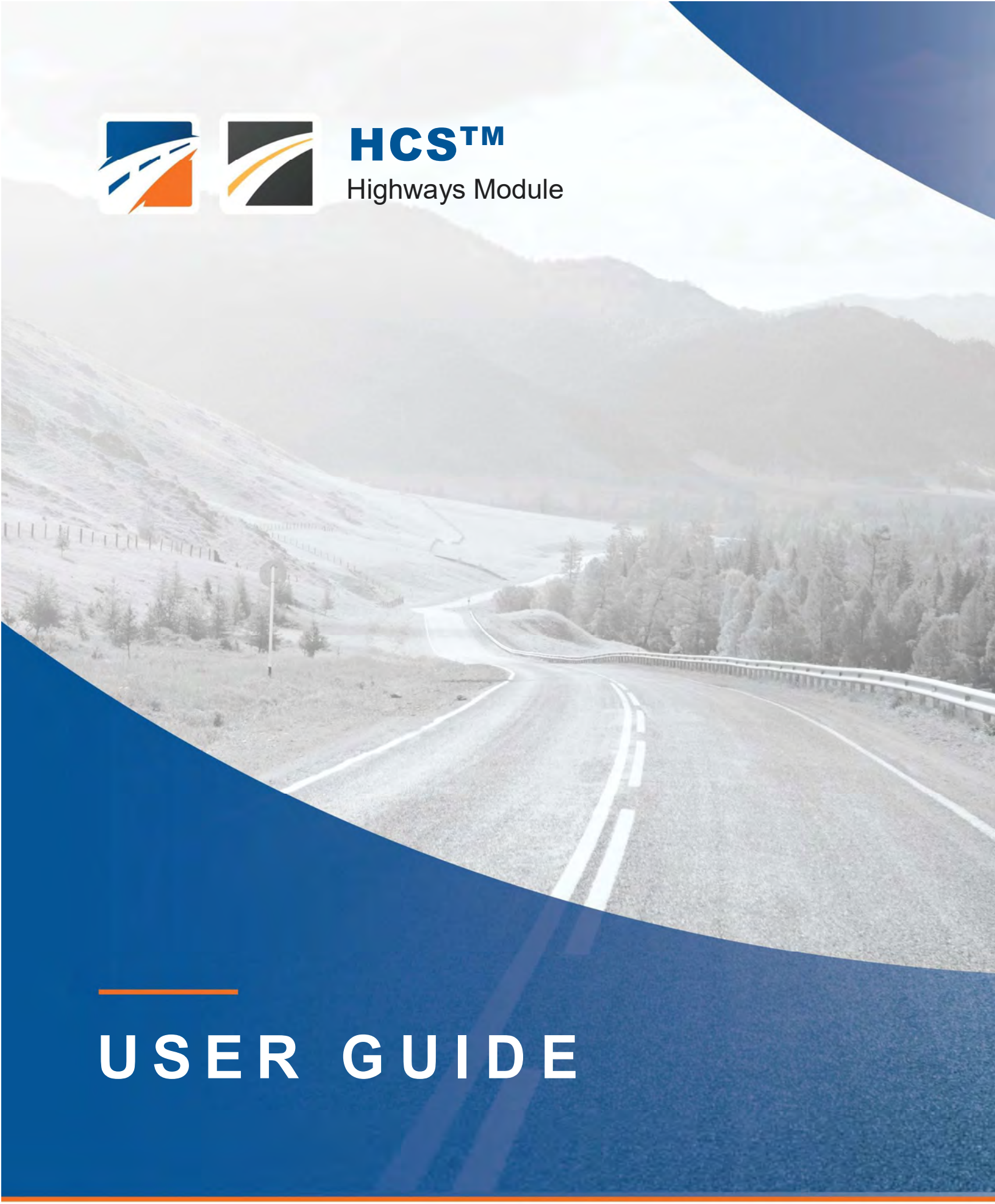

HCS™

Highways Module

USER GUIDE

UF Transportation Institute UNIVERSITY of FLORIDA | McTrans

Contents

Introduction

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Acknowledgements

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We acknowledge the Transportation Research Board (TRB), the USDOT's Federal Highway Administration (FHWA), the American Traffic Safety Services Association (ATSSA), the Institute of Transportation Engineers (ITE), and the American Association of State Highway and Transportation Officials (AASHTO) for all text, figures, and references included in HCS and express our sincere appreciation for permission to include this information.

Trademarks and Copyrights

Getting Started

Getting Started

To begin, click on File then New (or the “New File…” button on the Start page).

Normal Windows keyboard and mouse functions are available. Tabbing, clicking to a new field, or pressing the Enter key will trigger a recalculation and update the report.

Multilane Highway Analysis

Multilane Highway analyses will estimate Capacity and Level of Service (LOS) for a given set of traffic and geometric conditions. This type of analysis is oriented toward the evaluation of an existing or planned segment or facility. The methodology and procedures of application use the HCM Chapter 12 procedures.

Two-Lane Highway Analysis

Two-lane Highway analyses will estimate Capacity and Level of Service (LOS) for a given set of traffic and geometric conditions. This type of analysis is oriented toward the evaluation of an existing or planned segment or facility. The methodology and procedure of application use the HCM Chapter 15 procedures.

General Controls

Menu Items

New – Creates a new Multilane or TwoLane file (*.xuf) and starts a new analysis project; shortcut is Ctrl+N

> **Multilane Segment** – Creates a new Multilane file (*.xuf) and starts a new Multilane Segment analysis project
>
> **Two-Lane Segment** – Creates a new TwoLane file (*.xuf) and starts a new TwoLane Segment analysis project
>
> **Two-Lane Facility** – Creates a new TwoLane file (*.xuf) and starts a new TwoLane Facility analysis project
>
> **Two-Lane (2016) Segment** – Opens the *HCS7 TwoLane* module which uses the HCM6E TwoLane methodology

Open – Opens an existing Multilane or TwoLane file (*xuf, *.xhm, or *.xh2); shortcut is Ctrl+O

Open TwoLane 2016 – Opens the *HCS7 TwoLane* module which uses the HCM6E TwoLane methodology

Example Folder – Opens folder with all HCS examples in File Explorer

Save – Saves an open Multilane or TwoLane file (*.xuf) using the current file name; shortcut is Ctrl+S

Save As… – Saves an open Multilane or TwoLane file (*.xuf) using a specified file name; shortcut is F12

Close – Closes an existing Multilane or TwoLane file (*.xuf); shortcut is Ctrl+W

Units

> **USC Units** – Changes the units of the current file to U.S. Customary
>
> **Metric Units** – Changes the units of the current file to Metric

Print – Brings up printer selection and prints a Multilane or TwoLane report to the printer or specified file type; shortcut is Ctrl+P

Print Preview – Displays preview of current report before printing; shortcut is Ctrl+F2

View

> **Page View** – Changes the view to display inputs and report by pages; shortcut is F9
>
> **Full View**
>
> > **Report -> Right** – Changes the view to display both the input screen and report simultaneously; the report is displayed on the right portion of the screen; shortcut is F10
> >
> > **Report -> Bottom** – Changes the view to display both the input screen report simultaneously; the report is displayed on the bottom portion of the screen; shortcut is F11

Report

> **Formatted Report** – Displays formatted report including the most important values; shortcut is F4
>
> **Text Report** – Displays text report with input, intermediary, and final results; shortcut is F6

Import From CSV – Imports the analysis inputs of both directions from a CSV file into the *.xuf file for a Multilane file; imports the analysis inputs of the segment(s) from a CSV file into the *.xuf file for a TwoLane file

Export To CSV – Exports the analysis inputs of both directions from the *.xuf file into a CSV file for a Multilane file; exports the analysis inputs of the segment(s) from the *.xuf file into a CSV file for a TwoLane file

Default Settings – Opens a dialog box for the user to input defaults for Analyst, Agency, and Jurisdiction, which will be applied to all new files; also allows selection of USC or SI units, which will be applied to all new files; shortcut is Alt+F

Help

Contents – Provides access to glossary, acknowledgements, copyrights, and information on the HCM procedures; shortcut is Ctrl+F1

Index – Allows user to search keywords within the glossary

Search – Allows user to search for any word within the glossary

User Guide – Opens a comprehensive user guide in PDF format; shortcut is Ctrl+G

HCM6 Reference Guide – Opens the McTrans website in the default web browser to access the Highway Capacity Manual Reference Guide PDF

HCS Updates – Sends the HCS version number anonymously without any personally identifiable information to McTrans to check for a newer version

HCM/HCS Training – Opens the McTrans Training Page in the default web browser to view the latest training opportunities

HCQS Web Page – Opens the TRB Highway Capacity and Quality of Service Committee page in the default web browser

Support

Frequently Asked Questions – Opens the McTrans support page for HCS in the default web browser

HCS on the Web – Opens the McTrans HCS Overview page in the default web browser

McTrans on the Web – Opens the McTrans home page in the default web browser

E-mail McTrans – Composes a new e-mail addressed to McTrans in the default e-mail client with registration number, serial key, module, and version number already populated in the Subject field

About HCS – Opens an about window with software version information, EULA, general acknowledgements, contact information, and other relevant links

Exit – Exits the *HCS Highways* module; shortcut is Alt+F4

Multilane Highway Segments

HCM Chapter 12

The Highway Capacity Software (*HCS*) faithfully implements the methodology prescribed in the Highway Capacity Manual (HCM) for analyzing Basic Freeway and Multilane Highway Segments. These segments are outside the influence of merging, diverging, and weaving maneuvers. In the case of multilane highways, they are also outside the influence of signalized intersections. Because of the similar operational characteristics of basic freeway and multilane highway segments, they are analyzed with the same methodology.

Chapter 12 focuses on *uninterrupted flow*, which refers to access-controlled facilities, with access and egress being controlled through grade-separated cross streets and ramp movements to access the facility. For multilane highways, uninterrupted flow also exists when there are no traffic control devices that interrupt traffic and where no platoons are formed by upstream traffic signals.

The methodologies in this chapter are limited to *uncongested flow* conditions. Uncongested flow conditions require that the demand-to-capacity ratio for the segment is less than or equal to 1.0. Uncongested flow on freeways and multilane highways further means that there are no queuing impacts on the segment from downstream bottlenecks. The HCM does not currently provide a method for evaluating oversaturated multilane highways, other than to identify them as LOS F.

The bicycle methodology is identical for two-lane highways and multilane highways. Details are provided in Chapter 15, Two-Lane Highways. Bicycle levels of service for multilane highway segments are based on a bicycle LOS score, which is in turn based on a traveler perception model.

Operational Data

Geometric Data

For multilane highway segments, there are inputs for each direction. The number of lanes for both directions is entered. The user chooses the type of Terrain (Level, Rolling, or Specific Grade). If Specific Grade is chosen, fields for Percent Grade and Grade Length will enable for the user to change. Length of the segment, Lane Width, Base Free Flow Speed, and Right Side Clearance are also available as inputs. Access-Point Density, Median (left) Side Clearance, and Median Type are also included for each direction. However, if a Median Type is selected for one direction, the other direction will automatically update to reflect the same Median Type.

Checkboxes are provided for Measured FFS to indicate if it is necessary for the current analysis. When Measured FFS is checked, the following fields are disabled: Lane Width, Right Side Clearance, Median (Left) Side Clearance, and Access-Point Density. The input for Base Free Flow Speed is then taken as the measured Free Flow Speed.

Demand Data

Demand, Peak Hour Factor, Percent Single-Unit Trucks, and Percent Tractor-Trailers are included as inputs for multilane highway segments.

If ‘Mixed Flow Model’ is checked, the mixed-flow model will be used to assess capacity, speed, and density in addition to the traditional passenger-car-equivalent (PCE) method. Results of both methods will be provided in the

reports. There is also the option to include a managed lane analysis. If 'Managed Lane' is checked under Geometric Data, managed lane sections will be added to the bottom of the input screen, which will allow coding of geometric data, demand data, and adjustment factor inputs related to the managed lane.

Adjustment Factors

Driver Population and Weather Conditions are taken into account. This affects the Speed and Capacity Adjustment Factors. However, if the user chooses to override the default values based on driver population and weather conditions, they can change the adjustment factors.

Bicycle LOS

Outside Lane Width, Shoulder Width, Speed Limit, Pavement Condition Rating, and Percent Occupied Parking are included as inputs for the evaluation of bicycle level of service.

Results

A multilane highway segment can be characterized by three performance measures: density in passenger cars per mile per lane (pc/mi/ln), space mean speed in miles per hour (mi/h), and the ratio of demand flow rate to capacity (v/c). Since speed is constant through a broad range of flows and the v/c ratio is not directly discernible to road users (except at capacity), the service measure for multilane segments is density.

Level of Service (LOS) Criteria for Basic Freeway and Multilane Highway Segments:

	Density (pc/mi/ln) [USC]	Density (pc/km/ln) [SI]
LOS A	≤11	≤7
LOS B	>11 - 18	>7 – 11
LOS C	>18 - 26	>11 – 16
LOS D	>26 - 35	>16 – 22
LOS E	>35 - 45	>22 - 28
LOS F	>45 or v/c>1.0	>28 or v/c>1.0

Bicycle levels of service for multilane highway segments are based on a bicycle LOS score, which is in turn based on a traveler perception model.

Bicycle Level of Service (LOS) Criteria for Multilane Highway Segments:

	Bicycle LOS Score
LOS A	≤1.5
LOS B	>1.5 - 2.5
LOS C	>2.5 - 3.5
LOS D	>3.5 - 4.5
LOS E	>4.5 - 5.5
LOS F	>5.5

Multilane Highway Report

The report page shows a formatted version of the analysis in a dynamic form, reacting to changes in the Multilane page. All or a portion can be copied to the Windows clipboard for insertion into other files by right-clicking into the report and selecting Copy.

Both formatted and text reports are available for viewing and printing. The formatted report provides data and results that are most important to the user, and are displayed in a clean and more presentable fashion. The text report provides more details to the user, rather than a summary.

The user can switch between reports by clicking on the button found at the bottom of the Report page.

Two-Lane Highways

HCM Chapter 15

This Highway Capacity Software (*HCS*) faithfully implements the methodology prescribed in the Highway Capacity Manual (HCM) for analyzing Two-Lane Highways. Two-lane highways have one lane for use of traffic in each direction. The principal characteristic that distinguishes two-lane highway operation from that of other uninterrupted-flow facilities is that passing maneuvers take place in the opposing lane of traffic. Passing maneuvers are limited by the availability of gaps in the opposing traffic stream and by the availability of sufficient sight distance for a driver to discern the approach of an opposing vehicle safely. As demand flows and geometric restrictions increase, opportunities to pass decrease. This creates platoons within the traffic stream, with trailing vehicles subject to additional delay because of the inability to pass the lead vehicles.

Chapter 15 presents methodologies for analyzing two-lane highway operations under uninterrupted-flow conditions. Uninterrupted flow exists when there are no traffic control devices that interrupt traffic and where no platoons are formed by upstream signals or roundabouts. In general, any segment that is more than 2.0 mi from the nearest signalized intersection fits into this category. When traffic signals are less than 2.0 mi apart, the facility should be classified as an urban street and analyzed with the methodologies of Chapter 16, Urban Street Facilities, and Chapter 18, Urban Street Segments.

The methodology is most directly used to determine the LOS on a uniform directional segment of two-lane highway by estimating the service measure of Follower Density that defines LOS. Such an analysis can also be used to determine the capacity of the directional segment or the service flow rate that can be accommodated at any given LOS.

Operational Data

Geometric Data

On the Input page for a Segment analysis or the Details page for a Facility analysis, the user can choose the Coded Type, which includes the following options: Passing Constrained, Passing Zone, and Passing Lanes. Other inputs include, Measured FFS, Analyze Bicycle Results, Free-Flow Speed, Speed Limit, Lane Width, Shoulder Width, Percent Grade, Access Point Density, Pavement Condition Rating, and Percent Occupied Parking.

Checkboxes are provided for Measured FFS and Analyze Bicycle Result to indicate if they are necessary for the current analysis. When Measured FFS is checked, the Access-Point Density field is disabled and the Free-Flow Speed field is enabled. The input for Free Flow Speed is then taken as the measured Free Flow Speed. When Analyze Bicycle Results is checked, the Pavement Condition Rating and Percent Occupied Parking fields are enabled for the user to edit. Bicycle results will also be added to both the formatted and text reports.

Demand Data

On the input page for a Segment analysis, Directional Demand, Opposing Demand, Peak Hour Factor, and Total Trucks are included as inputs for two-lane highway segments. Opposing Demand is only enabled when the Segment Coded Type selected is Passing Zone.

