APPENDIX L

USER GUIDE for USLIMITS

March 2012

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Background

Speed limits are selected to balance travel efficiency versus safety. It can be argued that a rational speed limit is one that is safe, that most people consider appropriate, that will protect the public, and can be enforced. Many practitioners also feel that better methods are needed to identify appropriate speed limits especially in urban roads having higher traffic volumes, a mix of road users, and more roadside activity. Many practitioners and researchers have argued that a knowledge-based expert system can provide assistance to the practitioner in setting the appropriate speed limit for specific conditions on a road section.

Expert systems for recommending maximum posted speed limits have been used in Australia for more than a decade starting in the late 1980's. The first expert system (VLIMITS) was developed for the province of Victoria by the Australian Road Research Board (ARRB). Subsequently systems were developed for different provinces in Australia and New Zealand. These systems are collectively referred to as the XLIMITS programs. Based on their experience in developing the XLIMITS programs, FHWA contracted with ARRB to adapt XLIMITS for use in the USA, but with changes made to reflect speed setting philosophy in this country (such as posting in 5 mi/h multiples). This resulted in the USLIMITS Version 1.0.

Version 2 of the expert system described in this user guide (hereafter called USLIMITS2) employs a decision algorithm to advise the user of the appropriate maximum speed limit for the specific road section of interest. Unlike the original version, USLIMITS2 was developed based on input from a panel of experts in the USA that included traffic engineers, enforcement personnel, decision makers, and researchers from different parts of the country. The expert system is accessed through the Internet and provides recommended speed limits for speed zones on all types of roadways from rural two-lane roads to urban freeway segments. The types of speed limits not addressed by the system include statutory limits such as maximum limits set by State legislatures for Interstates and other roadways, temporary or part-time speed limits such as limits posted in work zones and school zones, and variable speed limits that are raised or lowered based on traffic, weather, and other conditions.

Objective of this Guide

The primary objective of this guide is to assist the user in recommending an appropriate maximum speed limit for specific conditions on a road section. The guide provides information needed to use the USLIMITS2 system. Included is a section on "Getting Started" which is followed by detailed definitions of the variables that are used in the expert system, descriptions of the data that need to be collected by the user, and the results that can be expected from this program. Example applications for a variety of road and area conditions are included to illustrate the input and output results for typical speed zoning situations.

For details regarding the decision rules that were used to develop this expert system, users should refer to the Decision Rules document that can also be downloaded from the expert system.

Considerable effort has been expended to check the appropriateness of the maximum speed limit recommendations made by USLIMITS2, however, the user is responsible for collecting and inputting the information requested by the program. Engineering experience and knowledge should be used in collecting the required information and when interpreting the results.

Accessing the Expert System

Since this program is accessed through the Internet the user is only required to have a computer with web-browsing software connected to the Internet. Any web browser version developed in 2003 or later would be sufficient. Examples include Netscape (Version 6.0 or later), MS Explorer (Version 5.5 or later), and Firefox (Version 0.8 or later). The final results are output to the user's computer screen and can be saved in a Microsoft Word file, a Microsoft Excel file, and a project file (.txt file). Users do not need any special skills to access and use the system. However, to obtain useful results from the system, the user is required to provide specific engineering and crash information about the road section that is being examined.

Getting Started

The original USLIMITS2 version of the program asked users to create an account. With the transfer of USLIMITS2 to the FHWA server, there are no user accounts anymore.

The user is asked to either create a new project or revise/update an existing project. In order to be able to revise/update an existing project, the user should have a .txt file in their local computer that was created while using this application for a project.

A "HELP" tab is provided on the Home Page as well as successive screens to provide the user with background information on the expert system. This information includes a brief description of the site background, the complete NCHRP 3-67 Final Report, this User Guide for USLIMITS2, and flow charts illustrating the decision rules used in the system.

Creating New Projects

Selecting the "Click here to Enter a New Project" will take the user to the "NEW PROJECT ENTRY" screen. The user is required to input or select from a pull down menu, the following information:

- State
- County
- City/Area
- User Name (i.e., name of the Analyst who is conducting the study)
- Route/Street Name
- Begin and End Termini of the study route. This input is optional.
- New or Existing Route
- Route Type, i.e., Limited Access Freeway, Road Section in Undeveloped Area, and Road Section in Developed Area. (See guidance below for assistance in selecting a route type.)

- Project Date, i.e., the current date or any date the user selects.
- Project/File Name (At the completion of the USLimits process, an output file will be created that contains all of the entered data. The Project/File Name input, with the entry date appended, will be used as the default name for the output file.)
- Project Number
- Project Description. This input is optional and is used to record any information the user wishes such as purpose of study, requesting source, study dates, etc.

After the project description information is entered, the user is required to press the "Submit" button to go to the next screen and input the engineering data for the road segment under investigation. This input is described in the "Input Variables" section of this guide.

Revise/Update Existing Projects

If the user had already created projects using the system and saved the information as .txt files in their local computer, they can upload them into the system and revise/update them. When the user clicks on 'Revise or Update an existing project', they will be taken to a window that will allow them to browse their local computer for projects that they had created earlier. Once the user has identified the project that they want to edit, they can 'submit' them by clicking on the 'submit' button.

This will take the users to a screen will provide a brief description of basic project information, that the user will not be able to change. Following the basic project information box are the previous input engineering variables which the user can change or update. A description of each of these variables is given in the "Input Variables" section of this guide.

Selecting a Route and Area Type

Selecting a Route and Area Type is an extremely important step in using the expert system. Guidance is provided in this section to assist the user in selecting the appropriate Route and Area Type for the road or street segment they are studying.

This expert system has three primary sets of decision rules corresponding to the following three route types: Limited Access Freeway, Road Sections in Undeveloped Areas, and Road Sections in Developed Areas.

GUIDANCE: The identification of freeways and expressways sections with limited access control is straightforward because these road segments do not have at-grade intersections or other direct access features such as driveways, signals, on-street parking, etc. However, distinguishing between a road section in an undeveloped area and a road section in a developed area can sometimes be challenging because the study road segment may have both rural and urban characteristics. For example, a road in an undeveloped area may have one traffic signal and several residential and small business driveways. Conversely, a road segment in a developed area may not have any residential or commercial driveways, or traffic signals. When the user is in doubt as to which category a study section falls, it is suggested that two analyses be performed. The first analysis should be conducted using a road section in an undeveloped area,

and the second analysis should be conducted assuming a road segment in a developed area. The results of these analyses should be compared to identify which analysis best describes the study section characteristics.

Definitions of each route and area type along with photographs illustrating typical characteristics of these sections are given in the following paragraphs.

Limited Access Freeway – This route type includes U.S. and state numbered freeways and expressways and Interstate routes where access to and from the facility is limited to interchanges with grade separations. Opposing directions of travel are separated by a median on these high-speed routes which typically have posted speed limits ranging from 55 mph in urban areas to 75 mph in some rural states. Some urban areas may have short segments directly connecting the freeway to surface streets where the posted speed limit is as low as 35 mph. Photographs of typical freeway sections are shown later in this document.

Users should select this category only when they desire to obtain a speed limit recommendation for a limited access facility with grade separated intersections. If the facility includes at-grade intersections, then the user should select either Road Sections in Undeveloped Areas or Road Sections in Developed Areas depending on the area type defined later in this section.

NOTE: During the development of this expert system, the project team decided that the system should provide maximum speed limit *recommendations* for street and road segments based on existing knowledge and experience. At that time, the highest maximum speed limit on limited access highways in the United States was 75 miles per hour. Consequently, the maximum speed limit recommended by USLIMITS2 is 75 miles per hour.

The reason for imposing a 75 mile per hour upper limit was to prevent users in the United States from receiving a ***recommended*** speed limit that was not based on empirical evidence and the knowledge and experience of experts. For example, a recommended speed limit of 85 miles per hour on a freeway would not be recommended in this system because currently there is very little evidence to suggest how and under what conditions such a limit would be appropriate.

As of June 2010, the highest legal permitted maximum speed limit in the United States was 80 miles per hour for passenger cars which was established by the Texas Transportation Commission for specific sections of I-10 and I-20 in rural western Texas. The 80 mph limit on these Interstate sections was posted in May 2006. In November 2009, the Utah Department of Transportation announced that their one-year experiment involving increasing the maximum speed limit to 80 miles per hour on certain sections of I-15 resulted in no increase in crashes or vehicle speeds. In a related matter, the Texas Transportation Code, Section 545.3531, also authorized the Transportation Commission to establish a maximum speed limit of not more than 85 miles per hour on the Trans-Texas Corridor.

In the future, when additional experience with 80 mile per hour and higher speed limits has occurred in the United States and the empirical evidence suggests that these limits are

acceptable, then an increase in the *recommended* maximum limit could be considered in the next revision of USLIMITS2.

Road Section in Undeveloped Area – An undeveloped area is generally an area where the human population is low and the roadside primarily consists of the natural environment with some built elements such as utility poles, fences, and an occasional driveway. Access to the road is not restricted and posted speed limits are typically in the 40 mph to 65 mph range depending upon terrain and road design features. Rural road sections with lower speed limits usually have narrower pavement widths, little or no shoulders, and horizontal and vertical curvature that limits driver speeds. Rural road sections with higher speed limits usually have improved geometric design features such as 12-foot lanes, 8-foot or greater shoulders which may be paved, and horizontal and vertical curvature that supports higher travel speeds. Photographs of typical road sections in undeveloped areas are shown below.

Users should select this category only when they desire to obtain a speed limit recommendation for a rural road section. Roads in undeveloped areas usually do not have the features found in urban or developed areas such as on-street parking, traffic signal systems, sidewalks, curb and gutter, street lighting, frequent driveways and public street intersections serving homes and businesses, etc. Also pedestrian and bicycle activity is generally minor in undeveloped areas.

NOTE: As previously noted, during the development of this expert system, the project team decided that the system should provide maximum speed limit *recommendations* for street and road segments based on existing knowledge and experience. While there were a few exceptions, at that time the highest maximum speed limit in rural areas in the United States was 65 mph. Consequently, the maximum speed limit recommended by USLIMITS2 was set at 65 mph.

Posted speed limits higher than 65 mph include Texas where a 75 mph maximum limit for passenger cars is permitted on state highways in rural counties with a population density of less than 15 persons per square mile. In Montana, Utah, and a few other western states, maximum speed limits of 70 mph are permitted on numerous stretches of non-interstate public highways.

In the future, when additional experience with 70 mph and higher speed limits on two-lane and other rural roads has occurred in the United States and the empirical evidence suggests that these limits are acceptable, then an increase in the *recommended* maximum limit could be considered in the next revision of USLIMITS2.

Road Section in Developed Area – A developed or built-up area is an area where the built environment has generally replaced most of the natural environment. Access is not restricted and posted speed limits are usually in the 25 mph to 50 mph range depending on geometric design of the facility. Urban road sections with lower speed limits are found in downtown and residential areas with considerable pedestrian and other non-motorized movements, on-street parking activity, numerous driveways serving residential and commercial development, and traffic signal systems. Urban road sections with higher speed limits have been

designed to have little pedestrian activity, no on-street parking, and traffic control which favors through traffic movement. Routes in this category include one-way streets.

