You Are Viewing an Archived Copy from the New Jersey State Library

FHWA-NJ-2008-001

Development of New Jersey Rates for the NJCMS Incident Delay Model

FINAL REPORT
September 2012

Submitted by

Steven I-Jy Chien, Ph.D.
Professor of Civil and Environmental Engineering
New Jersey Institute of Technology

Kaan Ozbay, PhD.
Professor of Civil and Environmental Engineering
Rutgers, the State University of New Jersey

NJDOT Research Project Manager
Paul Thomas

In cooperation with

New Jersey
Department of Transportation
Bureau of Research
And
U.S. Department of Transportation
Federal Highway Administration

You Are Viewing an Archived Copy from the New Jersey State Library

DISCLAIMER STATEMENT

The contents of this report reflect the views of the author(s) who is (are) responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the New Jersey Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

You Are Viewing an Archived Copy from the New Jersey State Library

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. FHWA NJ-2008-001	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Development of New Jersey Rates for the NJCMS Incident Delay Model		5. Report Date September 2012 6. Performing Organization Code NJIT / Rutgers
7. Author(s) Steven Chien, Kaan Ozbay, Feng-Ming Tsai, Anil Yazici		8. Performing Organization Report No.
9. Performing Organization Name and Address New Jersey Institute of Technology University Heights Newark, New Jersey 07102-1982		10. Work Unit No. 11. Contract or Grant No.
12. Sponsoring Agency Name and Address New Jersey Department of Transportation PO 600 Trenton, NJ 08625	Federal Highway Administration U.S. Department of Transportation Washington, D.C.	13. Type of Report and Period Covered Final Report 14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

This study developed a working database for calculating incident rates and related delay measures, which contains incident related data collected from various data sources, such as the New Jersey Department of Transportation (NJDOT) Crash Records, Traffic Operation Center (TOC) incident data, TOC Emergency Service Patrol (ESP) data, and New Jersey Turnpike and Garden State Parkway incident data. In order to improve the output accuracy of non-recurring delay estimated by the New Jersey Congestion Management System (NJCMS), there is a need to develop the NJ specific incident rates, response times, and clearance times for both peak and off-peak periods. This study determined whether new data in the form of actual field observations of incidents (from the beginning to the end of an incident) will be reasonable and useful to supplement and tie together the existing data. An assessment of cost and benefit analysis was conducted, while a list of recommendations were provided at the end of this report.

17. Key Words Congestion management system, Crashes, Incidents, Response time, Clearance time, Safety, Information Systems		18. Distribution Statement	
19. Security Classif. (of this report) Unclassified	20. Security Classif.. (of this page) Unclassified	21. No of Pages 92	22. Price

Form DOT F 1700.7 (8-69)

You Are Viewing an Archived Copy from the New Jersey State Library

ACKNOWLEDGEMENTS

This project could not have been accomplished without the assistance of numerous individuals. The authors would like to acknowledge the support of the New Jersey Department of Transportation (NJDOT) for the preparation of this report. The authors thank Ira Levinton, John Allen, William Hoffman, and Robert Sasor offering valuable comments on earlier drafts of this report that greatly helped in producing this final version. The authors also express gratitude to Michael Pilsbury, Eddy Exantus, and Mark Smith for their assistance in providing Incident and Emergency Service Patrol data to the research team.

You Are Viewing an Archived Copy from the New Jersey State Library

TABLE OF CONTENTS

Page

You Are Viewing an Archived Copy from the New Jersey State Library

You Are Viewing an Archived Copy from the New Jersey State Library

LIST OF TABLES

You Are Viewing an Archived Copy from the New Jersey State Library

You Are Viewing an Archived Copy from the New Jersey State Library

You Are Viewing an Archived Copy from the New Jersey State Library

LIST OF FIGURES

Page

You Are Viewing an Archived Copy from the New Jersey State Library

You Are Viewing an Archived Copy from the New Jersey State Library

EXECUTIVE SUMMARY

In order to improve the accuracy of the non-recurring delay estimation, the NJDOT seeks to update incident rates and related parameters employed by the NJCMS incident delay module. Various incident databases such as the NJDOT Crash Records, the Traffic Operation Center (TOC) incident data, the Emergency Service Patrol (ESP) data, the Incident Management Response Team (IMRT) data, the New Jersey Turnpike (NJTPK) incident log, the Garden State Parkway (GSP) incident log, the Central Dispatch Unit (CDU), and the Police Accident Reports were studied based on the needs required by the New Jersey Congestion Management System (NJCMS). In this study, the meaning of incidents refers to the same definition employed in the NJCMS including both crashes and disablement incidents. As a result, numbers, locations, and durations of various types of incidents were identified and retrieved from the above databases for approximating incident rates as well as the associated information such as response and clearance times.

A working database was developed to gather Year-2005 data and calculate crash (i.e., fatal, injury, property damage) rates, disablement incident (i.e., Mechanical/Electrical, Stall, Flat Tire, Abandoned, Debris, Other) rates, and incident duration. The most updated NJCMS (SD version, released in 2005) with the study developed New Jersey specific incident rates was applied for estimating numbers of all types of incidents, including crashes and disablement incidents. After conducting a scenario analysis, the results indicated that the existing incident rates employed in the NJCMS significantly under estimate crashes on New Jersey highways.

Due to the limited data on major New Jersey highways, the rates of disablement incidents developed in this study were based on the 2005 TOC-ESP data. The studied ESP service was not 24 hours a day / 7 days a week (24/7) and only applied to 14 New Jersey freeways. Therefore, the disablement incidents were unable to be fully reported to the TOC, and the resulting disablement incident rates would be underestimated if only the ESP data are applied. This study recommends that the study developed crash rates should be used and the study developed rates of disablement incidents should be applied in the NJCMS with upward adjustments to account for undetected incidents. In this study, the mean clearance time for freeway links are within the acceptable difference compared with that in the existing NJCMS tables. However, the standard deviations of response and clearance times are different in the range of an order of magnitude.

In order to improve the accuracy of the incident rates and duration time calculation, the following items are recommended for the NJDOT's consideration:

1. Ensure crash and disablement incident records with completed information and consistent definitions of each data field.

You Are Viewing an Archived Copy from the New Jersey State Library

- Fill out all incident record fields for every detail of each record. A great percentage (i.e., 55%) of the discarded records in this study was because of missing Standard Route Identifier (SRI) numbers. Almost all of the records are non-state routes and not on the NJCMS network. These would primarily be streets without route numbers. However, records with SRI numbers without milepost were proportionally distributed to the NJCMS links by county and SRI.

- Standardized the formats of the ESP databases for the TOC North and South to effectively consolidate data. The inconsistent data fields include the time a disablement incident happened, lane closure information, and milepost.

- Include more information in the NJDOT Crash Records, such as the direction of the route (i.e., eastbound, westbound, southbound, or northbound). The additional information will help improve the accuracy of the incident rates estimation, because the current ADT of the NJCMS links are directional.

2 Classify types of incidents in the crash/disablement incident databases based on the definitions employed by the NJCMS. Otherwise, a table should be developed to map various types of incidents to the NJCMS definitions. The principles summarized in Tables I-3a and I-3b were developed for consideration.

3 Increase the ESP service coverage over time and space. The existing ESP does not offer 24/7 service and is restricted to freeways. Note that the rates of upward adjusted disablement incidents addressed in Tables I-7a and I-7b are suggested to apply into the NJCMS.

4 Improve the accuracy of the incident time entries. This can be done by collecting incident data with the latest technologies, such as hand held devices or portable computers. The emergency personnel should be aware of the importance of data integrity and accuracy.

5 Study the traffic volume adjustment factors in the NJCMS. It is suggested that a technical memorandum, which includes the current methods employed to convert traffic volume between daily and annual should be documented. Because weekend traffic volumes are generally lower than weekdays for commuter routes, the NJDOT should thoroughly investigate whether the traffic volume adjustments for converting from AADT to average weekday work properly in the NJCMS.

You Are Viewing an Archived Copy from the New Jersey State Library

INTRODUCTION

Background

The New Jersey Congestion Management System, called the NJCMS, is a system of software and data tables that enables planners / engineers / analysts at the New Jersey Department of Transportation (NJDOT) and the Metropolitan Planning Organizations (MPOs) to analyze and monitor the performance of the roadway network through reporting performance measures including levels of service, volume to capacity ratios, delays and travel speeds statewide, or at the county, corridor or link level of analysis. The NJCMS was developed by the NJDOT in response to a legislative mandate of the Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991 to manage traffic congestion within the state's planning process. The NJCMS has been in use for congestion analysis since 1996. The major functions of the NJCMS are to identify, measure, and monitor operating conditions along transportation facilities. These facilities are grouped within corridors, based on local and regional travel patterns, to assess congestion not only on a route and milepost basis but also on a corridor, county, MPO, and statewide basis.

One of the NJCMS features is estimating non-recurring delay caused by crashes or disablement incidents on highways. In order to ensure the most realistic estimates of the system, a great deal of reasonably accurate data such as rates of various incident types is essential. The existing NJCMS runs with Central 4.0 and PPSUITE. PPSUITE updates and supersedes previous releases of the past Processor for Air Quality (PPAQ) and Performance Queries for Surface Transportation (PEQUEST). PPSUITE consists of a number of linked programs (e.g. PPEVENT, PPQUEST) analyzing transportation networks and compiling performance measures. PEQUEST provides system performance reporting capabilities for both general operations analysis (e.g. recurring delay for each link) and emissions analysis (e.g. daily emission for each mobile vehicle class). PPEVENT compiles incidents and non-recurring (incident) delay.

However, since some of the incident related inputs such as incident rates as well as clearance and response times were based on national data, New Jersey specific data is needed to calculate reasonably accurate rates and related measures for the NJCMS. In this study, the research team aimed to develop a prototype working database for gathering incident related information, which is heavily applied in this study for the NJCMS to provide reasonably accurate estimates for delay related measures.

While various incident reports exist in New Jersey, they do not readily provide such data required by the NJCMS. To this end, the research team conducted a feasibility study to determine if and how the Police Accident Reports, the Traffic Operation Centers' Incident Databases, the Emergency Service Patrol Records, and other existing incident

You Are Viewing an Archived Copy from the New Jersey State Library

data can be integrated and utilized to provide consistent and reasonably accurate delay estimates for non-recurring congestion.

A recent research study conducted by Spasovic et al. [34] used the NJCMS outputs to calculate non-recurring delay attributed to incidents on New Jersey roadways. The results of this study included delay and cost per affected person by county, delay and cost per peak period trip by county, and other measures of traffic congestion. The study found that non-recurring congestion accounts for approximately 25 percent of total congestion statewide. Enhancing the NJCMS incident delay model by updating and improving the reasonableness of input parameters would greatly assist planners / engineers / analysts in obtaining accurate estimates for analyzing transportation improvement alternatives. Note that other states tend to have approximately 40% of their total congestion being from non-recurring delay. In comparison, New Jersey has much higher rate of recurring delay due to the higher density of traffic.

Objectives and Scope of Work

The NJDOT seeks to develop new incident rates and related measures (e.g., clearance and response times, etc.) for estimating non-recurring delay with the NJCMS. In order to improve the reasonableness of the estimated non-recurring delay, various incident reports such as the NJDOT Crash Records, the Police Accident Reports, the Traffic Operation Center (TOC) Incident Data, the Emergency Service Patrol (ESP) Records, and the New Jersey Turnpike Authority Incident Data are investigated. However, it is a challenge to integrate the data of these resources and establish a reliable working database for calculating the rates of incidents by facility type and time of the day for New Jersey highways. The main objectives of this study are thus grouped in five categories listed below:

- Determine if and how the existing incident reports and databases can be used to generate New Jersey specific estimates of incident rates, response time, and clearance time
- Determine if new data in the form of actual field observations of incidents (from the beginning to the end of an incident) will be reasonable and useful to supplement and tie together the existing data
- Develop an up-to-date working incident database to store the required information and generate reasonably accurate estimates for the NJCMS
- Conduct a cost and benefit analysis of this study
- Recommend methods to improve the data quality and the resulting accuracy from the NJCMS

You Are Viewing an Archived Copy from the New Jersey State Library

In addition to the sections of Introduction and Summary, the development of a methodology for generating incident related measures for the NJCMS is discussed in two parts. Part I concentrates on the calculation of the incident rates conducted by the NJIT team, while Part II focuses on the response times and clearance times conducted by the Rutgers team.

Research Approach

This section gives an overview of the research approach for developing the working incident database and estimating the rates of incidents. Figure 1 shows the proposed methodology and data process flows, which indicates that the study started with identifying the available data sources, collecting related incident data, and then mapping the collected data onto the links within the NJCMS. A working database for incidents is then developed to store the mapped information for incident rate calculations. The reasonableness of the results is analyzed and the cost and benefit assessment is given, while the recommendations are discussed. The analysis of the NJCMS rates of incidents as well as the response and clearance times are discussed in Part I and Part II, respectively.

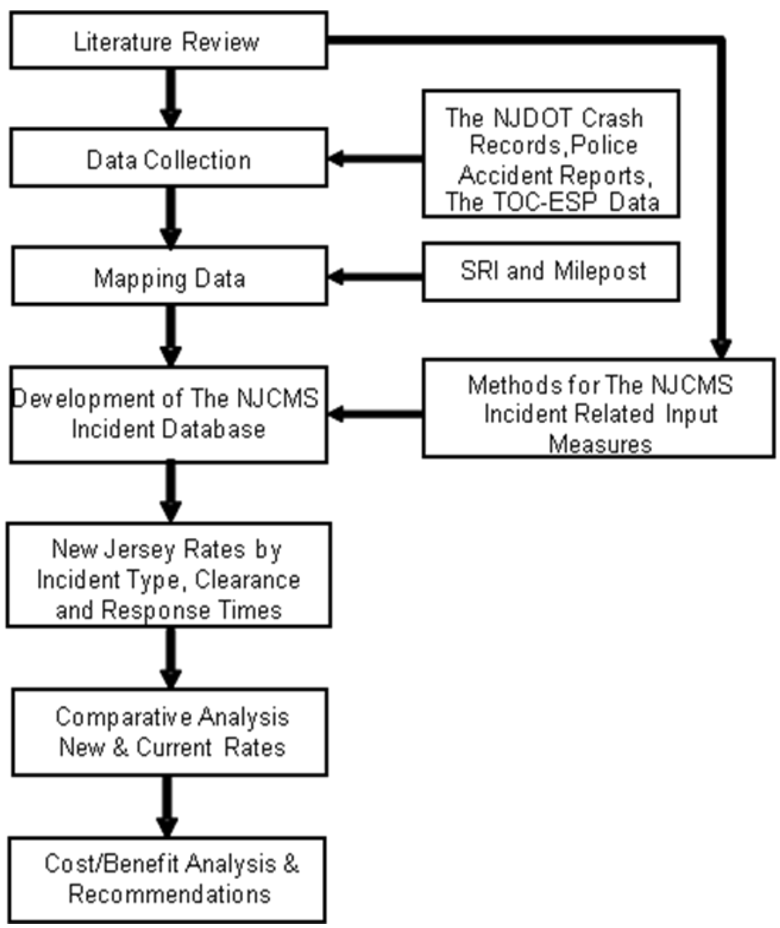


Figure 1. Research Approach

You Are Viewing an Archived Copy from the New Jersey State Library

PART I – RATES OF CRASHES AND DISABLEMENT INCIDENTS

Literature review

The NJCMS Program

The NJCMS includes traffic volumes, roadway geometry, and roadway operational information for approximately 5,253 bi-directional links that make up the Interstate, State, and many county roadways in all 21 New Jersey counties. These links were classified into two classes: freeways and arterials.

There are three groups of data needed by the NJCMS, including input data files containing route segment (e.g. traffic volumes, geometry, speed limits); mapping data shape files (e.g. MapInfo, ArcView); and common data which contain hourly traffic patterns and equivalencies. Intermediate and output files are produced by the PPSUITE/PEQUEST runs. One of the key output files generated by the NJCMS is the Incident (or Non-recurring) Delay File (i.e., SDNONRE.DBF). This file contains detailed link data including the total numbers of incidents by type and the resulting non-recurring delay by type of incident and period of time (e.g. AM/PM Peak, Mid-day/Night Off-peak). The performance measures can be estimated for an area or corridor for vehicle hours of delay, person hours of delay, Levels of Service, volume to capacity ratios, etc. The Incident Delay File is calculated in the NJCMS based on basic roadway segment volume, capacity, speed limit and geometric attributes as well as the key system input files, including the Accident Rate File (i.e., *accrates.dbf*) and the Incident Parameters File (i.e., *incident.dat*).

In the Accident Rate File, the average crash rates per million vehicle miles (MVM) of travel stratified by county, facility type, time period, and crash severity are included. For example, this file includes fatal, injury, and property damage crash rates for Bergen County freeways during the morning peak period. The rates included in the existing NJCMS were based on State Police Accident Reports. In several instances, data limitations required that supplemental records for similar locations be used to augment data for the facility types within counties with too few crashes and VMT.

The Incident Parameters File contains incident rates by incident type and time period; as well as the lane blockage extent (including shoulders) and the remaining lane capacity; and the response and clearance time distributions. The response time is defined as duration between the onset of an event and when the clearing service (e.g. police, tow truck) arrives on the scene, which is dependent on the Incident Management System in place. This option is utilized as a convenience to allow the user to uniformly vary like incident management systems without the need for extensive file editing. Unlike the response time, the clearance time is the elapsed time between the arrival of

You Are Viewing an Archived Copy from the New Jersey State Library

the emergency service (e.g. police, tow truck) and when the incident is removed from the roadway and the roadway capacity is restored, The clearance time duration varies with the incident location (e.g. in a lane, left/right shoulder). The incident related input parameters of the NJCMS are summarized in Table I-1.

Table I-1. The NJCMS Incident Input Parameters

Event Parameters	Categories	Units	Range
Incident Rate (AM/PM Peak, Midday/Night Off-peak, ADT/C*)	Fatal, Injury, Property Damage, Mechanical/Electrical, Stall, Flat Tire, Abandoned, Debris, Other	MVM**	0.00-999.9
Percent Blockage	Fatal, Injury, Damage, Mechanical/Electrical, Stall, Flat Tire, Abandoned, Debris, Other	%	0.00-100.0
Percent capacity Remaining	Fatal, Injury, Damage, Mechanical/Electrical, Stall, Flat Tire, Abandoned, Debris, Other	%	0.00-100.0
Response Time	No detection or incident management system, Management center, FSP/MAP, Other system	Min.	0.00-999.9
Clearance Time	Fatal, Injury, Damage, Mechanical/Electrical, Stall, Flat, Abandoned, Debris, Other	Min.	0.00-999.9

**C: Capacity (veh/hr)*
***MVM: Million Vehicle Miles*

The parameters listed above can be referred in a FHWA report titled "A Methodology for Measurement and Reporting of Incidents and the Prediction of Incident Impacts on Freeways" by Ball Systems and California Polytechnic by Sullivan et al. [36]. As indicated in an NJCMS project report titled "Congestion Management and Intermodal System Development" by Raytheon Infrastructure Services Incorporated (1996), the 1993 crash records compiled by the NJDOT were used to validate the national rates from that FHWA report for crash events. The New Jersey crash rates found in Accident Rate File supersede the use of the national crash rates included in the Incident Parameters File.

Since the NJCMS employed data based on a national averages (i.e., information in Incident Parameters File), New Jersey specific incident rates are needed to make better estimates of non-recurring delay for New Jersey highways. The New Jersey based incident rates should be developed by type of incident and by time of day. The types of crashes include fatal, personal injury, and property damage only, while disablement incident types include mechanical/electrical, stall, flat tire, abandoned, debris, and others. Additionally, the percent blockage of lanes and shoulders, the percent capacity remaining, and the response and clearance times need to be determined for all incident types.

You Are Viewing an Archived Copy from the New Jersey State Library

This study used the most recent NJCMS (SD version, released in 2005) with study developed New Jersey specific incident rates based on Year 2005 estimated traffic volumes, which were calculated from assumed growth rates applied to base year 2001 volumes. In order to employ study developed incident rates in the NJCMS, two control files (i.e., NJCMSPPNET.CTL, NJCMS.CTL) were customized by the following setup:

- Define the time period: AM (7,8,9); MD (10,11,12,13,14,15); PM (16,17,18); NT (19,20,21,22,23,24,1,2,3,4,5,6). Note that hours are end hour. where MD represents mid-day and NT represents night-time.
- Adopt the New Jersey specific incident rate file: The Accident Rate File, *accrates.dbf*, will not supersede the incident rate file in the Incident Parameter File.

Incident Rates and Duration

Incident duration is affected by the location and severity of an incident by Ozbay, et al. (28, 29), and the response procedures of incident management strategies employed. Generally, incident durations can be obtained from Police Accident Reports and from ESP Reports. Some important studies have been conducted through a descriptive analysis of incident data, including incident types, rates and durations that are summarized as follows:

Goolsby (17) collected incident duration data from police reports and reported an average duration time of 45 minutes for non-injury crashes and 18 minutes for vehicle stalls. This database exhibited large standard deviations of 19 minutes for crashes, and 15 minutes for stalls that were mainly attributed to weather conditions, incident severity, and police workloads. Later, Giuliano (16) found out that the mean incident duration is about 37 minutes with a standard deviation of 30 minutes. In contrast, Cohen and Nouveliere (7) found a different mean incident duration of 26 minutes with a standard deviation of 23 minutes. Sullivan (35) proposed an empirical model to estimate the number of freeway incidents and their associated delays. In fact, this work constitutes the basis of the model that is used by the NJDOT CMS software. Sullivan determined an incident duration distribution according to the incident type, the existing incident management strategies and the incident location.

A research effort for modeling the freeway incident clearance time is part of a project that has been conducted by Khattak, et al. (23), where a method that provides successively-improved accuracy of incident clearance times as the time progresses was developed. In that study, 121 incident records provided by the Iowa DOT Communications Center were used. Since the data set was not large enough, the 1988 Chicago Area Expressway Accidents Annual Report (CAA), published by the Chicago Police Department, was applied to examine the validity of the study data. A series of tests demonstrated that the studied data set is un-biased and well represents the distribution to the large Chicago Area Expressway Accidents (CAA) database. Incident

You Are Viewing an Archived Copy from the New Jersey State Library

reports were applied to find out the significance of the variables to the dependent variable: the predicted incident clearance time.

Non-recurring Delay Estimation

The basic incident delay estimation model proposed by Morales [25] is a "deterministic queuing model" that estimates the queuing delays based on a function of capacity reduction. That model attempted to incorporate the impact of time-dependent variation in capacity and demand as a result of incident management activities.

Although the deterministic queuing model is a widely applied method for approximating incident delays, it is not as accurate as a simulation-based approach to handle dynamic traffic and heterogeneous geometric conditions. To remedy this problem, more regression-based delay models were developed by employing empirical data. For example, Garib, et al. [14] developed regression models to predict incident delays using the I-880 data in California.

By employing simulation data obtained from a calibrated simulation model, Chien, et al. [5, 6] developed a number of regression models for incident delays, including queuing and moving delays, considering various roadway geometric conditions and durations of incidents. A great amount of traffic, geometry, and control data on a segment of New Jersey I-80 was collected and applied to develop and calibrate a CORSIM model. Simulated travel time and delays were obtained under different ratios of demand and capacity, and geometric conditions.

Methodology

Incident Rate

In this study, the incident rates were categorized into nine incident types, which are based on an FHWA report by Ball Systems and California Polytechnic by Sullivan et al. [36], in which the rates are based on crashes/disablement incidents occurring in both directions and on a two-way ADT. The NJCMS estimates traffic volumes by direction on each route in different time periods (i.e., AM, PM, MD, NT), and generates the hourly capacity.

Therefore, the numbers of crashes and disablement incidents were calculated for each NJCMS link for both directions combined. In contrast, the incident rates (per million vehicle miles, MVM) for each NJCMS incident category were calculated by different facility types, time periods, and average daily traffic to hourly capacity ratios (ADT/C) in

You Are Viewing an Archived Copy from the New Jersey State Library

each direction separately. Equation 1 is developed to calculate the rates of incidents for the NJCMS needs. Thus,

$$R_{f,c,t,ADT/C} = \frac{10^6 \times I_{f,c,t,\mathrm{D},ADT/C}}{D \times \sum_{S_{ADT/C}} (ADT_{s_{ADT/C},f,t} L_s)} \qquad \forall f,c,t,ADT/c \qquad (1)$$

Where:

$R_{f,c,t,ADT/C}$: Incident rate by facility type *f*, incident type *c*, time period *t*, and ADT vs. capacity ratio (= ADT/C)

$I_{f,c,t,ADT/C}$: Annual number of incidents by facility type *f*, incident type *c*, time period *t*, and ADT/C

$S_{ADT/C}$: The number of NJCMS links (*S*) within a range of *ADT/C*

$ADT_{s_{ADT/C},f,t}$: Average Daily Traffic onin the NJCMS links by facility type *f*, time period *t*, and ADT/C (vehicles per day)

L_s : The length of the NJCMS link (miles)

D : Number of days per year (= 365 or 366)

c : Index of Incident type (see Table I-1)

t : Index of time period (see Table I-2)

f : Index of facility type (see Table I-2)

Table I-2. The Index of Incident Rates

Facility Type *f*	Time Period Index *t*	ADT/C Range
1 : Freeway	1 : AM Peak (6:00 AM – 9:00 AM)	1 : 0 – 7
2 : Arterial	2 : PM Peak (3:00 PM – 6:00 PM)	2 : 7 – 10
	3 : Midday (9:00 AM – 3:00 PM)	3 : 10 – 999
	4 : Night (6:00 PM – 6:00 AM)	

The number of incidents can be obtained from the NJDOT Crash Records and ESP databases, which were categorized into nine incident types. In order to calculate the rate of each incident type, a NJCMS link-based working database must be in place so that the incident related data including the route number, the ADT, the lane capacity, the traffic volume, the length of the link, the facility type, the number of lanes, and the incident management type can be properly placed. The rates of all incident types can be calculated based on this data.

Mapping Incident data

As discussed earlier in this report, the format and definition of the incident data in the identified databases are inconsistent. For example, the incidents in the TOC-ESP database were classified into 12 types, and the vehicle disablement was further detailed into 11 types, which are different from that of the NJCMS. In order to map TOC-ESP

You Are Viewing an Archived Copy from the New Jersey State Library

incident types into the NJCMS incident categories, the TOC-ESP incident types were summarized in Tables I-3a and I-3b, in which each type of ESP incident is properly assigned to match a type of incident in the NJCMS.

Table I-3a. Incident Types - TOC-ESP vs. the NJCMS

Incident Types (Reason for Stop)	NJCMS Categories	Incident Types (Reason for Stop)	NJCMS Categories
Disabled	See *Table I-3b*	Pedestrian	Other
Abandoned	Abandoned	Fire	Other
Debris	Debris	No Assist	Other
Crash	Crash	Other	Other
Stuck Mud	Stall	Lost	Other
Stuck Snow	Stall	Blank	Other

Table I-3b. Incident Types in TOC-ESP vs. Disablement Incident Types in the NJCMS

Incident Types (Disablement)	NJCMS Categories	Incident Types (Disablement)	NJCMS Categories
Out of Fuel	Stall	Lock-Out	Other
Flat Tire	Flat Tire	Other	Other
Electrical	Electrical / Mechanical	Unknown	Other
Mechanical	Electrical / Mechanical	OK cell phone/Wave	Other
Fuel System	Electrical / Mechanical	Blank	Other
Cooling System	Electrical / Mechanical		

Statewide NJcms incident study

As indicated in the beginning of this report, the major objective of this study is to develop incident rates and related delay measures for estimating non-recurring delay using the NJCMS. Note that the incident rates were derived based on incident records in 2005 (e.g. NJDOT Crash Records, TOC-ESP databases) that occurred on the NJCMS links. The incident rates calculation and data analyses are discussed next.

