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High Collision Concentration Location: Table C Evaluation and Recommendations




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# High Collision Concentration Location: Table C Evaluation and Recommendations

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**California PATH Research Report**
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Final Report for Task Order 6215

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CALIFORNIA PARTNERS FOR ADVANCED TRANSIT AND HIGHWAYS

# HIGH COLLISION CONCENTRATION LOCATION

## TABLE C EVALUATION AND RECOMMENDATIONS

PREPARED FOR

Caltrans

Task Order 5215-6215

PREPARED BY

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Traffic Safety Center
Setting New Directions in Traffic Safety

CALIFORNIA PATH

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# Abstract

This report describes the research work that was conducted to improve the effectiveness and consistency of methods for identifying High-Concentration Collision Locations (HHCL) within the California State Highway System that have collision frequencies significantly greater than expected when compared to other locations. The accuracy and reliability of HCCL reports are critical as the outcome of the screening process is the basis for follow-up field investigation as well as potential safety improvements. During the course of the project, the research team from the Traffic Safety Center (TSC) and California Partners for Advanced Transit and Highways (PATH) of University of California at Berkeley conducted extensive literature reviews and surveys, and interacted with a number of out-of-state agencies and experts to gather the latest information and techniques regarding HCCL. The primary findings and conclusions are summarized in the report with recommendations for potentially addressing and improving the process of identifying HCCL.

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- Nevada DOT: http://www.geoplace.com/uploads/FeatureArticle/0505ta.asp

# GLOSSARY OF ACRONYMS

| | |
|---|---|
| **AADT** | Average Annual Daily Traffic |
| **ADT** | Average Daily Traffic |
| **CHP** | California Highway Patrol |
| **CM** | Countermeasure |
| **CRP** | Continuous Risk Profile |
| **EB** | Empirical Bayes |
| **EPDO** | Equivalent Property Damage Only (Method) |
| **FHWA** | Federal Highway Administration |
| **GIS** | Geographical Information System |
| **HCCL** | High-Concentration Collision Locations |
| **LOS** | Level Of Service |
| **PATH** | California Partners For Advanced Transit And Highways |
| **PCF** | Primary Collision Factor |
| **PDO** | Property Damage Only |
| **SHS** | State Highway System |
| **SHSIP** | Strategic Highway Safety Implementation Plan |
| **SPF** | Safety Performance Function |
| **SWITRS** | Statewide Integrated Traffic Records System |
| **TASAS** | Traffic Accident Surveillance And Analysis System |
| **TSC** | University Of California, Berkeley Traffic Safety Center |
| **TSN** | Transportation System Network |
| **VMT** | Vehicle Miles Traveled |

# 1 EXECUTIVE SUMMARY

This report describes the research work that was conducted under PATH Task Order 5215 and its extension, Task Order 6215, "Methods for Identifying High-Concentration Collision Locations (HCCL)." The subject matter is related to regularly published Caltrans reports, entitled Table C, that are used to screen for locations within the California State Highway System that have collision frequencies significantly greater than expected when compared to other locations. The accuracy and reliability of such reports are critical as Table C is the basis for follow-up field investigation as well as potential safety improvements.

In recent years, a Caltrans Table C Task Force reviewed the practices of Table C and subsequently made recommendations for improvements based on feedback from the users of such reports. Some immediate revisions were made to correct certain issues addressed by the Task Force. However, it was clear from the review that a more thorough research effort should be made to hone methodologies to carry out the screening and identification of HCCL, so that the overall execution of safety investigation and safety improvements performed over the California state highway network can be more efficient and consistent. This project arises from the need to address these issues.

During the course of the project, the research team from the Traffic Safety Center (TSC) and California Partners for Advanced Transit and Highways (PATH) of University of California at Berkeley conducted extensive literature reviews and surveys, and interacted with a number of out-of-state agencies and experts to gather the latest information and techniques regarding HCCL. The issues involving HCCL are broad, encompassing a wide range of spatial and temporal parameters. Furthermore, the methodologies deserve to be investigated in depth as there are numerous logistical, mathematical and statistical details that may affect the outcome of Table C.

## PRIMARY FINDINGS AND RECOMMENDATIONS

The primary findings and conclusions are summarized in the report with recommendations for potentially addressing and improving the process of identifying HCCL. These findings and recommendations are organized into seven categories (Table 1):

## TABLE 1:
## CATEGORIES OF ISSUES ADDRESSED IN THIS REPORT

| |
|---|
| **PHYSICAL STRUCTURE OF ANALYSIS UNITS—WHAT IS A SITE?** |
| • Should Analyses Be Conducted Within Categories Of Locations Or Should All Locations Be Compared Together? |
| • If Analyses Are To Be Conducted Using Rate Groups, How Should Rate Groups Be Defined? |
| • Segmentation Within Categories (Fixed Window, Moving Fixed Window, Variable Window, Continuous) |
| **TEMPORAL STRUCTURE OF ANALYSIS** |
| • Length Of Time Used To Calculate The Base Rate |
| • Length Of Time Used To Estimate Risk At A Specific Site |
| • Frequency With Which The Analysis Is Conducted |
| **CHOICE OF OUTCOME(S)** |
| • Expected Frequency Versus Observed Frequency Compared To Expected Frequency (Excess Frequency) |
| • Weighting By Level Of Severity (PDO, Injury, Fatality) |
| • Analyses By Different Collision Types |
| **CRITERIA FOR SELECTION OF LOCATIONS** |
| • Table C Method |
| • Empirical Bayes (EB) |
| • Safety Performance Function (SPF) |
| • Continuous Risk Profile (CRP) |
| **FORMAT AND CONTENT FOR REPORTING SITES** |
| • Information Provided (e.g., Highway, Non-Highway, and Collision Factors) |
| • Integrated Data System |
| **DATA QUALITY** |
| • Implications For Highway Inventory |
| • Traffic Volume |
| • Collision Data |
| **APPROACHES OTHER THAN SITE-SPECIFIC APPROACHES** |
| • Individual Sites Versus Types Of Sites |
| • Corridors |

Various levels of resources are required to implement the recommendations made in this report. Some minor issues can be addressed with no changes to the current Table C and require minimum programming efforts, such as fixing data errors or eliminating double counting of collisions. Other issues require in-depth evaluation and significant resources, such as re-categorization of rate groups or adjustments of statistical approaches in screening HCCL. Specific observations and recommendations are summarized below.

## 1.1 PHYSICAL STRUCTURE OF ANALYSIS UNITS —WHAT IS A SITE?

### 1.1.1 SHOULD ANALYSES BE CONDUCTED WITHIN CATEGORIES OF LOCATIONS OR SHOULD ALL LOCATIONS BE COMPARED TOGETHER?

**TABLE C:**

The current Table C procedure for selecting sites involves comparing individual sites to the average of all sites within a particular subgroup called a "rate group."

**OBSERVATIONS:**

- The process of identifying HCCLs involves comparing individual sites to the average of all sites within that rate group, however, the average varies substantially among different rate groups.
- The result is "local" optimization but probably not "global" optimization.
- Some of the rate groups have a very small number of member sites, leading to instability in determining HCCLs.
- Causal factors and countermeasures vary substantially among different roadway categories, so there may be important reasons for conducting analyses within individual categories of sites.

**RECOMMENDATIONS:**

- Study the implication of local optimization (determine the extent to which local optimization precludes global optimization). This can be done by comparing:
  - the rates and number of collisions identified by Table C as HCCLs to those that would be chosen within the group of sites as a whole.
  - the cost and effectiveness of treatments within different rate groups.
- Consider separately the relevance of each dimension that is used, or could be used, to define rate groups. Each dimension defining rate groups should be justified in terms of one or more of the reasons given above.

### 1.1.2 IF ANALYSES ARE TO BE CONDUCTED USING RATE GROUPS, HOW SHOULD RATE GROUPS BE DEFINED?

**TABLE C:**

In Table C, the most important such characteristic is site (intersection, ramp, roadway). Other characteristics further define categories, know as "rate groups."

**OBSERVATIONS:**

- Virtually every approach to defining HCCLs divides the roadway into separate categories.
- The rationale for the particular structure used for Table C has never been formally defined beyond the necessity of comparing "apples to apples."
- Cost and effectiveness of countermeasures may not be equal across different categories.

**RECOMMENDATIONS:**

- Review variables that define rate groups and determine which, if any, can be eliminated. Maintain categories that meet basic criteria.
- Review variables that currently do not define rate groups and determine which, if any, should be added.
- Examine differences in outcome across different rate groups.
- Develop formal rationales for roadway categories based on similarities in type of traffic flow and collision patterns.
- Consolidate rate groups with fewer than 100 members.
- Determine how the effectiveness and cost of each countermeasure (CM) may vary across rate groups.

### 1.1.3 SEGMENTATION WITHIN CATEGORIES (FIXED WINDOW, MOVING FIXED WINDOW, VARIABLE WINDOW, CONTINUOUS)

**TABLE C:**

Table C uses a "sliding window" approach in which a 0.2 mile window is moved in increments of 0.02 mile.

**OBSERVATIONS:**

- There are various ways to establish site segmentation which include: an entire road section, segments of fixed length, and the Table C moving window approach, which employs a moving frame of 0.2 mile.
- The use of a 0.2 mile segment may mask locations where risk is spread over different lengths.

- For highway segments, a method called Continuous Risk Profile (CRP), which detects risk locations of various lengths shows promise in determining high collision sites.

**RECOMMENDATIONS:**

- Avoid using segments of too long or too short a length, which can mask variations or produce unstable estimates.
- For highway segments test the CRP method as an alternative to the moving fixed window approach.

## 1.2 TEMPORAL STRUCTURE OF ANALYSIS

### 1.2.1 LENGTH OF TIME USED TO CALCULATE THE BASE RATE

**TABLE C:**

Base rates are calculated using data from a three year period.

**OBSERVATIONS:**

- If a rate group has a sufficient number of member sites, three years should be sufficient to provide stable estimates of base rates.

**RECOMMENDATIONS:**

- Maintain a three year period.
- Evaluate trends over an extended period of time to determine if there is "drift" in underlying base rates.

### 1.2.2 LENGTH OF TIME USED TO ESTIMATE THE RISK AT A SPECIFIC SITE

**TABLE C:**

Table C analysis is run quarterly to capture rapid changes in highway safety. If a location has more than four accidents and is found statistically significant during the last 3, 6 or 12 months, then inspection is required.

**OBSERVATIONS:**

- The current method, and most other methods used assume that risk is constant over time and they are not designed to detect changes in risk over time.
- Any time period less than a year may be too short to yield a stable estimate of HCCL, no matter how the estimate is calculated. One year is adequate for sites with high volume but may not be adequate for sites with low volume.

**RECOMMENDATIONS:**

- Eliminate estimates based on any time period less than one year.
- For all sites, use a method proposed by Ezra Hauer to determine stability of estimates and to determine whether the time period should be one year, two years, or three years.
- Utilize a method recommended in SafetyAnalyst for determining changes in risk. This should be applied to all sites on a quarterly basis, particularly to sites that are experiencing other changes.

### 1.2.3 FREQUENCY WITH WHICH THE ANALYSIS IS CONDUCTED

**TABLE C:**

The Table C Report is generated quarterly.

**OBSERVATIONS:**

- The survey conducted by the Table C Task Force indicated that Caltrans users of the Table C report are in favor of having a quarterly report, as opposed to a biannual or yearly report.
- For identifying differences in risk when risk is presumed to be constant, a quarterly report is probably unnecessary and is more likely to produce false positives due to random events with respect to the site.

**RECOMMENDATIONS:**

- The Table C report should be produced quarterly.
- An analysis to simply detect a difference between an actual count and an expected count for similar locations should be done only on a yearly basis.
- Other quarters could include reports on sub-topics, particularly analyses of potential changes in risk.

## 1.3 CHOICE OF OUTCOME(S)

### 1.3.1 EXPECTED FREQUENCY VERSUS OBSERVED FREQUENCY COMPARED TO EXPECTED FREQUENCY (EXCESS FREQUENCY)

**TABLE C:**

Table C uses observed compared to expected frequency; i.e., excess frequency.

**OBSERVATIONS:**

- Most approaches to identifying HCCLs compare observed collision frequency to expected collision frequency. It has been argued that using expected frequency will result in a higher benefit-cost ratio. The argument for using expected frequency depends on the assumption that cost and effectiveness of a given countermeasure are constant over sites.

**RECOMMENDATIONS:**

- Review existing literature for information bearing on cost and effectiveness of countermeasures over different types of sites within broad categories where the same countermeasure is relevant.
- Consider approaches that would focus on expected frequency (as opposed to excess frequency).

### 1.3.2 WEIGHTING BY LEVEL OF SEVERITY (PDO, INJURY, FATALITY)

**TABLE C:**

Table C treats collisions of all severities with equal weight.

**OBSERVATIONS:**

Many approaches to identifying HCCLs weight collisions by severity, with weighting increasing for PDO, injury, and fatality collisions. This approach has two major flaws:

- Since fatality is rare, if fatality is weighted too heavily it creates instability in the estimates.
- It assumes that collisions of different severity are similarly distributed across locations. In fact, PDO, injury, and fatal collisions have substantially different distributions. We have noted that the distribution of fatal and severe injury appear more closely related to one another than to minor injury or PDO.

**RECOMMENDATIONS:**

- Conduct analyses of California data to determine the site-distribution of collisions of different severity.
- Depending on the results of these analyses, consider conducting separate Table C analyses for grouping of different levels of severity.
- Make a relatively small programming change in TASAS to keep the five level severity level of collisions now included in SWITRS. This will make possible grouping appropriate levels of severity in the HCCL analysis as determined above.

### 1.3.3 ANALYSES BY DIFFERENT COLLISION TYPES

#### TABLE C:

Table C combines all types of collisions in the same analysis.

#### OBSERVATIONS:

- Different types of collisions have dramatically different distributions; e.g., run-off-the-road collisions versus rear end collisions.
- Caltrans already has some programs for identifying HCCLs for specific types of collisions; e.g., run-off-road collisions, wet weather collisions.

#### RECOMMENDATIONS:

- Create "Table C" options for specific kinds of collisions. This approach is already used for "wet" highway collisions in order to generate a Wet Table C, which is used to help engineers identify where slippery pavements might be the cause of an unusually high number of collisions. Similar tables could be created for other categories of collisions, such as rear end collisions, DUI collisions, etc.
- Conduct analyses of specific types of collisions, especially those which are fairly high in number and are likely to have a unique distribution and/or which are amendable to specific countermeasures.

## 1.4 CRITERIA FOR SELECTION OF LOCATIONS

### 1.4.1 METHOD FOR CHOOSING HCCLS

#### TABLE C:

Table C lists sites where the observed number of collisions exceeds the 99.5% confidence interval as estimated using a formula. However, for most rate groups this formula assumes that the collision rate (number of collisions per unit of volume) is constant across changes in volume.

#### OBSERVATIONS:

- We reviewed four methods for determining HCCL: the process used for producing Table C ($N_E$), the Safety Performance Function (SPF), the Empirical Bayes (EB) method, and a newly developed method called the Continuous Risk Profile (CRP).
- It is almost universally acknowledged that rate is not a constant across changes in traffic volume. We have confirmed from analyzing empirical data that there is a non-linear relationship between rate and volume within a number of rate groups.

- As described above, a function showing the relationship between volume (and other factors) and number of collisions; i.e., SPF combined with the EB method will almost certainly improve estimates of expected collisions. One potential issue regarding the use of SPFs for highway segments is spatial correlation of collision clusters, especially along freeway segments.
- For highway segments CRP shows promise for identifying high collision sites and does not require changes to the current Caltrans collision database.

**RECOMMENDATIONS:**

- Discontinue use of the current Table C formula used to calculate the expected number of collisions.
- For intersections, ramps, and highway segments test the SPFs and EB methods.
- For highway segments, test the CRP method.

## 1.5 FORMAT AND CONTENT FOR REPORTING SITES

### 1.5.1 INFORMATION PROVIDED (E.G., HIGHWAY, NON-HIGHWAY, AND COLLISION FACTORS)

**TABLE C:**

A Table C report of potential investigation locations includes the following information: location (postmile and route), rate group, total accidents in 36, 24, 12, 6 and 3 months, ADT, rate (per million vehicles or per million vehicle miles traveled), and whether investigation is required or simply recommended.

**OBSERVATIONS:**

- Some states; e.g., Colorado provide a much more complete set of information about HCCL sites.
- Table C is generated based on data from AADT database, which contains significantly more information than currently included in the Table C report.
- Current procedure does not require quantifying the benefit of the countermeasures that have already been installed as a result of Table C investigation.

**RECOMMENDATIONS:**

- Expand the Table C report to include:
    - collision patterns.
    - comparison of collision patterns to other similar sites; e.g., within the same rate group.
    - trends over time at the site compared to overall trends at similar sites.

- additional information that could be derived from TASAS or otherwise linked to type of site and collision pattern.

### 1.5.2 INTEGRATED DATA SYSTEM

#### TABLE C:

The Table C report provides limited data only in a list format.

#### OBSERVATIONS:

- Table C is distributed as an isolated report with no apparent systematic follow-up.
- Providing Table C reports within the context of a broader data system may facilitate use and provide tracking capability.

#### RECOMMENDATIONS:

- Develop an integrated data system within which the Table C report is generated.
- The integrated data system would include:
  - maps of Table C locations.
  - information on collision patterns available by pointing to and clicking on a site.
  - tracking information including: results of investigation, installation of countermeasures, and evaluation, such as pre-post-collision history.

## 1.6 DATA QUALITY

TASAS provides three primary types of data: highway and inventory, volume, and collision data. The detailed description of these variables is provided in Appendix B as shown in the Transportation System Network (TSN), TSAR reference card. Completeness and quality of data clearly impact HCCL identification.

### 1.6.1 HIGHWAY INFRASTRUCTURE

#### TABLE C:

The State Highway System (SHS) includes more than 15,000 miles of highways, 14,000 ramps and 18,000 intersections. Variables include characteristics of different types of sites:

- Standard fields (functional classification, highway group, etc.)
- Highway fields (lanes and other design features)
- Intersection fields (configuration, traffic control device, etc.)
- Ramps fields (configuration)

**OBSERVATIONS:**

- Relatively minor issues include missing design information, overlapping sites (intersections within 250 feet of one another) and double listings. These may well be accounted for in Table C programming.
- A more important issue is the small number of sites for some rate groups.
- Important types of information are omitted, such as curvature and slopes for highway segments. Sites within rate groups with features such as sharp curves and slopes tend to have higher collision frequencies than other sites without these characteristics within the same rate groups.

**RECOMMENDATIONS:**

There are at least several potential solutions:

- One approach is to identify the upstream and downstream directions of the roadway and assign collisions to the upstream or downstream intersection only when it is recognized that a second intersection is within a specified distance. This should eliminate the double counting problem.
- Another method involves the re-categorization of site types and an overhaul of rate groups. For example, if intersections are treated as "segments" of a continuous roadway, then the calculation of safety performance will depend on the use of the chosen methods in screening and identifying HCCL on a continuous highway segment.

### 1.6.2 VOLUME DATA

**TABLE C:**

Traffic volume data are obtained from Traffic Data Office (in Traffic Operations). AADT are available for all intersections, ramps, and roadway segments. AADT is calculated once per year for the period of October 1 through September 30. Volume data is collected at all sites on a rotating basis once every three years.

**OBSERVATIONS:**

- Data are often out of date and many data points are interpolated.
- Some values are missing or out-of-range.
- There is possible bias in volume estimates due to limited sampling.
- Does not account for the effect of variation in traffic demand by time of day and day of the week.

**RECOMMENDATIONS:**

Check TASAS database based on some of the results given previously:

- Add missing sites if appropriate.

- Screen sites with no accidents over a long period of time for closed roads or non state-managed roads (additional statistical criteria may be used to reduce number of sites to check).
- Check traffic volume information for sites with missing, incorrect or out-of-range values.
- Create methodology for checking TASAS data.
- Create feedback loop from Table C to TASAS to reduce number of errors.
- Improve quality of traffic information data and reduce underreporting rate value and variance. For traffic volumes, it would be beneficial to consider two traffic volume fields, begin_adt and end_adt, if Table C can be made compatible with this update.
- Set up ongoing system to monitor quality of volume data and make improvements.
- Develop statistical model of volume data to facilitate projects, interpolations, etc.

### 1.6.3 COLLISION DATA

#### TABLE C:

Collision data are obtained from the California Highway Patrol (CHP) from a database called SWITRS, which is intended to include all police-report traffic collisions in the state. Collision data are extracted by CHP from the SWITRS database and contain information about collision characteristics and parties involved, coded by CHP, as well as site location, coded by Caltrans. Between 1994 and 2004, more than 1,800,000 accidents were recorded on California state highways.

#### OBSERVATIONS:

SWITRS is an extremely valuable source of information for analyzing traffic collision patterns in the State of California and it is very well maintained and documented. However, analyses of SWITRS data indicate three primary issues:

- Underreporting of collisions, especially PDO and minor collisions.
- Information about location and movement preceding collision that is internally inconsistent or out-of-range.
- Missed identification and underestimation of expected accident frequency.
- Inaccurate location information, for example overlapping sites, inaccurate direction, non-existent intersections.

**RECOMMENDATIONS:**

- Perform systematic range and missing value checks.
- Prepare reports on out-of-range and missing data as feedback to CHP and other police agencies.
- Test models of extrapolation and interpolation.

## 1.7 APPROACHES OTHER THAN SITE-SPECIFIC APPROACHES

### 1.7.1 INDIVIDUAL SITES VERSUS TYPES OF SITES

**TABLE C:**

Table C is currently designed to identify specific sites, such as intersections, ramps, and 0.2 mile segments.

**OBSERVATIONS:**

- Methods such as Table C focus on comparing sites with common characteristics to sites which have a high number of collisions. Such sites have one or more characteristics that differentiate them from the other sites, often design characteristics that may in fact appear in other sites which also have a high number of collisions. Possible examples include access points on limited access HOV lanes, and excess collisions on freeway lanes near ramps.

**RECOMMENDATIONS:**

- Statistical models such as the SPF, EB, and CRP methods should be developed to identify patterns of collisions related to various design features.

### 1.7.2 CORRIDORS

**TABLE C:**

Table C focuses on individual sites and does not consider the effects of adjacent sites.

**OBSERVATIONS:**

- In some cases, HCCLs are adjacent to or near one another.
- In some cases, a series of segments (or intersections) show such a low density that a Table C HCCL identification would not be made. However, these could amount to a high density of collisions if segments longer than 0.2 mile, or clusters of intersections were observed. An example is a rural roadway with relatively high traffic and a high cumulative number of collisions spread somewhat uniformly along an extended section of roadway.

- There are several methods for identifying sites longer than 0.2 mile or for identifying clusters of specific sites, such as intersections.

**RECOMMENDATIONS:**

All of the following methods are feasible within the context of the current TASAS data system.

- Develop statistical methodology for identifying corridors using, for example, a “sliding window” of different lengths.
- Develop a method for looking at segments of different lengths (e.g., 1⁄2 mile segments). This is being developed in the context of developing the 5% report for the Strategic Highway Safety Implementation Plan (SHSIP).
- Examine traffic density in “natural” segments; i.e., segments between intersections or exchanges.
- Plot collisions using Geographical Information System (GIS) so that collision patterns can be linked with the wealth of GIS-based information; e.g., satellite photos, population distribution, weather patterns, etc.

# 2 BACKGROUND

## 2.1 TABLE C

There are approximately 190,000 reported collisions on California state routes annually. One of the department's goals is to reduce the number and severity of these collisions. To help achieve this goal, each quarter the Department publishes "Table C," a list of high concentration collision locations (HCCL). There are 170 traffic safety investigators in Caltrans who review approximately 10,000 locations annually. Roughly 700 improvements are initiated annually as a result of the HCCL program. Traffic investigators also receive an annual "Wet Table C" that identifies high wet pavement collision concentration locations.

Table C makes use of the Traffic Accident Surveillance and Analysis System (TASAS) database, which provides information about the highway network, such as design characteristics and traffic volumes, as well as a history of police reported accidents. Across California, more than 15,000 miles of state highways, 14,000 ramps and 19,000 intersections are detailed in the Highway Database. Information is obtained and updated by reviewing construction plans and consulting with district TASAS coordinators

The data in TASAS are distributed into four different tables. The first three provide the description and design characteristics of the highway sites studied, classified as segments, intersections, and ramps (Highway Database). The fourth table provides detailed information about all accidents reported by the police during a period of about 10 years (Collision Database).

## 2.2 CALTRANS REVIEW OF TABLE C

In 2002 Caltrans completed a review of the HCCL investigation process and made the following short-term and long-term recommendations.[1]

### 2.2.1 SHORT-TERM TABLE C RECOMMENDATIONS

**Identify And Eliminate Repeat Locations**

Repeat locations are defined as 100% the same postmile limits as any "required" location identified during the previous three quarters. Repeat locations will be screened out and will not be included in the list sent to the districts for investigations.

**Identify and Eliminate Overlap Locations**

An overlap location is defined as an overlapping segment of 51% to 99.99% with any "required" location identified during the previous three quarters. Overlap locations will be screened out and not sent to the districts

[1] Caltrans Table C Task Force Summary Report of Task Force's Findings and Recommendations. September, 2002.

**Combine Adjacent Highway Locations**

These locations are defined as highway segments adjacent to one another. The adjacent locations will be combined in the report to the districts and analyzed in a single investigation. Combined locations will not exceed one mile in length.

**Send Out Only "Required" Locations**

Only those locations marked with a "Req" will be sent to the districts

**Update Intersection Traffic Volume**

Update intersection traffic volume

**Eliminate TASAS Programming Converting Of Injury Severity Levels**

Eliminate the programming routine in TASAS that converts the five injury severity levels received from SWITRS into three levels.

