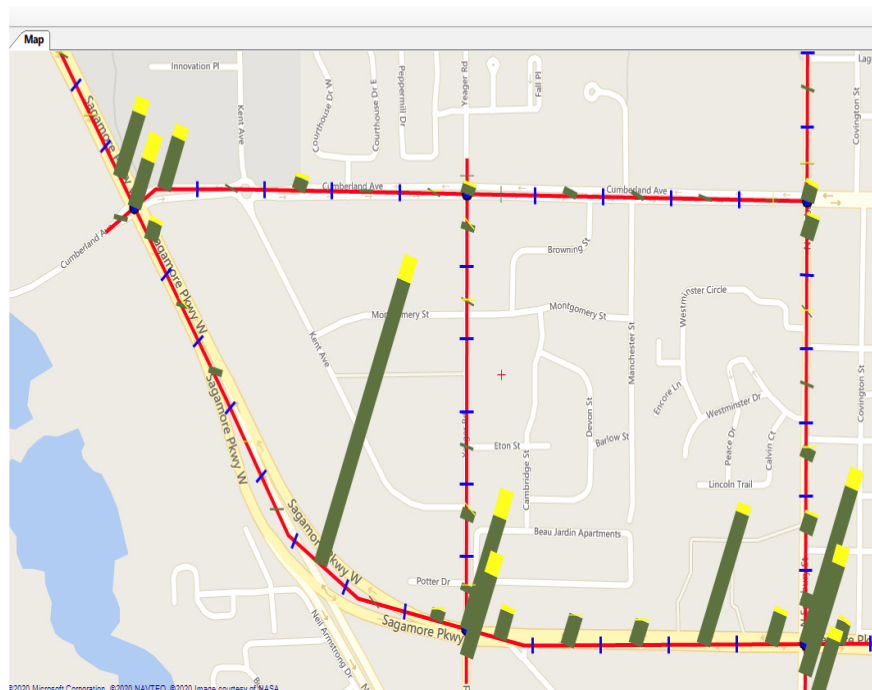


# JOINT TRANSPORTATION RESEARCH PROGRAM

INDIANA DEPARTMENT OF TRANSPORTATION  
AND PURDUE UNIVERSITY



## Collision Diagram Builder: Phase II Corridor Edition



**Andrew P. Tarko, Jose Thomaz, Mario Romero**

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## PREFACE

The Collision Diagram Builder–Corridor Edition (Corridor CDB) is a tool developed by the Center for Road Safety at the request of the Indiana Department of Transportation. Its development was supported through the Joint Transportation Research Program of Purdue University and the Indiana Department of Transportation. The primary objective of the tool is to expand the existing Collision Diagram Builder to make it useful for analyzing spatial patterns of various types of crashes at multiple intersections and on segments in corridors and networks of considerable size. The expanded CDB displays crashes at major intersections—a feature available in the original version—and between these intersections on roads divided by the user into short segments to allow analysis of crash grouping between intersections. This user manual describes Corridor CDB and presents examples that illustrate its features. Corridor CDB runs in the MS Windows environment with a 64-bit operating system. In order to render the maps that are a part of the tool, the software requires an Internet connection.

## OVERVIEW

The 2016 workshop for INDOT introduced the Collision Diagram Builder (CDB) for Intersections. The workshop has also confirmed a need for expansion of the CDB to make it better fit a corridor-based crash pattern analysis. Although the existing tool could be used repeatedly for each intersection of a studied corridor, segments could not be handled properly. Given the large geographical scope of analysis and a larger number of crashes, a more aggregate display of crash patterns is needed to reveal the large-scale crash grouping more effectively. Corridor CDB has been developed with this objective in mind.

Corridor CDB is a computer application that supports the following operations:

- creating user-defined road corridors and grids of multiple road segments and intersections;
- displaying crashes aggregated and visualized at levels suitable for large road corridors and grids; and
- exporting data of selected intersections for detailed analysis with the Intersection CDB and providing input support for RoadHAT.

### Defining a Corridor Layout

Although the remainder of the manual refers mostly to corridors, the CDB features can be used to define road networks of any shape and complexity. The Corridor CDB has several tools to facilitate defining road corridors. The program provides the user with options to execute the following tasks:

- add, edit or delete road segments;
- automatically identify all intersections;
- remove undesired intersections;
- split any segment into smaller segments of user specified length;

- manually change the length of individual segments or groups of segments; and
- trim external segments at any end intersection.

### Crash Assignment and Aggregation

Once a corridor is defined, crashes need to be assigned to the corridor intersections and segments (more precisely, sub-segments). CDB for corridor provides means for the user to do the following:

- assign crashes in the user-defined buffer around the corridor to the corridor elements using crash geo-coordinates;
- inspect and correct the assignment of individual crashes, if needed;
- display crash frequency bars for each sub-segment and intersection;
- display crash frequency bars by direction of travel;
- display crash frequency bars divided by user-selected crash attributes, such as severity, surface conditions, light conditions, or manner of collision;
- apply user-selected filters to the crash frequency bars;
- control the angle, scale and width of the crash frequency bars; and
- save files with the crash frequency bars.

### Support for Intersection CDB and RoadHAT

Once the user has properly defined sub-segments and intersections along a corridor and assigned crashes, Corridor CDB can export data files which can be used as input to Intersection CDB. The program also allows the user to automatically count crashes broken down by severity along sub-segments of user defined length and position. These counts can be copied and pasted in the RoadHAT as its input.

## INSTALLATION

The Corridor CDB program, in its current version, is distributed as a self-contained application. Any supplementary instructions will be included in the readme.txt file. The user should click on the setup.exe file to start the installation process. Once the installation is completed, the program can be accessed through the Windows Start Menu under the name Corridor CDB. When the program is run for the first time, it creates a folder called CDBCorridor\_Data/Studies in the user's windows documents folder. This folder is a default location for new study folders to be created.

## DATA REQUIREMENTS

The Corridor CDB helps the user assign crashes and identify crash patterns on segments and at intersections within the studied corridor. The program automatically assigns each crash to its location as determined by its geo-coordinates and aggregates crashes according to user-defined criteria defined on the police-reported crash information. Thus, police crash data is required.

Corridor CDB can also be used to export data to Intersection CDB, and therefore, both programs require the same types of data files. The following tables from the Indiana State Police (ISP) database should be provided by the user:

- Collision (Record Type = 10)
- Unit (Record Type = 20)
- Factors (Record Type = 22)

The three types of tables should be in the CSV-format files and should follow the specifications of the ISP database ARIES.

It is recommended that the data files contain crash data only for the county (or townships) with the study corridor. Keeping the file as small as necessary reduces both the need for computational resources and the processing time.

Corridor CDB uses an online Microsoft Bing map on which the corridor is defined by the user and then assigned crashes and created crash frequency bars displayed. Therefore, an internet connection is necessary to run the program.

## USER INTERFACE

The user interface of Corridor CDB (see Figure 1) is composed of five components: a toolbar area and four panels.

1. The *Toolbars* provide the project management options. The two toolbars offer tools to create and edit the corridor components and to import and assign crashes. It also facilitates exporting an image of the user-defined corridor, the visualized crash patterns, the segment and

intersection tables, and also facilitates changing the type of a background map.

2. The *Background Map* panel of the interface is the area where roads of the studied corridor are drawn by the user and where crash locations and frequency bars are displayed.
3. The *Crash Table* displays the user-imported crash data. It allows the user to identify each crash on the map and to check the source data for this crash, regardless if crash is assigned or unassigned.
4. The *Corridor Elements Tables* display detailed information about the roads, sub-segments, and intersections included in the studied corridor. These tables are automatically updated, and they reflect the currently user-defined and edited corridor elements. The tables display the road names, lengths of sub-segments, the coordinates of intersection and sub-segment ends, and the counts of crashes assigned to intersections and sub-segments by user-defined categories.
5. The *Visualization Controls* offer the user options to modify the way crashes are aggregated and displayed.

Except for the toolbars, the sizes of panels can be changed, and their positions rearranged. A panel starts floating after clicking on its top bar dragging from its original position. To dock the panel, drag the panel towards a desired position until the interface shows the panel docked.

## TOOLBARS

### Study Options

The Study menu (Figure 2) on the top toolbar displays optional operations on the study files. New Study option creates a new study, Open Study option opens an existing study, Save Study option saves changes to the

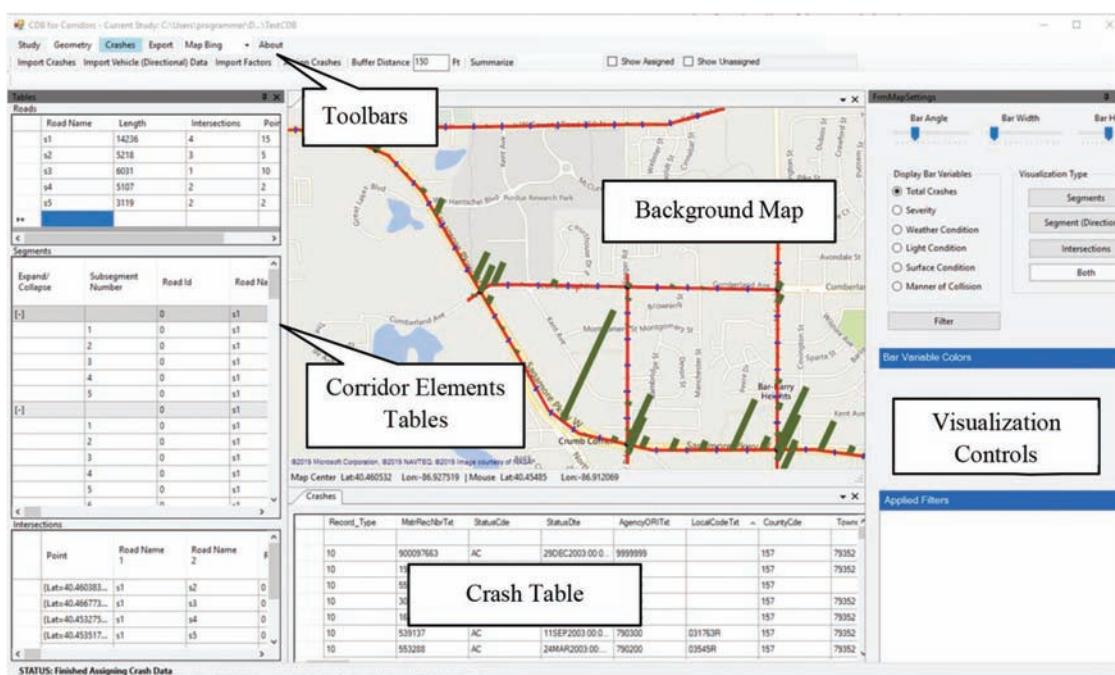
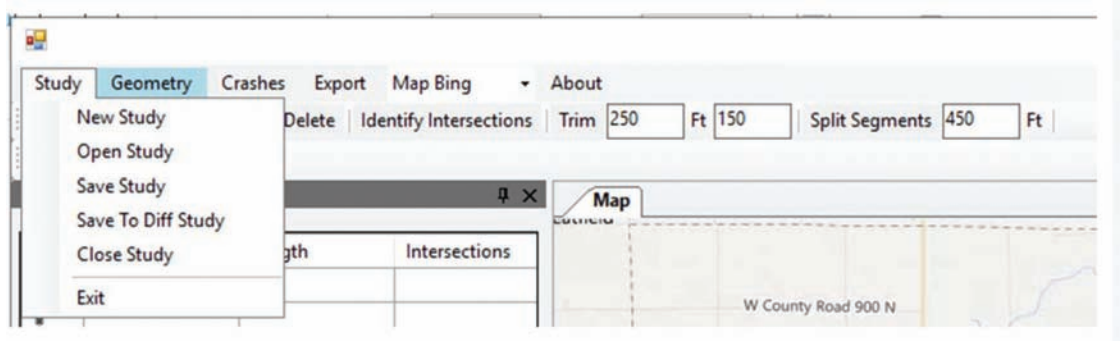