Segments Input

On the Segments page for a Facility analysis, the geometric and demand data can be found under the Segments Input section. In this section, the user can add, insert, or delete segments within the facility using the buttons Add Segment, Insert Segment, and Delete Segment, respectively. The Type of segment can be specified as Passing Constrained, Passing Zone, or Passing Lanes. For each segment, the corresponding segment Name, Length, Speed Limit, Directional Volume, Opposing Volume, Peak Hour Factor, and Heavy Vehicle Percentage can be entered. Opposing Volume is only enabled when the segment type selected is Passing Zone. For each segment, a Details link is also provided. Clicking the Details link for a segment will bring the user to the Details page for that specific segment.

Subsegments

On the Input page for a Segment analysis or the Details page for a Facility analysis, the user can add, insert, or delete subsegments within the current segment using the buttons Add Subsegment, Insert Subsegment, and Delete Subsegment, respectively. The Type of each subsegment can be specified as Tangent or Horizontal Curve and the corresponding Length can also be entered. If the subsegment type selected is Horizontal Curve, the user can specify the corresponding Radius and Superelevation.

Bicycle LOS

On the Input page for a Segment analysis or the Details page for a Facility analysis, Lane Width, Shoulder Width, Speed Limit, Pavement Condition Rating, and Percent Occupied Parking are included as inputs for the evaluation of bicycle level of service.

Facility Graphic

On the Segments page for a Facility analysis, a facility graphic is provided under the Segment Input section to help better visualize the facility being analyzed. It provides information on the Segment Type, Segment Length in feet, and Segment ID. This same graphic can be found on the Details page for a Facility analysis, with the currently viewed segment being highlighted. The user can switch between segment inputs by selecting the desired segment in the graphic itself. The user also has the option of changing the color of the graphic based on difference performance measures, which include Speed and Follower Density. Selecting 'None' will leave the graphic the color of a road. A legend for different colors appears to the side of the graphic when any of the other options are selected.

Results

If the volume-to-capacity ratio is less than or equal to 1.0, follower density is used as the service measure for all two-lane highways. However, two sets of LOS thresholds are used to account for differences in driver perception between driving on higher-speed versus lower-speed highways.

On higher-speed two-lane highways (≥50 mi/h, ≥80 km/h in metric), absolute speed and delay due to passing restrictions are generally both important to motorists. Higher-speed two-lane highways are most commonly encountered as inter-city connecting routes. Lower-speed two-lane highways (<50 mi/h, or <80 km/h in metric) are typically encountered as intra-city routes and in scenic and rural-developed areas. There highways generally have posted speed limits of 35-45 mi/h (or 56.3-72.4 km/h in metric) and have limited passing opportunities. Thus, for two-lane highways in these areas, high speeds are usually not expected and higher percentages of followers are generally tolerated. Consequently, the follower density thresholds for a given LOS are higher for lower-speed highways than higher-speed highways.

Level of Service (LOS) Criteria for Two-Lane Highways:

	Follower Density (followers/mi) Higher-Speed Highways Posted Speed Limit ≥ 50 mi/h	Follower Density (followers/mi) Lower-Speed Highways Posted Speed Limit < 50 mi/h
LOS A	≤2.0	≤2.5
LOS B	>2.0 - 4.0	>2.5 - 5.0
LOS C	>4.0 - 8.0	>5.0 - 10.0
LOS D	>8.0 - 12.0	>10.0 - 15.0
LOS E	>12.0	>15.0

Note: LOS F exists when demand exceeds capacity.

Level of Service (LOS) Criteria for Two-Lane Highways in Metric units:

	Follower Density (followers/km) Higher-Speed Highways Posted Speed Limit ≥ 80 km/h	Follower Density (followers/km) Lower-Speed Highways Posted Speed Limit < 80 km/h
LOS A	≤1.2	≤1.6
LOS B	>1.2 - 2.5	>1.6 - 3.1
LOS C	>2.5 - 5.0	>3.1 - 6.2
LOS D	>5.0 - 7.5	>6.2 - 9.3
LOS E	>7.5	>9.3

Note: LOS F exists when demand exceeds capacity.

Bicycle levels of service for two-lane highway segments are based on a bicycle LOS score, which is in turn based on a traveler perception model.

Bicycle Level of Service (LOS) Criteria for Two-Lane Highway Segments:

	Bicycle LOS Score
LOS A	≤1.5
LOS B	>1.5 - 2.5
LOS C	>2.5 - 3.5
LOS D	>3.5 - 4.5
LOS E	>4.5 - 5.5
LOS F	>5.5

Two-Lane Highway Report

The report page shows a formatted version of the analysis in a dynamic form, reacting to changes in the Input page for a Segment analysis or the Segments and Details pages for a Facility analysis. All or a portion can be copied to the Windows clipboard for insertion into other files by right-clicking into the report and selecting Copy.

Both formatted and text reports are available for viewing and printing. The formatted report provides data and results that are most important to the user, and are displayed in a clean and more presentable fashion. The text report provides more details to the user, rather than a summary.

The user can switch between reports by clicking on the button found at the bottom of the Report page.

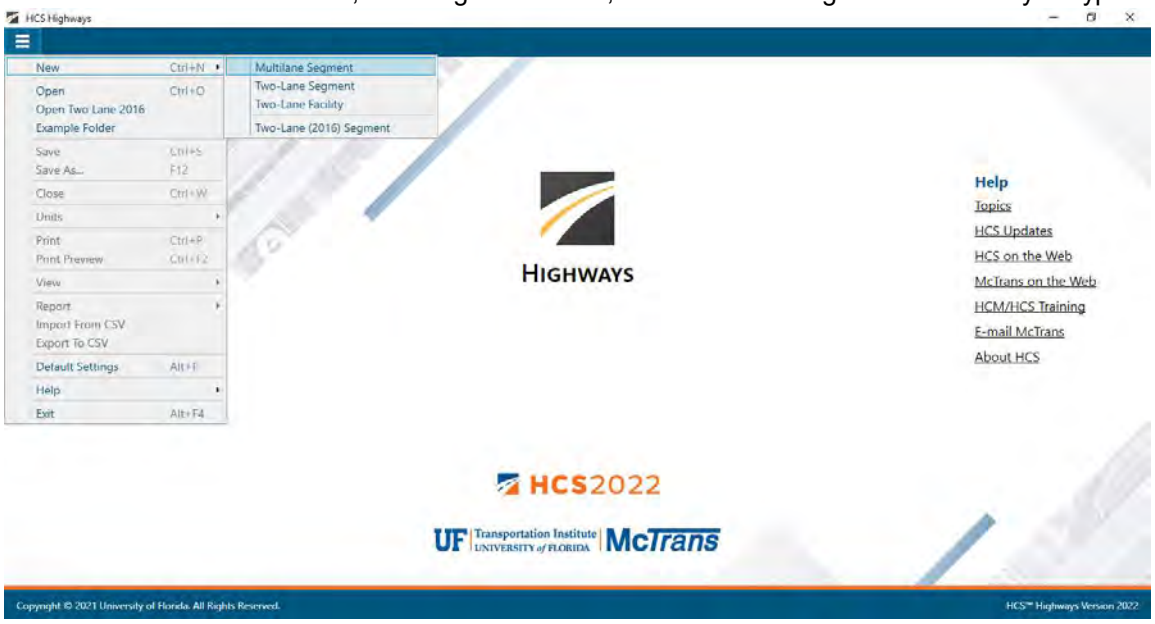
How To

Create a New File

1. From the Start screen, there are three options for creating a new file:

Note: A new file can be created if an existing file is already open; you do not need to start from the Start screen.

a. Selecting *File* > *New* from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen, hovering over “New”, and then selecting one of the analysis types.

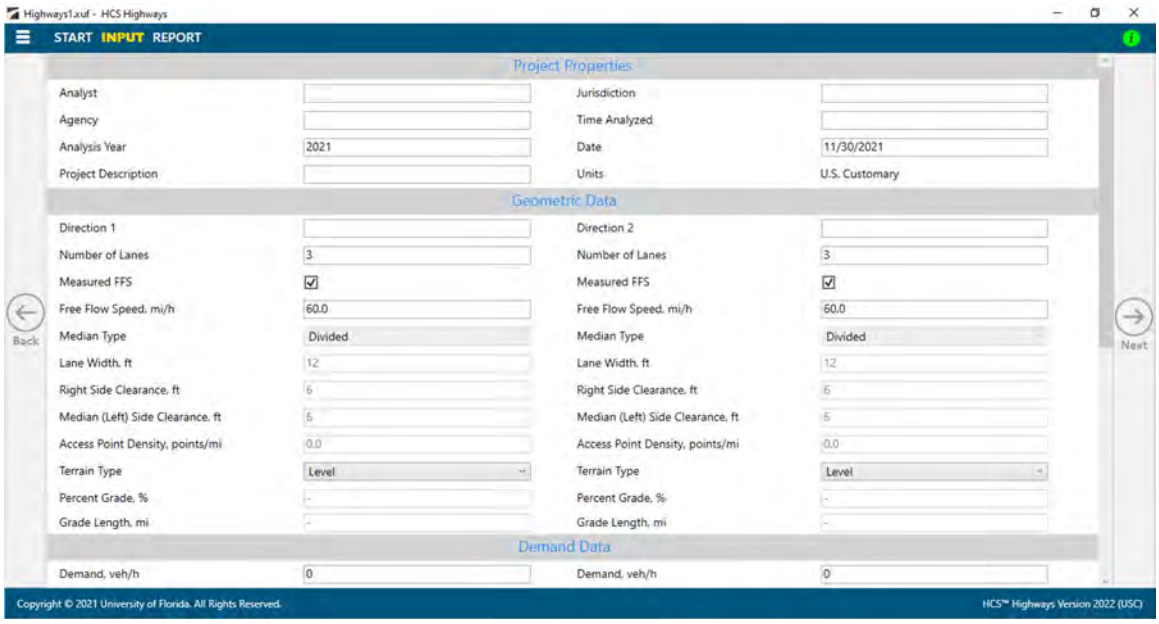


b. Selecting “New File…” from the Start screen; this can be found below in the red box. A Select New File Type dialog box will pop up after selecting “New File…” which allows you to choose the desired analysis type.

c. Using the keyboard shortcut “Ctrl+N”, selecting one of the analysis types from the Select New File Type dialog box, and clicking “OK”

2. Once a new file is created, you will be brought to the input page of the selected analysis type if in Page View or the input screen split with the report either on the right or the bottom of the screen if in Full View.

    a. Page View

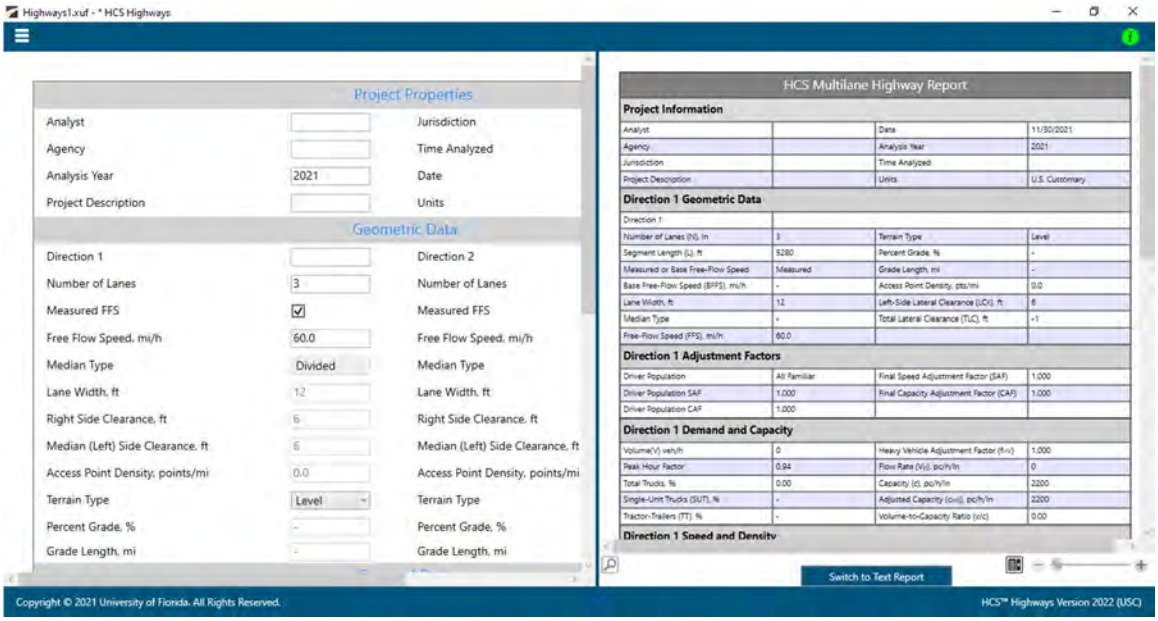


    i. If Multilane Segment or Two-Lane Segment was selected, you will be brought to the Input page.

    ii. If Two-Lane Facility was selected, you will be brought to the Segments page.

    iii. If Two-Lane (2016) Segment was selected, the *HCS7 TwoLane* module will open.

b. Full View

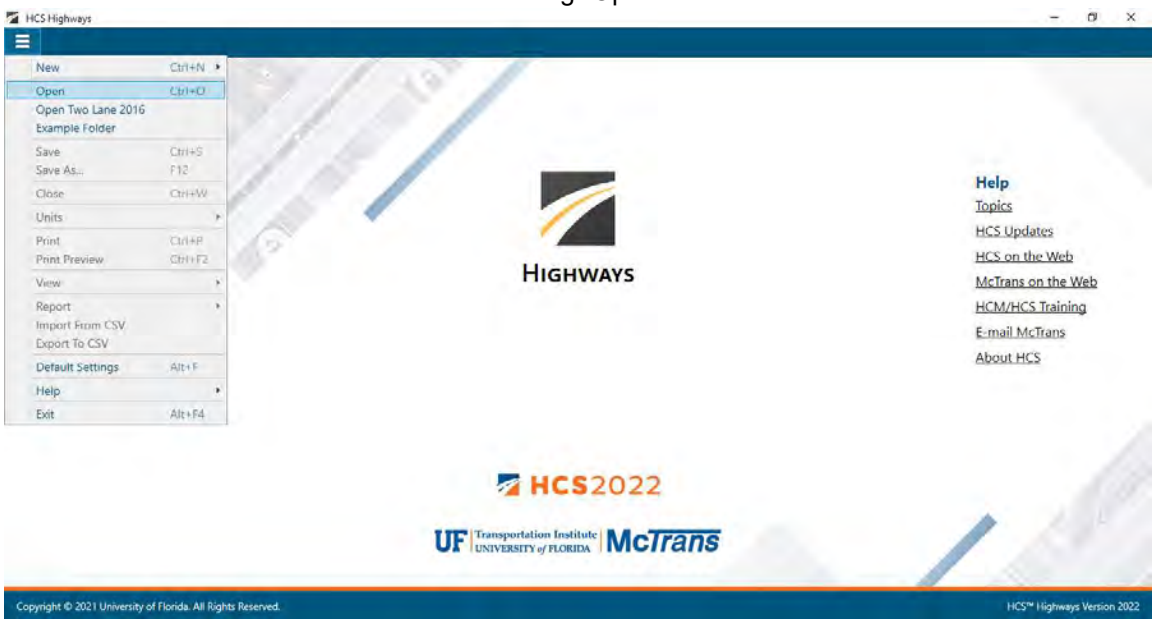


Open an Existing File

1. From the Start screen, there are six options for opening an existing file:

Note: A file can be opened even if another file is currently open; you do not need to start from the Start screen.

a. Selecting *File* > *Open* from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen and then selecting “Open”

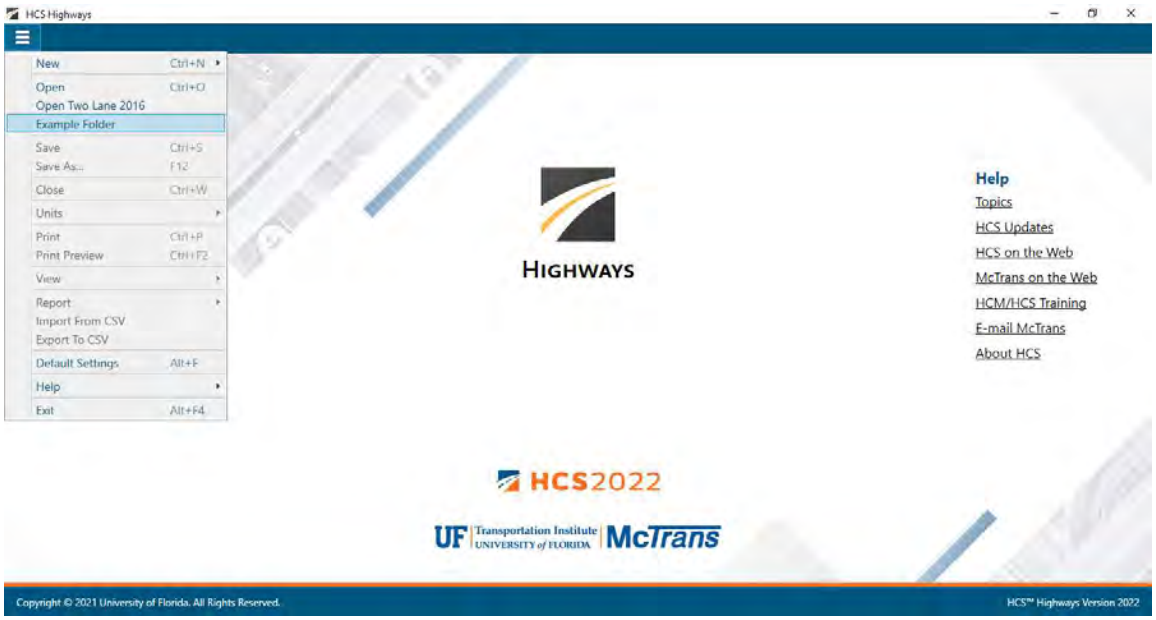


b. Selecting “Open File…” from the Start screen; this can be found below in the red box

c. Using the keyboard shortcut “Ctrl+O”

d. Selecting a file under the Recent files list from the Start screen; this can be found below in the red box

