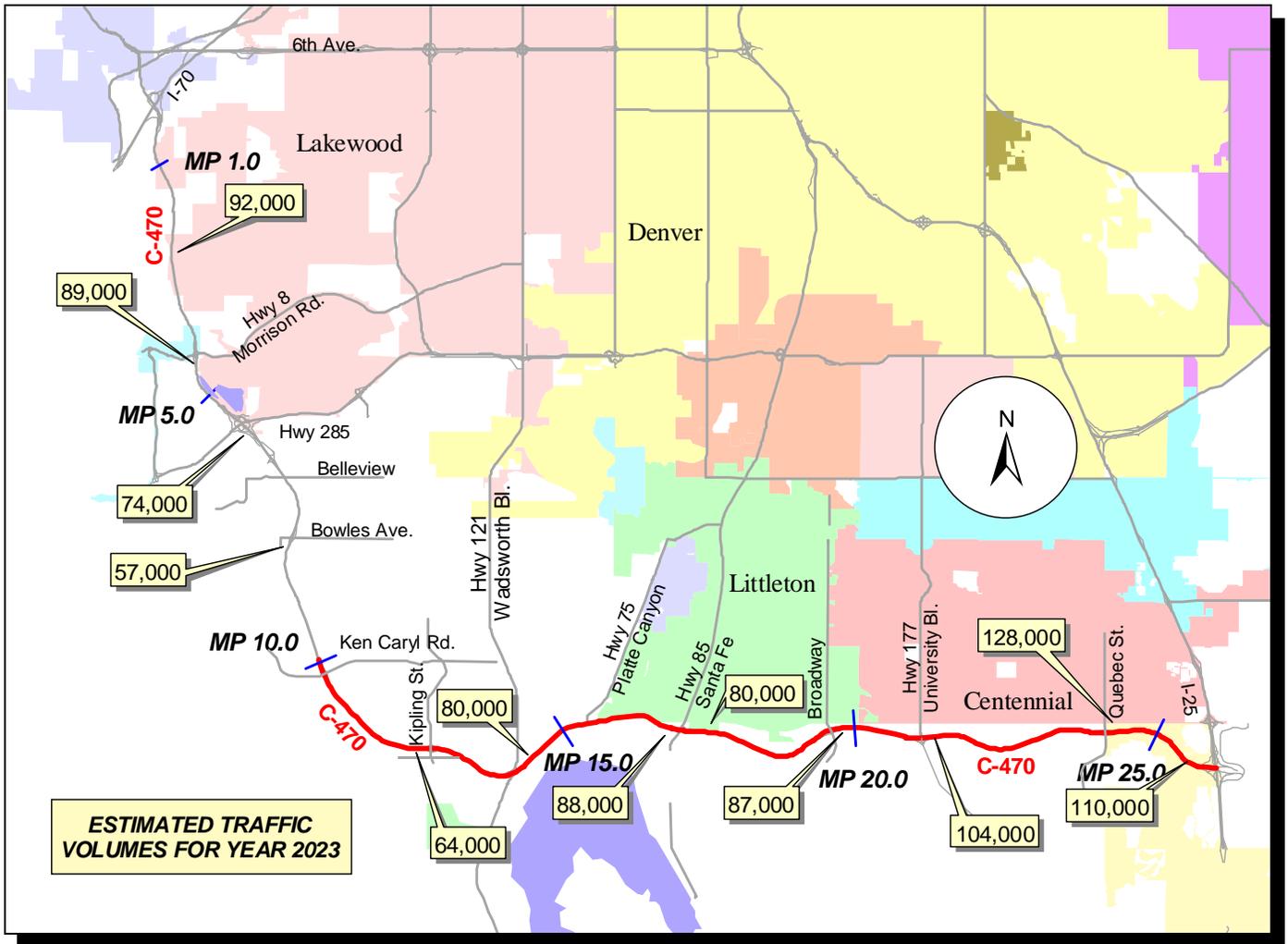


Figure 2: C-470 Location Map and Mainline Volume (Estimated 2023 ADT)