<u>Available Databases for the NJCMS Incident Table Updates</u>

The data sources involved in this analysis include Year-2005 NJDOT Crash Records, as well as disablement incidents and ESP data provided by NJDOT-TOCs. All records were mapped onto the NJCMS links based on the Standard Route Identifier (SRI) and the milepost. However, these incident records do not contain directional information (e.g. eastbound or westbound), so they cannot be allocated onto directional links. Table I-4 illustrates that 112,293 crash records and 62,185 incidents were mapped onto the NJCMS links, in which the distribution of data without the required information is summarized. The NJDOT crash records are recognized as the most complete database

You Are Viewing an Archived Copy from the New Jersey State Library

for categorizing the crash types and calculating the crash rates. Therefore the incomplete 4,846 crash records were dropped from the TOC-ESP incident database. Incidents with SRIs that lack mileposts reference were proportionally distributed to the NJCMS links by county and SRI (route) based on the data with mileposts on the roads in each county. The Year-2005 NJDOT Crash Records are studied and deemed as a fairly complete database to be applied for calculating crash rates of each type.

As shown in Table I-4, there are 11,921 crashes and 264 disablement incidents with missing milepost information which can be distributed to the routes by county. In general, the adjustment factor for each county and route is equal to the ratio of the number of incidents with milepost divided by the total number of incidents with and without mileposts. The adjustment factor varies over crash types (e.g. fatal, injury, property damage) and disablement incident types (e.g. mechanical/electrical, stall, flat tire, abandoned, debris, and other). Crashes/Disablement incidents with mileposts are multiplied by adjustment factors for all the NJCMS links to compensate for the missing milepost information and account for the total records. Note that for those counties and routes without missing milepost records, the adjustment factor is 1.00.

Table I-4. NJDOT Crash Records and TOC-ESP Disablement Incidents (2005)

	NJDOT Crash Records	**TOC-ESP Disablement Incidents**
Records on the NJCMS links	112,293 (35.6%)	62,185 (85.8%)
Missing milepost	11,921 (3.8%)	264 (0.4%)
No SRI or route	110,768 (35.1%)	2,467 (3.5%)
Missing incident time	528 (0.2%)	11 (0.0%)
SRI or milepost out of NJCMS coverage range	79,925 (25.3%)	1,630 (2.3%)
Crashes dropped	—	4,846 (6.8%)
Total records	**315,435 (100%)**	**71,403 (100%)**

The available records for incident rate calculations are shown in Table I-5. It indicates the total number of crashes/disablement incidents on the NJCMS/ESP links, in which the data without mileposts were justified. While developing the query database some of the crash records were eliminated due to the missing ADT/C (e.g. about 2,774 records). The developed query database classified the NJDOT Crash Records and the TOC-ESP Disablement Incidents into specified groups (e.g. facility type, time period, and ADT/C) for 121,440 and 61,931 records, respectively.

You Are Viewing an Archived Copy from the New Jersey State Library

Table I-5. Qualified Data (2005) for Study Developed NJCMS Incident Rates

	NJDOT Crash Records	TOC-ESP Disablement Incidents
Total number of records*	124,214	61,931**
Missing ADT/C	2,774	0
Query result (facility type, time period, ADT/C)	**121,440**	**61,931**

** Include the records with and without mileposts on the NJCMS links*
*** 518 disablement incident records were dropped from records since no regular ESP service is provided along the given routes.*

Study Developed Incident Rates

According to incident records (2005 data), the rates by incident type, facility type, ADT/C, and time period were calculated by employing Equation 1. Note that the calculated rates of disablement incidents in this report were based on the ESP data of fourteen NJ freeways (see Table I-10). The ESP service started at 4 AM and ended at 8 PM (e.g., 16 hours) daily. In order to better estimate disablement incidents while considering 8-hour operation in the nighttime and 1-hour ESP service rotation in the mid-day, the calculated incident rates were adjusted.

Considering that some types of incidents (e.g., stall/abandon, mechanic/electronic, etc.) might not fully report in the ESP database because the ESP service did not respond to every disablement incident. For example, many disablement incidents with short duration were likely resolved before the arrivals of the ESP patrols, and those cases will be missed in the TOS-ESP database. As recommended by the NJDOT planners, the calculated incident rates of disablement incidents were adjusted up by 20% for both the periods of mid-day and nighttime. The incident type of stall and abandoned vehicles was suggested to adjust up by 100%, while 20% and 30% for the electrical/mechanical and other disablement incidents, respectively. Note that the developed incident rates for flat tire and debris are not adjusted. The adjustment factors by different time periods and disablement incident type are shown in Table I-6.

Table I-6. The Incident Rates Adjustment Factors for Disablement Incidents

NJCMS Categories / Time Periods	Elecl/ Mechl	Stall	Flat Tire	Aband	Debris	Other
AM PEAK	1.2	2.0	1.0	2.0	1.0	1.3
PM PEAK	1.2	2.0	1.0	2.0	1.0	1.3
MID-DAY	1.44	2.4	1.2	2.4	1.2	1.56
NIGHT	1.44	2.4	1.2	2.4	1.2	1.56

You Are Viewing an Archived Copy from the New Jersey State Library

The study developed incident rates are the product of calculated incident rates and the adjustment factors by different incident types and time periods. Note that the existing NJCMS incident rates for freeways and arterials were based on a national average, which are identical for both facility types. In this study, these were updated for better estimation in incident (i.e. non-recurring) delays.

Comparing the existing and study developed crash and incident rates, it was found that the study developed crash rates on both freeways and arterials are much higher than the existing rates used in NJCMS. However, the study developed rates of disablement incidents are generally lower than those in existing NJCMS, except for the PM and Mid-day periods under light congestion density (i.e., ADT/C=0-7). As shown in Table I-7a, the study's results exhibit a positive relationship between the rates of crashes of routes and the volume to capacity ratios of the routes. Note that the highest rates of disablement incidents were found at the lowest ADT/C ratio.

By comparing the total incident rates in the sections entitled "Study Developed Rates for NJCMS" in both Tables I-7a and I-7b, one can see that the highest total incident rates all exist at the light congestion density (i.e., ADT/C: 0-7) and the second highest rates all occur at the heavy congestion density (i.e., ADT/C: 10-999) during different time periods. The total incident rates on arterials (e.g. Table I-7b) by different time periods and ADT/C ranges are all greater than the rates on freeways (e.g. TableI-7a). Note that the rates of disablement incidents on arterials are assumed the same as the rates for that of freeways because of unavailable disablement incident records on arterials.

In Tables I-7a and I-7b, the existing, calculated, and study developed (2005 data) NJCMS incident rates with Equation 1 for freeways and arterials are summarized.

You Are Viewing an Archived Copy from the New Jersey State Library

Table I-7a. The Existing NJCMS, Calculated and Study Developed Incident Rates on Freeways (number of incidents per million vehicle miles)

Time Periods	ADT/C Range	Fatal	Injury	Property Damage	Crash Rate	Elecl /Mechl	Stall	Flat Tire	Aband	Debris	Other	Disable Incident Rate	Total Incident Rate
Existing Rates in the NJCMS													
AM PEAK	0-7	0.011	0.269	0.269	0.549	1.553	1.392	1.125	1.830	0.127	0.773	6.800	7.349
	7-10	0.009	0.227	0.227	0.463	1.828	1.579	1.392	1.911	0.199	0.330	7.239	7.702
	10-999	0.047	1.150	1.150	2.347	5.857	3.936	3.907	2.679	0.538	3.295	20.212	22.559
PM PEAK	0-7	0.011	0.269	0.269	0.549	1.553	1.392	1.125	1.830	0.127	0.773	6.800	7.349
	7-10	0.009	0.227	0.227	0.463	1.828	1.579	1.392	1.911	0.199	0.330	7.239	7.702
	10-999	0.047	1.150	1.150	2.347	5.857	3.936	3.907	2.679	0.538	3.295	20.212	22.559
MID-DAY	0-7	0.011	0.269	0.269	0.549	1.553	1.392	1.125	1.830	0.127	0.773	6.800	7.349
	7-10	0.006	0.138	0.138	0.282	0.893	0.801	0.849	1.224	0.131	0.248	4.146	4.428
	10-999	0.011	0.271	0.271	0.553	1.315	0.833	0.912	2.330	0.552	0.516	6.458	7.011
NIGHT	0-7	0.011	0.269	0.269	0.549	1.553	1.392	1.125	1.830	0.127	0.773	6.800	7.349
	7-10	0.006	0.138	0.138	0.282	0.893	0.801	0.849	1.224	0.131	0.248	4.146	4.428
	10-999	0.011	0.271	0.271	0.553	1.315	0.833	0.912	2.330	0.552	0.516	6.458	7.011
Calculated Rates for the NJCMS													
AM PEAK	0-7	0.007	0.251	0.912	1.170	2.022	0.512	1.962	0.844	0.538	0.848	6.727	7.897
	7-10	0.002	0.309	1.222	1.533	1.226	0.255	1.381	0.334	0.172	0.466	3.834	5.367
	10-999	0.001	0.332	1.398	1.731	1.769	0.405	1.668	0.499	0.303	0.541	5.184	6.915
PM PEAK	0-7	0.005	0.298	0.958	1.260	2.935	1.052	2.547	0.746	0.705	1.322	9.307	10.567
	7-10	0.003	0.319	1.233	1.555	1.960	0.602	1.760	0.353	0.259	0.934	5.867	7.422
	10-999	0.001	0.377	1.518	1.896	2.373	0.806	1.939	0.450	0.311	0.808	6.687	8.583
MID-DAY	0-7	0.005	0.304	1.016	1.326	2.687	0.952	2.617	1.063	0.956	1.498	9.773	11.099
	7-10	0.004	0.351	1.204	1.560	1.537	0.473	1.750	0.439	0.378	0.814	5.391	6.951
	10-999	0.007	0.378	1.241	1.627	1.922	0.715	1.943	0.554	0.435	0.930	6.501	8.128
NIGHT	0-7	0.014	0.346	1.148	1.508	1.503	0.556	1.378	0.901	0.402	0.641	5.381	6.889
	7-10	0.007	0.403	1.380	1.790	0.723	0.243	0.642	0.345	0.170	0.363	2.486	4.276
	10-999	0.006	0.462	1.392	1.860	1.154	0.409	0.895	0.637	0.202	0.467	3.763	5.623
Study Developed Rates for the NJCMS													
AM PEAK	0-7	0.007	0.251	0.912	1.170	2.426	1.024	1.962	1.688	0.538	1.102	8.741	9.911
	7-10	0.002	0.309	1.222	1.533	1.471	0.510	1.381	0.668	0.172	0.606	4.808	6.341
	10-999	0.001	0.332	1.398	1.731	2.123	0.810	1.668	0.998	0.303	0.703	6.605	8.336
PM PEAK	0-7	0.005	0.298	0.958	1.260	3.522	2.104	2.547	1.492	0.705	1.719	12.089	13.349
	7-10	0.003	0.319	1.233	1.555	2.352	1.204	1.760	0.706	0.259	1.214	7.495	9.050
	10-999	0.001	0.377	1.518	1.896	2.848	1.612	1.939	0.900	0.311	1.050	8.660	10.556
MID-DAY	0-7	0.005	0.304	1.016	1.326	3.869	2.285	3.140	2.551	1.147	2.337	15.330	16.656
	7-10	0.004	0.351	1.204	1.560	2.213	1.135	2.100	1.054	0.454	1.270	8.226	9.786
	10-999	0.007	0.378	1.241	1.627	2.768	1.716	2.332	1.330	0.522	1.451	10.118	11.745
NIGHT	0-7	0.014	0.346	1.148	1.508	2.164	1.334	1.654	2.162	0.482	1.000	8.797	10.305
	7-10	0.007	0.403	1.380	1.790	1.041	0.583	0.770	0.828	0.204	0.566	3.993	5.783
	10-999	0.006	0.462	1.392	1.860	1.662	0.982	1.074	1.529	0.242	0.729	6.217	8.077

You Are Viewing an Archived Copy from the New Jersey State Library

Table I-7b. Existing NJCMS, Calculated and Study Developed Incident Rates on Arterials (number of incidents per million vehicle miles)

Time Periods	ADT/C Range	Fatal	Injury	Property Damage	Crash Rate	Elecl /Mechl	Stall	Flat Tire	Aband	Debris	Other	Disable Incident Rate	Total Incident Rate
Existing Rates in the NJCMS													
AM PEAK	0-7	0.011	0.269	0.269	0.549	1.553	1.392	1.125	1.830	0.127	0.773	6.800	7.349
	7-10	0.009	0.227	0.227	0.463	1.828	1.579	1.392	1.911	0.199	0.330	7.239	7.702
	10-999	0.047	1.150	1.150	2.347	5.857	3.936	3.907	2.679	0.538	3.295	20.212	22.559
PM PEAK	0-7	0.011	0.269	0.269	0.549	1.553	1.392	1.125	1.830	0.127	0.773	6.800	7.349
	7-10	0.009	0.227	0.227	0.463	1.828	1.579	1.392	1.911	0.199	0.330	7.239	7.702
	10-999	0.047	1.150	1.150	2.347	5.857	3.936	3.907	2.679	0.538	3.295	20.212	22.559
MID-DAY	0-7	0.011	0.269	0.269	0.549	1.553	1.392	1.125	1.830	0.127	0.773	6.800	7.349
	7-10	0.006	0.138	0.138	0.282	0.893	0.801	0.849	1.224	0.131	0.248	4.146	4.428
	10-999	0.011	0.271	0.271	0.553	1.315	0.833	0.912	2.330	0.552	0.516	6.458	7.011
NIGHT	0-7	0.011	0.269	0.269	0.549	1.553	1.392	1.125	1.830	0.127	0.773	6.800	7.349
	7-10	0.006	0.138	0.138	0.282	0.893	0.801	0.849	1.224	0.131	0.248	4.146	4.428
	10-999	0.011	0.271	0.271	0.553	1.315	0.833	0.912	2.330	0.552	0.516	6.458	7.011
Calculated Rates for the NJCMS													
AM PEAK	0-7	0.009	0.728	1.792	2.530	2.022	0.512	1.962	0.844	0.538	0.848	6.727	9.257
	7-10	0.006	0.666	1.788	2.460	1.226	0.255	1.381	0.334	0.172	0.466	3.834	6.294
	10-999	0.000	0.732	1.819	2.551	1.769	0.405	1.668	0.499	0.303	0.541	5.184	7.735
PM PEAK	0-7	0.014	1.282	2.874	4.170	2.935	1.052	2.547	0.746	0.705	1.322	9.307	13.477
	7-10	0.008	1.212	2.834	4.053	1.960	0.602	1.760	0.353	0.259	0.934	5.867	9.920
	10-999	0.004	1.245	3.137	4.386	2.373	0.806	1.939	0.450	0.311	0.808	6.687	11.073
MID-DAY	0-7	0.012	1.194	2.736	3.942	2.687	0.952	2.617	1.063	0.956	1.498	9.773	13.715
	7-10	0.003	1.170	2.769	3.942	1.537	0.473	1.750	0.439	0.378	0.814	5.391	9.333
	10-999	0.005	1.158	2.838	4.001	1.922	0.715	1.943	0.554	0.435	0.930	6.501	10.502
NIGHT	0-7	0.030	1.237	2.748	4.016	1.503	0.556	1.378	0.901	0.402	0.641	5.381	9.397
	7-10	0.028	1.256	2.593	3.877	0.723	0.243	0.642	0.345	0.170	0.363	2.486	6.363
	10-999	0.017	1.166	2.697	3.879	1.154	0.409	0.895	0.637	0.202	0.467	3.763	7.642
Study Developed Rates for the NJCMS													
AM PEAK	0-7	0.007	0.251	0.912	1.170	2.426	1.024	1.962	1.688	0.538	1.102	8.741	11.271
	7-10	0.002	0.309	1.222	1.533	1.471	0.510	1.381	0.668	0.172	0.606	4.808	7.268
	10-999	0.001	0.332	1.398	1.731	2.123	0.810	1.668	0.998	0.303	0.703	6.605	9.156
PM PEAK	0-7	0.005	0.298	0.958	1.260	3.522	2.104	2.547	1.492	0.705	1.719	12.089	16.259
	7-10	0.003	0.319	1.233	1.555	2.352	1.204	1.760	0.706	0.259	1.214	7.495	11.548
	10-999	0.001	0.377	1.518	1.896	2.848	1.612	1.939	0.900	0.311	1.050	8.660	13.046
MID-DAY	0-7	0.005	0.304	1.016	1.326	3.869	2.285	3.140	2.551	1.147	2.337	15.330	19.272
	7-10	0.004	0.351	1.204	1.560	2.213	1.135	2.100	1.054	0.454	1.270	8.226	12.168
	10-999	0.007	0.378	1.241	1.627	2.768	1.716	2.332	1.330	0.522	1.451	10.118	14.119
NIGHT	0-7	0.014	0.346	1.148	1.508	2.164	1.334	1.654	2.162	0.482	1.000	8.797	12.813
	7-10	0.007	0.403	1.380	1.790	1.041	0.583	0.770	0.828	0.204	0.566	3.993	7.870
	10-999	0.006	0.462	1.392	1.860	1.662	0.982	1.074	1.529	0.242	0.729	6.217	10.096

You Are Viewing an Archived Copy from the New Jersey State Library

Scenario Analysis

In order to investigate the reasonableness of the incident rates estimated by the NJCMS, three scenarios were applied. The first scenario, S1, employed the existing incident rate file (i.e., *incident.dat*) and the crash rate file (i.e., *accrates.dbf*), which overwrote the crash rate *in incident.dat*. The second scenario, S2, was implemented by using the existing incident rate file (i.e., *incident.dat*) only; therefore, the crash rate file was not overwritten. Finally, the third scenario, S3, was implemented by using the study developed incident rates (i.e., *incident_n.dat*) for estimating numbers of incidents.

The estimated results based on the three scenarios against the actual numbers of incidents are compared and summarized in Tables I-8 and I-9, respectively. Table I-8 shows that the number of crashes with S2 was underestimated because the national average crash rates employed by the NJCMS (see Tables I-7a and I-7b) are less than the study developed rates based on Year-2005 data. However, the number of crashes estimated by the NJCMS with S1 was 5.2% higher than the actual number of crash records. Comparing to the results with S3 (the study developed crash rates), the estimated NJCMS number of crashes is only 1.8% above the actual number of crashes from of Year-2005 data and is recommended to be employed by the NJCMS. It is worth noting that the slightly overestimated results might be contributed by the conversion of average daily traffic (ADT) into average weekday traffic (AWT), and the resulting conversions between daily and annual VMT deserves further investigation to examine the difference.

Table I-8. Year 2005 Crash Data vs. the NJCMS Estimates under Various Scenarios

NJCMS Category / NJCMS Output	Fatal	Injury	Property Damage	Total
With *accrates.dbf* overwrite (S1)	241	54,504	82,934	137,691
With existing *incident.dat* (S2)	850	20,991	20,991	42,839
With study developed *incident_n.dat* (S3)	***418***	***36,585***	***96,338***	***133,347***
Actual number of records	***413***	***35,318***	***95,242***	***130,973***

In Table I-9, the actual numbers of disablement incidents recorded were based on the ESP data collected on a limited number of highways. The estimated numbers of disablement incidents were the same by employing *accrates.dbf* and *incident.dat* since the same rates from the *incident.dat* were applied. The number of disablement incidents estimated by using study developed incident rates is 81% of what was generated by S1 or S2. Therefore, it is recommended applying the study developed disablement incident

You Are Viewing an Archived Copy from the New Jersey State Library

rates in the NJCMS. The rates could be applied with using upward adjustment factors to account for the unrecorded incidents.

Table I-9. Year 2005 Disablement Incident Data vs. the NJCMS Estimates under Various Scenarios

Incident Category / Data Source	Elecl /Mechl	Stall	Flat Tire	Aban	Debris	Other	Total
With *accrates.dbf* overwrite (S1)	28,302	21,136	20,195	24,495	3,704	12,842	110,673
With existing *incident.dat* (S2)	28,302	21,136	20,195	24,495	3,704	12,842	110,673
With study developed *incident_n.dat* (S3)	***26,744***	***14,286***	***20,989***	***14,273***	***4,819***	***11,943***	***93,055***
Actual number of records	***18,606***	***6,008***	***17,833***	***6,369***	***4,434***	***8,680***	***61,931***

A further analysis was conducted to compare the results of incidents on the links with the ESP service estimated by the NJCMS with the study developed incident rates shown in Tables I-7a and I-7b. The roadway sections in the NJCMS with the ESP services are summarized in Table I-10, which was based on the TOC-North and TOC-South ESP coverage areas in 2005. The TOC-ESP service covers 6 routes with 221 miles in TOC-North and 8 routes with 167 miles in TOC-South, respectively.

Table I-10. Highway Sections with the ESP Services (2005)

Routes	Mileposts	Miles	Counties
I-195	0.0 to 34.17	34.17	Mercer, Monmouth, and Ocean
I-280	0.0 to 16.9	16.9	Morris, Essex and Hudson
I-287	0.0 to 67.5	67.5	Middlesex, Somerset, Morris, Passaic, and Bergen
I-295	1.0 to 67.77	66.77	Salem, Gloucester, Camden, Burlington, and Mercer
I-676	0.0 to 3.79	3.79	Camden
I-76	0.0 to 1.95	1.95	Camden
I-78	3.8 to 58.5	54.7	Warren, Hunterdon, Somerset, Union, and Essex
I-80	0.5 to 68.1	67.6	Warren, Sussex, Morris, Essex, Passaic, and Bergen
I-95	0.1 to 9.15	9.05	Mercer
NJ 24	0.0 to 10.59	10.59	Morris, Union, and Essex
NJ 29	0.0 to 2.9	2.9	Mercer
NJ 42	6.4 to 14.28	7.89	Camden and Gloucester
NJ 55	20.0 to 60.53	40.53	Cumberland
US 440	0.0 to 4.0	4.0	Middlesex

You Are Viewing an Archived Copy from the New Jersey State Library

As summarized in Tables I-11 through I-14, the number of crashes and disablement incidents were estimated based on highway sections by time period (e.g. peak and off-peak). The comparison between the number of Year-2005 NJDOT Crash Records and the number of crashes estimated by the NJCMS using the study developed rates during the AM and PM peak periods was categorized into three types shown in Table I-11. Note that the numbers within parentheses were estimated by the NJCMS using the study developed rates. It was found that the actual total number of crashes in each incident type is generally less than the number estimated by the NJCMS. However, the estimated total number of crashes on these 14 highway sections was about 20 percent higher than that from the actual crash records.

Table I-11. Crashes on the NJCMS Links with the ESP Services (AM and PM)

Data Source \ Incident Category	Fatal	Injury	Property Damage	Total
I-195	1 (1)	41 (72)	164 (248)	206 (321)
I-280	0 (1)	136 (92)	590 (358)	726 (451)
I-287	3 (4)	283 (393)	1188 (1,522)	1,474 (1,919)
I-295	5 (3)	198 (310)	729 (1,178)	932 (1,492)
I-676	1 (0)	17 (19)	43 (71)	61 (91)
I-76	0 (0)	39 (22)	160 (86)	199 (108)
I-78	5 (3)	269 (292)	916 (1,118)	1,190 (1,412)
I-80	5 (3)	443 (437)	1,562 (1,726)	2,010 (2,166)
I-95M	1 (1)	44 (23)	260 (80)	305 (103)
NJ 24	0 (0)	71 (61)	267 (250)	338 (311)
NJ 29	0 (0)	9 (17)	29 (40)	38 (57)
NJ 42	2 (0)	75 (191)	299 (478)	376 (669)
NJ 55	2 (1)	54 (94)	158 (353)	214 (448)
US 440	0 (0)	35 (94)	115 (237)	150 (331)
Total	25 (18)	1,714 (2,118)	6,480 (7,743)	8,219 (9,879)

( ): Number of crashes estimated by the *NJCMS using the study developed rates*

You Are Viewing an Archived Copy from the New Jersey State Library

Similarly, the recorded and the NJCMS estimated numbers of disablement incidents in the AM and PM peaks are categorized into six types and summarized in Table I-12, where the numbers within parentheses were obtained from the NJCMS output using the study developed rates. The estimated total number of disablement incidents for these ESP routes was 14% higher than that from the recorded disablement incident records.

Table I-12. Disablement Incidents on the NJCMS Links with the ESP Services (AM and PM)

Incident Category / Data Source	Elecl /Mechl	Stall	Flat Tire	Aband	Debris	Other	Total
I-195	832 (737)	243 (388)	811 (559)	213 (376)	140 (148)	305 (237)	2,544 (2,444)
I-280	467 (638)	130 (304)	392 (503)	67 (254)	31 (86)	168 (267)	1,255 (2,052)
I-287	1,107 (2,874)	537 (1,396)	1,160 (2,222)	152 (1,182)	303 (410)	759 (1,128)	4,018 (9,212)
I-295	2,752 (2,459)	724 (1,226)	2,363 (1,882)	839 (1,066)	598 (385)	691 (917)	7,967 (7,934)
I-676	217 (170)	108 (88)	156 (129)	71 (78)	64 (30)	76 (61)	692 (557)
I-76	240 (143)	73 (68)	167 (110)	61 (52)	20 (17)	65 (61)	626 (451)
I-78	1,287 (2,214)	398 (1,086)	1,394 (1,709)	299 (940)	325 (332)	1,172 (844)	4,875 (7,125)
I-80	1,458 (3,212)	331 (1,572)	1,490 (2,419)	187 (1,310)	92 (448)	531 (1,187)	4,089 (10,148)
I-95M	190 (254)	50 (136)	148 (192)	53 (132)	47 (53)	69 (79)	557 (847)
NJ 24	63 (420)	20 (202)	75 (312)	8 (158)	3 (51)	33 (160)	202 (1,303)
NJ 29	103 (50)	36 (26)	80 (38)	35 (26)	18 (10)	59 (16)	331 (166)
NJ 42	622 (475)	218 (234)	468 (343)	180 (178)	94 (58)	141 (169)	1,723 (1,457)
NJ 55	901 (818)	246 (418)	642 (616)	465 (378)	246 (140)	208 (277)	2,708 (2,647)
US 440	138 (235)	31 (116)	119 (170)	24 (88)	26 (29)	106 (83)	444 (721)
Total	10,377 (14,701)	3,145 (7,256)	9,465 (11,205)	2,654 (6,220)	2,007 (2,196)	4,383 (5,483)	32,031 (47,062)

( ): Number of disablement incidents estimated by NJCMS using the study developed rates

You Are Viewing an Archived Copy from the New Jersey State Library

On the other hand for the off-peak periods (i.e., MD and NT), the actual and the NJCMS estimated numbers of crashes are summarized in Table I-13, which indicated that the actual total number of crashes is fairly close (i.e. about 5 %) to what was estimated by the NJCMS using the study developed rates.

