lane on WB Loop 1604 should begin at the Red Land Road entrance ramp instead of the Bulverde entrance ramp, as the benefits of the third auxiliary lane beginning at the Bulverde entrance are not great enough to justify the added length. This third auxiliary lane should be terminated at the direct connection exit ramp.

Finally, on WB Loop 1604, the direct connection ramp would add the third auxiliary lane, the frontage road ramp forced to merge with that third auxiliary lane and the third auxiliary lane being dropped at the Blanco exit. The Blanco exit ramp would be relocated upstream of its present location and the Stone Oak entrance ramp would be located downstream of the Blanco exit ramp. One additional operational improvement would be the construction of an auxiliary lane from the Blanco entrance ramp to the Bitters exit ramp. The addition of the 780 vph that enter from the Blanco entrance ramp creates a volume of approximately 5,300 vph on WB Loop 1604. The merge condition in Alternative I created a major bottleneck that extended back to the direct connection ramp. This auxiliary lane provides additional storage and though queuing still occurs on the main lanes, the queue does not extend back to the direct connection ramp.

Only one at grade interchange was modeled, which was the frontage road intersections at US 281 and Loop 1604. The existing conditions indicate that this interchange operates at LOS F, with approximately 117 seconds of delay per vehicle. The direct connections reduce the delay to approximately 28 seconds per vehicle, which equates to a LOS C. This savings of 90 seconds per vehicle does not sound significant, however it is across every approach at the interchange The delay is not nearly as severe on SB US 281 at Loop 1604 or WB Loop 1604 at US 281. The NB US 281 wait is longer, it is in excess of 300 seconds, and could be longer as the queue extended beyond the limits of the model. .

It is important to quantify the delay in terms of a monetary figure, so that the full impact of saving nearly a minute and half of delay per vehicle can be understood. There were approximately 7,000 vph using the US 281/Loop 1604 diamond interchange, and each vehicle saves nearly 90 seconds, everyday motorists will save nearly 175 hours of delay in one peak hour. Based on the traffic data that was provided the interchange is very busy for most of the day. If we multiply the 175 times 8 hours, motorists in San Antonio will save nearly 1,400 hours of delay per day. Since this interchange is busy on weekends and just weekdays this equates to nearly 511,000 hours of delay every year. Based on the 2007 TTI Urban Mobility Report, the average cost of delay is $14.60 per hour. If we multiply 511,000 hours by $14.60, the total delay savings are in excess of $7 million. Just conservatively though if the interchange is only busy for 6 hours a day for 300 days a year, then the annual savings by reducing congestion will be over $4.5 million.