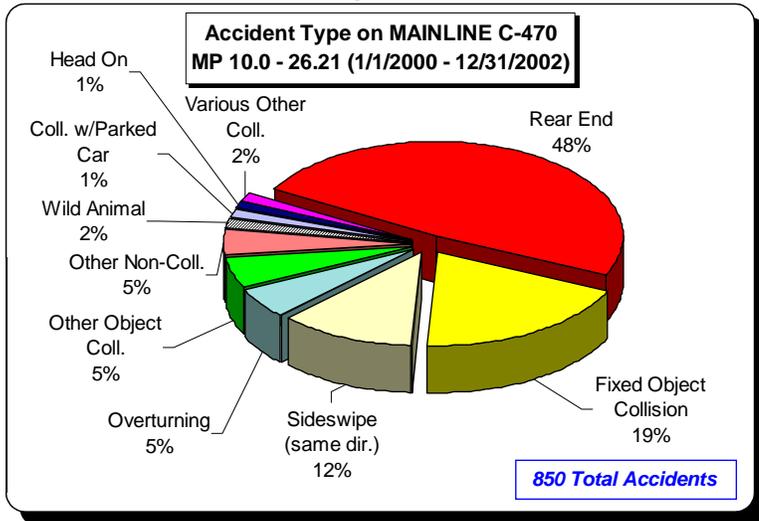


The twenty year projections for traffic growth suggest an increase in volume of 20% - 30% may be expected along the study segment. Currently, highway users experience congested conditions, unnecessary delay and increased crash potential in several locations during peak morning and afternoon volume periods. Drivers at interchange merge-diverge zones contending with the increased vehicle density and reduced maneuvering room of peak hours initiate disruptions in the traffic stream that inevitably cause breakdown in the overall traffic flow and rapid backups. Without additional capacity, these conditions can only be expected to worsen with increased future freeway usage.

Accident History and Problem Analysis

The accident history for the period of January 1, 2000 through December 31, 2002 was examined to identify the accident type distribution profile. Approximately 1,565 accidents occurred within the study corridor during the 3 year study period. This includes those accidents reported on the crossing streets and ramps within interchanges.

Figure 3a



On an accident severity basis, this 3 year total includes:

Property Damage Only (PDO) crashes:
1,140 or 73% of the total

Injury (INJ) crashes:
417 or 27% of the total

Fatal (FAT) crashes:
8 or 0.5% of the total

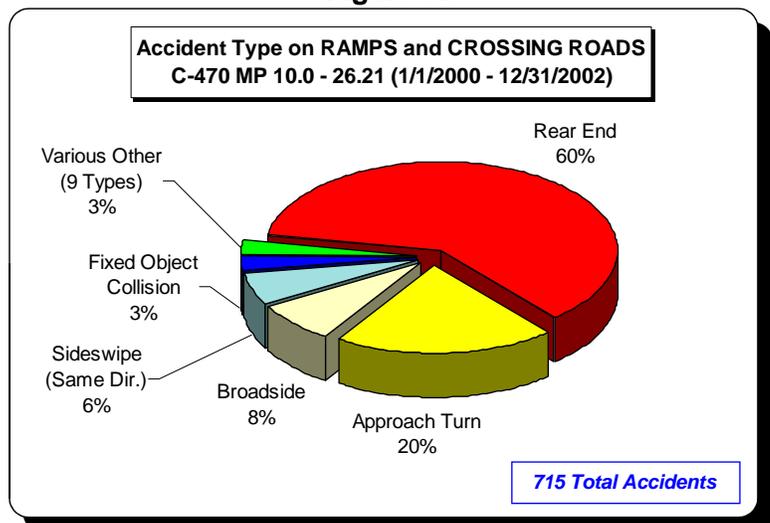
Of the eight fatal accidents, most (7) involved eastbound at-fault vehicles and three crashes involved alcohol. Three of these fatal accidents, occurring between MP 14.97 and 15.1, involved eastbound vehicles crossing the median in the vicinity

of a highway curve. Two fatal collisions occurred between MP's 23 & 24. The Region is installing a cable rail median barrier within this general area.

Figures 3 show accident types and proportions detected over the 3 year study period. Figure 3a presents the distribution profile by accident type for the mainline segment of C-470 while figure 3b details the type of accidents occurring on interchange cross streets and ramps.