### 2.2.2 LONG-TERM TABLE C RECOMMENDATIONS

**Modify The Selection Criteria**

Minimum number of collisions and statistical significance threshold should be evaluated.

**Weigh The Severity Of Collisions**

Include fatal, injury, and property damage collisions only (consider weighing the severity as Fatal, Severe Injury, Visible Injury, Complain of Pain, PDO). This would provide a means to combine Fatal + SI or Complain of Pain +PDO and come up with more reasonable distribution of injury levels. Consider prioritization of investigations by collision severity.

**Analyze The Segment By Collision Or Revise Length**

Should the selection of location be made on the number of collisions and/or collision rate and not constrained by the segment length of 0.2 mile?

From this review, and in light of the long-term recommendations, Caltrans initiated Task Order 5215-6215 with the California Partners for Advanced Transit and Highways (PATH) and the University of California, Berkeley Traffic Safety Center (TSC). PATH and TSC proposed to evaluate the methodologies used for the identification of high-concentration collision locations.

# 3 THE CURRENT REPORT

## 3.1 BASIC TASK

This project evaluates existing methods used by Caltrans to generate Table C with the aim of improving Caltrans' current procedures and identifying attributes of Table C that can be improved.

## 3.2 STEPS ACCOMPLISHED IN PREPARING THIS REPORT

- **Extensive review of literature (see Appendix E) and interviews with other state DOTs completed August 2005**
- **Extensive consultation with national experts in this area throughout the project period**
- **Sample data analyses using TASAS data, report completed May 2006**
- **Extensive consultation with Caltrans safety personnel throughout the project period**

## 3.3 GENERAL CONSIDERATIONS

It is important to bear in mind that the intent of Table C as currently designed is limited to network screening. Network screening is just one of several steps in a process to identify sites with the greatest potential for improvement. SafetyAnalyst, a comprehensive system being developed by the Federal Highway Administration (FHWA) for identifying and treating high collision sites, includes steps in addition to screening.[2] SafetyAnalyst components are being developed as "tools" for use by practitioners. The tools are shown in Table 2:

[2] SafetyAnalyst: Software Tools for Safety Management of Specific Highway Sites: Task K: White Paper for Module 1-Network Screening. Federal Highway Administration Task No. DTFH61-01-F-00096. December, 2002.

**TABLE 2:**
**SAFETY ANALYST COMPONENTS**

| *Safety Analyst Component* | Description |
|---|---|
| *Network Screening* | Identify sites with potential for safety improvements. |
| *Diagnosis* | Used to diagnose the nature of safety problems at specific sites. |
| *Countermeasure Selection* | Assist users in the selection of countermeasures to reduce accident frequency and severity at specific sites. |
| *Economic Appraisal* | Perform an economic appraisal of a specific countermeasure or several alternative countermeasures for a specific site. |
| *Priority Ranking* | Provide a priority ranking of sites and proposed improvement projects based on the benefit and cost estimates determined by the economic appraisal tool. |
| *Evaluation* | Provide the capability to conduct before/after evaluations of the implementations. |

Combining and coordinating additional components could be a future goal for Caltrans, and SaftyAnalyst could be a framework for achieving this goal. However, the present focus is on the network screening process. Different methods employed for choosing an HCCL will result in different sets of chosen locations. A basic guiding principle throughout this report is that benefit per unit of cost should be maximized. This principle has been articulated by Ezra Hauer as follows: "...money should go where it achieves the greatest effect in terms of saving accidents and reducing their severity." To ignore this principle would mean that it is justified "...to save one accident when, for the same money, more could be saved. Such justifications are not easy to find."[3]

Whether a site or set of sites will yield the "biggest bang for the buck" can only be accurately determined after an onsite investigation. Such an assessment requires an understanding of the characteristics of collisions—particularly a measure of the impact—on a site and an estimate of the effectiveness and cost (in the case of Benefit/Cost) of the countermeasure. Knowledge about the collisions can be gained with some accuracy prior to an onsite investigation. Countermeasure benefits and costs can be accurately determined only after an onsite investigation. Each decision made about selecting HCCLs will impact the benefit/cost ratio, and the aim is to anticipate this as accurately as possible in the screening phase.

The ultimate goal of this process is to choose sites with the most potential for improvement. At this stage of screening it is unknown which sites will ultimately have the largest potential for improvement, and different sites may have varying potential for

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[3] Hauer, E., J. Kononov, B.K. Allery and M.S. Griffith, Screening the road network for sites with promise. Transportation Research Record 1784, pp 27-31 National Academies Press, Washington, D.C.., 2002 http://ca.geocities.com/hauer@rogers.com/Pubs/ScreeningforSWIPs.pdf.

improvement. Our intent is to choose methods and approaches that will increase the likelihood that sites chosen will be those with the greatest potential for improvement.

In the following section we list the major elements of methods for determining HCCLs Each of the following chapters explores these elements in detail. In each case, the guiding principle will be the likelihood that a particular decision will lead to most effective use of highway safety resources.

## 3.4 STRUCTURE AND ORGANIZATION

Approaches to identifying HCCLs can be defined in terms of seven basic issues:

**Physical Structure Of Analysis Units**

- Should Analyses Be Conducted Within Categories Of Locations Or Should All Locations Be Compared Together?
- If Analyses Are To Be Conducted Using Rate Groups, How Should Rate Groups Be Defined?
- Segmentation Within Categories (Fixed Window, Moving Fixed Window, Variable Window, Continuous)

**Temporal Structure Of Analysis**

- Length Of Time Used To Calculate The Base Rate
- Length Of Time Used To Estimate Risk At A Specific Site
- Frequency With Which The Analysis Is Conducted

**Choice Of Outcome(s)**

- Expected Frequency Versus Observed Frequency Compared To Expected Frequency (Excess Frequency)
- Weighting By Level Of Severity (PDO, Injury, Fatality)
- Analyses By Different Collision Types

**Criteria For Selection Of Locations**

- Table C method
- Safety Performance Function (SPF)
- Empirical Bayes (EB)
- Continuous Risk Profile (CRP)

**Format And Content For Reporting Sites**

- Information Provided (e.g., Highway, Non-Highway, and Collision Factors)
- Integrated Data System

**Data Quality**

- Implications For Highway Inventory
- Traffic Volume
- Collision Data

**Approaches Other Than Site-Specific Approaches**

- Individual Sites Versus Types Of Sites
- Corridors

# 4 FINDINGS AND RECOMMENDATIONS

## 4.1 PHYSICAL STRUCTURE OF ANALYSIS UNITS —WHAT IS A SITE?

### 4.1.1 PHYSICAL STRUCTURE OF ANALYSIS

By definition, the process of identifying HCCLs depends on being able to identify specific locations. In California, the state highway system is divided into three major location groups: intersections, ramps, and roadway segments. Each of these major groups is further divided into subgroups (called "rate groups") based on various characteristics. All analyses are conducted independently within rate groups.

**THE MAIN ISSUES OF PHYSICAL STRUCTURE OF ANALYSIS ARE:**

- **Should analyses be conducted independently within rate groups, or should all categories of sites be compared together?**
- **If analyses are to be conducted within rate groups, how should rate groups be defined?**
- **For analyses of roadway segments, how should such segments be subdivided in the analysis?**

### 4.1.2 SHOULD ANALYSES BE CONDUCTED WITHIN CATEGORIES OF LOCATIONS OR SHOULD ALL LOCATIONS BE COMPARED TOGETHER?

The current Table C procedure for selecting sites involves comparing individual sites to the average of all sites within that particular rate group. Taking intersections as an example, a "base rate" for each rate group is derived by calculating the number of collisions per one million vehicles for the entire set of intersections within the rate group. The expected number of collisions for a particular intersection is then calculated by multiplying the base rate by the traffic volume at that intersection. If the actual number exceeds the expected[4] number by a significant amount (see section below on statistical modeling and statistical tests), then the intersection is considered to be an HCCL. For any particular ADT this method maximizes rate since, at that volume, the number of collisions for achieving significance will be reached only if the rate is substantially higher than the base rate for that rate group.

However, base rates vary substantially among different rate groups. One consequence is that, for a particular volume, selected sites identified as HCCL in rate groups with low base rates may have much lower rates, and lower collision frequencies, than sites not

[4] The term 'expected' corresponds roughly to 'average in the long run' as used in the theory of probability. From a statistical sense, it requires freezing all the relevant conditions of a specified time-period, and repeating it many times. For more clarification see Hauer (1997), Observational before-After Studies in Raod Safety, page 25.

selected in rate groups with high base rates. An example is intersections in the "no control" category, which are subdivided into rural, suburban, and urban. The base rates are 0.11, 0.35, and 0.06, respectively, for rural, suburban, and urban (Table 3). In this case, intersections selected in the urban and rural categories are likely to have much lower rates than intersections selected in the suburban category. This means that many suburban intersections with relatively high rates (compared to "no control" intersections in rural and urban areas) will not be selected as HCCLs. There are some intersections in rural areas that are not chosen that have higher risk than the criteria for urban intersections. There are some intersections selected in urban areas that would not be selected if they were in rural areas (Figure 1). Finally, the overall level of risk of selected sites will be lower when selection is done separately for urban and rural intersections.

**TABLE 3:
BASE RATES FOR RURAL, SUBURBAN, AND URBAN INTERSECTIONS
FOR "NO CONTROL" INTERSECTIONS (TYPES F, M, AND S)**

| RATE GROUP | | BASE RATE | + ADT FACTOR | PCT FAT | PCT INJ | PCT F+ I | INTERSECTION TYPE * | CONTROL TYPE | AREA | ACC COSTS ($1000) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | F+ I | ALL |
| I | 01 | 0.11 | 0.0000 | 3.5 | 42.0 | 45.5 | F, M AND S | NO CONTROL | RURAL | 371.4 | 171.2 |
| I | 06 | 0.35 | 0.0000 | 0.8 | 32.3 | 33.1 | F, M AND S | NO CONTROL | SUB-URBAN | 147.9 | 51.6 |
| I | 11 | 0.06 | 0.0000 | 2.6 | 42.8 | 45.4 | F, M AND S | NO CONTROL | URBAN | 249.7 | 115.5 |

The same issue arises when other comparisons are made among other rate groups for intersections and among rates groups for ramps and highway groups (see Appendix A where the list of rate groups in the current Table C method is given).

The approach used in the Table C method, conducting analyses within categories of roadways, can generally be described as "maximizing locally" instead of "maximizing globally." Unless risk, however defined, is spread evenly across rate groups, maximizing locally will inherently result in a suboptimal global maximum.[5] The same issue arises if some other criterion is used to select HCCLs.

It might be argued that global optimization is preferable because it produces the segments that have the highest overall risk, however defined.[6] Nevertheless, there are several factors that suggest maintaining some levels of categorization when evaluating road risk.

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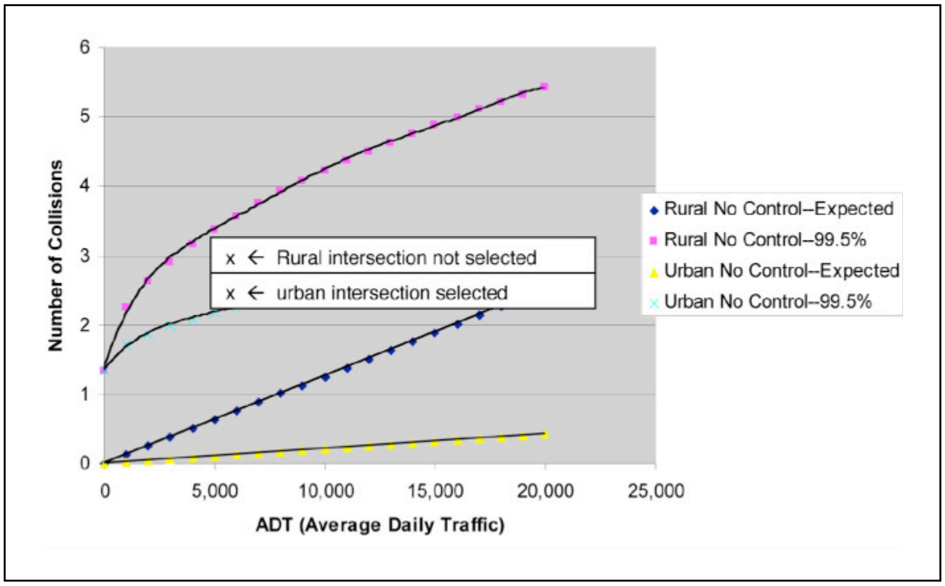
5 The phenomenon can be illustrated in the following way. Suppose that we are asked to put together the best baseball team comprised of members of professional baseball teams in California. Suppose further that we are asked to chose half the players from Major League teams, and the other half from Minor League Teams. This would be optimizing locally (within Major and Minor teams), but certainly would not be optimizing globally (i.e., producing the best possible baseline team).

6 Just as choosing a baseball team from among all professional players in California in a combined group will result in the best team.

**FIGURE 1:
EXPECTED NUMBER OF COLLISIONS AND 99.5% CONFIDENCE INTERVAL
FOR RURAL/NO CONTROL AND URBAN/NO CONTROL INTERSECTIONS**




First, risk across some categories may not be inherently comparable, at least not while using current approaches. For example, risk in intersections is defined in a different way (per entering vehicles) than risk along a roadway segment (per roadway mile or per vehicle mile traveled).

Second, constraints brought about by political considerations or funding streams may dictate that risk be evaluated within categories defined by particular categories. One example may be the rural/suburban/urban distinction presently embodied in the Table C rate group structure.

Third, and perhaps most importantly, the cost and effectiveness of countermeasures may not be equal across different categories. This means that the cost-benefit ratio might differ across different types of sites even if traffic volumes were the same. Such differences in the cost and effectiveness of countermeasures at different types of sites should be considered when defining categories of sites, i.e., in the context of Table C, when defining rate groups.[7]

Overall, there are good reasons to move in the direction of global optimization, but there are also reasons to maintain categories of sites within which HCCLs are determined.

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[7] NCHRP 17-25: Crash Reduction Factors for Traffic Engineering and its Improvements. http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rrd_299.pdf.

**RECOMMENDATIONS:**

- Study the implication of local optimization, i.e., determine the extent to which local optimization reduces global optimization. This can be done by comparing:
    - the rates and number of collisions identified as Table C HCCLs to those that would be chosen within the group of sites as a whole.
    - the cost and effectiveness of treatments within different rate groups.
- Consider separately the relevance of each dimension that is used, or could be used, to define rate groups. Each dimension defining rate groups should justified in terms of one or more of the reasons given above.

### 4.1.3 IF ANALYSES ARE TO BE CONDUCTED USING RATE GROUPS, HOW SHOULD RATE GROUPS BE DEFINED?

As stated in the previous section, California's State Highway System is divided into three major groups: intersections, ramps, and roadway segments, and each group is defined further into subgroups called "rate groups." Virtually every approach that we reviewed divides the roadway into categories in one way or another.[8] The basic rationale in every case is to define groups with common characteristics and then conduct a comparison within these groups. A site with a higher risk with respect to other similar sites is selected as a candidate for further investigation. The informal rationale often given is that this it is necessary to compare within similar categories "apples to apples, and oranges to oranges."

The variables used to differentiate rate groups within the broad categories of intersection, ramp, and roadway are as follows:

Formally, the approach defines two types of site characteristics:

**SET A: Site Characteristics That Are Used To Define Categories**

In Table C, the most important such characteristic is site (intersection, ramp, roadway).

**INTERSECTION**

- Control Type (no control, stop and yield [except 4-way])
- Intersection Type (F,M,S versus T, Y, Z)
- Area (rural, urban, suburban)

[8] Mid-Term Report, Task Order 5215, "Literature Review of Methods for Identifying High Concentration Collision Locations," May, 2005.

**RAMP**

- Ramp Type (frontage road, etc.)
- Ramp Area (1-4, 1-3, etc.)
- Area (rural, urban, suburban)

**ROADWAY**

- Highway Type (conventional two lanes or less, etc.)
- Terrain or ADT (flat, etc.)
- Area (rural, urban, suburban)

### SET B: All Other Characteristics That Could Affect Collisions

This includes any characteristics which are not part of Set A. For the Table C method the only variables that are systematically used are traffic volume. There is additional information in TASAS, such as collision information, environmental condition, road condition, volume, shoulder width, speed limit, etc. There is also information not available in TASAS that could be included, such as road geometric information (curvature, slope) and vehicle occupant information. For example, currently curve and grade information are collected in the Caltrans new digitized highway photolog database, currently in a "not ready format." However, it may be possible to extract it from the digitized photolog.

In general, a method utilizing categories of sites holds constant characteristics within Set A, and looks for variation in collisions that is presumably caused by some characteristic in Set B, and does not arise simply by chance. The main task is to examine the rationale for defining characteristics in Set A versus those in Set B.

### PRINCIPLE 1:
### Exclude From SET A Characteristics That Are Often Used To Define Countermeasures

We don't want Set A to include characteristics that would often be identified as countermeasures, e.g., rumble strips. Using this characteristic to define Table C categories means that it might be overlooked as a possible factor (when absent) in run-off-the road collisions, and therefore might not be considered as a countermeasure. We generally want Set A to consist of categories that are not amenable to change.

### PRINCIPLE 2:
### Include In SET A Characteristics That Define Fundamental Differences In The Nature Of Sites

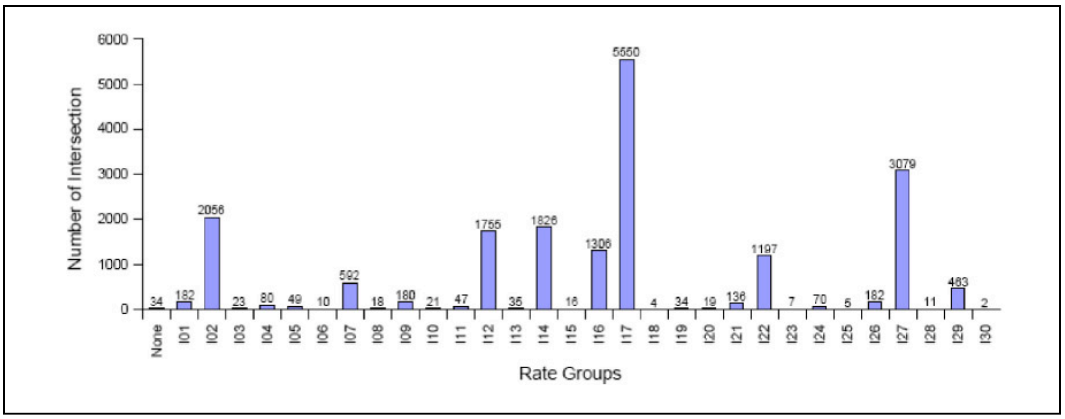
We want Set A to include characteristics that define a basic or fundamental difference in type of site. Intersections, ramps, and roadways are very different entities. Intersections and ramps are usually discrete entities, whereas roadway segments are of variable length. Risk is defined in various ways; for example, risk by usage can be defined as follows:

- Risk in intersections is defined as the number of collisions divided by the sum of the number of entering vehicles.
- Risk at ramps is defined as the number of collisions divided by the number of vehicles passing through the ramp.
- Risk on roadway segments is defined as the number of vehicle miles traveled (VMT).

Risk can also be defined independent of use as follows:

- Risk for intersections can be defined simply as the frequency.
- Risk for ramps and roadways can be defined in terms of the number of collisions per unit of length (density).

**FIGURE 2:**
**AVERAGE NUMBER OF INTERSECTIONS FOR EACH RATE GROUP BETWEEN 1994 AND 2003**




There appear to be fundamental differences in how risk is defined in the three major site categories. Some of these same considerations might apply to other divisions defining rate groups, e.g., signalized versus unsignalized intersections, two-lane roadways versus freeways, etc. These considerations suggest that these dimensions be maintained.

Cost and effectiveness of countermeasures may not be equal across different categories. For example, at intersections with lower rates or frequencies, cost of countermeasures may be lower, or effectiveness may be higher, which would tend to increase the benefit cost ratio for these intersections in relation to intersections with higher rates or frequencies.

**PRINCIPLE 3:**

### We Want SET A Characteristics To Define Categories That Are Of Sufficient Size That Statistical Analyses Are Meaningful

Clearly, categories that are too small lead to highly uncertain estimates of risk. Taking intersections as an example, we have noted that some of the rate groups defined in the Table C process have very small numbers. Second, there is a very uneven number of sites across categories, leading to substantial differences in statistical variation and therefore, especially among categories with few sites that increase false negatives and false positives (Figure 2).

**PRINCIPLE 4:**
**Political Or Funding Constraints**

Constraints due to political considerations or funding streams may dictate that risk be evaluated within categories defined by particular categories. For example, some funding streams may be directed toward safety on rural roads, rail crossings, or areas surrounding schools.[9] It may be necessary to evaluate variation in risk within such categories.

**RECOMMENDATIONS:**

- Review variables that define rate groups and determine which, if any, can be eliminated. Maintain categories that meet basic criteria.
- Review variables that currently do not define rate groups and determine which, if any, should be added.
- Examine differences in outcome across different rate groups.
- Develop formal rationales for roadway categories based on similarities in type of traffic flow and collision patterns.
- Consolidate rate groups with a smaller number of member sites.
- Determine how the effectiveness and cost of each countermeasure (CM) may vary across rate groups.

### 4.1.4 SEGMENTATION WITHIN CATEGORIES (FIXED WINDOW, MOVING FIXED WINDOW, VARIABLE WINDOW, CONTINUOUS)

Ezra Hauer has discussed this issue at length in several publications.[10] This issue has also been addressed by the SafetyAnalyst White Paper on Network Screening (2002).[11]

**Entire Road Section:** One possible site is an entire road section, entailing averaging over the entire road section. In Table C road sections can be of varying length, from a fraction of a mile to several miles in length. For long road sections, peaks in collision risk will be eclipsed by averaging with lower collision strengths. Shorter road sections, while not having the advantage of mixing wide variations in risk, will be much more unstable. As a result, false positives are likely.

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[9] SAFETEA-LU (Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users) http://www.fhwa.dot.gov/safetealu/legis.htm.

[10] Hauer, E., J. Kononov, B.K. Allery and M.S. Griffith, Screening the road network for sites with promise. Transportation Research Record 1784, pp 27-31 National Academies Press, Washington, D.C.., 2002 http://ca.geocities.com/hauer@rogers.com/Pubs/ScreeningforSWIPs.pdf

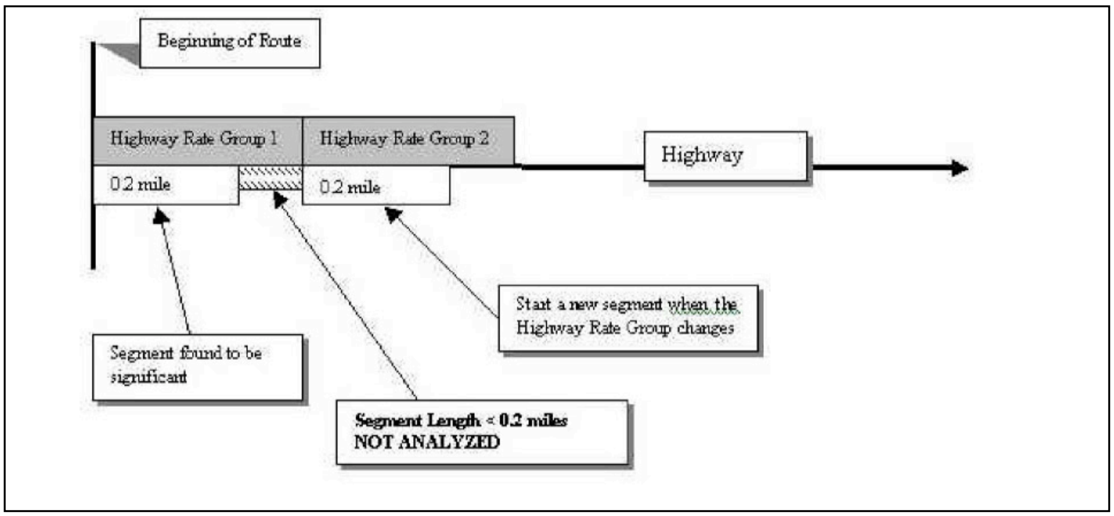
[11] SafetyAnalyst: Software Tools for Safety Management of Specific Highway Sites: Task K: White Paper for Module 1-Network Screening. Federal Highway Administration Task No. DTFH61-01-F-00096. December, 2002.

The state of Colorado has a similar approach in screening sites for potential safety improvements.[12,13] For example, when evaluating safety risks on interstate freeways, a segment is defined as a section of the freeway between junctions or entry and exit ramps. For other typical roadways, instead of using a segment of fixed length, a segment is defined as a stretch between two intersections or junctions.

**Segments Of Fixed Length:** Segments that are too long mask variations that occur within a section. The longer the section, the more this will occur. Segments that are too short will produce very unstable estimates.

**Table C Moving Window Approach:** Table C currently uses a fixed-length moving window approach, moving a frame of 0.2 mile which moves in increments of 0.02 mile. With each increment a statistical test is performed, and 0.2 mile segments that are in the top 0.5% region are selected for detailed study.

**FIGURE 3:**
**ILLUSTRATION OF SEGMENT LENGTHS NOT CURRENTLY ANALYZED**
**(FROM THE TABLE C TASK FORCE REPORT, 2002)**




There are two important concerns with the fixed-length moving window approach as utilized in producing Table C.

The first concern is that since the window is fixed at 0.2 mile (or any other length), some segments will not be evaluated. This can happen in two ways. First, a highway segment with a length of less than 0.2 mile will not be evaluated. Second, there can also be "leftover" segments when a 0.2 mile segment is found to be significant and the remaining portion of the entire segment is less than 0.2 mile. This concern was noted in the Table C

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[12] Kononov, J. (2002) Use of Direct Diagnostics and Pattern Recognition Methodologies in Identifying Locations with Potential for Accident Reduction. Transportation Research Record. 2002.