NOTE: As previously noted, during the development of this expert system, the project team decided that the system should provide maximum speed limit *recommendations* for street and road segments based on existing knowledge and experience. While there may be some exceptions, at that time the maximum speed limit on urban surface streets in the United States was approximately 50 mph. Consequently, the maximum speed limit *recommended* by USLIMITS2 was set at 50 mph. Roads and streets within city boundaries may have posted speed limits higher than 50 mph; however, these streets typically have geometric design and traffic characteristics more similar to rural roads and limited access freeways.

In the future, when additional experience with 55 mph and higher speed limits on urban roads in built up areas has occurred in the United States and the empirical evidence suggests that these limits are acceptable, then an increase in the *recommended* maximum limit could be considered in the next revision of USLIMITS2.

Roads in developed areas are further subdivided into residential subdivision/neighborhood street, residential collector street, commercial street, and a street serving a large complex such as a major shopping mall, university or medical complex, etc. Definitions as well as photographs illustrating the features of typical road sections in developed areas are shown on the following pages.

Residential Subdivision/Neighborhood Street – A residential neighborhood street is a public street located within a subdivision or group of homes that serves the motorized and non-motorized activities of residents. Posted speed limits generally range from 25 to 35 mph. Two-way traffic operations are permitted along with on-street parking on both sides of the road, however, the pavement width is typically too narrow to allow unimpeded bidirectional traffic and on-street parking. These streets usually do not carry through traffic. Commercial development is not permitted in the area.

Residential Collector Street – A residential collector street carries both through traffic from residential neighborhoods and local traffic generated by residents who live along the corridor. Posted speed limits generally range from 25 mph to 45 mph. The pavement widths permit full time operation of bidirectional traffic. On-street parking on one or both sides may or may not be permitted. Development along the street is primarily single- and multi-family homes. Typically there are more than 30 residential driveways per mile. The corridor may contain a small amount of commercial development; usually convenience stores at major intersections.

Commercial Street – A commercial street is a street that serves both through traffic and local commercial activities. Development along the corridor is primarily commercial with more than 30 business driveways per mile. Posted speed limits generally range from 25 mph to 45 mph. The streets usually tend to be multilane and on-street parking on one or both sides may or may not be permitted.

Street Serving Large Complexes – Large area business developments typically include shopping malls, office buildings and industrial complexes. Streets that serve large complexes generally are designed to carry large volumes of traffic to and from the complex and typically are designed to manage access to carry through volumes. The streets tend to be multilane facilities and the number of access driveways is usually less than 30 per mile. Posted speed limits generally range from 35 mph to 50 mph.

Photographs illustrating the different road and area types are shown in the following pages:

Limited Access Freeway – Includes Interstate, US and other routes where access is limited to grade separated crossings. The systems are located in rural and urban areas.

Road Section in Undeveloped Area - Includes roads in rural areas. The road section may have some scattered development with typically less than 30 commercial and residential driveways per mile. Posted speed limits are usually in the 40 to 65 mph range.

Road Section in Developed Area – Includes roads in built-up areas. Posted speed limits typically range from 25 to 50 mph depending upon road and development conditions. Specific categories of roads in developed areas include;

1. Residential Subdivision/Neighborhood Street
2. Residential Collector Street
3. Commercial Street
4. Street Serving Large Complexes

Residential Subdivision/Neighborhood Street – Predominately includes streets serving a group of homes or subdivisions that provides motorized and non-motorized trips for local residents. Posted speed limits usually range from 25 to 35 mph.

Residential Collector – Includes mostly residential single-family homes and multi-family development with more than 30 driveways per mile.

Commercial Street – Includes mostly shopping and service business with typically more than 30 driveways per mile. This category also includes downtown streets.

Street Serving Large Complexes – Includes shopping malls, office buildings, industrial complexes, etc. There are high volume driveways. The number of driveways is usually less than 30 per mile

For each route type, the following input variables are required:

Limited Access Freeway

Operating Speed: 85th percentile speed and 50th percentile speed
Section Length
Annual Average Daily Traffic
Presence/absence of adverse alignment
Current statutory limit for this type of road
Terrain
Is this section transitioning to a non-limited access highway?
Number of Interchanges within this section
Crash Statistics

Road Section in Undeveloped Area

Operating Speed: 85th percentile speed and 50th percentile speed
Section Length
Annual Average Daily Traffic
Presence/absence of adverse alignment
Current statutory limit for this type of road
Is this section transitioning to a road section in a developed area?
Roadside Rating
Divided/Undivided Section
Number of through lanes
Crash Statistics

Road Sections in Developed Areas

Operating Speed: 85th percentile speed and 50th percentile speed
Section Length
Annual Average Daily Traffic
Presence/absence of adverse alignment
Current statutory limit for this type of road
Whether it is a One-Way Street?
Number of Through Lanes
Area Type
Number of driveways within the section
Number of traffic signals within the section
Presence/usage of on-street parking
Extent of ped/bike activity
Crash Statistics

The following paragraphs provide a detailed description of each of these input variables

Input Variables

Operating Speed

85th Percentile Speed – The 85th percentile speed is the speed at or below which 85 percent of the drivers travel on a road segment. The 85th percentile speed should be taken from speed data collected during a 24-hour weekday period. Typically the data are collected with commercially available roadside units which sort and present the results in text as well as graphical format.

Speed studies should be conducted using the format and procedures described in your jurisdiction's publications for establishing speed zones. If your jurisdiction does not have a specific written procedure, additional information is found in the ITE Manual of Transportation Engineering Studies, November 2010.

The road cross section of the speed zone segment being studied should be uniform with similar roadside development. If the number of lanes, road function, or development changes with a study section, the segment should be further subdivided with the measurement of 85th percentile speeds in each segment. Another factor that should be taken into consideration when determining the start and end points of a speed zone is the location of adverse-alignment such as sharp horizontal curves, where the advisory speed may be less than the speed limit. The 85th percentile speed used in the analysis for a general speed limit should not be taken from data collected in the adversely aligned section.

This program is not designed to handle the unusual situations where the 85th percentile speed on limited access freeways is less than 35 mph, less than 25 mph on road sections in undeveloped areas, or less than 20 mph on road sections in developed areas. If a portion of the section has adverse alignment or the section is a transition zone, the program will allow users to enter 85th percentile speeds less than 45 mph (but higher than 35 mph) on freeways, and less than 35 mph (but higher than 25 mph) on road sections in undeveloped areas.

50th Percentile Speed – The 50th percentile speed is the speed at or below which 50 percent of the drivers travel on a road segment. The 50th percentile speed should be taken from speed data collected during a 24-hour weekday period. In this program, the difference between the 85th percentile speed and the 50th percentile speed cannot exceed 15 mph.

Adverse Alignment

Adverse alignment of the road includes road features with vertical and/or horizontal alignments which differ significantly from the alignment of the general road. Adverse alignment segments typically have poor sight distance, reverse curves, and other features such as narrow pavement widths and shoulders that reduce operating speeds below the general speed limit for the section. When adverse alignment is present in a study section, a warning will be provided along with the general recommended speed limit for the section. Sections with adverse

alignment typically require posting advisory speed warnings which are lower than the general speed limit for the section. This program does not suggest numerical values that can be used to determine the advisory speed warnings for adverse alignment. If adverse alignment is present, the system gives the following warning as part of the recommended speed limit:

> Sections with adverse alignments may need specific advisory speed warnings which may be different from the general speed limit for the section. See Procedures for Setting Advisory Speeds on Curves for more guidance, Publication No. FHWA-SA-11-22, June 2011.

Transition Zone

For projects on limited access freeways, users are asked to indicate if this section is transitioning to a non-limited access road. For projects with road sections in undeveloped areas, users are asked if the section is transitioning to a road section in a developed area. The answers are mainly used to determine if the operating speed is too low for a particular roadway type – lower operating speeds are typically used in transition zones.

Section Length

This refers to the length of the study section in miles.

Statutory Limit

This refers to the statutory limit for this type of facility in that jurisdiction. Statutory speed limits are limits established by legislative authority and are generally applicable throughout a political jurisdiction. Users should consult the vehicle codes in their state or jurisdiction to determine the statutory limit for the type of facility under study. Many of the laws are available on-line at the state or the local jurisdiction web site. If the recommended speed limit is higher than the statutory limit, the system provides a warning message.

Terrain (only for Limited Access Freeways)

Terrain is classified as Level/Flat, Rolling, or Mountainous which is defined in the following paragraphs.

Level/flat:

Level/flat terrain is that condition where highway sight distances, as governed by both horizontal and vertical restrictions, are generally long. Maximum freeway grades are typically less than 3 percent in flat terrain.

Rolling:

Rolling terrain is that condition where the natural slopes consistently rise above and fall below the road grade and where occasional steep slopes offer some restriction to normal horizontal and vertical roadway alignment. Maximum freeway grades are typically less than 4 percent in rolling terrain.

Mountainous:

Mountainous terrain is that condition where longitudinal and transverse changes in the elevation of the ground with respect to the road are abrupt. Maximum freeway grades are typically less than 6 percent in mountainous terrain, but may exceed 7 percent in some areas. In this program, the maximum speed limit for mountainous sections on limited access freeways is 70 mph.

Annual Average Daily Traffic (AADT)

The daily flow of motor traffic is averaged out over the year to give the Average Annual Daily AADT, a useful and simple measurement of how many vehicles use the facility during an average day.

Number of Interchanges (only for Limited Access Freeways)

The number of interchanges within the section is used to calculate the average interchange spacing which is equal to the length of the section divided by the number of interchanges. If the number of interchanges in a section is equal to zero, then the interchange spacing is set equal to the length of the section.

Crash Statistics and Analysis

In order for the system to conduct an analysis of the crash data, the following inputs are requested:

Length of the study period in years and months (we recommend at least 3 years of crash data; if less than 1 year of data are input, the program suggests that additional data should be collected and the process repeated)
Total number of crashes in the section
Total number of injury and fatal crashes in the section
The average AADT for the study period

This information is used to calculate the rate of total crashes and rate of injury and fatal crashes per 100 million vehicle miles. The user is then asked to input the average rate of total crashes and average rate of injury and fatal crashes (again per 100 million vehicles miles) for similar road sections in their jurisdiction. To determine the average crash/injury rate for similar sections, users should select a group of sections that have the same or similar geometry, i.e., number of lanes, median type, etc., and similar traffic volumes and area type.

If the user does not provide average rates, default values from the Highway Safety Information System (HSIS) are used. HSIS is a multi-state database that contains crash, roadway inventory, and traffic volume data for 8 States in the nation. In most of these states, the information in this database is limited to state-maintained facilities. Crash rates and injury rates were calculated using the latest 3 years of data that were available: California (2000-2002), Illinois (2001-2003), Maine (2002-2004), Minnesota (2002-2004), North Carolina (2001-2003),

Ohio (2002-2004), Utah (1998-2000), and Washington (2002-2004). Table L.1 shows the average crash and injury rates calculated based on HSIS data.