Table I-13. Crashes on the NJCMS Links with the ESP Services (MD and NT)

Data Source \ Incident Category	Fatal	Injury	Property Damage	Total
I-195	2 (2)	50 (74)	214 (248)	266 (324)
I-280	0 (2)	207 (92)	580 (310)	787 (404)
I-287	10 (7)	354 (411)	1229 (1,366)	1,593 (1,785)
I-295	8 (6)	211 (311)	708 (1,031)	927 (1,349)
I-676	0 (0)	37 (19)	59 (64)	96 (83)
I-76	0 (0)	64 (22)	159 (72)	223 (94)
I-78	9 (6)	328 (307)	972 (1,019)	1,309 (1,331)
I-80	14 (8)	470 (486)	1676 (1,578)	2,160 (2,073)
I-95M	2 (1)	83 (36)	302 (121)	387 (158)
NJ 24	1 (1)	45 (68)	167 (219)	213 (289)
NJ 29	1 (0)	8 (19)	22 (42)	31 (61)
NJ 42	1 (2)	98 (180)	258 (430)	357 (611)
NJ 55	1 (2)	70 (84)	216 (277)	287 (363)
US 440	1 (1)	49 (100)	111 (239)	161 (340)
Total	50 (38)	2,074 (2,210)	6,673 (7,018)	8,797 (9,266)

( ): Number of crashes estimated by the NJCMS using the study developed rates

You Are Viewing an Archived Copy from the New Jersey State Library

In Table I-14, the actual and the NJCMS estimated numbers of disablement incidents during the off-peak periods (i.e., MD and NT) are summarized. The actual number of disablement incidents is close to that estimated by the NJCMS using the study developed rates.

Table I-14. Disablement Incidents on the NJCMS Links with the ESP Services (MD and NT)

Data Source \ Incident Category	Elecl/ Mechl	Stall	Flat Tire	Aband	Debris	Other	Total
I-195	734 (662)	252 (394)	673 (533)	240 (497)	171 (178)	306 (371)	2,376 (2,634)
I-280	370 (487)	123 (274)	347 (410)	90 (305)	48 (103)	179 (267)	1,157 (1,845)
I-287	817 (2,294)	507 (1,315)	931 (1,894)	278 (1,493)	349 (492)	820 (1,242)	3,702 (8,729)
I-295	2,369 (1,997)	739 (1,162)	2,383 (1,637)	1,217 (1,327)	815 (455)	848 (1,089)	8,371 (7,667)
I-676	153 (141)	95 (82)	134 (114)	133 (98)	99 (35)	82 (78)	696 (548)
I-76	220 (108)	47 (60)	150 (91)	101 (62)	48 (20)	92 (58)	658 (400)
I-78	826 (1,747)	243 (1,008)	1,038 (1,429)	338 (1,178)	250 (383)	795 (944)	3,490 (6,689)
I-80	976 (2,710)	325 (1,598)	1,227 (2,171)	308 (1,800)	119 (548)	469 (1,415)	3,424 (10,243)
I-95M	149 (337)	54 (202)	157 (269)	73 (262)	60 (91)	74 (187)	567 (1,347)
NJ 24	33 (346)	19 (204)	57 (276)	12 (216)	8 (62)	18 (176)	147 (1,280)
NJ 29	80 (48)	25 (29)	57 (38)	51 (36)	20 (13)	49 (27)	282 (190)
NJ 42	569 (356)	190 (216)	474 (278)	286 (218)	101 (62)	196 (178)	1,816 (1,309)
NJ 55	724 (613)	194 (365)	552 (491)	542 (437)	265 (148)	182 (334)	2,459 (2,387)
US 440	138 (196)	26 (120)	112 (154)	29 (122)	56 (35)	130 (98)	491 (725)
Total	8,158 (12,043)	2,839 (7,030)	8,292 (9,784)	3,698 (8,054)	2,409 (2,623)	4,240 (6,460)	29,636 (45,993)

( ): Number of disablement incidents estimated by NJCMS using the study developed rates

You Are Viewing an Archived Copy from the New Jersey State Library

Data Analysis

Figure I-1 shows the percentage distribution over all crash types based on Year-2005 data. Crashes in this database were classified into three types: fatal, injury, and property damage only. There were a total of 121,440 crash records in this database, in which 72.1 percent of all crashes were property damage only, 27.6 percent injury, and less than 1 per [illegible] an killed or injured) were a

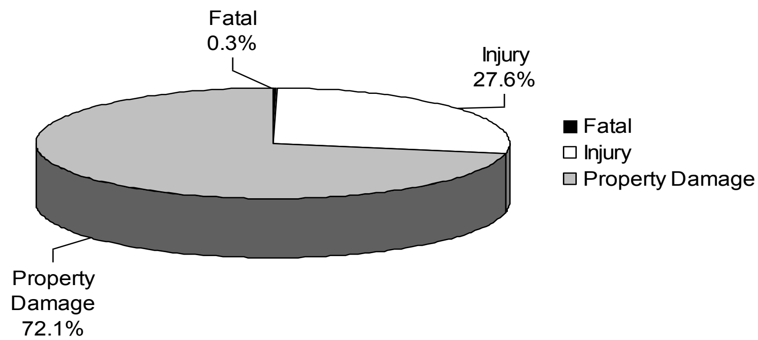


Figure I-1. Percentage Distribution by Crash Type

Figure I-2 shows the percentage distribution of all disablement incident types. The disablement incidents in the TOC-ESP database were classified into six types: mechanical/electrical, stall, flat tire, abandoned, debris, and other, which are consistent with the definitions employed in the NJCMS. The crash records, which comprised about 8 percent of the ESP data, were excluded from this report, because the NJDOT Crash Records were employed for calculating the crash rates. As shown in Figure I-2, a total of 61,931 disablement incident records were in this database, in which 30 percent of all were mechanical/electrical incidents, 29 percent were flat tire incidents, and the four other disablement incident types made up the remaining 41 percent of the database.

There were 5,253 bi-directional NJCMS links, which were analyzed on the basis of their operational capabilities and facility types. Further analysis was conducted by comparing the incident rates on freeways and arterials. The total numbers and rates of crashes and disablement incidents with rates on freeways and arterials distributed by county are shown in Tables I-15 and I-16. However, it is worth noting again that the disablement incidents were only based on data collected from the ESP routes and that the ESP service hours are for less than 24 hours per day.

You Are Viewing an Archived Copy from the New Jersey State Library

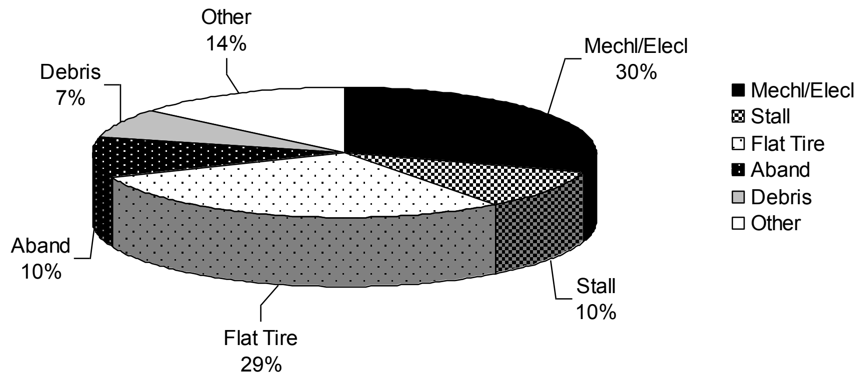


Figure I-2. Percentage Distribution by Disablement Incident Type (ESP Routes Only)

Table I-15. Crashes and Disablement Incidents on Freeways by County

COUNTY	Crashes (per year)	Disable Incidents (per year)	Annual VMT from NJCMS Freeways	Annual VMT from ESP Sections	Crash Rate (per MVM)	Disable Incident Rate (per MVM)
Atlantic	1,064	0	778,233,933	0	1.367	0
Bergen	3,051	1,417	2,088,078,776	651,224,363	1.461	2.176
Burlington	1,320	5,972	1,418,190,537	561,280,088	0.931	10.640
Camden	2,286	9,078	1,244,891,609	839,097,055	1.836	10.819
Cape May	310	0	254,669,228	0	1.217	0
Cumberland	163	1,362	160,244,933	160,244,933	1.017	8.499
Essex	3,923	3,570	1,571,304,148	814,779,142	2.497	4.382
Gloucester	1,059	8,118	1,033,445,367	787,661,973	1.024	10.306
Hudson	2,223	297	848,648,060	82,286,460	2.619	3.615
Hunterdon	700	2,517	524,332,822	524,332,822	1.335	4.800
Mercer	1,189	5,794	997,844,109	526,412,199	1.192	11.007
Middlesex	5,237	3,136	3,465,033,648	576,058,783	1.511	5.445
Monmouth	1,760	2,312	1,693,402,325	217,609,329	1.039	10.625
Morris	3,229	6,226	2,085,593,547	2,085,593,547	1.548	2.985
Ocean	1,452	910	1,231,140,101	114,629,379	1.179	7.939
Passaic	1,303	1,808	693,479,563	433,880,501	1.879	4.168
Salem	295	827	337,437,240	100,810,920	0.874	8.203
Somerset	1,480	5,649	920,841,601	920,841,601	1.607	6.135
Sussex	12	0	16,487,517	16,487,517	0.728	0.000
Union	4,213	2,579	1,937,314,697	598,014,555	2.175	4.312
Warren	684	358	587,128,177	542,139,678	1.165	0.660
Total	36,953	61,931	23,887,741,939	10,553,384,845	1.547	5.868

The numbers of incidents in 2005 were classified by counties, and the annual VMT was projected based on Year-2001 NJCMS traffic volume with assumed growth rates to

You Are Viewing an Archived Copy from the New Jersey State Library

2005. Table I-15 shows that the listed rates of disablement incidents were calculated based on the annual VMT of the links with ESP services. It was found that the rates of crash and disablement incidents differ from county to county, and the highest freeway rates of crash and disablement incidents were found in Hudson County and Mercer County, respectively.

The disablement incident rates on arterials by county in Table I-16 are not available because there are currently no ESP patrols on arterials. The derived crash rates distributed by counties for arterials were based on the NJDOT Crash Records and summarized below. Note that the highest crash rate was found in Union County.

Table I-16. Crashes and Rates on Arterials by County

COUNTY	Crashes (per year)	Annual VMT from NJCMS Arterials	Crash Rate (per MVM)
Atlantic	3,195	997,881,362	3.202
Bergen	8,756	2,481,571,452	3.528
Burlington	4,050	1,432,873,265	2.826
Camden	4,998	1,270,477,790	3.934
Cape May	876	345,116,656	2.538
Cumberland	1,085	299,051,057	3.628
Essex	7,216	1,188,848,911	6.070
Gloucester	2,250	781,561,282	2.879
Hudson	4,350	823,539,027	5.282
Hunterdon	1,239	576,158,750	2.150
Mercer	4,494	1,093,001,934	4.111
Middlesex	8,029	2,110,728,342	3.804
Monmouth	7,114	2,208,407,267	3.221
Morris	4,540	1,409,334,395	3.221
Ocean	4,434	1,288,354,178	3.442
Passaic	5,331	1,331,204,137	4.005
Salem	595	267,722,454	2.222
Somerset	3,370	939,800,068	3.586
Sussex	1,749	569,286,004	3.072
Union	5,751	871,417,383	6.600
Warren	1,064	371,717,219	2.862
Total	84,487	22,658,052,934	3.729

You Are Viewing an Archived Copy from the New Jersey State Library

In Figure I-3, the crash rate in Essex, Hudson, and Union Counties on freeways and arterials are relatively higher than that of the other counties. As expected, the crash rates on arterials were higher than that on freeways, because freeways had much less crashes and had greater annual VMT than that on arterials. In contrast, the rates of disablement incidents for Burlington, Camden, Gloucester, Mercer, and Monmouth Counties seemed significantly higher than that of the other counties.

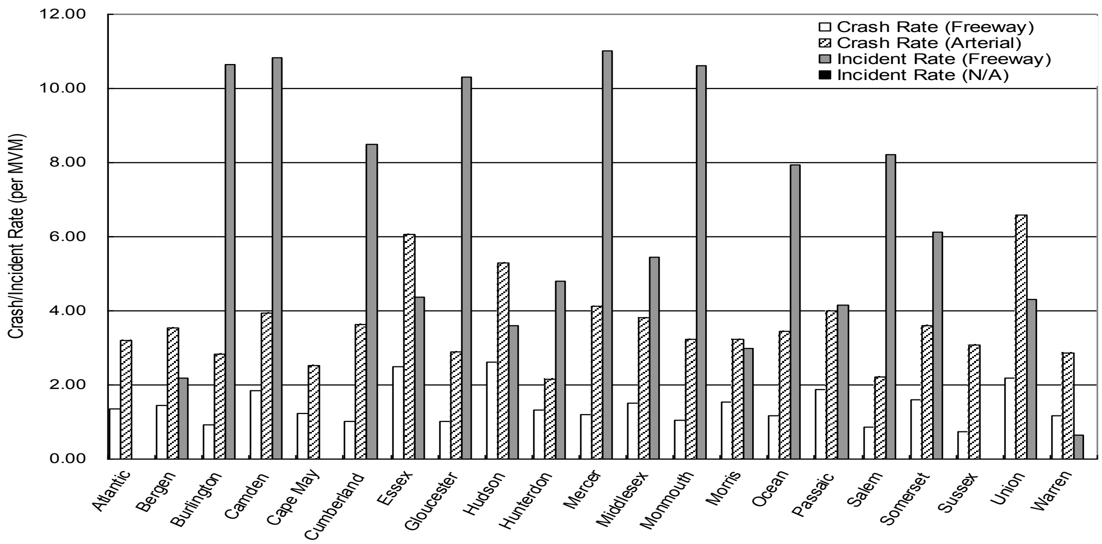


Figure I-3. Incident Rates by Counties

In terms of the numbers of crashes, Figure I-4a illustrates the top 10 counties in New Jersey based on Year-2005 NJDOT Crash Records. The highest number of over 12,000 crashes was found in Middlesex County. The crash rates in these counties ranged between 2.10 to 4.00 crashes per MVM. In addition, Figure I-4b was developed to illustrate the top 10 counties with highest crash rates, in which the highest crash rate (for all 3 types of crashes) was found in Essex County. Although Middlesex County had the highest number of crashes in 2005 as shown in Figure I-4a, the crash rate was not even listed in the top 10 counties for crash rates. It was found that Middlesex County had a very large VMT (e.g. more than 5 billion per year, the highest of the 21 counties) in 2005. Therefore, the crash rate of Middlesex County did not exceed that of the other counties.

In terms of the numbers of disablement incidents, Figure I-5a shows the distributions of disablement incidents by type on ESP service routes over the top 10 counties based on the Year-2005 TOC-ESP database. There were six counties (i.e., Middlesex, Union, Essex, Morris, Camden and Mercer County) appearing in both the top 10 lists for highest numbers of crashes and disablement incidents (Figures I-4a and I-5a) respectively**)**. The highest number of disablement incidents was found in Camden County, where 34 percent of all were caused by mechanical/electrical incidents. For the “other” type of disablement incident, Somerset County seemed relatively high comparing to the other counties.

You Are Viewing an Archived Copy from the New Jersey State Library

Figure I-5b indicates the top 10 counties with highest rates of disablement incidents on ESP service routes, in which the highest disablement incident rate was about 11.01/MVM in Mercer County. Moreover, it was found that Camden, Gloucester, Burlington, Mercer, Somerset, and Middlesex Counties were on the top 10 lists for both numbers and rates of disablement incidents.

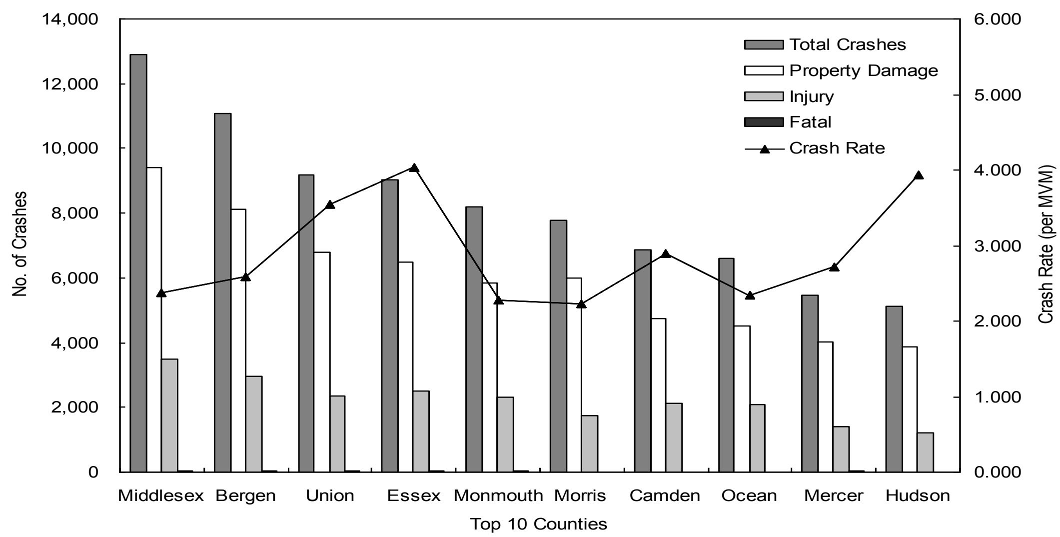


Figure I-4a. The Top 10 Counties in Number of Crashes

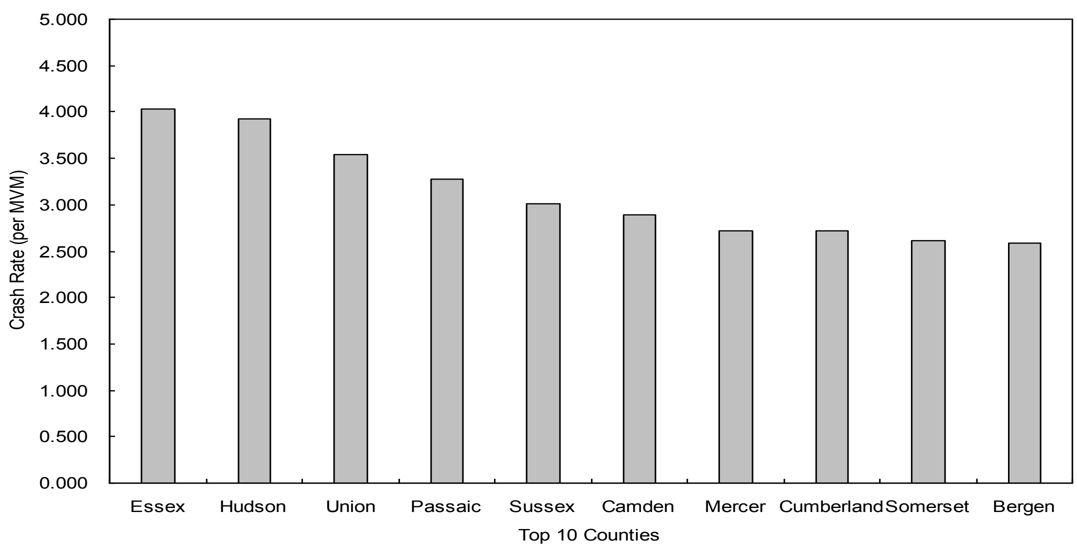


Figure I-4b. The Top 10 Counties in Crash Rates

You Are Viewing an Archived Copy from the New Jersey State Library

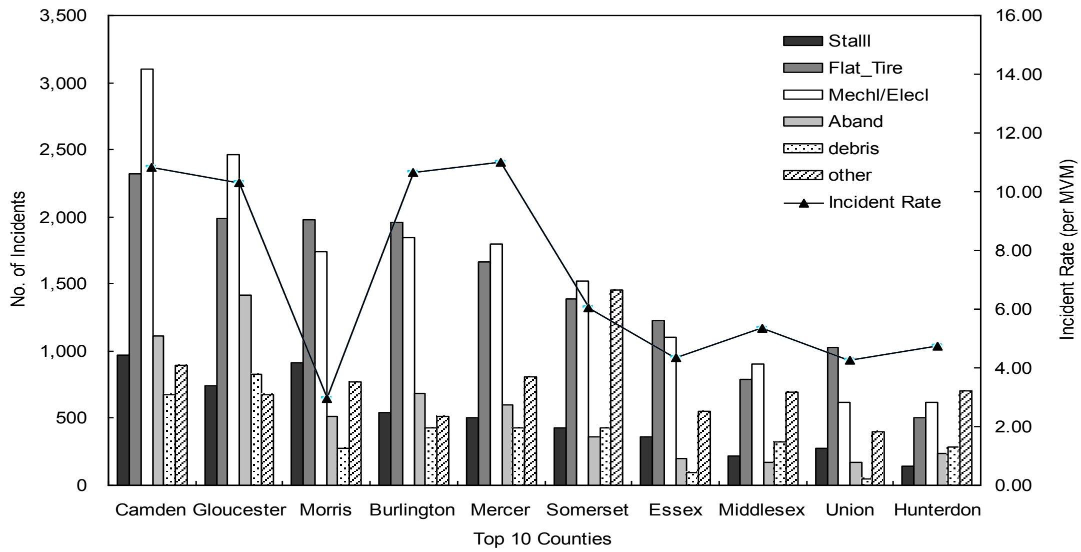


Figure I-5a. The Top 10 Counties in Number of Disablement Incidents

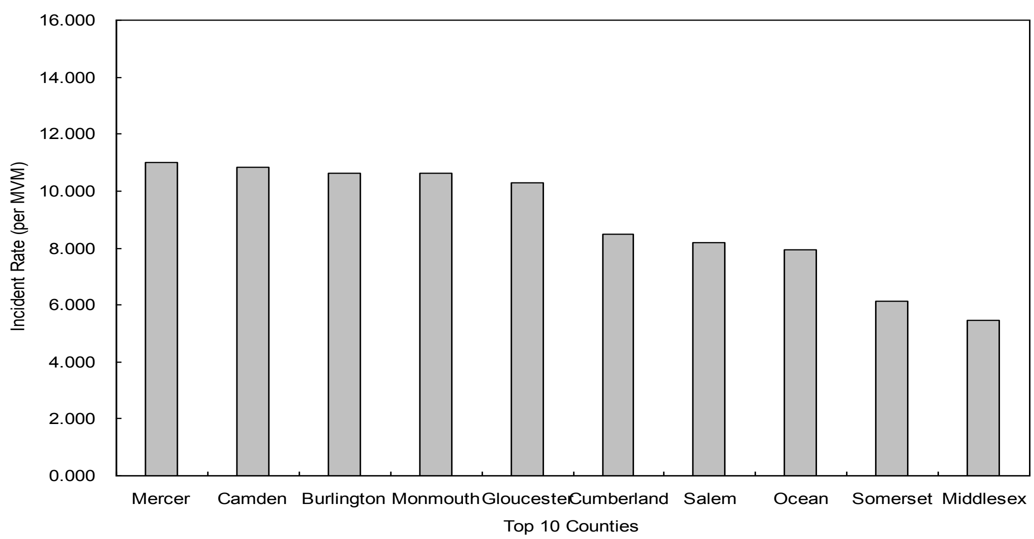


Figure I-5b. The Top 10 Counties in Rates of Disablement Incidents

Figure I-6 illustrates the distribution of crashes by severity and facility type, which indicates that the majority of crashes occurred on arterials (more than 69 percent) and most of the crashes on freeways and arterials were in the property damage only category.

You Are Viewing an Archived Copy from the New Jersey State Library

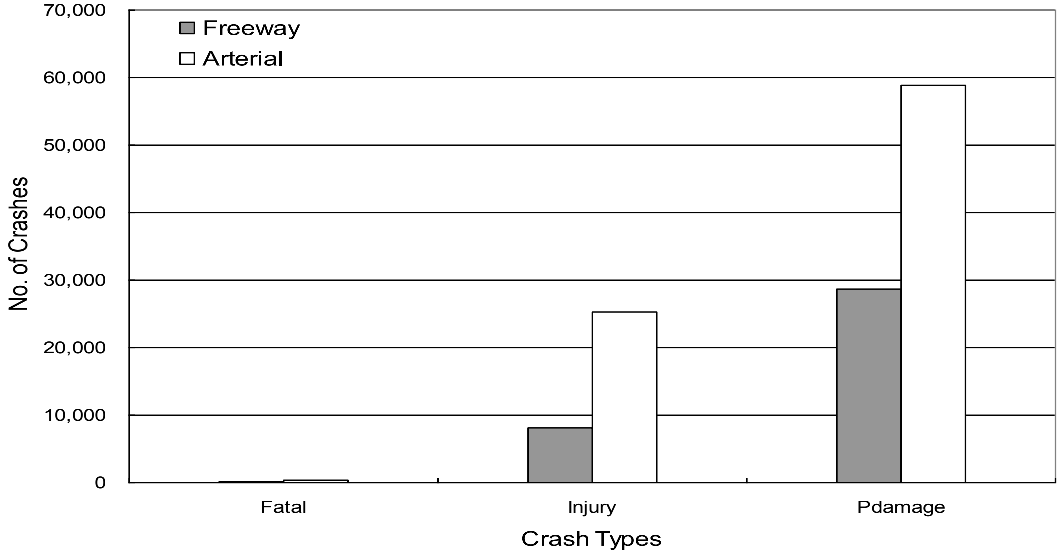


Figure I-6. Distribution of Crashes by Facility Type

There are more than 300 routes covered by the NJCMS, including those under state or public authority jurisdiction and some county routes. Figure I-7a represents the top 10 routes for number of crashes based on the Year-2005 NJDOT Crash Records. The highest number of crashes was found on the Garden State Parkway (GSP); while the New Jersey Turnpike (I-95) was ranked the second highest. Crashes with property damage only were the majority for all of the top 10 routes.

Figure I-7a also indicates that the NJCMS routes with the highest crash rates were not the ones with the highest number of crashes. Instead, the GSP and the New Jersey Turnpike had relatively low crash rates comparing to all the other top 10 routes because of their large VMT. Figure I-7b shows the top 10 state routes with the highest crash rates, where the highest was NJ 439. None of the top 10 routes shown in Figure I-7a appeared in Figure I-7b, because the state routes with high crash rates have considerably less VMT; therefore, the crash rates were higher.