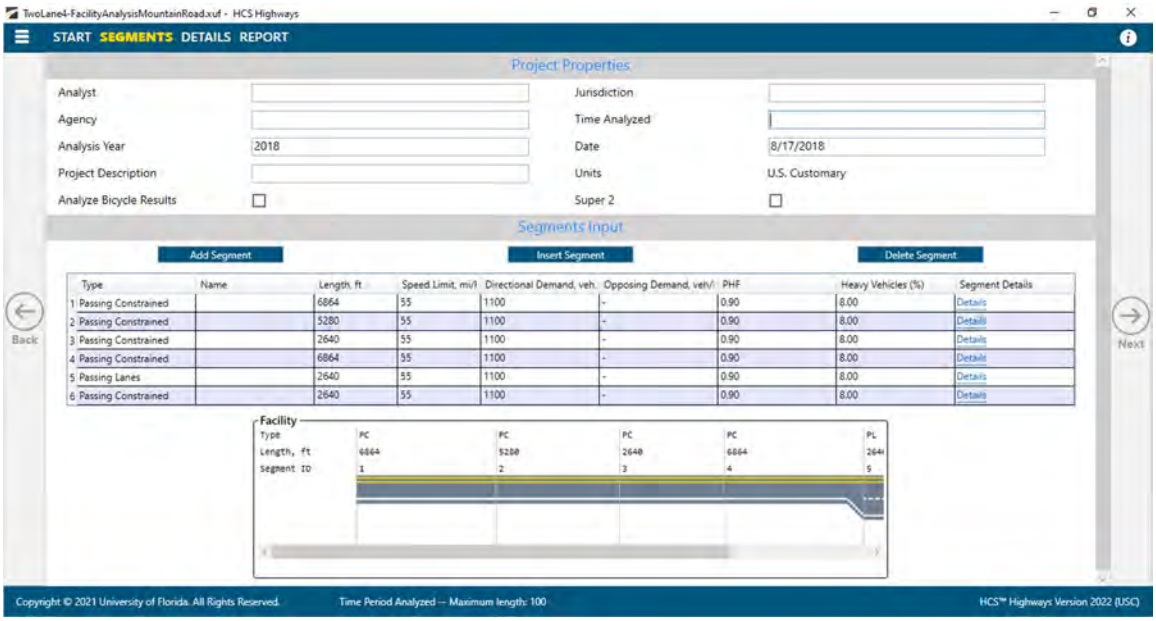
e. Selecting *File* > *Example Folder* from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen and then selecting "Example Folder". Opening the example folder will open the path of the HCS example files in File Explorer. The desired example file can be double-clicked or right-clicked and selecting 'Open', which will open the example file in the Highways program.



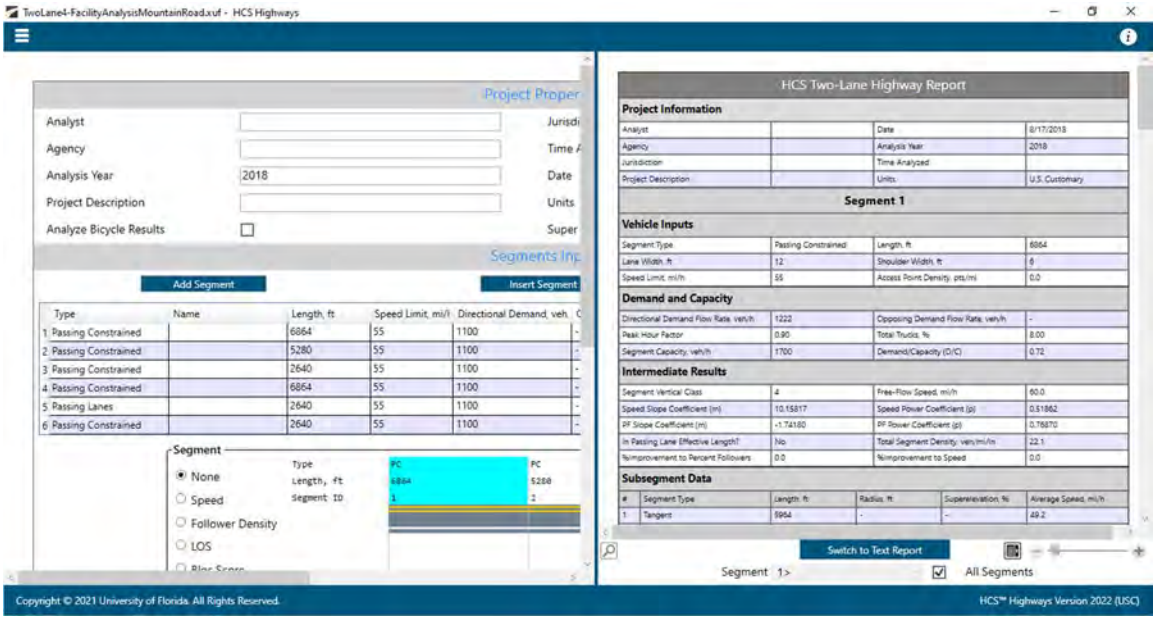
f. Selecting "Example Folder…" from the Start screen; this can be found below in the red box. Opening the example folder will open the path of the HCS example files in File Explorer. The desired example file can be double-clicked or right-clicked and selecting 'Open', which will open the example file in the Highways program.

2. Once an existing file is opened, you will be brought to the corresponding input page if in Page View or the input screen split with the report either on the right or the bottom of the screen if in Full View

    a. Page View



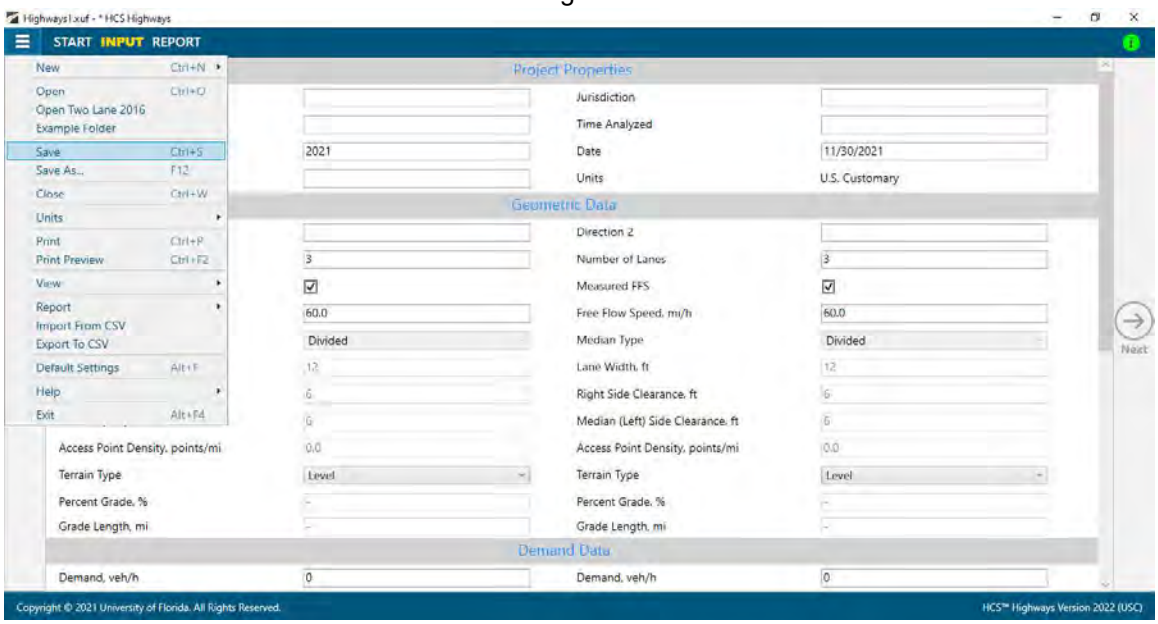
b. Full View



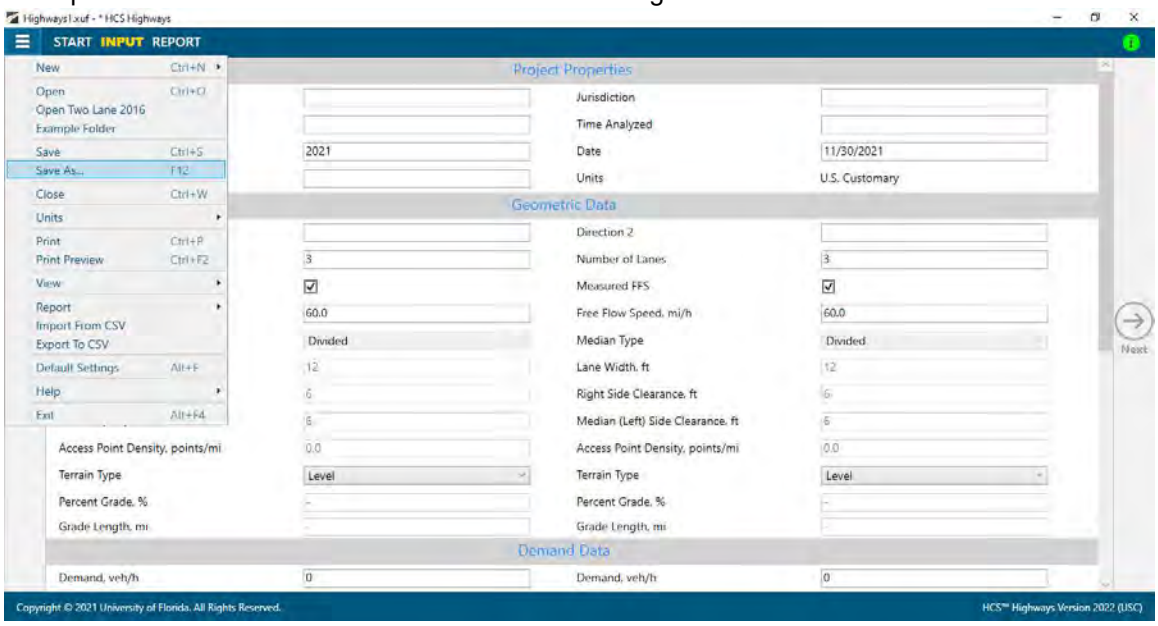
Save a File

1. There are five options for saving an open file:

   a. Selecting *File* > *Save* from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen and then selecting “Save”



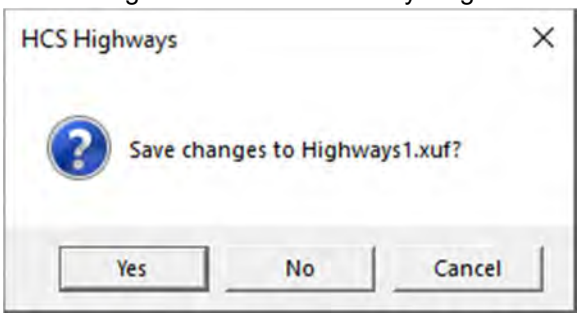
b. Selecting *File* > *Save As…* from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen and then selecting “Save As…”



c. Using the keyboard shortcut “Ctrl+S” for Save

d. Using the keyboard shortcut “F12” for Save As

e. Exiting the program or closing the file without saving changes beforehand; this will prompt you to save changes to the file before anything is closed



i. Selecting “Yes” will save the file if it is an existing file. If the file has not been previously saved, the Save As dialog box will pop up allowing you to change the file name and save it.

ii. Selecting “No” will exit the program or close the file without saving the file

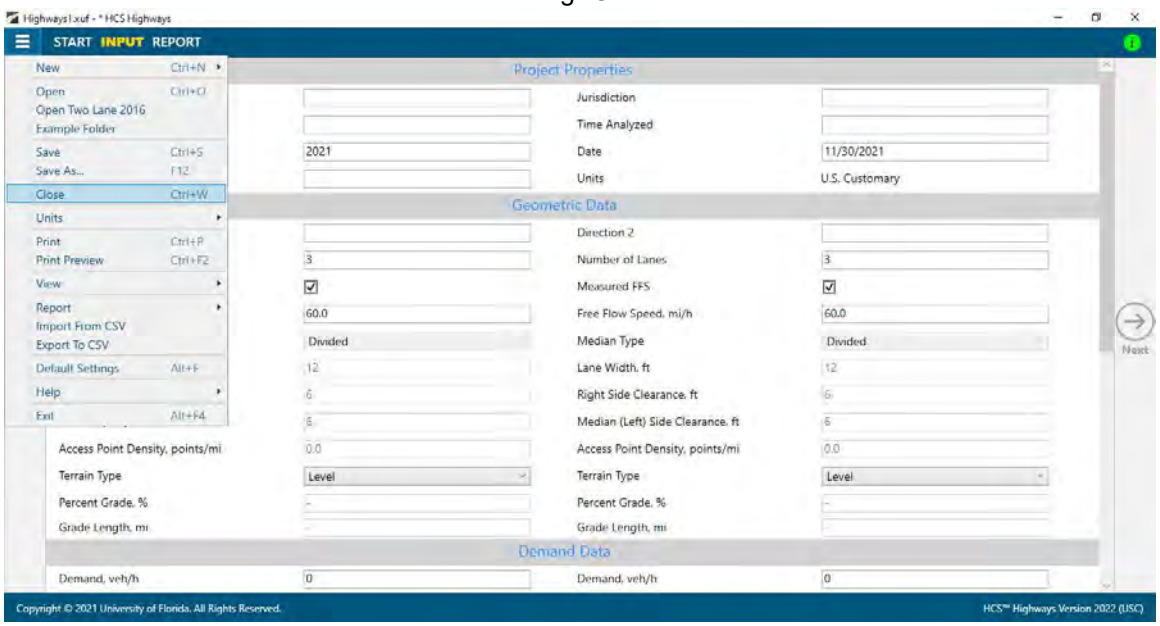
iii. Selecting “Cancel” will prevent the file from closing

Note: Using Save with an existing file will save a file without prompting you to specify a file name. Using Save with a new file will bring up the Save As dialog box for you to specify a file name for saving. Using Save As will always bring up the Save As dialog box for you to specify a file name for saving.

