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# SIGNAL WARRANT ANALYSIS

PROPOSED U.S. 287 BYPASS,  
LAMAR, COLORADO

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## 1.0 EXECUTIVE SUMMARY

The *Manual of Uniform Traffic Control Devices 2000* (MUTCD 2000) contains eight (8) nationally recognized traffic signal warrants that are, collectively, thought of as a starting point for determining whether or not a traffic signal should be considered to improve existing or anticipated traffic conditions. The warrants take into consideration such factors as vehicular and pedestrian traffic volumes, travel speed and accident data, and the physical characteristics of the intersection. Generally, traffic signals should not be installed unless one or more of these signal warrants are met.

Signal warrant analysis was completed for the proposed U.S. 287 bypass of Lamar, Colorado. The bypass would connect to existing portions of U.S. 287 at locations north and south of Lamar. Access to U.S. 50 east of the city would also be provided.

Analysis was conducted with respect to interchange design recommendations at the north, east, and south junctions of the proposed bypass. The east and south interchange recommendations contain only free movements. Hence, signal warrant analysis was conducted solely at the north interchange of the proposed bypass.

The recommended interchange north of Lamar is a standard diamond design with intersections at the north and south crossroad terminals. Signal warrant analysis was conducted at both of these locations.

Existing Highway 196 and U.S. 50/287 are the primary roadways at the north and south intersections. Minor roadways are composed of westbound and eastbound off and on-ramps from existing U.S. 50/287 and the proposed U.S. 287 bypass. Signal warrant analysis was completed in part using anticipated 2025 turning movement volumes. A summary of the warrant results at the north and south intersections follows:

**Table 1**  
**Traffic Signal Warrant Analysis Results: North Intersection Summary**

Warrant No.	Warrant Title	Satisfied
1	Eight-Hour Vehicle Volume	No
2	Four-Hour Vehicle Volume	No
3	Peak Hour	No
4	Pedestrian Volume	No
5	School Crossing	No
6	Coordinated Signal System	No
7	Crash Experience	No
8	Roadway Network	No

**Table 2**  
**Traffic Signal Warrant Analysis Results: South Intersection Summary**

<b>Warrant No.</b>	<b>Warrant Title</b>	<b>Satisfied</b>
1	Eight-Hour Vehicle Volume	No
2	Four-Hour Vehicle Volume	No
3	Peak Hour	No
4	Pedestrian Volume	No
5	School Crossing	No
6	Coordinated Signal System	No
7	Crash Experience	No
8	Roadway Network	No

It was determined that the north intersection will not meet any signal warrants under anticipated 2025 operating conditions. Similarly, it is anticipated that the south intersection will not meet any traffic volume warrants with the application of a right turn reduction for the eastbound movement. Signal installation is therefore not recommended at these locations under anticipated 2025 traffic conditions. However, traffic volumes and other signal warrant factors should be monitored at these locations following construction.

## 2.0 INTRODUCTION

This report summarizes the process and results of a traffic signal warrant analysis conducted by Kirkham Michael Consulting Engineers. Analysis was completed for the proposed U.S. 287 bypass of Lamar, Colorado. The bypass would connect to existing portions of U.S. 287 at locations north and south of Lamar. Access to U.S. 50 east of the city would also be provided.

Analysis was conducted with respect to interchange design recommendations at the north, east, and south junctions of the proposed bypass. The east and south interchange recommendations contain only free movements. Hence, signal warrant analysis was conducted solely at the north interchange of the proposed bypass.

The proposed interchange is located approximately 1/4 mile north of Lamar between the Amity Canal and the Vista Del Rio Ditch. The interchange would provide access to existing U.S. 50/287 west and south of the facility. Access to Highway 196 and the proposed bypass would be provided at north and east legs of the interchange respectively. The location of the proposed interchange is displayed in Figure 1.

The proposed north interchange is a standard diamond design with intersections at north and south crossroad terminals. Signal warrant analysis was conducted at both of these locations in accordance with the Manual on Uniform Traffic Control Devices 2000, (MUTCD 2000).