Table L.1: Average crash and injury rates based on data from HSIS States

ROADWAY CLASS	AADT Category	Crash-Rate per 100MVM	Injury and Fatal Rate per 100MVM
Urban Freeways (interchange spacing <= 1 mile)	0 - 24,999	103.58	30.36
	25,000 - 49,999	90.39	27.52
	50,000 - 74,999	97.41	29.66
	75,000 - 99,999	102.29	31.04
	100,000 - 149,999	108.57	32.53
	150,000 - 199,999	113.34	33.60
	200,000+	116.63	32.16
Urban 2 lane roads (Developed areas)	0 - 2,499	366.41	101.29
	2,500 - 4,999	223.05	73.52
	5,000 - 7,499	217.15	71.86
	7,500 - 9,999	222.49	73.24
	10,000 - 14,999	250.38	80.57
	15,000 - 19,999	277.84	89.48
	20,000+	280.83	85.70
Urban multilane divided non freeways (Developed areas)	0 - 9,999	327.34	111.27
	10,000 - 14,999	248.60	86.05
	15,000 - 19,999	282.36	94.13
	20,000 - 24,999	305.39	99.84
	25,000 - 29,999	341.35	109.94
	30,000 - 34,999	355.14	111.86
	35,000 - 44,999	325.49	107.62
	45,000+	260.07	85.48
Urban multilane undivided non freeways (developed areas)	0 - 9,999	394.68	126.61
	10,000 - 14,999	383.00	121.22
	15,000 - 19,999	376.86	119.54
	20,000 - 24,999	414.71	127.40
	25,000+	412.30	124.49
Rural Freeways (Interchange spacing >1 mile)	0 - 24,999	55.30	17.99
	25,000 - 49,999	55.70	16.65
	50,000+	55.31	18.10
Rural 2 lane roads (Undeveloped areas)	0 - 1,249	232.45	84.46
	1,250 - 2,499	165.13	57.78
	2,500 - 3,749	142.02	49.86
	3,750 - 4,999	134.01	46.88

	5,000 - 6,249	131.43	47.79
	6,250 - 7,499	125.97	46.04
	7,500 - 8,749	132.13	48.69
	8,750 - 9,999	129.02	48.05
	10,000+	123.98	47.37
Rural multilane divided non freeways (Undeveloped areas)	0 - 4,999	147.75	48.26
	5,000 - 9,999	101.22	31.32
	10,000 - 14,999	88.30	28.92
	15,000 - 19,999	89.28	31.52
	20,000 - 24,999	92.54	31.57
	25,000+	93.75	32.59
Rural multilane undivided non freeways (Undeveloped areas)	0 - 4,999	166.79	53.86
	5,000+	149.17	49.88

Using the average rate provided by the user or from HSIS, the system calculates a critical rate using the following formula (see Zegeer and Deen (1977), "Identification of Hazardous Locations on City Streets", *Traffic Quarterly*, Vol. 31(4), pp. 549-570.)

$$R_C = R_a + K\sqrt{\frac{R_a}{M}} + \frac{1}{2M}$$

Where:

R_C = critical rate for a given road type
R_a = average rate for a given road type
K = constant associated with the confidence level (1.645 for 95% confidence)
M = 100 million vehicle miles

It is important that the user/practitioner undertake a comprehensive crash study to determine probable causes and appropriate countermeasures that could be implemented to reduce the frequency and severity of crashes. If the crash and/or injury rate is higher than the corresponding critical value (crash or injury level is considered High in this case) or at least 30% higher than the corresponding average rate (crash or injury level is considered Medium in this case), the system will ask the user if the crash or injury rate can be reduced by implementing traffic and/or geometric measures. Depending on the answer to this question, the system provides a recommended speed limit.

Roadside Rating (only for Road Sections in Undeveloped Areas)

The roadside hazard rating is a measure of roadside conditions including: shoulder width and type, side-slope, clear zone distance, and presence/absence of fixed objects on the roadside.

The scale ranges from 1 to 7, with 1 representing the lowest hazard (best conditions), and 7 representing the highest hazard (worst conditions). These scales are based on the following work that was conducted in the late 1980's for the Federal Highway Administration: Zegeer, C.V., Hummer, J., Reinfurt, D., Herf, L., and Hunter, W., *Safety Effects of Cross-Section Design for Two-Lane Roads*, Volume I-Final Report, FHWA-RD-87/008, October 1987.

Following is a description of ratings 1 through 7. Photographs illustrating these ratings are provided following the description.

Rating = 1

- Wide clear zones free from obstacles greater than or equal to 9 m (30 ft) from the pavement edgeline.
- Sideslope flatter than 1:4.
- Recoverable in a run-off-road situation.

Rating = 2

- Clear zone free from obstacles between 6 and 7.5 m (20 and 25 ft) from pavement edgeline.
- Sideslope about 1:4.
- Recoverable in a run-off-road situation.

Rating = 3

- Clear zone free from obstacles about 3 m (10 ft) from pavement edgeline.
- Sideslope about 1:3 or 1:4.
- Rough roadside surface.
- Marginally recoverable in a run-off-road situation.

Rating = 4

- Clear zone free from obstacles between 1.5 and 3 m (5 to 10 ft) from pavement edgeline.
- Sideslope about 1:3 or 1:4.
- May have guardrail (1.5 to 2 m [5 to 6.5 ft] from pavement edgeline).
- May have exposed trees, poles, or other objects (about 3 m or 10 ft from pavement edgeline).
- Marginally forgiving in a run-off-road situation, but increased chance of a reportable roadside collision.

Rating = 5

- Clear zone free from obstacles between 1.5 and 3 m (5 to 10 ft) from pavement edgeline.
- Sideslope about 1:3.
- May have guardrail (0 to 1.5 m [0 to 5 ft] from pavement edgeline).

- May have rigid obstacles or embankment within 2 to 3 m (6.5 to 10 ft) of pavement edgeline.
- Virtually non-recoverable in a run-off-road situation.

Rating = 6

- Clear zone free from obstacles less than or equal to 1.5 m (5 ft).
- Sideslope about 1:2.
- No guardrail.
- Exposed rigid obstacles within 0 to 2 m (0 to 6.5 ft) of the pavement edgeline.
- Non-recoverable in a run-off-road situation.

Rating = 7

- Clear zone free from obstacles less than or equal to 1.5 m (5 ft).
- Sideslope 1:2 or steeper.
- Cliff or vertical rock cut.
- No guardrail.
- Non-recoverable in a run-off-road situation with a high likelihood of severe injuries from roadside collision.

Rural roadside hazard rating of 1.

Rural roadside hazard rating of 2.

Rural roadside hazard rating of 3.

Rural roadside hazard rating of 4.

Rural roadside hazard rating of 5.

Rural roadside hazard rating of 6.

Rural roadside hazard rating of 7.

Number of Through Lanes

The user is requested to input the total number of through traffic lanes in both directions of travel. On a one-way street, this is the number of through lanes in one direction.

Divided/Undivided Section

The user is asked to determine the presence/absence of a median by selecting from the following categories:

Undivided
Divided
Two-Way Left-Turn-Lane (TWLTL)

One-Way Street (only for Road Section in Developed Area)

The user is asked to state if the study section is a one-way street.

Number of Driveways in the Section

This refers to the number of driveways and unsignalized access points in the section. Access points on both sides of the road should be included in this count. This information is used to calculate the number of driveways per mile in the section (number of driveways divided by section length).

Number of Traffic Signals within the Section

This refers to the number of signalized intersections in the section. Traffic signals are defined as stop and go signals. Flashing beacons and warning beacons should not be included in this count. This information is used to calculate the number of signals per mile (number of signals divided by section length).

Presence/Usage of On-Street Parking

Users are asked to select between 'High' and 'Not High'. 'High' parking activity and usage typically occur in downtown and/or CBD areas. These areas usually have parking on both sides of the road with parking time limits that do not exceed 60 minutes, with at least 30 percent of parking spaces occupied during weekdays.

Extent of Ped/Bike Activity

Users are asked to select between 'High' and 'Not High'. Examples of areas with 'High' pedestrian and bicycle activity include:
(1) Residential developments with four or more housing units per acre interspersed with multifamily dwellings,

(2) Hotels located with 1/2 mile of other attractions such as retail stores, recreation areas, or senior centers,
(3) Downtown or CBD areas, and
(4) the presence of paved sidewalks, marked crosswalks, and pedestrian signals.

Output

The expert system provides an advisory recommended maximum speed limit along with the necessary limitations and warnings. The output can be printed and saved in a Microsoft Word file and a Microsoft Excel file. The Microsoft Word and Excel files also show the data that were input by the user for a particular project. The Word file can be formatted depending on the needs of the user. In addition, it is also possible to create a project file (.txt file) that can be used later for revising/updating the project. The .txt file is stored in the user's computer.

It is well known that driver response to speed limits is at least partially dependent on the level of enforcement and the enforcement tolerance. With regard to enforcing the speed limit, there is a wide range of unofficial enforcement tolerances used throughout the US ranging from 5 to 20 mph. However, a speed limit set with the assistance of this expert system should be enforced within 5 to 7 mph of the recommended speed limit. This allows only for reasonable speed odometer and instrument errors. Above this limit, the motorist is exceeding the safe and reasonable speed of traffic.

In addition to the recommended speed limit, the following limitations and warnings are provided:

<u>Warnings for All Roadway Types</u>

If the final recommended speed limit is higher than the statutory limit, the following warning is provided to the user:

> The final recommended speed limit is higher than the statutory speed limit for this type of road.

If the user indicates that there is adverse alignment in the section:

> Sections with adverse alignments may need specific 'maximum safe speed warnings' which may be different from the general speed limit for the section. This program does not provide maximum safe advisory speed warnings for adverse alignments.

If Length of Section is shorter than the Minimum Section Length, then the following message is provided:

> A section length of <Length> miles is too short for speed zoning on public streets and roads for the recommended speed limit. You may consider lengthening the speed zone (if that is possible) or using the speed limits from adjacent sections (if they are appropriate for this section). If the 85th percentile speeds and other data you provided

are representative of conditions for this short section, then the speed limit noted above should be considered. If the data were taken in a road section with adverse horizontal and vertical alignment, in a construction zone, or in an area with unique geometric and/or traffic control features, then the above noted speed limit may not be appropriate because this expert system is not designed to recommend advisory speeds for sharp horizontal curves, within the limits of construction zones, or in other special traffic situations.

The minimum section length for a particular speed limit is based on Table L.2 (this is the same guideline that is used in USLIMITS 1.0 and Australian XLIMITS expert systems)

Table L.2 Minimum Section Lengths

Speed Limit	Minimum Length
30mph	0.30 miles
35mph	0.35 miles
40mph	0.40 miles
45mph	0.45 miles
50mph	0.50 miles
55mph	0.55 miles
60mph	1.20 miles
65mph	3.00 miles
70mph	6.20 miles
75mph	6.20 miles

If the user does not enter crash data, the following warning is provided:

Crash data were not entered for this project. A comprehensive crash study is a critical component of any traffic engineering study. We suggest that you repeat this process when crash data become available.