Close a File

1. There are three options for closing an open file:

a. Selecting *File* > *Close* from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen and then selecting “Close”



b. Using the keyboard shortcut “Ctrl+W”

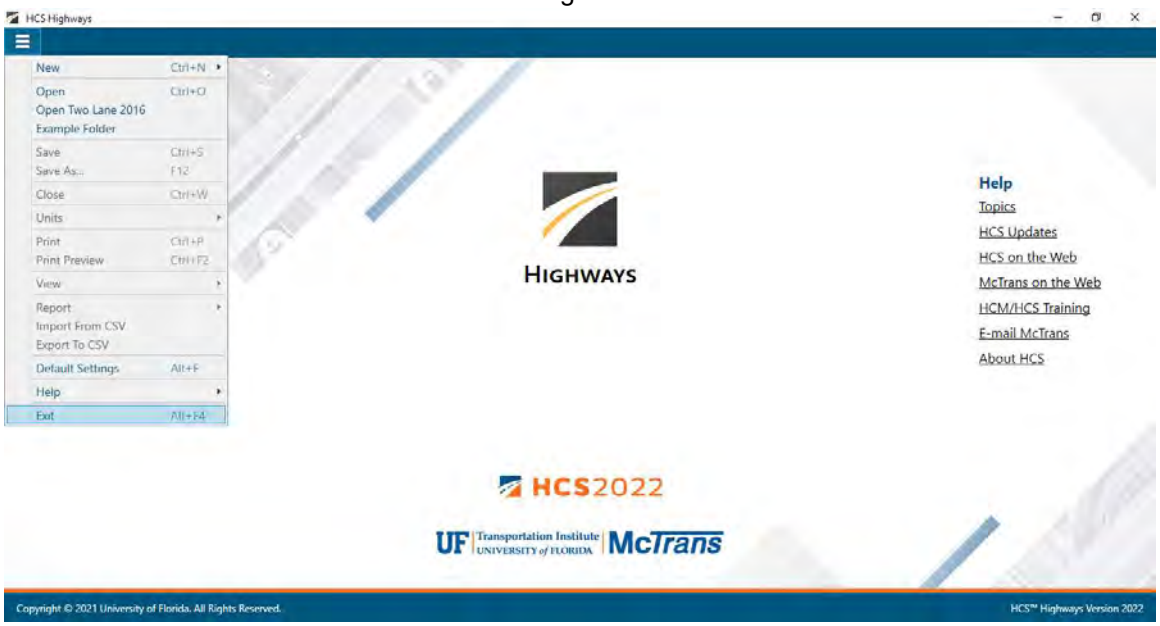
c. Exiting the program itself; please see *How To: Exit the Program*

Exit the Program

1. From the Start screen, there are three options for exiting the program:

Note: The program can be exited even if a file is still open; you do not need to start from the Start screen.

a. Selecting *File* > *Exit* from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen and then selecting “Exit”

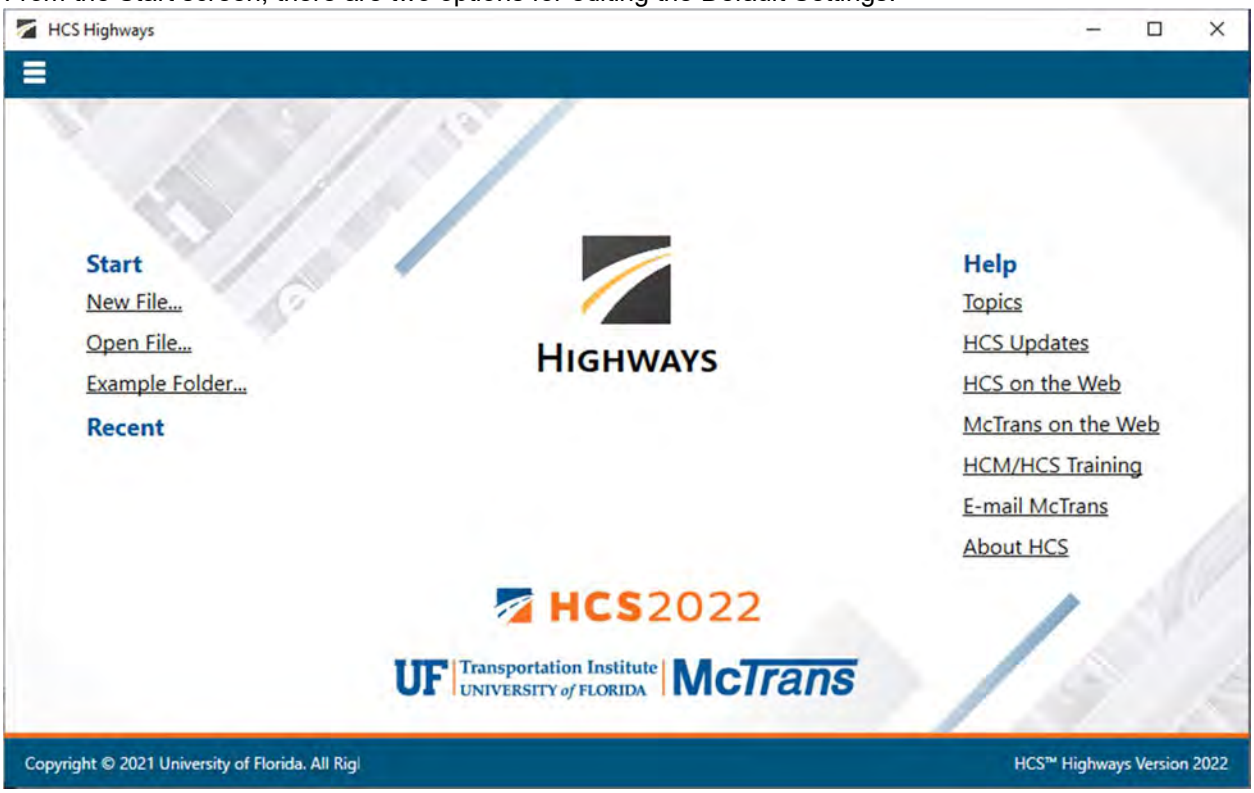


b. Using the keyboard shortcut “Alt+F4”

c. Selecting “X” in the top right-hand corner of the screen; this can be found below in the red box

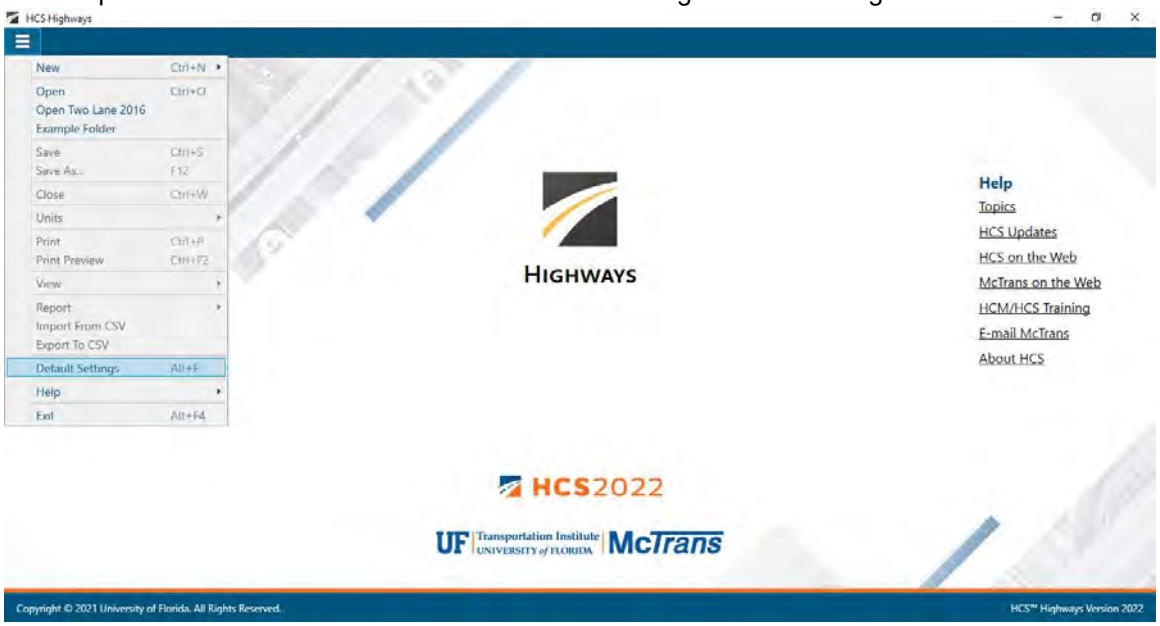
Edit the Default Settings

1. From the Start screen, there are two options for editing the Default Settings:



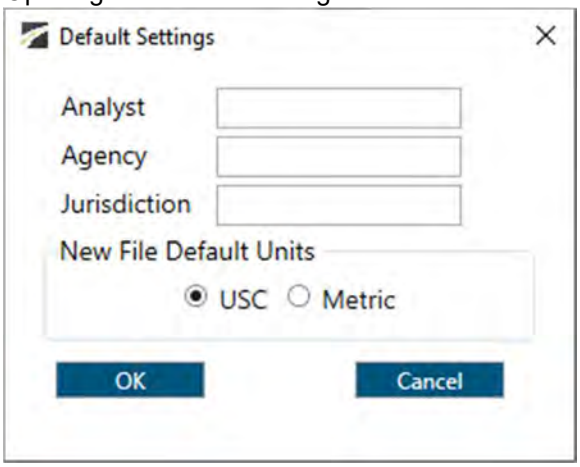
Note: The Default Settings can be changed even if an existing file is already open; you do not need to start from the Start screen.

   a. Selecting *File* > *Default Settings* from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen and then selecting “Default Settings”



   b. Using the keyboard shortcut “Alt+F”

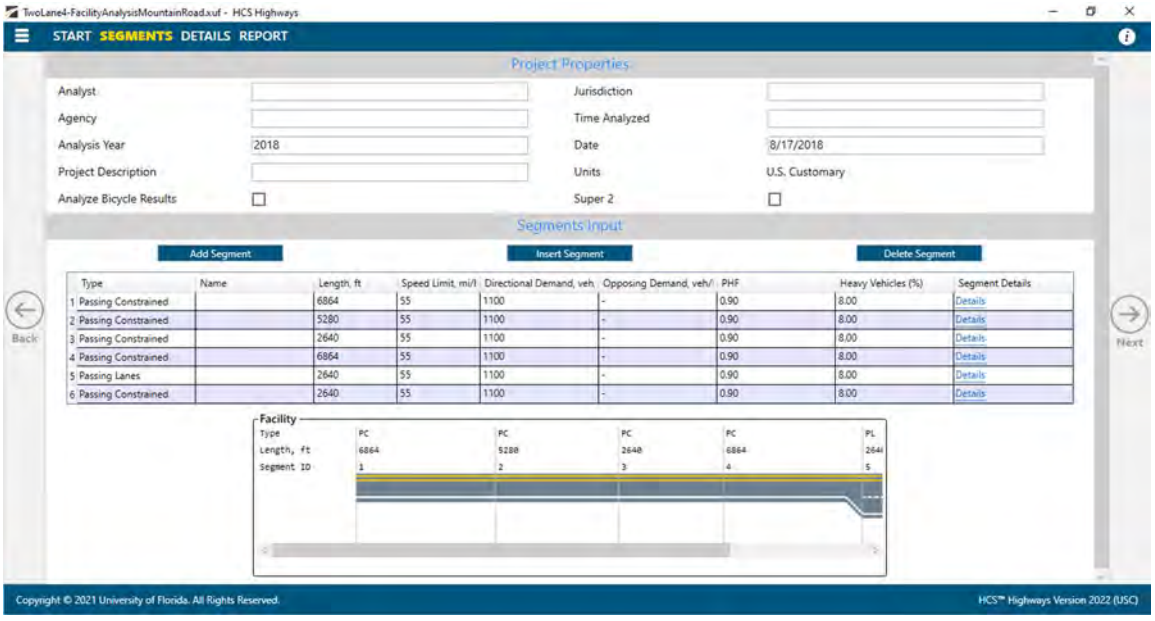
2. Opening the Default Settings will cause a Default Settings window to pop up:



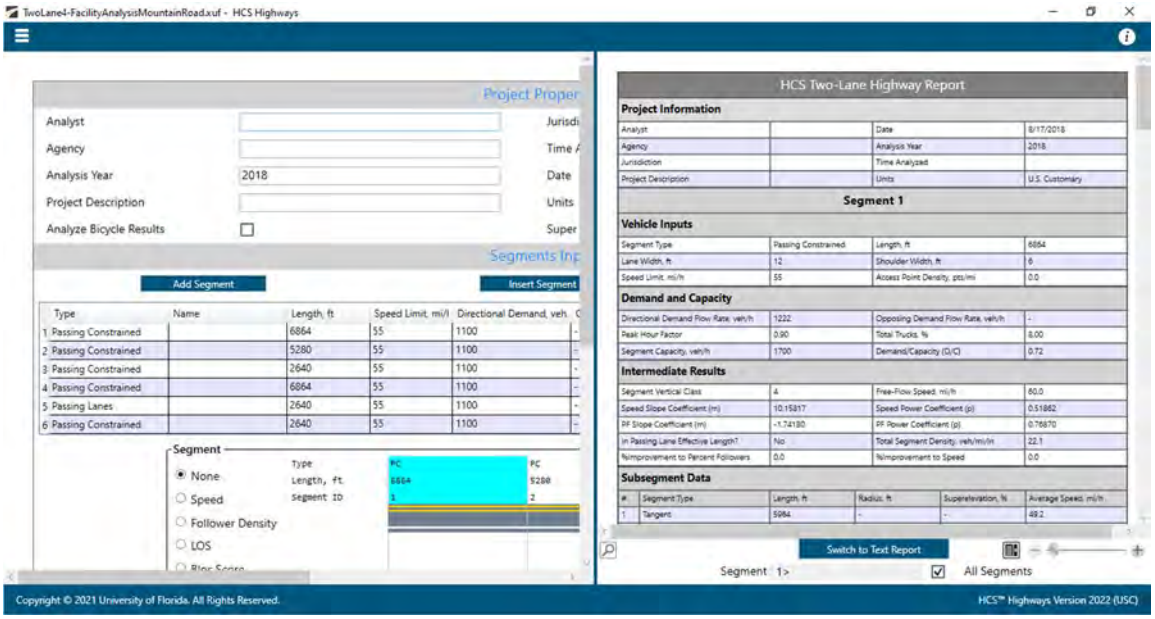
3. You can specify Analyst, Agency, and Jurisdiction by clicking in the corresponding text boxes and typing the desired text.
4. Under 'Units', you are given the option of running the analysis in either *U.S. Customary (USC)* or *SI (Metric)* units.
5. Clicking "OK" will save the changes made and close the Default Settings window; clicking "Cancel" will close the Default Settings window without saving any changes.
6. When a new file is created, the Analyst, Agency, and Jurisdiction fields will automatically be populated with the text specified in the Default Settings.
7. When starting a new file, the inputs and results will display according to the units specified in the Default Settings.

Change the View

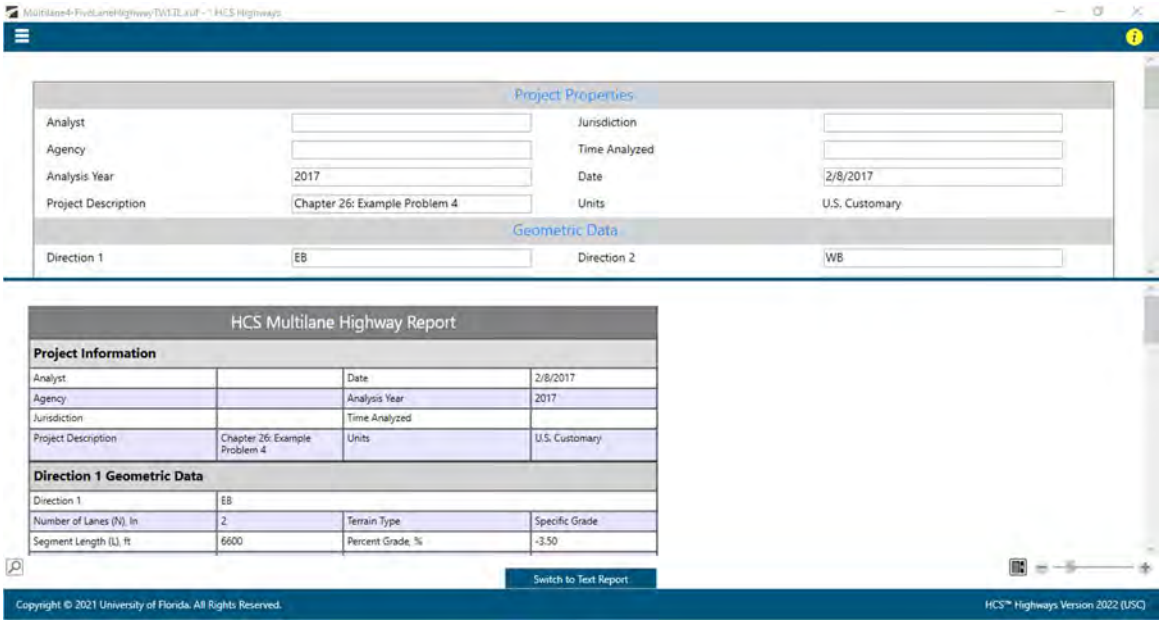
1. When a file is open, there are three main options for the view of the program:
    a. Page View: the input and results reports are separated into pages as seen below. You can navigate between pages using the "Back" and "Next" buttons or by clicking the page names found at the top of the screen.