### 2.1 Purpose

The purpose of this analysis is to determine if traffic signals are warranted and appropriate at two intersections of a recommended interchange alternative north of Lamar, Colorado. Analysis was completed in part with anticipated 2025 turning movement volumes at each intersection. Likewise, existing and anticipated development conditions near the interchange were utilized in the evaluation.

### 2.2 Background

Signal warrant analysis was completed in support of the traffic analysis portion of the interchange evaluation for the proposed U.S. 287 bypass. Analysis was completed to determine if signals are deemed appropriate at two intersections of the recommended north interchange alternative.

### **3.0 ANTICIPATED CONDITIONS**

#### **3.1 Roadway and Intersection Conditions**

Two intersections were evaluated to determine if traffic signals are warranted for anticipated 2025 traffic volumes at a proposed diamond interchange north of Lamar. Refer to Figure 2 for anticipated AM, noon, and PM traffic volumes and lane configurations at each intersection.

Highway 196 composes the north and south legs of the north intersection. The road is anticipated to be a two-way two-lane facility with 12-ft lanes and paved shoulders. The posted speed limit for this roadway is anticipated to be 55 mph at the intersection.

The westbound off-ramp from the proposed bypass and the westbound on-ramp to U.S. 50/287 are the east and west legs of the north intersection respectively. Ramps are anticipated to be single lanes. The posted speed limit for the westbound off-ramp is anticipated to be 50 mph, while the on-ramp will provide acceleration for vehicles entering existing U.S. 50/287.

The south intersection will provide access to the eastbound U.S. 287 bypass. The south leg of the intersection is composed of existing U.S. 50/287. It is anticipated that this roadway will be divided with two lanes in each direction. However, one lane is terminated in each direction north of the intersection, where the roadway meets Highway 196. The posted speed limit on existing U.S. 50/287 south of the intersection is anticipated to be 35 mph. It is anticipated that the speed limit north of the intersection on Highway 196 will be increased to 55 mph. Curb and gutter will be absent on all roadway approaches at this intersection.

East and west legs of the south intersection are composed of the eastbound on-ramp to the proposed U.S. 287 bypass and the off-ramp from existing U.S. 50/287. Ramps are anticipated to be single lanes with a posted speed limit of 50 mph.

#### **3.2 Adjacent Land Use**

Currently, land near the site of the proposed interchange facility is generally undeveloped and primarily used for agricultural purposes. Growth in and around Lamar is anticipated to be minimal and follow historical trends. No known projections indicate any anticipated interruption from past growth patterns. It was assumed that land use will remain constant though the 2025 analysis period, with land near the interchange remaining largely undeveloped.

#### **3.3 Nearby Signalized Intersections**

A critical factor in the determination if whether or not a traffic signal should be installed at a particular location is the proximity of other signalized intersections. Signals spaced too closely together often result in poor traffic progression and unnecessary driver delay. Signal spacing of a quarter mile to a half-mile is preferred.

Currently, no signalized intersections are located near the site of the proposed interchange. Land use near the facility is anticipated to remain constant, with no future signalized intersections existing near those intersections under analysis.

**Figure 2 - Intersection Configuration**

### 3.4 Vehicular Traffic Volumes

Anticipated turning movement traffic volumes using the proposed interchange in the year 2025 were necessary for signal warrant analysis. Turning movement volumes in this report were obtained from analysis conducted by CH2MHill using a travel demand forecasting model. A license plate origin-destination survey and traffic counts in and around the City of Lamar were used in the development of this model. Population and employment growth rates in and around the city were then used to determine year 2025 traffic volumes and turning movements. The model was used to estimate average daily traffic (ADT) as well as anticipated AM, noon, and PM peak hour volumes. Refer to the technical memorandum *Summary of Data Collection, Travel Demand Forecasting Model Development, and Traffic Results for the U.S. 287 at Lamar Project* for a more in depth explanation of forecasting methods and procedures.