If Crash or Injury Level is High or Medium, the following message is provided:

The crash rate of the section is <crash_rate> per 100 MVMT. The average rate for similar sections is <Ca> per 100 MVMT, and the critical rate is <Cc> per 100 MVMT. The crash rate of this section is <crash_diff> % higher (or lower) than the average crash rate for similar sections. The rate of injury crashes for the section is <injury_rate> per 100 MVMT. The average rate for similar sections is <Ia> per 100 MVMT, and the critical rate is <Ic> per 100 MVMT. The rate of injury crashes for this section is <Injury_diff>% higher (or lower) than the average rate for similar sections. A comprehensive crash study should be undertaken to identify engineering and traffic control deficiencies and appropriate corrective actions. The speed limit should only be reduced as a last measure after all other treatments have either been tried or ruled out.

Warnings for Limited Access Freeways

If 85^{th} percentile speed is > 77 mph, then the following warning:

Based on the information gathered from experts in the U.S., this program does not recommend speed limits higher than 75 mph.

Warnings for Road Sections in Undeveloped Areas

If 85th percentile speed is > 67 mph, then the following warning:

Based on the information gathered from experts in the U.S., this program does not recommend speed limits higher than 65 mph for non-limited access road sections in undeveloped areas.

Warnings for Road Sections in Developed Areas

If 85th percentile speed is > 52 mph, then the following warning:

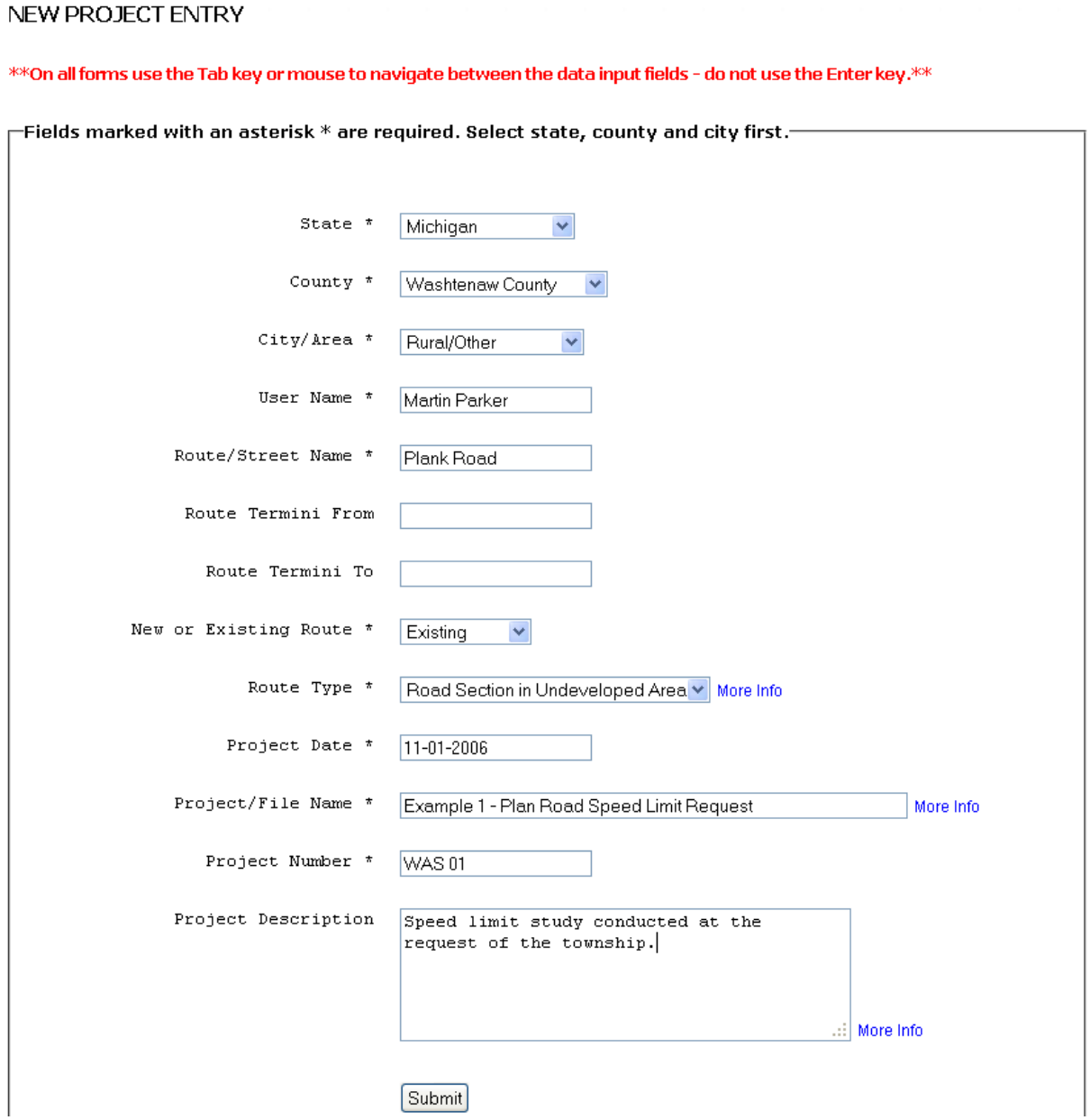
Based on the information gathered from experts in the U.S., this program does not recommend speed limits higher than 50 mph for non-limited access road sections in developed areas.

Examples

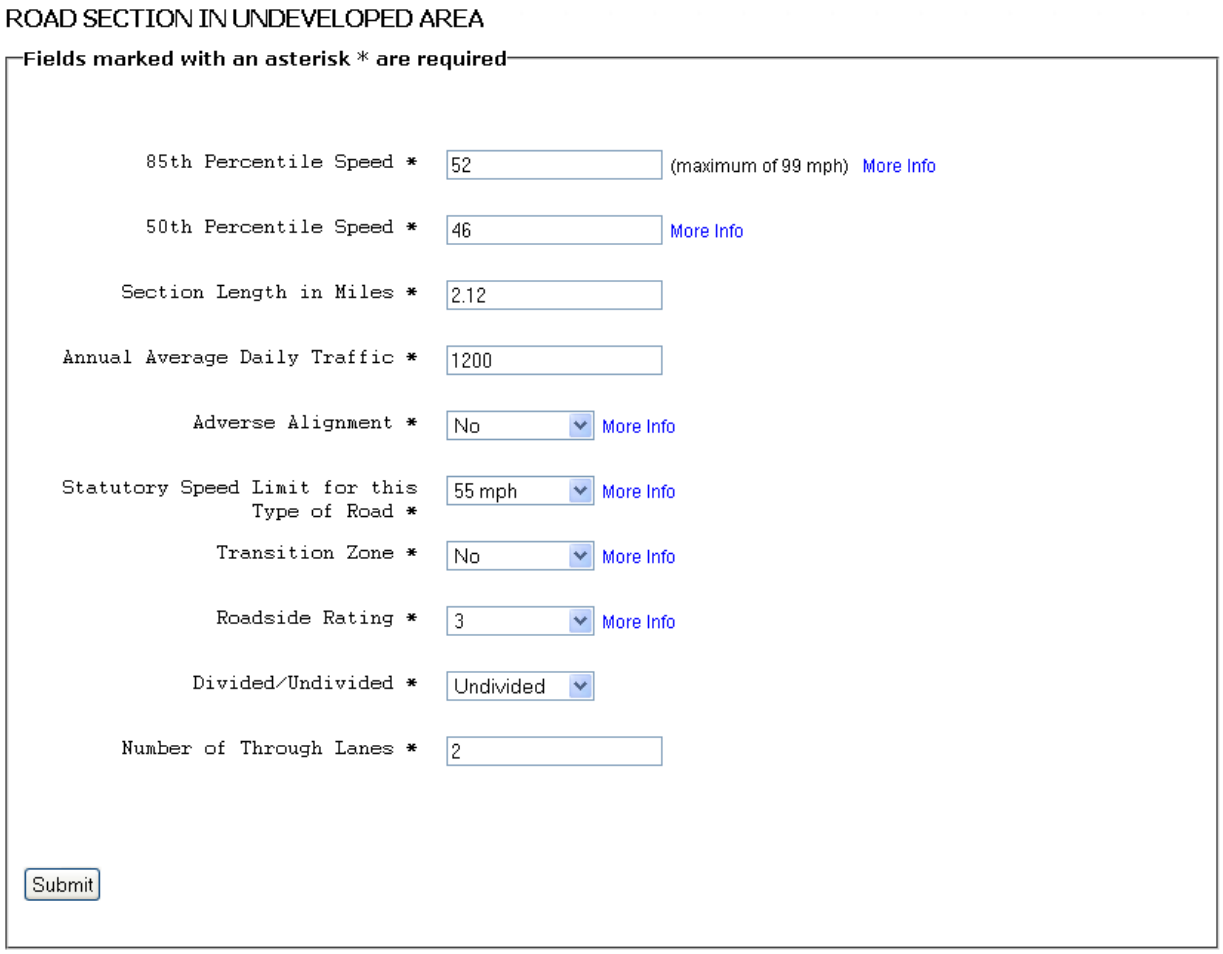
Example 1 – Speed Limit Request on a Two-Lane Road in an Undeveloped Area

The first example is a two-lane road in a rural area. At the request of the Township officials, the engineer has been asked to conduct a traffic and engineering investigation to determine if the existing maximum 50 mile per hour speed limit should be lowered. Based on data collected during the investigation, the USLIMITS2 screens below show the input variables and final suggested speed limit for this road section.

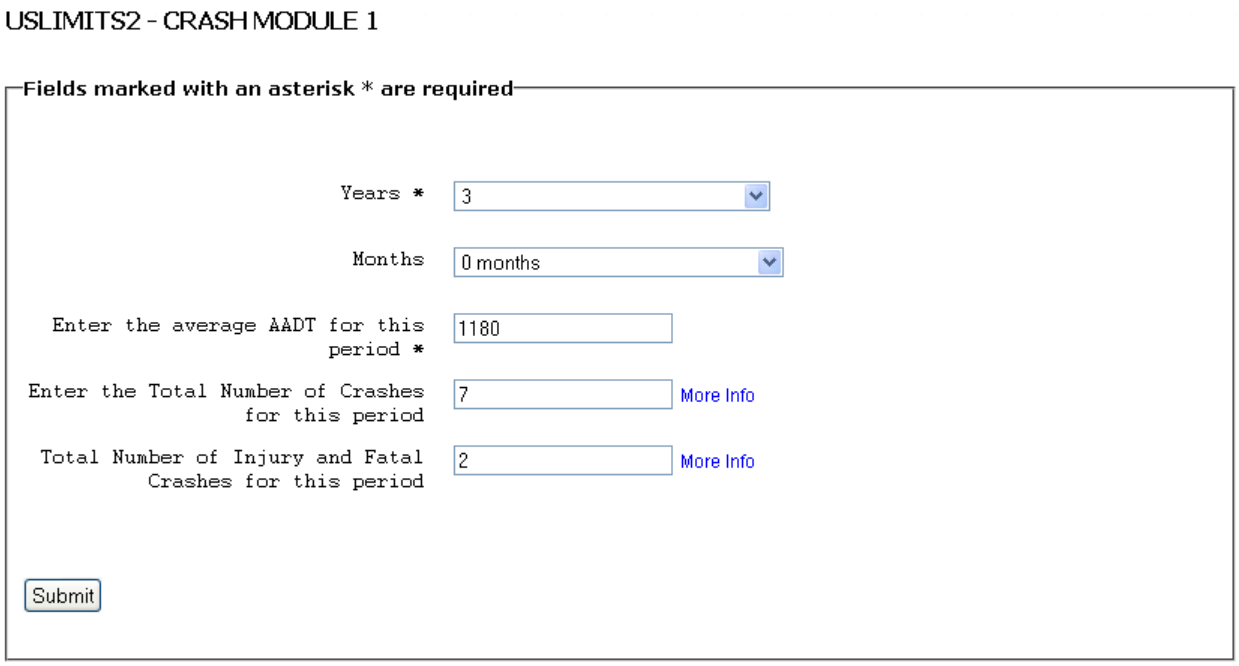
This is the Basic Location Information input screen.