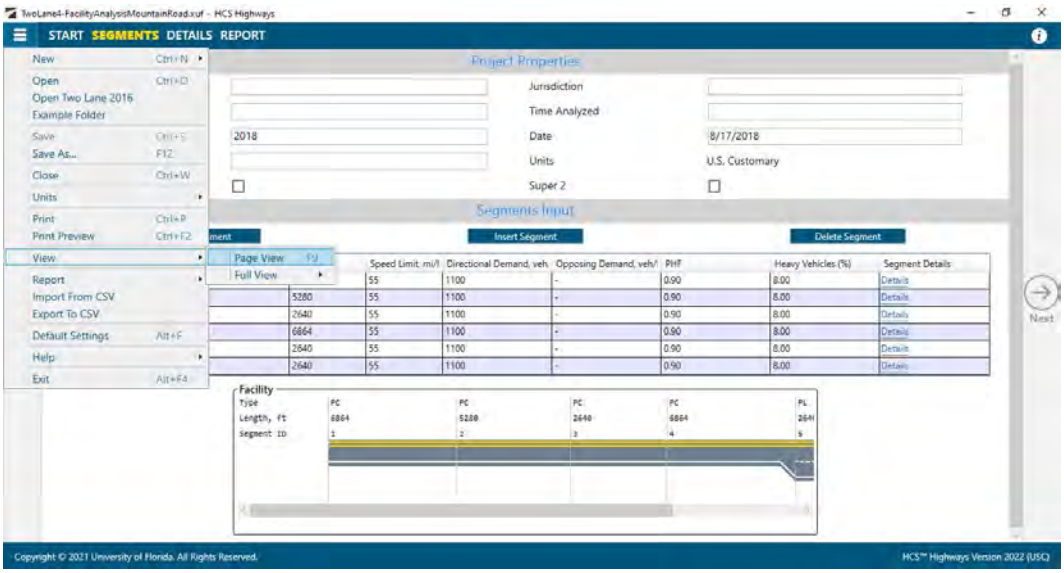
b. Full View with the report on the right of the screen: the screen is split with all inputs on the left side and the results reports on the right side. You can access all inputs and view all of the current report by using the corresponding scroll bars. There is also a screen splitter that can be moved to adjust the views of the input screen and results report.



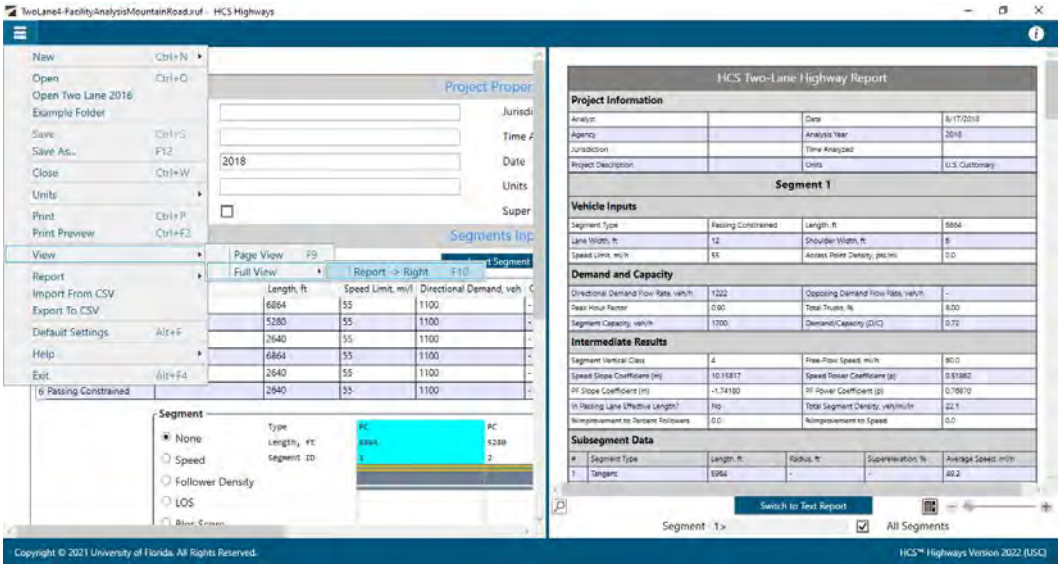
c. Full View with the report on the bottom of the screen: the screen is split with all inputs on the top of the screen and the results reports on the bottom of the screen. You can access all inputs and view all of the current report by using the corresponding scroll bars. There is also a screen splitter that can be moved to adjust the views of the input screen and results report.



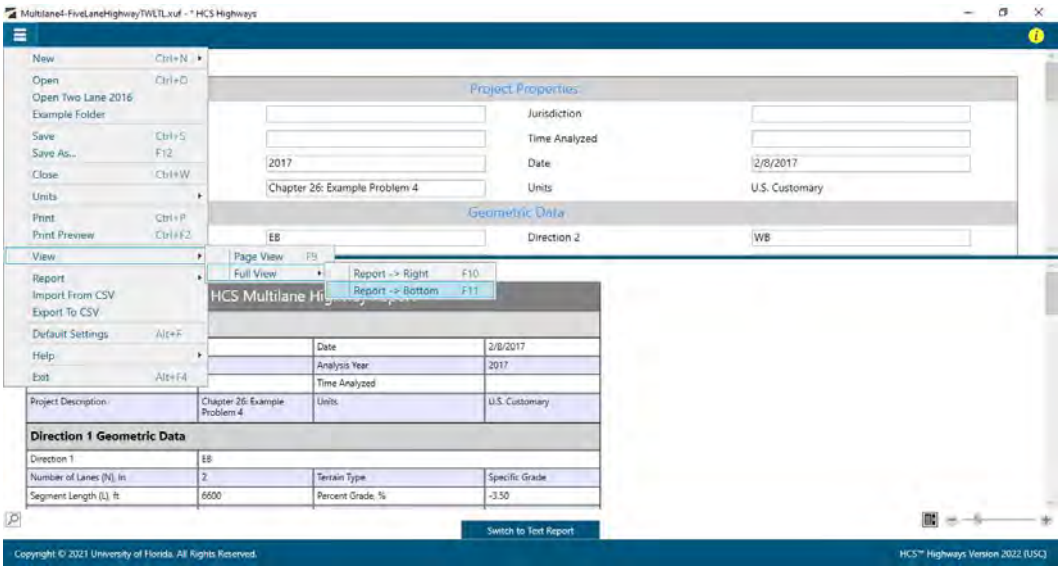
2. Views can be changed by using the main menu items or the keyboard shortcuts.
   a. Main Menu Items
      i. To switch to Page View, select *File* > *View* > *Page View* from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen, hovering over “View”, and then selecting “Page View”.



ii. To switch to Full View with the report on the right of the screen, select *File* > *View* > *Full View* > *Report -> Right* from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen, hovering over “View”, hovering over “Full View”, and then selecting “Report -> Right”.



iii. To switch to Full View with the report on the bottom of the screen, select *File* > *View* > *Full View* > *Report -> Bottom* from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen, hovering over “View”, hovering over “Full View”, and then selecting “Report -> Bottom”.



b. Keyboard Shortcuts

   i. Page View: keyboard shortcut is “F9”

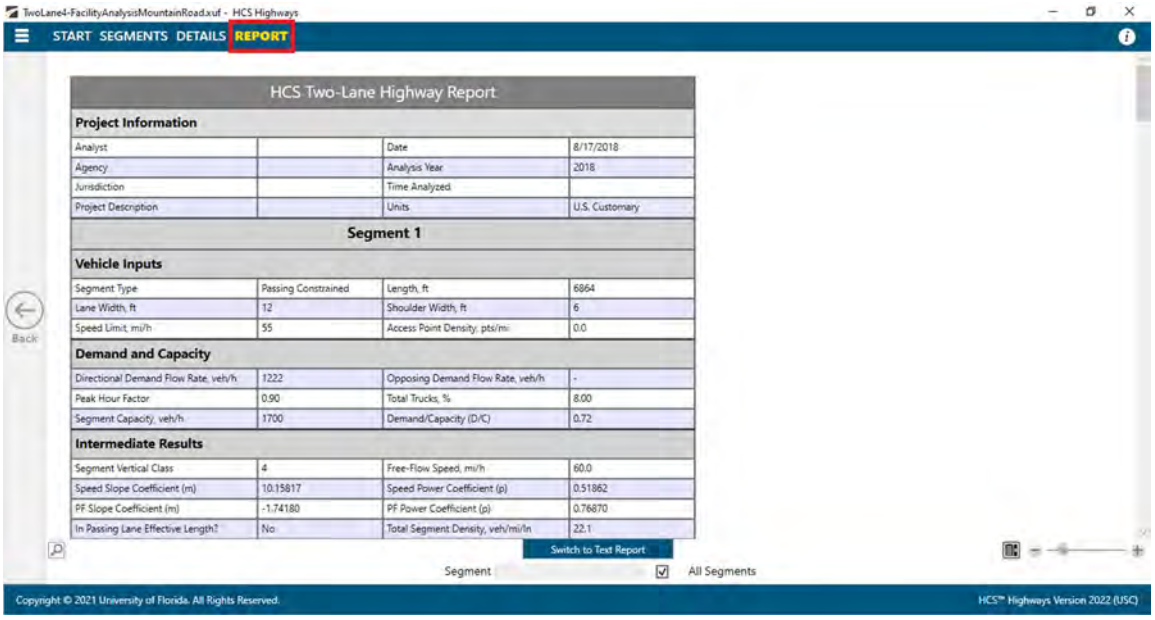
   ii. Full View with report on the right of the screen: keyboard shortcut is “F10”

   iii. Full View with report on the bottom of the screen: keyboard shortcut is “F11”

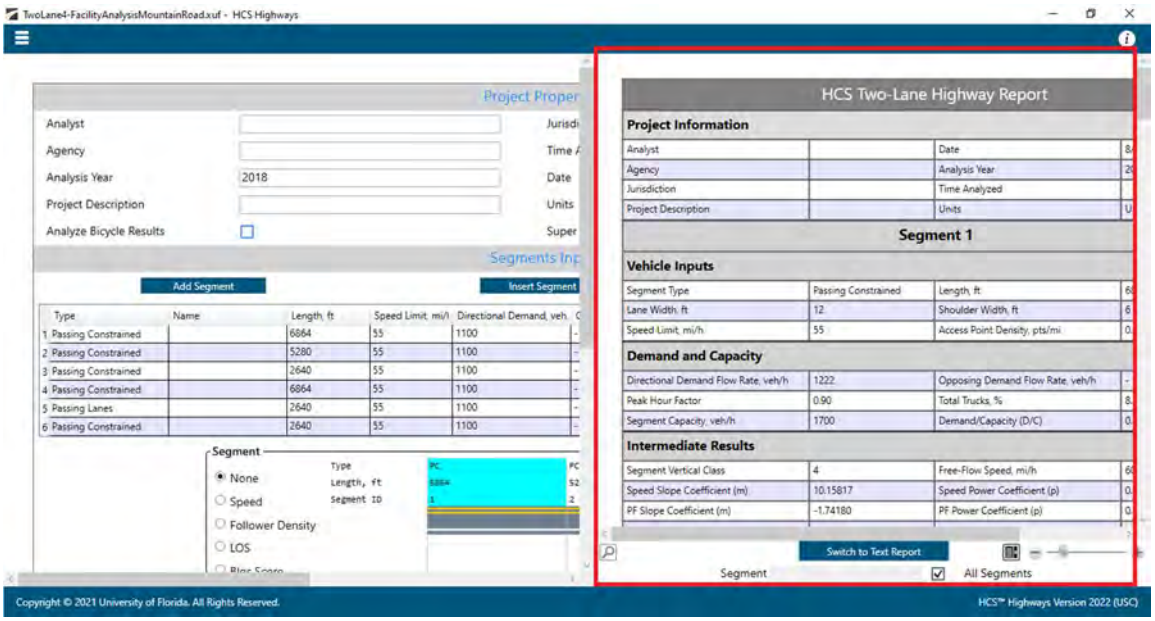
View Results of the Analysis

1. After editing all the necessary inputs, results of the analysis can be found in the form of reports. Reports can be found on the Report page if using Page View or on the results portion of the split screen if using Full View.

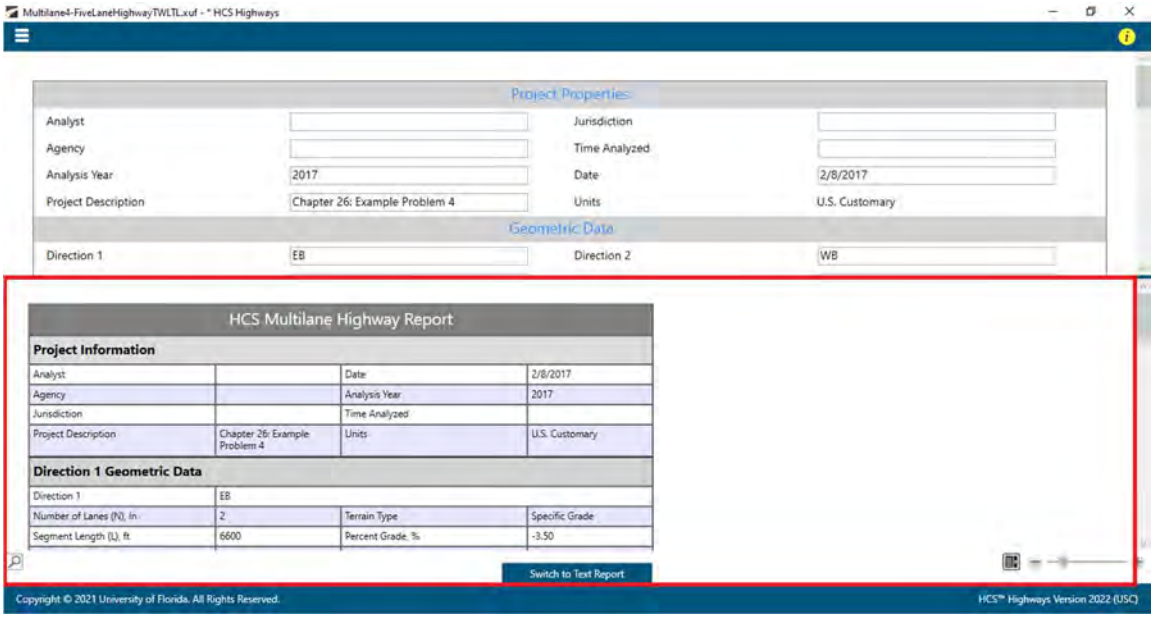
   a. Page View with Report page displayed



   b. Full View with the report on the right of the screen

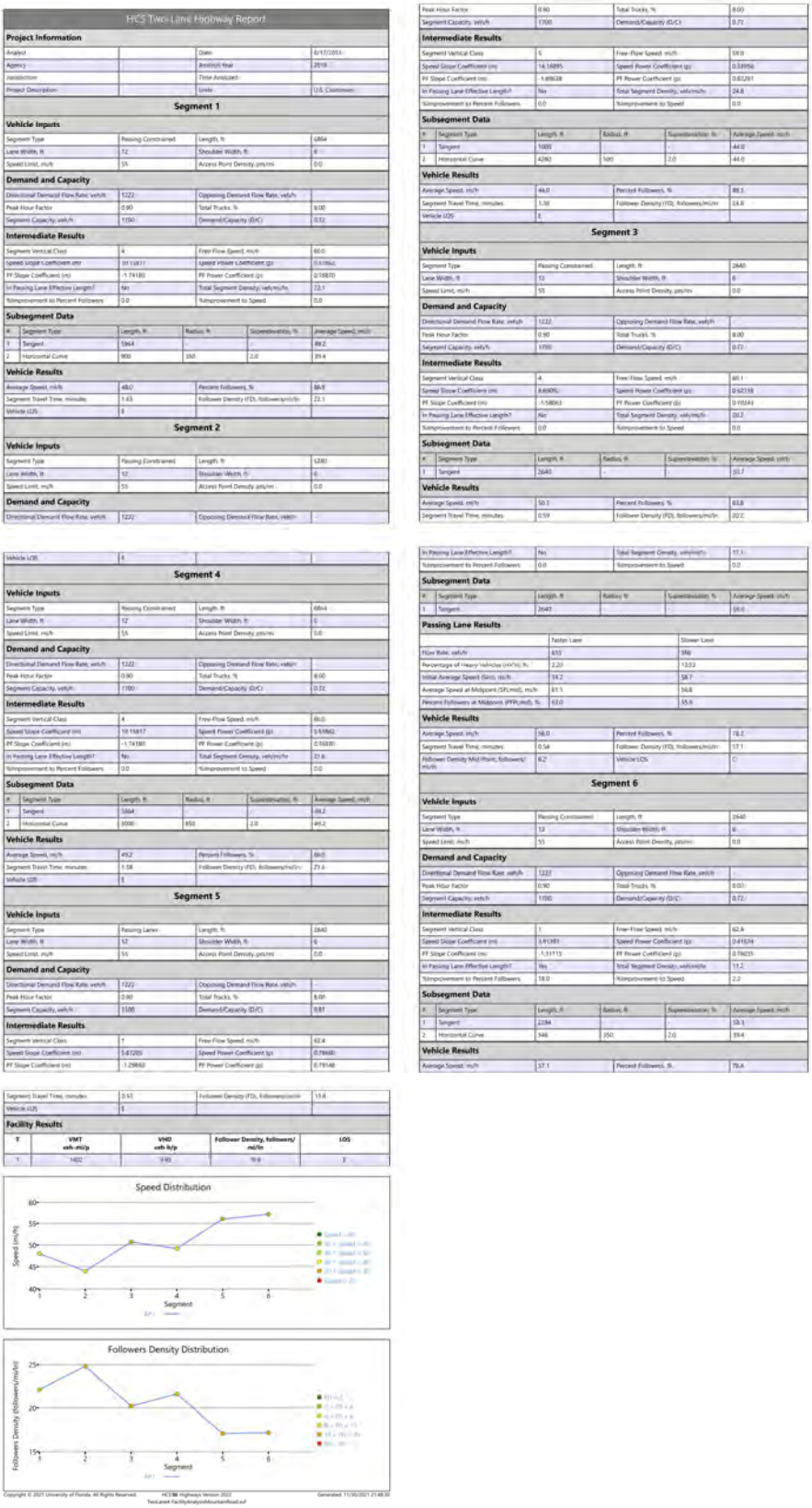


c. Full View with the report on the bottom of the screen



2. There are two options for reports: Formatted and Text

a. Formatted reports show the most important results in a presentable format



HCS Two-Lane Highway Report

Project Information

Analyst		Date:	6/17/2013
Agency		Analysis Year	2010
Jurisdiction		Time Analyzed:	
Project Description:		Units:	U.S. Customary