Figure 1 User interface of Corridor CDB.





**Figure 2** Managing a study.

currently open study, Save to Diff Study option saves files of the currently open study to another study folder, Close Study option closes an open study, and Exit option exits the program.

The user starts a study by selecting the Study/New Study option (Figure 2). The default location of the new study folder is Documents/CDBCORRIDOR\_Data/Studies. The new study folder can be created elsewhere by selecting a different path.

Once a project name is typed and confirmed, it becomes default for the new study and a folder under this name is created in the default or user-selected location. Any subsequently generated corridor data, road, segment and intersection tables as well as any imported crash data are saved to the new folder by pressing the Save Study option in the Study menu. The user also has the option to save the current work in a different study folder by selecting the Save to Diff Study option. This action lets the user preserve the original study data and save modifications in a different folder.

The user can open a previously created and saved study by selecting the option Open Study. When the user selects this option, the program loads the existing corridor map, and populates the tables for roads, segments, intersections, and crash data with the existing data from the selected study. The crash assignments to the existing corridor are executed automatically.

The Close Study option should be used before creating a new study or opening a different one. This option resets the map and all tabulations, bringing the program to a clean state.

### Geometry Tools

The Geometry menu on the top bar (Figure 3), displays below another toolbar with tools needed to define a corridor.

Selecting the Add Line button in the toolbar highlights this button in blue and the user may start drawing

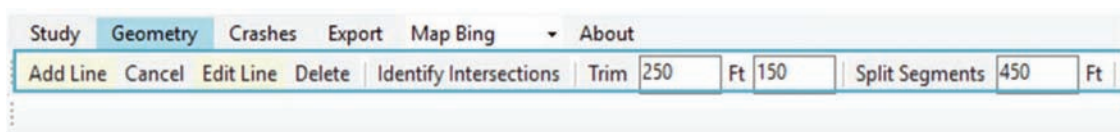
a polyline that represents the centerline of a road. A polyline is a sequence of points (vertices) connected with straight lines. The button remains blue until it is clicked again to finish drawing a polyline. While the Add Line button is blue, the user can keep extending the polyline by repeatedly clicking the left button of the mouse at desired locations of new vertices. If the user reaches the limit of the visible area and wants to continue drawing the same polyline, the user can display the invisible area by *left-clicking anywhere in the map and dragging it* to reveal more map. This action moves the map and does not generate a new line. Then, releasing the left button and clicking again at the desired location of a new vertex without dragging the map switches the tool back to its drawing mode and another line is added.

At each click of the mouse, a new vertex is drawn, and a red line connects the points. The first vertex of the polyline is colored red. The last vertex marked by the user is colored green. All intermediate vertices are colored yellow. The user may enter the name of the currently drawn road in the text box in the Editing area located by default on the left panel (Figure 4) at any time before completing the polyline. To complete drawing the polyline, the user clicks on the Add Line button. If the user clicks on the Add Line button to finish defining the road before entering its name, a pop-up reminder will be displayed. Once the process of adding lines for a road is finished, the highlighted vertex markers disappear, and the red line remains (Figure 5).

The process of adding lines can be interrupted at any time by pressing the Cancel button. This action will turn off the Add Line mode and erase all the vertex markers and lines drawn during this mode. The Add Line button will return to gray color.

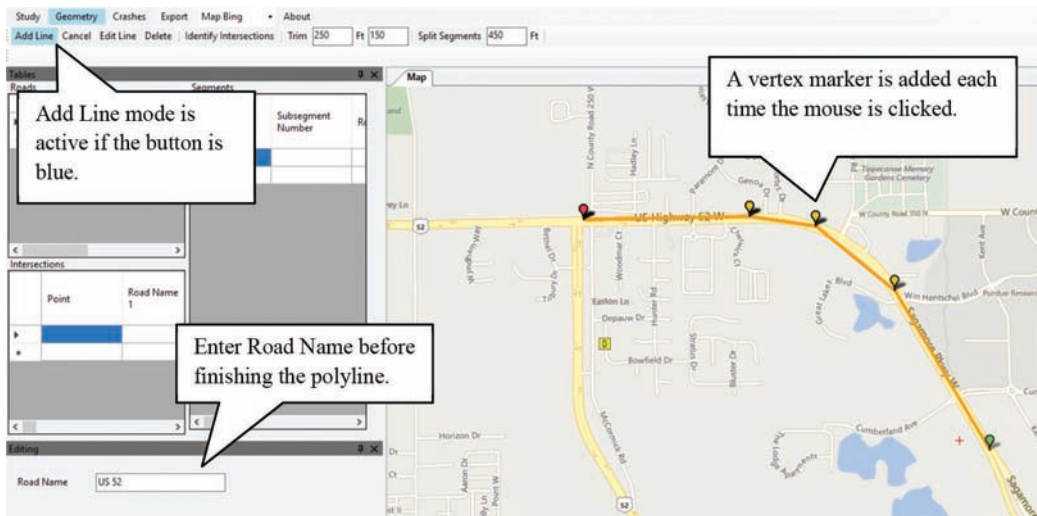
Complex networks are obtained by drawing roads repeatedly. These roads may cross each other (Figure 6).

After all centerlines of the study roads are drawn, intersections may be identified and segments between

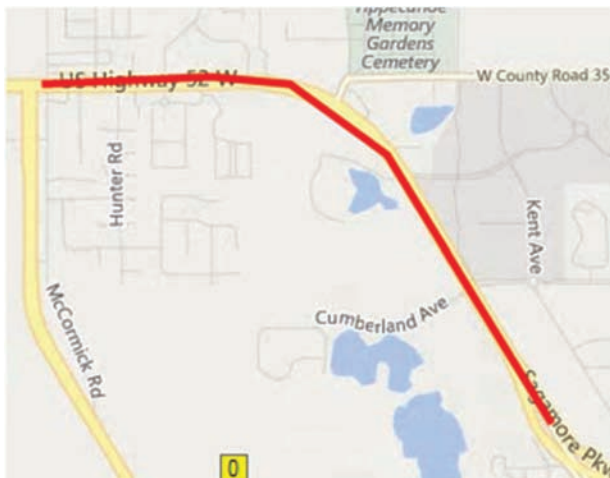


**Figure 3** Corridor geometry creation commands.





**Figure 4** Drawing lines on the map.



**Figure 5** The red color indicates that the adding line mode is turned off.

intersections split into smaller sub-segments. The Identify Intersections button executes identification of every intersection of two or more roads represented by the polylines. The identified intersections are marked with blue circles (Figure 7).

Some crossing points identified as intersections are overpasses. The user may delete such points by clicking the Delete button (Delete mode turns on) and then by clicking on all identified intersection (blue circles) to be removed. The selected for deletion intersections turn yellow (Figure 8). Clicking the Delete button again deletes all the marked intersections at once. Pressing the Identify Intersections button again restores all the deleted intersections.

The Trim button (Figure 9) trims all segments that do not connect two intersections to the length specified by the user (Figure 10). There is also a field for a minimum trimming length (150 ft in Figure 9) in case the drawn length of an intersection leg is already less than

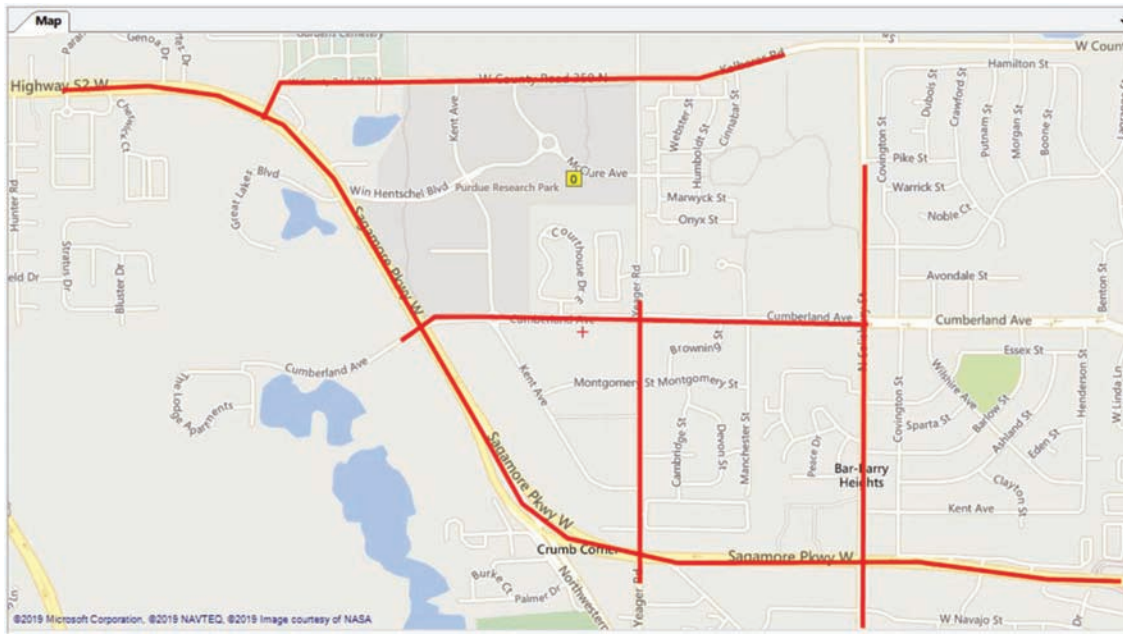
the trimming length. In such case, the leg will be trimmed to the minimum length. If the length of the leg is less than the minimum trimming length, the leg will be removed (i.e., trimmed to length zero). Trimming is optional, and the Edit Line command will show how the user can prevent certain segments from being trimmed.