[13] Kononv,J. and Janson,B. (2002) Diagnostic Methodology for Detection of Safety Problems. Transportation Research Record. 2003.

Task Force Report: "The Table C program does not analyze highway segments less than 0.2 mile in length.[14] Examples include segments just before intersections, route breaks and district boundaries, and at changes in rate group (Figure 3)."

The second concern is that the fixed window may not "fit" actual risk profiles. The segment of roadway with increased risk may be shorter or longer than the length of the fixed window or may be of variable magnitude. As we have argued in our paper describing the Continuous Risk Profile (CRP), both false negatives and false positives can arise. The CRP method addresses this concern by allowing a much closer "fit" to the underlying risk instead of forcing an arbitrary 0.2 mile (or any other fixed length). More discussions of CRP can be found in the next section or in a working paper describing this approach.[15]

#### 4.1.5 CONCLUSION

Within the roadway segment category, the choice of 0.2 mile segment is somewhat arbitrary. Based on the review of historical collision data, many high-risk locations are usually smaller in size. The use of a 0.2 mile segment (or any other fixed length) may mask the safety risk levels, causing a miss of the high-risk locations. In addition, by using a fixed-length segmentation, artificial limitations are imposed on the system when segments smaller than the fixed size are not automatically included in the process. The CRP may be useful as part of the Table C method that identifies risk on highway segments. We suggest testing the CRP as a possible alternative to the moving fixed window approach for the portion of the Table C method that analyzes highway segments, as opposed to intersections and ramps.

- Avoid using segments of too long or too short a length, which can mask variations or produce unstable estimates.
- For highway segments test the CRP method as an alternative to the moving fixed window approach.

### 4.2 TEMPORAL STRUCTURE OF ANALYSIS

This section addresses the time frames defining expected rates or numbers based on historical data, the time frames during which actual collision experience at a particular sites is assessed for comparison to expected experience, and the frequency with which analyses are conducted and reports generated. These time elements, particularly the first two above, have substantial impacts on thresholds for determining HCCLs. In particular, there is a trade-off between sensitivity and stability, with short time intervals being able to reflect short-term changes but suffering from much greater instability. The frequency of outputs or reports of Table C or other HCCL screening methods will have significant impacts on the efficiency of resource utilization needed for the follow-up of safety investigations.

[14] Caltrans Table C Task Force Summary Report of Task Force's Findings and Recommendations. September, 2002.

[15] Chung K, Ragland DR. A Method for Generating a Continuous Risk Profile for Highway Collisions.

### THE MAIN TOPICS WITHIN THE TEMPORAL STRUCTURE OF HCCL SCREENING ARE:

- **Length of time used to calculate the base rate**
- **Length of time used to calculate the risk at a specific site**
- **Frequency with which the analysis is conducted**

Major observations and recommendations for these issues are described in the sub-sections below.

### 4.2.1 LENGTH OF TIME USED TO CALCULATE THE BASE RATE

#### TABLE C:

In Table C a "base rate," the number of collisions per 1,000,000 vehicles (for intersections and ramps), or number per vehicle miles traveled (for highway segments), is calculated and used to generate an expected number of collisions. Base rates are calculated using data from a three year period for any particular rate group.

#### OBSERVATIONS:

This issue is often not made explicit in discussions of selecting HCCLs. The usual approach is to calculate a base rate (or base SPF) over a fixed period of time and then compare actual collisions over successive periods of time to an expected number of collisions based on this fixed period of time. In this approach the base rate is periodically updated. The Table C method uses this approach. If a rate group has a sufficient number of member sites, three years should be sufficient to provide stable estimates of base rates; the stability appears adequate with as few as 100 member sites in a rate group. As indicated above, some rates groups have fewer member sites and three years is not adequate to develop stable base rates for these sites. While the time period could be increased, but this would tend to average out any change in the underlying risk for these sites. If the base period is limited to three years, then sites with fewer than 100 member sites should be consolidated with other rate groups.

#### RECOMMENDATIONS:

- Maintain a three-year base period.
- Evaluate trends over an extended period of time to determine if there is "drift" in underlying base rates.

### 4.2.2 LENGTH OF TIME USED TO ESTIMATE RISK AT A SPECIFIC SITE

#### TABLE C:

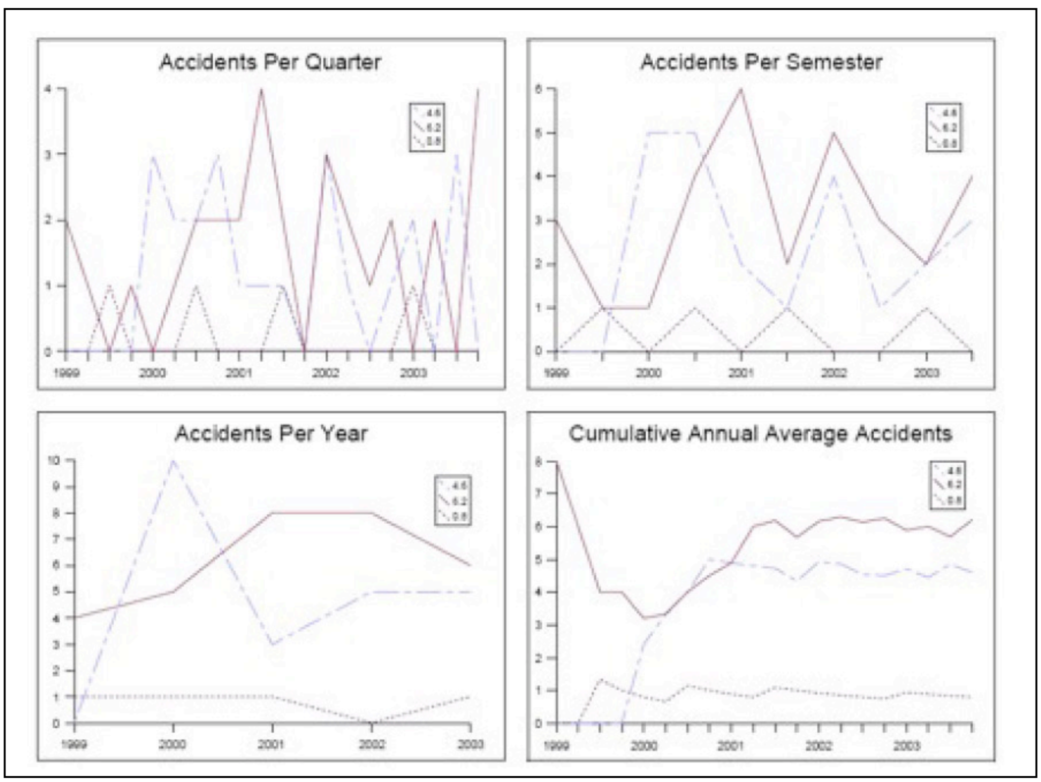
Table C analysis is run every quarter to capture rapid changes in highway safety. If a location has more than four accidents and is found to bestatistically significant during the last 3, 6 or 12 months, then inspection is required.

### OBSERVATIONS:

**Other States:** The periods of time used in the Table C approach are unusually short for an HCCL identification process. Other states generally use time periods ranging from a year to several years. In Kansas, where an automated state-wide analysis does not take place, different areas use different analysis periods. In more densely traveled areas, a two-year collision history is usually analyzed; in rural areas, a five-year history is typically analyzed. In some cases, a three-year history is used. Idaho calculates HCCL based on the most recent three-year history; New York, a two-year history. Washington uses a two-year period for high accident "locations" (segments less than 1 mile in length) and a five-year period to identify high accident "corridors" (highway segments greater than one mile in length).[16]

**Tradeoff Between Stability And Sensitivity To Change:** Selecting a short period of study is more sensitive to change in risk but leads to an increased instability. The challenge is to select an optimal value for the analysis period subject to data constraints and evolution of risk with time.

**FIGURE 4:**
**EXAMPLE OF ACCIDENT FREQUENCY FOR THREE INTERSECTIONS IN ALAMEDA COUNTY**




[16] Mid-Term Report, Task Order 5215, "Literature Review of Methods for Identifying High Concentration Collision Locations," May, 2005.

**Increase In Stability With Increased Time:** Due to the rarity of the events we are studying, a small analysis period provides very unstable results. Figure 4 shows the evolution of accident frequencies for three intersections (picked randomly) counted by quarters, semesters and years. It can be seen that the quarterly frequency is very unstable, as predicted. If the intersections are ranked by number of accidents for each period, the ranking would change with every period. In the third quarter of 1999, the intersection with the lowest annual average accident rate (0.8) is ranked as the most dangerous. The intersection with an average annual accident rate of 4.6 has a higher or equal rank than the intersection with annual average accident rate of 6.2 for eight quarters out of 20. If the safety of an intersection can be considered equal to the annual average over the 5 years considered, the percentage of incorrect ranking decreases when the period increases.

**Increased Accuracy By Modifying The Time Period:** As seen in the three-intersection example, above, the larger the analysis period, the more likely the average number of accidents converges toward a constant level. We have conducted several tests to determine the optimal length of time.[17] If risk is assumed to remain constant over time then stability increases rapidly for up to 3 years and then increases more slowly (i.e., most of the gain is in the first three years). If risk is assumed to change over time, then stability increases. But bias also increases, since the increased time is averaged over a period of changing risk. A similar dilemma is faced in changing window lengths in the analysis of highway segments. Ezra Hauer has suggested a method for determining adequacy of stability, which could be used to determine stability for varying time intervals at sites with varying traffic volumes. This is because sites with higher volumes will have greater stability.[18]

**Detecting Changes In Risk:** There is some ambiguity in the goal of the Table C method, as in other HCCL methods. There are two generic goals; one is to determine high risk locations in a set of locations where risk is assumed to be constant over time. The method utilized by the Table C method is optimally designed to meet this goal. Another goal is to detect change over time. Most current methods are not optimal for achieving this goal. As described above, a brief interval of one quarter is insufficient to detect such change and a too-long period will not be sensitive to change, because any change will be averaged out over a length of time. A statistical approach for this has been developed by Ezra Hauer and is described in SafetyAnalyst.[19] The method models change over time instead of simply calculating the difference between the actual and expected number of collisions within a particular time interval.

The ideal sampling period may depend on the specific areas being studied and, particularly variations in roadways and traffic patterns. In areas where the traffic level is steady and the roadway geometry has not shifted meaningfully, the longer analysis period

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[17] Brillault Y. High Collision Concentration Locations. Technical Report. May 2006.

[18] SafetyAnalyst: Software Tools for Safety Management of Specific Highway Sites: Task K: White Paper for Module 1-Network Screening. Federal Highway Administration Task No. DTFH61-01-F-00096. December, 2002.

[19] Ibid.

will yield more reliable data. However, in high-growth or recently renovated areas, the monitoring of data over shorter time spans will more likely reflect current conditions.

There are two main conclusions relevant to revision of the Table C method. First, any time period less than a year is too short to provide a stable estimate of HCCL, no matter how it is calculated. One year is adequate for sites with a high volume but may not be adequate for sites with a low volume. Statistical methods for determining stability should be conducted for sites with lower and higher collision frequencies.

Second, the Table C method and most other methods are not designed for detecting changes over time.

**RECOMMENDATIONS:**

- Eliminate estimates based on any time period less than one year.
- For all sites, use a method proposed by Ezra Hauer to determine stability of estimates. Use that method to decide whether, for particular sites, the time period should be one year, two years, or three years.
- Utilize a method proposed by Ezra Hauer for determining changes in risk. This should be routinely applied to all sites on a quarterly basis, and particularly to sites that are experiencing other changes.

### 4.2.3 FREQUENCY WITH WHICH THE ANALYSIS IS CONDUCTED

#### TABLE C:

The main Table C Report is generated quarterly and the Wet Table C Report is generated yearly in October.

**OBSERVATIONS:**

The survey conducted by the Table C Task Force indicated that Caltrans users of the Table C report are in favor of having a quarterly report, as opposed to a biannual or yearly report. For identifying differences in risk when risk is presumed to be constant, a quarterly report is probably unnecessary. When combined with use of quarterly collision frequencies, it is most likely to produce false positives when random events (with respect to the site) produce a spike in collisions at a particular site.

However, we could develop approaches to detect change on a more frequent basis. Sites where change is detected should then be investigated for changes in traffic volume or other features.

**RECOMMENDATIONS:**

- The Table C report should be produced quarterly.
- However, an analysis to simply detect a difference between an actual count and an expected count for similar locations should be done only on a yearly basis.

- Other quarters should include reports on sub-topics, especially analyses of potential change in risk.

## 4.3 CHOICE OF OUTCOME(s)

The specific outcome of interest will have a major impact on the HCCLs chosen. There are three major dimensions to this question:

- **Expected frequency versus excess frequency**
- **Weighting by level of severity**
- **Analyses by specific types of collisions**

### 4.3.1 EXPECTED FREQUENCY VERSUS OBSERVED FREQUENCY COMPARED TO EXPECTED FREQUENCY (EXCESS FREQUENCY)

**TABLE C:**

Table C uses observed compared to expected frequency, i.e., excess frequency.

**OBSERVATIONS:**

In the Introduction the argument is made that potential cost-effectiveness should be a major goal of HCCL analysis. If this is the case, it has been argued that expected collision frequency is the critical outcome, and not the expected excess frequency over an average frequency for a category of sites. To illustrate, suppose that illumination reduced nighttime accidents by 30%.[20] You have a two-lane road on which the average number of night-time accidents is 2/mile-year and the observed number in a year was 6. You also have a multilane road of similar length on which the average number of night-time accidents is 20/mile-year and the observed number in a year was 18. Based on excess frequency the two-lane road would be chosen for treatment. However, if illuminating the two road segments costs the same amount, and the effectiveness is the same, then would you choose the multilane road first in spite of the fact that there was nothing deviant about its accident record? If you illuminate the two-lane road first you have failed to reduce (18-6)*0.35 accidents.

The above example assumes that the cost and effectiveness of the countermeasure are the same for both roads. There is relatively little research on the effectiveness and cost of countermeasures across different types of sites and this assumption needs to be considered on a case-by-case basis.[21]

Importantly, the concept of 'rate group' itself derives from the practice of comparing the observed frequency (or rate) to an expected frequency (or rate) for the group and to

[20] Example provided by Ezra Hauer, personnel communication, August 2007.

[21] Although most methods for determining HCCLs compare an observed to expected frequency (or rate), widely used Accident Reduction Factors (ARF) are calculated based on a proportion of the absolute frequency, and not the excess frequency.

determine sites where the difference is large as meriting attention. However, if one assumes that the effect of a countermeasure is to reduce the expected accident frequency (not the expected excess) by some fixed proportion, then one should not be concerned with the "base rate" for a particular category of site. The application of common countermeasures provides one rationale for grouping types of sites, i.e., for grouping rate groups.

**RECOMMENDATIONS:**

- Review existing literature that will determine cost and effectiveness of countermeasures over different types of sites, within broad categories where the same countermeasure is relevant.
- Consider approaches that focus on expected frequency versus excess frequency.

### 4.3.2 WEIGHTING BY LEVEL OF SEVERITY (PDO, INJURY, FATALITY)

**TABLE C:**

Table C treats collisions of all severities with equal weight.[22]

**OBSERVATIONS:**

There are many approaches to identifying HCCLs weight collisions by severity. Of the 15 state agencies we consulted with, 11 weighted collisions by severity.[23] In all cases weight was greater for collisions of greater severity, ranging from PDO to fatal collisions. The exact method use to weight collisions varied substantially. Most approaches to injury severity weighting use variations on the "equivalent property-damage-only" (EPDO) method. In this method, weights of fatal and injury crashes are compared to the weight of PDO collisions. For example, the state of Iowa currently weights PDO collisions by 1, injury collisions by 5, and fatal collisions by 8 (2). Researchers at the University of Limburgh suggest weights 1, 3, and 5, respectively. Another approach to using weights is to use numbers that reflect the actual cost of each collision. For example, Washington State assigns a weight of $1,100,000 for each fatal collision, $70,000 for each evident injury collision, $35,000 for each possible injury collision, and $6,500 for each property damage only collision. With these weights, the Washington DOT essentially analyzed "collision-dollars" per mile instead of collisions per mile. This method is formally equivalent to the EPDO since the essential feature is not the absolute amount, but the ratio. Whether EPDO or the cost approach is used, the ratio of the weights is usually

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[22] A distinction needs to be made between weighting collisions by severity for the purpose of identifying HCCLs and weighting collisions for the purpose of deploying countermeasures. While Caltrans does not currently weight collisions for identifying HCCLs (i.e., Table C), weighting by severity is used to calculate a "Safety Index" which in turn is used to determine whether a countermeasure should be implemented (Highway Safety Improvement Program Guidelines, Chapter 5, Traffic Safety Index).

[23] Mid-Term Report, Task Order 5215, "Literature Review of Methods for Identifying High Concentration Collision Locations," May, 2005.

based on average total costs of property, injury, and fatality collisions. Using these weights, a severity index is developed for each highway segment using the following formula:

$$[1]\quad SI = [WfF + WmM + WcC + P]/T$$

where *SI* is severity index,

*Wx* are weights for fatal, major, and complaint of pain collisions,

*P* is DO collisions,

*T* is total crashes at site.[24]

It seems reasonable to attach more importance to collisions of greater severity. However, whatever the specific approach used for combining and weighting collisions with different levels of severity, there are two major problems:

First, since fatality is rare, if fatality is weighted too heavily it creates instability in the estimates. This is very clear from formula [1] above: putting more weight on an unstable variable increases the stability of the overall estimate.

Second, combining collisions with different levels of severity assumes that collisions of different severity are similarly distributed across locations. Consider a situation where collisions of different severity have the same distribution. In this case combining collisions of different severity would enhance stability and weighting would not be needed. However, consider a situation where collisions of different severity are completely independent with respect to location. In this case, combining collisions with different severity would introduce conflicting information into the determination of HCCLs, regardless of the weighting. Site-specific information linking collisions of a given level of severity would tend to cancel out site-specific information linking collisions of a different level of severity.

In fact, although systematic studies are limited, the evidence suggests that PDO, injury, and fatal collisions have substantially different distributions.[25] In extensive data analyses produced for the California Strategic Highway Safety Implementation Plan (SHSIP), we noted that the distribution of fatal and severe injury appear more closely related to one another than to minor injury or PDO, at least at the county level.[26] Clearly, statistical tests should be conducted using California data to determine the degree to which collisions of different severity are distributed similarly across sites.

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[24] Pawlovich, M.D. Safety Improvement Candidate Location (SICL) Methods. Iowa Department of Transportation, Highway Division, Engineering Bureau, Office of Traffic Safety. 2002.

[25] Deng Z, Evan J. Analysis of Factors Affecting the Severity of Head-On Crashes: Two-Lane Rural Highways in Connecticut. Transportation Research Record, Vol 1953, 2006, pgs. 137-146 and Brown B, Baass K. Seasonal Variation in Frequencies and Rates of Highway Accidents as Function of Severity, Journal, Transportation Research Record, Volume 1581 / 1997, 59-65.

[26] Unpublished Analyses for the California Strategic Highway Safety Implementation Plan (SHSIP), Spring 2007.

An issue specific to TASAS is that its injury variable is limited to three levels (fatal, injury, and PDO). SWITRS, from which TASAS injury data is derived, has five levels of severity (fatal, severe injury, visible injury, complain of pain, and PDO). Collapsing from five to three variables is unnecessary and inconsistent with national studies and federal program requirement (e.g., SHSIP reporting) focusing on more detailed injury levels.

**RECOMMENDATIONS:**

- Conduct analyses of California data to determine the site-distribution of collisions of different severity.
- Depending on the results of these analyses, consider conducting separate Table C analyses for grouping of different levels of severity.
- Make a relatively small programming change in TASAS to include all five levels of collision severity available in SWITRS. This will allow grouping appropriate levels of severity in the HCCL analysis as determined above.

### 4.3.3 ANALYSES BY DIFFERENT COLLISION TYPES

**TABLE C:**

The current method in Table C combines all types of collisions in the same analysis.

**OBSERVATIONS:**

Different types of collisions, e.g., run-off–the-road collisions and rear end collisions, have dramatically different distributions. As with combining collisions with different levels of severity, combining different types of collisions introduces conflicting information into the determination of HCCLs. Site-specific information linking collisions of a given type tends to cancel out site-specific information linking collisions of another type. Furthermore, factors contributing to collisions or injuries, e.g., alcohol or speeding, may not be directly related to roadway site characteristics. It may be important to identify clusters of these collisions so that appropriate non-traffic engineering countermeasures can be applied.

Many types of collisions occur in numbers high enough for relatively stable HCCLs to be identified. Numerous U.S. states conduct HCCL analyses of different types of collisions.[27] and Caltrans already has programs for identifying HCCLs for specific types of collisions, e.g., run-off-road collisions.[28]

[27] Mid-Term Report, Task Order 5215, "Literature Review of Methods for Identifying High Concentration Collision Locations," May, 2005.

[28] Khorashadi A. Procedure for identifying state highway locations with Run-Off-Road (ROR) collision concentrations, Traffic Safety Program, California Department of Transportation September 2006

**RECOMMENDATIONS:**

- Create "Table C" options for specific kinds of collisions. This approach is already used for "wet" highway collisions in order to generate a Wet Table C. The goal of this approach is to help engineers identify where slippery pavements might be the cause of an unusually high number of collisions. Similar tables could be created for other categories of collisions, such as rear end collisions, DUI collisions, etc.
- Conduct yearly analyses of specific types of collisions, especially those which are fairly high in number and are likely to have a unique distribution and/or which are amenable to specific countermeasures.

## 4.4 CRITERIA FOR SELECTION OF LOCATIONS

### 4.4.1 METHOD FOR CHOOSING HCCLS

Most methods for choosing HCCLs begin by calculating an expected number of collisions for a particular site and determining the distribution around the expected number. Then, the actual number of collisions is determined for individual sites and a site is designated as an HCCL if the actual number exceeds the expected number by a certain amount, e.g., if the number is above the 95% confidence interval. Four such methods have been reviewed: the method used for producing Table C ($N_E$), the Safety Performance Function (SPF), the Empirical Bayes (EB) method, and a newly developed method called the Continuous Risk Profile (CRP). The first three of these methods rank sites based on their position in an expected distribution and then selects HCCL sites that are on the upper end of that distribution. Each of these methods has been applied to both discrete sites (sites without a distance dimension such as intersections and ramps) and extended sites (such as roadway segments). The CRP calculates a base density of collisions (such as number per unit of distance) to produce a continuous density profile in relation to the base density.[29] The CRP can be modified to accommodate rates or even SPFs. A critical feature of the CRP is that road segments of variable length can then be designated as HCCLs.

**IN THE FOLLOWING SECTION, THESE FOUR METHODS WILL BE COMPARED FOR PURPOSES OF CHOOSING HCCLS.**

- **Table C (NE )**
- **Safety Performance Function (SPF)**
- **Empirical Bayes (EB)**
- **Continuous Risk Profile (CRP) (for highway segments only)**

[29] Chung K, Ragland DR. A Method for Generating a Continuous Risk Profile for Highway Collisions. Presented at the Transportation Research Board Meetings, January 2007. http://repositories.cdlib.org/its/tsc/UCB-TSC-TR-2007-6/

#### 4.4.1.1 Table C Method

For the Table C approach the expected number is calculated by the following formula:[30]

The average number of accidents
(1) $N_E = ADT \times t \times L \times R_E \div 10^6$
Where
ADT = Average Daily Traffic, vehicle per day
t = time, in days = #quarters x days/quarter (Table C)
x days/time period (Table B)
L = length, in miles
(= l for Ramps and Intersections)
$R_E$ = Average Accident Rate, in accident/million vehicle(ACCS/MV) or accident/million vehicle mile (ACCS/MVM)
= Base Rate + ADT factor

Based on the type of facility, each type of highway, ramp or intersection is placed in a rate group. Each rate group has a base rate and ADT factor that are determined by analyzing all accidents in a three-year time period. (See Appendix B, C, & D for the rate groups for intersections, ramps, and highway segments.)

Then, a 99.5% upper confidence interval is calculated as follows:

(2) $N_E + 2.576(N_E)^{1/2} + 1.329$

$N_E$ and the corresponding 99.5% upper confidence interval are defined for each site. If the actual number at that site is greater than the 99.5% confidence limit, the site is designated as an HCCL. The critical question is whether $N_E$ is a good estimator of the number of collisions that will occur at a particular site over a period of time. $N_E$ is relatively easy to calculate and understand. However, there are five important issues:

First, for most of the rate groups (all of the intersection and ramp segments, and most of the highway segments) the ADT factor is set to ‘0,’ so that the rate is not adjusted by the ADT factor. This means the rate is assumed to be constant over volume and therefore that the number of collisions is a linear function of volume. Virtually all researchers now working in this area maintain that the collision rate is not constant over volume and, equivalently, that the number of collisions is not a linear function of volume.[31] Empirical checks for specific types of sites show that this is also true for TASAS data, i.e., the rate changes with volume. Depending on the actual relationship between rate and volume, the implication of assuming a linear relationship between collision rate is that both false positives and false negatives will be increased.