Rear end collisions are the predominant accident types on both the mainline and interchange locations of the C-470 corridor. Collisions of this type typically imply the existence of congested traffic circumstances resulting from capacity limitations on the existing highway. The higher fraction of approach turn and broadside type accidents shown in Figure 3b also reflects intersection-related conflicts associated with the ramp intersections at interchanges.

Figure 3b



Observed safety issues related to freeway **segments** (not those occurring at interchange ramps or crossing roadways) will be examined in the following section of this study. Similarly, an examination of safety problems associated with the included interchanges will follow separately.

FREEWAY SEGMENTS

Safety Performance Function Analysis

We have refined the assessment of the magnitude of safety problems on freeway segments through the use of Safety Performance Functions (SPF). The SPF reflects the complex relationship between traffic exposure, measured in ADT, and accident count for a unit of road section measured in accidents per mile, per year. The SPF models provide an estimate of the normal or expected accident frequency and severity for a range of ADT among similar facilities. Two kinds of Safety Performance Functions were calibrated. The first one addresses the total number of accidents and the second one looks only at severe accidents or those involving an injury or fatality. SPFs allow us to assess the magnitude of the safety problem from a frequency and severity standpoint.

All of the dataset preparation was performed using the Colorado Department of Transportation (CDOT) accident databases. Accident history for various facilities was prepared over a period of 13 years. Average Daily Traffic (ADT) for each roadway segment for each of the 13 years was entered into the same dataset. Figure 4 illustrates how the dataset was prepared for urban freeway facilities.

Figure 4



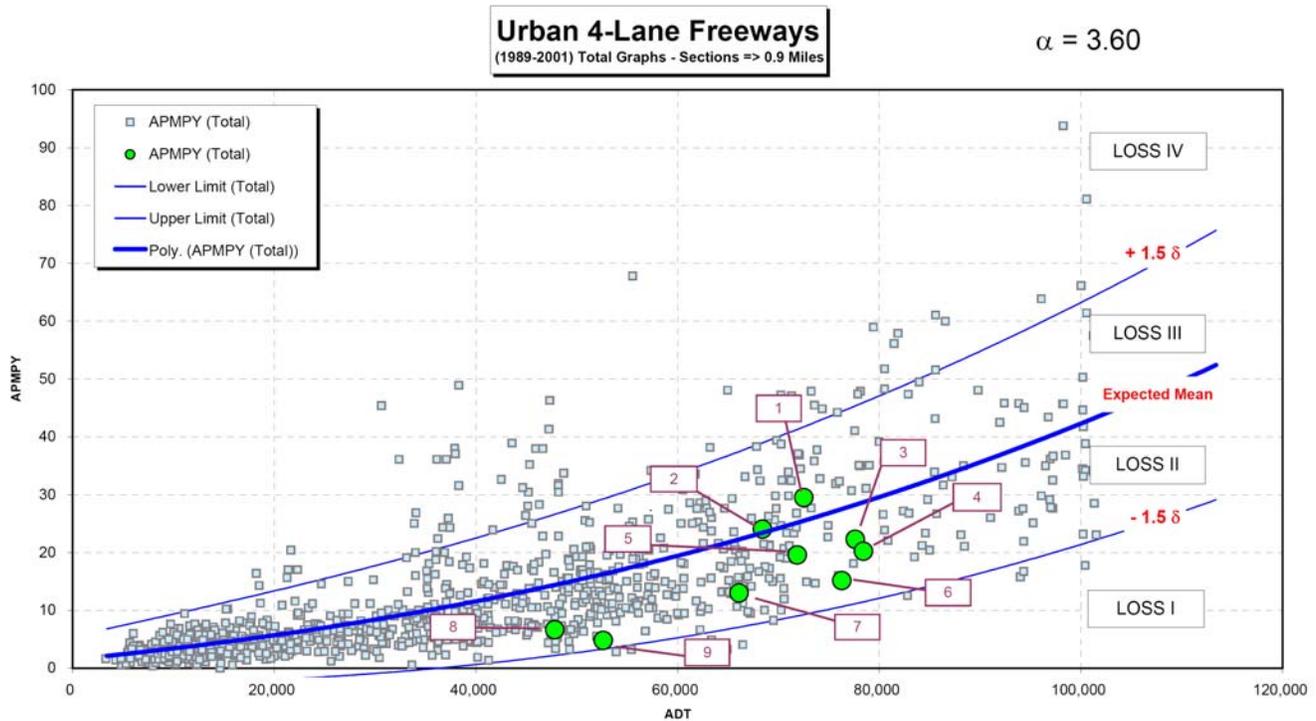
Development of the SPF lends itself well to the conceptual formulation of *Level of Service of Safety* (LOSS). The level of service concept uses qualitative measures that characterize the safety of a roadway segment referenced to expected performance and severity. If the level of safety predicted by the SPF will represent a normal or expected number of accidents at a specific level of ADT, then the degree of deviation from the norm can be stratified to represent specific levels of safety.