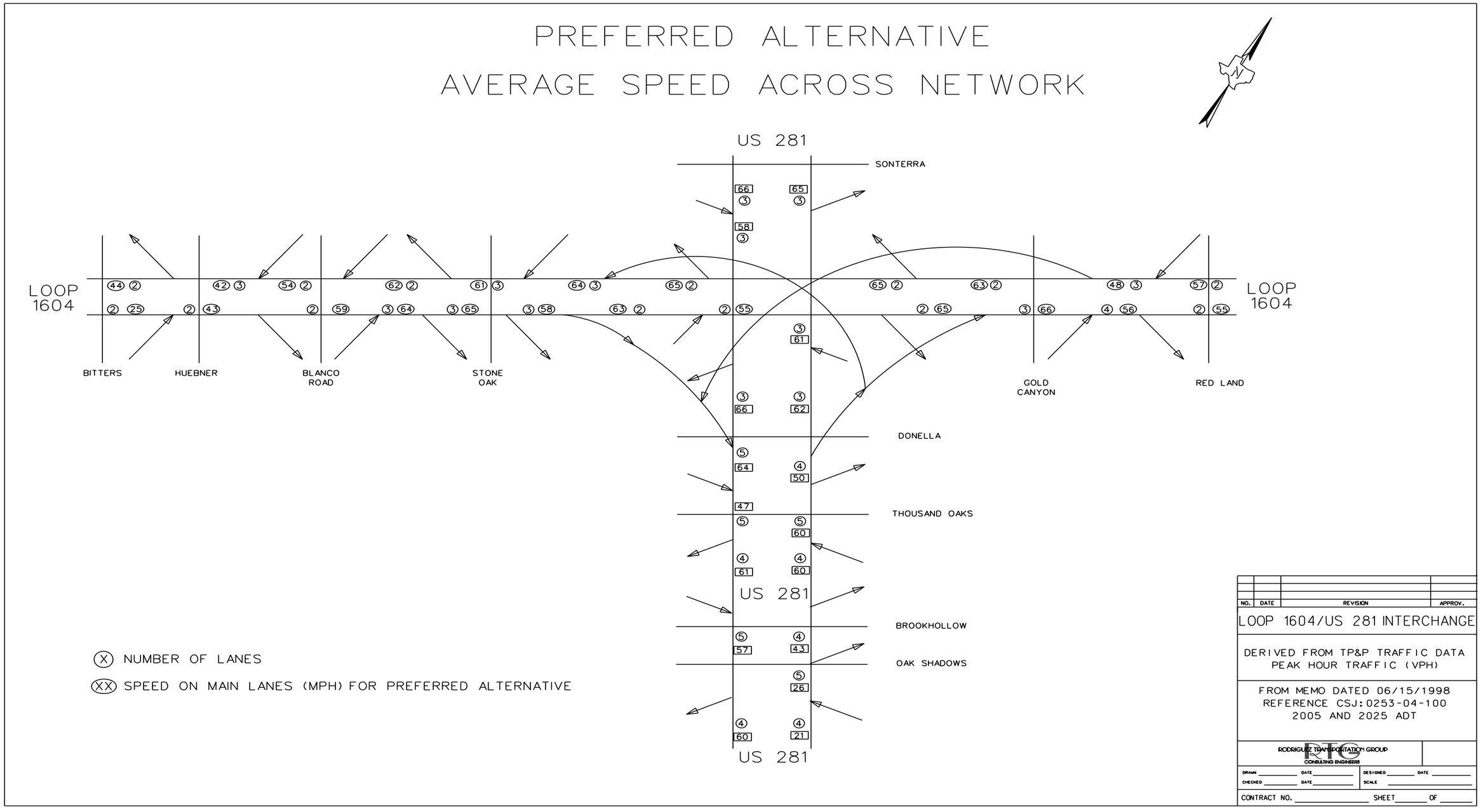


Figure 4: Preferred Alternative—Number of Lanes and Average Speeds

CONCLUSIONS

- There is severe congestion at the interchange of US 281 and Loop 1604. The average vehicle waits approximately two minutes. The delay on NB US 281 is far greater, in excess of 300 seconds during the peak period. There is a safety issue with vehicles queuing back to the main lanes of NB US 281.
- With the addition of the direct connection ramps the average vehicle's delay will be reduced by nearly a minute and a half per vehicle at the three diamond interchange at US 281 and Loop 1604. Furthermore, the cost savings associated with this reduced delay will save San Antonio motorists $4.5 million, conservatively.
- There will need to be added improvements on EB and WB Loop 1604 to accommodate the additional volumes from the direct connection ramp. They are currently being metered by the diamond interchange, but that will not be the case once the direct connection ramp are constructed.
- The NB and SB main lanes of US 281 at Thousand Oaks will need to be restriped to accommodate a fifth lane in each direction so that traffic operations will not be negatively affected by the direct connection ramps.
- On EB Loop 1604 an auxiliary lane is recommended between the Blanco entrance ramp and the proposed direct connection exit ramp. An auxiliary lane is also recommended on EB Loop 1604 at the entrance of the NB US 281 direct connection ramp, with the terminus of this lane occurring near Red Land Road.
- On WB Loop 1604 an auxiliary lane should be added at the Red Land Road entrance ramp and terminated at the direct connection exit ramp. Further downstream (West of US 281) on WB Loop 1604 a third auxiliary lane should be added by the NB US 281 direct connection entrance ramp. The existing frontage road ramp should be merged. The third auxiliary lane should be terminated at the Blanco exit ramp which will be relocated to the east of the Stone Oak entrance ramp. An auxiliary lane should also be constructed from the Blanco Road entrance to the Bitters Road exit.
- The direct connection exit ramp from EB Loop 1604 to SB US 281 can operate at a very high level of service with just one lane, *assuming* that only two lanes are on EB Loop 1604. If Loop 1604 is expanded, it is recommended that a two lane direct connection ramp should be constructed.
- It should also be noted that the capacity of Loop 1604 is constrained by the fact that there are only two main lanes in each direction east and west of the modeled area, if and when additional capacity is added to the through lanes of Loop 1604 the operations of the modeled area are likely to differ.