The Edit Line button turns the edit mode on. The button remaining blue indicates the edit mode active. Clicking the button again turns the edit mode off. A second toolbar appears in the edit line mode (Figure 11). This toolbar provides tools for modifying the polylines by inserting and deleting vertex markers. Other tools are used to split segments with splitters and to modify the sub-segments by adding or deleting splitters, and by changing the distribution of splitters along segments. Preventing trimming of selected lines is also possible.

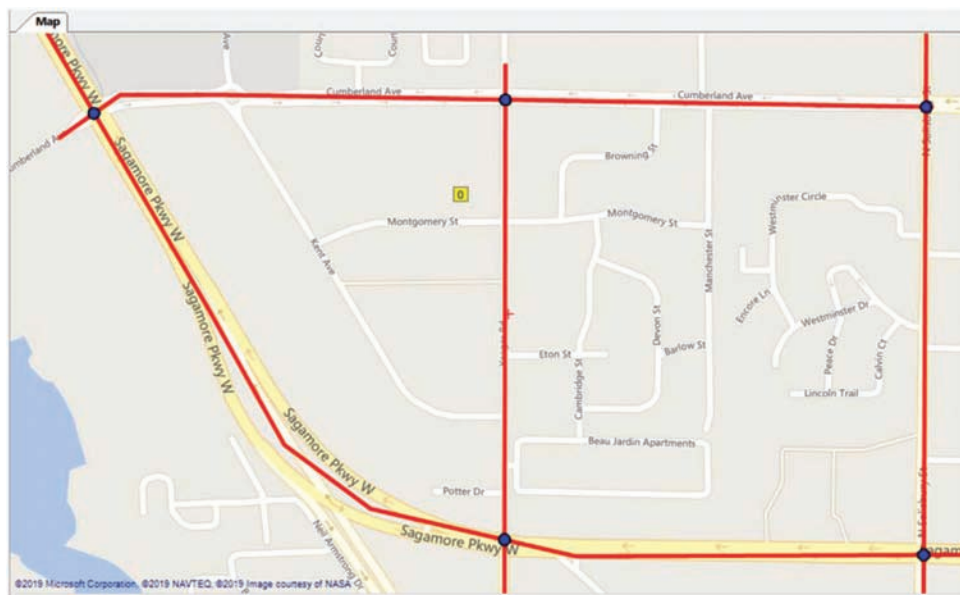
Once the Edit Line mode is turned on, the user clicks on a road to edit. The selected road changes its color from red to orange and the vertex markers of the polyline appear. The box with the name of the road reappears to give the user an opportunity to rename the road.

The Edit Line toolbar allows the following operations on a polyline:

- *Move any vertex marker.* To adjust a marker position, the user clicks on the point and drags it to a new position.
- *Insert new vertex markers.* Refining a curve or extending the road (Figure 12) is done by clicking on the Insert Point button, to activate the insert mode, and by clicking with the mouse at the desired position of the new vertex marker. Multiple vertex markers are entered by clicking repeatedly in a sequence. If a new vertex is within the segment limit, the road shape adjusts follow the new point. If a new vertex is outside of the segment limit, the road is extended to the new point. Once all the desired points are added, the user presses the Insert Point button again to deactivate the insert mode. The road remains selected until the Edit Line button is clicked for the second time.
- *Delete vertex markers.* To delete a vertex marker, the user clicks on the Delete Point button to activate the delete



**Figure 6** Complex network of roads.



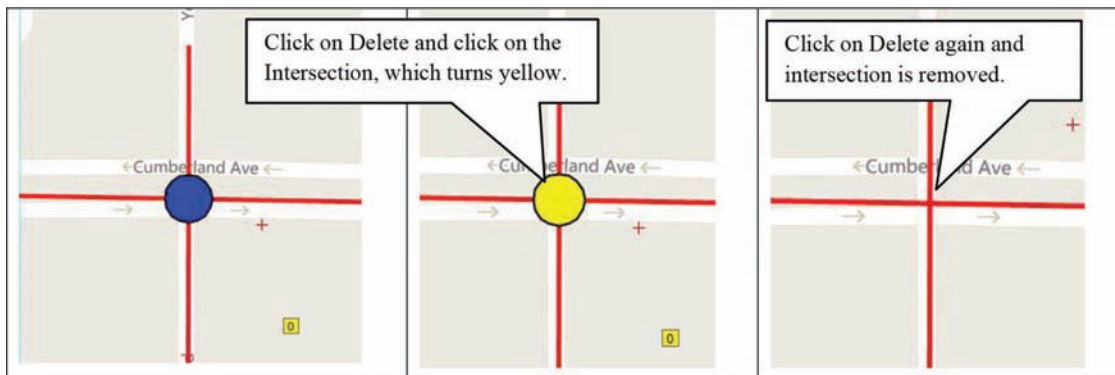
**Figure 7** Identified intersections.

mode, and then click on the vertex marker. A marker is clicked on is immediately removed and the road shape adjusts accordingly. The user may delete multiple vertex markers by clicking on them in sequence. To turn off the delete mode, the user clicks on the Delete Point button again. The road remains selected until the Edit Line button is clicked.

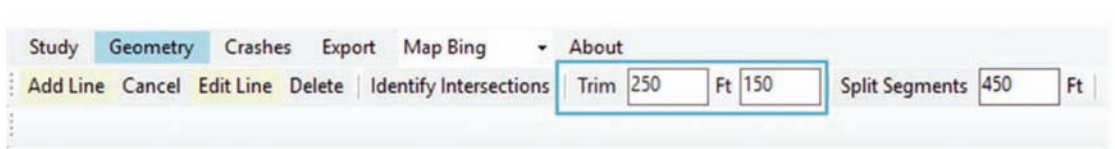
- **Add splitters.** To further divide or change the lengths of sub-segments of a selected road, the user presses the Add Splitter button to activate the insert mode, and then click with the mouse at the desired position of a new splitter (Figure 13). The user may insert multiple splitters. Once all the desired splitters are added, the user presses the

Add Splitters button again to deactivate the insert mode. The road remains selected until the Edit Line button is clicked for the second time.

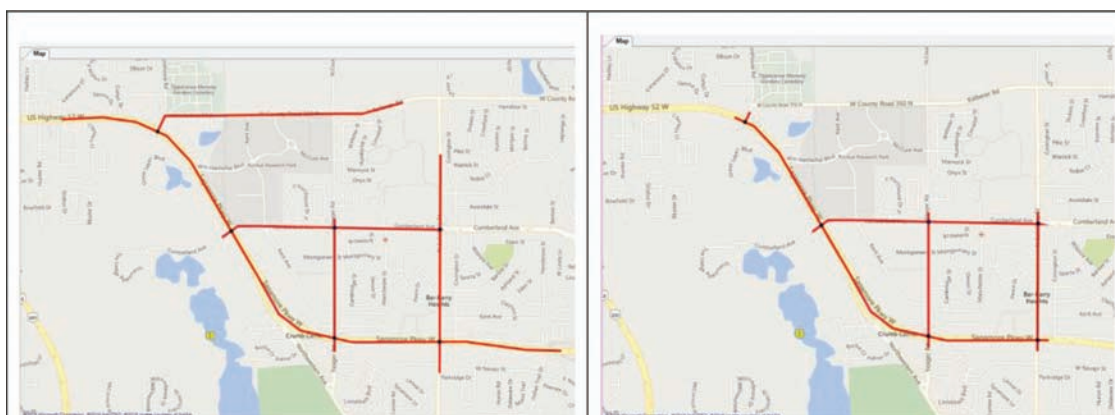
- **Delete splitters.** The Delete Splitters button is used to combine adjacent road sub-segments. The user should click the Delete Splitters button to activate the delete mode. Clicking on multiple splitters changes their color and pressing the Delete Splitters button deletes them (Figure 14). The road remains selected until the Edit Line button is clicked.
- **Use the No Trim button to prevent a road from being trimmed at intersections.** Once the No Trim button is clicked, the user selects the red and the green vertex markers



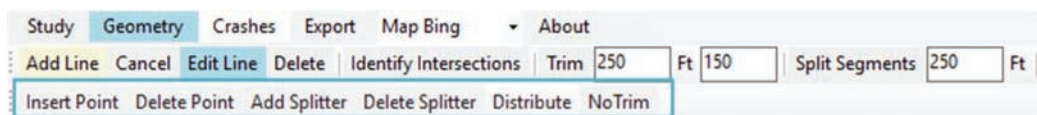
**Figure 8** Deleting an intersection.



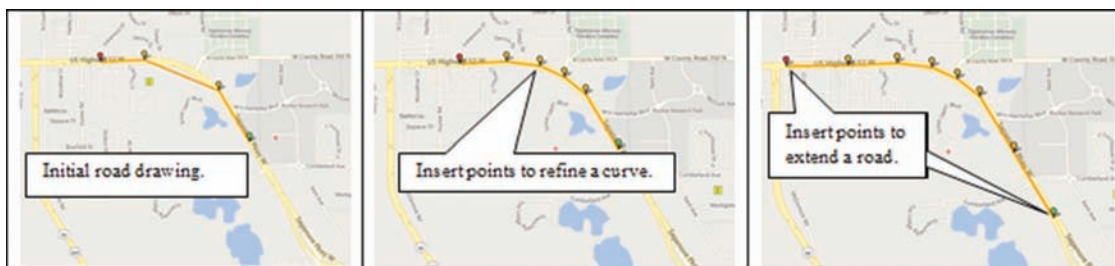
**Figure 9** Trim button.