Segment 1

Vehicle Inputs

Segment Type	Passing Constrained	Length, ft	6864
Lane Width, ft	12	Shoulder Width, ft	6
Speed Limit, mi/h	55	Access Point Density, pts/mi	0.0

Demand and Capacity

Directional Demand Flow Rate, veh/h	1222	Opposing Demand Flow Rate, veh/h	
Peak Hour Factor	0.90	Total Trucks, %	8.00
Segment Capacity, veh/h	1700	Demand/Capacity (D/C)	0.72

Intermediate Results

Segment Vertical Class	4	Free-Flow Speed, mi/h	60.0
Speed Slope Coefficient (m)	10.11817	Speed Power Coefficient (p)	0.63862
PF Slope Coefficient (m)	-1.74180	PF Power Coefficient (p)	0.55870
In Passing Lane Effective Length?	No	Total Segment Density, veh/mi/ln	23.7
%Improvement to Percent Followers	0.0	%Improvement to Speed	0.0

Subsegment Data

#	Segment Type	Length, ft	Radius, ft	Superelevation, %	Average Speed, mi/h
1	Tangent	5864	-	-	59.2
2	Horizontal Curve	1000	350	2.0	39.4

Vehicle Results

Average Speed, mi/h	48.0	Percent Followers, %	58.9
Segment Travel Time, minutes	1.63	Follower Density (FD), followers/mi/ln	23.1
Vehicle LOS	E		

Segment 2

Vehicle Inputs

Segment Type	Passing Constrained	Length, ft	5280
Lane Width, ft	12	Shoulder Width, ft	6
Speed Limit, mi/h	55	Access Point Density, pts/mi	0.0

Demand and Capacity

Directional Demand Flow Rate, veh/h	1222	Opposing Demand Flow Rate, veh/h	

Peak Hour Factor	0.90	Total Trucks, %	8.00
Segment Capacity, veh/h	1700	Demand/Capacity (D/C)	0.72

Intermediate Results

Segment Vertical Class	5	Free-Flow Speed, mi/h	59.9
Speed Slope Coefficient (m)	14.14895	Speed Power Coefficient (p)	0.59956
PF Slope Coefficient (m)	-1.69038	PF Power Coefficient (p)	0.82291
In Passing Lane Effective Length?	No	Total Segment Density, veh/mi/ln	24.8
%Improvement to Percent Followers	0.0	%Improvement to Speed	0.0

Subsegment Data

#	Segment Type	Length, ft	Radius, ft	Superelevation, %	Average Speed, mi/h
1	Tangent	5089	-	-	44.8
2	Horizontal Curve	4280	500	2.0	44.0

Vehicle Results

Average Speed, mi/h	44.0	Percent Followers, %	89.3
Segment Travel Time, minutes	1.38	Follower Density (FD), followers/mi/ln	24.8
Vehicle LOS	E		

Segment 3

Vehicle Inputs

Segment Type	Passing Constrained	Length, ft	2640
Lane Width, ft	12	Shoulder Width, ft	6
Speed Limit, mi/h	55	Access Point Density, pts/mi	0.0

Demand and Capacity

Directional Demand Flow Rate, veh/h	1222	Opposing Demand Flow Rate, veh/h	
Peak Hour Factor	0.90	Total Trucks, %	8.00
Segment Capacity, veh/h	1700	Demand/Capacity (D/C)	0.72

Intermediate Results

Segment Vertical Class	4	Free-Flow Speed, mi/h	60.1
Speed Slope Coefficient (m)	8.60905	Speed Power Coefficient (p)	0.62338
PF Slope Coefficient (m)	-1.58063	PF Power Coefficient (p)	0.91043
In Passing Lane Effective Length?	No	Total Segment Density, veh/mi/ln	20.2
%Improvement to Percent Followers	0.0	%Improvement to Speed	0.0

Subsegment Data

#	Segment Type	Length, ft	Radius, ft	Superelevation, %	Average Speed, mi/h
1	Tangent	2640	-	-	60.7

Vehicle Results

Average Speed, mi/h	50.7	Percent Followers, %	83.8
Segment Travel Time, minutes	0.59	Follower Density (FD), followers/mi/ln	20.2

Vehicle LOS	E		

Segment 4

Vehicle Inputs

Segment Type	Passing Constrained	Length, ft	6864
Lane Width, ft	12	Shoulder Width, ft	6
Speed Limit, mi/h	55	Access Point Density, pts/mi	0.0

Demand and Capacity

Directional Demand Flow Rate, veh/h	1222	Opposing Demand Flow Rate, veh/h	
Peak Hour Factor	0.90	Total Trucks, %	8.00
Segment Capacity, veh/h	1700	Demand/Capacity (D/C)	0.72

Intermediate Results

Segment Vertical Class	4	Free-Flow Speed, mi/h	60.0
Speed Slope Coefficient (m)	10.11817	Speed Power Coefficient (p)	0.63862
PF Slope Coefficient (m)	-1.74180	PF Power Coefficient (p)	0.55870
In Passing Lane Effective Length?	No	Total Segment Density, veh/mi/ln	23.6
%Improvement to Percent Followers	0.0	%Improvement to Speed	0.0

Subsegment Data

#	Segment Type	Length, ft	Radius, ft	Superelevation, %	Average Speed, mi/h
1	Tangent	5864	-	-	59.2
2	Horizontal Curve	1000	350	2.0	39.2

Vehicle Results

Average Speed, mi/h	49.2	Percent Followers, %	58.9
Segment Travel Time, minutes	1.58	Follower Density (FD), followers/mi/ln	23.6
Vehicle LOS	E		

Segment 5

Vehicle Inputs

Segment Type	Passing Lane	Length, ft	2640
Lane Width, ft	12	Shoulder Width, ft	6
Speed Limit, mi/h	55	Access Point Density, pts/mi	0.0

Demand and Capacity

Directional Demand Flow Rate, veh/h	1222	Opposing Demand Flow Rate, veh/h	
Peak Hour Factor	0.90	Total Trucks, %	8.00
Segment Capacity, veh/h	1500	Demand/Capacity (D/C)	0.81

Intermediate Results

Segment Vertical Class	1	Free-Flow Speed, mi/h	62.4
Speed Slope Coefficient (m)	5.67205	Speed Power Coefficient (p)	0.78660
PF Slope Coefficient (m)	-1.29860	PF Power Coefficient (p)	0.79148

In Passing Lane Effective Length?	No	Total Segment Density, veh/mi/ln	17.1
%Improvement to Percent Followers	0.0	%Improvement to Speed	0.0

Subsegment Data

#	Segment Type	Length, ft	Radius, ft	Superelevation, %	Average Speed, mi/h
1	Tangent	2640	-	-	59.0

Passing Lane Results

	Faster Lane	Slower Lane
Flow Rate, veh/h	653	569
Percentage of Heavy Vehicles (HV%), %	2.20	13.53
Initial Average Speed (Si), mi/h	59.2	58.7
Average Speed at Midpoint (Sf),mid), mi/h	61.1	56.8
Percent Followers at Midpoint (PFPLmid), %	63.0	55.9

Vehicle Results

Average Speed, mi/h	58.0	Percent Followers, %	78.2
Segment Travel Time, minutes	0.54	Follower Density (FD), followers/mi/ln	17.1
Follower Density Mid-Point, followers/mi/ln	6.2	Vehicle LOS	C

Segment 6

Vehicle Inputs

Segment Type	Passing Constrained	Length, ft	2640
Lane Width, ft	12	Shoulder Width, ft	6
Speed Limit, mi/h	55	Access Point Density, pts/mi	0.0

Demand and Capacity

Directional Demand Flow Rate, veh/h	1222	Opposing Demand Flow Rate, veh/h	
Peak Hour Factor	0.90	Total Trucks, %	8.00
Segment Capacity, veh/h	1700	Demand/Capacity (D/C)	0.72

Intermediate Results

Segment Vertical Class	1	Free-Flow Speed, mi/h	62.4
Speed Slope Coefficient (m)	5.91301	Speed Power Coefficient (p)	0.81674
PF Slope Coefficient (m)	-1.51713	PF Power Coefficient (p)	0.76015
In Passing Lane Effective Length?	Yes	Total Segment Density, veh/mi/ln	11.2
%Improvement to Percent Followers	18.0	%Improvement to Speed	2.0

Subsegment Data

#	Segment Type	Length, ft	Radius, ft	Superelevation, %	Average Speed, mi/h
1	Tangent	2284	-	-	59.1
2	Horizontal Curve	346	350	2.0	39.4

Vehicle Results

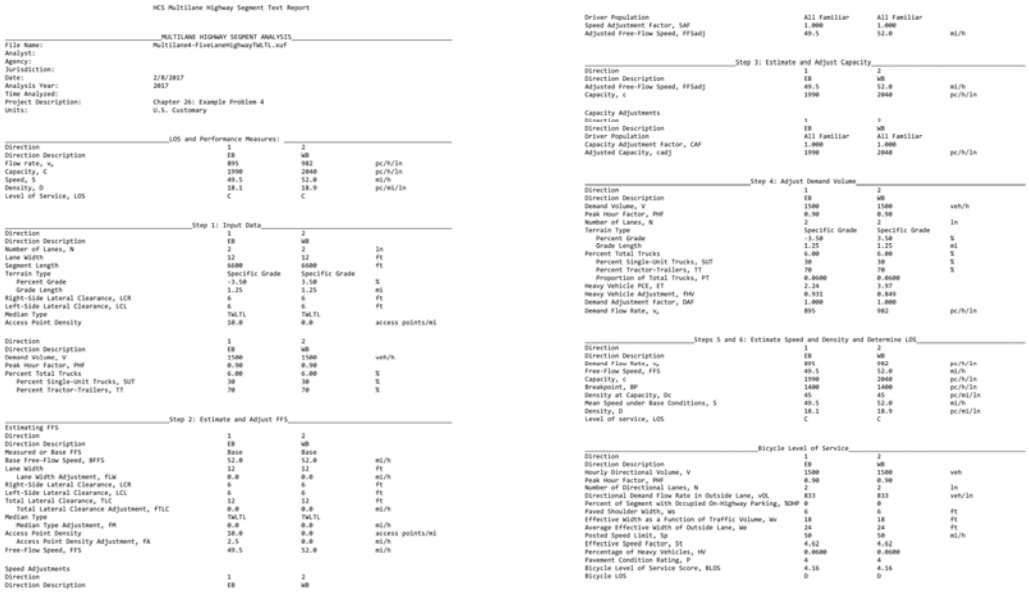
Average Speed, mi/h	57.1	Percent Followers, %	78.4

Segment Travel Time, minutes	0.53	Follower Density (FD), followers/mi/ln	13.8
Vehicle LOS	B		

Facility Results

T	VMT veh-mi/p	VHD veh-h/p	Follower Density, followers/mi/ln	LOS
1	1402	3.93	19.9	E

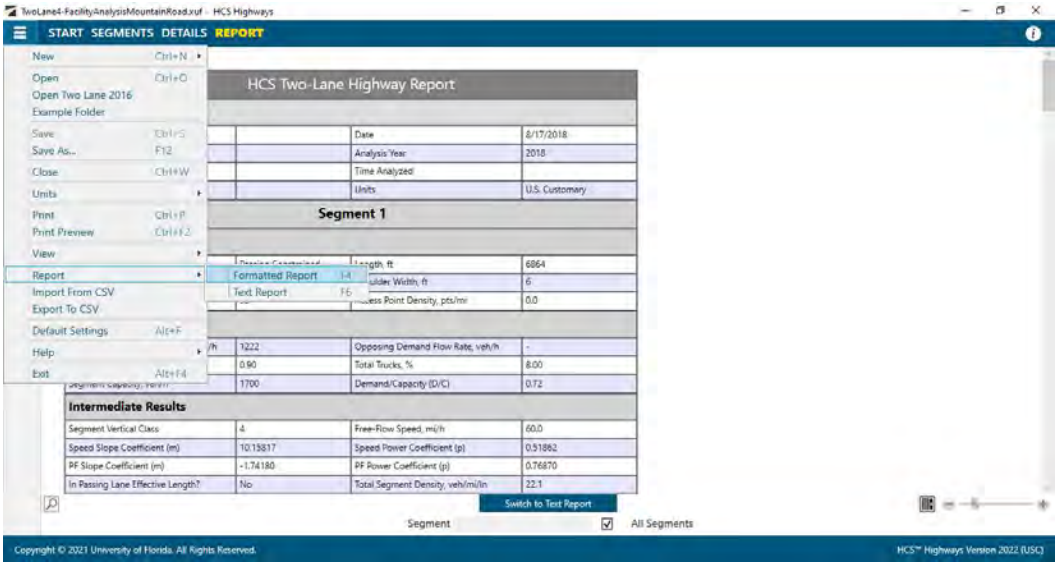
b. Text reports show a more detailed analysis in plain text



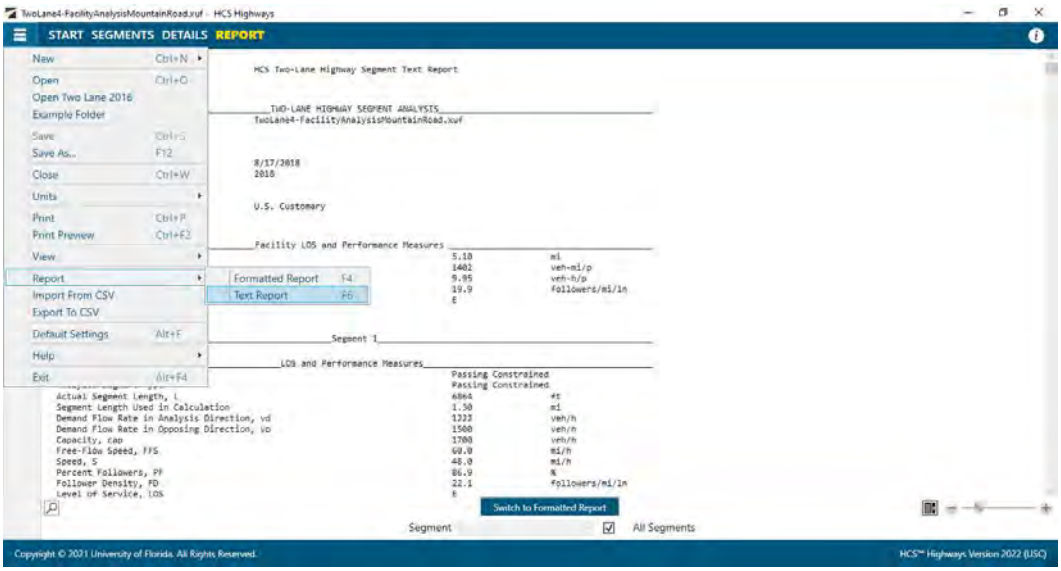
3. The type of report displayed can be changed by using the main menu items, keyboard shortcuts, or toggle buttons found under the report

    a. Main Menu Items

        i. To switch to the Formatted Report, select *File* > *Report* > *Formatted Report* from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen, hovering over “Report”, and then selecting “Formatted Report”.



        ii. To switch to the Text Report, select *File* > *Report* > *Text Report* from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen, hovering over “Report”, and then selecting “Text Report”.