You Are Viewing an Archived Copy from the New Jersey State Library

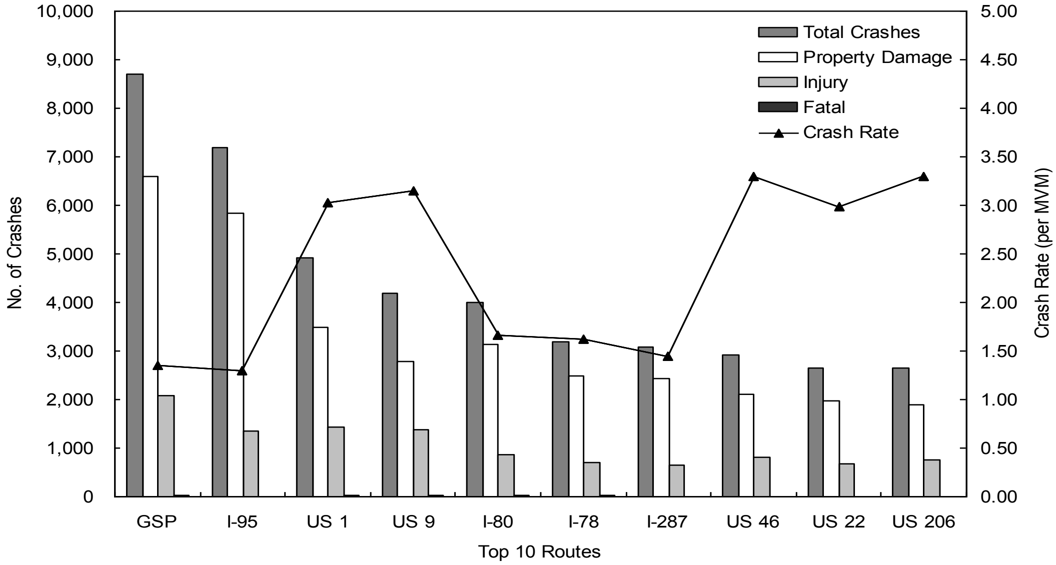


Figure I-7a. The Top 10 Routes in Number of Crashes

The top 10 ESP service routes for the numbers of disablement incidents are shown in Figure I-8a. Both the highest number and rate of disablement incidents were found on I-295. The mechanical/electrical and flat tire incidents comprised the major portion of all disablement incidents on these routes. I-80 was found to be the second highest route in terms of the numbers of disablement incidents, which was followed by I-78 and I-287. However, the rates of disablement incidents on I-78, I-80, and I-287 were relatively low compared to all other routes because of their high VMT.

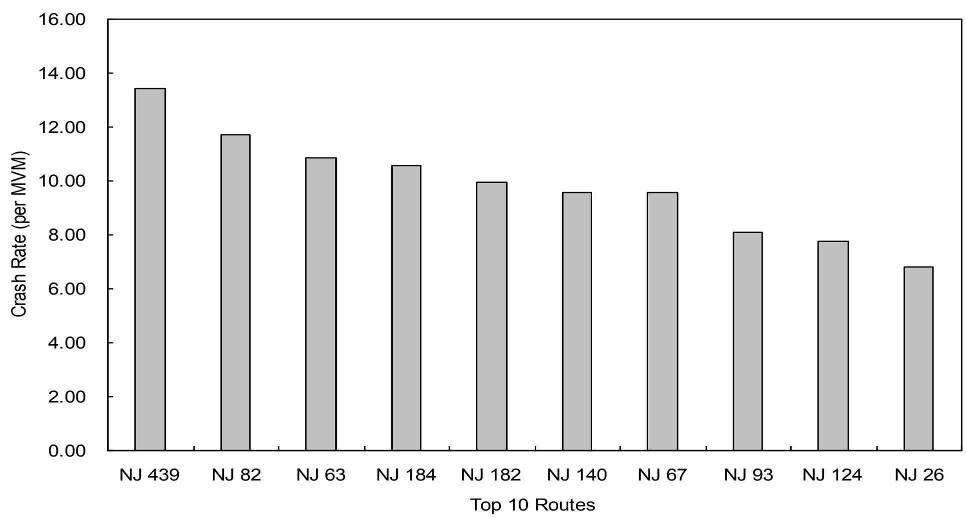


Figure I-7b. The Top 10 State Routes in Crash Rates

You Are Viewing an Archived Copy from the New Jersey State Library

Figure I-8b ranks the 10 ESP service routes by disablement incident rate. It was found that the highest disablement incident rate was on I-676, and the second highest was on NJ 29. The rates of disablement incidents for the first 7 routes were distributed between 10 to 14 disablement incidents per MVM.

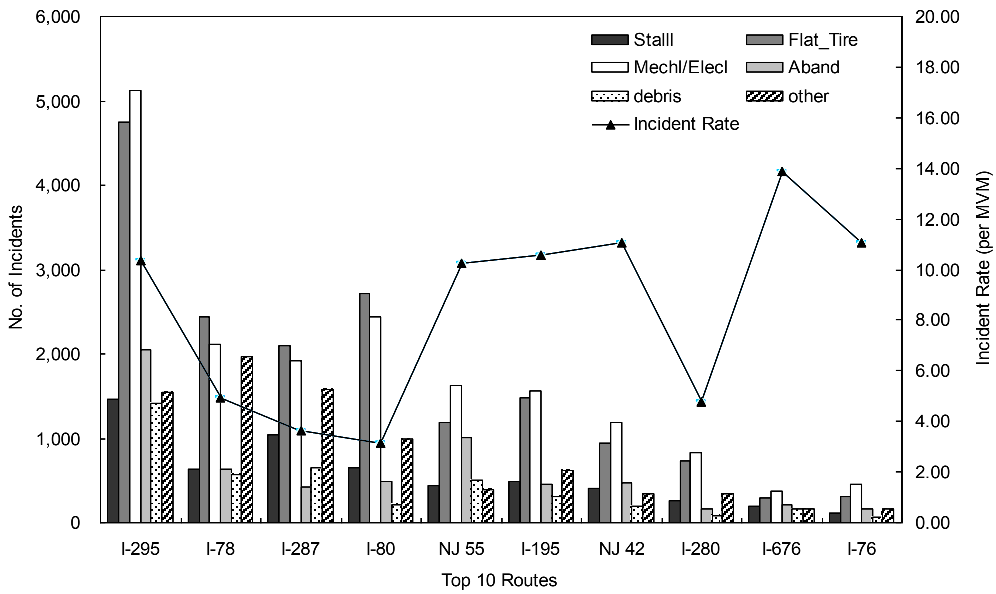


Figure I-8a. The Top 10 Routes in Number of Disablement Incidents

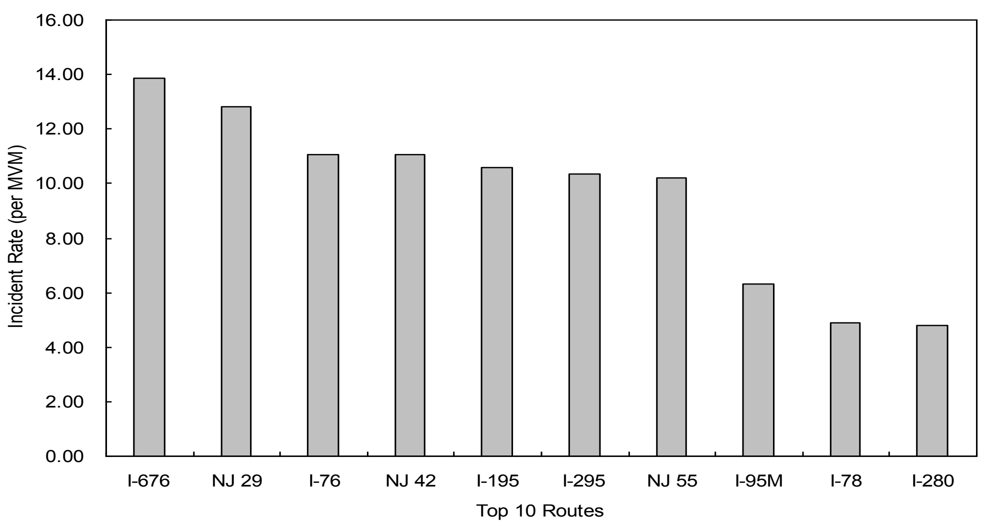


Figure I-8b. The Top 10 Routes in Rates of Disablement Incidents

Figure I-9 shows the number of disablement incidents by month on the ESP service routes (i.e., six routes in TOC-North and eight routes in TOC-South shown in Figures I-10 and I-11 respectively) based on 2005 data. The distribution of disablement incidents was relatively higher during the summer season (e.g. June, July, and August).

You Are Viewing an Archived Copy from the New Jersey State Library

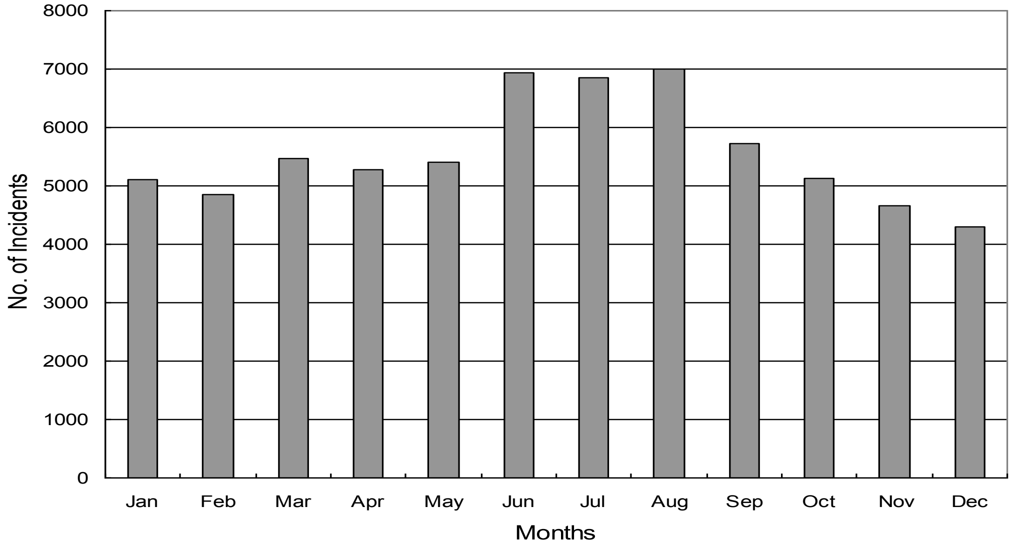


Figure I-9. The Distribution of Disablement Incidents over Time (2005)

You Are Viewing an Archived Copy from the New Jersey State Library

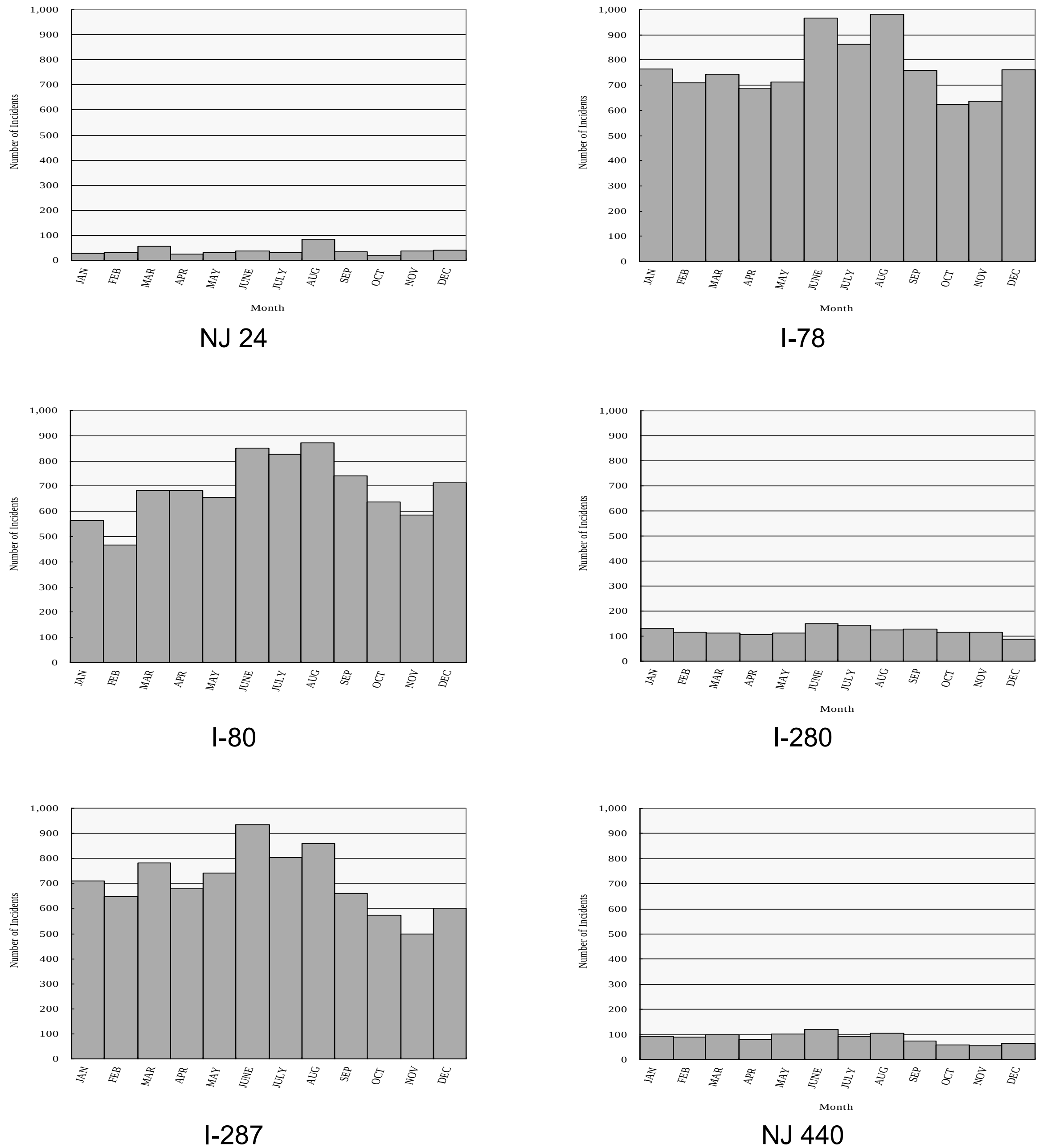
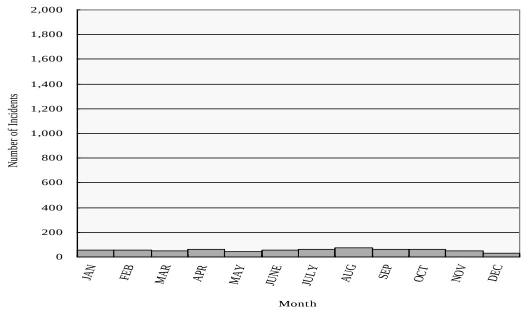
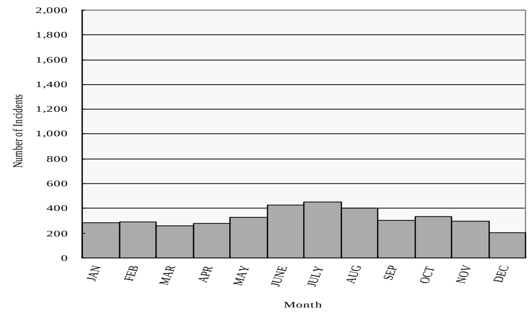


Figure I-10. Disablement Incidents (2005) for the ESP Routes in Northern New Jersey

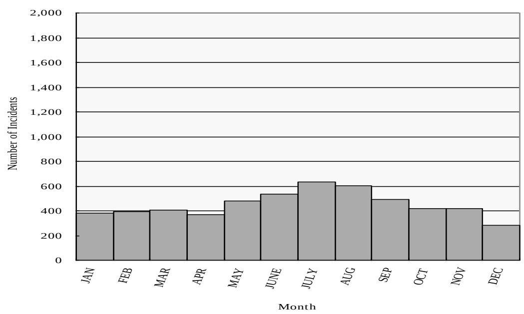
You Are Viewing an Archived Copy from the New Jersey State Library



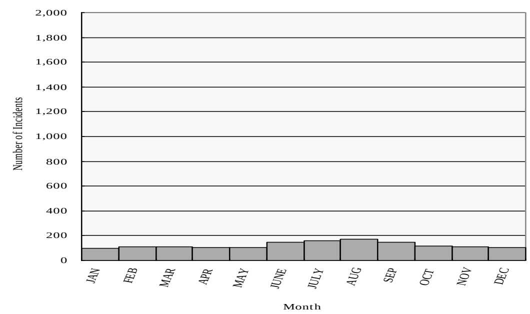
NJ 29



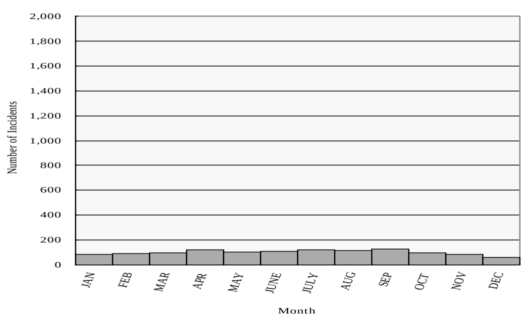
NJ 42



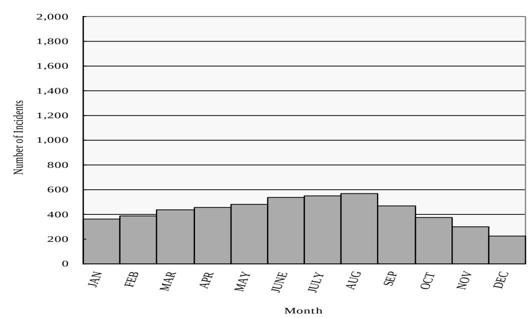
NJ 55



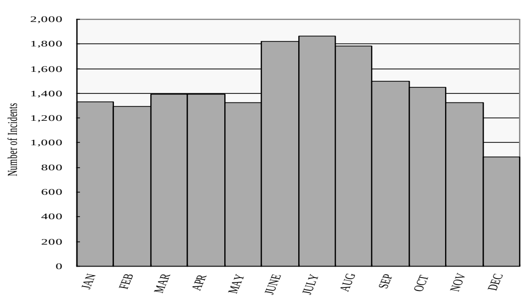
I-76



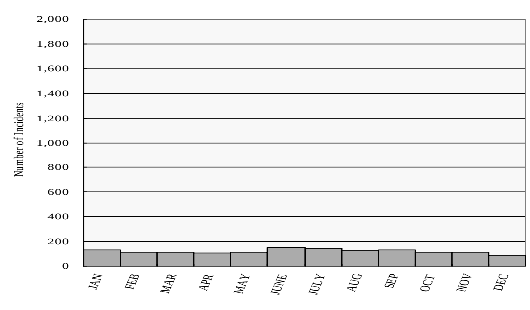
I-95M



I-195



I-295



I-676

Figure I-11. Disablement Incidents (2005) for the ESP Routes in Southern New Jersey

You Are Viewing an Archived Copy from the New Jersey State Library

An analysis of the crashes and disablement incidents by time period is shown in Figures I-12 and I-13, respectively, in which the numbers and rates of crashes for different time periods were illustrated. It was found that the maximum number of crashes occurred during the midday (MD); followed by the nighttime (NT), the PM peak, and then the AM peak. However, the highest crash rate for injury and property damage only crashes occurred during the PM peak period, but the most fatal crashes occurred in the nighttime.

Mid-day was also found to be the most often incident time period for all types of disablement incidents (see Figure I-13). However, in general there were more disablement incidents found during the PM or AM periods than the nighttime (NT), but note that the ESP service did not cover the whole nighttime period.

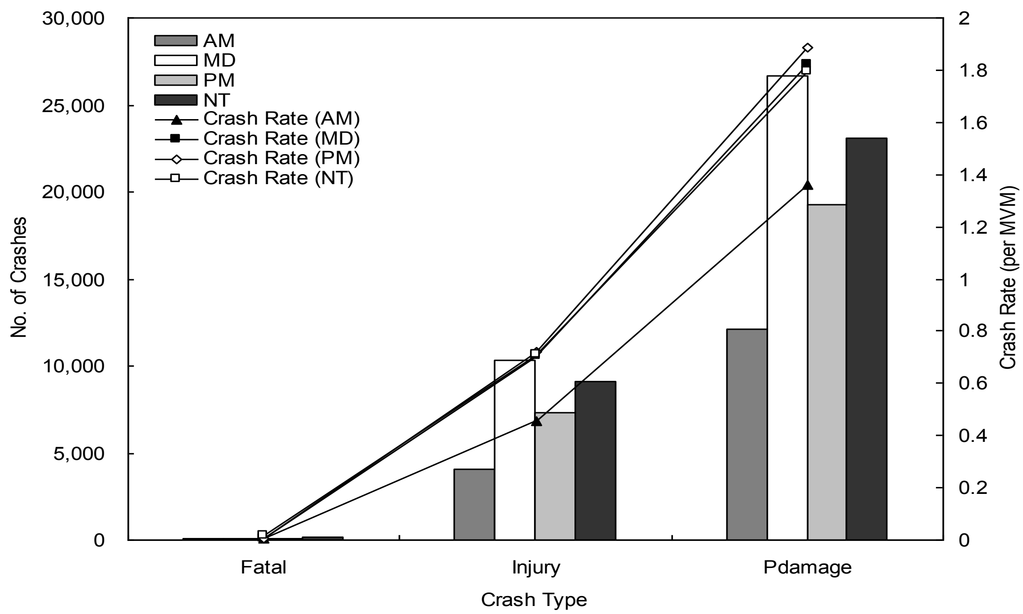


Figure I-12. The Numbers and Rates of Crashes for Year 2005

In general, the ESP service runs from 4:00 AM to 8:00 PM, Monday through Friday. The daily peak periods defined in this study were 6:00 AM to 9:00 AM in the morning, and 3:00 PM to 6:00 PM in the afternoon. Figure I-14 illustrates the number of disablement incidents by hour on the ESP service routes. As expected, the disablement incidents mostly all occurred during the period of ESP coverage between 4:00 AM to 8:00 PM when the ESP services are deployed almost continuously. There is a gap in the data around 11:00 AM, where incidents are not recorded due to shift changes. The disablement incidents that occurred during the peak periods were about 45 percent of all disablement incidents on the ESP service routes. The hourly distributions of disablement incidents by route for routes with ESP service are shown in Figures I-15 and I-16, which indicated that the most disablement incidents occurred on I-78, I-80, I-287, and I-295. The results also indicated that the TOC-ESP service operates almost

You Are Viewing an Archived Copy from the New Jersey State Library

regularly between 4:00 AM to 8:00 PM, and the disablement incidents that occurred after 8:00 PM and before 4:00 AM were not complete in the TOC-ESP database.

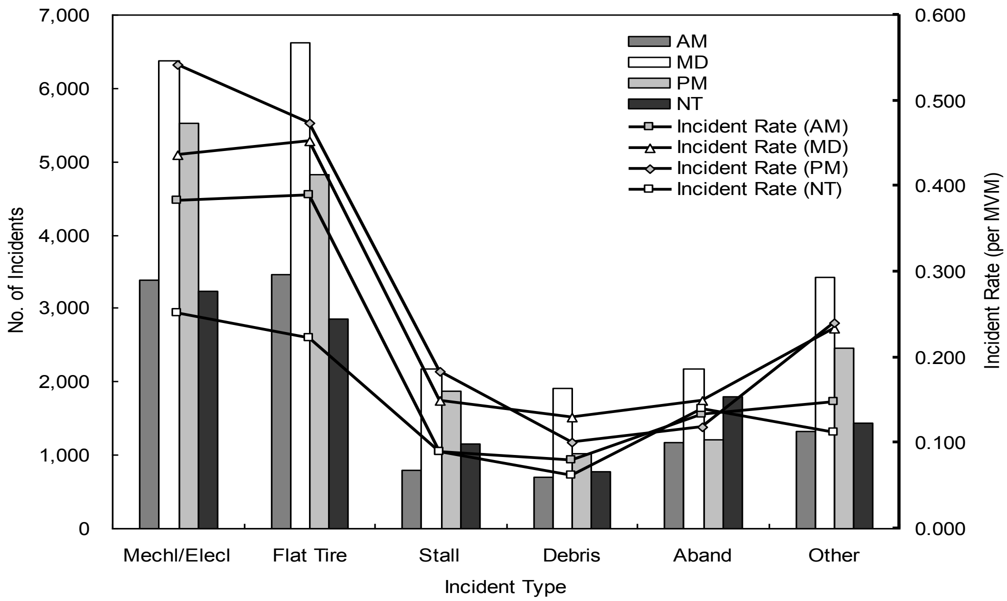


Figure I-13. The Numbers and Rates of Disablement Incidents (2005)

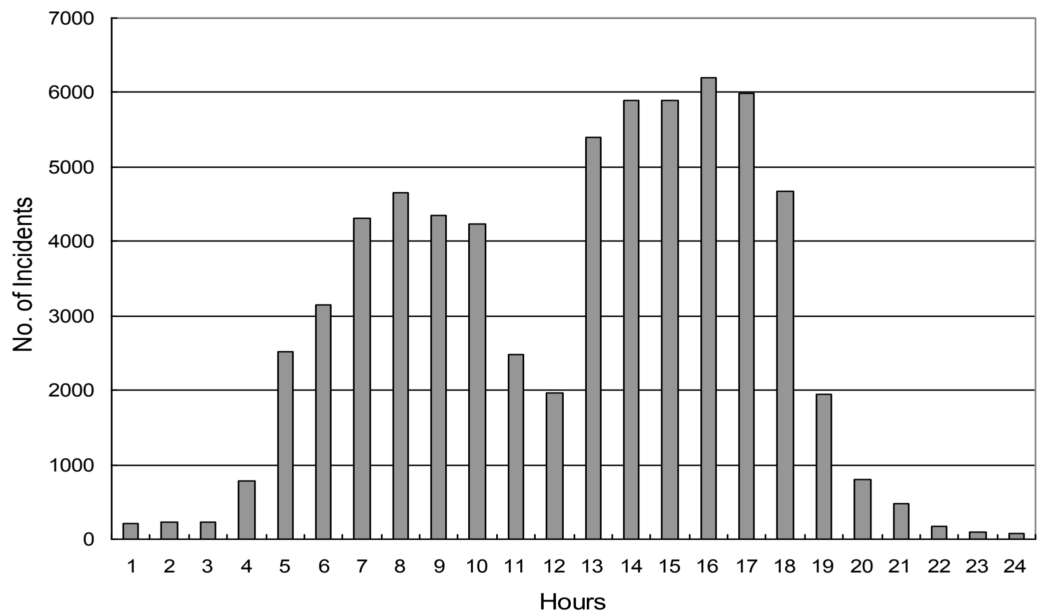


Figure I-14. The Number of Disablement Incidents over 24 Hours a Day (2005)