Results of the forecasting model with the addition of the proposed U.S. 287 bypass indicate that the north intersection will accommodate approximately 8,700 vehicles per day. It is anticipated that approximately 12,800 vpd will utilize the south intersection in the year 2025.

### 3.5 Accident History

No applicable accident information is available since intersections at the site of the proposed interchange have not yet been constructed.

## 4.0 TRAFFIC SIGNAL WARRANT ANALYSIS

Using anticipated future conditions, a traffic signal warrant analysis was conducted for two intersections at an interchange of the proposed U.S. 287 bypass north of Lamar. Analysis was completed in accordance with the *Manual on Uniform Traffic Control Devices 2000*, (MUTCD 2000).

The MUTCD contains eight (8) nationally recognized traffic signal warrants that are, collectively, thought of as a starting point for determining whether or not a traffic signal should be considered to improve existing or anticipated traffic conditions. Warrants take into consideration factors related to traffic operation and safety at the study location. The following warrants were examined in accordance with the MUTCD 2000:

- Warrant 1, Eight-Hour Vehicular Volume
- Warrant 2, Four-Hour Vehicular Volume
- Warrant 3, Peak Hour
- Warrant 4, Pedestrian Volume
- Warrant 5, School Crossing
- Warrant 6, Coordinated Signal System
- Warrant 7, Crash Experience
- Warrant 8, Roadway Network



It should be noted that these warrants are only a starting point and that traffic signal control is, generally speaking, not a “cure-all” solution. Furthermore, traffic signal installation can lead to a net reduction in both the operational efficiency and the safety of an intersection. Therefore, it is important that the analyst consider how the intersection fares against the criteria of each of the traffic signal warrants before making an installation recommendation. In light of this, analysis was conducted for both intersections with respect to MUTCD warrants. A description and the results of each warrant test follows.

**4.1 Warrant 1: Eight-Hour Vehicular Volume**

Warrant 1 applies where a large volume of intersecting traffic is a primary reason for consideration of a traffic signal. It is likewise intended for application in cases where high traffic volumes on a major street contribute to excessive delay on an intersecting minor roadway. A traffic signal should be considered if one of the following two conditions is met for each of the highest 8 hours in an average weekday:

**Table 3: Eight-Hour Volume Warrant Requirements**

**Condition A- Minimum Vehicular Volume**

# Of Lanes On Each Approach		Minimum Volume Required To Meet Warrant (vph)	
Major Street	Minor Street	Major Street	Minor Street
1	1	350	105
2 or more	1	420	105
2 or more	2 or more	420	140
1	2 or more	350	140

**Condition B- Interruption of Continuous Traffic**

# Of Lanes On Each Approach		Minimum Volume Required To Meet Warrant (vph)	
Major Street	Minor Street	Major Street	Minor Street
1	1	525	53
2 or more	1	630	53
2 or more	2 or more	630	70
1	2 or more	525	70

It is anticipated that warrant 1 will not be met at the north intersection. Although only the anticipated AM, noon, PM, and daily 2025 traffic volumes were estimated at this location, minor road traffic volumes during each of the peak hours do not meet volume requirements set forth by either Condition A or Condition B. It is therefore reasonable to assume that minor road volumes will not be met for eight other off-peak hours of the day.

The Eight Hour Volume warrant is anticipated to be met during the AM, noon, and PM peak traffic hours at the south intersection. It is difficult to determine if warrant conditions will be met during five other off-peak hours of the day. However, it is anticipated that approximately 90% of eastbound minor road traffic during each peak hour is composed of right-turning vehicles at this location. Peak hour traffic volumes do not meet minor road warrant conditions when a right turn