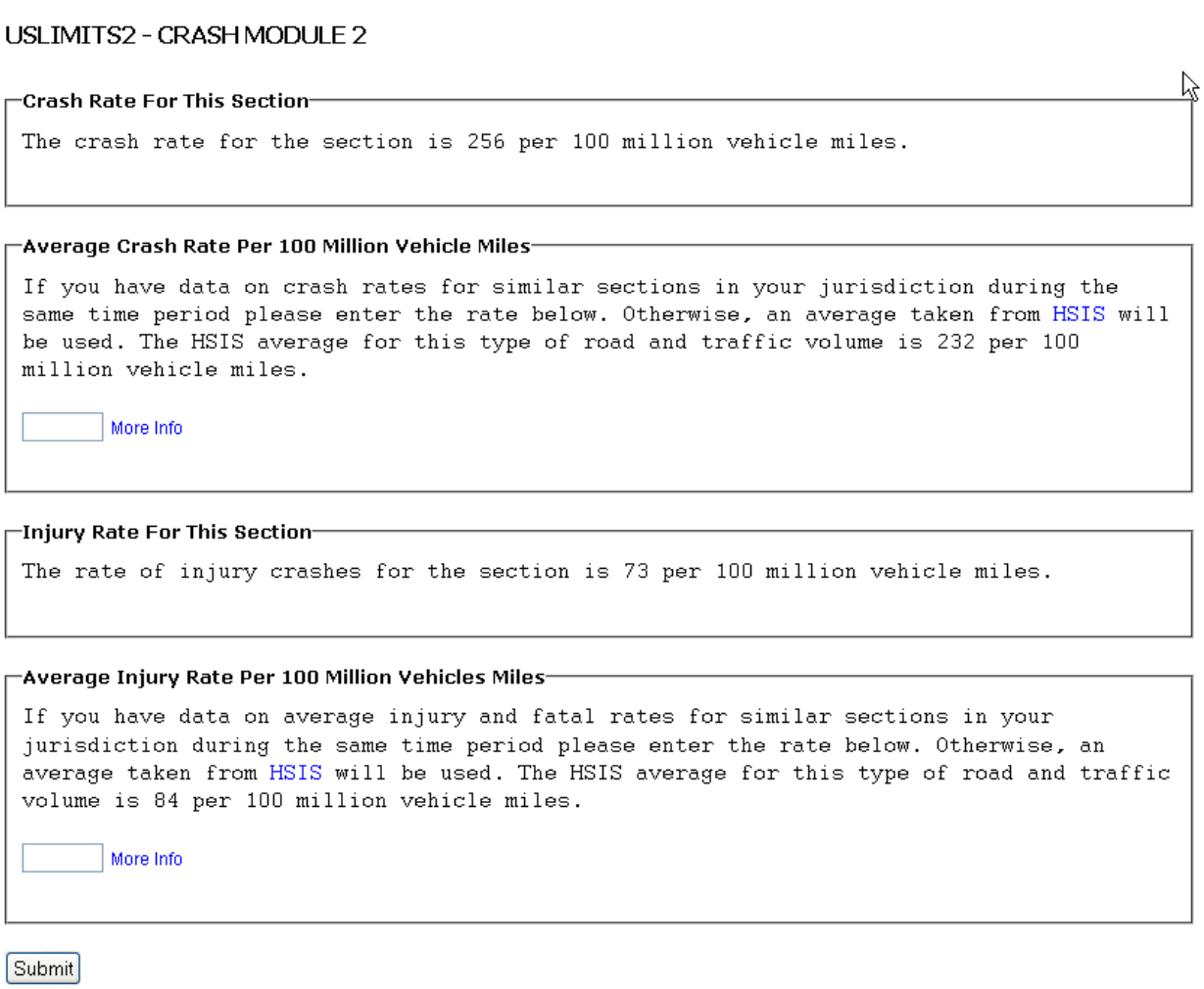
This is the basic input screen for the 85th percentile speed and other variables.



This is the input screen for the crash data.



This is the crash summary generated by USLIMITS2 based on the crash data input by the user.



This screen provides a summary of the crash calculations.

USLIMITS2 - CRASH MODULE 3

Results

Crash Rate Computations

The crash rate for this section is 256 per 100 million vehicle miles.

The Crash Rate in this section is 10% Higher than the average of similar sections.

The Critical Crash Rate is 488 per 100 million vehicle miles.

Injury Rate Computations

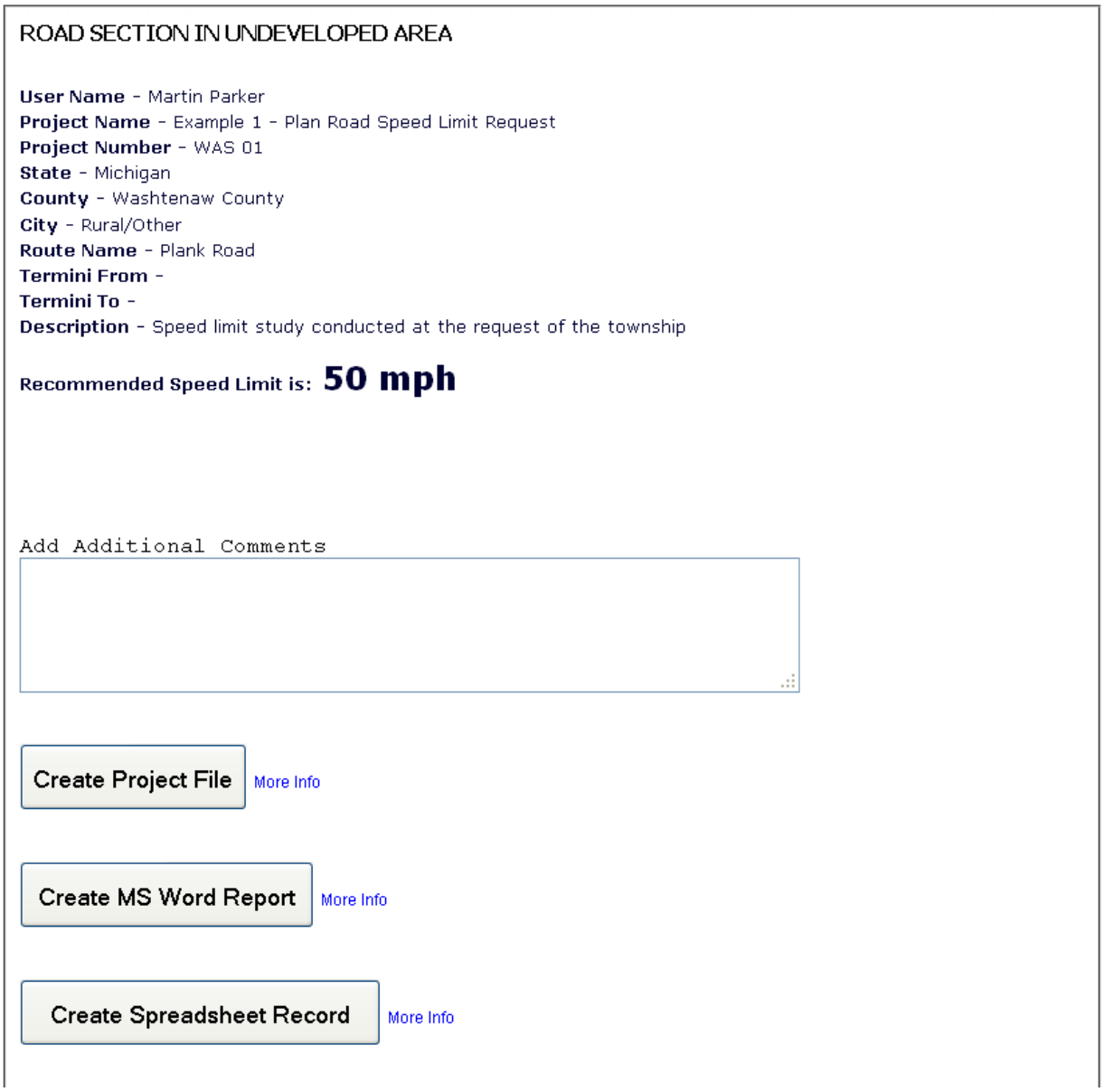
The rate of injury crashes for this section is 73 per 100 million vehicle miles.

The Rate of Injury and Fatal Crashes for this section is 14% Lower than the average rate of similar sections.

The Critical Injury Rate is 246 per 100 million vehicle miles.

Submit

This is the final output screen showing the advisory recommended speed limit for this rural road section.



The results can also be printed to a Microsoft Word file as shown below.

USLIMITS2 Data Output

Road Section in Undeveloped Area

Basic Project Information

User Name - Martin Parker
Project Name - Example 1 - Plan Road Speed Limit Request
Project Number - WAS 01
Project Date - 11-01-2006
State - Michigan
County - Washtenaw County
City - Rural/Other
Route Type - Road Section in Undeveloped Area
Route Name - Plank Road
Termini From -
Termini To -
Route Status - Existing
Description - Speed limit study conducted at the request of the township.