**Figure 10** Trimming intersection legs.



**Figure 11** Edit line commands.



**Figure 12** Inserting points.



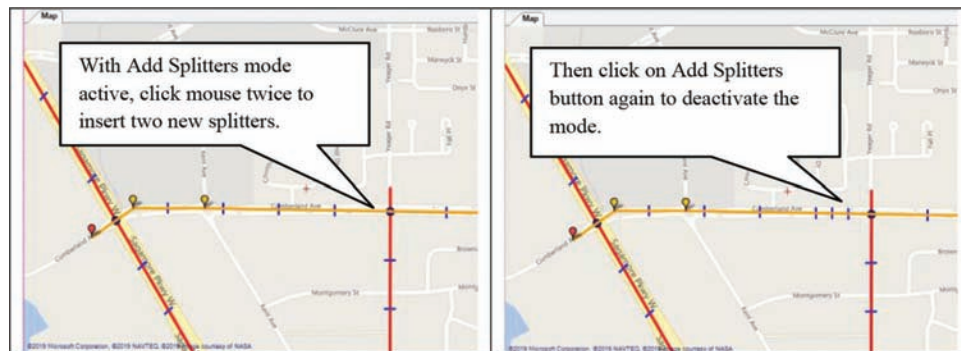


Figure 13 Inserting splitters.

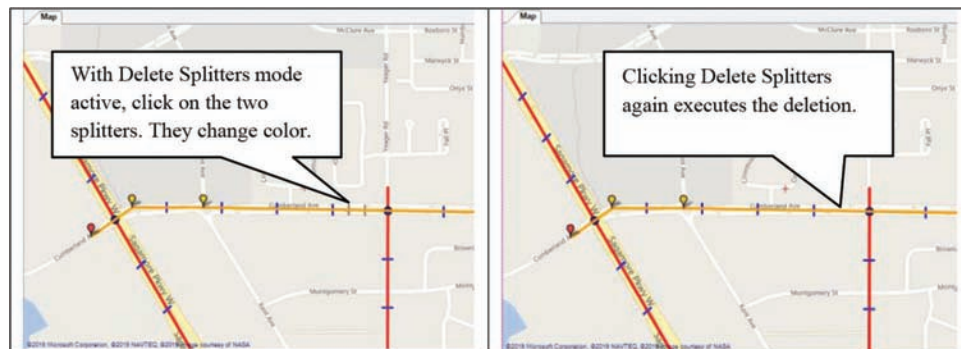


Figure 14 Deleting splitters.

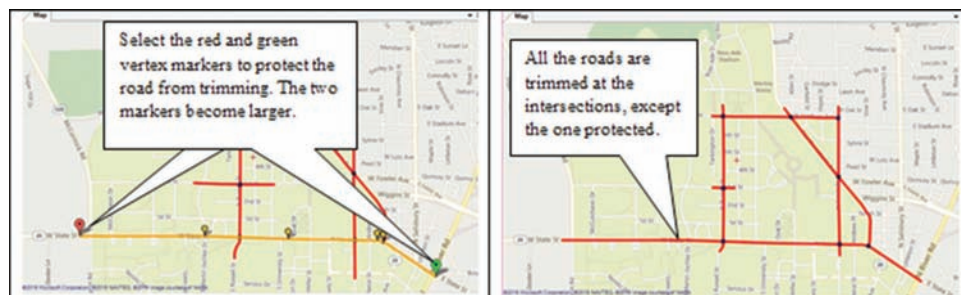


Figure 15 Example of using No Trim button.

of a road (Figure 15). The markers become larger and they indicate that the road is protected from trimming. The user clicks the No Trim button again to complete the operation and save the new no trim status for that road.

- *Distribute a group of splitters at equal distances along a segment of the selected road.* When a road has been selected in Edit Line mode, the user may change the length of any sub-segments by going directly to the segment table, clicking on the desired sub-segment length field of the table and manually changing the length (Figure 16). When the user clicks on the sub-segment length field, the splitter on the map to be affected becomes thicker.
- *Evenly distribute a group of sub-segments on a road segment.* The user may evenly distribute a group of sub-segments on a road segment by highlighting the table cells with lengths of the group of sub-segments and clicking the Distribute button. The program recalculates the lengths to be equal (Figure 17) and updates the sub-segments displayed on the map (Figure 18).

## Crash Tools

The Crashes option in the main menu (Figure 3) displays a toolbar that allows the user to import crash data, to assign them to the corridor, and to summarize the crash patterns along the road segments (Figure 19).

The Import Crashes, Import Vehicle, and Import Factors buttons let select and import files containing crash data. These data files must include csv values in tables that follow the ARIES format.

Once the crash data are imported, the user uses the Assign Crashes button to identify crashes that are within the Buffer Distance value (can be modified by the user) to the corridor roads. The default buffer distance is 150 ft. The crash geo-coordinates are used to calculate the distances of the crash to the roads. Thus, any data cleaning should happen before the crash data are imported by the program.

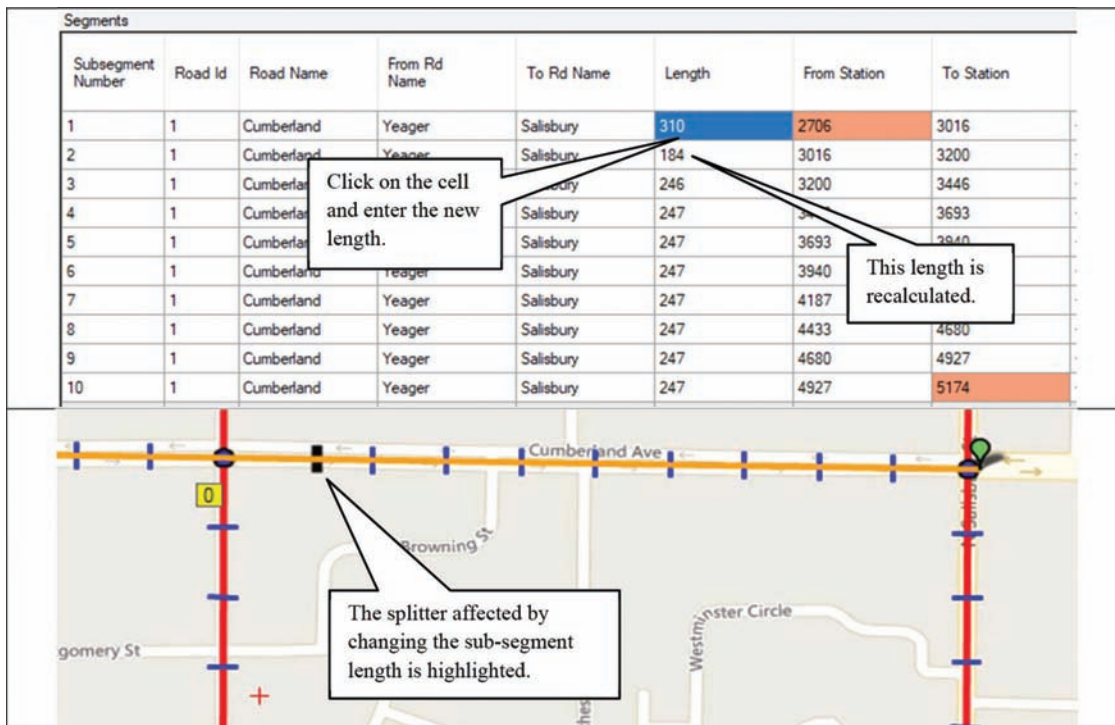


Figure 16 Editing sub-segment length on Segments table.