b. Keyboard Shortcuts

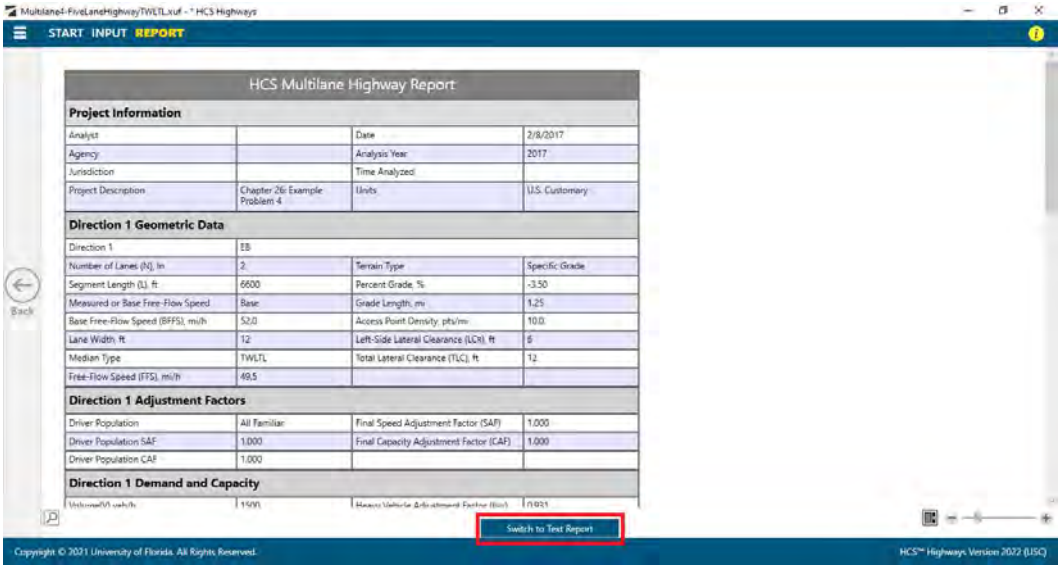
   i. Formatted Report: keyboard shortcut is “F4”

   ii. Text Report: keyboard shortcut is “F6”

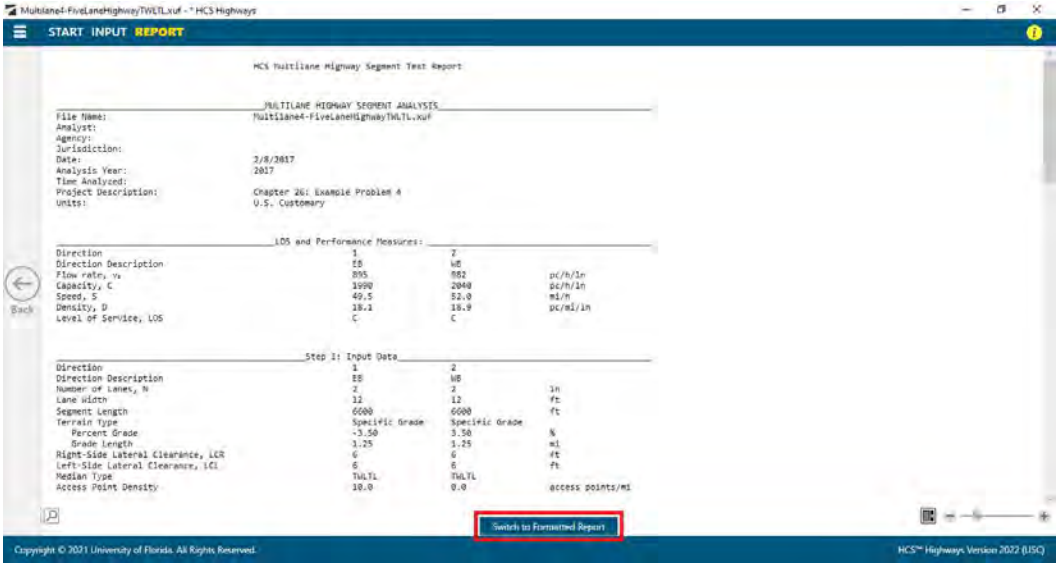
c. Report Toggle Buttons

   i. Toggle buttons are available at the bottom of the screen underneath the report.

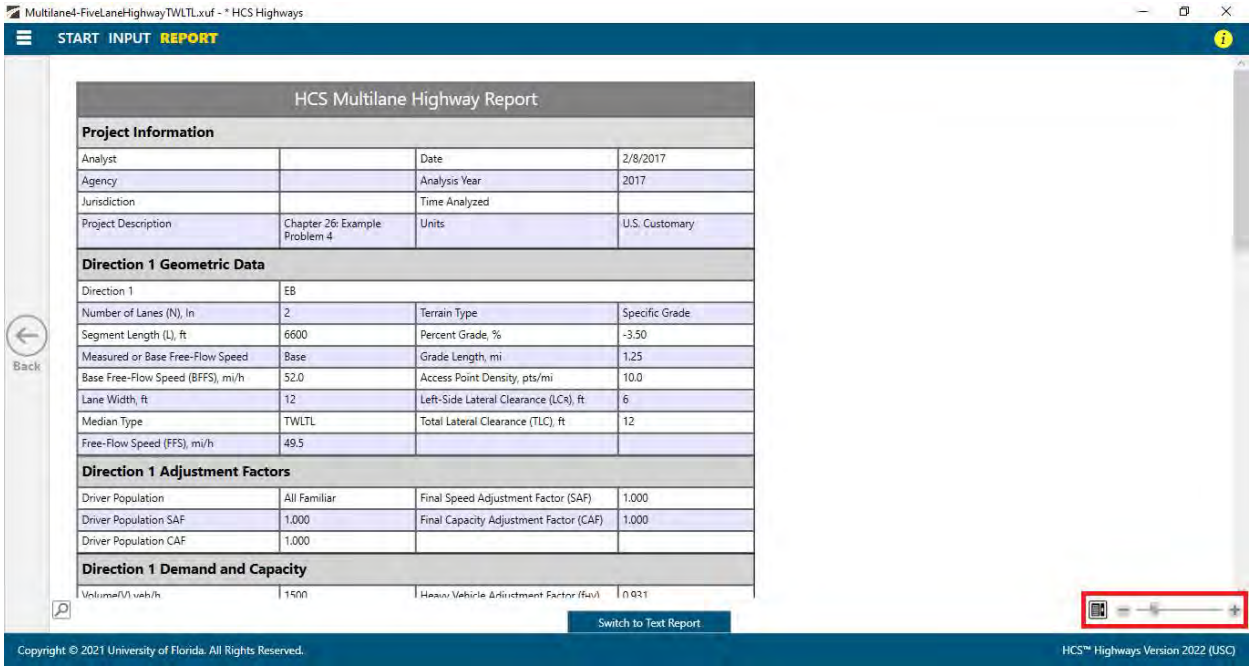
   ii. If the formatted report is currently being displayed, the toggle button will say “Switch to Text Report” which will allow you to display the text report if clicked.



iii. If the text report is currently being displayed, the first toggle button will say “Switch to Formatted Report” which will allow you to display the formatted report if clicked.



4. The magnification of the report currently being displayed can be changed using the zoom slider found at the bottom right-hand corner of the screen.



a. To zoom in, drag the slider to the right; to zoom out, drag the slider to the left

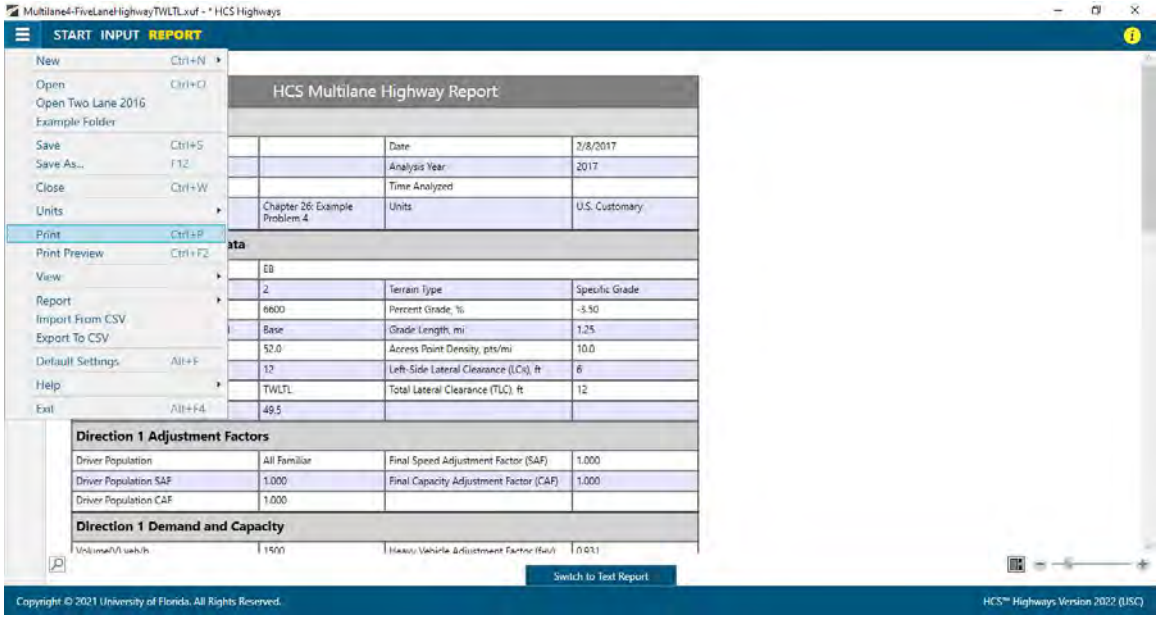
b. Clicking the plus (+) button will zoom in; clicking the minus (-) button will zoom out

c. Holding down “ctrl” on the keyboard and scrolling up on the mouse wheel will zoom in; holding down “ctrl” on the keyboard and scrolling down on the mouse wheel will zoom out

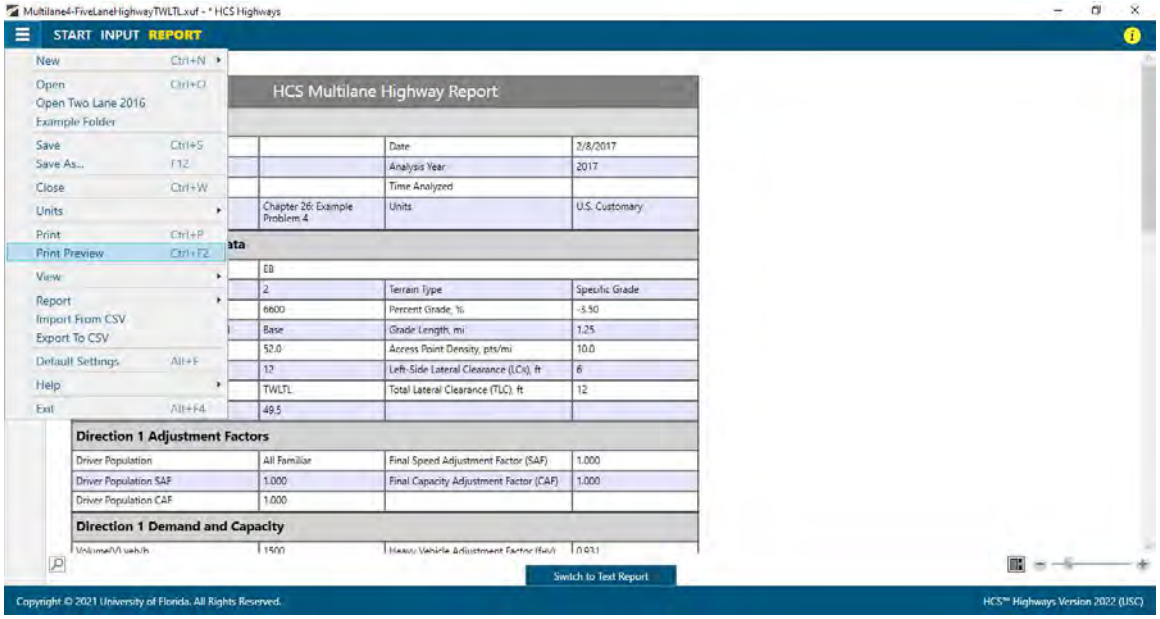
Print a Report

1. There are four options for printing a report:

a. Selecting *File* > *Print* from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen and then selecting “Print”



b. Selecting *File* > *Print Preview* from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen and then selecting “Print Preview”

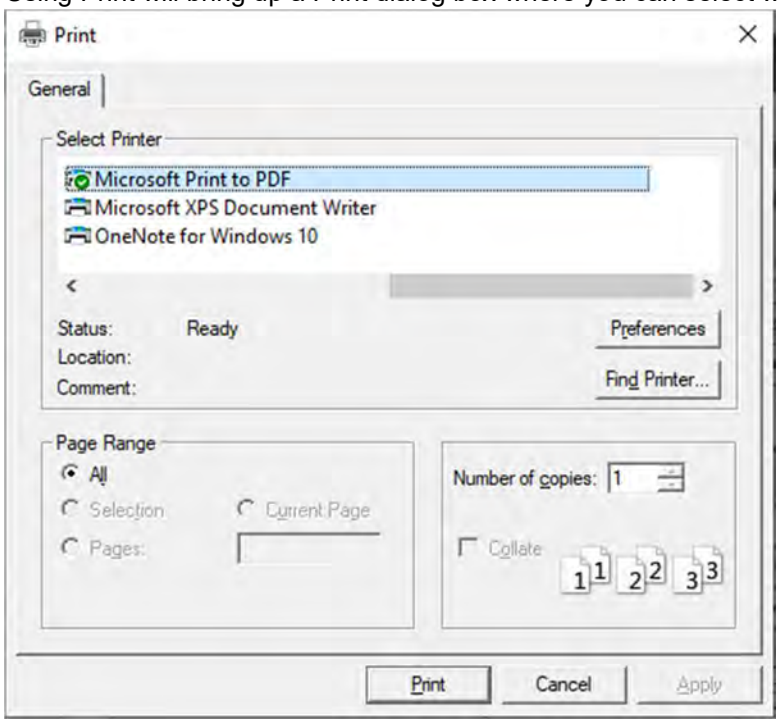


c. Using keyboard shortcut “Ctrl+P” for Print

d. Using keyboard shortcut “Ctrl+F2” for Print Preview

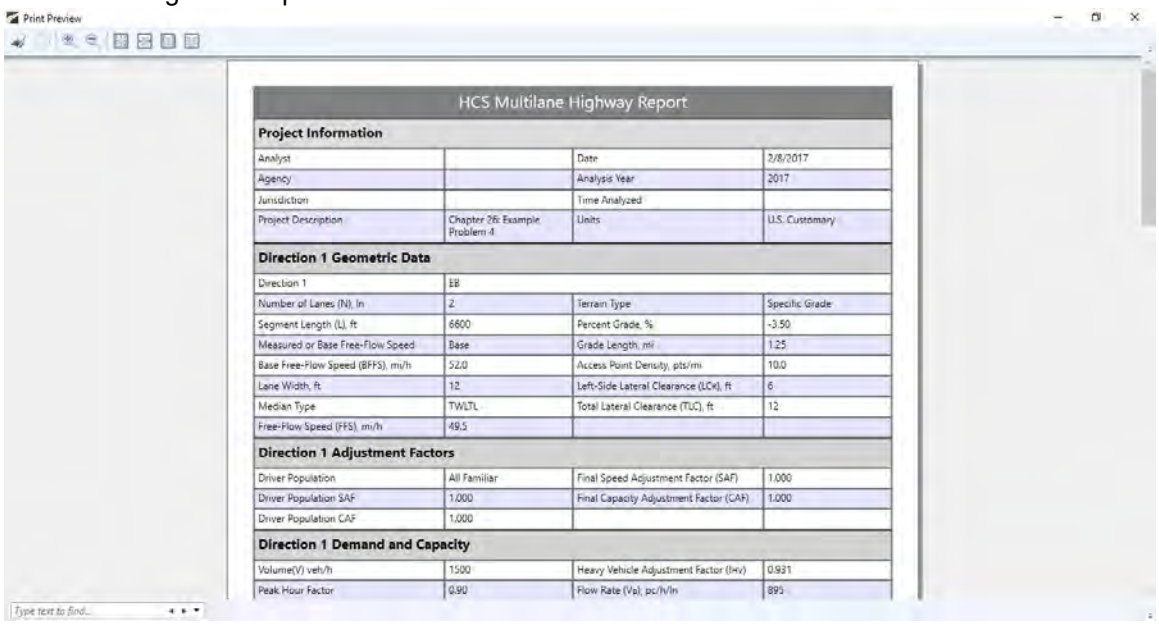
2. Print

    a. Using Print will bring up a Print dialog box where you can select which printer to print to



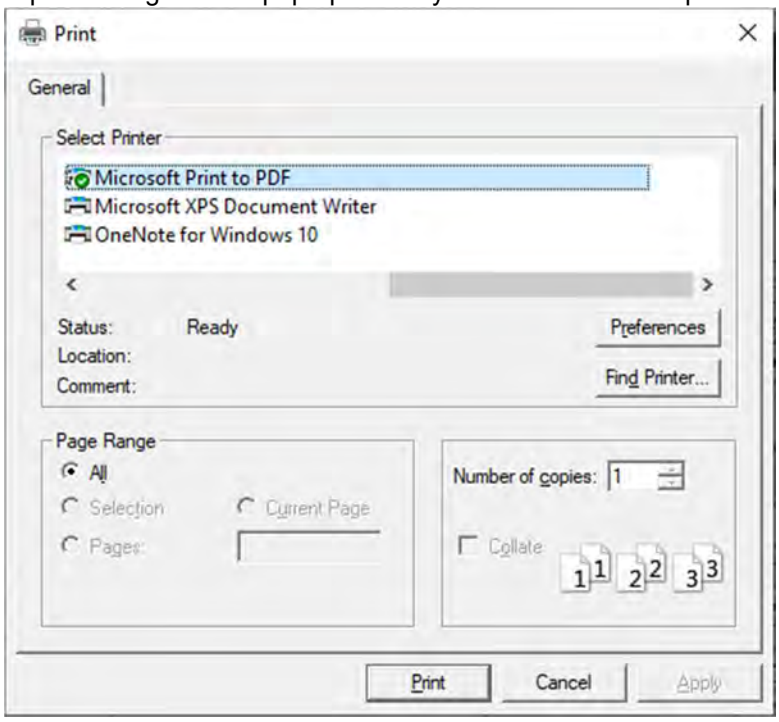
3. Print Preview

    a. Using Print Preview will bring up a window where you can view how the report will look on paper before sending it to the printer



    b. The print icon in the toolbar found in the top left-hand corner can then be selected

c. A print dialog box will pop up where you can select which printer to print to



Glossary of Terms

Access Point Density

Access Point Density, or *APD*, is the measure of access points per mile (or access points per kilometer in metric).