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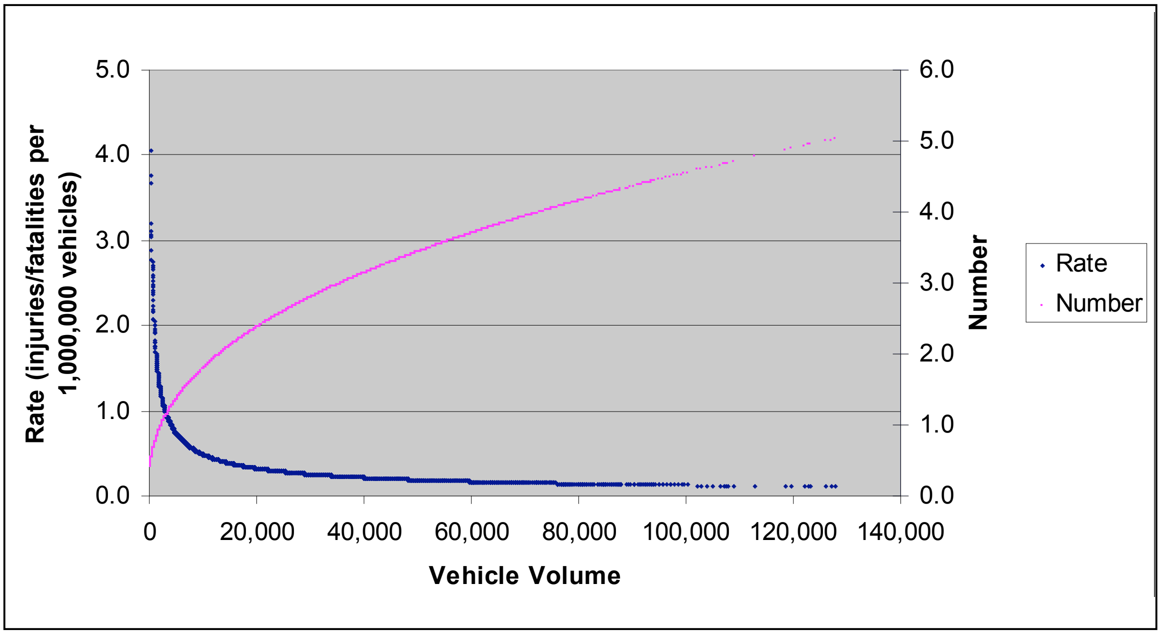
[30] Caltrans Table C Task Force Summary Report of Task Force’s Findings and Recommendations. September, 2002.

[31] Hauer E. On exposure and accident rate. Traffic Eng. Contr. 36 (3), 199510. Hauer, E. Overdispersion in Modeling Accidents on Road Sections and in Empirical Bayes Estimation. Accident, Analysis and Prevention, Vol. 33, 2001, pp. 799-808.

FIGURE 5:
RATE (NUMBER PER 100,000,000 VEHICLES)
AND NUMBER OF COLLISIONS




Second the ADT factor is an amount proportional to the ADT that is added to the rate. There appears to be no standard statistical approach for estimating the ADT factor and the only approach is to check, visually and manually, how it fits the data.

Third, $N_E$ does not permit the inclusion of variables other than traffic volume, e.g., shoulder width, number of lanes, etc. This can result in a biased estimate of expected frequency and increase its variance. It should be noted that, implicitly, the Table C approach takes into account some roadway attributes by categorizing roadways into various different rate groups based on specific variables (see above).

Fourth, and applicable only to roadway segments, this method does not account for potential serial correlation among highway segments. Collision numbers are serially correlated in adjacent sites because hot spots tend to generate secondary collisions in neighboring sites.[32] This will affect the estimate of variability and therefore the confidence interval calculation.

Fifth, the method implicitly assumes that all the factors causing the high collision rates in the segment reside within that segment. When the collision rates are high due to secondary collisions in the vicinity, this method will also detect collisions in neighboring sites without showing the relationship between the collision rates of the primary segment and those of the adjacent sites. This results in the detection of multiple adjacent sites and was one of the issues addressed by Table C task force.

32 Washington S, Karlaftis MG, Mannering FL. Statistical and Econometric Methods for Transportation Data Analysis. CRC Press, 2003.

## IN SUMMARY, THE TABLE C APPROACH POSSESSES THE FOLLOWING CHARACTERISTICS:

### STRENGTHS:

- Relatively easy to calculate and understand.
- Allows variation in collision frequency as a function of traffic volume.
- Allows a non-linear relationship between number of collisions and traffic volume, although via a functional relationship that does not lend itself to modeling the non-linearity.

### WEAKNESSES:

- Biased if assumption about constant rate is not true. In the case where rate declines with volume (the most likely case), false positives will arise at sites with low volumes, and false negative will arise at sites with high volumes.
- Has a functional relationship that does not lend itself to modeling non-linearity.
- Does not include variables other than volume as predictors of expected risk.
- The one parameter that can be adjusted, the ADT factor, has apparently not been adjusted recently.
- Implicitly assumes that all the factors causing high collision rates reside within the segment.

### RECOMMENDATIONS:

This method shares some characteristics with more advanced methods (see below), but is limited in its functional form. In addition, it appears that the single parameter that can be adjusted—the ADT factor—has not been adjusted recently. We recommend that NE be replaced by more sophisticated methods (see below).

#### 4.4.1.2 Safety Performance Functions (SPF)

Safety Performance Functions (SPF) are a predictive tool to estimate the safety of a highway site with specific design characteristics and traffic volumes. A safety performance function can be defined by:

$N_E=f(AADT,x)$

Where:- $N_E$ is the expected annual accident frequency
- *AADT* is the Annual Average Daily Traffic
- *x* are design characteristics and other variables.

The procedure for obtaining an SPF has been described in detail in a SafetyAnalyst white paper and elsewhere.[33] This procedure involves identifying the appropriate functional form, identifying the significant variables, and calculating the parameters of the model empirically using data from a combined set of sites. SPFs have been successfully used in a wide range of situations.

Note that the Table C formula has some similarities to the SPF as both show a relationship between frequency and volume. However, there are three differences:

- **Table C assumes a fixed rate, although in some cases modified by traffic volume**
- **Table C has a different way of handling traffic volume; Table C traffic volume is used as a factor adjusting rate, while in SPF traffic volume is a predictive variable in itself**
- **Table C has no provision for including factors other than rate and traffic volume**

We constructed and tested an SPF for intersection data in TASAS. For this exercise we chose three-legged intersections. We produced several SPF models and compared them with Table C. To evaluate the model, we generated SPFs using data from years 1996–1999 and compared this to the actual collision rates during years 2000–2003. The objective was to calculate the difference between the number of collisions predicted and the number of collisions observed. Each of several different SPFs were superior to Table C predictions. In general, the superiority of the SPF over the Table C prediction was related to the greater amount of information taken into account by the SPF. The superiority of the SPF also increased with its complexity.

Use of SPFs has become nearly a norm in determining HCCLs. One example of the application of SPF is provided by Kononov and Allery from Colorado DOT.[34,35] They have proposed using confidence intervals around SPFs to define a “Level of Service” (LOS) of safety for roadway segments. Collision frequencies beyond a particular confidence region would be considered high risk locations for further investigation. Kononov And Allery use SPF with ADT as the only variable as apposed to safety analyst that has other factors.

The SPF has several advantages over $N_E$ and is a far more effective model for calculating the expected accident frequency and the associated distribution. The issue of serial correlation still persists for highway segments. The serial correlation arises because hot

[33] SafetyAnalyst: Software Tools for Safety Management of Specific Highway Sites: Task K: White Paper for Module 1-Network Screening. Federal Highway Administration Task No. DTFH61-01-F-00096. December, 2002.

[34] Kononov, J. (2002) Use of Direct Diagnostics and Pattern Recognition Methodologies in Identifying Locations with Potential for Accident Reduction. Transportation Research Record. 2002.

[35] Kononv,J. and Janson,B. (2002) Diagnostic Methodology for Detection of Safety Problems. Transportation Research Record. 2003.

spots tend to generate secondary collisions in neighboring sites. The resulting SPF could be shifted in one direction or another, increasing false positives or false negatives. The magnitude of this bias is not known.

### IN SUMMARY, THE SAFETY PERFORMANCE FUNCTIONS (SPF) APPROACH HAS THE FOLLOWING CHARACTERISTICS:

#### STRENGTHS:

- Allows variation as a function of traffic volume.
- Allows great flexibility in determining the relationship between number of collisions and traffic volume.
- Allows inclusion of other variables defining individual sites.

#### WEAKNESSES:

- Does not take into account actual collision counts at the individual sites in its modeling, as compared to the EB approach (see below).
- May not be suitable for analyzing sites (such as urban freeways) where the collision numbers are not independent.

#### RECOMMENDATIONS:

- The method using SPF should be systematically compared to Table C and the EB method where the collision counts are not correlated.
- The impact of serial correlation among sites should be evaluated.
- The impact of missing parameters should be evaluated.

### 4.4.1.3 Empirical Bayes Estimate

The Empirical Bayes (EB) method is a method that combines two different types of information: the expected accident frequency based on experience in the entire set of comparable sites and the observed frequency of accidents at a specific site. The expected accident frequency can be obtained using the SPF calculated for the highway site. The observed accident frequency can be based on one or multiple years. The basic principle of the EB method is that there is important information contained in the actual observation made at a particular site that is not used in generating the SPF.

Making two assumptions (such as that accident frequency at a given site follows a Poisson distribution, and that the average accident frequency of comparable sites follows a Gamma distribution) a simple estimate of the site safety can be obtained using the Empirical Bayes method:

$N = w\,N_E + (1\text{-}w)\,N_O$

Where:- $N_E$ is the annual average expected accident frequency
- $N_O$ is the annual average observed accident frequency
- $w$ is the specific weighting factor to apply
- $N$ is the Empirical Bayes Estimate

The weighting factor can be interpreted as a "trust factor," as it indicates which of the two clues seems to be the most relevant. The weight factor is a function of the analysis period length, the estimated accuracy of the SPF, and the expected accident frequency. The formula of the weight is:

$$W = \frac{1}{1 + T \times k \times N_E}$$

Where:- $N_E$ is the annual average expected accident frequency
- $T$ is the analysis period length
- $k$ is a characteristic parameter of the SPF (dispersion parameter)

It is apparent that the weight decreases with the analysis period. Indeed, as noted elsewhere in this report, provided that the real risk of a site remains constant over the years, the longer the analysis period, the better the annual average approximates the real average. Consequently, if the analysis period is long, the weight is small and the EB estimate mostly uses the observed average accident frequency.

The EB method can be applied very easily, provided SPFs have already been calculated.

## THE PROCEDURE TO OBTAIN AN EB ESTIMATE FOR A SPECIFIC HIGHWAY SITE IS AS FOLLOWS:

1. **Calculate annual average accident frequency over the analysis period considered using SPF**
2. **Calculate weight using the characteristic parameter of the SPF used in previous step**
3. **Calculate EB estimate using observed and expected average accident frequency**

The EB method has been used in a large number of applications. The most important feature of the EB method is that, by combining the expected frequency generated by the SPF with the observed frequency, the regression to the mean phenomenon is mitigated. In some cases the gain over SPF is small but, given that it is fairly easy to calculate once an SPF has been established, it should be considered as a potential method for determining HCCLs.

## IN SUMMARY, THE EMPIRICAL BAYES (EB) APPROACH HAS THE FOLLOWING CHARACTERISTICS:

### STRENGTHS:

- Allows variation as a function of traffic volume.
- Allows great flexibility in determining the relationship between number of collisions and traffic volume.
- Allows inclusion of other variables defining individual sites.
- Accounts for regression to the mean.

### WEAKNESSES:

- More difficult to calculate.
- Less intuitive.
- Not suitable for analyzing sites (i.e., urban freeways) where the collision numbers are not independent.

### RECOMMENDATIONS:

- The method using SPF in conjunction with the EB approach should be systematically compared to Table C and SPF only.
- The impact of serial correlation among sites should be evaluated to test the suitability of using SPF and EB for screening highway networks.
- The impact of missing parameters should be evaluated.

#### 4.4.1.4 The Role Of Predictive Variables In SPF And EB Models

As described above, the SPF and EB models are very flexible, allowing a number of variables to be included in the model. The most important variable (and most powerful predictor) is usually traffic volume; i.e., more vehicles usually means more collisions. There are three potential uses of this capability:

**1. Standardization (“Comparing Apples To Apples”):**

Including traffic volume inherently “standardizes” for volume. That is, sites are evaluated in relation to other sites with the same volume. Other variables entered into the model have a similar function. For example, adding a variable for shoulder width in effect “standardizes” for shoulder width. If shoulder width is inversely related to collisions, the expected frequency for segments with low shoulder width is “adjusted” upward. The general principle is the intent to compare sites with similar sites. When this is the intent, then the actual number of collisions at a site can be compared with that predicted by the SPF when all the variables have been set to those characterizing the site. This means that excess collisions (i.e., any amount by which the actual is greater than the predicted) are due either to noise (i.e., chance) or to some feature that is not available or at least is not used in the model. In fact, the purpose of further investigation would be to identify those features not included in the model.

An important implication is that some of the chosen sites will have fewer collisions than other sites which are not chosen. Using traffic volume as an example, some of the chosen sites will have fewer collisions (with lower volume) than some sites (with higher volume) which are not chosen. This is consistent with an assumption that the potential for reducing collisions is proportional to the excess collisions, and not to the absolute number of collisions. The actual result of this in terms of maximizing cost-benefit has not been determined.[36]

**2. Identifying Impacts of Design:**

There is a danger that variables included in the SPF model might be neglected in terms of selecting countermeasures. For example, a model including shoulder width permits comparison of sites while controlling for shoulder width, but might take the focus off shoulder width. However, the fact that shoulder width is predictive of collisions means that shoulder width is a design feature that should be addressed across the entire set of sites.

**3. Identifying Roadway Categories:**

Another potential role for variables in an SPF model is to assist in identifying roadway categories. The Table C method, and most other methods, begins by dividing the roadway system into categories of similar types. To determine what defines "similar," the SPF can be calculated using data within a category or within a cluster of categories combined. In the former case, variables are identified to "standardize" comparisons among sites. In the latter case, variables in the model provide a possible tool for defining categories. This can be accomplished by calculating an SPF for two rate groups combined, then introducing interaction terms to determine if factors such as traffic volume operated in the same way across the two rate groups. If so, there would a rationale for combining the groups, and therefore increasing the size. An analysis demonstrating the feasibility of this approach has been conducted by combining different rate groups defining three-legged intersections. The analysis indicated that it was possible to combine rate groups, resulting in a single rate group with a larger size and therefore leading to increased stability of expected collisions. It is suggested that this strategy be utilized in helping combine rate groups into large entities in cases where the numbers of sites are very small.

#### 4.4.1.5 Continuous Risk Profile (CRP) Method

Continuous risk profile (CRP) is a new method for assessing collision risk along a roadway which addresses the limitation of a method that requires arbitrary segmentation of a roadway for analysis. Continuous risk refers to the concept that the road under examination is not segmented, but rather is considered as a whole. This method produces a continuous profile, the shape of which reflects the true underlying risk along the roadway. The CRP method has been developed by Chung and Ragland to be used by

[36] SafetyAnalyst: Software Tools for Safety Management of Specific Highway Sites: Task K: White Paper for Module 1-Network Screening. Federal Highway Administration Task No. DTFH61-01-F-00096. December, 2002.

Caltrans traffic engineers.[37] However, the general methods used for continuous risk profiling are also applicable for any jurisdiction that examines collision concentration in urban freeway areas.

## A CONTINUOUS RISK PROFILE (CRP) IS DEVELOPED IN FOUR STEPS:

1. **Calculating a cumulative count of collisions along the roadway**
2. **Estimating the excess risk compared to the reference risk defined by the user**
3. **Pre-filtering frequencies with a small domain (i.e., the "noise")**
4. **Profiling excess risk continuously along the roadway**

A cumulative count of collisions, *A(d),* can be calculated for each location *d*. A(d) represents the total number of collisions along the roadway from the starting postmile $d_0$ to d. Then, a "rescaled" cumulative collision count is calculated using the formula $A(d) - B(d - d_0)$, where B is a rescaling factor. The rescaled cumulative collision count curve amplifies the changes in the slope of the curve and makes it easier to observe how risk changes continuously with respect to the distance (such as the number of collisions observed at a given postmile). Similar rescaling techniques have been used to study the propagation of kinematic waves.[38,39] The statistical fluctuations displayed in the rescaled cumulative collision counts can cause false positives which can be prefiltered by using a moving average as follows:[40]

$$M(d) = \frac{\sum_{i=-\min(L/l,(d-d_0)/l)}^{\min(L/l,(d_{end}-d)/l)} f(d + i \times l)}{\min(L/l,(d_{end}-d)/l) + \min(L/l,(d-d_0)/l) + 1} \qquad (1)$$

For

$$d = d_0 + k \times l \text{ and } k = 1,2,\ldots\frac{d_{end} - d_0}{l}$$

[37] Chung K, Ragland DR. A Method for Generating a Continuous Risk Profile for Highway Collisions.

[38] Cassidy, M.J., and J.R. Windover. Methodology for Assessing Dynamics of Freeway Traffic Flow. Transportation Research Record, No. 1484, 1995, pp. 73-79.

[39] Chung, K., and M.J. Cassidy. Test of Theory of Driver Behavior on Homogeneous Freeways. Transportation Research Record, No.1883, 2004, pp. 14-20.

[40] Cassidy, M.J., and J.R. Windover. Methodology for Assessing Dynamics of Freeway Traffic Flow. Transportation Research Record, No. 1484, 1995, pp. 73-79.

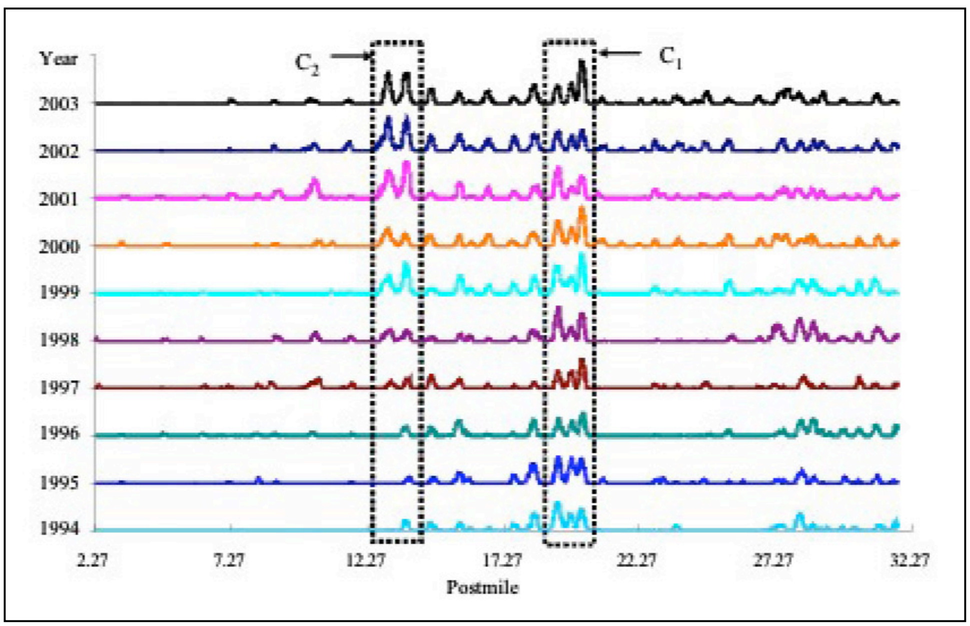
Where
$f(d) = k(d) - B(d - d_0)$
$d_0$ = beginning postmile
$d_{end}$ = ending postmile
$D_{start} < D_{end}$
$l$ = increment
2L = size of the moving average
k, $\frac{L}{l}$ and $\frac{d_{end} - d_0}{l}$ are integers

Then, using equation (2) only the positive portion of the rescaled smoothed cumulative curve is identified. This is done because only locations with high concentrations of collisions are of interest. Note that in equation (2), K(d) will not only identify high risk locations but also show the excess risk of the segment compared to the base risk, B. This allows us to determine where the risk started to increase and decrease as well as locations of the localized peaks in risk.

$$K(d) = Max\left(\frac{M(d+l) - M(d)}{l}, 0\right) \quad (2)$$

Figure 6 shows K(d) of I-880 Northbound separately from 1994 to 2003. The x-axis in Figure 6 is the postmile and the y-axis shows the K(d) of different years. To compare the risk across different years, the same base risk, B(d-d0), was used as a rescaling factor. More pronounced peaks in the figure mark sites with high risk.

**FIGURE 6:**
**CRP OF 880 NORTHBOUND SEPARATELY FROM 1994 TO 2003**



Data displayed in Figure 6 illustrate a strong consistency in high risk sites over the ten-year period. It is possible that the specificity illustrated in Figure 6 is the result of random fluctuations. However, it is visually apparent that the specific peaks are reproducible over successive years. This visual impression is supported by a strong statistical correlation observed over the years. To test the consistency of the cluster from milepost marker 19.0 to 20.3 (see the dotted box labeled C1 in Figure 6), cross correlation for successive pairs of years was calculated from 1994 to 2003. For each successive pair, the correlation was calculated by shifting the location of the previous year's cluster from its original location from -0.3 to 0.3 mile by increments of 0.01 mile (with 0 as its original location). Figure 7 shows the result of the cross-year correlation. The x-axis in the figure is the distance shifted (in 0.01 mile increments) and the y-axis is the correlation resulting from shifting the curves. Table 4 shows the highest correlation and the corresponding shift for each comparison. Equation (3) shows how the cross correlation for successive pairs of years was calculated.

$$r_{y,y-1}(i) = \frac{\sum_{d}(k_y(d) - \bar{k}_y)(k_{y-1}(d-i) - \bar{k}_{y-1})}{\sqrt{\sum_{d}(k_y(d) - \bar{k}_y)^2}\sqrt{\sum_{d}(k_{y-1}(d-i) - \bar{k}_{y-1})^2}} \quad (3)$$

where

$r_{y,y-1}(i)$ = correlation between two successive K(d) from year y and y-1 by shifting K(d) from year, y-1, by distance, $i$

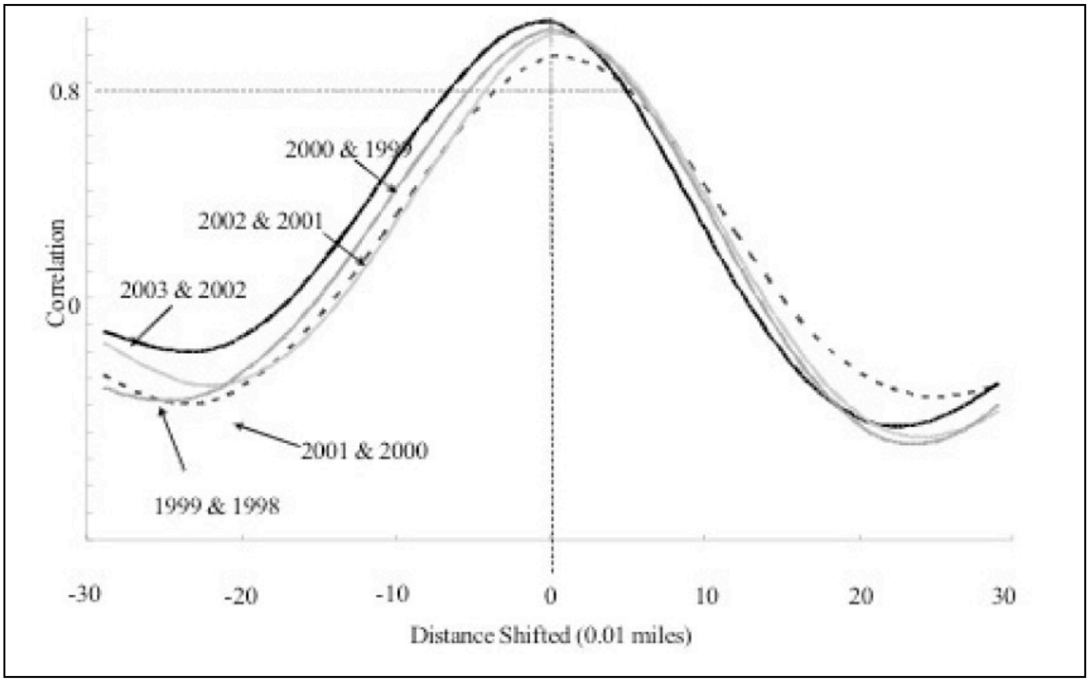
$k_y(d)$ = K(d) of year, y

$\bar{k}_y$ & $\bar{k}_{y-1}$ = means of corresponding series

$-0.3 < i < 0.3$ and $i$ was incremented in 0.01 miles

It is important to note that from 1998 to 2003 (Table 4), the highest correlation was achieved by not shifting the previous year's cluster; in other years (1994 to 1997) the highest correlation was achieved by shifting the previous year's cluster by a small distance, ranging from 0.01 mile to -0.03. This small variation could have been the result of how the data were collected in early years or due to variations in reported collision locations. More remarkably, Figure 7 shows how the correlation rapidly decreased as the shifting increased over a small distance. These findings show that the locations of the peak high risk are highly reproducible.