- LOSS-I - Indicates low potential for accident reduction
- LOSS-II- Indicates better than expected safety performance
- LOSS-III - Indicates less than expected safety performance
- LOSS-IV - Indicates high potential for accident reduction

Gradual change in the degree of deviation of the LOSS boundary line from the fitted model mean reflects the observed increase of variability in accidents/mile as ADT increases. This increase is consistent with a negative binomial error structure and reflects over-dispersion typical of this highway environment. Possible explanation for the over-dispersion in the urban freeway dataset may be the influence of different ramp volumes on the freeway safety performance. LOSS reflects how the roadway segment is performing in regard to its expected accident frequency and severity at a specific level of ADT. It only provides an accident frequency and severity comparison with the expected norm. It does not, however, provide any information related to the nature of the safety problem itself. If a safety problem is present, LOSS will only describe it's magnitude from a frequency and severity standpoint. The nature of the problem is determined through diagnostic analysis using direct diagnostic and pattern recognition techniques.

Figure 5 depicts the SPF calibrated specifically for all or *total accident* occurrence on urban 4-lane freeways. Data for three years of accident history (averaged together) on C-470 has been partitioned into nine separate segments, each including one interchange, and plotted for evaluation. The total accident SPF and inj+fat accident SPF analyses (shown in Figure 6) describe the magnitude of safety problems from a frequency and severity standpoint.