You Are Viewing an Archived Copy from the New Jersey State Library

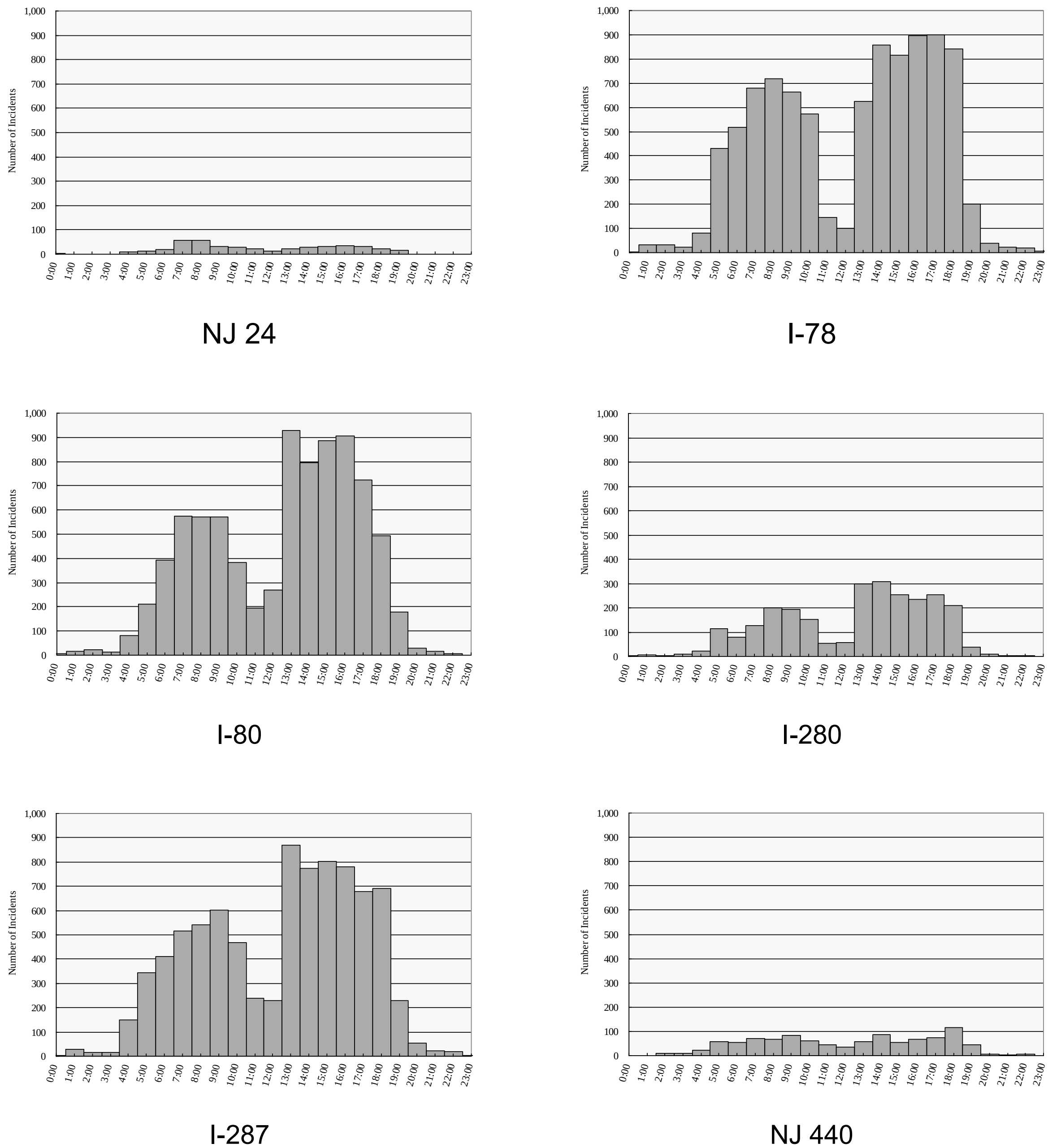


Figure I-15. Disablement Incidents over 24--Hours a Day for the ESP Routes in Northern New Jersey (2005)

You Are Viewing an Archived Copy from the New Jersey State Library

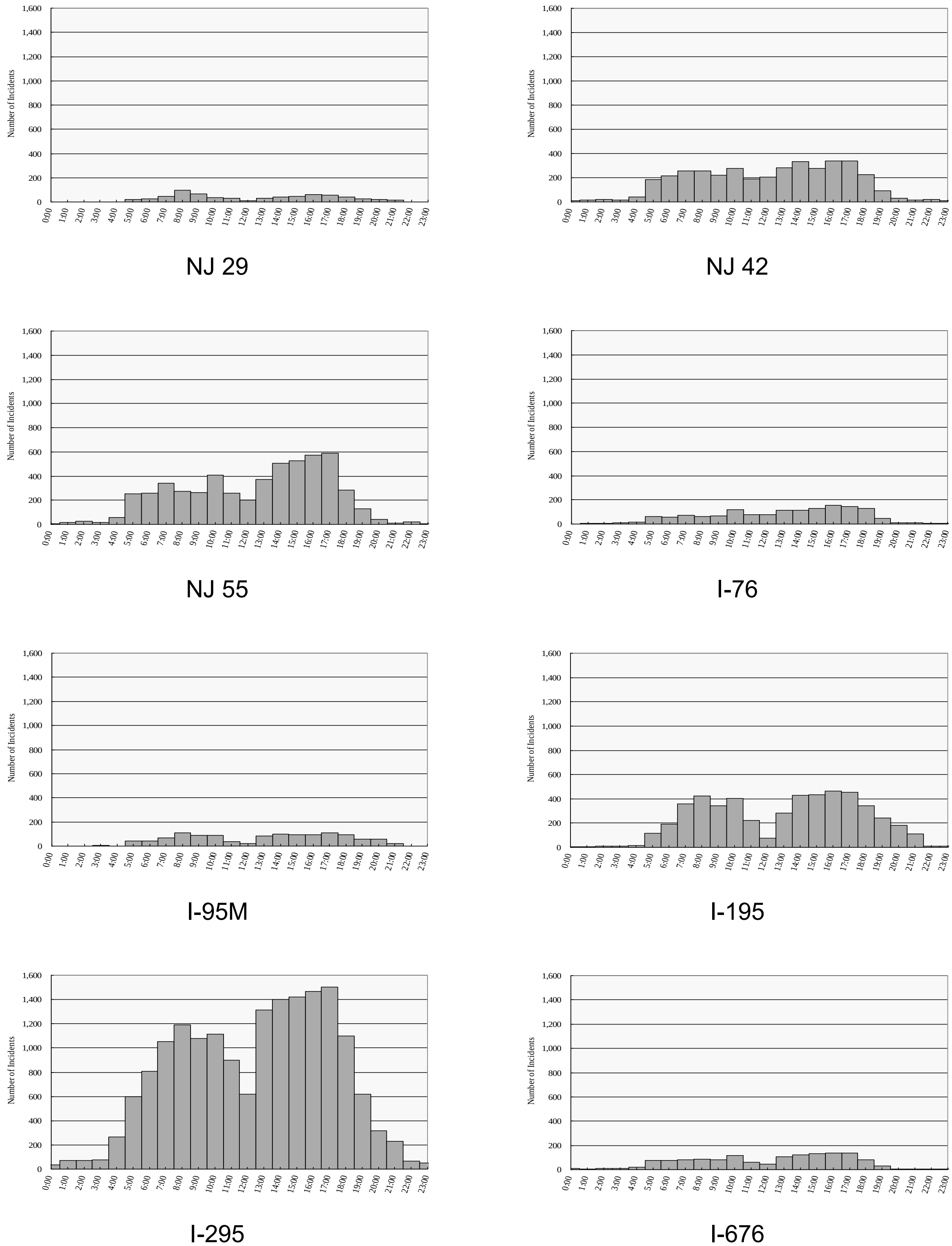


Figure I-16. Disablement Incidents over 24-Hours a Day for the ESP Routes in Southern New Jersey (2005)

You Are Viewing an Archived Copy from the New Jersey State Library

Figure I-17a illustrates the top 10 NJCMS links with the highest crashes per mile and their corresponding rates. Crashes on those links in both directions are summarized for this analysis. The highest number of crashes per MVM occurred on NJ 3 between mileposts 4.85 and 4.93 in Passaic County. The distribution of crash rates shown in Figure I-17a illustrates that a relatively high crash rate occurred at NJ 28 from milepost 2.22 to 2.34 and US 1 from milepost 54.49 to 54.67, where the crash rates were 119.07 and 77.30 per MVM, respectively. Figure I-17b illustrates the top 10 NJCMS links with high crash rates ranging from 60 to 120 crashes per MVM. It was found that most of these NJCMS links are of short distance, have low VMT (e.g. less than one million per year), and primarily contain high concentrations of crashes at specific interchanges or intersections.

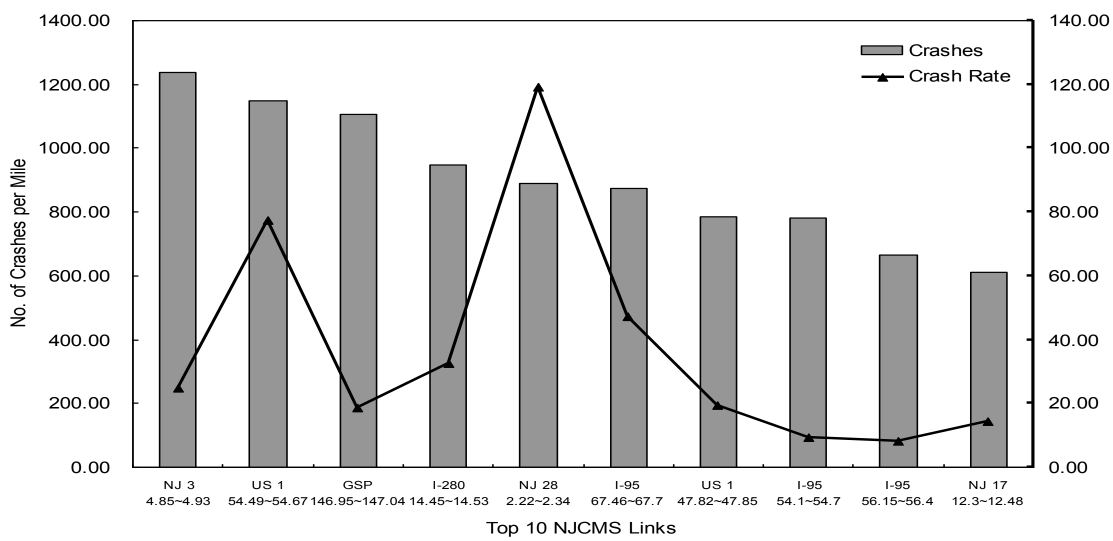


Figure I-17a. The Top 10 NJCMS Links in Number of Crashes per Mile

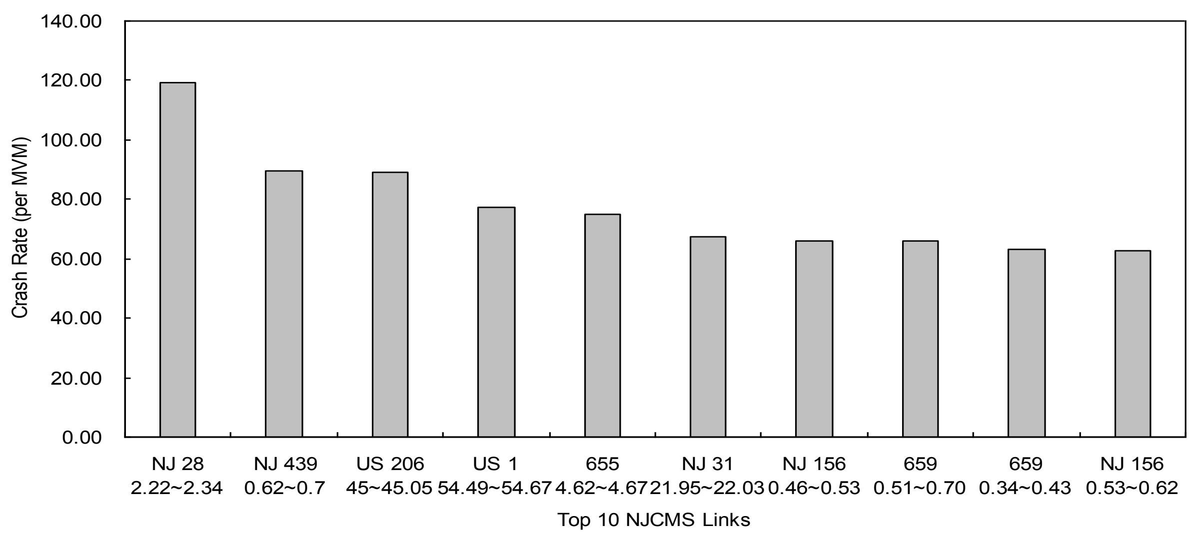


Figure I-17b. The Top 10 NJCMS Links in Crash Rates

You Are Viewing an Archived Copy from the New Jersey State Library

The top 10 NJCMS links on routes with ESP services for the number of disablement incidents per mile are identified in Figure I-18a, in which their corresponding rates of disablement incidents are also included. It was found that the highest number of disablement incidents per mile occurred on I-76 between mileposts 0.37 and 0.55 in Camden County, which is equivalent to an average of 120 disablement incidents per mile based on Year-2005 TOC-ESP data. The rates of disablement incidents for each of the top 10 NJCMS links on routes with ESP services were decreasing along with the number of crashes except for I-676 whose disablement incident rate was very high at nearly 25/MVM in 2005. In addition, Figure I-18b shows the top 10 NJCMS links on routes with ESP services with highest rates of disablement incidents, where NJ 55 from milepost 60 to 60.44 in Gloucester County was ranked the highest.

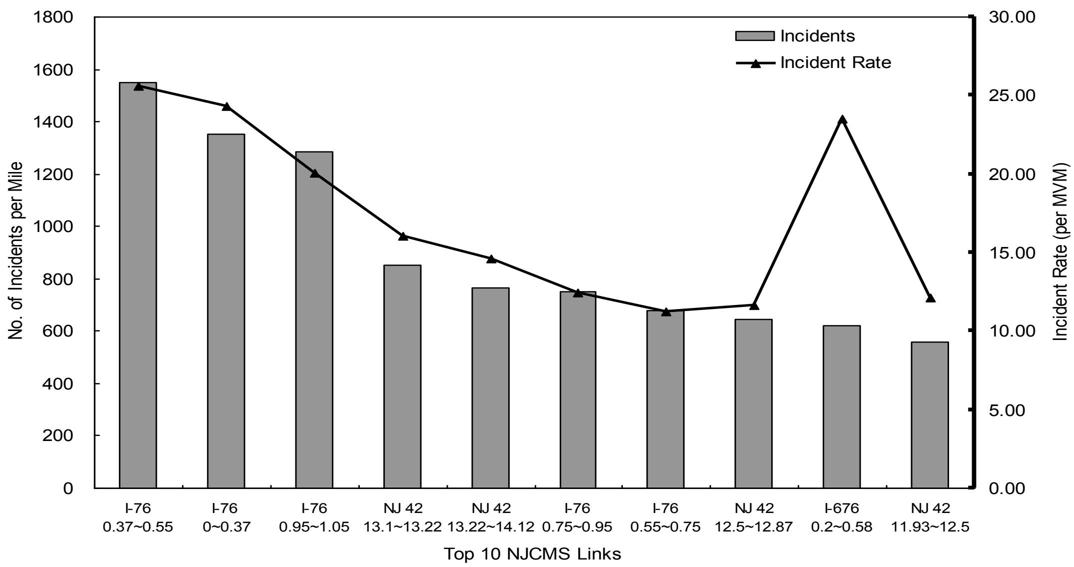


Figure I-18a. The Top 10 NJCMS Links in Number of Disablement Incidents per Mile

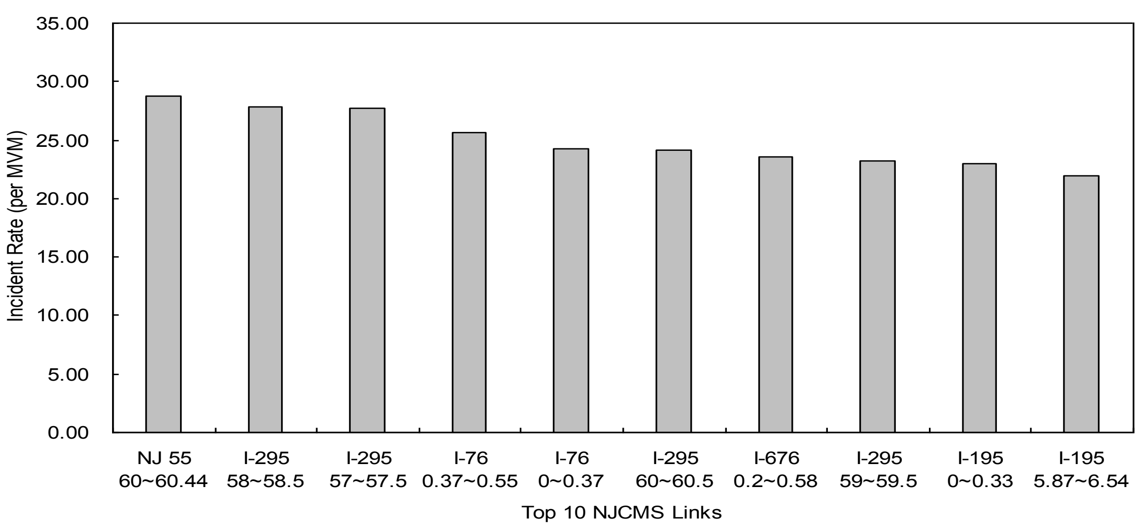


Figure I-18b. The Top 10 NJCMS Links in Rates of Disablement Incidents

You Are Viewing an Archived Copy from the New Jersey State Library

Figure I-19 shows the distribution of lane blockage based on the crashes recorded in Year-2005 TOC-incident data. This data source provided crash lane blockage information that was not addressed in NJDOT Crash Records. There were a total of 5,199 crash records in this database. As shown in Figure I-19, 59 percent of all the crash records were with one-lane blockage, 26 percent with two-lane blockage, and the other three categories (i.e., three and more lane blockage and other) made up the remaining 15 percent.

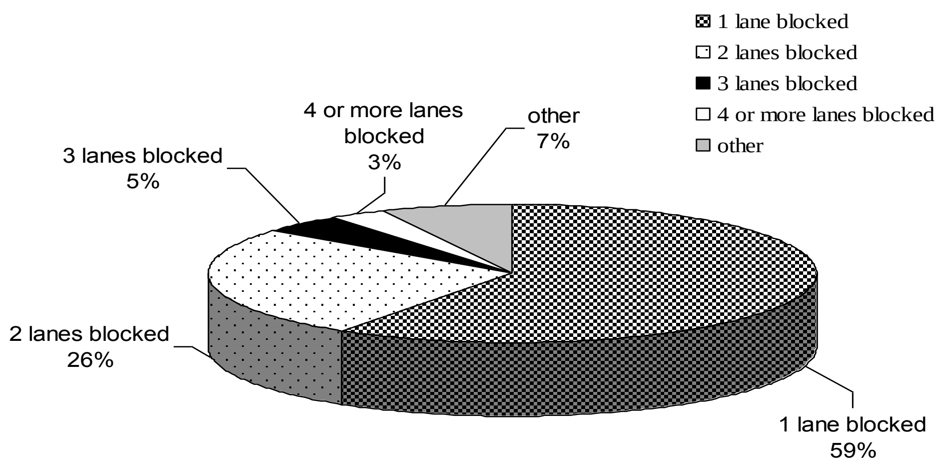


Figure I-19. Incidents with Lane Blockage in the TOC-Incident Data

The results of comparison of lane blockage percentage between 2005 TOC-incident data and the existing NJCMS are shown in Table I-17.

Table I-17. Comparison of Lane Blockage Percentages

Data Source \ Lane Blockage	1 Lane	2 Lanes	3 Lanes	4 or More Lanes	Right Shoulder	Left Shoulder
Existing NJCMS Percentage Blockage	31.8	6.2	1.1	0.3	50.2	10.4
Calculated from 2005 TOC-Incident Data	59.0	26.0	5.0	3.0	-	-

It was found that the lane blockage percentages from the TOC-incident database were generally higher than those with the existing NJCMS. However, the TOC-incident database is not representative of all incidents as it is mainly major incidents that tend to block lanes on the highway. Incidents confined to the shoulders are not generally covered by the TOC. Note that there were 7 % of the crash records in the TOC-incident database are without complete information, which would imply that these incidents did not block a lane, but likely blocked a shoulder.

You Are Viewing an Archived Copy from the New Jersey State Library

PART II – CLEARANCE TIME AND RESPONSE TIME

Literature Review

The literature on the study of incident durations is not as large as the literature on incident frequency. The main reason is that incident occurrence data is more readily available through police records, federal/state agencies, compared to incident duration information for which detailed incident timing information is needed. The additional information needed for incident duration is not limited to the detection / dispatch / clearance timing records because the dynamics of incident duration also depends on the response type (e.g. use of ambulance, heavy wrecker, traffic conditions etc.). The gathering of such data is difficult because it requires input from multiple agencies (e.g. towing companies, medical service centers etc.). The reported occurrence and clearance times of an incident are sufficient to calculate its total duration. To estimate the response and clearance times, additional information such as the arrival and departure times of the response team to the incident location is also required. In most of the studies published in the open literature, the true start time of an incident is not usually known. In these studies, incident durations are *modified* incident durations, i.e., the incident duration minus the detection time. Table II-1 shows a summary of related studies found in the literature in which the incident duration data consist of response and/or clearance times, year and location of the study, number of analyzed records, and models used. Table II-2 shows the significant factors that were found to affect the durations.

As seen in Table II-1, most of the studies focus on freeway durations and total incident time. Although some factors are widely agreed to increase the total incident duration, such as the existence of injury or lane closure, they mostly affect the clearance time and not the response time. In general, most of the mentioned factors affecting total incident duration are open to discussion for their influence, especially on response time. Even for factors which are determined to affect response time, such as time of day, there is no general consensus about its real effect. For instance, emergency response agencies can make an extra effort to respond to an incident during peak hours to avoid longer delays. However congested traffic conditions may not allow a very quick response. In those cases, the location specific factors, such as existence of HOV lanes or shoulders, can be a more important factor that affects the response time [(26)]. Nevertheless, in the current study**,** the factors cited in the literature mostly for total duration are used for the analysis, to provide insights in terms of their effects on response and clearance times individually. Unfortunately, not all the factors determined as important by other studies can be used in this study. Although available databases are rich in terms of number of incidents and time details, they lack some of the very important incident characteristics details, which will be discussed in the following sections.

You Are Viewing an Archived Copy from the New Jersey State Library

Table II-1. Summary of Literature on Incident Durations

Study	Number of Records	Place & Year	Type of Roadway	Available Incident Duration Components			Employed Estimation Model / Approach (If any)
				Response	Clearance	Total	
DeRose (12)	927	MI (06/1962-06/1963)	Freeway	X	X	√	-
Goolsby & Smith (17)	2271	Houston, IL (1968-1969)	Freeway	√	√	√	-
Juge et al. (22)	196	CA (1973-1974)	Freeway	X	X	√	-
Golob et at. (18)	332	Southern CA (1973-1974)	Freeway	X	X	√	-
Giuliano (16)	2604	Los Angeles, CA (09/1983-06/1984 & 09/1984-06/1985)	Freeway	X	X	√	-
Jones et al. (201)	2156[1]	Seattle, WA (04/1987-03/1989)	Freeway	√	√	√	Hazard Function
Wang (39)	121	Chicago, IL	Freeway	X	√	√	Time Sequential Model
Khattak et al. (23)	109[2]	Chicago, IL (1989-1990)	Freeway	√	X	√	Truncated Regression
Sethi et al. (30)	801	IL (04/23-29/1993)	Freeway/Arterial /Local	X	√	√	-
Garib et al. (14)	277[3]	Oakland, CA (02/1993-10/1993)	Freeway	√	√	√	Multiple Regression

You Are Viewing an Archived Copy from the New Jersey State Library

Sullivan (13)	34300[4]	Charlotte, Chicago, Houston, Los Angeles, Orlando, San Francisco (1993)	Freeway	√	√	√	Lognormal Distribution
Wu et al. (41)	696[5]	Northern VA, (3/3/1997-3/22/1997)	Freeway	X	X	√	Decision Trees
Ozbay & Kachroo (28)	650	VA (1994-95)	Freeway/ Non-Freeway	X	√	X	Decision Trees
Nam & Mannering (26)	681	WA (1994-1995)	NA[6]	√	√	√	Hazard Function
Smith & Smith (32)	6828	VA	Freeway	X	√	X	Decision Trees
Skarbadonis et al. (31)	2181	CA (Spring 1993)	Freeway	√	√	√	-
Ozbay & Noyan (29)	650	VA (1994-1995)	Freeway/ Non-Freeway	X	√	X	Bayesian Networks
CHART[7] (4)	241958	MD, DC (1996-2005)	Freeway/ Major Arterial	√	X	√	-
Lee & Fazio (24)	350000-400000[8]	OH (1999)	Freeway	√	√	√	Cox Regression

[1] 2156 records out of total 5637 had duration data and used for the duration analysis.
[2] The data sample is mentioned to be "larger" incidents provided by IDOT.
[3] Number of records used for duration analysis.
[4] Total numbers of records for 6 different study regions.
[5] Total numbers of records including test and validation data.
[6] No specific definition is made; it is referred as "highway".
[7] CHART: Coordinated Highways Action Response Team.
[8] Yearly average of records for the study area.

You Are Viewing an Archived Copy from the New Jersey State Library

Table II-2. Factors Influencing Incident Response and Clearance Times

Factors	Studies in the Literature
Incident/Disablement Type (Injury, fatality, property damage, stall, abandoned etc.)	18, 19, 20, 39, 23, 29, 13, 41, 28, 26, 31, 29, 4
Severity (Overturned vehicle, heavy vehicle involvement)	18, 19, 39, 29, 13, 28
Lane Closure	17, 18, 19, 20, 13, 13, 26, 31, 29, 4
Number/Type of Vehicles Involved	23, 13, 41, 28, 26, 32, 29
Number/Type of Response Vehicles/Agencies	39, 41, 28, 26, 32, 29
Time of Day	19, 20, 23, 13, 26, 4
Incident Location (Route, In-Lane/Shoulder)	23, 13, 26, 29, 4
Traffic conditions	17, 20,
Seasonal/Weekday Variation	20, 23, 26, 32
Weather/Environmental Conditions	39, 23, 13, 28, 26
Alcohol Involvement	20
Pavement Operations	39
Freeway Damage/Debris	39, 28
Response Timing[1]	39, 23, 13
Existence of Insurance	26

[1] Valid for clearance time.

Table II-3 and Table II-4 show the average response and clearance times along with the standard deviations in the parenthesis reported in the literature. Not all the studies use the same incident types (especially disablement types). The current study adopts incident type definitions given in Sullivan (13) and used in the NJCMS. Please note that all the studies do not have the same duration details for all the incident types either. For instance (10) assigns only one clearance time value for all disablements and crashes, Hence, the same duration is assigned to all types. Another example is the study described in (17) that only analyzes "stall" as a disablement or (28) that used different incident types such as vehicle fires, road hazards, etc., which cannot be placed in Table II-4. Overall, Table II-3 and Table II-4, give an idea about the order of magnitude of the duration times reported in the literature.

You Are Viewing an Archived Copy from the New Jersey State Library

Table II-3. Incident Response Times[1] (minutes) Reported in the Literature

Study	Crashes			Disablements					
	Property Damage	**Injury**	**Fatality**	**Abandoned**	**Electrical/ Mechanical**	**Stall**	**Tire**	**Debris**	**Other**
Goolsby & Smith (17)	12			-	-	9.4	-	-	-
Jones et al. (21)	9								
Wang (39)	7.55								
Khattak et al. (23)	7.5/14[2]								
Garib et al. (14)	NA[3]								
Sullivan (13)	20/12/12/10/20[4]			20/12/12/10/20[4] 25/15/15/10/25[5]					
Ozbay & Kachroo (28)									
Nam & Mannering (26)	26.2								
Skabardonis et al. (31)	20.8/11.5[6]			33.0/14.3[6]					
CHART (4)	11.47								
Lee & Fazio (24)	13 (11)[7]			-					

[1] Table presents the mean values and standard deviations are stated in parentheses if available.
[2] Response time of first/second emergency vehicle.
[3] Only the modeling/prediction details are presented. No explicit descriptive data statistics are given.
[4] All crashes and incidents "In-Lane" response times under: No Incident Management/Traffic Management Center/Incident Response Team/Freeway Service Patrol.
[5] Incidents at shoulder.
[6] Study investigates the implementation of FSP on incident duration and response. The numbers represents response times Before FSP/ After FSP.
[7] Study focuses on AM/PM peak times and the values presented are the average durations.