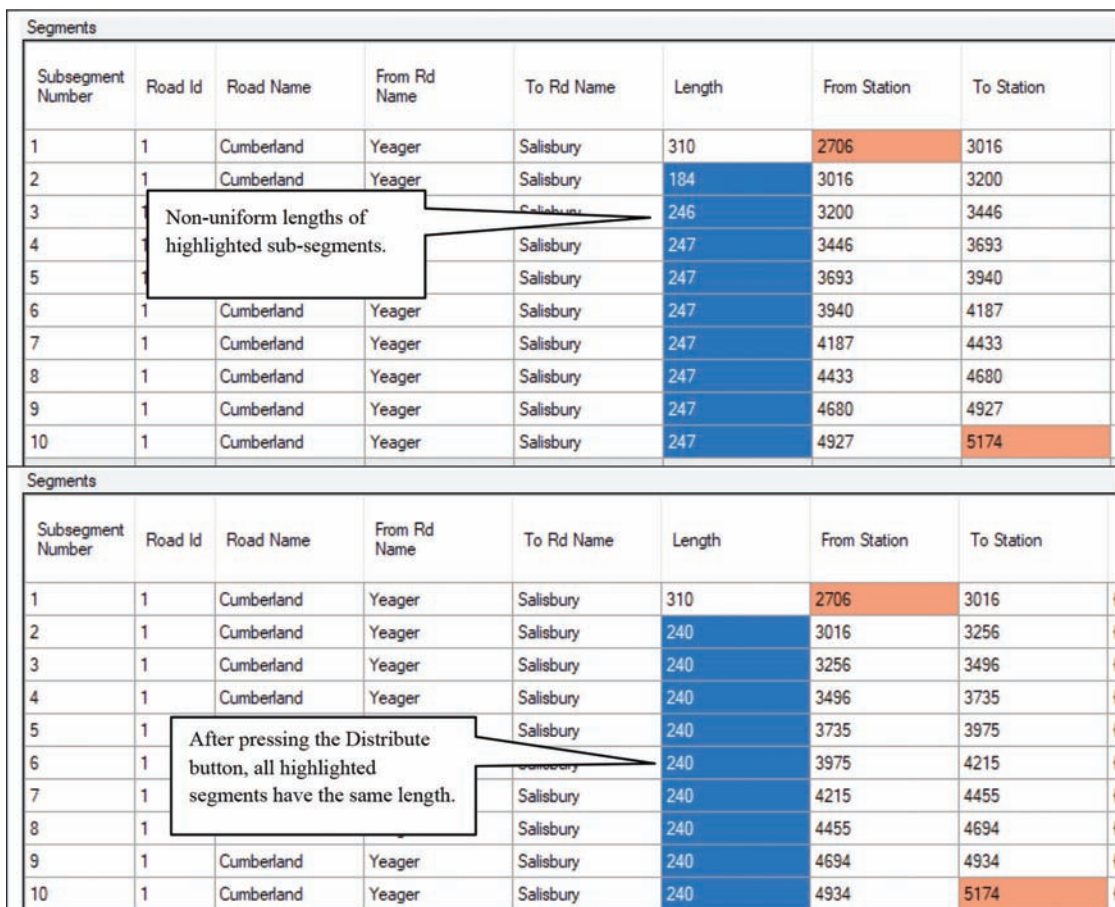
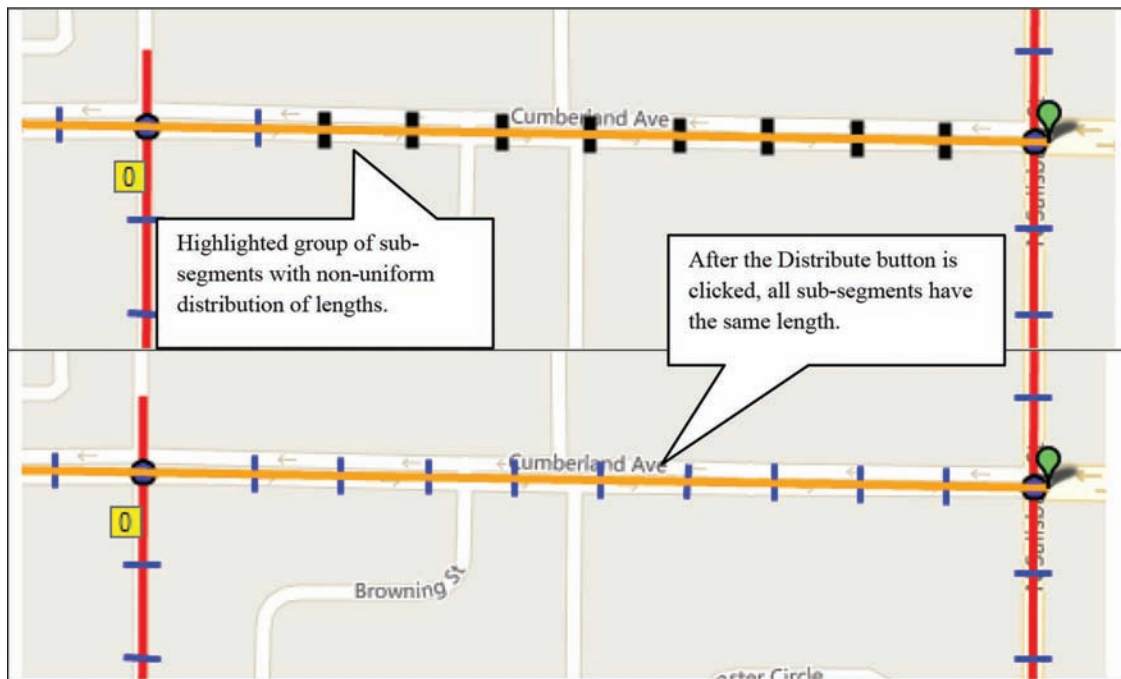
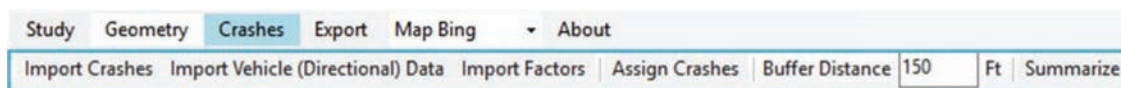


Figure 17 Sub-segment lengths adjusted by the Distribute button.



**Figure 18** Splitters reflect new sub-segment lengths adjusted by the Distribute button.



**Figure 19** Crashes toolbar.

Once the user clicks the Assign Crashes button, the distance from each imported crash to each road of the corridor is calculated and the crash is assigned to the nearest point on the nearest road if this distance is no longer than the acceptable buffer distance. If the Show Assigned checkbox is marked (Figure 20), the user sees yellow markers of assigned crashes (Figure 21).

Clicking on the Show Assigned button displays the assigned crashes in yellow. Clicking on the Show Unassigned checkboxes displays the unassigned crashes in gray (Figure 22).

Pointing to a crash marker with a cursor displays the crash master record number. If the user clicks on a crash, the map centers on that crash and the corresponding crash record in the table is highlighted and moved to the top row of the table (Figure 23). Conversely, if the user clicks on a crash record in the crash table, the map centers on the corresponding crash marker. The assigned crash marker is visible if the checkboxes showing assigned crashes is checked. The same applies to unassigned crashes.



**Figure 20** Show Assigned and Show Unassigned checkboxes for displaying crashes.

The Summarize button visualizes the numbers of crashes assigned to the corridor sub-segments and intersections (Figure 24).

### Export Tools

The Export menu (Figure 25) is used to export the results of the corridor analysis including the following:

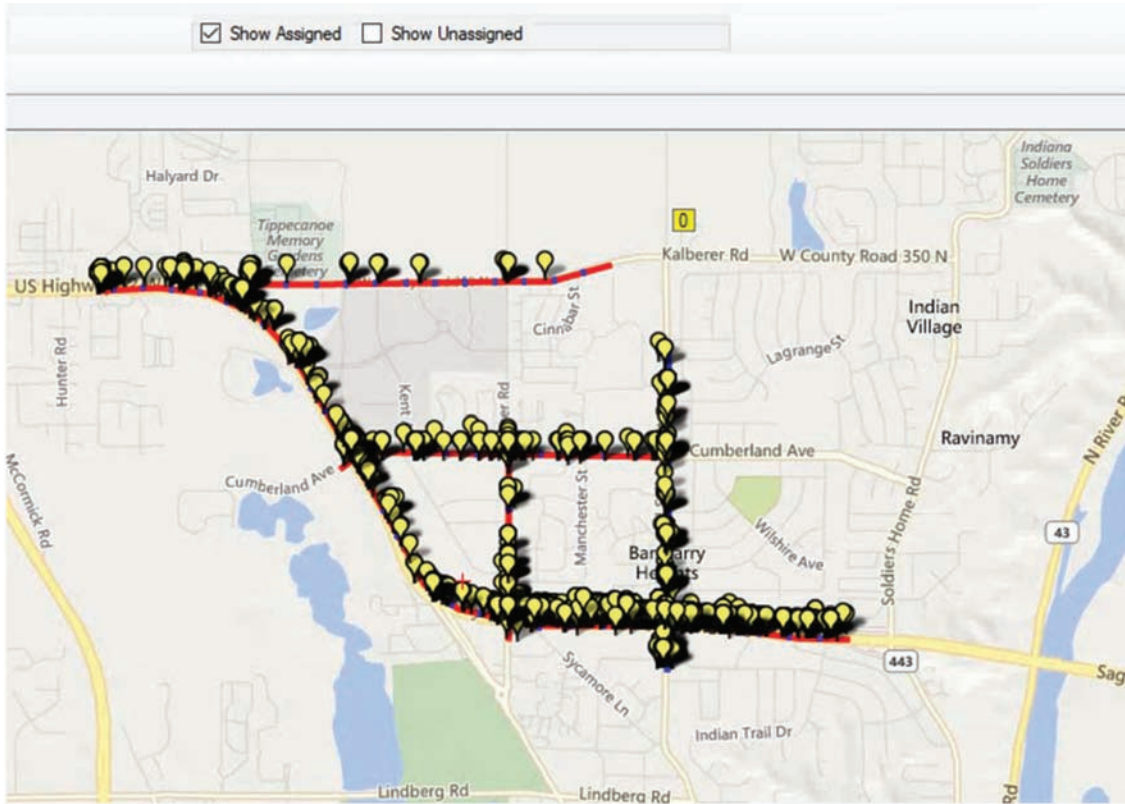
- a screen capture of the map and all elements displayed;
- a table of sub-segments with their lengths, end geo-coordinates, and crash counts by category;
- a table of intersections with the road names and intersection legs identifiers, geo-coordinates, and crash counts by category; and
- tables of crashes, vehicles, and factors for a user-selected intersection—these files are inputs to an Intersection CDB.

All the Export options require selecting a folder and its name to save the imported files. Figure 26 exhibits the Export map dialog and Figure 28 shows an example word document containing the map, legend and filters applied. The word document can be readily edited by the user including adding notes about the study.

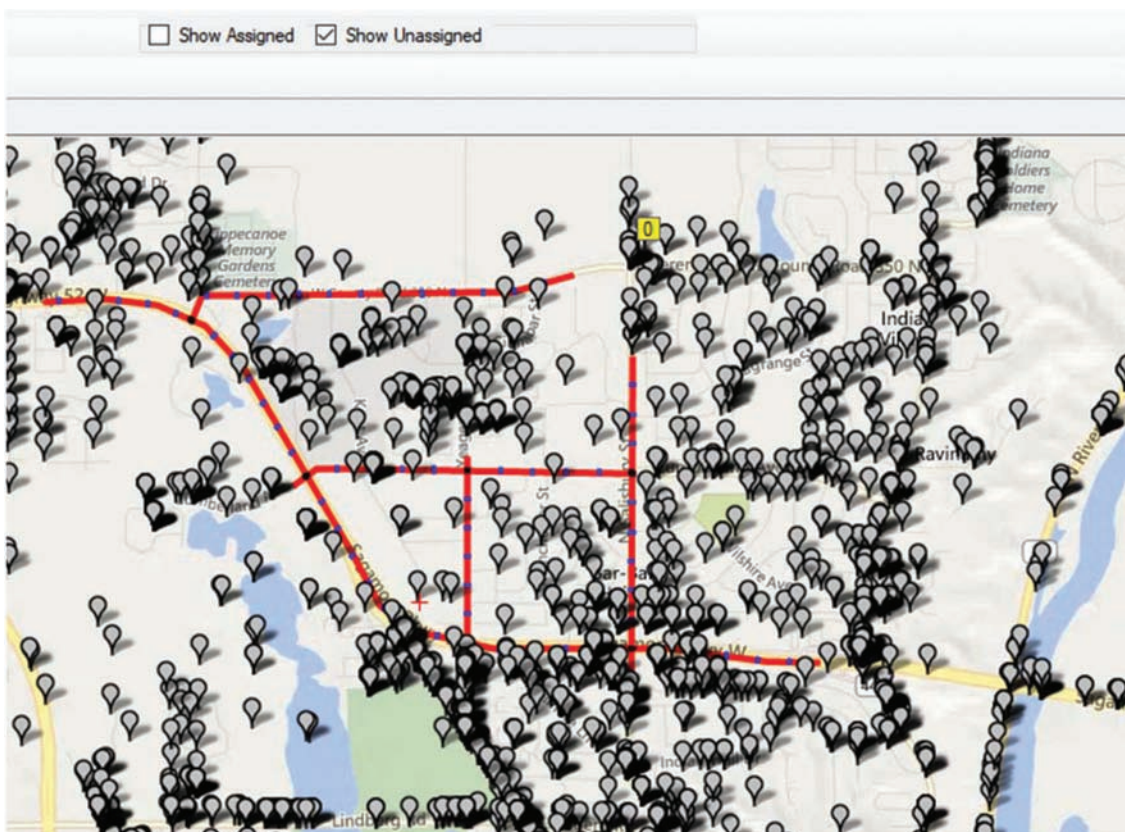
### Map Tools

The main menu map tools that allow the user to change the map mode by offering Map, Satellite, and