Figure 5: SPF for Total Accidents

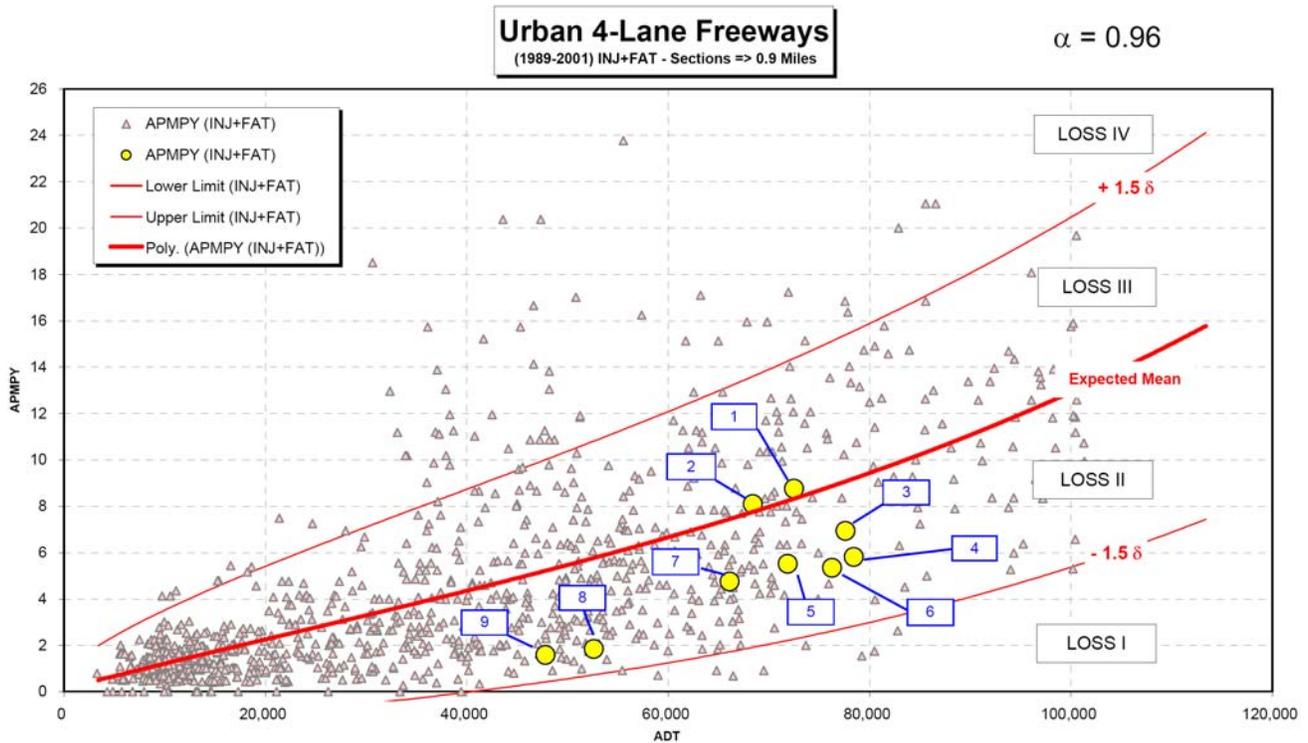


#	Location
1	MP 16.13 - 17.69, Includes Santa Fe Interchange Area.
2	MP 17.70 - 19.09, Includes Lucent Blvd. Interchange Area.
3	MP 22.63 - 24.88, Includes Quebec St. Interchange Area.
4	MP 24.89 - 26.21, Includes I-25 Interchange Area.
5	MP 19.10 - 20.30, Includes Broadway. Interchange Area.
6	MP 20.31 - 22.62, Includes University Blvd. Interchange Area.
7	MP 13.17 - 16.12, Includes Wadsworth & Platte Canyon (SH's 121 & 75) Interchange Areas
8	MP 9.03 - 11.34, Includes Ken Caryl Rd. Interchange Area.
9	MP 11.35 - 13.16, Includes Kipling Pkwy. Interchange Area.

From figure 5, it can be observed that most sections of mainline C-470 operate in the LOSS II zone (better than expected safety performance when compared with similar facilities). This is not unexpected as this highway is of comparatively recent construction and was designed to an interstate standard. Closer review indicates short segments near the Santa Fe Dr. interchange (SPF test location 1 above) and Lucent Blvd. interchange (SPF test location 2) exhibit recent total accident frequency levels in the LOSS III envelope which is slightly worse than expected for this type of highway. Figures 7, below, show the accident type breakdown for several of the SPF locations plotted in the above graph. In general, the observed SPF recorded on C-470 parallels the statewide model at the present user level with the few noted exceptions.

Figure 6 depicts the SPF graph calibrated for *injury and fatal accidents only* on urban, 4-lane freeways. Similar to the result for *total accident* frequency, we note that the majority of the corridor operates at a LOSS II level with slightly higher crash occurrence near the Santa Fe and Lucent Blvd. interchanges (locations flagged 1 & 2 below).

Figure 6: SPF for Injury and Fatal accidents



Legend

- | # | Location |
|---|--|
| 1 | MP 16.13 - 17.69, Includes Santa Fe Interchange Area. |
| 2 | MP 17.70 - 19.09, Includes Lucent Blvd. Interchange Area. |
| 3 | MP 22.63 - 24.88, Includes Quebec St. Interchange Area. |
| 4 | MP 24.89 - 26.21, Includes I-25 Interchange Area. |
| 5 | MP 19.10 - 20.30, Includes Broadway. Interchange Area. |
| 6 | MP 20.31 - 22.62, Includes University Blvd. Interchange Area. |
| 7 | MP 13.17 - 16.12, Includes Wadsworth & Platte Canyon (SH's 121 & 75) Interchange Areas |
| 8 | MP 11.35 - 13.16, Includes Kipling Pkwy. Interchange Area. |
| 9 | MP 9.03 - 11.34, Includes Ken Caryl Rd. Interchange Area. |