**FIGURE 7:
CROSS CORRELATION OF THE CONTINUOUS RISK PROFILE
(FROM POSTMILE 19.00 TO 20.3)**



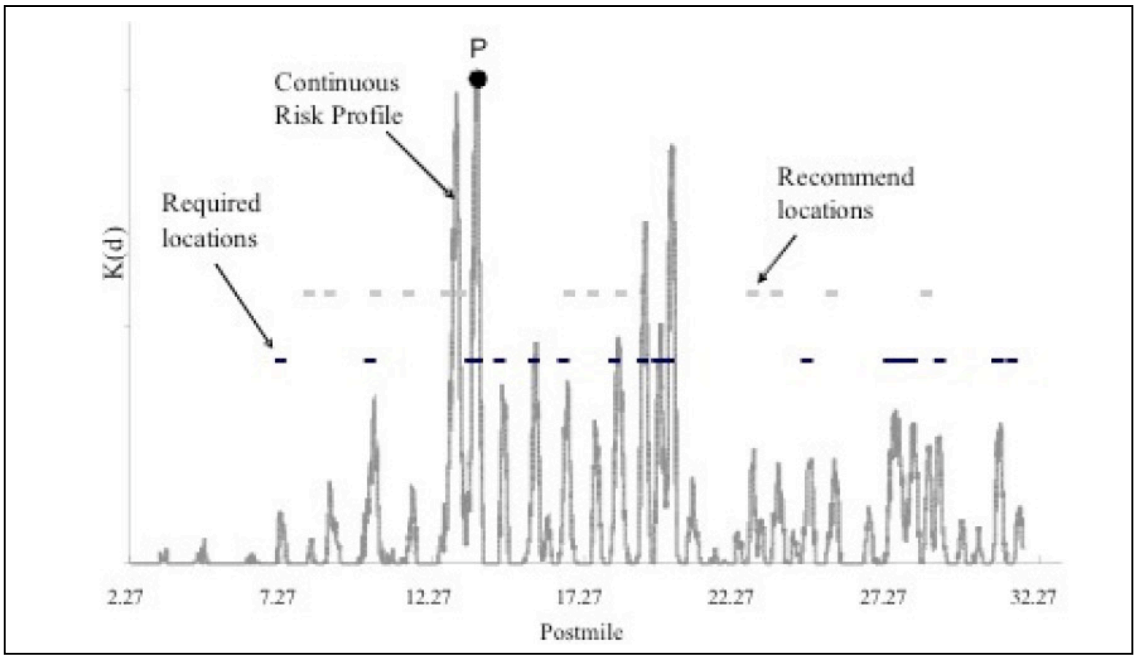

Data displayed in Figure 6 also shows those locations that displayed changes in risk profile over time. For example, between postmile 12.9 and 14.1 (dotted box labeled C2 in Figure 6), there was a relatively low risk profile that was consistent from 1994 to 1998. In 1998, the risk appeared to increase and a new pattern emerged that remained consistent in subsequent years. This pattern suggests that a change occurred in 1998 at this location; however, this change has not been investigated in this paper. This finding suggests that the methods presented in this study have the potential to detect the changes in risk over time.

**TABLE 4:
I-880 NORTHBOUND, ALAMEDA COUNTY, JULY 9, 2003**

| Year | Correlation | Distance Shifted (miles) |
|---|---|---|
| 2003 & 2002 | 0.83 | 0 |
| 2002 & 2001 | 0.90 | 0 |
| 2001 & 2000 | 0.80 | 0 |
| 2000 & 1999 | 0.93 | 0 |
| 1999 & 1998 | 0.88 | 0 |
| 1998 & 1997 | 0.82 | 0.01 |
| 1997 & 1996 | 0.95 | 0.01 |

Figure 6 shows sites identified for safety investigation by Table-C methodology and the continuous risk profile constructed using the same data. The data was taken from years 2000 to 2003 of the I-880 Northbound segment from postmile 2.27 to 32.27. The black dotted lines of varying length indicate the sites identified for required investigation using the Caltrans moving window approach: these are the locations with significantly high collision frequency. The gray dotted lines mark the sites that do not meet the criteria for required investigation but nevertheless are recommended for investigation: these are locations with high collision frequencies, but not as significant as the locations identified by the black dotted lines. The continuous gray line marked with notable peaks is the risk profile generated by the proposed continuous risk method.

**FIGURE 8:
COMPARISON OF CRP AND TABLE C METHODOLOGY
USING A FIXED-LENGTH MOVING WINDOW**




In Figure 8, sites chosen by the fixed moving window approach are juxtaposed with the continuous risk profile for the same stretch of freeway to illustrate several important points. First, it can be seen that the degree of specificity is much greater in the continuous risk profile. By definition, the fixed window approach described in section 4.4.1.1, Table C Method, does not allow variation in risk within the fixed-length window. When safety investigators visit sites identified by the fixed window approach, they must investigate a larger segment of the freeway, while the continuous approach allows the focus to remain on investigating a more specifically targeted area. Some might argue that the continuous approach simply reflects noise. However, as illustrated above, the specificity is most likely real because the peaks are highly reproducible over a number of years.

The lack of specificity in the moving window approach is an important limitation. This limitation can lead to both false negatives and false positives. False negatives can be produced if the moving window is substantially greater than the actual length of the high risk area. High risk locations will be diluted across a fixed window, and will not be accurately identified as high risk. Further, the more highly concentrated collisions are with respect to the length of the moving window, the more likely a false negative will occur.[41]

The fixed moving window approach can also produce false positives. For example, a false positive interval may be detected as a reflection of congestion-related collisions that are secondary to collisions at true risk sites in the vicinity. An advantage of the continuous risk profile approach is that it allows a greater insight into the causal factors in high collision areas. Collisions that occur while traffic is congested are often accompanied by secondary collisions in the vicinity because such collisions not only exacerbate traffic congestion but may also cause the closure of one or more lanes forcing drivers to initiate lane change maneuvers as they leave the collision location in areas in of dense traffic, leading to further collisions. Since a fixed window approach identifies extended stretches of freeway for investigation without differentiating levels of risks, this approach cannot identify sites where a high number of secondary collisions was observed. However, the continuous risk profile approach shows areas of peak risk and how the risk varies over distance in the peak area. (see Appendix A).

### IN SUMMARY, THE CONTINUOUS RISK PROFILE (CRP) APPROACH POSSESSES THE FOLLOWING CHARACTERISTICS:

#### STRENGTHS:

- Intuitive interpretation.
- Does not require changes in current Caltrans collision database.
- Does not require arbitrary segmentation of a roadway, but shows how risk varies continuously within or across segments.
- Can identify secondary collision clusters (i.e., clusters of collisions arising due to congestion caused by collisions in a primary cluster).
- When estimating the effect of countermeasures along the roadway, CRP captures the secondary benefit in the vicinity (i.e., reduction in collision rates in the adjacent sites) in graphical form.

#### WEAKNESS:

- Not suitable for comparing collision rates in a short segment or at isolated intersections.

#### RECOMMENDATIONS:

- The CRP should be systematically compared to other methods (Table C, SPF, and EB) where collisions on highway segments are likely to be correlated.

[41] Kononov, J. (2002) Use of Direct Diagnostics and Pattern Recognition Methodologies in Identifying Locations with Potential for Accident Reduction. Transportation Research Record. 2002.

#### 4.4.1.6 Comparison of Methods

We have provided an account of strengths and weaknesses of four different methods and four methods for calculated expected frequency of collisions were compared. Table 5 summarizes the strengths and weakness of each method.

**TABLE 5:
COMPARISON OF SAFETY PERFORMANCE FUNCTION,
EMPIRICAL BAYES, AND CONTINUOUS RISK PROFILE**

| | EASE OF USE/ UNDERSTANDING | ALLOW FOR EFFECTS TRAFFIC VOLUME | ALLOW FOR EFFECTS OF OTHER VARIABLES | APPROPRIATE MODEL |
|---|---|---|---|---|
| TABLE C ($N_E$) | Medium | Yes | No | No |
| SAFETY PERFORMANCE FUNCTION (SPF) | Low | Yes | Yes | Yes for Intersections and Ramps Questionable for Roadway Segments |
| EMPIRICAL BAYES (EB) | Low | Yes | Yes | Yes for Intersections and Ramps Questionable for Roadway Segments |
| CONTINUOUS RISK PROFILE (CRP) | Medium | Yes | Yes | Yes for Roadway Segment |

It is fairly clear that the current method used ($N_E$) should be replaced by more sophisticated methods, that some version of SPF or EB should be developed for intersections and ramps, and that there are two competing or possibly complementary methods for dealing with roadway segments.

Nonetheless, several1 questions remain:

- What form should the SPF take?
- How much is to be gained by developing an EB approach?
- What approach should be used for highway segments (SPF or CRP)?
- How will these new approaches be integrated into the current Table C system?

**RECOMMENDATIONS:**

- Pilot study in a single district to compare methods.

## 4.5 FORMAT AND CONTENT FOR REPORTING SITES

This section discusses the information to be included in the reports of HCCLs. The current Table C provides this list of information:

- Location
- Rate groups
- Total number of collisions different time intervals
- ADT
- Numbers of fatal and injury collisions

Although it is desirable to have concise and brief forms of reports distributed to users of Table C, there are advantages to enriching the outputs of HCCL screening of Table C with additional and supplementary information.

Since the original database (TASAS) contains a rich set of variables, it can be used to provide helpful input for the follow-up evaluation and investigation. For example, by dissecting the collision records and performing post-screening analyses, the patterns, collision factors and time history of collisions at identified sites can be compared to other similar sites. A report distributed with Table C, so-called "Table B," currently provides some level of summary data and data for specific collisions. However, the content and format of this information could be substantially enhanced. Furthermore, it would be ideal to link Table C to other existing database or data systems creating an integrated data system that can improve ease of use and overall efficiency. For example, if the results of Table C can be utilized in conjunction with map-based Geographical Information Systems (GIS), then the distribution of collisions along a highway or in a region can be clearly visualized. Although TASAS does in fact have postmile to describe locations on the state highway system, with GIS coordinates it would be possible to link to a wealth of GIS-based information, e.g., satellite photos, population distribution, and weather patterns,.[42] Finally, follow-up actions of safety investigations and safety improvements could be linked to and tracked within archived or existing Table C records by inquiries. This would greatly enhance the functionality of such reports.

Major observations and recommendations for these issues are described in the sub-sections below.

### 4.5.1 INFORMATION PROVIDED (E.G., HIGHWAY, NON-HIGHWAY, AND COLLISION FACTORS)

#### TABLE C:

A Table C report of potential investigation locations includes the following information: location ("postmile" and route), rate group, total number of accidents for periods of 36, 24, 12, 6 and 3 months, ADT, rate (per million vehicles or per million vehicle miles traveled), and whether investigation is required or simply recommended.

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[42] Data available through Caltrans: http://www.dot.ca.gov/hq/tsip/gis/datalibrary/gisdatalibrary.html Data from Association of Bay Area Counties (ABAG): http://store.abag.ca.gov/projections.asp#10

### OBSERVATIONS:

Some states provide a much richer set of information about HCCL sites. For example, a system developed in Colorado by Kononov and Allery includes an extensive collision analysis, site characteristics, and a comparison of rates and patterns to other sites in the same category, e.g., two lane rural roads, and information on potential countermeasures.[43]

There are several sources of data that could be included in an expanded Table C report. First, information from TASAS itself could be provided, including:

- Accident data in addition to location, e.g., primary collision factor (PCF), movement preceding collision, contribution of alcohol or drugs, weather conditions, etc.
- Information on general site characteristics (functional class, population code).
- Fairly extensive information on characteristics for each type of facility (intersection, ramp, or highway) (see Appendix A).

Second, additional data pertaining to collisions that occurred within the sites identified in Table C are later retrieved from TASAS. Safety engineers review the data prior to visiting the site. To further improve the productivity of the safety engineers, the current procedure needs to provide collision rate information in the vicinity of the site using a graphical method. Thus, engineers would have more complete knowledge of the collision rates downstream and upstream from the sites identified in Table C, as well as variations in collision rates within the site.

Third, Table C locations, TASAS, and the countermeasures installed along various locations should be linked together. Current procedures do not require quantifying the benefit of the countermeasures that have already been installed as a result of Table C and Wet Table C investigation, at least in a systematic way. Linking this information will allow better assessment of the effectiveness of different methods in reducing collision rates and justify the department's investment.

Finally, other sources of information not part of the set of Caltrans databases could be linked to location data. It is important to be able to link postmile with the wealth of GIS-based information, e.g., satellite photos, population distribution, weather patterns, alcohol outlets, etc. These sources of information could be important for revealing factors that potentially contribute to collisions as well as specific highway characteristics. In other projects our research team has successfully incorporated information obtained from GIS-based location data. We have found that the Caltrans linkage between postmile and GPS coordinates is not accurate and often there is a substantial offset. Caltrans is currently working on improving the linkage between postmile and GIS coordinates.

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[43] Jake Kononov, Bryan K. Allery, Explicit Consideration of Safety in Highway Planning & Design at the Colorado Dept of Transportation. Transportation Research Board, 85th Annual Meeting, Washington, D.C.

**RECOMMENDATIONS:**

Expand the Table C report to include:

- Collision patterns.
- Comparison of collision patterns to other similar sites, e.g., within the same rate group.
- Trends over time at the site compared to overall trends at similar sites.
- Other information that could be derived from TASAS or otherwise linked to the type of site and collision pattern.

### 4.5.2 INTEGRATED DATA SYSTEM

**TABLE C:**

The Table C report provides fairly limited data in a list format.

Table C appears to be distributed as an isolated report, with no apparent system of follow-up actions.

**OBSERVATIONS:**

- Providing Table C reports within the context of a broader data system may facilitate use and provide tracking capability.

**RECOMMENDATIONS:**

- Develop an integrated data system within which the Table C report is generated.
- The integrated data system would include:
  - maps of Table C locations.
  - information on collision patterns available by pointing to and clicking on a site.
  - tracking information including: results of investigation, installation of countermeasures, and evaluation, such as pre-/post-collision history

## 4.6 DATA QUALITY

Table C makes use of the TASAS database, which provides information about the California state highway network. Variables in this system are important for identifying HCCLs. The variables are described in Appendix B in the TSN TSAR reference card.

## THREE PRIMARY TYPES OF DATA:

- **Highway Inventory**
- **Volume Data**
- **Collision Data**

It is clear that the quality and completeness of these various types of data are crucial to HCCL analysis. In general, we have identified several types of issues with the data. The implications and recommendations surrounding these issues are as follows.

### 4.6.1 IMPLICATIONS FOR HIGHWAY INVENTORY

The State Highway System (SHS) includes more than 15,000 miles of highways, 14,000 ramps, and 18,000 intersections. Variables include characteristics of these different types of sites.

There are four types of highway inventory variables:

- Standard fields (functional classification, highway group, etc.)
- Highway fields (lanes and other design features)
- Intersection fields (configuration, traffic control device, etc.)
- Ramps fields (configuration)

#### PROBLEMS:

There are four problems with the highway inventory data:

**1. Missing Design Information For A Small Number Of Sites**

Some variables have incomplete information, although this is true for less than 1% of the total data. No recommendations are made at this time. However, whenever such segments or sites are recognized in data processing and the relevant data become available, corrections should be made to enhance data sets.

**2. A Relatively Small Number Of Sites For Some Rate Groups**

Some of the rate groups have a very small number of sites. The implication is that base rates calculated for these sites are likely to be very unstable. Rate groups with small numbers of sites should be combined with other groups.

**3. Overlapping Sites**

A small number of intersections within 250 feet of one another and with collisions occurring in between may be double counted. Double counting of intersection accidents is due to the overlapping of the ‘N’ area of distinct intersections. This overlapping of intersections’ ‘N’ area can cause inaccuracies when calculating the expected accident frequency and when estimating safety.

**RECOMMENDATIONS:**

There are at least several potential solutions:

- One approach is to identify the upstream and downstream directions of the roadway and assign collisions to the upstream or downstream intersection only when it is recognized that a second intersection is within a specified distance. This should eliminate the double counting problem.
- Another method involves the re-categorization of site types and an overhaul of rate groups. For example, if intersections are treated as "segments" of a continuous roadway, then the calculation of safety performance will depend on the use of the chosen methods in screening and identifying HCCL on a continuous highway segment.

#### 4. Double Listing

A small number of highway segments and ramps are listed twice. These errors are minimal and should not affect the results. However, whenever such segments or sites are recognized in data processing, corrections should be made to avoid repetition of errors.

### 4.6.2 VOLUME DATA

Traffic volume data are obtained from the Traffic Data Office (in Traffic Operations). Average Annual Daily Traffic (AADT) is available for all intersections, ramps, and roadway segments. The calculation of AADT is performed once each year based on data collected from October 1 through September 30. Volume is collected at all sites on a rotating basis once every three years. Using these traffic volume data, base rates for different roadway types are calculated in the following way:

- Highway segments: collisions/million vehicle miles
- Intersections: collisions/million vehicles entering the intersection (primary + secondary)
- Ramps: collisions/million vehicles traversing the ramp

**PROBLEMS:**

The research team has identified five issues pertaining to volume data:

#### 1. Data Often Out Of Date, Many Data Points Interpolated, And Other Problems With Data Accuracy

#### 2. Some Missing Or Out-Of-Range Values

We found missing volumes for about 1% of highway segments, 1% of intersections, and 2% of ramps. In itself, this number of missing volumes probably has minimal impact on Table C analyses. However, rates with these values should be eliminated from any analysis.

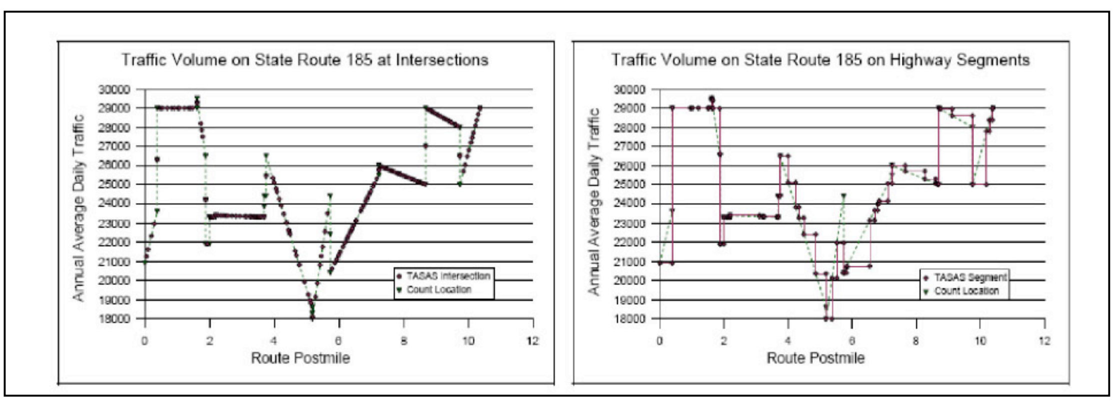
### 3. Out-Of-Range Volumes

We found that a fairly large number of intersections (about 5%) had very low AADTs (less than 10). A very small number of ramps (less than 1%) had very low AADTs. Such low volumes will result in very high rate estimates, and could bias outcomes.

### 4. Interpolation Or Extrapolation Of Volume Estimates

Uncertainty in traffic volume information arises from the frequency of traffic counts used for estimating the AADT. Traffic volumes on state routes are recorded by Caltrans. In general, for each route, traffic counts at fixed control stations are collected once every three years. Based on a single (or several) day count and other factors, the AADT is computed. Each year, an AADT is produced for every control station whether it has been updated or not. The resulting tables are accessible online on the Caltrans website. Based on several control stations' AADT, the traffic volume for each segment, intersection, and ramp is calculated in TASAS using linear interpolation. For intersection-crossing roads, traffic volumes are obtained either by counts, using the same method as for state routes but at a lower frequency (often once every 10 years), or by estimations. The extrapolation from the estimated traffic volume at several count locations to the traffic volume information coded in the Highway database is illustrated in Figure 9. For intersection-crossing roads, traffic volumes are obtained either by counts, using the same method as for state routes but at a lower frequency (often once every 10 years), or by estimations. Estimations are identified by a one for the last digit of the crossing street AADT and account for ~60% of attributed values.

FIGURE 9:
EXAMPLE OF EXTRAPOLATION FROM RECORDED TRAFFIC COUNTS TO TASAS TRAFFIC INFORMATION

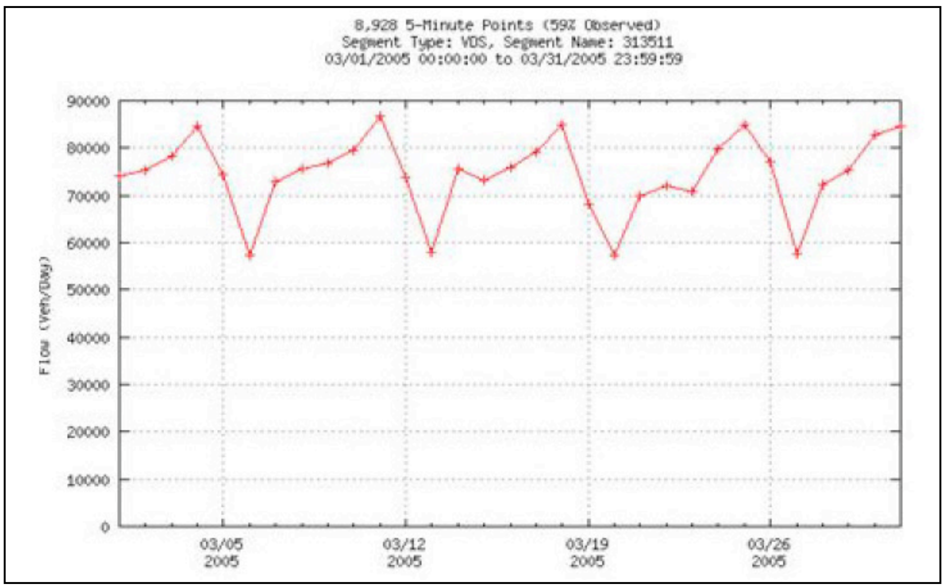



### 5. Potential Bias In Volume Estimates

Current procedures do not consider the effect of variations in traffic based on day of the week and traffic demand, e.g., two sites with the same AADT. However, one site has high peak demand (typically observed in Northern California) and the other moderate demand sustained throughout the day (typically observed in Southern California). This variation in traffic demand can affect collision rates, but it is not accounted for in the calculations.

Figure 10 shows the variations in traffic demand across different days observed on eastbound Highway-80 near the city of Roseville. The figure illustrates the fluctuations in daily traffic volume during a one-month period. The peaks on this chart occurred repeatedly on Fridays, when the traffic traveling in the Lake Tahoe and Reno direction was considerably higher than on the other days of the week. The initial step in the analysis of commuting-related incidents will be to examine the number of incidents during selected hours of the day or selected days of the week. The total number of accidents or the distribution of accident types in the selected windows, versus the overall distribution, will provide a basis for evaluating the contribution of traffic volume and congestion-related factors to the occurrence of collisions.

**FIGURE 10:**
**EXAMPLE OF PEMS DATA OVER 24-HOUR SPAN IN A DAY**




**RECOMMENDATIONS:**

Check TASAS database based on some of the results given previously:

- Add missing sites if appropriate.
- Screen sites with no accidents over a long period of time for closed roads or non state-managed roads (additional statistical criteria may be used to reduce number of sites to check).
- Check traffic volume information for sites with missing, incorrect or out-of-range values.
- Create methodology for checking TASAS data.
- Create feedback loop from Table C to TASAS to reduce number of errors.

- Improve quality of traffic information data and reduce underreporting rate value and variance. For traffic volumes, it would be beneficial to consider two traffic volume fields, begin_adt and end_adt, if Table C can be made compatible with this update.
- Set up ongoing system to monitor quality of volume data and make improvements.
- Develop statistical model of volume data to facilitate projects, interpolations, etc.

### 4.6.3 COLLISION DATA

Collision data are obtained from the California Highway Patrol (CHP) from a database called the Statewide Integrated Traffic Records System (SWITRS), which is intended to include all police-report traffic collisions in the state. Collision data are extracted by CHP from the SWITRS database and contain information about collision characteristics and parties involved, coded by CHP, as well as site location, coded by Caltrans. Between 1994 and 2004, more than 1,800,000 accidents were recorded on Californian state highways.

**PROBLEMS:**

There are five problems with the collision data:

**1. Underreporting**

Underreporting of accidents occurs when a proportion of accidents are not reported, resulting in underestimation bias in the observed accident frequency. Vogt and Bared noted that “the amount of any underreporting is a matter of speculation (one source in Minnesota thought there might be one minor unreported accident for each reported one because accident-prone drivers wish to avoid both penalties for intoxication and insurance premium increases).” A major concern is to estimate the underreporting rate, calculated as the number of observed accidents divided by the real number of accidents. It is important to determine both the rate of underreporting and how it varies from one area to another. In areas where the underreporting rate of accidents is less frequent, highways will incorrectly appear safer.

**2. Inaccurate Information**

In analyses of locations and movements preceding collision, we have found internally inconsistent information. However, the degree of inaccuracy is not known.

**3. Linkage Issues**

A small number of collisions could not be linked to a highway location (<1%). We have noted the following types of errors:

- Location errors
- Errors in movement preceding the collision and direction

### 4. Missed Identification And Underestimation Issues

Problems occur when a segment in a highway rate group that is less than 0.2 mile in length is ignored or not documented in the Table C and Wet Table C overview. For example, if a highway rate group is 0.5 mile long, and if the first and second 0.2 mile segments are significant, then the last segment in the analysis for this highway rate group will include 0.1 mile of the next highway rate group. In this case, the analysis will stop and restart at the beginning segment of the next highway rate group, and the last 0.1 mile of the previous highway rate group will be ignored.

Another problem during highway rate group analysis occurs when the moving window is reaching the “N” area of an intersection—250 feet beyond the intersection. The analysis process will stop and restart beyond the “N” area, because accidents at the intersections have already been analyzed in intersection analysis and will not be re-analyzed in the highway analysis. The collisions coded outside the intersection but within the ‘N' area (usually 250 feet) will have a file type of ‘H,’ but they are also included with the intersection analysis. It means that some collisions are counted twice, in both a highway file and an intersection file.

Implications for screening for HCCL are:

- Some sites are automatically considered as non-dangerous by Table C.
- Underestimation of expected accident frequency may occur.

### 5. Other Miscellaneous Issues

- In the accident file, some accidents are identified as “ramp” incidents, but their postmile fields are marked at locations before the postmile in the ramp file starts.
- In the accident file, there are ramp accidents that do not match any postmile in the ramp file.
- The highway accidents at some postmiles are recorded in two segments of the highway data due to overlapping highway segments.
- There are intersection accidents that do not match any location in the intersection data.