**Figure 21** Assigned crashes.



**Figure 22** Unassigned crashes.





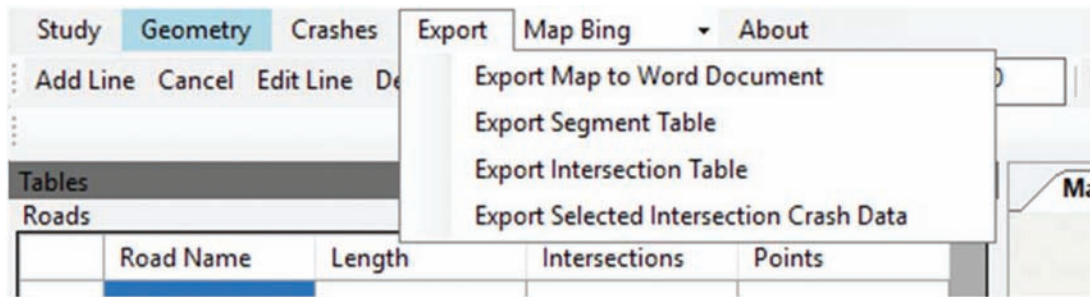


Figure 25 Options in the Export menu.

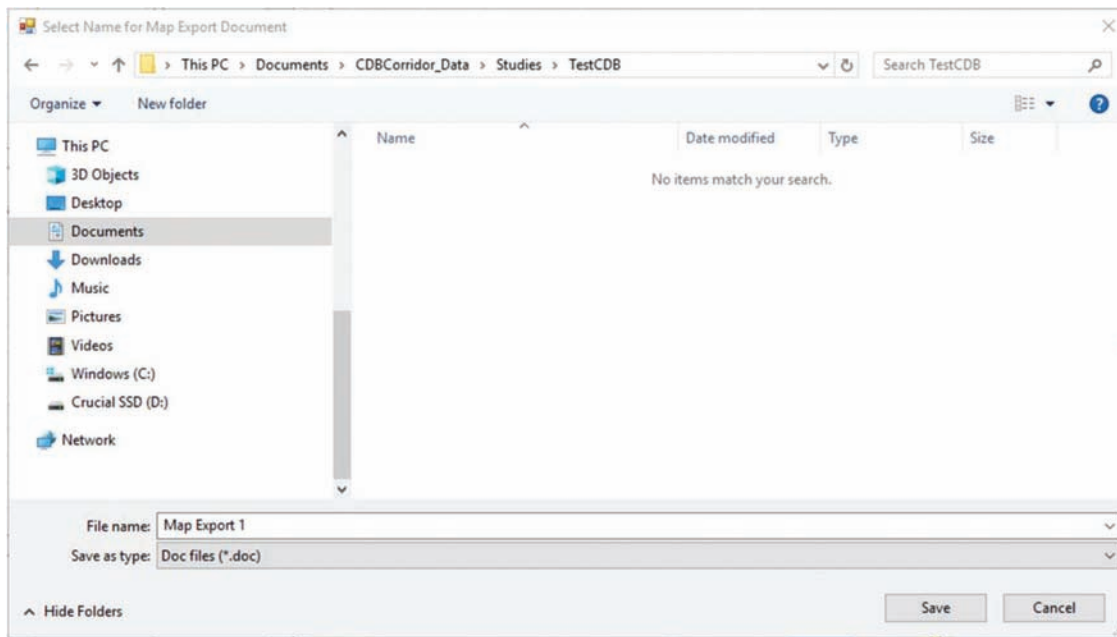


Figure 26 Export map dialogue.

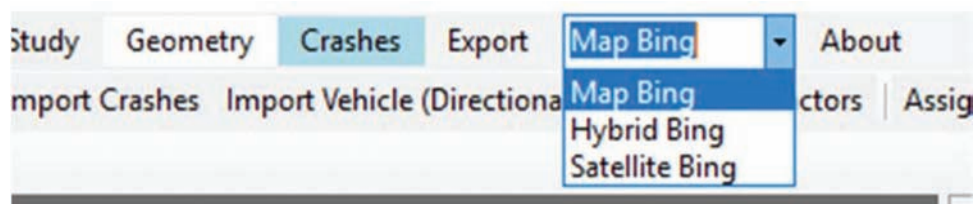


Figure 27 Selection of map views.

Hybrid views (Figure 27) from the Microsoft Bing map provider. The Map view is default, as fast to render and easy to interpret. The Satellite format may be preferred to zoom into an area and investigate specific segment or intersection element.

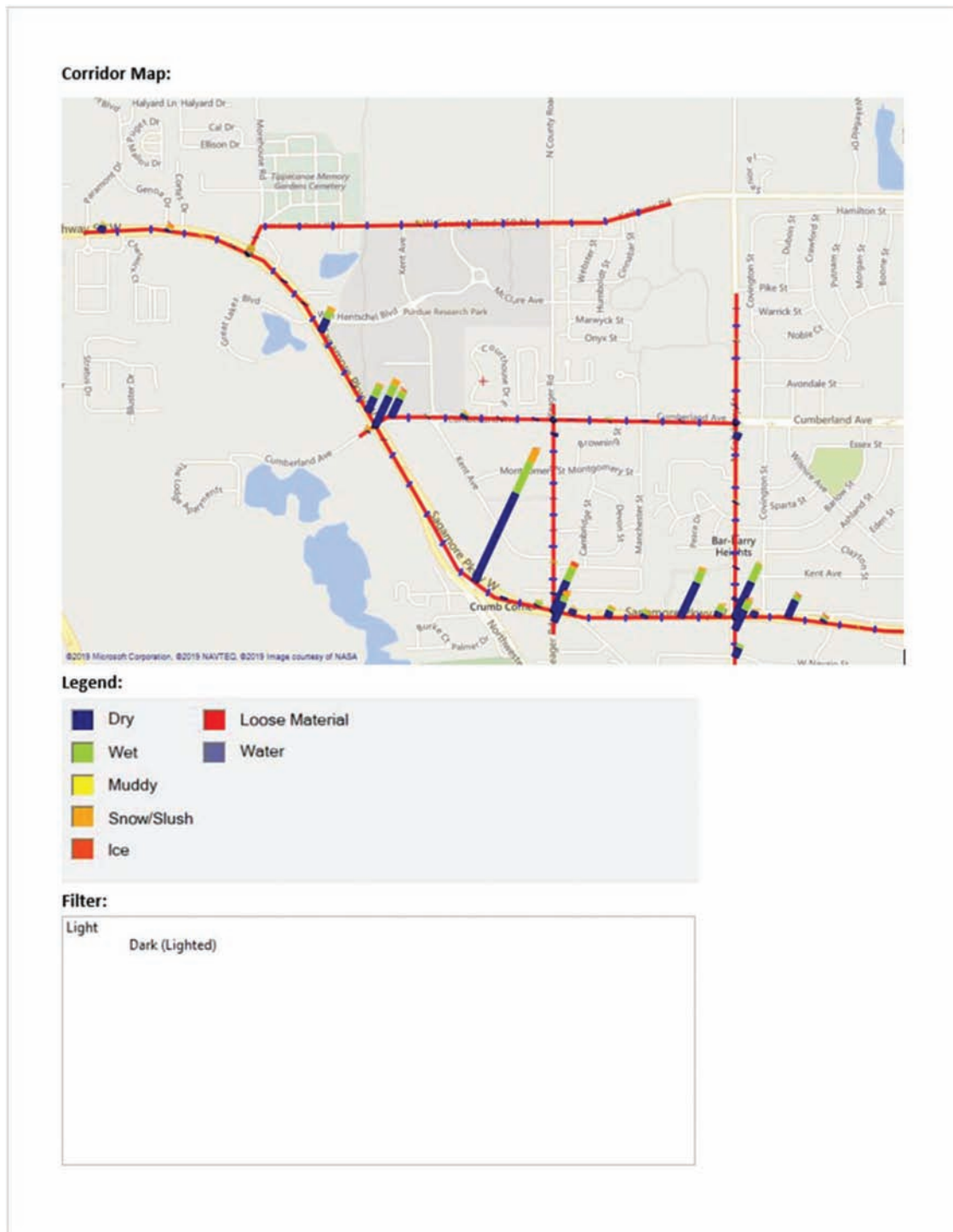
## VISUALIZATION CONTROLS

The visualization control panel (Figure 29) presents the user with an assortment of options to customize the crash frequency bars at the segments and intersections

along the corridor. To hold the panel open, user clicks on the small pin icon at the left end of the top title bar. A vertical pin keeps the panel open. The panel closes when the pin is horizontal, and the mouse moves to a different area of the interface.