Roadway Information

85th Percentile Speed - 52 mph
50th Percentile Speed - 46 mph
Section Length - 2.12 mile(s)
Statutory Speed Limit - 55 mile(s)
AADT - 1200
Adverse Alignment - No
Divided/Undivided - Undivided
Number of Lanes - 2
Roadside Hazard Rating - 3

Crash Data Information

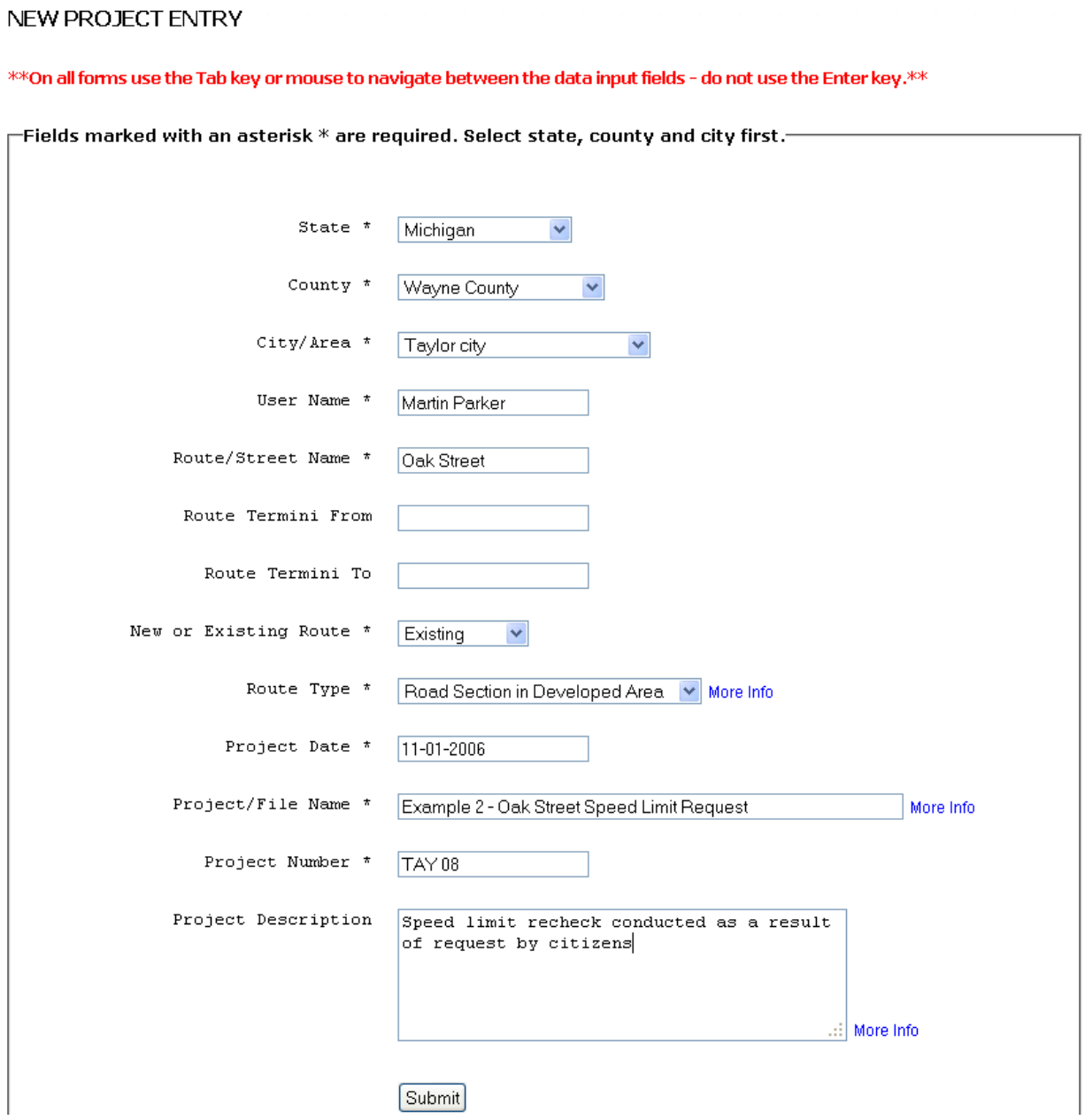
Crash Data Years/Months - 3/0
Crash AADT - 1180
Total Number of Crashes - 7
Total Number of Injury Crashes - 2
Section Crash Rate - 256
Section Injury Rate - 73
Crash Rate Average for Similar Sections - 232
Injury Rate Average for Similar Sections - 84

Recommended Speed Limit: 50

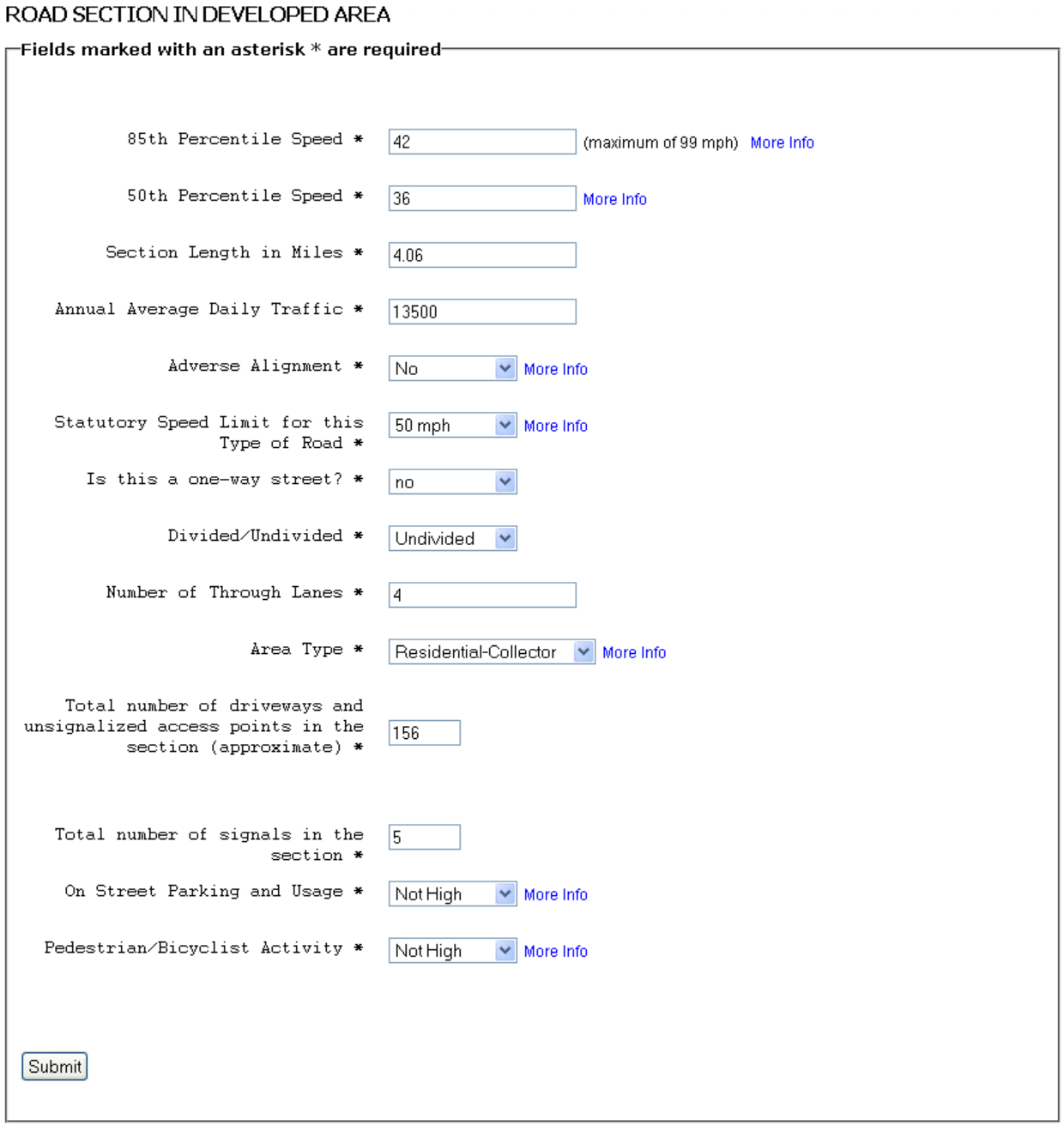
Example 2 – Speed Limit Request on a Multilane Road in a Developed Area

The second example is multilane residential collector street. Based on citizen's requests, the City Engineer has been asked to conduct a traffic and engineering investigation to determine if the existing 35 mile per hour speed limit is appropriate. Utilizing the data collected during the investigation, the USLIMITS2 screens below show the input variables and final suggested speed limit for this road section.

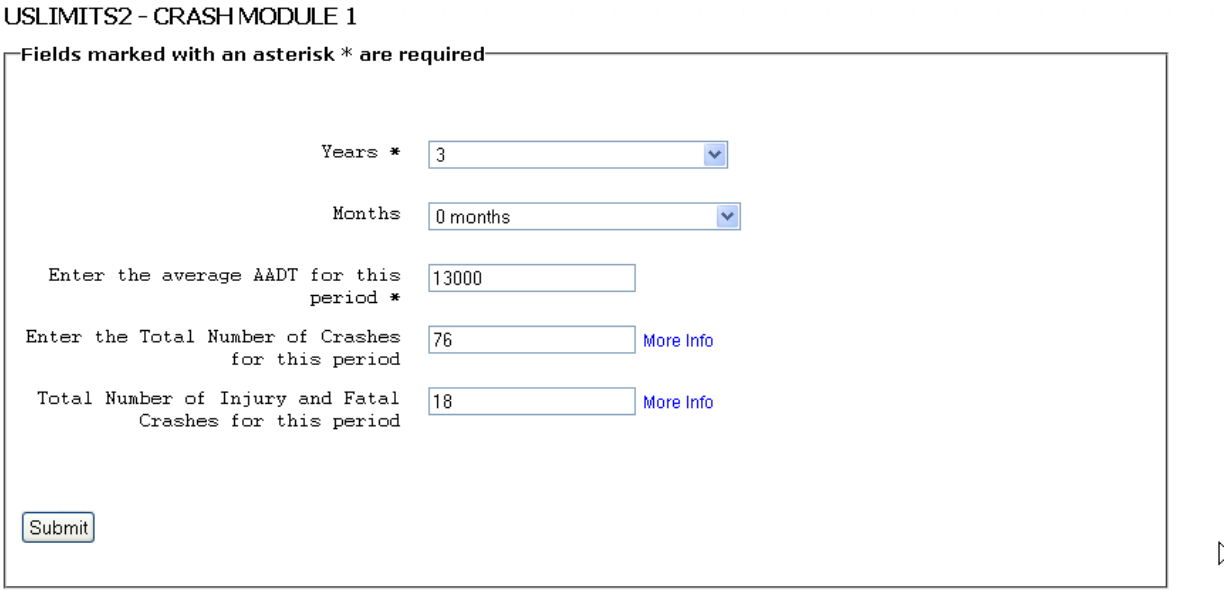
This is the Basic Location Information input screen.



This is the basic input screen for the 85th percentile speed and other variables.



This is the input screen for the crash data.



This is the crash summary generated by USLIMITS2 based on the crash data input by the user.

USLIMITS2 - CRASH MODULE 2

Crash Rate For This Section

The crash rate for the section is 132 per 100 million vehicle miles.

Average Crash Rate Per 100 Million Vehicle Miles

If you have data on crash rates for similar sections in your jurisdiction during the same time period please enter the rate below. Otherwise, an average taken from HSIS will be used. The HSIS average for this type of road and traffic volume is 383 per 100 million vehicle miles.

More Info

Injury Rate For This Section

The rate of injury crashes for the section is 31 per 100 million vehicle miles.