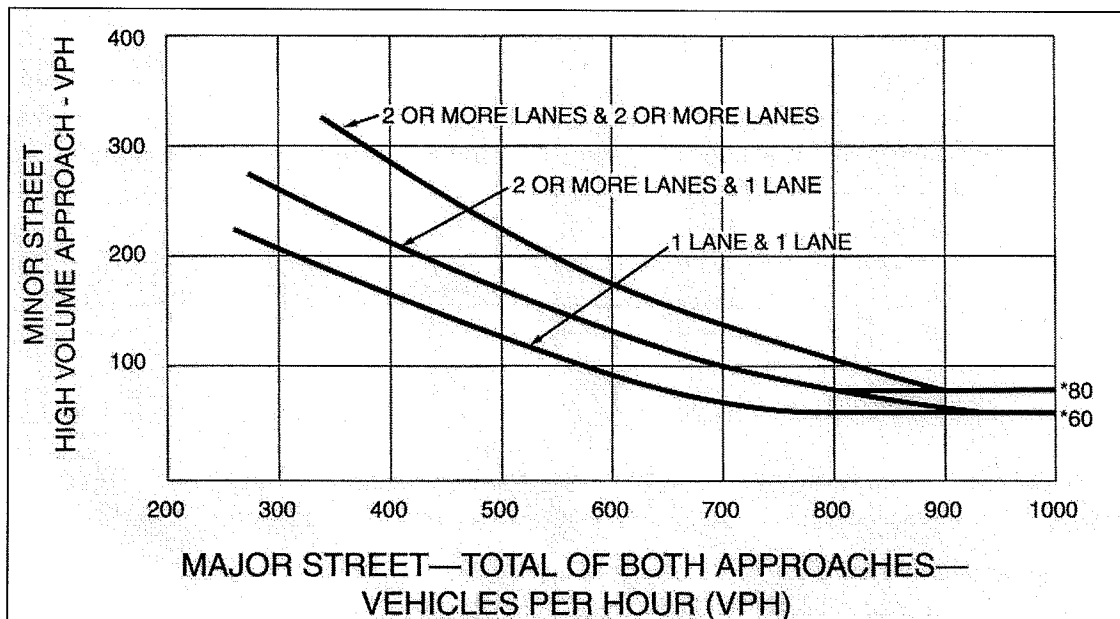
reduction is applied to the eastbound movement. Furthermore, most major-road through traffic is northbound, creating no conflicts between the primary traffic movements at this location.

Due to the difficulty of accurately estimating traffic volumes for eight distinct hours of a typical day more than 20 years into the future, this warrant is not considered applicable at this location. Furthermore, anticipated minor road traffic volumes during three peak hours of the day do not meet warrant conditions when a right turn reduction is applied.

**4.2 Warrant 2: Four-Hour Vehicular Volume**

Warrant 2 conditions are applied when the volume of intersecting traffic is the primary reason that signal installation is considered. This warrant is met when, at each of any 4 hours of an average weekday, approaching traffic volumes exceed a minimum determined primarily by lane configuration. The following curves are used to determine if the Four Hour Volume warrant is met.

**Figure 3: Four-Hour Volume Requirements**



(Figure 4c-2, 2000 MUTCD)

Year 2025 traffic volumes at the north intersection are not anticipated to meet the minimum conditions for signal consideration set forth by Warrant 2. Minor road volumes at this location during the AM, noon, and PM peak hours do not meet minimum conditions. It is not anticipated that minor street volumes will be met during four other off-peak hours at this location.