You Are Viewing an Archived Copy from the New Jersey State Library

Table II-4. Incident Clearance Times[1] Reported in the Literature (minutes)

Study	Crashes			Disablements					
	Property Damage	**Injury**	**Fatality**	**Abandoned**	**Electrical/ Mechanical**	**Stall**	**Tire**	**Debris**	**Other**
DeRose (12)	6.14			4.94					
Goolsby & Smith (17)	7			-	-	8.9	-	-	-
Wang (39)	71.60 (41.84)								
Sethi et al. (30)	49.07[2]	47.63[2]	-	24.32[2]					
Garib et al. (14)	NA[3]								
Sullivan (13)	19.72/27.09[4] (33.35/40.17)[5]			6.29/9.64[4] (39.46/33.98)[5]	16.36/18.65[4] (30.59/30.54)[5]	13.19/14.69[4] (36.14/26.56)[5]	13.19/14.69[4] (36.14/26.56)[5]	6.29/9.64[4] (39.46/33.98)[5]	13.19/14.69[4] (36.14/26.56)[5]
Ozbay & Kachroo (28)	33.6/42.61[6]	41.9/50.81[6]	65.6	7.5[7]				-	15.2/65.17[8]
Nam & Mannering (26)	136.8								
Smith & Smith (32)	NA[3]								
Skarbadonis et al. (31)	20			7/20[9]					
Lee & Fazio (23)	78 (56)[10]								

[1] Table presents the mean values and standard deviations are stated in parentheses if available.
[2] Original values are presented according to number of police cars dispatched. Weighted averages has been used for the above table.
[3] Only the modeling/prediction details are presented. No explicit descriptive data statistics are given.
[4] Values for incidents at Shoulder/In-Lane with no emergency response.
[5] Standard deviations of the total incident duration, e.g. response + clearance.
[6] Values for two different databases.
[7] All disablement incidents.
[8] Weighted average of incident types that do not exist in the table.
[9] Shoulder/Lane Blocking incident clearance times.
[10] Study focuses on AM/PM peak times and the values presented are the average durations.

You Are Viewing an Archived Copy from the New Jersey State Library

Data Analysis for the NJCMS Durations Table Updates

In this section, first the NJCMS response and clearance tables are presented to determine the required fields needed for the update of the duration times. Then the available incident databases are analyzed to determine their extent of use for the current study.

Required Database Fields for the NJCMS Incident Duration Tables

The NJCMS incident duration tables basically consist of two major types of roadways: freeway and arterials; and two components of incident duration: response and clearance times. Thus there are a total of 4 tables that need to be updated. Table fields differ between response and clearance time tables. However, table fields are the same for freeway and arterial tables.

Table II-5. A Sample NJCMS Response & Clearance Time Table

```
* Response & Clearing Times (Tables XXIX, XXX):
*-----------------------------------
*  Det/Mgt Type:         0          1          2          3          4
*                   NoIncMgt     MgtCtr    IncRspTeam    FSP/MAP      Other
* Response Time
RESPONSEtime CRASH      20         12         12         10         20
RESPONSEtime OTHER      25         15         15         10         25
RESPONSEtime STDEV    1.00       1.00       0.85       1.00       1.00
* Duration Mean & STD
*                      Crash Crash Crash Mech
*                      Fatal PInry PDmge Elec Stalled  Tire Aband Debris  Other
CLEARTIME INLANEMEan   27.09 27.09 27.09 18.65  14.69 14.69  9.64   9.64  14.69
CLEARTIME INLANESTdev  23.11 23.11 23.11 14.74  11.25 11.25 11.05  11.05  11.25
CLEARTIME SHLDRMEAn    19.92 19.72 19.72 16.36  13.19 13.19 11.29  11.29  13.19
CLEARTIME SHLDRSTDev   16.56 16.56 16.56 12.10  12.48 12.48 14.24  14.24  12.48
```

Regarding Table II-5, the following incident information is needed to update the NJCMS duration tables (*Table XXIX* and *Table XXX*):

1. **Response Time *(Table XXIX)*:** The amount of time (in minutes) between the onset of an incident and when the clearing service (e.g. police, tow truck) arrives on the scene.
2. **Clearance Time *(Table XXX)*:** The amount of time (in minutes) between the arrival~~s~~ of the clearing service (e.g. police, tow truck) and when the incident is completely cleared from the roadway and the full roadway capacity is restored.
3. **Existence of Incident Management (*Table XXIX*)**
    i. No Incident Management
    ii. Management Center
    iii. Incident Response Team
    iv. Freeway Service Patrol (FSP) / Motorist Assistance Patrol (MAP)
    v. Other
4. **Crash Types (*Table XXX*)**
    a. Fatal

You Are Viewing an Archived Copy from the New Jersey State Library

   b. Personal Injury
   c. Property Damage Only
5. **Disablement Types (*Table XXX*)**
   a. Electrical/Mechanical
   b. Stall
   c. Tire
   d. Abandoned
   e. Debris
   f. Other
6. **Incident Location(*Table XXX*)**
   a. In-Lane
   b. At Shoulder

Regarding the required fields mentioned above, the available databases are investigated to see if they have the required fields to be further used in the duration analysis.

Available Databases and Data Detail Requirements and Limitations for NJCMS Links Incident Duration Analysis

The summary and some general statistics of available databases can be seen in Table II-6. The incident types included in the (Central Dispatch Unit) (CDU) and statistically biased duration information of the IMRT make it impossible to use these two databases for further analysis as they cover specific types of incidents only. As mentioned in the remarks in Table II-6, the CDU covers incidents such as traffic light failures, down trees, etc., which are outside the scope of this study. In contrast, the IMRT database includes incidents that have durations higher than 2 hours, which introduces bias to the data. Hence, the ESP, the NJTPK and GSP Incident Logs [20], and the TOC-Incident databases are selected for further use. However, there are still certain limitations of each selected databases that does not allow for a full utilization of their records.

Link Coverage Limitations

The NJCMS database divides the New Jersey roadway network into links. The duration and incident rates are analyzed based on those links, which are determined by SRI numbers (8 digit numbers assigned for each roadway) and milepost intervals. Each link is categorized as either an arterial or a freeway and the duration analysis is done separately for those two types of links. Therefore, the incident databases must include the SRI and the milepost fields in order to map the records onto the NJCMS links. The two required fields are:

1. SRI Number
2. Milepost

You Are Viewing an Archived Copy from the New Jersey State Library

The SRI number is not absolutely necessary if the incident record includes the highway number for the location of the event, which appears to be the case for most of the available databases as the data being used is for State highways, not local roads. If the milepost information is missing, a detailed incident location description can be converted into milepost intervals, which is not likely to be done in most cases and will include human errors. Table II-7 shows the percentage of records with existing SRI (route) and milepost fields for the available databases.

Table II-6. Descriptive Statistics of the Available Databases

Database	Duration of Coverage	# of Records	Important Remarks
ESP *(Emergency Service Patrol)*	2005	66733	Mostly covers disablements; Incident records are kept only between 6 AM and 8 PM
IMRT *(Incident Management Response Team)*	(North& South) 05/97-09/02	864	Biased data (Incidents of more than 2 hours of duration)
	North 2003	156	
	South 2003	531	
	South 2004	283	
	South 2005	253	
	South 2006	199*	
GSP *(Garden State Parkway)* **Incident Log**[20]	3/2006-10/2006	28501	Includes only response time; lacks crash type and complete duration information
NJTPK *(New Jersey Turnpike)* **Incident Log**[20]	2005	77869	Lacks crash type details
CDU *(Central Dispatch Unit)*	2005	20374	Non-crash incidents (broken traffic lights etc.)
	01/2006-09/2006	13053	
TOC *(Traffic Operations Center)* **Incident South**	06/1998-12/1998	429	Only distinguishes Fatal/Non-Fatal, does not determine injury and property damage for crashes; The incident types are mainly irrelevant to the NJCMS tables, e.g. roadwork, down tree, down wire etc.
	1999	925	
	2000	1126	
	2001	1289	
	2002	1165	
	2003	1384	
	2004	1434	
	2005	1576	
	01/2006-05/2006	829	
TOC *(Traffic Operations Center)* **Incident North**	10/2002-12/2002	51	
	2003	1109	
	2004	2358	
	2005	3999	
	01/2006-05/2006	1779	

- Between 01/2006-08/2006

You Are Viewing an Archived Copy from the New Jersey State Library

As seen in Table II-7, the databases can be mapped onto the NJCMS network at very high rates (>90%). However, this mapping is limited by the coverage of the databases rather than the coverage of the NJCMS link system. For instance, the NJTPK database has many records however since the data only applies to the New Jersey Turnpike, its NJCMS link coverage is very low. Nevertheless, Table II-7 shows that almost all the incident records in the databases can be used for the analysis, within the limitations of incident information details further needed for updating the NJCMS duration tables. An example of a major lack of information is the freeway/arterial coverage of the databases. Table II-8 shows the coverage details of the databases. It can be said that there is an important lack of incident records for arterial links. Only the TOC-Incident North/South databases cover some arterial links. However, the duration details of these records do not allow the research team to use the TOC-Incident databases for the incident duration analysis. Thus, it can be said that the duration analysis can only be performed for freeway links and no update can be done for the NJCMS arterial tables.

Table II-7. Theoretical Mapping of Available Databases onto the NJCMS Links

Database	Year	Valid SRI Fields	Valid Milepost Fields	Total Possible Percentage Mapping onto the NJCMS Links
ESP	2005	66733/66733 100% [1]	100%	100%
GSP Incident Log[20]	3/2006-10/2006	100%	25961/28501 91%	91%
NJTPK Incident Log[20]	2005	100% [2]	77530/77869 99.5%	99.5%
TOC-Incident South	06/1998-05/2006	10109/10164 99.5% [1]	10140/10164 99.7%	99.5%
TOC-Incident North	10/2002-05/2006	9295/9297 ~100% [1]	9027/9297 97.1%	97.1%

[1] No SRI Numbers but Routes are given.
[2] Same facility but different SRI. Can be extracted from milepost info.

Table II-8. Freeway/Arterial Coverage for the Available Databases

Database	# of Records	Freeway Coverage	Arterial Coverage
ESP	66733	√	X
GSP[20]	25801	√	X
NJTPK[20]	77869	√	X
TOC-Incident North	9297	√	√
TOC-Incident South	10164	√	√

You Are Viewing an Archived Copy from the New Jersey State Library

Limitations of Incident Records

The time component details for each database are given in Table II-9. According to the stated fields in Table II-9, the required information needed for the NJCMS tables and the information available in the databases are given in Table II-10. It must be noted that the TOC-Incident database does not have detailed time components and has a field regarding total incident time which explicitly mentions the duration of the incident. In other words, no response or clearance time calculations can be done with the TOC-Incident database. Thus, the TOC-Incident database is also eliminated from the database list that can be used to update the NJCMS response and clearance time tables. The ESP database includes "Waiting Time Motorists" field from which the response time can be extracted. For the NJTPK and GSP incident logs, the response and clearance times are calculated through adding/subtracting relevant data fields.

Table II-9. Incident Duration Details in the Available Databases

	Detailed Incident Duration Information Fields			
Database	**Dispatcher, or E.M. Center Call Time**	**E.M. Response Units Notified Time**	**E.M. Response Units Enroute Time**	**Incident Completion Time**
ESP	X	X	√	√
GSP	√	√	√	X
NJTPK	√	√	√	√
TOC-Incident	√	X	X	√

Table II-10. Existence of Incident Response Time Details in Available Databases

Database	Response Time	Clearance Time
ESP	√	√
GSP(20)	√	X
NJTPK(20)	√	√
TOC-Incident	X	X

NJCMS Table XXIX Field Requirement Limitations

NJCMS Table XXIX (see Table II-5) shows the response times according to the incident management measures taken. As shown in Table II-11, each database obtained in this study can only be used for a single incident management type. NJTPK and GSP manage their incidents based on the calls received by the facility dispatcher system and the decisions made by the staff. Thus they can be regarded as the "Management Center" type for the NJCMS tables. ESP is categorized under "FSP/MAP".

You Are Viewing an Archived Copy from the New Jersey State Library

Table II-11. Existence of Required Incident Management Types in Available Databases

Database	No Incident Management	Management Center	Incident Response Team	FSP/MAP	Other
ESP	X	X	X	√	X
GSP[20]	X	√	X	X	X
NJTPK [20]	X	√	X	X	X

Although table fields are clear, there are major challenges in extracting required information from the available databases. First, only two types of incident management measures are identified on the NJCMS links:

1. No Incident Management
2. FSP/MAP

In that sense, *NJCMS Table XXIX* can be updated for only "No Incident Management" and "FSP/MAP" columns. A careful investigation of Table II-11 shows that all the databases have a certain type of incident management. However there is no database to be used to extract the "No Incident Management" response times. Therefore, one of the two required NJCMS fields is missing. Moreover, only one database fits into FSP/MAP category namely, the ESP database.

NJCMS Table XXX Field Requirement Limitations

NJCMS Table XXX (see Table II-5) shows the clearance time of incidents according to the incident location and incident type. Incidents can be divided into two major categories as "Crashes" or "Accidents" and "Disablements". As shown in Table II-12, the details of the crash information are mostly missing. None of the databases distinguishes between the accident/crash types. Almost all the databases have fields where additional comments and notes can be taken, but these fields are generally not filled in. Injury information for some records can be gathered from these comments/notes fields as well. However, since it is not mandatory for the officer to keep the injury/property damage information, there are only few records with such crash type details. Thus, they cannot be used for the analysis.

Table II-12. Crash Record Details in Available Databases

Database	Crash Type Details		
	Property Damage	Injury	Fatality
ESP	X	X	X
GSP [20]	X	X	X
NJTPK [20]	X	X	X

You Are Viewing an Archived Copy from the New Jersey State Library

Contrary to lack of detailed crash information, there are more than the required information for disablement type incidents. Table II-13 shows only the level of match between disablement incident types in the databases and NJCMS *Table XXX*. For instance, no database has “Stall” as a type of incident. However the “Other” field includes many different types that can be regarded as “Stall” when aggregated.

Table II-13. Disablement Incident Details Matching with the NJCMS Table Fields

Database	Disablement Type Details					
	Mechanical/ Electircal	Stall	Flat Tire	Abandoned	Debris	Other
ESP	√	X	√	X	X	√
GSP [20]	√	X	√	√	X	√
NJTPK [20]	√	X	√	√	X	√

Although, the timing details of the databases are sufficient, Table II-14 shows that the location In-Lane / shoulder) details which are required for *NJCMS Table XXX*, shown in Table II-5, exist only in the ESP database. As for the crash type, some location information can be gathered from the “Comments/Notes” fields in the available databases. However these records are few in numbers and if used, they might introduce bias to the location information. This lack of this location information restricts the durations for *NJCMS Table XXX* to be limited to being done based on the ESP data only.

Table II-14. Existence of Incident Location Details in Available Databases

Database	In-Lane	Shoulder
ESP	√	√
IMRT	X	X
GSP [20]	X	X
NJTPK [20]	X	X
TOC-Incident	X	X

Aggregation of incident types was done to match the ESP incident types to the NJCMS incident types. Table II-15 shows such aggregation for the ESP database. Yellow shaded types are the ones that are assumed to be under a category other than their actual types. Other databases are more detailed in terms of their disablement types. Similar associations of disablement types found in these databases can be made to aggregate the data according to the NJCMS based incident types.

You Are Viewing an Archived Copy from the New Jersey State Library

Table II-15. TOC Database Incident/Disablement Field Aggregation for NJCMS Table XXX

	Reason for stop	TOC-North 2005		TOC-South 2005		CMS Incident Type
1	Disabled	20829	67.48%	25043	61.78%	See below
2	Abandoned	1825	5.91%	4710	11.62%	Abandoned
3	Debris	1637	5.30%	2884	7.12%	Debris
4	Fire	120	0.39%	127	0.31%	Other
5	Pedestrian	31	0.10%	35	0.09%	Other
6	Accident	2932	9.50%	2569	6.34%	Crash
7	No Assist	1515	4.91%	-	-	Other
8	Other	1234	4.00%	1203	2.97%	Other
9	Lost	720	2.33%	1507	3.72%	Other
10	Stuck Mud	-	-	71	0.18%	Stall
11	Stuck Snow	-	-	192	0.47%	Stall
12	Blank	23	0.07%	2192	5.41%	Other
	Total	30866		40533		
	Disablement	**TOC-North 2005**		**TOC-South 2005**		
1—1	Out of Fuel	2758	13.24%	3175	12.68%	Stall
1—2	Flat Tire	8545	41.03%	9784	39.07%	Flat Tire
1—3	Electrical	875	4.20%	1240	4.95%	Mechanical / Electrical
1—4	Mechanical	5087	24.43%	6999	27.95%	Mechanical / Electrical
1—5	Fuel System	254	1.22%	918	3.67%	Mechanical / Electrical
1—6	Cooling System	1633	7.84%	2161	8.63%	Mechanical / Electrical
1—7	Lock-Out	29	0.14%	52	0.21%	Other
1—8	Other	736	3.53%	-	-	Other
1—9	Unknown	544	2.61%	128	0.51%	Other
1—10	OK cell phone/Wave	322	1.55%	247	0.99%	Other
1—11	Blank	42	0.20%	339	1.35%	Other
	Total	20825		25043		

Results and Discussion

In this section, the available databases were analyzed to determine if the field details in the databases are sufficient to update the existing NJCMS duration database. Some facts and assumptions used in the analysis are as follows:

- Not all the databases include the necessary incident time details or required incident types. Thus, the CDU, the IMRT and the TOC-Incident databases are eliminated

You Are Viewing an Archived Copy from the New Jersey State Library

before continuing with more detailed analysis. Below are some details regarding the databases and the shortcomings leading to these databases not being used for the final analysis:

- CDU: The database records are completely irrelevant to the NJCMS study, e.g. all the incidents included are roadside or maintenance related such traffic light failures, pothole repairs etc.

- TOC-Incident Database:

  - Duration Field Details: The TOC-Incident database includes only the total duration of an incident; hence the required details such as the response and clearance times required in the NJCMS tables cannot be obtained. This is the main reason for not being able to use this database for duration calculations.
  - Incident Type Coverage: Around 68% of the TOC-Incident records have incident types such as crash investigation, down tree, down wire, water main break etc., which are irrelevant in terms of the NJCMS incident type definitions.
  - Duration Statistics: Crash average total incident duration for the TOC database is 93 minutes, which is more than the double the average duration of the ESP database of around 44 minutes, and almost the triple of the current values employed by NJCMS. Please note that in contrast the NJTPK database exhibits acceptable duration values compared to the ESP database.

  Thus, both in terms of the incident details and the order of magnitude of the durations, the TOC-Incident database shows distinctly different features and characteristics compared to the NJCMS tables.

- IMRT Database:

  - Has only 253 records for 2005
  - Only has the total incident duration; no detail is given about the response and clearance times separately
  - No disablement type matches with the NJCMS incident definitions
  - Crash details include only “fatality” information; no information such as property damage or injury is given.
  - No information regarding in-lane versus / shoulder crashes is given
  - The database is biased; incidents with long duration are in the database.

You Are Viewing an Archived Copy from the New Jersey State Library

- The NJCMS tables are based on link types (arterial or freeway) rather than individual links. However, there is no database with the necessary details to be used for arterial links. Thus, the analysis can only be performed for freeway links.

- Regarding *NJCMS Table XXIX*; there are only two incident management schemes defined for the NJCMS links:

  1) No Incident Management
     - Unlike the crash rate analysis in which police reports can be used, all the databases that including duration come**s** from a traffic management system. Thus no duration inference can be made done with the available databases for the "No Incident Management" case.

  2) FSP/MAP
     - Only the ESP database qualifies to be used under this incident management type.

- Regarding *NJCMS Table XXX*:

  - None of the available databases clearly distinguishes between the crash types. Only the IMRT and the TOC-Incident distinguishes Fatality crashes but not Property Damage and Injury.

  - None of the disablement incident details match with the NJCMS definitions. However, the available databases have a wider range of disablement definitions and those detailed types can be aggregated under the NJCMS defined types.

  - The only database that has In-Lane/Shoulder detail for incident location is the ESP database.

- Table II-16 and Table II-17 show the NJCMS *Tables XXIX-XXX* which will be updated and the selected databases to be used for the update. As seen in both tables, many fields cannot be updated with the existing record details, and only the ESP database qualified to be used for in this update.

Overall, the ESP database turns out to be the only usable database for the NJCMS links duration update. However, the ESP database covers only the freeway links. Nevertheless, ESP stands as the only database that can be used directly for partially updating NJCMS Tables XXIX and XXX.

You Are Viewing an Archived Copy from the New Jersey State Library

Table II-16. Details in Available Databases for NJCMS Table XXIX Fields

		Incident Detection/Management Type				
		No Incident Management	**Management Center**	**Incident Response Team**	**FSP/MAP**	**Other**
Response Time	Crash	X	X[1]	X[1]	√ (ESP)	X[2]
	Other	X	X[1]	X[1]	√ (ESP)	X[2]
	St Dev	X	X[1]	X[1]	√ (ESP)	X[2]

Table II-17. Details in Available Databases for NJCMS Table XXX Fields

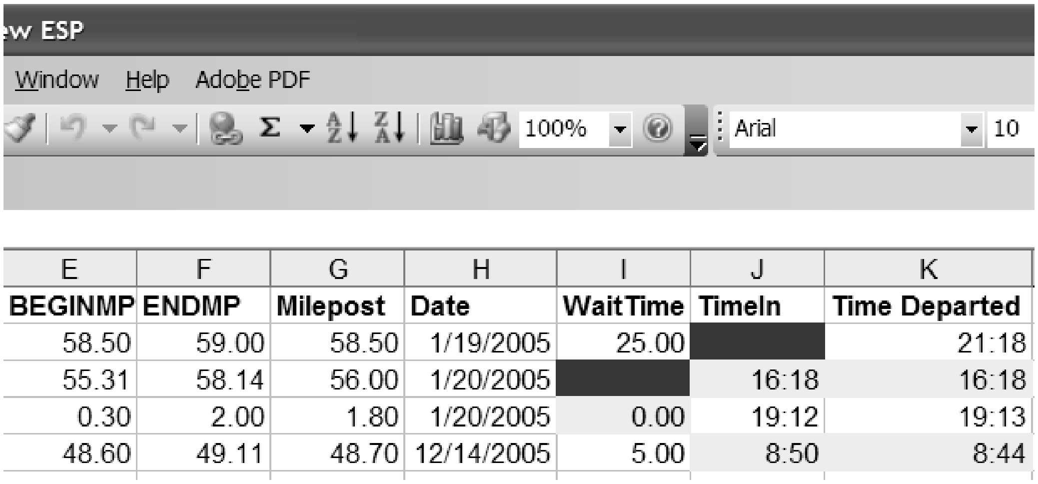
		Incident Type								
		Fatal	**Injury**	**Property Damage**	**Elecl/ Mechl**	**Stall**	**Flat Tire**	**Aband**	**Debris**	**Other**
Clearance Time	**In-Lane Mean**	X	X	X	√ (ESP)	√ (ESP)	√ (ESP)	√ (ESP)	√ (ESP)	√ (ESP)
	In-Lane St Dev	X	X	X	√ (ESP)	√ (ESP)	√ (ESP)	√ (ESP)	√ (ESP)	√ (ESP)
	Shoulder Mean	X	X	X	√ (ESP)	√ (ESP)	√ (ESP)	√ (ESP)	√ (ESP)	√ (ESP)
	Shoulder St Dev	X	X	X	√ (ESP)	√ (ESP)	√ (ESP)	√ (ESP)	√ (ESP)	√ (ESP)

Completeness of the Records in the Databases

Besides the limitations of the details in the data mentioned above, another problem in the databases is the reduction in the number of records due to incomplete data, such as missing entries and erroneous fields. Erroneous entries include having the same time entry for the response vehicle arrival and departure times which results in zero duration, or having non-chronological time records such as the incident cleared time being earlier than the call time etc. Such records are illustrated in Figure II-1 using actual records found in the ESP database. Some records include zero waiting time, and some others include missing or non-chronological time field entries. All these records are cleared before performing any calculations.

A summary of the eliminated records can be found in Table II-18. Please note that, if a record is incomplete in terms of response time calculation but complete regarding clearance time calculations, that specific record is eliminated only for response time calculations, but kept for clearance time calculations. The same approach is also followed for records with incomplete clearance times but valid response times. Then, only the response time for the specific record is used. This kind of approach helps to keep the maximum sample size for both duration type calculations.

You Are Viewing an Archived Copy from the New Jersey State Library



E	F	G	H	I	J	K
BEGINMP	ENDMP	Milepost	Date	WaitTime	TimeIn	Time Departed
58.50	59.00	58.50	1/19/2005	25.00		21:18
55.31	58.14	56.00	1/20/2005		16:18	16:18
0.30	2.00	1.80	1/20/2005	0.00	19:12	19:13
48.60	49.11	48.70	12/14/2005	5.00	8:50	8:44

Figure II-1. An Illustration of Incomplete Data Fields (Taken from ESP)

Table II-18. The Summary of Eliminated Records during the Duration Calculations

Reason of Elimination	ESP		NJTPK		GSP
	Response	**Clearance**	**Response**	**Clearance**	**Response**
Missing Duration Fields	5112	561	16813	23134	209
Zero Durations	27278	1624	2494	10806	6228
Non-chronological Entries	-	258	35	973	1281
Total Eliminated	32390	2443	19307	34913	7718
Eliminated percentage	48.5%	3.7%	24.8%	44.84%	27.1%
Total number of Records	66733		77869		28501

For the ESP database, which is the only database that covers more than one route, the distribution of eliminated records are analyzed and presented in Table II-19. As seen in Table II-19, in general response time durations generally have more incomplete records than the clearance time durations. Except for Route I-76, the eliminated clearance records exhibit similar percentages for all the study routes. In contrast, the percentage of eliminated records as a result of problems related to the response duration field varies amongst the various routes. The percentage of eliminated records fluctuates between 28.1% and 67.7%. The highest number of eliminated records was observed for Route I-76 for both the response and clearance times.

You Are Viewing an Archived Copy from the New Jersey State Library

Table II-19. Percentages of Eliminated Records for Each Route in the ESP Database

	ESP Routes													
	24	29	42	55	76	78	80	95	195	280	287	295	440	676
Response	28.1%	54.5%	64.3%	64.7%	67.7%	36.8%	30.4%	55.5%	50.1%	37.2%	38.1%	58.2%	47.2%	66.1%
Clearance	1.6%	2.2%	1.6%	2.3%	23.4%	1.7%	2.1%	2.1%	2.0%	1.7%	1.2%	1.9%	1.3%	2.3%

Preliminary Calculations for the NJCMS Tables

As mentioned in the previous section, if the data field restrictions are imposed without any assumptions (see Table II-16 and Table II-17) then only the ESP database could be used. The NJCMS duration table values would be updated based on the ESP database and given in Table II-20 and Table II-22. The ESP response and clearance time distributions for in-lane crash/disablement incidents are given in Figure II-2 - Figure II-5. There are a few data points that are considerably greater than the rest of the durations in the database. These higher durations are generally observed during the evening hours. However, these data points do not have a major effect on the mean and standard deviation mainly because they are very few of these observations in the overall database.