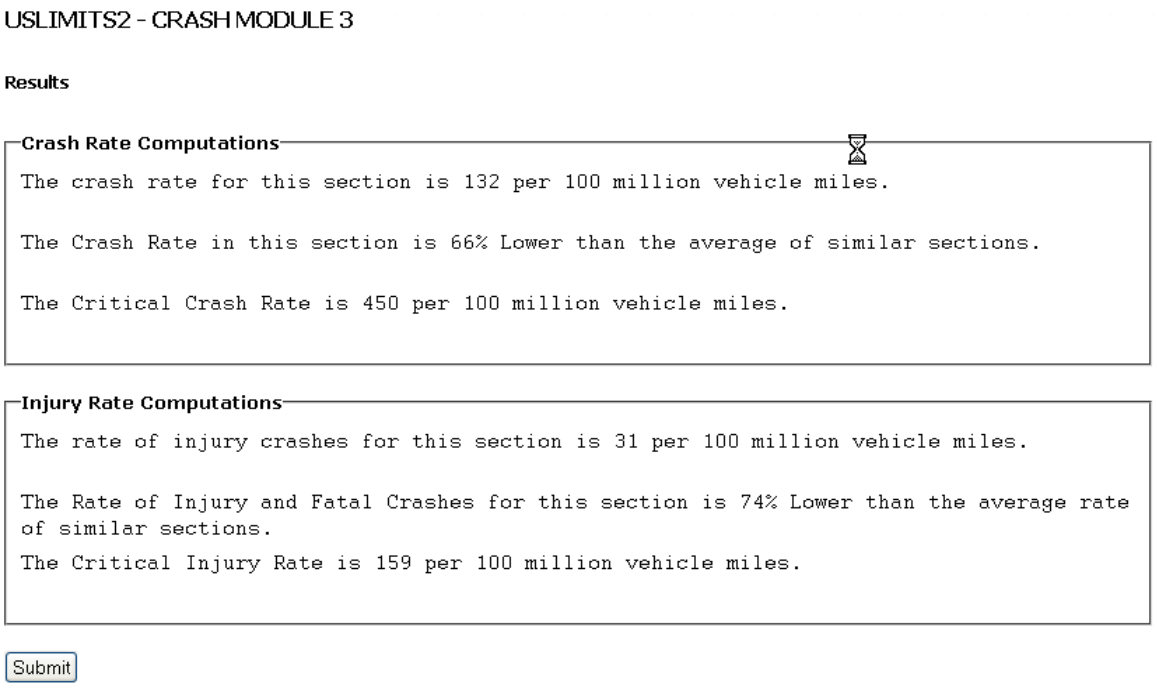
Average Injury Rate Per 100 Million Vehicles Miles

If you have data on average injury and fatal rates for similar sections in your jurisdiction during the same time period please enter the rate below. Otherwise, an average taken from HSIS will be used. The HSIS average for this type of road and traffic volume is 121 per 100 million vehicle miles.

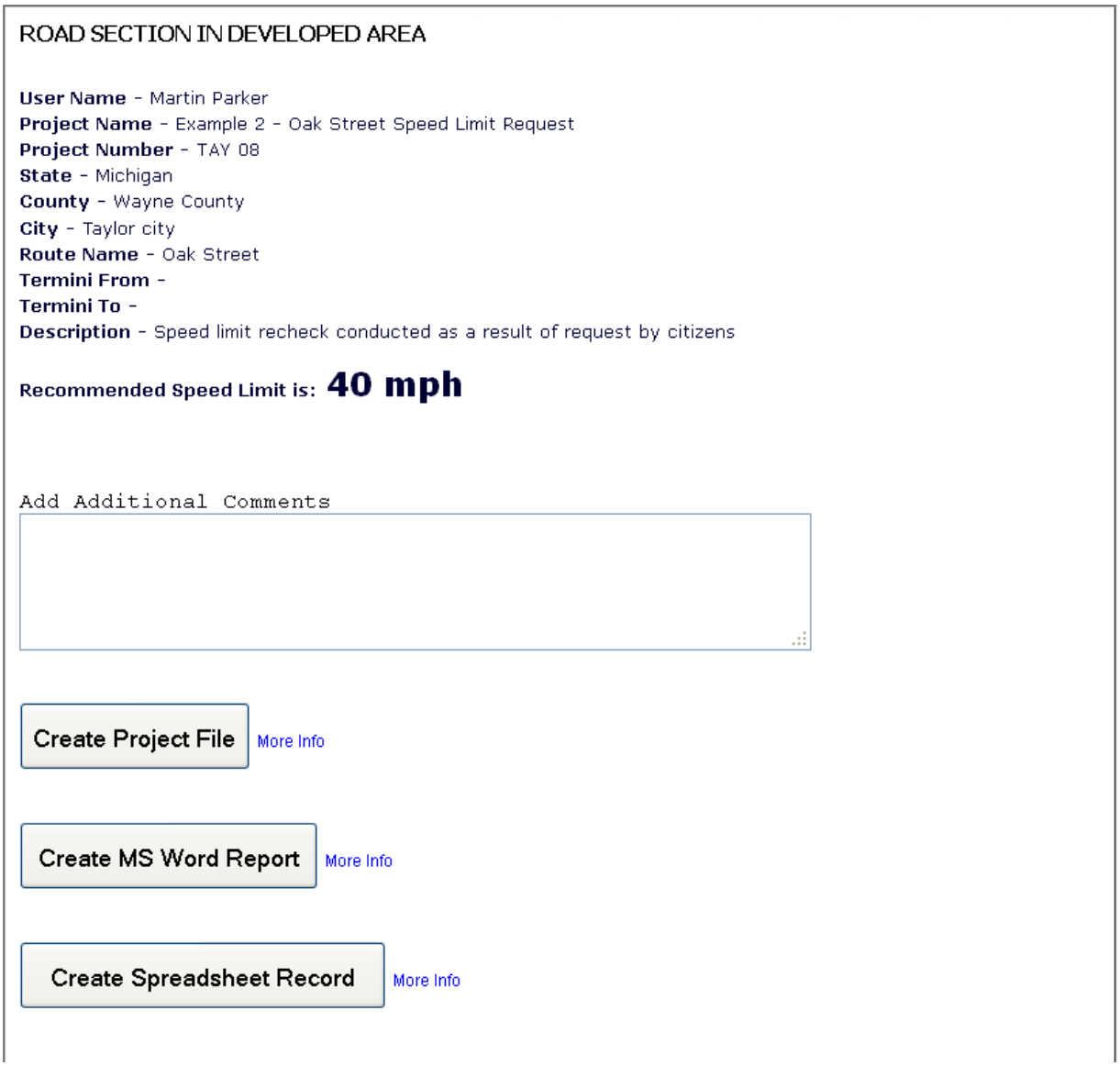
More Info

Submit

This screen provides a summary of the crash calculations.



This is the final output screen showing the advisory recommended speed limit for this urban multilane street.



The results can also be printed to a Microsoft Word file as shown below.

USLIMITS2 Data Output

Road Section in Developed Area

Basic Project Information

User Name - Martin Parker
Project Name - Example 2 - Oak Street Speed Limit Request
Project Number - TAY 08
Project Date - 11-01-2006
State - Michigan
County - Wayne County
City - Taylor city
Route Type - Road Section in Developed Area
Route Name - Oak Street
Termini From -
Termini To -
Route Status - Existing
Description - Speed limit recheck conducted as a result of request by citizens

Roadway Information

85th Percentile Speed - 42 mph
50th Percentile Speed - 36 mph
Section Length - 4.06 mile(s)
Statutory Speed Limit - 50 mile(s)
AADT - 13500
Adverse Alignment - No
One-Way Street - no
Divided/Undivided - Undivided
Number of Through Lanes - 4
Area Type - Residential-Collector
Number of Driveways - 156
Number of Signals - 5
On Street Parking and Usage - Not High
Pedestrian / Bicyclist Activity - Not High

Crash Data Information

Crash Data Years/Months - 3/0
Crash AADT - 13000
Total Number of Crashes - 76
Total Number of Injury Crashes - 18
Section Crash Rate - 132

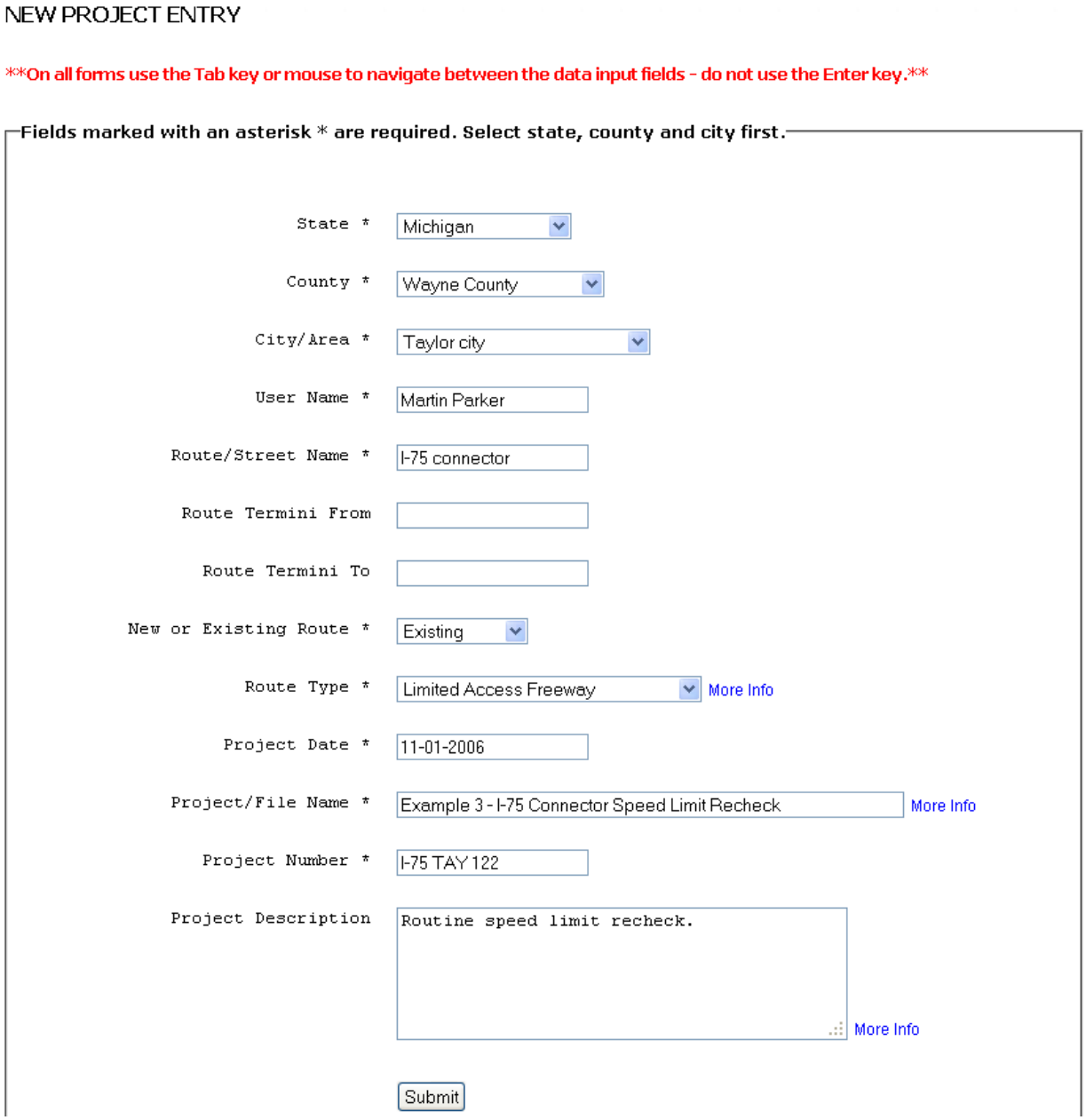
Section Injury Rate - 31
Crash Rate Average for Similar Sections - 383
Injury Rate Average for Similar Sections - 121