**RECOMMENDATIONS:**

- Perform systematic range and missing value checks.
- Prepare reports on out-of-range and missing data as feedback to CHP and other police agencies.
- Test models of extrapolation and interpolation.

Some of the problems with collision data are associated with reporting procedures, such as underreporting or missing information in the collision reports. Some of these problems are the result of human error. But site-specific errors discovered in data processing can and should be corrected to avoid repetition of these errors in the future.

# 4.7 APPROACHES OTHER THAN SITE-SPECIFIC APPROACHES

## 4.7.1 INDIVIDUAL SITES VERSUS TYPES OF SITES

### TABLE C:

Table C is currently designed to identify specific sites, such as intersections, ramps, and 0.2 mile segments.

### OBSERVATIONS:

Methods such as Table C focus on sites that fall in the same general category (e.g., rate groups), to identify those sites which have a high number of collisions in relation to other sites in that category. When such sites are identified they likely have one or more characteristics that differentiate them from the other sites and that contribute to collisions. Such characteristics may be design characteristics that may also appear in other sites with a high number of collisions. This suggests the need for a strategy that identifies both specific sites with high risk, and design features associated with high risk. The methodologies of SPFs, the EB method, and the CRP method all lend themselves to this strategy. Parameters in SPFs can represent design characteristics (e.g., shoulder width, curvature) that affect collision risk. These characteristics could be addressed on a large scale, and not merely as a feature of a specific high risk site. Identifying design characteristics associated with high collision frequency should be a natural by-product of SPF, CRP, or other analyses aimed at identifying individual sites.

One important design feature is shoulder width on HOV lanes. In a study of safety in relation to various design features of HOV lanes (in this case, a comparison of sites with limited versus continuous access facilities), narrower shoulder width was associated with higher collisions per mile (Figure 11).[44] This suggests a need to focus on the design of shoulder width in addition to focusing on individual sites.

Figure 11 shows the relationship between shoulder width and collisions/mile/hour relationship. Facilities with wider should width generally have fewer collisions per mile, regardless of whether the facility is a limited or continuous access facility.

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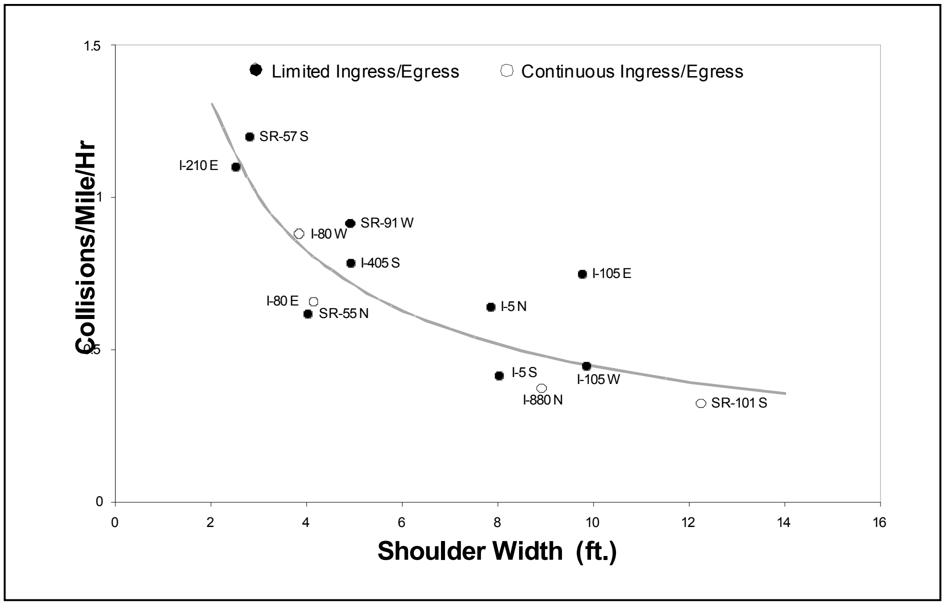
[44] Ragland DR, Jang K, Chan CY. Comparing Safety Performance of Limited versus Continuous Access High Occupancy Vehicle (HOV) Facilities—Summary. UC Berkeley Traffic Safety Center (TSC), Partners for Advanced Transit and Highways (PATH), Institute of Transportation Studies, University of California, August 2007.

**FIGURE 11:**
**SHOULDER WIDTH AND COLLISIONS/MILE/HOUR RELATIONSHIP**




## RECOMMENDATIONS:

Within the context of identifying individual sites with high collision risk, statistical models such as the SPF, EB, CRP and other methods can be used to identify patterns of collisions related to various design features. This is a natural by-product of the analyses that must be conducted anyway to identify HCCLs.

### 4.7.2 CORRIDORS

## TABLE C:

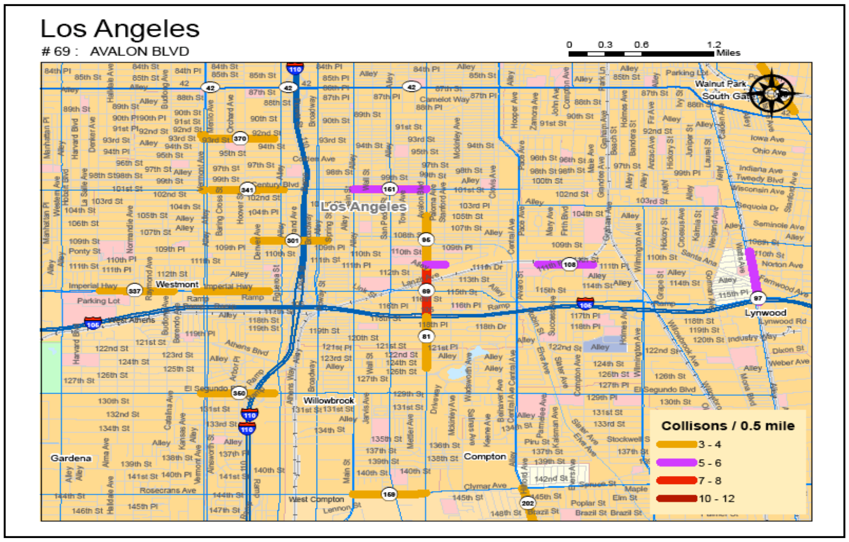
Table C focuses on individual sites.

## OBSERVATIONS:

One of the findings reported in the Table C Task Force Report is that many required or recommended highway segment locations are actually adjacent to one another. One of the recommendations was to combine adjacent locations which would create segments up to one mile in length. We have found that various methods of identifying high collision sites will often yield adjacent locations. For example, in conjunction with the Strategic Highway Safety Improvement Plan (SHSIP) for California we calculated the frequency of severe and fatal collisions for non-state highway roads in ½ mile segments. A map of a selected area of Los Angeles shows how these ½ mile segments can cluster, forming a corridor of high collision risk (Figure 12).[45]

[45] Analyses conducted for the 5% report for the Strategic Highway Safety Implementation Plan (SHSIP) for California, July 2007.

**FIGURE 12:**
**CLUSTERING OF HIGH COLLISION (FATAL AND SEVERE INJURY) RISK IN A SELECTED AREA OF LOS ANGELES.**
**COLLISIONS ARE ON NON-STATE HIGHWAY STREETS FOR 2003-2005**




With the current Table C method, clusters of adjacent sites are based on noted patterns among sites selected because of their high density of collisions. But there is reason to believe that traffic collisions may be affected by common factors within a large area rather than at a single intersection, ramp, or 0.2 mile highway segment. In addition, areas may have common features (such as non-optimal signal timing) in a number of related sites, and some countermeasures may be more effectively implemented across a set of sites or within a broader community. In other words, in some cases the most appropriate "unit of analysis" may be a broader area rather than a specific site.

There are several methods for identifying sites longer than 0.2 mile or for identifying clusters of specific sites, such as intersections. Several approaches include:

- Using "sliding windows" of different lengths.
- Applying methodology similar to Table C but choosing a much larger interval (e.g., 1⁄2 mile).
- Calculating collision frequencies, or rates, in highway segments larger than 0.2.
- Calculating continuous densities of collisions by plotting collisions using GIS methods and using existing software to calculate clusters, or to identify regions that show a high level of collision density.

**RECOMMENDATIONS:**

As a supplement to the Table C program for identifying specific sites, it is recommended that Caltrans develop and implement a parallel methodology for identifying clusters or "corridors" with high collision densities and that this be made part of a regular Table C reporting.

All of the following methods are feasible within the context of the current TASAS data system:

- Develop statistical methodology for identifying corridors using, for example, a "sliding window" of different lengths.
- Develop a method for looking at segments of different lengths (e.g., 1⁄2 mile segments).
- Examine traffic density in "natural" segments, i.e., segments between intersections or exchanges.
- Plot collisions using GIS so that collision patterns can be linked with GIS-based information, e.g., satellite photos, population distribution, weather patterns, etc.

# 5 NEXT STEPS

This report has covered specific topics in each of seven major dimensions of systems employed to identify HCCLs. We have made a number of recommendations in each of these areas. We anticipate that implementation of these recommendations should lead to lower false-negatives (the most crucial goal), lower false positives (very important for efficient use of engineering resources), higher flexibility in the type of sites identified, greater ability to identify change in risk, increased information to assist on-site investigation, and better overall "usability" for Caltrans engineers.

In each case we have begun with the current Table C approach and considered how it might be modified or expanded to improve HCCL selection. Many of the recommendations could be implemented without major restructuring of the Table C process. However, some recommendations would require greater changes.

In either case, a number of issues need to be addressed before further development and deployment, including the following:

- **Ease of use by Caltrans personnel**
- **Compatibility with existing Caltrans procedures and database**
- **Exact application using California data, e.g., calibration of SPFs, calculation of stability for specific sites, etc.**
- **Specific benefits of alternative options or methods, e.g., SPF/EB approach versus the CRP approach for highway segments**

To clarify these and other issues we propose that Caltrans conduct a pilot study for a single county or Caltrans district, using the following steps:

## 1. ESTABLISH A PILOT STUDY OVERSIGHT GROUP

This group would include: TASAS personnel, personnel from the district participating in the pilot, and national-level consultants experienced in this area.

## 2. DEVELOP METHODOLOGY FOR THE PILOT STUDY

Selection of a county or district for the test; one with a high level of interest and willingness to participate.

**Scope:** which options/approaches should be tested.

**Duration:** length of time needed.

**Performance measure(s):** e.g., predictive accuracy, reliability, usability.

## 3. OBTAIN ACCESS TO THE FHWA'S SAFETYANALYST SOFTWARE[46]

SafetyAnalyst, described above, is a system being developed by the FHWA to address site-specific safety improvements. The module includes programming to calculate SPFs, and implement the EB approach. For the proposed pilot study SafetyAnalyst could provide a means to:

- calibrate SPFs.
- implement the EB method.
- calculate stability of estimates.
- implement calculations for detecting change.

SafetyAnalyst does not offer a fixed method for identifying high collisions locations, instead, a range of options are offered at each step. The SafetyAnalyst software needs to be adapted for California data.

## 4. CONDUCT PILOT STUDY

The pilot study would be conducted under the direction of the "Pilot Study Oversight Group." The study would examine the procedures for adopting SafetyAnalyst software for California data, develop programs and procedures that are not part of the SafetyAnalyst system, conduct analyses, and prepare a report of results.

## 5. DETERMINE DIRECTION FOR FULL DEPLOYMENT

Based on the pilot study, develop a comprehensive system for HCCL and plan for deployment.

[46] SafetyAnalyst is available for states participating in a pooled program for developing the system. However, we have established that the SafetyAnalyst test software would be made available for testing in Caltrans if there is interest in doing so. http://www.tfhrc.gov/safety/pubs/06124/index.htm.

# 6 APPENDICES

## APPENDIX A: Intersection, Ramp, And Highway Rate Groups

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**APPENDIX A**
**—Intersection, Ramp, and Highway Rate Groups**

**APPENDIX A1**
**Intersection Rate Groups**

| RATE GROUP | BASE RATE | + ADT FACTOR | PCT FAT | PCT INJ | PCT F+I | INTERSECTION TYPE * | CONTROL TYPE | AREA | ACC COSTS ($1000) F+I | ALL |
|---|---|---|---|---|---|---|---|---|---|---|
| I 01 | 0.11 | 0.0000 | 3.5 | 42.0 | 45.5 | F, M AND S | NO CONTROL | RURAL | 371.4 | 171.2 |
| I 02 | 0.33 | 0.0000 | 2.4 | 45.3 | 47.7 | F, M AND S | STOP & YIELD SIGNS (EXC 4 WAY) | RURAL | 269.7 | 130.8 |
| I 03 | 0.76 | 0.0000 | 0.8 | 41.4 | 42.2 | F, M AND S | 4 WAY STOP | RURAL | 149.9 | 65.6 |
| I 04 | 0.70 | 0.0000 | 1.0 | 45.5 | 46.5 | F, M AND S | SIGNALS | RURAL | 159.6 | 76.4 |
| I 05 | 0.70 | 0.0000 | 1.3 | 43.3 | 44.5 | F, M AND S | 4 WAY FLASHERS | RURAL | 189.2 | 86.4 |
| I 06 | 0.35 | 0.0000 | 0.8 | 32.3 | 33.1 | F, M AND S | NO CONTROL | SUBURBAN | 147.9 | 51.6 |
| I 07 | 0.34 | 0.0000 | 1.2 | 40.4 | 41.5 | F, M AND S | STOP & YIELD SIGNS (EXC 4 WAY) | SUBURBAN | 164.8 | 70.7 |
| I 08 | 0.51 | 0.0000 | 0.4 | 36.4 | 36.8 | F, M AND S | 4 WAY STOP | SUBURBAN | 100.9 | 39.6 |
| I 09 | 0.58 | 0.0000 | 0.5 | 39.3 | 39.7 | F, M AND S | SIGNALS | SUBURBAN | 107.1 | 44.9 |
| I 10 | 0.55 | 0.0000 | 1.3 | 30.7 | 32.0 | F, M AND S | 4 WAY FLASHERS | SUBURBAN | 206.1 | 68.7 |
| I 11 | 0.06 | 0.0000 | 2.6 | 42.8 | 45.4 | F, M AND S | NO CONTROL | URBAN | 249.7 | 115.5 |
| I 12 | 0.22 | 0.0000 | 0.7 | 42.2 | 42.9 | F, M AND S | STOP & YIELD SIGNS (EXC 4 WAY) | URBAN | 108.5 | 48.8 |
| I 13 | 0.41 | 0.0000 | 0.5 | 45.0 | 45.5 | F, M AND S | 4 WAY STOP | URBAN | 90.1 | 43.2 |
| I 14 | 0.43 | 0.0000 | 0.4 | 43.9 | 44.3 | F, M AND S | SIGNALS | URBAN | 83.3 | 39.1 |
| I 15 | 0.62 | 0.0000 | 0.7 | 39.6 | 40.3 | F, M AND S | 4 WAY FLASHERS | URBAN | 112.1 | 47.6 |
| I 16 | 0.14 | 0.0000 | 1.8 | 43.5 | 45.3 | T, Y AND Z | NO CONTROL | RURAL | 229.3 | 106.1 |
| I 17 | 0.22 | 0.0000 | 1.8 | 42.6 | 44.3 | T, Y AND Z | STOP & YIELD SIGNS (EXC 4 WAY) | RURAL | 232.9 | 105.4 |
| I 18 | 0.60 | 0.0000 | 0.5 | 47.8 | 48.4 | T, Y AND Z | 4 WAY STOP | RURAL | 116.7 | 58.6 |
| I 19 | 0.50 | 0.0000 | 0.2 | 37.9 | 38.1 | T, Y AND Z | SIGNALS | RURAL | 97.5 | 39.6 |
| I 20 | 0.58 | 0.0000 | 2.2 | 39.4 | 41.7 | T, Y AND Z | 4 WAY FLASHERS | RURAL | 278.9 | 118.6 |
| I 21 | 0.13 | 0.0000 | 0.4 | 40.0 | 40.5 | T, Y AND Z | NO CONTROL | SUBURBAN | 97.2 | 41.7 |
| I 22 | 0.19 | 0.0000 | 0.9 | 40.5 | 41.4 | T, Y AND Z | STOP & YIELD SIGNS (EXC 4 WAY) | SUBURBAN | 139.3 | 60.0 |
| I 23 | 0.54 | 0.0000 | 0.5 | 33.3 | 33.8 | T, Y AND Z | 4 WAY STOP | SUBURBAN | 114.7 | 41.4 |
| I 24 | 0.43 | 0.0000 | 0.2 | 38.9 | 39.1 | T, Y AND Z | SIGNALS | SUBURBAN | 80.5 | 33.9 |
| I 25 | 0.55 | 0.0000 | 2.9 | 48.3 | 51.2 | T, Y AND Z | 4 WAY FLASHERS | SUBURBAN | 262.8 | 136.5 |
| I 26 | 0.10 | 0.0000 | 0.8 | 41.2 | 42.0 | T, Y AND Z | NO CONTROL | URBAN | 117.9 | 51.8 |
| I 27 | 0.14 | 0.0000 | 0.8 | 42.4 | 43.2 | T, Y AND Z | STOP & YIELD SIGNS (EXC 4 WAY) | URBAN | 116.0 | 52.4 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| I 28 | 0.18 | 0.0000 | 1.1 | 34.1 | 35.2 | T, Y AND Z | 4 WAY STOP | URBAN | 159.9 | 58.9 |
| I 29 | 0.28 | 0.0000 | 0.4 | 43.3 | 43.7 | T, Y AND Z | SIGNALS | URBAN | 83.8 | 38.9 |
| I 30 | 0.35 | 0.0000 | 0.7 | 47.5 | 48.2 | T, Y AND Z | 4 WAY FLASHERS | URBAN | 102.3 | 51.4 |

* INTERSECTION TYPES
F - FOUR-LEGGED
M -MULTI-LEGGED
S - OFFSET
T - TEE
Y - Y WYE
Z - OTHERS

Intersection, Ramp, Highway

Intersection
Control Type (No Control, Stop and Yield [Except 4-Way], Intersection Type (F,M,S versus T, Y, Z), Area (Rural, Urban, Suburban)

Ramp
Ramp Type (Frontage Road, etc.), Ramp Area (1-4, 1-3, etc.), Area (Rural, Urban, Suburban)

Highway

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**APPENDIX A2**
**—Ramp Rate Groups**

| RATE GROUP | BASE RATE | + ADT FACTOR | PCT FAT | PCT INJ | PCT F+I | RAMP TYPE | RAMP AREAS | ON/ OFF | AREA | ACC COSTS ($1000) F+ I | ALL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| R01 | 0.30 | 0.0000 | 1.5 | 48.5 | 50.0 | FRONTAGE ROAD | 1-4 | N/A | RURAL | 192.1 | 98.0 |
| R02 | 1.20 | 0.0000 | 0.5 | 28.6 | 29.1 | FRONTAGE ROAD | 1-4 | N/A | URBAN | 111.4 | 35.3 |
| R03 | 0.35 | 0.0000 | 1.5 | 48.5 | 50.0 | COLLECTOR ROAD | 1-4 | N/A | RURAL | 192.1 | 98.0 |
| R04 | 0.35 | 0.0000 | 0.5 | 28.6 | 29.1 | COLLECTOR ROAD | 1-4 | N/A | URBAN | 111.4 | 35.3 |
| R05 | 0.70 | 0.0000 | 1.0 | 33.7 | 34.7 | DIRECT, SEMI-DIR CONN (LT TRN TRAF) | 1-4 | OFF | RURAL | 187.6 | 67.7 |
| R06 | 0.60 | 0.0000 | 1.0 | 33.7 | 34.7 | DIRECT, SEMI-DIR CONN (LT TRN TRAF) | 1-4 | OFF | URBAN | 151.6 | 55.2 |
| R07 | 0.35 | 0.0000 | 1.0 | 33.7 | 34.7 | DIRECT, SEMI-DIR CONN (LT TRN TRAF) | 1-4 | ON | RURAL | 187.6 | 67.7 |
| R08 | 0.55 | 0.0000 | 1.0 | 33.7 | 34.7 | DIRECT, SEMI-DIR-CONN (LT TRN TRAF) | 1-4 | ON | URBAN | 151.6 | 55.2 |
| R09 | 1.15 | 0.0000 | 1.2 | 36.1 | 37.3 | DIAMOND | 1-4 | OFF | RURAL | 200.4 | 77.2 |
| R10 | 1.50 | 0.0000 | 0.3 | 40.1 | 40.4 | DIAMOND | 1-4 | OFF | URBAN | 77.8 | 33.8 |
| R11 | 0.55 | 0.0000 | 1.2 | 36.1 | 37.3 | DIAMOND | 1-4 | ON | RURAL | 200.4 | 77.2 |
| R12 | 0.80 | 0.0000 | 0.3 | 40.1 | 40.4 | DIAMOND | 1-4 | ON | URBAN | 77.8 | 33.8 |
| R13 | 0.45 | 0.0000 | 1.3 | 35.0 | 36.3 | SLIP | 1-4 | OFF | RURAL | 214.3 | 80.3 |
| R14 | 0.40 | 0.0000 | 0.4 | 38.3 | 38.7 | SLIP | 1-4 | OFF | URBAN | 87.8 | 36.4 |
| R15 | 0.35 | 0.0000 | 1.3 | 45.0 | 46.3 | SLIP | 1-4 | ON | RURAL | 184.7 | 87.7 |
| R16 | 0.35 | 0.0000 | 0.4 | 38.3 | 38.7 | SLIP | 1-4 | ON | URBAN | 87.8 | 36.4 |
| R17 | 0.60 | 0.0000 | 1.0 | 31.2 | 32.2 | DIRECT, SEMI-DIR CONN (RT TRN TRAF) | 1-4 | OFF | RURAL | 196.1 | 65.9 |
| R18 | 0.90 | 0.0000 | 0.7 | 35.5 | 36.2 | DIRECT, SEMI-DIR CONN (RT TRN TRAF) | 1-4 | OFF | URBAN | 118.9 | 45.6 |
| R19 | 0.45 | 0.0000 | 1.1 | 34.2 | 35.3 | DIRECT, SEMI-DIR CONN (RT TRN TRAF) | 1-4 | ON | RURAL | 196.5 | 72.0 |
| R2 | 0.60 | 0.0000 | 0.5 | 35. | 36. | DIRECT, SEMI-DIR CONN | 1-4 | ON | URB | 100. | 38.6 |