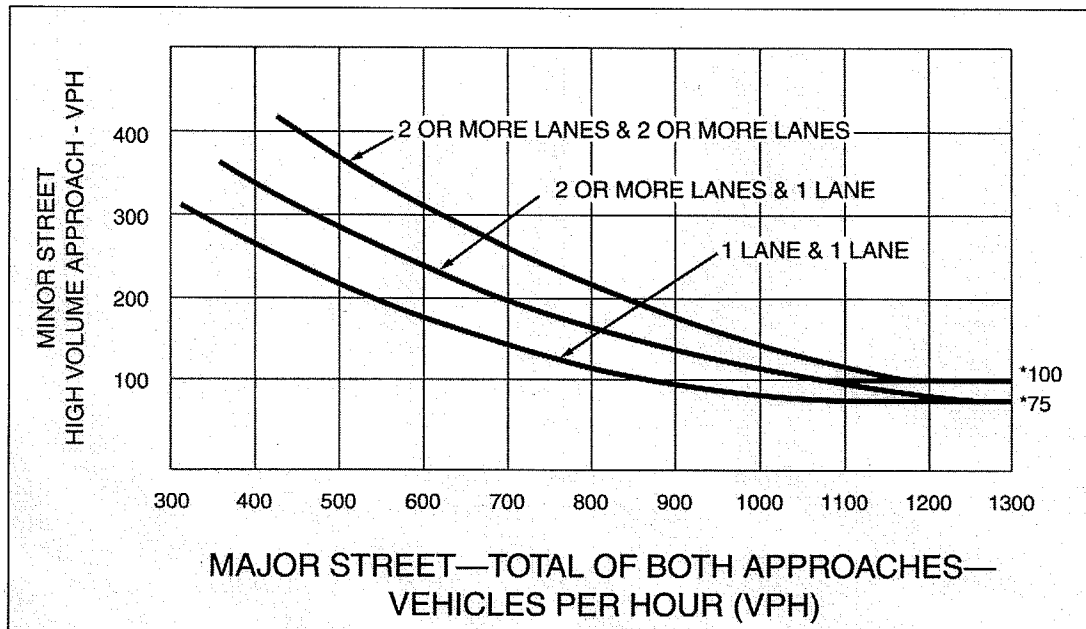
The Four-Hour warrant is met for each of the three anticipated peak hour volumes at the south intersection. It is reasonable to assume that conditions will also be met during one non-peak hour of the day. However, minor road peak hour volumes at this location do not meet warrant conditions when a right-turn reduction is applied. Furthermore, it should again be noted that the major traffic movements at this location are not anticipated to conflict.

4.3 Warrant 3: Peak Hour

The Peak Hour signal warrant is intended for use at locations in which high traffic volumes on a major street contribute to excessive delay on an intersecting minor street. This warrant is satisfied if during 1 hour of an average day either one of the two following conditions are met:

- Condition 1: The total stopped delay on the minor street approach exceeds four vehicle-hours and, the volume exiting the minor street approach exceeds 100 vehicles per hour and, the total volume entering the intersection during the peak hour exceeds 650 vph.
- Condition 2: The plotted points representing vehicles per hour on the major street and the corresponding vehicles per hour on the higher volume minor-street approach fall above the appropriate curve:

Figure 4: Peak-Hour Volume Requirements



(Figure 4c-4, 2000 MUTCD)

Results of the analysis show that Condition A is not met during the anticipated PM peak hour at the north intersection. The total stopped time delay experienced by westbound traffic at the off-ramp is anticipated to be minimal. Although the total entering volume at this intersection exceeds 650 vehicles, 100 total vehicles per hour are not anticipated to exit the off-ramp during the peak hour.

Based on anticipated turning movement volumes, Condition B is also not met. The plotted points representing the volumes on the major and minor approaches are not above the curve shown in Figure 4. Warrant 3 for signal installation is not met at the north intersection.

It is anticipated that Condition A will not be met at the south intersection during the 2025 peak hour. Although the minor street approach exceeds 100 vph and the entering volume during the

peak hour is anticipated to exceed 650 vehicles, the total delay experienced by eastbound motorists at the intersection is anticipated to be minimal.

Condition B is met with respect to anticipated traffic volumes at the south intersection. However, approximately 90% of the eastbound minor-road traffic volume at this location is composed of right-turning vehicles. Minor road volume conditions are not met when right turn reduction is applied to the eastbound movement at this location.

#### ***4.4 Warrant 4: Pedestrian Volume***

The pedestrian warrant is for application in the event that the traffic volume on the major street is so heavy that pedestrians experience excessive delay trying to cross the roadway. The warrant is satisfied if the pedestrian volume crossing the major street exceeds 100 persons for each of any 4 hours or 190 persons during any 1 hour of an average weekday. Likewise, the condition must be met that 60 or fewer gaps in traffic are counted that allow pedestrians to cross the major street during the same period when the pedestrian volume criterion is satisfied.