Recommended Speed Limit: 40

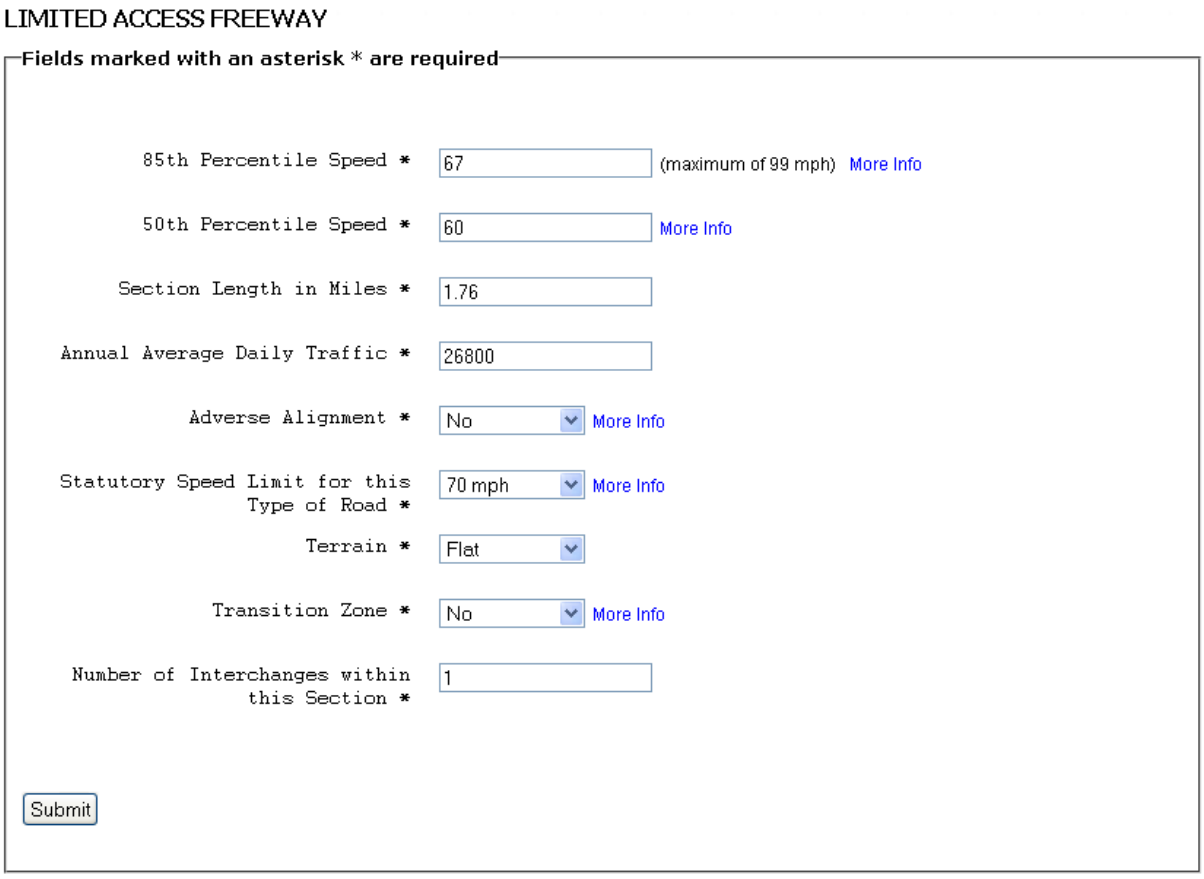
Example 3 – Speed Limit Recheck on an Urban Freeway Connector

This final example is a short freeway connector that runs between a high-volume, high-speed Interstate route and a non-limited access multilane urban arterial corridor. As a routine recheck of posted speed limits conducted every five years, the traffic engineer has been asked to conduct a traffic and engineering investigation to determine if the existing maximum 55 mile per hour speed limit is appropriate for conditions. Based on data collected during the investigation, the USLIMITS2 screens below show the input variables and final suggested speed limit for this freeway connector.

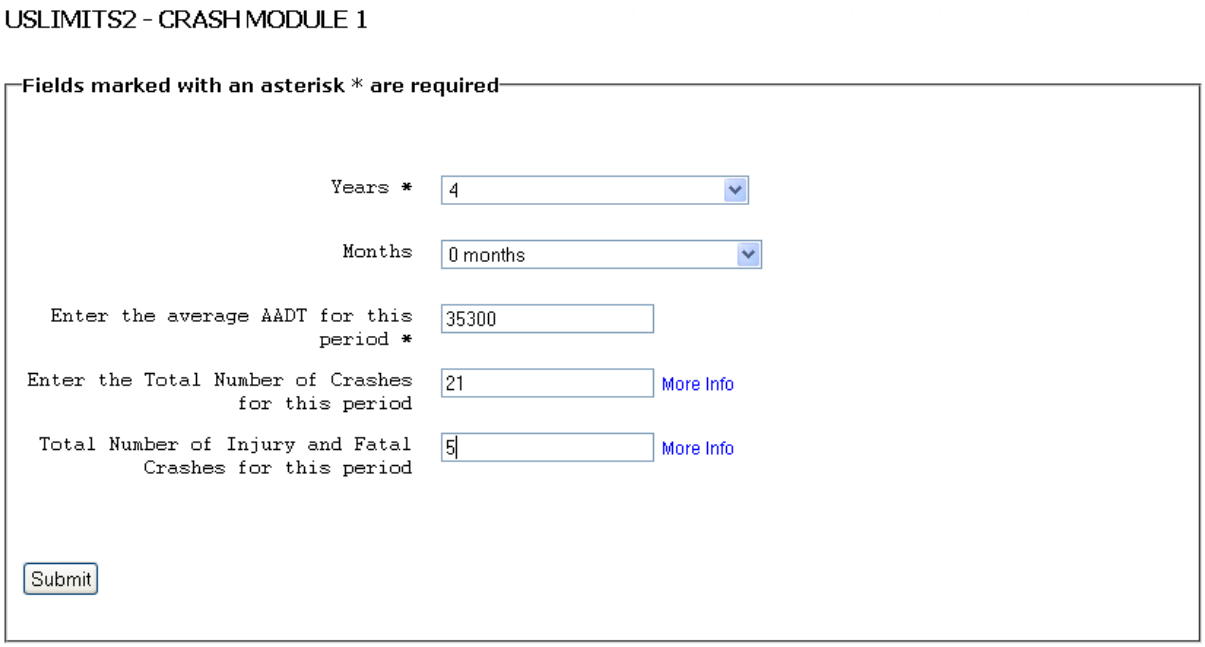
This is the Basic Location Information input screen.



This is the basic input screen for the 85th percentile speed and other variables.



This is the input screen for the crash data.



This is the crash summary generated by USLIMITS2 based on the crash data input by the user.

USLIMITS2 - CRASH MODULE 2

Crash Rate For This Section

The crash rate for the section is 23 per 100 million vehicle miles.

Average Crash Rate Per 100 Million Vehicle Miles

If you have data on crash rates for similar sections in your jurisdiction during the same time period please enter the rate below. Otherwise, an average taken from HSIS will be used. The HSIS average for this type of road and traffic volume is 56 per 100 million vehicle miles.

41 More Info

Injury Rate For This Section

The rate of injury crashes for the section is 6 per 100 million vehicle miles.

Average Injury Rate Per 100 Million Vehicles Miles

If you have data on average injury and fatal rates for similar sections in your jurisdiction during the same time period please enter the rate below. Otherwise, an average taken from HSIS will be used. The HSIS average for this type of road and traffic volume is 17 per 100 million vehicle miles.

11 More Info

Submit

This screen provides a summary of the crash calculations.

USLIMITS2 - CRASH MODULE 3

Results

Crash Rate Computations

The crash rate for this section is 23 per 100 million vehicle miles.

The Crash Rate in this section is 44% Lower than the average of similar sections.

The Critical Crash Rate is 59 per 100 million vehicle miles.

Injury Rate Computations

The rate of injury crashes for this section is 6 per 100 million vehicle miles.

The Rate of Injury and Fatal Crashes for this section is 50% Lower than the average rate of similar sections.

The Critical Injury Rate is 21 per 100 million vehicle miles.

Submit

This is the final output screen showing the advisory recommended speed limit and the appropriate notes for this freeway connector.

LIMITED ACCESS FREEWAY

User Name - Martin Parker
Project Name - Example 3 - O-75 Connector Speed Limit Recheck
Project Number - I-75 TAY 122
State - Michigan
County - Wayne County
City - Taylor city
Route Name - I-75 connector
Termini From -
Termini To -
Description - Routine speed limit recheck

Recommended Speed Limit is: 65 mph

Note: A section length of 1.76 miles is too short for speed zoning on public streets and roads for the recommended speed limit. You may consider lengthening the speed zone (if that is possible) or using the speed limits from adjacent sections (if they are appropriate for this section). If the 85th percentile speeds and other data you provided are representative of conditions for this short section, then the speed limit noted above should be considered. If the data were taken in a road section with adverse horizontal and vertical alignment, in a construction zone, or in a area with unique geometric and/or traffic control features, then the above noted speed limit may not be appropriate because this expert system is not designed to recommend speed limits for sharp horizontal curves, within the limits of construction zones, or in other special traffic situations.

Add Additional Comments

The results can also be printed to a Microsoft Word file as shown below.

USLIMITS2 Data Output

Limited Access Freeway

Basic Project Information

User Name - Martin Parker
Project Name - Example 3 - O-75 Connector Speed Limit Recheck
Project Number - I-75 TAY 122
Project Date - 11-01-2006
State - Michigan
County - Wayne County
City - Taylor city
Route Type - Limited Access Freeway
Route Name - I-75 connector
Termini From -
Termini To -
Route Status - Existing
Description - Routine speed limit recheck

Roadway Information

85th Percentile Speed - 67 mph
50th Percentile Speed - 60 mph
Section Length - 1.76 mile(s)
Statutory Speed Limit - 70 mile(s)
AADT - 26800
Terrain - Flat
Adverse Alignment - No
Interchanges - 1

Crash Data Information

Crash Data Years/Months - 4/0
Crash AADT - 35300
Total Number of Crashes - 21
Total Number of Injury Crashes - 5
Section Crash Rate - 23
Section Injury Rate - 6
Crash Rate Average for Similar Sections - 41
Injury Rate Average for Similar Sections - 11

Recommended Speed Limit: 65

Note: A section length of 1.76 miles is too short for speed zoning on public streets and roads for the recommended speed limit. You may consider lengthening the speed zone (if that is possible) or using the speed limits from adjacent sections (if they are appropriate for this section). If the 85th percentile speeds and other data you provided are representative of

conditions for this short section, then the speed limit noted above should be considered. If the data were taken in a road section with adverse horizontal and vertical alignment, in a construction zone, or in a area with unique geometric and/or traffic control features, then the above noted speed limit may not be appropriate because this expert system is not designed to recommend speed limits for sharp horizontal curves, within the limits of construction zones, or in other special traffic situations.