Please note that separate NJCMS duration tables are defined for arterial and freeway links, however in the current version of the NJCMS, duration tables are identical for arterials and freeways. Since the calculations can only be made for freeway links, only freeway duration tables are given for the both response times (NJCMS Table XXIX) and the clearance times (NJCMS Table XXX). The values in parentheses represent the original duration values in the NJCMS tables and the bold numbers show the values calculated using data.

While calculating the response times for non-crash incidents, all the records except the crashes (which equally mean disablements) in the ESP database are taken into account. However for the standard deviation calculations (St Dev field), the response times for both crashes and disablement incidents are considered. As seen in Table II-20, the response times calculated from the ESP database show variation between the “crash” and “other” (=disablements) incident types. As expected, the crash response times are shorter than those for the disablement incidents. Although the standard deviation is given by aggregating all the incident responses, individual calculations show that the standard deviations for the crashes and “other” incidents are 8.59 and 5.74 minutes, respectively, for the freeway links. Since overall the disablement incidents records dominate the database, the aggregate standard deviation comes out to be close to the disablement standard deviation which is 9.29. It can be said that although the old response time estimations are relatively close to the calculated values, the standard deviation used in the NJCMS tables differ in the order of magnitude compared to the

You Are Viewing an Archived Copy from the New Jersey State Library

calculated value. The standards deviations used in the CMS are quite small, with most being one minute.

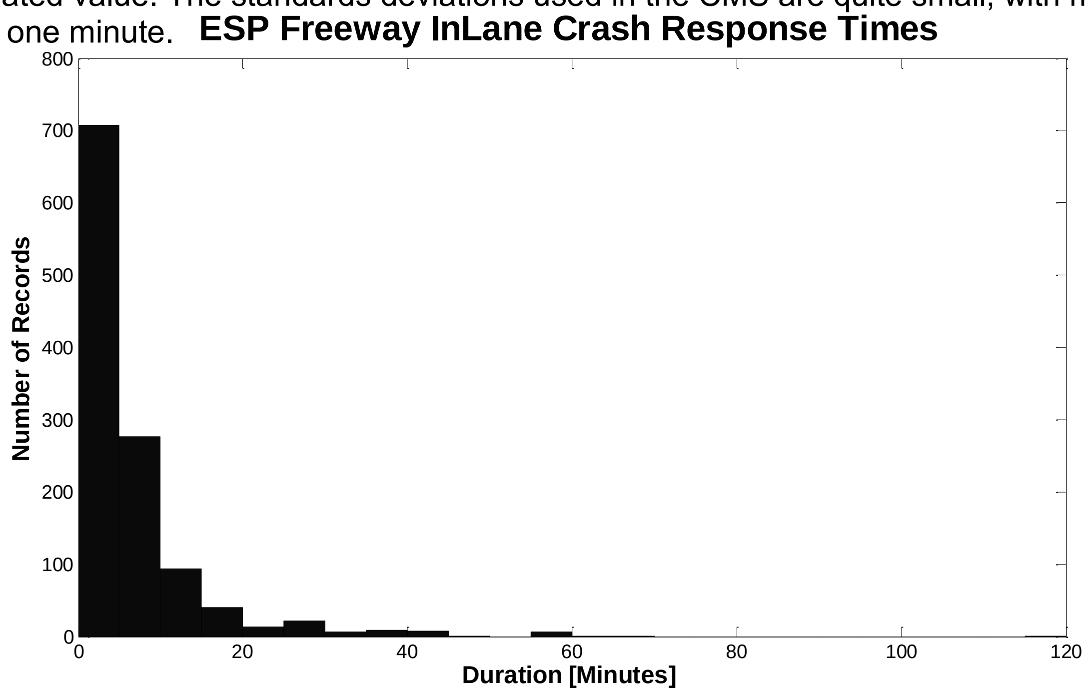


Figure II-2. ESP Database Crash Response Durations for In-Lane Incidents

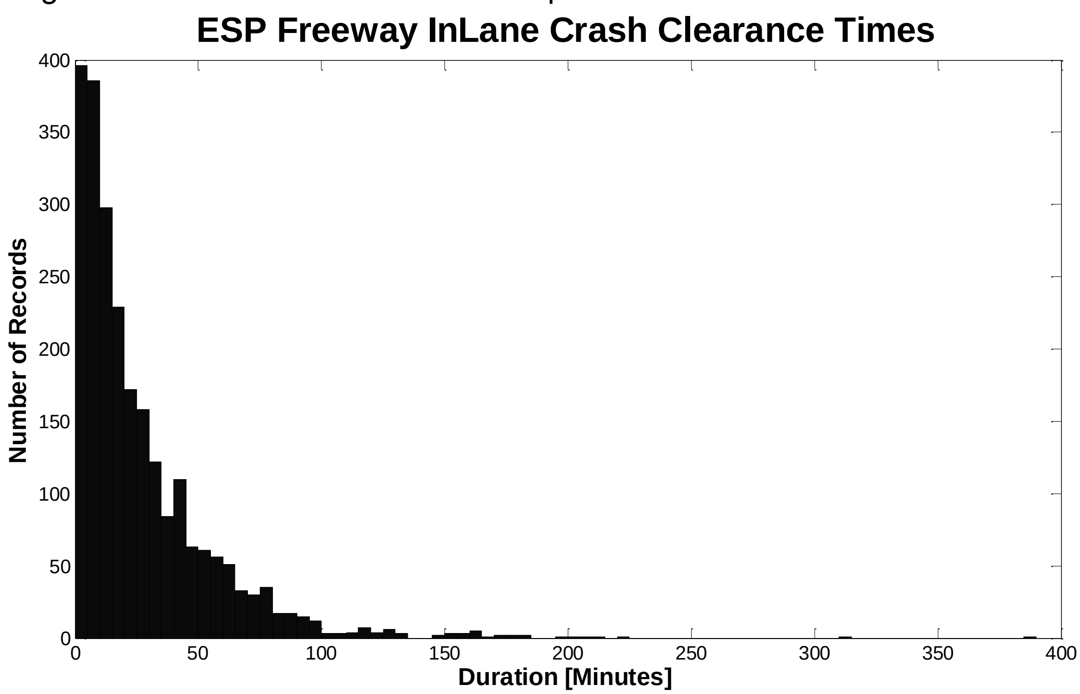


Figure II-3. ESP Database Crash Clearance Durations for In-Lane Incidents

You Are Viewing an Archived Copy from the New Jersey State Library

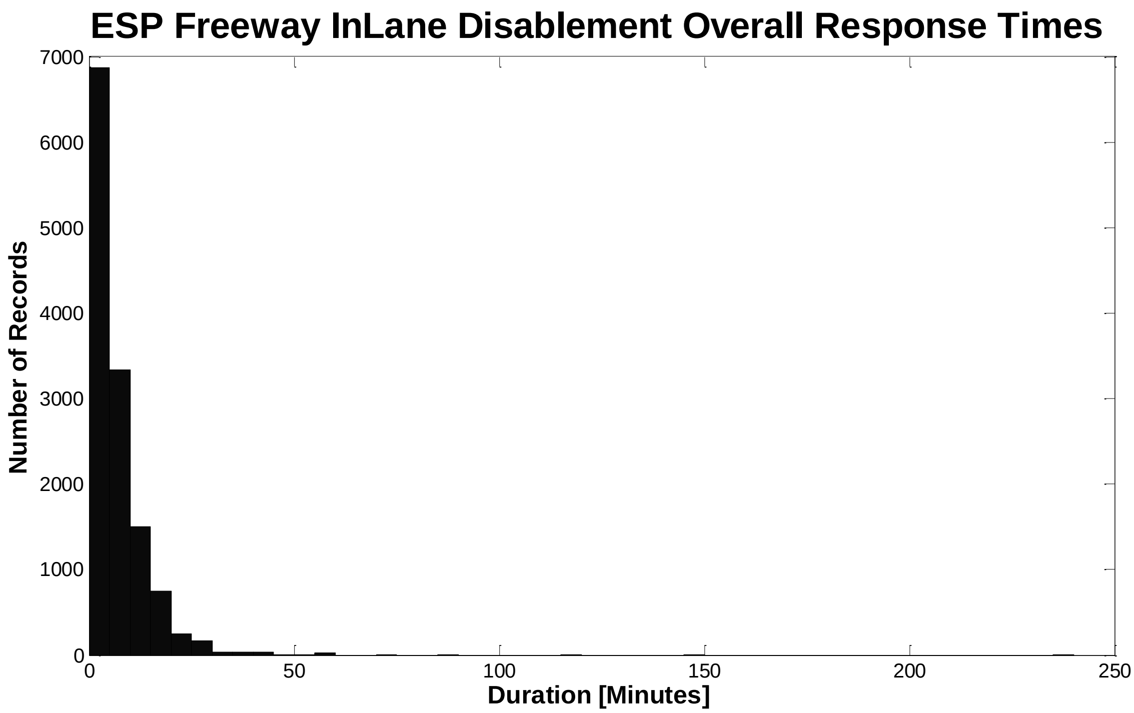


Figure II-4. ESP Database Disablement Incident Response Durations for In-Lane Incidents

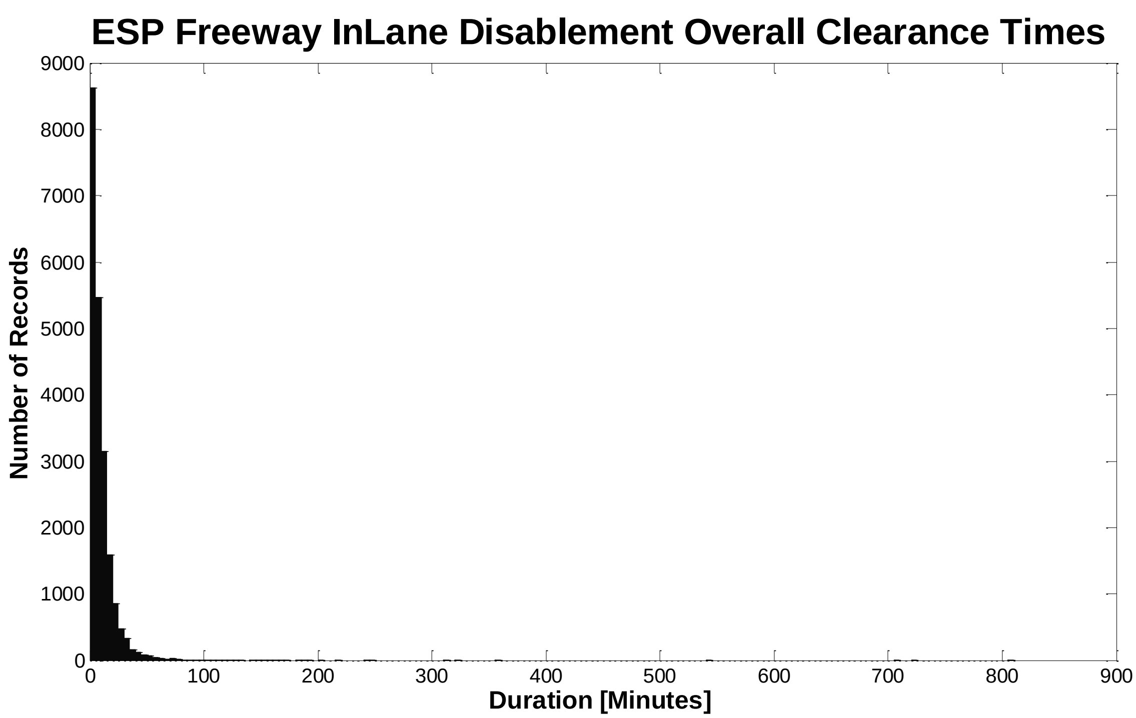


Figure II-5. ESP Database Disablement Incident Clearance Durations for In-Lane Incidents

You Are Viewing an Archived Copy from the New Jersey State Library

Table II-20. Calculated Response Time Values for NJCMS Freeway Links Table XXIX Using Only the ESP Database

		Incident Detection/Management Type				
		No Incident Management	**Management Center**	**Incident Response Team**	**FSP/MAP**	**Other**
Response Time	Crash	20	12	12	**8.35** (10)	20
	Other	25	15	15	**9.52** (10)	25
	St Dev	1	1	0.85	**10.52** (1)	1

Table II-22 shows the clearance times calculated using the location of the vehicle as "in-lane" or "shoulder". Since the ESP database includes 7 different attributes for location, assumptions given in Table II-21 were made to aggregate the ESP vehicle location field codes. It must be noted that some records had irrelevant entries in the location field and those records were assumed to be "Unable to Locate"

Table II-21. ESP Vehicle Location Field Code Assumptions

In-Lane	**Shoulder**
1: In Freeway Lanes 5: On Ramp 6: Unable to Locate	2: Left Shoulder 3: Right Shoulder 4: Median 7: Other

Table II-22. Calculated Clearance Times for NJCMS Freeway Links Table XXIX Using Only the ESP Database

		Incident Type								
		Fatal	**Property Damage**	**Injury**	**Elecl /Mechl**	**Stall**	**Flat Tire**	**Aband**	**Debris**	**Other**
Clearance Time	**In-Lane Mean**	27.09	27.09	27.09	**17.34** (18.65)	**12.35** (14.69)	**16.55** (14.69)	**6.21** (9.64)	**14.41** (9.64)	**21.81** (14.69)
	In-Lane St Dev	23.11	23.11	23.11	**30.91** (14.74)	**19.31** (11.25)	**13.22** (11.25)	**10.28** (11.05)	**16.90** (11.05)	**49.19** (11.25)
	Shoulder Mean	19.92	19.72	19.72	**10.83** (16.36)	**10.47** (13.19)	**12.17** (13.19)	**7.32** (11.29)	**6.97** (11.29)	**6.09** (13.19)
	Shoulder St Dev	16.56	16.56	16.56	**21.19** (12.10)	**19.36** (12.48)	**16.80** (12.48)	**16.37** (14.24)	**15.34** (14.24)	**15.89** (12.48)

Assumptions to Fully Utilize the Available Databases

It should be noted that in both the updated NJCMS tables shown above (Table II-20 and Table II-22), the ESP database is used without assumptions, except for the aggregation for the disablement type. No inference could be made about crash durations since the ESP does not distinguish between crash types (Table II-12). However, with some

You Are Viewing an Archived Copy from the New Jersey State Library

additional assumptions some of the other available databases can be incorporated into the study. Some facts and possible assumptions are:

1. The ESP database does not distinguish amongst the crash types, however in the current version of the NJCMS, durations are assigned the same value for all types, and thus similar assumptions can be made by assigning the same clearance time to all crash types in the case of values obtained from the ESP database. Same logic can be extended to the GSP and NJTPK databases.

2. The GSP and NJTPK databases can be used to update the NJCMS response time tables, however they are being valid only for toll authority routes since the incident response procedure is different from that for non-toll freeway routes. The NJTPK database can further be used for updating clearance time tables, but still being applicable to toll authority routes because of the reasons mentioned above. However since “the completion time” is missing in the GSP database, clearance times cannot be obtained from the GSP database. Following a similar procedure adopted for the ESP, GSP and NJTPK incident type fields must be aggregated to match the NJCMS table fields. However there are some important points that need to be considered.
   - Like the ESP database, the GSP and NJTPK databases do not have crash type details. Moreover, the GSP and NJTPK databases do not have “In-Lane/Shoulder” information. Thus, these databases can only be used for freeway duration tables without the details of the crash types and the incident locations.
   - The GSP and NJTPK can be considered to represent the “Management Center” case identified in the current version of the NJCMS tables. However for these two facilities there are also response teams involved. Thus, both “Management Center” and “Incident Response Team” can be updated together assuming that the duration values are equal for these two cases. Nevertheless, this assumption only applies to the toll authority routes as well.

Employing the assumptions given above, the NJCMS tables can be updated more comprehensively. The response time table updates are given in Table II-23. For the GSP, the response times are calculated by using the notification time and the arrival time information. The NJTPK database does not have the arrival time information but has the travel time information of the vehicle entering into the NJTPK from the closest exit to the incident, which can be used to approximate the arrival time. Thus, the time between incident notification and the entrance of the response vehicle from the NJTPK interchange is assumed to be the response time. The clearance time table updates are given in Table II-24. The identification summary of the databases associated with the calculated values is given in the tables with superscripts. The current NJCMS values are shown in parentheses.

You Are Viewing an Archived Copy from the New Jersey State Library

Table II-23. Calculated Response Time (in Minutes) Values for NJCMS Freeway Links Table XXIX Using All Databases

		Incident Detection/Management Type				
		No Incident Management	Management Center	Incident Response Team	FSP/MAP	Other
.Response Time	Crash	20	**23.65**[2] **28.03**[3] (12)	**23.65**[2] **28.03**[3] (12)	**8.35**[1] (10)	20
	Other	25	**24.89**[2] **29.60**[3] (15)	**24.89**[2] **29.60**[3] (15)	**9.52**[1] (10)	25
	St Dev	1	**21.92**[2] **31.80**[3] (1)	**21.92**[2] **31.80**[3] (0.85)	**10.25**[1] (1)	1

[1]ESP, [2]GSP, [3]NJTPK

The clearance time table updates are given in Table II-24. The identification summary of the databases associated with the calculated values is given in the tables with superscripts. The current NJCMS values are shown in parentheses.

Table II-24. Calculated Clearance Time (in Minutes) Values for NJCMS Freeway Links Table XXIX Using All Databases

		Incident Type								
		Fatal	Property Damage	Injury	Elecl /Mechl	Stall	Flat Tire	Aband	Debris	Other
Clearance Time	**In-Lane Mean**	**35.25**[1] **35.44**[2] (27.09)	**35.25**[1] **35.44**[2] (27.09)	**35.25**[1] **35.44**[2] (27.09)	**11.35**[1] **22.73**[2] (18.65)	**10.94**[1] **NA**[2] (14.69)	**14.38**[1] **26.45**[2] (14.69)	**6.21**[1] **22.87**[2] (9.64)	**5.09**[1] **NA**[2] (9.64)	**7.90**[1] **22.00**[2] (14.69)
	In-Lane St Dev	**45.61**[1] **32.84**[2] (23.11)	**45.61**[1] **32.84**[2] (23.11)	**45.61**[1] **32.84**[2] (23.11)	**18.25**[1] **49.64**[2] (14.74)	**18.85**[1] **NA**[2] (11.25)	**13.22**[1] **46.99**[2] (11.25)	**10.28**[1] **31.00**[2] (11.05)	**16.57**[1] **NA**[2] (11.05)	**23.26**[1] **39.92**[2] (11.25)
	Shoulder Mean	**21.33**[1] **35.44**[2] (19.92)	**21.33**[1] **35.44**[2] (19.72)	**21.33**[1] **35.44**[2] (19.72)	**9.81**[1] **22.73**[2] (16.36)	**9.74**[1] **NA**[2] (13.19)	**12.17**[1] **26.45**[2] (13.19)	**7.32**[1] **22.87**[2] (11.29)	**4.48**[1] **NA**[2] (11.29)	**5.24**[1] **22.00**[2] (13.19)
	Shoulder St Dev	**32.34**[1] **32.84**[2] (16.56)	**32.34**[1] **32.84**[2] (16.56)	**32.34**[1] **32.84**[2] (16.56)	**15.96**[1] **49.64**[2] (12.10)	**17.61**[1] **NA**[2] (12.48)	**16.80**[1] **46.99**[2] (12.48)	**16.37**[1] **31.00**[2] (14.24)	**10.79**[1] **NA**[2] (14.24)	**14.38**[1] **39.92**[2] (12.48)

[1] ESP, [2] NJTPK

As shown in Table II-23 and Table II-24, different databases give different mean and standard deviation values.

Analysis of Time of Day on Response and Clearance Times

Although not required for the NJCMS tables, the databases were also analyzed according to Time-of-Day (TOD). Morning and evening peaks are set to be 6 AM to 9 AM and 3 PM to 6 PM respectively, mid-day is assigned as 9 AM to 3 PM and night is assigned to be 6 PM to 6 AM. The results of the descriptive analysis can be found in

You Are Viewing an Archived Copy from the New Jersey State Library

Table II-25. The following observations can be made from the analysis results presented in Table II-25.

- Regarding the crash response time, the ESP and the GSP data shows that there is no significant fluctuation (both in terms of average value and the standard deviation) with respect to Time of Day (TOD). Only the NJTPK data shows a relatively higher average and standard deviation for the nighttime (about 1.5 times of the daytime value). Otherwise, peak and off-peak time response durations are consistent among the databases and through different TOD periods.

- For the crash clearance times, again there is no significant pattern for average duration or standard deviation values. The NJTPK data shows in general decreasing clearance times performance throughout the day (morning peak→off-peak→evening peak) and the standard deviation follows a similar pattern too. On the contrary, the average duration increases at night, and the standard deviation at night is about 1.5 to 2 times that of the daytime value. The ESP shows a significantly higher value for average clearance time duration and standard deviation at night (6 PM to 6 AM). The ESP has a relatively lower standard deviation of clearance times for the evening-peak. The data indicates that, peak time clearances are around 15% shorter than those in off-peak hours.

Table II-25. Crash/Disablement Response/Clearance Time Statistics (in Minutes) In Terms of Time-Of-Day

			Morning Peak (6AM-9AM)	**Mid-Day (9AM-3PM)**	**Evening Peak (3PM-6PM)**	**Night (6PM-6AM)**
Crash	ESP	Response	8.10 (8.48)	8.39 (7.52)	8.67 (8.60)	8.43 (8.82)
		Clearance	25.02 (34.51)	28.05 (38.25)	24.66 (28.23)	30.04 (49.36)
	GSP	Response	24.90 (13.86)	25.42 (24.98)	23.50 (16.05)	25.88 (30.11)
		Clearance	-	-	-	-
	NJTPK	Response	24.59 (19.72)	25.13 (20.96)	25.16 (21.88)	33.35 (36.58)
		Clearance	35.89 (30.92)	33.315 (26.11)	32.14 (25.82)	38.44 (40.61)
Disablement Incident	ESP	Response	9.73 (8.75)	9.23 (8.56)	9.10 (11.81)	9.98 (10.81)
		Clearance	10.68 (20.70)	10.30 (16.35)	10.51 (14.07)	10.67 (26.92)
	GSP	Response	25.19 (17.16)	23.72 (21.75)	24.50 (19.33)	25.56 (24.66)
		Clearance	-	-	-	-
	NJTPK	Response	28.80 (26.08)	25.73 (23.43)	25.40 (23.62)	34.98 (40.36)
		Clearance	33.28 (25.92)	32.28 (24.46)	28.98 (21.42)	34.74 (33.66)

* Numbers in parenthesis shows the standard deviation values

You Are Viewing an Archived Copy from the New Jersey State Library

For the disablement incident response times, all databases show the same level of performance (±1-2 minutes) all day except the NJTPK database which has higher average response times and standard deviations at night. Since this is also consistent with crashes too, we can say that the NJTPK has higher response time durations during nighttime between 6 PM to 6 AM.

You Are Viewing an Archived Copy from the New Jersey State Library

PART III – CONCLUSIONS AND RECOMMENDATIONS

NJCMS Incident Rates

The Part I of this study discussed a methodology to calculate the New Jersey based incident (i.e., crash and disablement) rates for replacing the information in *accrate.dbf* and *incident.dat* files in the NJCMS. The study developed crash rates summarized in Tables I-7a and I-7b were demonstrated more accurate to the existing rates of those currently employed by the NJCMS. The rates of disablement incidents developed in this study were based on the ESP data and the derived adjustment factors. The study developed incident rates on freeways and arterials for the NJCMS are shown in Table III-1. The number of crashes and disablement incidents with corresponding rates are sorted by the top 10 counties, routes, and the NJCMS links, and are shown in Tables III-2 to III-4.

Table III-1. Study Developed Incident Rates for the NJCMS (number of incidents per million vehicle miles)

Time Periods	ADT/C Range	Fatal	Injury	Property Damage	Elecl /Mechl	Stall	Flat Tire	Aband	Debris	Other
Incident Rates on Freeways										
AM PEAK	0-7	0.007	0.251	0.912	2.426	1.024	1.962	1.688	0.538	1.102
	7-10	0.002	0.309	1.222	1.471	0.510	1.381	0.668	0.172	0.606
	10-999	0.001	0.332	1.398	2.123	0.810	1.668	0.998	0.303	0.703
PM PEAK	0-7	0.005	0.298	0.958	3.522	2.104	2.547	1.492	0.705	1.719
	7-10	0.003	0.319	1.233	2.352	1.204	1.760	0.706	0.259	1.214
	10-999	0.001	0.377	1.518	2.848	1.612	1.939	0.900	0.311	1.050
MID-DAY	0-7	0.005	0.304	1.016	3.869	2.285	3.140	2.551	1.147	2.337
	7-10	0.004	0.351	1.204	2.213	1.135	2.100	1.054	0.454	1.270
	10-999	0.007	0.378	1.241	2.768	1.716	2.332	1.330	0.522	1.451
NIGHT	0-7	0.014	0.346	1.148	2.164	1.334	1.654	2.162	0.482	1.000
	7-10	0.007	0.403	1.380	1.041	0.583	0.770	0.828	0.204	0.566
	10-999	0.006	0.462	1.392	1.662	0.982	1.074	1.529	0.242	0.729
Incident Rates on Arterials										
AM PEAK	0-7	0.009	0.728	1.792	2.426	1.024	1.962	1.688	0.538	1.102
	7-10	0.006	0.666	1.788	1.471	0.510	1.381	0.668	0.172	0.606
	10-999	0.000	0.732	1.819	2.123	0.810	1.668	0.998	0.303	0.703
PM PEAK	0-7	0.014	1.282	2.874	3.522	2.104	2.547	1.492	0.705	1.719
	7-10	0.008	1.212	2.834	2.352	1.204	1.760	0.706	0.259	1.214
	10-999	0.004	1.245	3.137	2.848	1.612	1.939	0.900	0.311	1.050
MID-DAY	0-7	0.012	1.194	2.736	3.869	2.285	3.140	2.551	1.147	2.337
	7-10	0.003	1.170	2.769	2.213	1.135	2.100	1.054	0.454	1.270
	10-999	0.005	1.158	2.838	2.768	1.716	2.332	1.330	0.522	1.451
NIGHT	0-7	0.030	1.237	2.748	2.164	1.334	1.654	2.162	0.482	1.000
	7-10	0.028	1.256	2.593	1.041	0.583	0.770	0.828	0.204	0.566
	10-999	0.017	1.166	2.697	1.662	0.982	1.074	1.529	0.242	0.729

You Are Viewing an Archived Copy from the New Jersey State Library

The complete disablement incident data covering all the NJCMS links are needed for generating reasonably accurate rates of disablement incidents, which can be partially achieved by increasing the number of routes with ESP services and hours of operation. In addition, obtaining data from other available data sources will help to increase disablement incident data coverage.

The slightly overestimated number of crashes was likely caused by the conversion of traffic volume from daily to annual in the NJCMS; therefore, it deserves a further investigation to examine this difference. It was found that the number of disablement incidents reported by the ESP database is much less than the number what was generated by the NJCMS as indicated in Table I-9. A couple of reasons that might contribute to this issue were discussed. The ESP database does not cover 100% of the disablement incidents due to the hours of the ESP operation per day, and that the ESP patrols do not report disablement incidents which were cleared before the arrivals of the ESP patrols. To develop reasonable estimates, the derived upward adjustment factors (see Table I-6) shall be applied to estimate the number of disablement incidents and the associated delay using the NJCMS.