The operations available to the user in this panel include the following:

- display frequency bars only for segments, only for intersections, or for both types of roads;
- display separate frequency bars for one-directional segments;

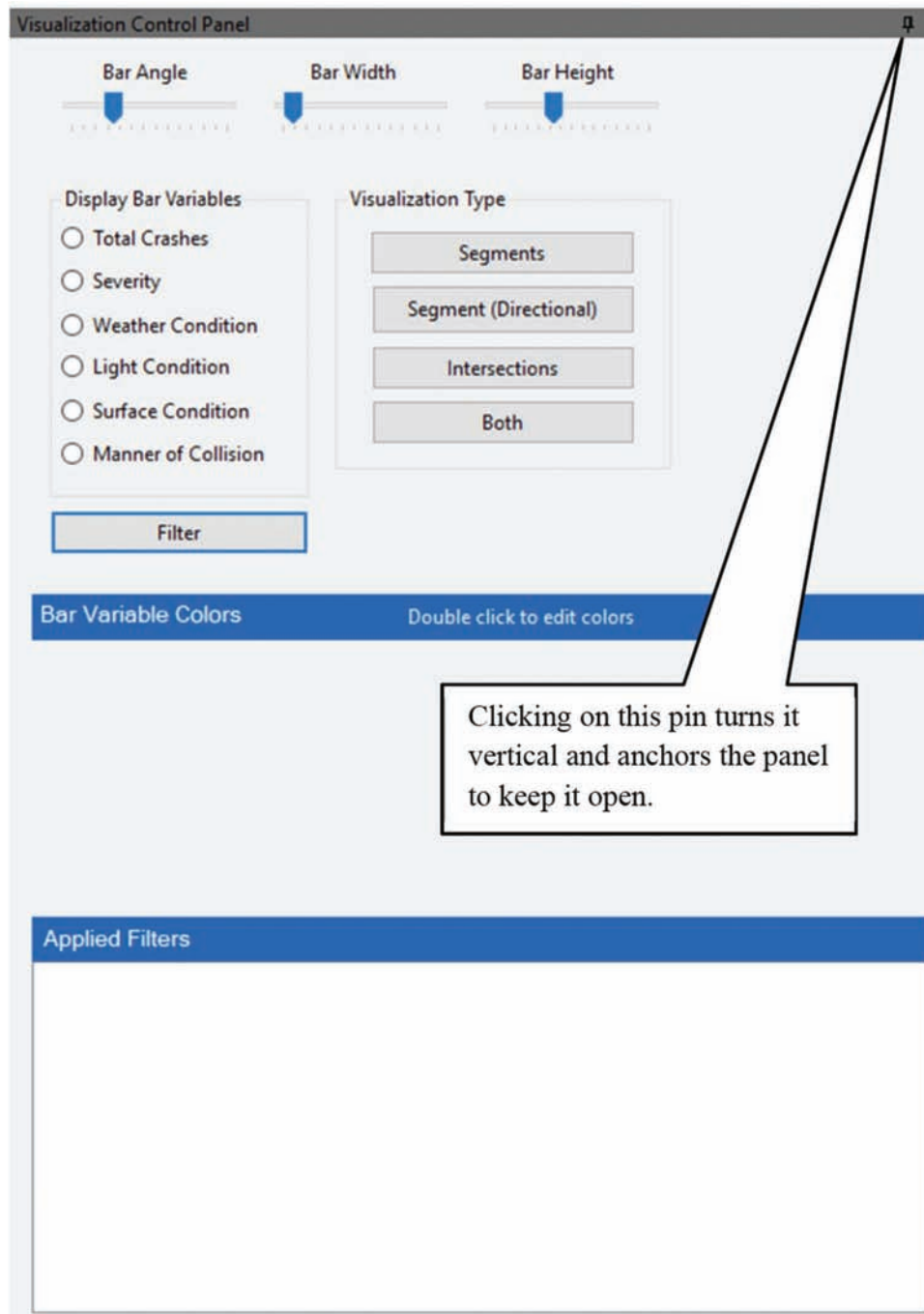


**Figure 28** Example of exported map, legend, and filters.

- control the angle, width, and height of the frequency bars;
- set filters that select crashes to be displayed on the frequency bars; and
- define variables whose values to be display on the crash frequency bars.

#### Visualization Type—Segments and Intersections

Crash frequencies are calculated for v sub-segments, one-directional sub-segments, and for intersections (Figure 30). An intersection crash involves at least two vehicles and the colliding first and second vehicles



**Figure 29** Visualization control panel.

must enter an intersection from different approach segments. A segment crash involves vehicles moving along the same segment. Some segments end at the intersection center and a segment crash may happen inside an intersection area. Thus, not the location of crash but the type of traffic interaction defines the type of crash. Dividing an intersection approach segment into short sub-segments provides an opportunity to determine how far upstream the impact of an intersection on safety reaches by inspecting the trend in the sequence of crash frequency bars on this approach segment.

The Segments option displays the frequency bars, which reflect the number of crashes on each sub-segment. The bars are placed at the centers of sub-segments (Figure 31). The Segments (Directional) option displays one frequency bar for each traffic direction of the sub-segments. A separate third bar will also be displayed for head-on crashes, if those are present. The bars will also be placed around the center of the sub-segments. The Intersection option displays frequency bars for intersection crashes at centers of intersections. A segment crash that occurs inside an intersection is

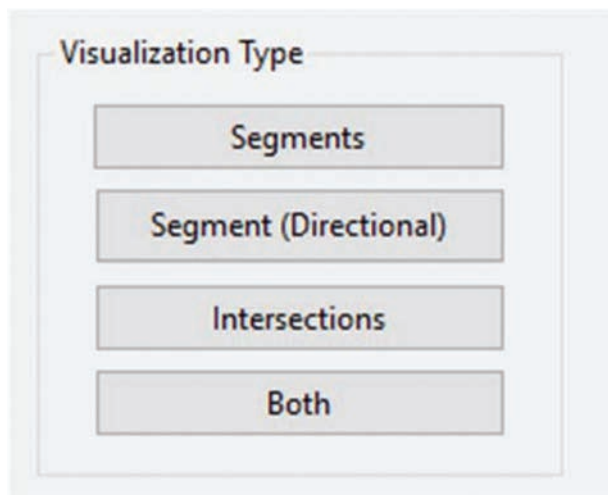


included in the first sub-segment ending at the intersection center on the segment from which the vehicles have approached the intersection.

### Display Bar Variables

The user selects a variable to be displayed on the frequency bars by selecting the corresponding radio in the list of Display Bar Variables included in the top left panel (Figure 32). The frequency bars show the distribution of crashes between various values (Dry, Wet, Muddy, etc.) of the Surface Condition variable.

The color legend for the selected display variable is displayed in lower area of the visualization panel. Any of the legend colors can be changed by double-clicking on a color square. This action will open a color palette (Figure 33) allowing the user to choose a different color.



**Figure 30** Visualization Type options.

### Filter

Frequency bars display the distribution of crashes between values of the selected variable. The crashes included in this analysis may be controlled by applying filters available in the Filter pulldown menu. A filter is a set of conditions on crash variables and values. Only crashes that meet the filtering conditions are displayed on the frequency bars.

The user may remove all the applied filters by selecting the option Reset All listed as first option in the Filter menu. To add a filter condition, the user clicks on a desired variable and the list of all possible values for this variable is presented for selection. More than one selection can be made. To select multiple values, it may be easier to click the All option, and then deselect the unwanted values. Reset unchecks all the value selections for the current variable.

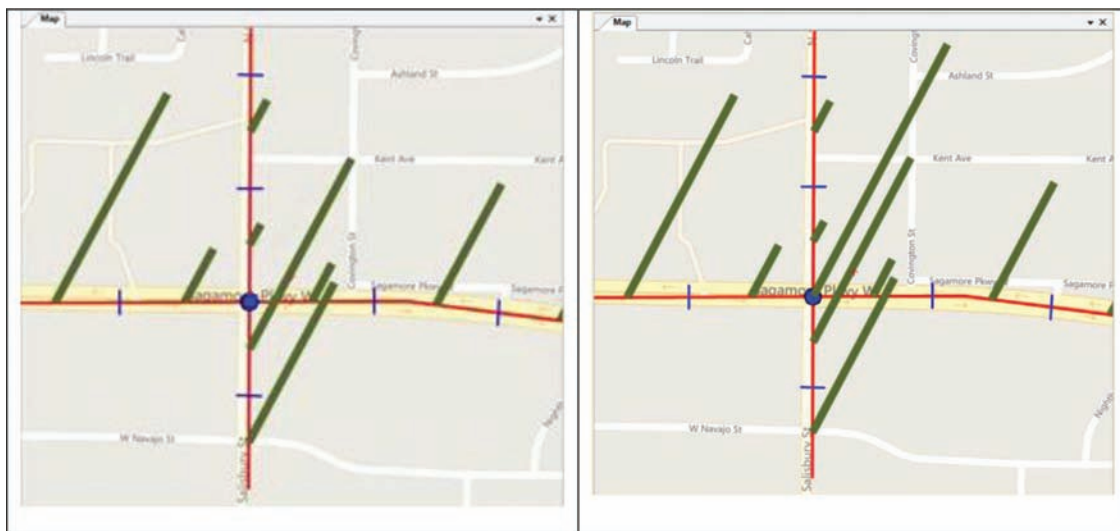
It is important that the user understands how Corridor CDB interprets the choices made in the filter list. The following three rules apply.

**Rule 1.** Selecting multiple values of the same crash attribute is equivalent to selecting a crash that has any of the selected attribute values. It is equivalent to applying the logical operator “OR” in the crash criterion. For instance, selecting the Snow and Sleet/Hail/Freezing Rain values of the Weather attribute (Figure 34) results in selecting crashes that occurred during snow OR Sleet/Hail/Freezing Rain conditions:

Weather = Snow OR Weather = Sleet/Hail/Freezing Rain.

**Rule 2.** Selecting values of different attributes results in selecting a crash that has ALL the selected attribute values. It is equivalent to applying the logical operator “AND.” For instance, selecting the Daylight value for attribute Light Conditions and selecting the Snow value for characteristic Weather leads to selecting crashes that happened during daylight conditions AND snow:

Light Conditions = Daylight AND Weather = Snow.



**Figure 31** Crash frequency bars for segments and intersections.

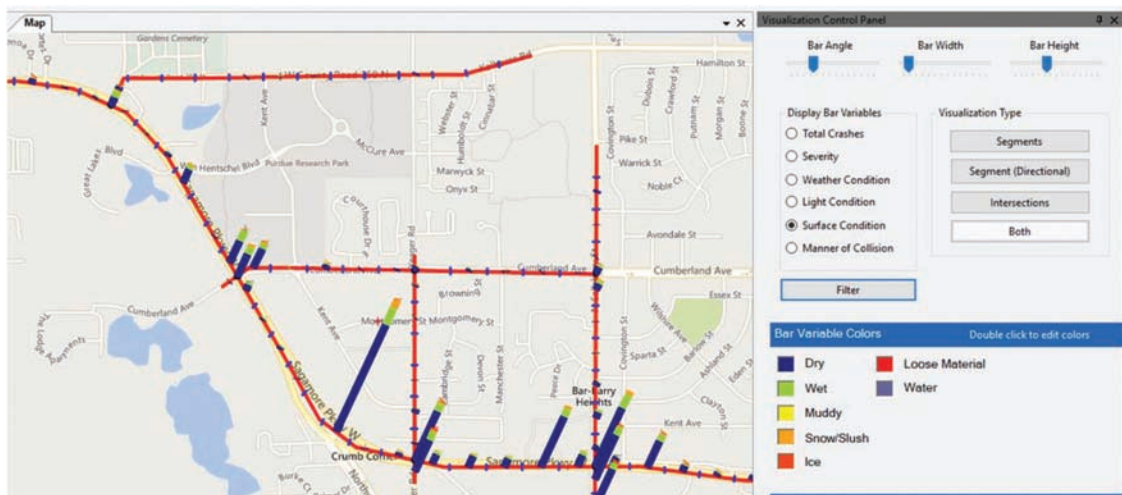


Figure 32 Display bar variables.