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| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | 5 | 0 | (RT TRN TRAF) | | | AN | 1 | |
| R 21 | 1.75 | 0.0000 | 0.9 | 42.2 | 43.1 | LOOP WITH LEFT TURN | 1-4 | OFF | RURAL | 157.2 | 70.0 |
| R 22 | 1.35 | 0.0000 | 0.3 | 36.9 | 37.2 | LOOP WITH LEFT TURN | 1-4 | OFF | URBAN | 80.0 | 32.3 |
| R 23 | 0.60 | 0.0000 | 0.9 | 42.2 | 43.1 | LOOP WITH LEFT TURN | 1-4 | ON | RURAL | 157.2 | 70.0 |
| R 24 | 0.85 | 0.0000 | 0.3 | 36.9 | 37.2 | LOOP WITH LEFT TURN | 1-4 | ON | URBAN | 80.0 | 32.3 |
| R 25 | 1.90 | 0.0000 | 0.7 | 34.8 | 35.5 | BUTTONHOOK | 1-4 | OFF | RURAL | 152.8 | 56.8 |
| R 26 | 1.15 | 0.0000 | 0.4 | 33.6 | 34.0 | BUTTONHOOK | 1-4 | OFF | URBAN | 92.8 | 34.2 |
| R 27 | 0.60 | 0.0000 | 0.7 | 34.8 | 35.5 | BUTTONHOOK | 1-4 | ON | RURAL | 152.8 | 56.8 |
| R 28 | 0.60 | 0.0000 | 0.4 | 33.6 | 34.0 | BUTTONHOOK | 1-4 | ON | URBAN | 92.8 | 34.2 |
| R 29 | 1.05 | 0.0000 | 1.5 | 36.2 | 37.7 | SCISSORS | 1-4 | OFF | RURAL | 229.5 | 89.0 |
| R 30 | 0.90 | 0.0000 | 0.3 | 34.6 | 34.9 | SCISSORS | 1-4 | OFF | URBAN | 81.8 | 31.2 |
| R 31 | 0.50 | 0.0000 | 1.5 | 36.2 | 37.7 | SCISSORS | 1-4 | ON | RURAL | 229.5 | 89.0 |
| R 32 | 0.55 | 0.0000 | 0.3 | 34.6 | 34.9 | SCISSORS | 1-4 | ON | URBAN | 81.8 | 31.2 |
| R 33 | 0.30 | 0.0000 | 2.0 | 64.7 | 66.7 | SPLIT | 1-4 | OFF | RURAL | 192.0 | 129.4 |
| R 34 | 0.25 | 0.0000 | 0.6 | 31.7 | 32.3 | SPLIT | 1-4 | OFF | URBAN | 116.2 | 40.3 |
| R 35 | 0.20 | 0.0000 | 2.0 | 48.0 | 50.0 | SPLIT | 1-4 | ON | RURAL | 230.3 | 117.2 |
| R 36 | 0.25 | 0.0000 | 0.6 | 31.7 | 32.3 | SPLIT | 1-4 | ON | URBAN | 116.2 | 40.3 |
| R 37 | 1.25 | 0.0000 | 2.0 | 53.6 | 55.6 | LOOP WITHOUT LEFT TURN | 1-4 | OFF | RURAL | 214.9 | 121.3 |
| R 38 | 1.25 | 0.0000 | 0.2 | 33.7 | 33.9 | LOOP WITHOUT LEFT TURN | 1-4 | OFF | URBAN | 72.5 | 27.2 |
| R 39 | 0.65 | 0.0000 | 1.7 | 21.4 | 23.1 | LOOP WITHOUT LEFT TURN | 1-4 | ON | RURAL | 358.7 | 85.9 |
| R 40 | 0.70 | 0.0000 | 0.2 | 33.7 | 33.9 | LOOP WITHOUT LEFT TURN | 1-4 | ON | URBAN | 72.5 | 27.2 |
| R 41 | 1.20 | 0.0000 | 1.0 | 34.7 | 35.7 | TWO-WAY RAMP SEGMENT | 1-4 | N/A | RURAL | 184.5 | 68.4 |
| R 42 | 0.70 | 0.0000 | 1.0 | 34.7 | 35.7 | TWO-WAY RAMP SEGMENT | 1-4 | N/A | URBAN | 148.8 | 55.7 |
| R 4 | 1.25 | 0.0000 | 0.9 | 13. | 14. | REST AREA, VISTA PT, TRK | 1-4 | OFF | RUR | 321. | 48.8 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | | | | 2 | 1 | SCALE | | | AL | 4 | |
| R 4 | 1.15 | 0.0000 | 0.9 | 13. | 14. | REST AREA, VISTA PT, TRK | 1-4 | OFF | URB | 272. | 41.8 |
| 4 | | | | 2 | 1 | SCALE | | | AN | 3 | |
| R 4 | 0.35 | 0.0000 | 0.9 | 13. | 14. | REST AREA, VISTA PT, TRK | 1-4 | ON | RUR | 321. | 48.8 |
| 5 | | | | 2 | 1 | SCALE | | | AL | 4 | |
| R 4 | 0.55 | 0.0000 | 0.9 | 13. | 14. | REST AREA, VISTA PT, TRK | 1-4 | ON | URB | 272. | 41.8 |
| 6 | | | | 2 | 1 | SCALE | | | AN | 3 | |
| R 4 | 1.35 | 0.0000 | 0.5 | 49. | 50. | OTHER | 1-4 | OFF | RUR | 115. | 59.8 |
| 7 | | | | 5 | 0 | | | | AL | 6 | |
| R 4 | 0.80 | 0.0000 | 0.5 | 34. | 35. | OTHER | 1-4 | OFF | URB | 101. | 38.1 |
| 8 | | | | 5 | 0 | | | | AN | 5 | |
| R 4 | 0.40 | 0.0000 | 0.5 | 49. | 50. | OTHER | 1-4 | ON | RUR | 115. | 59.8 |
| 9 | | | | 5 | 0 | | | | AL | 6 | |
| R 5 | 1.05 | 0.0000 | 0.5 | 34. | 35. | OTHER | 1-4 | ON | URB | 101. | 38.1 |
| 0 | | | | 5 | 0 | | | | AN | 5 | |
| R 5 | 2.50 | 0.0000 | 0.5 | 61. | 61. | OTHER | 1-4 | N/A | RUR | 108. | 68.3 |
| 1 | | | | 0 | 5 | | | | AL | 5 | |
| R 5 | 0.95 | 0.0000 | 0.5 | 61. | 61. | OTHER | 1-4 | N/A | URB | 80.2 | 50.9 |
| 2 | | | | 0 | 5 | | | | AN | | |
| R 5 | 0.75 | 0.0000 | 0.4 | 33. | 34. | DIAMOND | 1-3 | OFF | RUR | 122. | 44.2 |
| 3 | | | | 6 | 0 | | | | AL | 4 | |
| R 5 | 0.90 | 0.0000 | 0.7 | 37. | 38. | DIAMOND | 1-3 | OFF | URB | 115. | 46.6 |
| 4 | | | | 7 | 4 | | | | AN | 1 | |
| R 5 | 0.50 | 0.0000 | 0.4 | 33. | 34. | DIAMOND | 1-3 | ON | RUR | 122. | 44.2 |
| 5 | | | | 6 | 0 | | | | AL | 4 | |
| R 5 | 0.45 | 0.0000 | 0.7 | 37. | 38. | DIAMOND | 1-3 | ON | URB | 115. | 46.6 |
| 6 | | | | 7 | 4 | | | | AN | 1 | |
| R 5 | 0.30 | 0.0000 | 0.6 | 30. | 31. | SLIP | 1-3 | OFF | RUR | 150. | 49.9 |
| 7 | | | | 7 | 3 | | | | AL | 7 | |
| R 5 | 0.20 | 0.0000 | 0.6 | 30. | 31. | SLIP | 1-3 | OFF | URB | 118. | 39.8 |
| 8 | | | | 7 | 3 | | | | AN | 3 | |
| R 5 | 0.15 | 0.0000 | 0.6 | 30. | 31. | SLIP | 1-3 | ON | RUR | 150. | 49.9 |
| 9 | | | | 7 | 3 | | | | AL | 7 | |
| R 6 | 0.20 | 0.0000 | 0.6 | 30. | 31. | SLIP | 1-3 | ON | URB | 118. | 39.8 |
| 0 | | | | 7 | 3 | | | | AN | 3 | |
| R 6 | 0.30 | 0.0000 | 0.9 | 43. | 44. | DIRECT, SEMI-DIR CONN | 1-3 | OFF | RUR | 154. | 71.2 |
| 1 | | | | 8 | 7 | (RT TRN TRAF) | | | AL | 4 | |
| R 6 | 0.45 | 0.0000 | 0.9 | 31. | 32. | DIRECT, SEMI-DIR CONN | 1-3 | OFF | URB | 148. | 50.6 |
| 2 | | | | 5 | 4 | (RT TRN TRAF) | | | AN | 0 | |
| R 6 | 0.40 | 0.0000 | 0.9 | 43. | 44. | DIRECT, SEMI-DIR CONN | 1-3 | ON | RUR | 154. | 71.2 |
| 3 | | | | 8 | 7 | (RT TRN TRAF) | | | AL | 4 | |
| R 6 | 0.40 | 0.0000 | 0.9 | 31. | 32. | DIRECT, SEMI-DIR CONN | 1-3 | ON | URB | 148. | 50.6 |
| 4 | | | | 5 | 4 | (RT TRN TRAF) | | | AN | 0 | |
| R 6 | 3.20 | 0.0000 | 0.3 | 28. | 28. | LOOP WITH LEFT TURN | 1-3 | OFF | RUR | 117. | 36.3 |
| 5 | | | | 1 | 4 | | | | AL | 8 | |
| R 6 | 1.20 | 0.0000 | 0.3 | 28. | 28. | LOOP WITH LEFT TURN | 1-3 | OFF | URB | 88.6 | 28.0 |

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| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | | | | 1 | 4 | | | | AN | | |
| R 6 | 0.45 | 0.0000 | 0.3 | 28. | 28. | LOOP WITH LEFT TURN | 1-3 | ON | RUR | 117. | 36.3 |
| 7 | | | | 1 | 4 | | | | AL | 8 | |
| R 6 | 0.90 | 0.0000 | 0.3 | 28. | 28. | LOOP WITH LEFT TURN | 1-3 | ON | URB | 88.6 | 28.0 |
| 8 | | | | 1 | 4 | | | | AN | | |
| R 6 | 1.20 | 0.0000 | 1.0 | 40. | 41. | LOOP WITHOUT LEFT | 1-3 | OFF | RUR | 170. | 72.5 |
| 9 | | | | 2 | 2 | TURN | | | AL | 2 | |
| R 7 | 0.90 | 0.0000 | 0.4 | 28. | 28. | LOOP WITHOUT LEFT | 1-3 | OFF | URB | 100. | 31.6 |
| 0 | | | | 3 | 7 | TURN | | | AN | 3 | |
| R 7 | 0.85 | 0.0000 | 1.0 | 40. | 41. | LOOP WITHOUT LEFT | 1-3 | ON | RUR | 170. | 72.5 |
| 1 | | | | 2 | 2 | TURN | | | AL | 2 | |
| R 7 | 0.75 | 0.0000 | 0.4 | 28. | 28. | LOOP WITHOUT LEFT | 1-3 | ON | URB | 100. | 31.6 |
| 2 | | | | 3 | 7 | TURN | | | AN | 3 | |
| R 7 | 0.50 | 0.0000 | 0.4 | 50. | 50. | TWO-WAY RAMP | 1-3 | N/A | RUR | 107. | 56.3 |
| 3 | | | | 0 | 4 | SEGMENT | | | AL | 7 | |
| R 7 | 0.70 | 0.0000 | 0.4 | 50. | 50. | TWO-WAY RAMP | 1-3 | N/A | URB | 79.6 | 42.1 |
| 4 | | | | 0 | 4 | SEGMENT | | | AN | | |
| R 7 | 0.50 | 0.0000 | 0.3 | 38. | 38. | OTHER | 1-3 | OFF | RUR | 107. | 43.7 |
| 5 | | | | 2 | 5 | | | | AL | 2 | |
| R 7 | 0.55 | 0.0000 | 0.3 | 35. | 35. | OTHER | 1-3 | OFF | URB | 81.5 | 31.4 |
| 6 | | | | 0 | 3 | | | | AN | | |
| R 7 | 0.50 | 0.0000 | 0.3 | 38. | 38. | OTHER | 1-3 | ON | RUR | 107. | 43.7 |
| 7 | | | | 2 | 5 | | | | AL | 2 | |
| R 7 | 0.50 | 0.0000 | 0.3 | 35. | 35. | OTHER | 1-3 | ON | URB | 81.5 | 31.4 |
| 8 | | | | 0 | 3 | | | | AN | | |
| R 7 | 0.55 | 0.0000 | 0.3 | 33. | 33. | OTHER | 1-3 | N/A | RUR | 111. | 39.9 |
| 9 | | | | 0 | 3 | | | | AL | 8 | |
| R 8 | 0.55 | 0.0000 | 0.3 | 33. | 33. | OTHER | 1-3 | N/A | URB | 83.3 | 30.4 |
| 0 | | | | 0 | 3 | | | | AN | | |

Table C Task Force Summary 16

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**APPENDIX A3**
**Highway Rate Groups**

| RATE GROUP | BASE RATE | + ADT FACTOR | PCT FAT | PCT INJ | PCT F+I | HIGHWAY TYPE | TERRAIN OR ADT | DESIGN SPEED | AREA | ACC COSTS ($1000) F+I | ALL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| H 01 | 1.15 | 0.35/00 | 3.4 | 45.1 | 48.5 | CONVENTIONAL 2 LANES OR LESS | FLAT | ≤55 | RURAL | 345.4 | 169.6 |
| H 02 | 0.90 | 0.35/00 | 3.8 | 44.6 | 48.5 | CONVENTIONAL 2 LANES OR LESS | FLAT | >55 | RURAL | 376.7 | 184.8 |
| H 03 | 1.30 | 0.35/00 | 2.2 | 46.0 | 48.2 | CONVENTIONAL 2 LANES OR LESS | ROLL | ≤55 | RURAL | 251.9 | 123.5 |
| H 04 | 0.80 | 0.35/00 | 3.7 | 46.2 | 49.9 | CONVENTIONAL 2 LANES OR LESS | ROLL | >55 | RURAL | 360.8 | 182.1 |
| H 05 | 1.65 | 0.40/00 | 2.1 | 48.2 | 50.3 | CONVENTIONAL 2 LANES OR LESS | MTN | ≤55 | RURAL | 237.0 | 121.2 |
| H 06 | 1.25 | 0.40/00 | 2.7 | 44.8 | 47.5 | CONVENTIONAL 2 LANES OR LESS | MTN | >55 | RURAL | 294.7 | 142.1 |
| H 07 | 2.95 | 0.0000 | 0.4 | 38.3 | 38.7 | CONVENTIONAL 2 LANES OR LESS | | <45 | SUBURBAN | 99.0 | 40.8 |
| H 08 | 1.90 | 0.0000 | 1.0 | 41.4 | 42.4 | CONVENTIONAL 2 LANES OR LESS | | 45-55 | SUBURBAN | 145.8 | 64.1 |
| H 09 | 1.50 | 0.0000 | 1.7 | 40.8 | 42.5 | CONVENTIONAL 2 LANES OR LESS | | >55 | SUBURBAN | 203.9 | 89.0 |
| H 10 | 3.05 | 0.0000 | 0.4 | 40.5 | 41.0 | CONVENTIONAL 2 LANES OR LESS | | <45 | URBAN | 95.6 | 41.6 |
| H 11 | 1.75 | 0.0000 | 1.3 | 45.2 | 46.6 | CONVENTIONAL 2 LANES OR LESS | | ≥45 | URBAN | 158.0 | 75.8 |
| H 12 | 1.00 | 0.0000 | 3.1 | 45.0 | 48.1 | CONVENTIONAL 3 LANES | | | RURAL | 323.8 | 157.8 |
| H 13 | 1.30 | 0.0000 | 2.2 | 42.2 | 44.4 | CONVENTIONAL 3 LANES | | | SUBURBAN | 237.7 | 107.8 |
| H 14 | 2.05 | 0.0000 | 0.9 | 38.0 | 38.9 | CONVENTIONAL 3 LANES | | | URBAN | 132.0 | 53.8 |
| H 15 | 0.60 | 0.0000 | 6.0 | 46.6 | 52.7 | EXPRESSWAY 3 LANES OR LESS | FLAT | | RURAL | 512.5 | 272.0 |
| H 16 | 0.60 | 0.0000 | 3.8 | 42.9 | 46.7 | EXPRESSWAY 3 LANES OR LESS | ROLL | | RURAL | 388.4 | 183.5 |
| H 17 | 1.20 | 0.0000 | 1.5 | 42.5 | 44.0 | EXPRESSWAY 3 LANES OR LESS | MTN | | RURAL | 207.7 | 93.6 |
| H 18 | 0.90 | 0.0000 | 5.6 | 52.8 | 58.3 | EXPRESSWAY 3 LANES OR LESS | | ≤55 | SUBURBAN | 402.3 | 236.2 |

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| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| H 19 | 0.90 | 0.0000 | 5.6 | 42.1 | 47.7 | EXPRESSWAY 3 LANES OR LESS | | >55 | SUBURBAN | 477.7 | 230.0 |
| H 20 | 1.00 | 0.0000 | 1.5 | 44.9 | 46.4 | EXPRESSWAY 3 LANES OR LESS | | | URBAN | 163.9 | 78.2 |
| H 21 | 1.20 | 0.0000 | 2.8 | 49.8 | 52.6 | UNDIVIDED 4 LANES | FLAT | | RURAL | 280.9 | 149.6 |
| H 22 | 1.65 | 0.0000 | 2.2 | 38.4 | 40.6 | UNDIVIDED 4 LANES | ROLL/MTN | | RURAL | 284.5 | 117.9 |
| H 23 | 2.55 | 0.0000 | 1.1 | 37.1 | 38.3 | UNDIVIDED 4 LANES | | ≤55 | SUBURBAN | 163.8 | 65.2 |
| H 24 | 2.55 | 0.0000 | 2.0 | 41.1 | 43.1 | UNDIVIDED 4 LANES | | >55 | SUBURBAN | 226.6 | 99.9 |
| H 25 | 4.95 | 0.0000 | 0.4 | 39.4 | 39.8 | UNDIVIDED 4 LANES | | <45 | URBAN | 86.9 | 37.0 |
| H 26 | 3.35 | 0.0000 | 0.6 | 42.5 | 43.2 | UNDIVIDED 4 LANES | | ≥45 | URBAN | 100.0 | 45.5 |
| H 27 | 1.50 | 0.0000 | 2.0 | 37.0 | 39.0 | UNDIVIDED 5-6 LANES | FLAT | | RURAL | 273.4 | 109.1 |
| H 28 | 2.85 | 0.0000 | 1.7 | 50.0 | 51.7 | UNDIVIDED 5-6 LANES | ROLL/MTN | | RURAL | 203.1 | 106.9 |
| H 29 | 0.95 | 0.0000 | 3.1 | 46.9 | 50.0 | UNDIVIDED 5-6 LANES | | ≤55 | SUBURBAN | 281.7 | 142.9 |
| H 30 | 0.95 | 0.0000 | 1.0 | 32.8 | 33.8 | UNDIVIDED 5-6 LANES | | >55 | SUBURBAN | 167.1 | 59.1 |
| H 31 | 4.45 | 0.0000 | 1.0 | 26.1 | 27.1 | UNDIVIDED 5-6 LANES | | <45 | URBAN | 179.4 | 51.5 |
| H 32 | 1.95 | 0.0000 | 0.4 | 45.1 | 45.6 | UNDIVIDED 5-6 LANES | | ≥45 | URBAN | 82.3 | 39.7 |
| H 33 | 0.90 | 0.0000 | 2.9 | 43.9 | 46.8 | DIVIDED 4 LANES | FLAT | | RURAL | 314.3 | 149.2 |
| H 34 | 1.65 | 0.0000 | 1.0 | 35.5 | 36.5 | DIVIDED 4 LANES | ROLL/MTN | | RURAL | 182.1 | 69.0 |
| H 35 | 1.85 | 0.0000 | 0.7 | 43.1 | 43.8 | DIVIDED 4 LANES | | ≤55 | SUBURBAN | 118.9 | 54.3 |
| H 36 | 1.70 | 0.0000 | 1.8 | 40.4 | 42.2 | DIVIDED 4 LANES | | >55 | SUBURBAN | 213.3 | 92.3 |
| H 37 | 3.35 | 0.0000 | 0.5 | 42.3 | 42.8 | DIVIDED 4 LANES | | <45 | URBAN | 92.5 | 41.9 |
| H 38 | 2.10 | 0.0000 | 0.7 | 43.8 | 44.4 | DIVIDED 4 LANES | | ≥45 | URBAN | 106.7 | 49.6 |
| H 39 | 1.05 | 0.0000 | 2.4 | 30.0 | 32.4 | DIVIDED 5 LANES OR MORE | FLAT | | RURAL | 360.6 | 119.5 |
| H 40 | 1.50 | 0.0000 | 1.6 | 50.0 | 51.6 | DIVIDED 5 LANES OR MORE | ROLL/MTN | | RURAL | 195.9 | 103.0 |
| H 41 | 2.75 | 0.0000 | 1.2 | 43.1 | 44.4 | DIVIDED 5 LANES OR MORE | | ≤55 | SUBURBAN | 157.9 | 72.3 |

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| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| H 42 | 2.10 | 0.0000 | 0.9 | 33.3 | 34.3 | DIVIDED 5 LANES OR MORE | | >55 | SUBURBAN | 155.0 | 55.8 |
| H 43 | 2.40 | 0.0000 | 0.7 | 56.8 | 57.5 | DIVIDED 5 LANES OR MORE | | <45 | URBAN | 94.2 | 55.8 |
| H 44 | 2.40 | 0.0000 | 0.7 | 46.1 | 46.8 | DIVIDED 5 LANES OR MORE | | ≥45 | URBAN | 103.8 | 50.7 |
| H 45 | 0.50 | 0.0070 | 2.6 | 42.6 | 45.2 | DIV. EXPRESSWAY 4 LNS OR MORE | | ≤65 | RURAL | 297.3 | 136.6 |
| H 46 | 0.50 | 0.0070 | 3.0 | 44.7 | 47.6 | DIV. EXPRESSWAY 4 LNS OR MORE | | >65 | RURAL | 318.5 | 153.7 |
| H 47 | 0.90 | 0.0170 | 1.5 | 43.2 | 44.8 | DIV. EXPRESSWAY 4 LNS OR MORE | | ≤65 | SUBURBAN | 180.7 | 83.2 |
| H 48 | 0.75 | 0.0100 | 0.8 | 40.8 | 41.5 | DIV. EXPRESSWAY 4 LNS OR MORE | | >65 | SUBURBAN | 130.7 | 56.6 |
| H 49 | 1.75 | 0.0000 | 0.5 | 40.7 | 41.2 | DIV. EXPRESSWAY 4 LNS OR MORE | | ≤55 | URBAN | 94.0 | 41.1 |
| H 50 | 1.35 | 0.0000 | 1.3 | 44.5 | 45.9 | DIV. EXPRESSWAY 4 LNS OR MORE | | >55 | URBAN | 149.7 | 70.9 |
| H 51 | 0.45 | 0.50 / 00 | 2.4 | 40.2 | 42.6 | FREEWAY 4 LANES OR LESS | ≤15000 | ≤65 | RURAL | 292.8 | 127.0 |
| H 52 | 0.45 | 0.55 / 00 | 4.0 | 44.9 | 48.8 | FREEWAY 4 LANES OR LESS | ≤15000 | >65 | RURAL | 390.9 | 192.8 |
| H 53 | 0.45 | 0.0035 | 3.4 | 40.1 | 43.4 | FREEWAY 4 LANES OR LESS | >15000 | ≤65 | RURAL | 377.0 | 165.9 |
| H 54 | 0.40 | 0.0035 | 3.1 | 40.3 | 43.4 | FREEWAY 4 LANES OR LESS | >15000 | >65 | RURAL | 350.4 | 154.4 |
| H 55 | 0.25 | 0.0050 | 2.2 | 40.1 | 42.3 | FREEWAY 5-6 LANES | | | RURAL | 276.2 | 119.1 |
| H 56 | 0.20 | 0.0035 | 1.5 | 36.7 | 38.2 | FREEWAY 7 LANES OR MORE | | | RURAL | 227.5 | 89.4 |
| H 57 | 0.50 | 0.50 / 00 | 3.6 | 43.6 | 47.2 | FREEWAY 4 LANES OR LESS | ≤15000 | ≤65 | SUBURBAN | 332.2 | 158.9 |
| H 58 | 0.45 | 0.55 / 00 | 2.7 | 39.0 | 41.7 | FREEWAY 4 LANES OR LESS | ≤15000 | >65 | SUBURBAN | 291.5 | 123.9 |
| H 59 | 0.75 | 0.0050 | 1.2 | 36.8 | 38.0 | FREEWAY 4 LANES OR LESS | >15000 | ≤65 | SUBURBAN | 174.1 | 68.6 |
| H 60 | 0.50 | 0.0035 | 1.3 | 35.7 | 37.0 | FREEWAY 4 LANES OR LESS | >15000 | >65 | SUBURBAN | 186.7 | 71.6 |
| H 61 | 0.20 | 0.0060 | 1.5 | 33.8 | 35.3 | FREEWAY 5-6 LANES | | | SUBURBAN | 212.7 | 77.7 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| H 62 | 0.25 | 0.0035 | 0.6 | 32.2 | 32.7 | FREEWAY 7 LANES OR MORE | SUBURBAN | 127.5 | 44.4 |
| H 63 | 0.40 | 0.0100 | 1.1 | 35.5 | 36.6 | FREEWAY 4 LANES OR LESS | URBAN | 155.8 | 59.6 |
| H 64 | 0.40 | 0.0055 | 0.6 | 30.4 | 31.0 | FREEWAY 5-6 LANES | URBAN | 118.9 | 39.6 |
| H 65 | 0.40 | 0.0035 | 0.5 | 31.0 | 31.5 | FREEWAY 7-8 LANES | URBAN | 106.9 | 36.4 |
| H 66 | 0.35 | 0.0030 | 0.5 | 30.6 | 31.1 | FREEWAY 9-10 LANES | URBAN | 107.6 | 36.2 |
| H 67 | 0.35 | 0.0025 | 0.4 | 29.8 | 30.2 | FREEWAY 11 LANES OR MORE | URBAN | 97.9 | 32.3 |

BASE RATES:
HIGHWAY SEGMENTS ACCIDENTS/MILLION VEHICLE MILES (MVM)
INTERSECTIONS ACCIDENTS/MILLION VEHICLE (MV) ENTERING THE INTERSECTION
RAMPS ACCIDENTS/MILLION VEHICLE (MV) TRAVERSING THE RAMPS

ADT FACTOR:
VALUE TO BE ADDED TO THE BASE RATE.

"0.60/" MEANS 0.60 DIVIDED BY ADT IN THOUSANDS;
I.E., WITH 5,000 ADT, 0.12 WOULD BE ADDED TO THE BASE RATE.