Table III-2. The Number of Incidents with Rates in the Top 10 Counties

Rank	Crash Rates	No. of Crashes	Disable Incident Rates	No. of Disable Incidents
1	Essex	Middlesex	Mercer	Camden
2	Hudson	Bergen	Camden	Gloucester
3	Union	Union	Burlington	Morris
4	Passaic	Essex	Monmouth	Burlington
5	Sussex	Monmouth	Gloucester	Mercer
6	Camden	Morris	Cumberland	Somerset
7	Mercer	Camden	Salem	Essex
8	Cumberland	Ocean	Ocean	Middlesex
9	Somerset	Mercer	Somerset	Union
10	Bergen	Hudson	Middlesex	Hunterdon

You Are Viewing an Archived Copy from the New Jersey State Library

Table III-3. The Number of Incidents with Rates in the Top 10 Routes

Rank	Crash Rates	No. of Crashes	Disable Incident Rates	No. of Disable Incidents
1	NJ 439	GSP	I-676	I-295
2	NJ 82	I-95	NJ 29	I-78
3	NJ 63	US 1	I-76	I-287
4	NJ 184	US 9	NJ 42	I-80
5	NJ 182	I-80	I-195	NJ 55
6	NJ 140	I-78	I-295	I-195
7	NJ 67	I-287	NJ 55	NJ 42
8	NJ 93	US 46	I-95M	I-280
9	NJ 124	US 22	I-78	I-676
10	NJ 26	US 206	I-280	I-76

Table III-4. The Number of Incidents with Rates in the Top 10 NJCMS Links

Rank	Crash Rates	No. of Crashes	Disable Incident Rates	No. of Disable Incidents
1	NJ 28 2.22~2.34	NJ 3 4.85~4.93	NJ 55 60~60.44	I-76 0.37~0.55
2	NJ 439 0.62~0.7	US 1 54.49~54.67	I-295 58~58.5	I-76 0~0.37
3	US 206 45~45.05	GSP 146.95~147.04	I-295 57~57.5	I-76 0.95~1.05
4	US 1 54.49~54.67	I-280 14.45~14.53	I-76 0.37~0.55	NJ 42 13.1~13.22
5	655 4.62~4.67	NJ 28 2.22~2.34	I-76 0~0.37	NJ 42 13.22~14.12
6	NJ 31 21.95~22.03	I-95 67.46~67.7	I-295 60~60.5	I-76 0.75~0.95
7	NJ 156 0.46~0.53	US 1 47.82~47.85	I-676 0.2~0.58	I-76 0.55~0.75
8	659 0.51~0.70	I-95 54.1~54.7	I-295 59~59.5	NJ 42 12.5~12.87
9	659 0.34~0.43	I-95 56.15~56.4	I-195 0~0.33	I-676 0.2~0.58
10	NJ 156 0.53~0.62	NJ 17 12.3~12.48	I-195 5.87~6.54	NJ 42 11.93~12.5

This study developed a working database for calculating incident rates by facility type, time period, ADT/C ratio, and incident type. Year-2005 NJDOT Crash Records and TOC-ESP data were employed as a Statewide incident case study for creating the working database. One of the major benefits of this database is to provide a prototype platform to gather single- and multi-year incident records and effectively calculate incident rates to be employed by the NJCMS.

Improvements of the Incident Data Accuracy and Coverage

The accuracy of the incident and delay estimation highly depends on the integrity of the data sources. The number of records with missing mileposts, SRIs, and incident times must be minimized. Therefore, a consistent format to store the ESP data in the TOC-North and the TOC-South is recommended to reduce the time for processing and merging data from these two sources. Finally, in terms of the amount of crash data, the

You Are Viewing an Archived Copy from the New Jersey State Library

NJDOT Crash Records seem to be a fairly complete database to be employed for approximating crash rates.

To improve the accuracy and coverage of incident data collection, a couple of innovated methods are discussed below:

- Mayday systems for emergency notification have become quite popular with motorists. Such systems are usually bundled with supplementary services like driving directions supported by a commercial call center. Mayday systems have proven to be a significant commercial success for vehicle manufactures, including General Motors' (GMs') OnStar™, Ford/Lincoln RESCU, and American Automobile Association's RESPONSE system.

- The cellular geo-location technology can help to rapidly locate the incident location. Two basic technologies are included in this system: network-based and GPS-based. A network-based solution may require access to information available only from the local carrier. The location is determined according to triangulation by the cell phone network itself. For GPS-based regions, the Mayday center will receive positional information directly from the calling phone.

Detection of Incidents and Incident Durations

Detection of incidents and incident duration can be done via creating a temporary data collection program in collaboration with the State police which attend almost all the relevant traffic accidents / incidents. This will require a careful coordination with the State police and preparation of an experimental data collection plan. The main cost of this option will be student and Principal Investigator time and some over-time, if needed, for the State police.

This approach is tested with success before by Professor Ozbay and his colleagues in Northern Virginia in the late 1990's. This approach is proven to collect reliable data with minimum cost. The steps of this approach can be as follows:

1. Preparation of a comprehensive data collection plan based on previous experience and New Jersey specific factors.
2. Coordination with State police.
3. Training of the State police.
4. Experimental tests to ensure accuracy and reliability of the proposed data collection plan under the close supervision of the research team (1 -2 weeks).
5. Analysis of the experimental test results.
6. Modification of the data collection plan based on Step 5.

You Are Viewing an Archived Copy from the New Jersey State Library

7. Execution of the final data collection program (1-2 months) preferably in different time frames to capture seasonal effects.
8. Analysis of the collected data and development of methods to extend these results to other roads in New Jersey.
9. Recommendations for future similar data collection efforts.

This option will require a maximum of 12 months of graduate student and 1 month of Principal Investigator times. There will not be any need for aerial data collection which is not feasible for this type of accident data collection. There will be no need for any equipment such as cameras, etc. There are ways to improve this data collection effort in terms of measuring non-recurring delay caused by accidents / incidents by deploying a number of EZ Pass readers along the test road. However, this will increase the cost of the experiment considerably. Thus, using EZ Pass it is not recommended for the limited data collection program unless measuring delays is a major need. Finally, a simple data entry program can be developed to ensure the quality of the data collected but this will also increase the costs and time to execute the data collection program. Thus, this is also a task that is not recommended for the limited data collection effort.

NJCMS Response and Clearance Times

This NJCMS study aims at determining actual incident data statistics rather than forecasted ones. As mentioned above, a considerable percentage of the data is discarded because of incomplete information, such as missing duration fields. This elimination, in turn, is likely to affect the standard deviation values because of the decrease in sample size. Data elimination is not the only factor affecting the standard deviation (or variance) of incident durations. The incident types (e.g. property damage and injury/fatality crashes) have distinct durations and standard deviations according to the literature. However no such distinction is made for the NJCMS tables. The possible results of this overall averaging of incident durations will be briefly discussed in the following section.

Besides the missing fields, sometime entries produce unreasonable duration values such as zero or few minutes of response and clearance times, or large numbers of hours of incident duration for relatively unimportant incidents. Simple delay calculations presented below can give an idea about the importance of standard deviation and duration accuracy. Such analysis is presented in Appendix A and it is clearly shown that the variation of the incident durations is vital for reliable delay estimates.

Overall, important recommendations regarding the NJCMS study can be summarized as follows:

You Are Viewing an Archived Copy from the New Jersey State Library

1. Incident record fields must be filled in full. The emergency officers must be kept aware of the need for every detail of each record and trained to input all the required information.

2. Accuracy in incident time entries should be ensured. This can be done by collecting the records by latest technology devices such as hand held computers, or educating the emergency personnel to make them aware of the importance of incident time accuracy. According to the Rutgers research team's prior experience, it can be recommended that the time entries should be kept in 24-hour format rather than AM/PM. This avoids the confusion, especially during mid-day and midnight. Although it seems like a minor detail, such simplifications for the data collection will improve the completeness and quality of the data.

3. The response and clearance times for the NJTPK and the GSP are unique to these toll facilities and should only be applied as such. Because of the facility and operational specific characteristics, the performances of these facilities are expected to be different than other freeways. Thus, the observed response times are different from the default values used in the CMS for freeways without incident management. Moreover, the CMS values are obtained as a result of an old study conducted in 1993 at various study locations in the USA, such as Charlotte, Chicago, Houston, Los Angeles, Orlando, and San Francisco (13). Thus, these differences between the CMS default and the NJTPK and GSP observed values should be considered normal given the spatial and temporal differences of the data sources.

4. Although not included in the scope of this current study, citing the previous literature, some additional incident details can be collected, and the NJCMS can be modified for better delay estimation. For instance, as presented using a small example given in Appendix A, the severity of an incident can make a considerable difference in delay estimation, thus more detailed delay calculations can be performed according to severity. Moreover, the lane in which the incident has occurred and the number of closed lanes can also be added to the NJCMS tables and used in delay calculations for better delay estimation.

Future Research

Future research can be concentrated on the following areas listed below:

1 Develop a mathematical model to predict incident rates by facility types, incident types, and time periods. This model can be employed for predicting values for incident rate tables for estimating future incident delay considering

You Are Viewing an Archived Copy from the New Jersey State Library

projected traffic growth, roadway capacity change, etc. The following work has to be conducted before the model development:

- Improve the data integrity and format consistency.
- Collect additional incident data on the NJCMS links without ESP services.
- Employ the procedure and methodology developed in this study to calculate annual incident rates.

2 Develop a mathematical model to predict clearance/response times and duration considering types of incidents, types of facilities, and time periods. This model can be employed for predicting values for clearance and response time tables for estimating future incident delay according to the projected traffic growth and the road capacity change. The following work has to be conducted before model development:

- Explore more data sources for clearance/response times and durations (e.g. AAA might need NJDOT's assistance to acquire the related data).
- Develop a database for managing crash/disablement incidents with New Jersey State police records.
- Develop a sample size determination procedure and a sample selection method.
- Develop data processing and management methodology.

3 Investigate the current methods employed by the NJCMS for estimating recurring and non-recurring delay. The following work has to be conducted before model development:

- Collect more data for approximating recurring and non-recurring delay by employing simulation and analytical approaches.
- Evaluate the delay estimated by the NJCMS against observations collected from field data. The calibration of parameters employed by the NJCMS for delay estimation is necessary in case the discrepancy between collected data and model output is significant.
- Develop methods to improve the accuracy of the NJCMS delay estimation if there is a need. The research team has conducted studies for NYSDOT and the NJTPK in the field of incident delay estimation as well as for NJDOT on various roadways (e.g., US 1, 46, NJ 139, and I-80) in estimating delay caused by construction activities and would assist the NJDOT with further study.

You Are Viewing an Archived Copy from the New Jersey State Library

Implementation Plan

Given the positive results of this research effort, the research team also developed a user-friendly computer application to assist NJDOT personnel in calculating incidents rates to be employed by the NJCMS. The following deliverables allow for implementation of this study:

- MS-Access based *Application.* This computer application can operate on any personal computer. The application will allow personnel to input collected incident data and create a query to generate a working database.

- MS-Excel based *Application.* This computer application can operate on any personal computer. The application will allow personnel to generate traffic volume data in a specific year. The working database can also be imported to an Excel worksheet for the incident rate calculation and the generated Excel worksheet can be sorted by incident categories for specific requirements.

Cost and Benefits Assessment

The NJDOT has invested a significant amount of funds for the deployment of the New Jersey Congestion Management System (NJCMS), which has been applied for analyzing and monitoring the performance of New Jersey highways statewide, and on the basis of county, corridor or link level. The tables of incident rates as well as the durations of the response and clearance times are important inputs to the NJCMS to estimate non-recurring delays. The efforts in identifying available data sources, collecting and processing data, developing a working database, and analyzing results have been documented in this report.

The tool developed in this study is very helpful, user friendly, and efficient in updating future incident related information with little modification. Employing the developed tool can improve the resulting accuracy by at the least labor cost. By comparing the numbers of crashes estimated by employing the S3 (i.e., study developed rates) and S1 (i.e., existing crash rate), it was found that the NJCMS output from the study developed rates resulted in reducing the overall estimation error from 5.2% to 1.8% as indicated in Table I-8. In addition to better estimation with the product of this project, the cost invested in this project would reduce the future expenses in collecting new data and updating the NJCMS incident related input measures. The cost for conducting this project was $198,993, and the estimated future cost for updating the incident rates can be reduced to $65,000 (e.g., 6-month student's time and 1-month Principal Investigator's time.)

You Are Viewing an Archived Copy from the New Jersey State Library

REFERENCES

1. Al-Deek, H.M., Garib, A.M., and Radwan, A.E. "Methods for Estimating Congestion Part-II: New Method," *ASCE Transportation Engineering Journal*, August 1994.

2. Balke, K, Fenno, D., and Ullman, B. "Incident Management Performance Measures," prepared for FHWA by Texas Transportation Institute, 2002.

3. Cambridge Systematics, Sketch Methods for Estimating Incident-Related Impacts, 1998.

4. Chang G-L. and Rochon S., "Performance Evaluation and Benefits Analysis for CHART: Coordinated Highways Action Response Team", Final Report, 2005.

5. Chien, S., Wen, H., Qiu, J., and Ting, C. "Lane Occupancy Delay Estimation Systems (LODES) for Logistics Management," *Logistics Information Management*, Vol. 15, No. 1 and 2, 2002, pp. 58 ~ 71.

6. Chien, S., Goulias, D., and Yaholom, S. "Simulation Based Estimations of Delays at Freeway Work Zones," *Journal of Advanced Transportation*, Vol. 36, No. 2, 2002, pp. 131~156.

7. Cohen, Harry and Southworth, F. "On the Measurement and Valuation of Travel Time Variability Due to Incidents on Freeways," *Journal of Transportation and Statistics,* pp 123- 131, December 1999.

8. Congestion Management and Intermodal Systems Development, prepare for NJDOT by Raytheon Infrastructure Services Incorporated, 1996.

9. Daniel, J., Tsai, F., and Chien, S. "Factors Influencing Truck Crashes on Roadways with Intersections," *Journal of Transportation Research Board*, TRR No.1818, 2002, pp. 54~59.

10. Daniel, J., and Chien, S. "Truck Safety Factors on Urban Arterials," *Journal of Transportation Engineering*, ASCE, Vol. 130, No. 6, 2004, pp. 742~752.

11. Delaware Valley Regional Planning Commission (DVRPC), Incident Data Collection – A Technical Memorandum, September 2005.

12. DeRose Jr. F., "An Analysis of Random Freeway Traffic Accidents and Vehicle Disabilities", *Highway Research Record*, Vol.59, 1964, pp. 53-65.

13. Edward C. Sullivan, "New Model for Predicting Freeway Incidents and Incident Delays", *Journal of Transportation Engineering*, Vol.123 No.4, 1997, pp. 267-275.

14. Garib A., Radwan E., Al-Deek H., "Estimating Magnitude and Duration of Incident Delays", *Journal of Transportation Engineering*, Vol. 123 No.6, 1997, pp. 459-466.

You Are Viewing an Archived Copy from the New Jersey State Library

15. Garmen Associates, The New Jersey Congestion Management System Installation and Users Guide - Version 1.5, October 1999.

16. Giuliano, G. “Incident Characteristics, Frequency, and Duration on a High Volume Urban Freeway,” Transportation Research A, 23A, No. 5, 1989.

17. Goolsby M.E. and Smith W., “Influence of Incidents on Freeway Quality of Service”, *Highway Research Record*, Vol.349, 1971, pp. 41-46.

18. Golob T. F., Recker W. W., Leonard J. D., “An Analysis of the Severity and Incident Duration of Truck Involved Freeway Accidents”, *Accident Analysis and Prevention*, Vol.19, (1987), pp. 375-395.

19. Genevieve Guliano, “Incident Characteristics, Frequency, and Duration of a High Volume Urban Freeway”, *Transportation Research Part A*, Vol.23, 1989, pp. 387-396.

20. GSP and NJTPK Catalogs (Email Communication by B. Bartin on 9/28/2006 and 08/ 24/2006).

21. Jones B, Janssen L., and Mannering F., “Analysis of the Frequency and Duration of Freeway Accidents in Seattle”, *Accident Analysis and Prevention*, Vol.4, 1991, pp. 239-255.

22. Juge J., Kennedy K., Wang T., Early Detection and Rapid Removal of Disabled Vehicles and Other Hazards from The Freeway, California Department of Transportation and Department of California Highway Patrol, Final Report, 1974.

23. Khattak A. J., Schofer J. L., Wang M-H., A Simple Time Sequential Procedure for Predicting Freeway Incident Duration, PATH Program Report, Institute of Transportation Studies, University of California at Berkeley, November 1994.

24. Lee J-T and Fazio J., “Influential Factors in Freeway Crash Response and Clearance Times by Emergency Management Services in Peak Periods”, *Traffic Injury Prevention*, Vol.6, 2005, pp.331-339.

25. Morales, J. M. “Analytical Procedures for Estimating Freeway Traffic Congestion,” *ITE Journal*, 57(1), 1986, pp. 45-99.

26. Nam D., Mannering F., “An Exploratory Hazard-based Analysis of Highway Incident Duration”, *Transportation Research Part A*, Vol.34, 2000, pp.85-102.

27. NYMTC Congestion management System Description and procedures, New York Metropolitan Transportation Council, 2003.

28. Ozbay K. and Kachroo P., *Incident Management in Intelligent Transportation Systems*, Artech House Inc., 1999.

You Are Viewing an Archived Copy from the New Jersey State Library

29. Ozbay K. and Noyan N., "Estimation of Incident Clearance Times Using Bayesian Networks Approach", *Accident Analysis and Prevention*, Vol.38, 2006, pp.542-555.

30. Sethi V., Koppelman F. S., Flannery C. P., Bhandari N., Schofer J.L., Duration and Travel Time Impacts of Incidents, ADVANCE Project Technical Report, The Transportation Center, Northwestern University, 1994.

31. Skabardonis A, Betty K. F., Bertini R. L., Varaiya P. P., Noeimi H., Rydzewski D., "I-880 Field Experiment: Analysis of Incident Data", *Transportation Research Record 1603,* 2001, pp. 72-79.

32. Smith K. W. and Smith B. L., Forecasting the Clearance Time of Freeway Accidents, Center for Transportation Studies, University of Virginia, 2001.

33. Smith, B, Evans, M, and Babiceanu, S. "Development of Incident Data Collection Standards for Virginia Department of Transportation Freeway Operations," prepare for FHWA by Virginia Transportation Research Council, 2005.

34. Spasovic, Lazar N., and Dimitrijevic, B. "Mobility and the Costs of Congestion in New Jersey," New Jersey Institute of Technology, National Center for Transportation and Industrial Productivity, 2003.

35. Sullivan, E., "New Model for Predicting Freeway Incidents and Incident Delays," *Journal of Transportation Engineering*, Vol. 123, No. 4, 1997, pp. 267-275.

36. Sullivan, E., Taff, S., and Daly, J. "A Methodology for Measurement and Reporting of Incidents and Prediction of Incident Impacts on Freeways," prepared for FHWA by Cal Poly State University for Ball Systems Engineering Division, 1995.

37. Todd Olmstead, "Pitfall To Avoid When Estimating Incident-Induced Delay by Using Deterministic Queuing Models", Transportation Research Record 1683.

38. Urbitran Associates, PPSUITE Transportation System Performance Evaluation and Emissions Analysis - Program Documentation, 2003.

39. Wang Mu-Han, Modeling Freeway Incident Clearance Times, Master Thesis, Northwestern University, 1991.

40. Wei C-H. and Lee Y., "Sequential Forecast of Incident Duration Using Artificial Neural Network Models", *Accident Analysis and Prevention*, Article in Press, 2007.

41. Wu W., Kachroo P., Ozbay K., "Validation of WAIMSS Incident Duration Estimation Model", 1998, IEEE.

You Are Viewing an Archived Copy from the New Jersey State Library

APPENDIX A

The simple deterministic queuing delay can be calculated by the area or the shaded region in Figure A-1 (a).

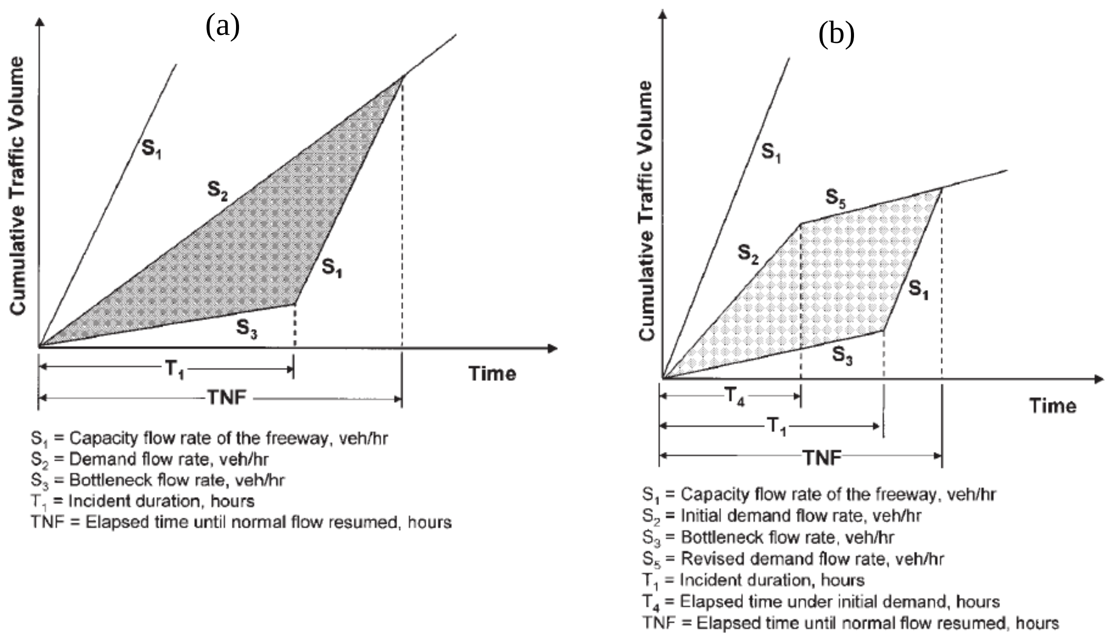


Figure A-1. Diagrams for (a) Simple and (b) More Realistic Delay Calculations (Source: Olmstead[37])

The formula for the calculation is:

$$\text{Delay} = T_1^2 \frac{(S_1 - S_3)(S_2 - S_3)}{2(S_1 - S_2)}$$

where,
S_1: Capacity flow rate of the freeway, veh/hr
S_2: Demand flow rate, veh/hr
S_3: Bottleneck flow rate, veh/hr
T_1: Incident duration, hr

By assigning S_1=6480 veh/hr (3 lane highway), S_2=5000 veh/hr and S_3=4320 veh/hr (1 lane closed, 2 lanes operational), the following delay profile shown in Figure A-2 can be calculated for different possible incident durations. Table A-1 also shows the additional delay for each additional five minutes on the incident duration.

You Are Viewing an Archived Copy from the New Jersey State Library

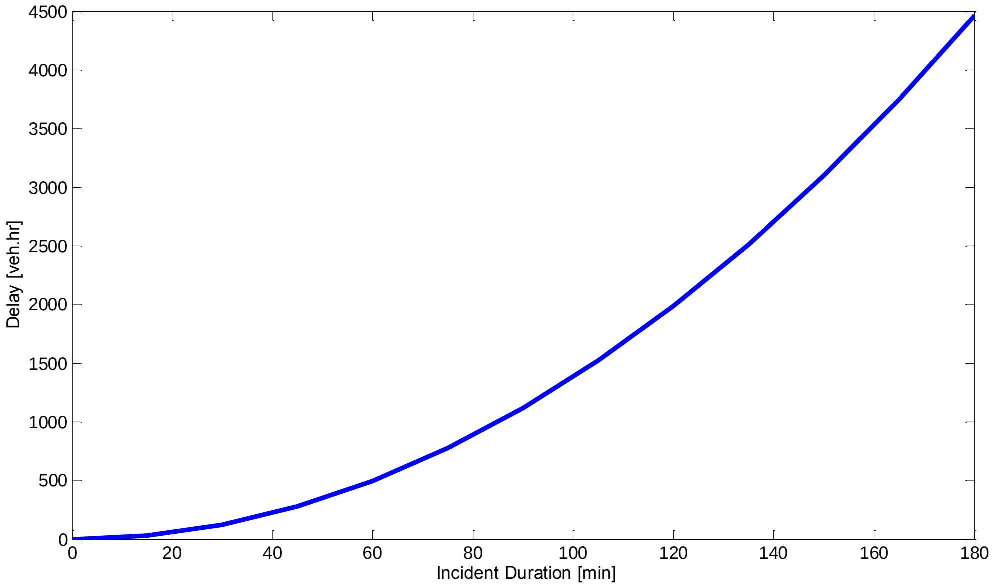


Figure A-2. Delay due to Different Incident Durations

Table A-1. Additional Delay for Each Additional Five Minutes of Incident Duration

Incident Duration (mins)	0-5	5-10	10-15	15-20	20-25	25-30
Additional Delay (veh.hr)	3.4459	10.338	17.23	24.122	31.014	37.905

As shown in Table A-1, even 5 minutes of change in incident duration affects the delay considerably according to simple deterministic queuing based delay calculations. Please note that the above calculations are simple representations of traffic delay. In real life, the capacity decrease due to an incident can be higher because of rubbernecking and violating the delay calculation assumption, that traffic does not continue its normal flow momentarily after the incident is cleared. Hence, the presented differences can be more dramatic in real life situations. Thus, the accuracy of incident durations is important for delay calculations, therefore the incident time details should be recorded with care for obtaining reliable delay estimates.

Although the deterministic queuing delay model is not the only approach for conducting the delay analysis, it is commonly used by practitioners to calculate the delay. However as discussed in Olmstead [37], "the average delay due to incidents is a larger value than delay due to an average incident". By simply, plugging in arbitrary incident durations in the deterministic delay equation, Olmstead [37] shows that "improper averaging, such as taking the average of incident durations without considering their severity results in over or underestimating the total delay". It is shown that the underestimation of total delay

You Are Viewing an Archived Copy from the New Jersey State Library

due to using grand average is a function of (*a*) incident duration variance, (*b*) the severity of the type of incident, and (*c*) the number of incidents of the incident type under consideration. The mathematical formula for the underestimation (using a more realistic delay model as shown in Figure A-1(b) and assuming T_4 and S_5 is independent of T_1) is:

$$Underestimate = n\frac{(S_1 - S_3)(S_5 - S_3)}{2(S_1 - S_5)}Var(T_1)$$

where

S_1: Capacity flow rate of the freeway, veh/hr
S_2: Initial demand flow rate, veh/hr
S_3: Bottleneck flow rate, veh/hr
S_5: Revised demand flow rate. veh/hr
T_1: Incident duration, hours
T_4: Elapsed time under initial demand, hours

The underestimation formula proposed in Olmstead [37] clearly shows the importance of considering variance. Elimination of incident records due to incomplete fields can affect the reliability and accuracy of the standard deviation (or variance) of the incident duration. Based on the analysis, it is recommended, at least, to divide the incidents into two distinct categories namely, in-lane and shoulder so that the variance will be smaller and better delay estimates will be obtained. The in-lane and shoulder location difference is used in the NJCMS**,** however the severity of the types of crashes is not used for determining the location distributions or the duration times and included in the NJCMS tables. Overall, the lack of severity details and the decrease in sample size due to incomplete records might reduce the accuracy and reliability of the incident duration variance and in turn may result in the underestimation of the incident delay.