Figure 33 User-selectable colors.

*Rule 3.* If the user selects multiple values for any attribute and also multiple attributes, then the crashes that meet a combination of rules 1 and 2 are selected. For example, selecting the Snow and Sleet/Hail/Freezing Rain values of the Weather and selecting the Rear End value of the Manner of Collision attribute results in selecting crashes that occurred during Snow OR Sleet/Hail/Freezing Rain conditions AND where of the rear end type:

(Weather = Snow OR Weather = Sleet/Hail/Freezing Rain) AND Manner of Collision = Rear End.

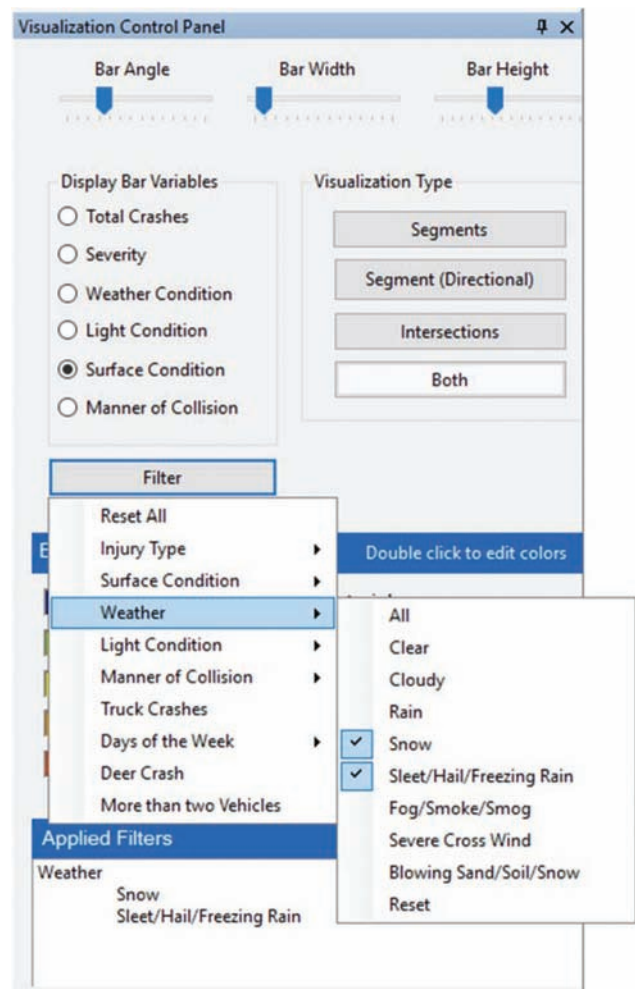
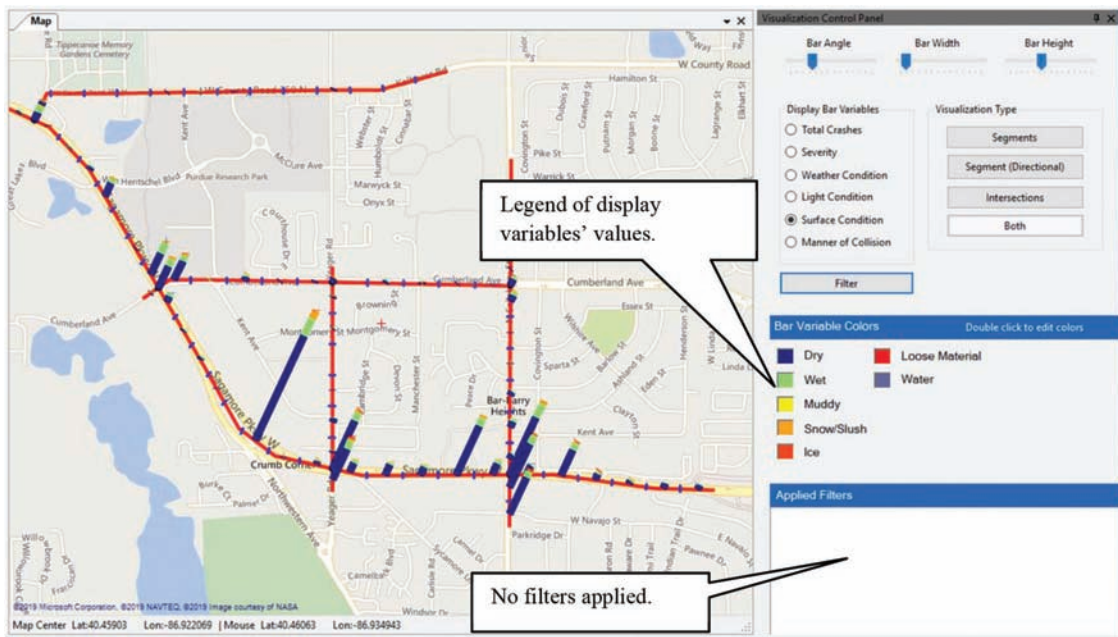
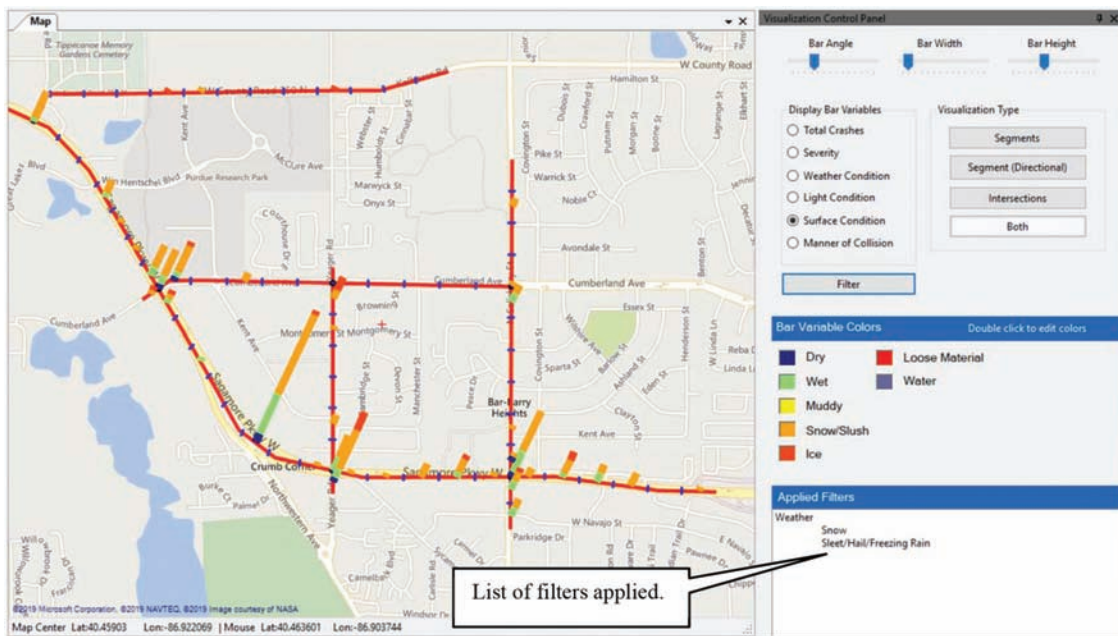


Figure 34 Filter selection.

On Figure 34, only crashes satisfying the values of Snow and Sleet/Hail/Freezing Rain for the attribute weather are selected for display.



**Figure 35** Frequency bars with crashes distributed by surface condition—no filters.



**Figure 36** Frequency bars with crashes distributed by surface condition—weather filters applied.

After selecting which crashes are selected for aggregation, the user should select the proper attribute used to visualize the frequency bars. This attribute could be one of the attributes used for filtering or a completely different one. On Figure 34, crashes are filtered using the Snow and Sleet/Hail/Freezing Rain values of the Weather attribute but have the frequency bars broken down using the attribute Surface Conditions.

Figure 35 exhibits the frequency bars representing the distribution of all crashes broken down by the attribute surface condition and without any filters applied. Figure 36 displays the frequency bars, which display again the distribution of all crashes by surface condition. This time, however, only crashes that occurred during snow, sleet, hail, or freezing rain. The selected filters are displayed at the lower end of the visualization



control panel (Figure 36.) A quick comparison shows that while for the unfiltered crashes the majority of crashes happen in dry road surfaces, for filtered crashes only a few cases of dry surface conditions appear in the

bars. Wet road surfaces along with surfaces presenting snow and slush are now the most frequent occurrences, as one would expect for weather conditions filtered for values of Snow or value of Sleet/Hail/Freezing Rain.

## About the Joint Transportation Research Program (JTRP)

On March 11, 1937, the Indiana Legislature passed an act which authorized the Indiana State Highway Commission to cooperate with and assist Purdue University in developing the best methods of improving and maintaining the highways of the state and the respective counties thereof. That collaborative effort was called the Joint Highway Research Project (JHRP). In 1997 the collaborative venture was renamed as the Joint Transportation Research Program (JTRP) to reflect the state and national efforts to integrate the management and operation of various transportation modes.

The first studies of JHRP were concerned with Test Road No. 1 — evaluation of the weathering characteristics of stabilized materials. After World War II, the JHRP program grew substantially and was regularly producing technical reports. Over 1,600 technical reports are now available, published as part of the JHRP and subsequently JTRP collaborative venture between Purdue University and what is now the Indiana Department of Transportation.

Free online access to all reports is provided through a unique collaboration between JTRP and Purdue Libraries. These are available at <http://docs.lib.purdue.edu/jtrp>.

Further information about JTRP and its current research program is available at <http://www.purdue.edu/jtrp>.

## About This Report

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