"0.017" MEANS 0.017 TIMES ADT IN THOUSANDS;
I.E., WITH 20,000 ADT, ADD 0.34 TO THE BASE RATE.

| | ACCIDENT COSTS ($1,000) | | | |
|---|---|---|---|---|
| | F | I | PDO | AVG |
| RURAL | 3900.0 | 77.4 | 4.0 | 139.4 |
| URBAN | 3500.0 | 52.2 | 4.0 | 40.4 |
| SUBURBAN | 3600.0 | 62.4 | 4.0 | 58.9 |
| AVERAGE | 3700.0 | 58.7 | 4.0 | 60.1 |

# APPENDIX B: Transportation System Networks

## TSAR Reference Card (December, 2004)

### ACCIDENT CODE DEFINITIONS

#### ACCIDENT SUMMARY FIELDS

**110 SEVERITY (1)**
F - Fatal
I - Injury
P - Property Damage Only

**120 ACCIDENT TIME (4)**
HHMM 24 Hour Clock

**508 FILE TYPE (1)**
H - Highway
I - Intersection
R - Ramp

**510 HOUR OF DAY (2)**
00 - 12Mid
01 - 1 A.M.
02 - 2 A.M.
03 - 3 A.M.
04 - 4 A.M.
05 - 5 A.M.
06 - 6 A.M.
07 - 7 A.M.
08 - 8 A.M.
09 - 9 A.M.
10 - 10 A.M.
11 - 11 A.M.
12 - 12 Noon
13 - 1 P.M.
14 - 2 P.M.
15 - 3 P.M.
16 - 4 P.M.
17 - 5 P.M.
18 - 6 P.M.
19 - 7 P.M.
20 - 8 P.M.
21 - 9 P.M.
22 - 10 P.M.
23 - 11 P.M.
25 - Unknown

**514 SIDE OF HIGHWAY (1)**
N - Northbound
S - Southbound
E - Eastbound
W - Westbound

**515 INTERS/RAMP ACC LOC (1)**
1 - Ramp Intersection ( Exit)
2 - Ramp
3 - Ramp Entry
4 - Ramp Area, Intersection Area
5 - In Intersection
6 - Outside Intrs – Nonstate Rte
- - Does Not Apply

**517 COMMON ACC NO (9)**
NCIC Number/Officer's Badge No.

**518 REPORTING LEVEL (1)**
1 - Below Reporting Level
2 - Above Reporting Level
< - Not Stated or Undetermined

**519 PRIMARY COLLISION FACTOR (1)**
1 - Influence of Alcohol
2 - Following Too Close
3 - Failure to Yield
4 - Improper Turn
5 - Speeding
6 - Other Violations
B - Improper Driving
C - Other Than Driver
D - Unknown
E - Fell Asleep
< - Not Stated

**520 DAY OF WEEK (1)**
1 - Sunday
2 - Monday
3 - Tuesday
4 - Wednesday
5 - Thursday
6 - Friday
7 - Saturday

**521 WEATHER (1)**
A - Clear
B - Cloudy
C - Raining
D - Snowing
E - Fog
F - Other
G - Wind
< - Not Stated

**522 LIGHTING (1)**
A - Daylight
B - Dusk/Dawn
C - Dark – Street Light
D - Dark – No Street Light
E - Dark – Inoperative Street Light
F - Dark – Not Stated
< - Not Stated

**523 ROAD SURFACE (1)**
A – Dry
B – Wet
C - Snow, Icy
D – Slippery
< - Not Stated

**524 ROADWAY CONDITION (1)**
A - Holes, Ruts
B - Loose Material
C - Obstruction on Road
D - Construction – Repair Zone
E - Reduced Road Width
F – Flooded
G – Other
H - No Unusual Condition
< - Not Stated

**525 RIGHT OF WAY CONTROL (1)**
A - Control Functioning
B - Control Not Functioning
C - Controls Obscured
D - No Controls Present
< - Not Stated

**526 TYPE OF COLLISION (1)**
A - Head-On
B – Sideswipe
C - Rear End
D – Broadside
E - Hit Object
F – Overturn
G - Auto-Pedestrian
H – Other
< - Not Stated

**527 NO. MOTOR VEH. INVOLVED (2)**
01 to 99

## ACCIDENT CODE DEFINITIONS

### PARTY SUMMARY FIELDS

**0 = Examine All Parties Involved    1-9 = Examine Only Specified Party No.**

**6 0 # PARTY TYPE (1)**
A – Passenger Car/Station Wagon
B – Passenger Car w/Trailer
C – Motorcycle
D – Pickup/Panel Truck
E – Pickup/Panel w/Trailer
F – Truck, Truck Tractor
G – Truck/Tractor w/Trailer
2 - Truck/Tractor w/2 Trailers
3 - Truck/Tractor w/3 Trailers
4 – Single Unit Tanker
5 - Truck/Tractor w/1 Tank Trailer
6 - Truck/Tractor w/2 Tank Trailer
H - School Bus
I - Other Bus
J - Emergency Vehicle
K - Highway Construction Equip. **
L – Bicycle
M - Other Vehicle
N - Other Non-Vehicle
O - Spilled Load
P – Disengaged Tow
Q - Uninvolved Vehicle
R – Moped
T – Train
U – Pedestrian
V - Dismounted Pedestrian
W - Animal-Livestock
X - Animal-Deer
Z - Animal-Other
< - Not Stated

**6 1 # DIRECTION TRAVEL (1)**
N – Northbound
S – Southbound
E – Eastbound
W – Westbound
< - Not Stated
- - Does Not Apply

**6 2 # VEH. HWY. INDICATOR (1)**
1 - On State Route
2 - Not on State Route
3 - Intersecting State Route
< - Not Stated
- - Does Not Apply

**6 3 # SPECIAL INFO (1)**
A – Hazardous Materials
B – Cell Phone in use*
C – Cell Phone not in use*
D – Cell Phone none/unknown*
< - Not Stated
- - Does Not Apply

*** Codes Eff. 04-01-01**

** Includes Equipment engaged in Const/Maint activities as of 02/22/2000

**6 4 # PERSONS KILLED (2)**
00 - 99

**6 5 # PERSONS INJURED (2)**
00 - 99

**6 6 # PRIMARY OBJ STRUCK (2)**

**6 8 # OTHER**
01 - Side of Bridge Railing
02 - End of Bridge Railing
03 - Pier, Column, Abutment
04 - Bottom of Structure
05 - Bridge End Posts in Gore
06 - End of Guardrail
07 - Bridge Approach Guardrail
10 - Light or Signal Pole
11 - Utility Pole
12 - Pole (Type Not Stated)
13 - Traffic Sign/Sign Post
14 - Other Signs Not Traffic
15 - Guardrail
16 - Median Barrier
17 - Wall (exc. Soundwall)
18 - Dike or Curb
19 - Traffic Island
20 - Raised Bars
21 - Concrete Object (HDWL, D.I.)
22 - Guidepost, Culvert, PM
23 - Cut Slope or Embankment
24 - Over Embankment
25 - In Water
26 - Drainage Ditch
27 - Fence
28 - Trees
29 - Plants
30 - Sound Walls
40 - Natural Material on Road
41 - Temp Barricades, Cones, Etc.
42 - Other Object On Road
43 - Other Object Off Road
44 - Overturned
45 - Crash Cushions-Sand (After 01/01/96, Before Both 45)
46 - Crash Cushion-Other (After 01/01/96, Before Both 45)
51 - Call Box (After 01/01/96)
98 - Unknown Object Involved
99 - No Object Involved
VI - Thru V9 - Vehicle 1 to 9
<< - Not Stated
-- - Does Not Apply

## ACCIDENT CODE DEFINITIONS

### PARTY SUMMARY FIELDS

**0 = Examine All Parties Involved     1-9 = Examine Only Specified Party No.**

6 7 # **PRIMARY LOC. OF COLL (1)**

6 9 # **OTHER**

A - Beyond Median or Stripe – Left(NE-2LN)
B - Beyond Shoulder Drivers Left
C - Left Shoulder Area
D - Left Lane
E - Interior Lanes
F - Right Lane
G - Right Shoulder Area
H - Beyond Shoulder Drivers Right
I - Gore Area
J – Other
V - HOV Lane(s)     (After 01/01/96)
W -HOV Buffer Area     (After 01/01/96)
<< - Not Stated
-- - Does Not Apply

7 4 # **1ST OTHER ASSOC FACTOR (1)**

7 5 # **2ND**

1 - Influence of Alcohol
2 - Following Too Close
3 - Failure To Yield
4 - Improper Turn
5 – Speeding
6 - Other Violations
A – Cell Phone*   (INATTN)
B – Electronic Equip*   (INATTN)
C – Radio/CD/Headphn* (INATTN)
D – Smoking*   (INATTN)
E - Vision Obscurement
F – Inattention - Other
G - Stop & Go Traffic
H - Enter/Leave Ramp
I - Previous Collision
J - Unfamiliar with Road
K - Defective Veh. Equipment
L - Uninvolved Vehicle
M – Other
N - None Apparent
P – Wind
R - Ramp Accident
S - Runaway Vehicle
T – Eating*   (INATTN)
U – Children*   (INATTN)
V – Animals*   (INATTN)
W – Personal Hygiene*   (INATTN)
X – Reading*   (INATTN)
< - Not Stated
- - Does Not Apply

* Inattention Codes Eff. 01-01-01

7 6 # **MOVE PRECEDING COLL. (1)**

A - Stopped
B - Proceeding Straight
C - Ran Off Road
D - Making Right Turn
E - Making Left Turn
F - Making U-Turn
G - Backing
H - Slowing, Stopping
I - Pass Other Vehicle (2Wy-2Ln)
J - Change Lanes
K - Parking
L - Enter From Shoulder
M - Other Unsafe Turn
N - Cross Into Opposing Lane (Undiv. Only)
O - Parked
P - Merging
Q - Traveling Wrong Way
R - Other
< - Not Stated
- - Does Not Apply

**PEDESTRIAN**

2 - Xing Xwalk – Intersection
3 - Xing Xwalk – Not Intersection
4 - Xing – Not Xwalk
5 - Roadway – Include Shoulder
6 - Not in Roadway
7 - Approach/Leave School Bus

7 7 # **1ST SOBRIETY (1)**

7 8 # **2ND (DRUG/PHYSICAL) (1)**

A - Had Not Been Drinking (0%)
B - HBD – Under Influence (>0.08%)
C - HBD Not Under Influence (0.01-.07%)
D - HBD – Impairment Unknown
E - Under Drug Influence
F - Other Physical Impairment
G - Impairment Unknown
H - Not Applicable
I - Driver Fatigue
< - Not Stated
- - Does Not Apply

## HIGHWAY CODE DEFINITIONS

## STANDARD FIELDS

**209 HIGHWAY GROUP (1)**
R - Independent Alignment – Right
L - Independent Alignment – Left
D - Divided Highway
U - Undivided Highway
X - Unconstructed Highway

**214 CITY CODE (4)**
Alpha - See Valid City Table

**216 FEDERAL AID (1)**
0 - None of the Following
2 - In Lieu of Interstate
3 - In Lieu of Primary

**217 FUNCTIONAL CLASS COMPONENT (1)**
0 - None
1 - Principal Arterial W/ C/L Prin Arterial
2 - Principal Arterial W/ C/L Minor Arterial
3 - Principal Arterial Non-Connecting Link
4 - Minor Arterial
5 - Major Collector
6 - Minor Collector
7 - Local

**218 FA ROUTE PREFIX (1)**
I - Interstate
P - Primary
5 - FAS or FAU
6 - FAS or FAU – Not Final Alignment
$ - Non FA

**219 FA ROUTE (3)**
000 - Not Federal Route
001 – 999 - Valid FA Route

**220 TOLL / FOREST (1)**
0 - None
1 - Toll Road & Bridges
2 - Forest Highways

**221 NATIONAL LANDS (1)**
0 - None
1 - National Monuments
2 - National Recreation Area
3 - National Forests
4 - National Military Reservation
5 - National Indian Reservation
6 - Bureau Land Management

**222 SCENIC / FREEWAY SYSTEMS (1)**
0 - Non-Fwy, Non-Scenic, Non-Expwy
1 - Scenic (Non-Fwy, Non-Expwy
2 - Fwy & Exp System (Non-Scenic)
3 - Fwy & Exp System (Scenic)

**223 POPULATION CODE (1)**
B - Urban
R - Rural
U - Urbanized

**224 INSIDE/OUTSIDE CITY (1)**
I - Inside City
O – Outside City

## HIGHWAY FIELDS

**150 TOTAL NUMBER LANES (2)**
00 to 99

**225 NON-ADD MILEAGE (1)**
A - Normal
N - Non Add

**227 TERRAIN (1)**
F - Flat
R - Rolling
M - Mountainous

**228 DESIGN SPEED (1)**
<30
30
35
40
45
50
55
60
65
70

### ADT DATA

**233 ADT (AHEAD) (6)**
999999

### ACCESS DATA

**242 ACCESS CONTROL (1)**
C - Conventional
E - Expressway
F - Freeway
S - One-Way City Street

### MEDIAN DATA

**263 MEDIAN TYPE (1)**

**UNDIVIDED**

A - Not Separated or Striped
B – Striped
C – Reversible Peak Hour Lane(s)

**DIVIDED**

E – Reversible Peak Hour Lane(s)
F - Two-Way Left Turn Lane
G – Continuous Left Turn Lane
H – Paved Median
J – Unpaved Median
K – Separate Grades
L – Separate Grades w/Retaining Wall
M – Sawtooth – Unpaved
N – Sawtooth – Paved
P – Ditch
Q – Separate Structure
R – Railroad
S - Bus Lanes
T – Paved Area Occasional Traffic Lane
U – Railroad & Bus Lanes
V – Contains Reversible Pk Hr Ln(s)
Z – Other

**262 CURB & LANDSCAPE (1)**
1 – Curbed Median
2 – Curbed Median with Trees
3 – Curbed Median with Shrubs
4 – Raised Traffic Bars
5 – Median with Trees
6 – Median with Shrubs
7 - No Curbs or Shrubs/No Median

**264 MEDIAN BARRIER (1)**
A – Cable Barrier
B - Cable Barrier w/ Glare Screen
C - Metal Beam Barrier
D - Metal Beam Barrier w/ Glare Screen
E – Concrete Barrier
F – Concrete Barrier w/ Glare Screen
G – Bridge Barrier Railing
H - Chain Link Fence
J – Guardrail in Median Both Roadway
K – Guardrail in Median Left Roadway
L – Guardrail in Median Right Roadway
M - Two-Way, One Lane Road
N - Thrie Beam Barrier
P - Thrie Beam Barrier w/ Glare Screen
Q - Conc. Barrier, Both Ways Inside Both Shoulders
R - Conc. Barrier, Left Rdwy Median Shoulder Area
S - Conc. Barrier, Right Rdwy Median Shoulder Area
X – External Barriers on Median Type = C or E
Y - Other Not Included Above
Z - No Barriers

**265 MEDIAN WIDTH (2)**
00 Feet, Undivided
01 to 99 Feet, Divided

**266 MEDIAN VARIANCE (1)**
V – Variable
Z - No Variance
P - Over 100' Median & No Var.

### LEFT RIGHT ROADBED

**252 272 SURFACE TYPE (1)**

**PCC**
B - Bridge Deck
C - Concrete

**AC**
H - Base & Surface ≥7" Thick
M - Base & Surface <7" Thick
O - Oiled Earth – Gravel
P - Bridge Deck

**UNPAVED**
E - Earth
F - Undetermined
G - Bridge Deck (All Not Codes B or P)

**253 273 NUMBER OF LANES (2)**
00 to 99

**254 274 SPECIAL FEATURES (1)**
A - One Lane Road w/Turnouts for Passing
B - Lane Transitions
C - Passing or Truck Climbing Lane
D - Bus Lane (for buses only not in Median)
E - Auxiliary Lane (inc in No. Lanes Field)
G - Tunnel
H - Toll Plazas & Approaches
J - "Bug" or Border Patrol Stations
N - Median Lane is HOV Lane
P - Median Lanes are HOV Lanes
Q - Reversible Peak Hour Lane(s)
Z - No Special Features

**255 275 OUTSIDE TOTAL SHOULDER (2)**

**256 276 OUTSIDE TREATED SHOULDER (2)**
00 to 99 Feet

**258 278 INSIDE TOTAL SHOULDER (2)**

**259 279 INSIDE TREATED SHOULDER (2)**
00 to 99 Feet

**257 277 TRAVELED WAY WIDTH (3)**
000 to 999 Feet

## INTERSECTION FIELDS

**412 INTERSECTION TYPE (1)**
F - Four-Legged
M - Multi-Legged
S - Offset
T - Tee
Y - WYE
Z - Other

**417 CONTROL TYPE (1)**
A - No Control
B - Stop Signs on Cross Street Only
C - Stop Signs on Mainline Only
D - Four-Way Stop Signs
E - Four-Way Flasher (Red on Cross Street)
F - Four-Way Flasher (Red on Mainline)
G - Four-Way flasher (Red on All)
H - Yield Signs (On Cross Street Only)
I - Yield Signs (On Main Line Only)
J - Signals Pretimed – 2 phase
K - Signals Pretimed – Multi-Phase
L - Signals Semi-Traffic Actuated – 2 Phase
M - Signals Semi-Traffic Actuated – Multi Phase
N - Signals Full-Traffic Actuated – 2 Phase
P - Signals Full-Traffic Actuated – Multi-Phase
Z - Other

**422 LIGHTING (1)**
N - No
Y - Yes

### MAIN LINE

**432 SIGNAL MAST ARM (1)**
N - No
Y - Yes

**433 LEFT TURN CHANNELIZATION (1)**
C - Curbed Median Left Turn Channelization
N - No Left Turn Channelization
P - Painted Left Turn Channelization
R - Raised Bars – Left Turn Channelization

**434 RIGHT TURN CHANNELIZATION**
N - No Right Turn Channelization
Y - Channelization Provided For Right Turns

**435 TRAFFIC FLOW (1)**
N - Two-Way Traffic - No Left Turns Permitted
P - Two-Way Traffic - Left Turns Permitted
R - Two-way-Traffic – Left Turns Restricted During Peak Hours
W - One-Way Traffic
Z - Other

**436 NUMBER OF LANES (1)**
0 to 9

### INTERSECTING STREET (ROUTE)

**452 SIGNAL MASRT ARM (1)**
N - No
Y -Yes

**453 LEFT TURN CHANNELIZATION (1)**
Same as Intersection Item

**454 RIGHT TURN CHANNELIZATION (1)**
Same as Intersection Item

**455 TRAFFIC FLOW (1)**
Same as Intersection Item

**456 NUMBER OF LANES (1)**
0 to 9

## RAMP FIELDS

**301 ON/OFF INDICATOR (1)**
O – On
F – Off
Z – Other

**316 RAMP TYPE (1)**
A - Frontage Road
B - Collector Road
C - Direct or Semi-Direct Connector (Left)
D - Diamond Type Ramp
E - Slip Ramp
F - Direct or Semi Direct Connector (Right)
G - Loop-w/Left Turn
H - Buttonhook Ramp
J - Scissors Ramp
K - Split Ramp
L - Loop-w/o Left Turn
M - Two-Way Ramp Segment
R - Rest Area, Vista Point, Truck Scale
Z – Other
P - Dummy-Paired
V - Dummy-Volume Only

**359 AREA 4 (1)**
N - No
Y - Yes

# APPENDIX C: TASAS Table C Potential Investigation Locations

* * * S A M P L E * * *

TASAS TABLE C POTENTIAL INVESTIGATION LOCATIONS .2
MILE
AXR254 A 04 - 08- 97 DISTRICT 04 DATA FOR 94 - 01- 01 THRU 96- 12- 31
PAGE 1 0
ALL ACCIDENTS
CONFIDENCE LEVEL 99.5 PERCENT

SCL R RATE* ------ TOTAL ACCIDENTS------ * * --- AVE
ADT * * -- 12 MOS RATE ACCS/MV- MVM *
LOCATION DESCRIPTION RMP U GRP 36 MO 24 MO 12 MO 6 MO 3 MO 1000
VEH ACTUAL AVERAGE INV
LNS S ACCS ACCS ACCS ACCS ACCS MA IN
X- ST F+I TOT F+I TOT REQ

037 SOL 8.445 SACRAMENTO ST XXX S I24 29 Y 19 Y 8 N 4 N 0 N 27.9
4.0 0.00 0.69 0.18 0.39 +
037 SOL 9.287 TO 9.487 EAST 02D U H14 17 Y 11 Y 5 N 3 N 1 N 14.6
- 0.94 4.68 0.78 2.00
037 SOL 9.844 BROADWAY XXX U I14 64 Y 41 Y 22 Y 16 Y 10 Y 45.0
8.9 0.36 1.12 0.20 0.45 + REQ
037 SOL R 11.147 TO R 11.347 EAST 03D U H64 15 Y 12 Y 4 N 2 N 1 N 37.0
- 0.37 1.48 0.28 0.81
037 SOL R 11.497 EB OFF TO COLUMBUS PKWY F F U R18 18 Y 12 Y 6 Y 3 N 2 N 3.8
- 0.00 4.33 0.36 0.90 + REQ
037 SON 2.109 TO 2.309 WEST 02D R H45 11 Y 7 Y 2 N 1 N 1 N 15.0
- 1.82 1.82 0.34 0.71
037 SON R 6.109 TO R 0.064 02U R H02 11 N 10 Y 1 N 1 N 1 N 24.9
- 0.55 0.55 0.48 0.91
061 ALA 19.070 HIGH ST RT B'VIEW DR LT X - X U I14 29 Y 19 Y 10 N 7 N 5 N 21.2
7.9 0.28 0.94 0.20 0.45 +
061 ALA 19.440 OTIS DR & BROADWAY X - X U I14 25 Y 18 Y 9 N 4 N 1 N 9.8
17.1 0.41 0.92 0.20 0.45 +
061 ALA 20.080 PARK ST. X - X U I14 27 Y 20 Y 9 N 3 N 1 N 10.3
17.5 0.30 0.89 0.20 0.45 +
061 ALA 20.150 OAK ST. X - X U I14 15 Y 12 Y 4 N 3 N 2 N 10.2
2.6 0.43 0.85 0.20 0.45 +

# APPENDIX D: TASAS Sample of Table B Format

```
1                                              TASAS TABLE B  SELECTIVE ACCIDENT RATE CALCULATION
 AXR251-A 03-11-05                                         REQUEST ACTIVITY REPORT                                          PAGE    1
-                          DT REQ  A L RTE  D    TIME PERIOD         SELECT LOCATION      S SEQ R A   AVE   PC PC  ADT ADT R RR PR
         MESSAGE               NO  S T      I   FROM       TO        BEGIN         END    C 123 T P  RATE   IN FA MAIN XST T UA DT
0*    *    *    *    *     03 0001 C H 049  T  01/01/94-08/30/03 PLA  000.000-PLA  002.400 I       P                             13
```

```
1                                                         TASAS TABLE B DISTRICT 13
 AXR253-A  03-11-05                                SELECTIVE ACCIDENT RATE CALCULATION                                              PAGE    1
                                                                  ROUTE SEQUENCE
-                                             RA *-NUMBER OF ACCIDENTS/SIGNIFICANCE* PER *ADT * TOTAL *-ACCIDENT RATE ACCS/MV+ OR MVM-*
 L O C A T I O N   D E S C R I P T I O N     GRP                    MULTI            KLD  MAIN  MV+ OR       ACTUAL           AVERAGE
                                             (RUS) TOT FAT   INJ  F+I  VEH   WET DARK INJ  X-ST   MVM     FAT  F+I   TOT  FAT  F+I   TOT
0049  PLA     0.000 THRU PLA  002.399         H    186   1    78   79   90    19   63   1   8.9   74.97  .013 1.05  2.48 .034 1.00  2.10
 03-0001     2.400M  94-01-01 03-08-30116 MO NA    H97                                 127
```

```
1AXR261                                           TABLE B ACCIDENT RECORDS                              03-11-05          PAGE    1
0               RTES      P LOC                 I S D     ACCIDENT       COMMON  P ENVIR R R T NO     P D V S PERSN O L O L O L O L OA M SD
                  U       R POST              F R O A    DATE    TIME   ACCIDENT C COND  C W O MTR    T I H I   K  I S O S O S O S O  F O  P
 REQ NO     DIST NO F CO  E MILE              T L H Y MO DA YR HHMM     NUMBER  F W L S   C C VEH       R I          P C O C O C O C 12 V 12
0
  0001        03  049  PLA  000.020           H - N 7 08-31-96 1500 922006837 5 A A A H A C 03    D N 1 < 00 00 V2D --- --- --- F< B A<
                                                                                                  D N 1 < 00 00 V1D V3D --- --- N< A A<
                                                                                                  A N 1 < 00 00 --- V2D --- --- N< A A<
  0001        03  049  PLA  000.020           H - N 3 05-09-00 1745 922007726 5 A A A H A C 02    A N 1 < 00 01 V2F --- --- --- F< B G<
                                                                                                  D N 1 < 00 02 V1F --- --- --- N< A A<
  0001        03  049  PLA  000.020           H - S 2 08-26-02 1105 922009403 6 A A A H A H 02    D S 1 D 00 00 V2F --- --- --- N< G A<
                                                                                                  A S 1 D 00 00 V1F --- --- --- N< A A<
  0001        03  049  PLA  000.040           H - N 3 09-05-95 1730 922008172 3 A A A H A E 02    A N 1 < 00 00 --- --- --- --- N< E G<
                                                                                                  C N 1 < 00 01 23H 44H --- --- N< B A<
  0001        03  049  PLA  000.040           H - N 1 07-20-97 1646 922005741 5 A A A H A C 02    J N 1 < 00 00 V2F --- --- --- << B A<
                                                                                                  A N 1 < 00 00 V1F --- --- --- K< A A<
  0001        03  049  PLA  000.040           H - S 3 12-01-98 0020 922007921 5 B D B H D E 01    A S 1 < 00 00 01H --- --- --- 6< D G<
  0001        03  049  PLA  000.040           H - N 3 07-15-03 0745 922009538 6 A A A H A B 02    G N 1 C 00 00 V2D --- --- --- 6< N A<
                                                                                                  A S 1 C 00 00 V1F --- --- --- N< G A<
  0001        03  049  PLA  000.045           I 5 N 4 07-20-94 0350 922007648 5 A D A H A E 01    D N 1 < 00 01 23J --- --- --- 6< B G<
  0001        03  049  PLA  000.045           I 5 S 3 01-23-96 1620 922007811 C C B D H A A 02    A S 1 < 00 00 V2H --- --- --- N< D A<
                                                                                                  D N 2 < 00 00 V1F --- --- --- N< A A<
  0001        03  049  PLA  000.045           I 5 N 7 06-15-96 1455 922006837 C A A A H A E 01    D W 1 < 00 01 23J --- --- --- K< B A<
  0001        03  049  PLA  000.045           I 5 S 5 02-19-98 1030 922009904 5 B A B H D E 01    A S 1 < 00 01 17H --- --- --- N< C A<
  0001        03  049  PLA  000.060           H - N 4 06-06-01 1415 922013067 6 A A A H A E 02    A N 1 D 00 00 --- --- --- --- N< E G<
                                                                                                  A N 1 C 00 00 23H --- --- --- N< B A<
  0001        03  049  PLA  000.100           H - N 5 09-07-00 0720 922011161 6 A A A H D E 01    A N 1 < 00 00 23H 44H --- --- F< C A<
```

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