It is reasonable to assume that anticipated minimal development near the proposed interchange location will lead to low pedestrian volumes at both intersection locations. Subsequently, it is anticipated that this warrant will not be met at either location.

#### ***4.5 Warrant 5: School Crossing***

Warrant 5 is for application in areas where school children cross the major roadway. The warrant is satisfied based on the number of gaps in the traffic stream and the number and size of the groups of children crossing the major roadway. A minimum of 20 students must cross the major roadway during a period in which the number of adequate crossing gaps is less than the number of minutes in the same period.

It is anticipated that school crossings will be absent at both intersections. Therefore, it is anticipated that conditions for Warrant 5 will not be met at either location.

#### ***4.6 Warrant 6: Coordinated Signal System***

The signal system warrant is applicable in situations where installing a traffic signal is needed in order to maintain proper platooning of vehicles.

Traffic signals are not anticipated near either intersection along the proposed bypass. Therefore, Warrant 6 is not considered applicable.

#### ***4.7 Warrant 7: Crash Experience***

Warrant 7 is satisfied if adequate countermeasures have been installed and have failed to reduce the crash frequency and five or more crashes susceptible to correction by a traffic signal have occurred within a 1 year period. Furthermore, for 8 hours of an average day, traffic volumes must exceed a minimum value determined primarily by the lane configuration of intersection approaches.

No applicable accident information is available since intersections at the site of the proposed interchange have not yet been constructed. Warrant 7 is not considered applicable.

**4.8 Warrant 8: Roadway Network**

The roadway network warrant is applicable at intersections of two major roadways. A major roadway is defined as being part of a street and/or highway system, and is a major route on an official city, county or state transportation plan.

Ramps are not defined as major roadways by CDOT or the City of Lamar. Therefore, the criteria for Warrant 8 is not met.

**5.0 CONCLUSIONS AND RECOMMENDATIONS**

Year 2025 traffic conditions at the north intersection of the proposed interchange are not anticipated to satisfy the criteria for installation of traffic signals. Traffic volumes at this intersection are not anticipated to cause excessive delay or vehicle conflict. Furthermore, installation of a traffic signal at this location is not anticipated to improve traffic operation or the overall safety of the intersection. Results of the signal warrant analysis at this location are displayed in Table 5 below.

Traffic conditions at the south intersection of the proposed interchange are also not anticipated to satisfy the criteria for signal installation. Installation of a traffic signal at this location is not anticipated to improve traffic operations or the overall safety of the intersection.

It should be noted that the south intersection is anticipated to meet the Four Hour and Peak Hour Volume warrants for signal installation when the total minor-road traffic volume is applied. However, minor road volume is significantly minimized through application of a right turn reduction at this location. The high volume of eastbound right turns and a relatively low volume of conflicting southbound through vehicles are anticipated to result in minimal vehicle conflict at the intersection. Results of the traffic signal warrant analysis at the south intersection of the proposed interchange is displayed in Table 6.

**Table 5**

**Traffic Signal Warrant Analysis Results: North Intersection Summary**

<b>Warrant No.</b>	<b>Warrant Title</b>	<b>Satisfied</b>
1	Eight-Hour Vehicle Volume	No
2	Four-Hour Vehicle Volume	No
3	Peak Hour	No
4	Pedestrian Volume	No
5	School Crossing	No
6	Coordinated Signal System	No
7	Crash Experience	No
8	Roadway Network	No

**Table 6**

**Traffic Signal Warrant Analysis Results: South Intersection Summary**

<b>Warrant No.</b>	<b>Warrant Title</b>	<b>Satisfied</b>
1	Eight-Hour Vehicle Volume	No
2	Four-Hour Vehicle Volume	No
3	Peak Hour	No
4	Pedestrian Volume	No
5	School Crossing	No
6	Coordinated Signal System	No
7	Crash Experience	No
8	Roadway Network	No

Signal installation is not recommended at either intersection under anticipated 2025 traffic conditions. However, it is recommended that traffic volumes and other signal warrant factors be monitored at these locations following construction.