In Multilane, the number of access points per mile is determined by dividing the total number of access points (i.e., driveways and unsignalized intersections) on the right side of the highway in the direction of travel by the length of the segment in miles (or kilometers in metric). An intersection or driveway should only be included in the count if it influences traffic flow. Access points that go unnoticed by drivers, or with little activity, should not be used to determine access-point density.

In TwoLane, access points are major driveways and side roads where significant traffic enters and/or leaves the two-lane highway within the analysis segment. Access points lower the free-flow speed for the segment. By lowering the free-flow speed, access points will also indirectly affect the average speed and the follower density.

The total number of access points on an analysis segment is the sum of the number of active major driveways and road or street approaches (on both sides of the highway) where traffic enters and/or leaves the two-lane highway within the segment. Residential driveways and other low-volume driveways and side roads (generally with ADT below 20 vehicles per day) should not be counted as access points. If the two-lane highway has a physical median barrier, or barrier striping, that prevents access to driveways on the opposite side of the barrier, then the access points on the opposite side of the median should not be included in the total for the segment.

Note that the methodology for estimating segment speeds does not provide for the computation of the effects of intersection delays *within* a two-lane highway analysis segment. Therefore, segments cannot include all-way stop, roundabout, or signal-controlled intersections between their endpoints. The segment must be split into smaller segments so that these intersections fall at the segments' start- or endpoints. Intersections at the beginning or end point of a segment do not count as access points.

Access-Point Density Adjustment

The exhibit below presents the adjustment to FFS for various levels of access-point density. Studies indicate that for each access point per mile, the estimated FFS decreases by approximately 0.25 mi/h, regardless of the type of median.

Access-Point Density (access points/mi)	Reduction in FFS, f_A (mi/h)
0	0.0
10	2.5
20	5.0
30	7.5
≥40	10.0

Note: Interpolation to the nearest 0.1 is recommended.

Access Point Density is measured in access points per mile (or access points per kilometer in metric), and the corresponding Access Point Density Adjustment is measured in miles per hour (or kilometers per hour in metric).

Add Segment

Clicking on the button 'Add Segment' will add a row of inputs with the default Segment Type of 'Passing Constrained' along with the default values for the Passing Constrained segment type. The user can add an unlimited number of segments and can manually change the inputs to the desired values.

Add Subsegment

Clicking on the button 'Add Subsegment' will add a row of inputs with the default Subsegment Type of 'Tangent' along with the default values for the Tangent subsegment type. The user can add an unlimited number of subsegments and can manually change the inputs to the desired values.

Agency

This field is provided to document the agency or company associated with the analysis or project.

Analysis Year

This field is provided to document the year for which the analysis is being performed. For example, a current or past operational year or a future design or planning year might be coded here.

Analyst

This field is provided to document the name of the analyst.

Analyze Bicycle Results

A checkbox is provided for the user to indicate whether or not to analyze bicycle results. Checking this box will enable inputs relevant to the bicycle LOS procedure and display bicycle results on the formatted and text reports. Likewise, leaving this box unchecked will disable inputs relevant to the bicycle LOS procedure and will remove the bicycle results from the formatted and text reports.

Base Free-Flow Speed

The methodology covers multilane highway segments with a FFS in the range of 45 to 70 mi/h. There is not a great deal of information available to help establish a base value. In one sense, it is like the design speed—it represents the potential FFS based only on the highway's horizontal and vertical alignment, not including impacts of lane widths, lateral clearances, median type, and access points. The design speed may be used for BFFS if it is available.

Although speed limits are not always uniformly set, BFFS for multilane highways may be estimated, if necessary, as the posted or statutory speed limit plus 5 mi/h for speed limits 50 mi/h and higher and as the speed limit plus 7 mi/h for speed limits less than 50 mi/h.

For metric units, Base Free-Flow Speed is measured in kilometers per hour, with a range of 72.4 to 112.7 km/h.

Bicycle LOS

Bicycle levels of service for multilane highway segments are based on a bicycle LOS score, which is in turn based on a traveler perception model. The bicycle LOS score is based, in order of importance, on give variables:

- Average effective width of the outside through lane,
- Motorized vehicle volumes and speeds,
- Heavy vehicle (truck) volumes, and

- Pavement condition.

The LOS ranges for bicycles on multilane highways are given in the following table:

LOS	Bicycle LOS Score
A	≤1.5
B	>1.5–2.5
C	>2.5–3.5
D	>3.5–4.5
E	>4.5–5.5
F	>5.5

The data required for evaluating bicycle LOS on a multilane highway and used in the development of the LOS model are as follows:

- Width of the outside through lane: 10 to 16 ft (or 3.0 to 4.9 m in metric),
- Shoulder width: 0 to 6 ft (or 0 to 1.8 m in metric),
- Motorized vehicle volumes: up to 36,000 annual daily traffic (AADT),
- Number of directional through lanes,
- Posted speed,
- Heavy vehicle percentage, and
- Pavement condition: 2 to 5 on the FHWA 5-point pavement rating scale.

Bicycle LOS Score

LOS score is a numerical output from a traveler perception model that typically indicates the average rating that travelers would give a transportation facility or service under a given set of condition.

The bicycle LOS model for multilane highways uses a traveler perception index calibrated by using a linear regression model. The model fits independent variables associated with roadway characteristics to the results of a user survey that rates the comfort of various bicycle facilities. The resulting bicycle LOS index computes a numerical LOS score, generally ranging from 0.5 to 6.5, which is stratified to produce a LOS A to F result.

The bicycle LOS score can be calculated from the following equation:

$$BLOS = 0.507 \ln(v_{OL}) + 0.1999 S_t(1 + 10.38HV)^2 + 7.066(1/P)^2 - 0.005(W_e)^2 + 0.760$$

where

$BLOS$ = bicycle level of service score;

v_{OL} = directional demand flow rate in the outside lane (veh/h);

S_t = effective speed factor;

HV = percentage of heavy vehicles (decimal); if V <200 veh/h, then HV should be limited to a maximum of 50%;

P = FHWA's 5-point pavement surface condition rating; and

W_e = average effective width of the outside through lane (ft).

For metric units, the width listed in the calculations above are measured in meters. However, it is converted to feet for calculations and then converted to meters for end results.

Capacity Adjustment Factor

The Capacity Adjustment Factor (CAF) is the factor used to allow the user to adjust the capacity for reduced-capacity situations or to match field measurements. The capacity in any cell of the time-space domain can be

reduced to represent incident situations such as construction and maintenance activities, adverse weather, traffic accidents, and vehicle breakdowns. Similarly, capacity can be increased to match field measurements.

Central Angle

Central Angle is a horizontal curve specific input. The central angle, along with the radius, of the curve will automatically adjust the segment length and control points accordingly.

Coded Type

There are three coded types: Passing Constrained, Passing Zone, and Passing Lane.

In the analysis methodology, these segment types are defined as follows:

- **Passing Constrained**: Length of two-lane highway in which passing in the oncoming lane is either prohibited or effectively negligible due to lack of utilization of passing zone(s). The latter might be due to insufficient sight distance and indicates an area where passing should be formally prohibited.
- **Passing Zone**: Length of two-lane highway for which passing in the oncoming lane is permitted, and the length and location of such passing zone provides reasonable accommodation of passing maneuvers under certain traffic conditions.
- **Passing Lane**: This segment type consists of an added lane in the same direction as the analysis direction, with the intent to break up platoons that have formed upstream by allowing faster vehicles to pass slower vehicles.

D-factor

D is the proportion of traffic moving in the peak direction of travel on a given roadway during the peak hour. It is used, along with AADT (annual average daily traffic) and the *K*-factor (proportion of AADT occurring during the peak hour), in the following equation to determine the demand volume (*V*) or directional peak-hour volume (*DDHV*) in a planning and preliminary engineering analysis:

$V = DDHV = AADT \times K \times D$

While the consideration of directional distribution is not mandated in the analysis of multilane facilities, the distribution has a dramatic effect on both design and LOS.

Date

This field is provided to document the date when the analysis is performed.

Delete Segment

After the user selects a segment to delete, clicking on the button ‘Delete Segment’ will delete the row of inputs corresponding to the selected segment. Multiple segments can be selected and deleted at the same time.

Delete Subsegment

After the user selects a subsegment to delete, clicking on the button ‘Delete Subsegment’ will delete the row of inputs corresponding to the selected subsegment. Multiple subsegments can be selected and deleted at the same time.

Demand

The number of vehicles or other roadway users desiring to use a given system element during a specific analysis period, typically 1 h or 15 min.

Demand volume is the number of vehicles that arrive to use the facility. Under noncongested conditions, demand volume is equal to the observed volume.

Direction Description

This field is provided to document the description of the direction being analyzed (e.g., EB, WB, NB, SB).

Directional Demand

The demand volume for the analysis direction (V_d), in vehicles per hour, at the entrance of the segment being analyzed. This is then adjusted to account for the peak 15-min volume within the analysis hour.

Directional Flow Rate in the Outside Lane

The directional demand flow rate of motorized traffic in the outside lane is calculated on the basis of the hourly directional volume, the peak hour factor, and the number of directional lanes (two or more for passing lanes or multilane highways):

$$v_{OL} = \frac{V}{PHF \times N}$$

where

v_{OL} = directional demand flow rate in the outside lane (veh/h),

V = hourly directional volume (veh/h),

PHF = peak hour factor, and

N = number of directional lanes.

Driver Population

Driver population describes the level of driver familiarity in the traffic stream and is used in adjustments for speed and capacity. The base traffic stream characteristics for basic freeway and multilane highway segments are representative of traffic streams composed primarily of commuters or drivers who are familiar with the facility.

The driver population adjustment factor f_p had previously been used in the HCM to reflect the effects of unfamiliar drivers in the traffic stream and was applied as an increase in demand volume. With the addition of a unified speed flow equation in Chapter 12 of the HCM and the ability to adjust both the base FFS and capacity in all freeway segment chapters (12-14) to account for incidents and weather events, the driver population factor is no longer used. Instead, FFS and capacity adjustment factors SAF_{pop} and CAF_{pop} are applied in combination with other applicable SAFs and CAFs.

Analyst judgment is still required when applying recommended adjustments. However, should there be expectations of significant presence of unfamiliar drivers, the values shown in the exhibit below can serve as a guide for the analysis.

Level of Driver Familiarity	CAF_{pop}	SAF_{pop}
All familiar drivers, regular commuters	1.000	1.000
Mostly familiar drivers	0.968	0.975
Balanced mix of familiar and unfamiliar drivers	0.939	0.950
Mostly unfamiliar drivers	0.898	0.913
All or overwhelmingly unfamiliar drivers	0.852	0.863

Effective Speed Factor

The effect of motor vehicle speed on bicycle quality of service is primarily related to the differential between motor vehicle and bicycle travel speeds. For example, a typical cyclist may travel in the range of 15 mi/h. An increase in motor vehicle speeds from 20 to 25 mi/h is more readily perceived than a speed increase from 60 to 65 mi/h, since the speed differential increased by 100% in the first instance compared with only 11% in the latter.

The following equation shows the calculation of the effective speed factor that accounts for this diminishing effect.

$S_t = 1.1199 \ln(S_p - 20) + 0.8103$

where

S_t = effective speed factor, and

S_p = posted speed limit (mi/h).

For metric units, the posted speed limit is measured in kilometers per hour. However, this is converted to miles per hour for the calculation of the effective speed factor.

Effective Width

The effective width of the outside through lane depends on both the actual width of the outside through lane and the shoulder width, since cyclists will be able to travel in the shoulder where one is provided. Moreover, striped shoulders of 4 ft or greater provide more security to cyclists by giving cyclists a dedicated place to ride outside of the motorized vehicle travelway. Thus, an 11-ft lane and adjacent 5-ft paved shoulder results in a larger effective width for cyclists than a 16-ft lane with no adjacent shoulder.

Parking occasionally exists. On-highway parking reduces the effective width, because parked vehicles take up shoulder space and bicyclists leave some shy distance between themselves and parked cars.

The following equations are used to calculate the effective width W_e on the basis of the paved shoulder width W_s and the hourly directional volume V:

If W_s is greater than or equal to 8 ft:

$$W_e = W_v + W_s - (\%OHP \times 10 \text{ ft})$$

If W_s is greater than or equal to 4 ft and less than 8 ft:

$$W_e = W_v + W_s - 2 \times [\%OHP(2 \text{ ft} + W_s)]$$

If W_s is less than 4 ft:

$$W_e = W_v + [\%OHP(2 \text{ ft} + W_s)]$$

with, if V is greater than 160 veh/h:

$$W_v = W_{OL} + W_s$$

Otherwise,

$$W_v = (W_{OL} + W_s) \times (2 - 0.005V)$$

where

W_v = effective width as a function of traffic volume (ft),

W_{OL} = outside lane width (ft),

W_s = paved shoulder width (ft),

V = hourly directional volume per lane (veh/h),

W_e = average effective width of the outside through lane (ft), and

$\%OHP$ = percentage of segment with occupied on-highway parking (decimal).

For metric units, Effective Width is measured in meters. All widths listed in the calculations above are measured in meters. However, they are converted to feet for calculations and then converted to meters for end results.

Free Flow Speed

1. The average speed of vehicles on a given segment, measured under low-volume conditions, when drivers are free to drive at their desired speed and are not constrained by the presence of other vehicles or downstream traffic devices.
2. The theoretical speed when both density and flow rate are zero.

The free-flow speed (FFS) can be determined either through direct field measurement (preferred) or by estimation.

For multilane highway segments, the adjusted free-flow speed is determined by subtracting each speed adjustment from the base free-flow speed according to HCM Equation 12-3 for Multilane Highway Segments, which can be found below.

$FFS = BFFS - f_{LW} - f_{TLC} - f_M - f_A$

where

FFS = free-flow speed of the multilane highway segment (mi/h);

$BFFS$ = base FFS for the multilane highway segment (mi/h);

f_{LW} = adjustment for lane width (mi/h);

f_{TLC} = adjustment for total lateral clearance (mi/h);

f_M = adjustment for median type (mi/h); and

f_A = adjustment for access-point density (mi/h).

If a field measured free-flow speed is entered, no subsequent adjustments are made and the adjusted free-flow speed will simply be the field-measured free-flow speed.

For metric units, free-flow speed, along with all the corresponding adjustments, are measured in kilometers per hour.

For two-lane highways, the operating conditions of the facility in terms of a base free-flow speed (BFFS) that reflects the facility's geometric characteristics must be characterized to estimate the FFS. As part of this estimation process, it is recognized that the posted speed limit is intended to inform motorist of appropriate operating speed for the given geometric conditions. The FFS is calculated with HCM Equations 15-3 through 15-6, which can be found below:

$FFS = BFFS - a(HV\%) - f_{LS} - f_A$

with

$a = \max[0.0333, a_o + a_1 \times BFFS + a_2 \times L + \max(0, a_3 + a_4 \times BFFS + a_5 \times L) \times v_o/1000]$

where

FFS = free-flow speed in the analysis direction (mi/h);

$BFFS$ = base free-flow speed (mi/h);

$HV\%$ = percentage of heavy vehicles in the analysis direction (%) (e.g., 5% is expressed as 5);

f_{LS} = adjustment for lane and shoulder width (mi/h), from Equation 15-5;

f_A = adjustment for access-point density (mi/h), from Equation 15-6;

a_0-a_5 = coefficient values from Exhibit 15-12

L = segment length (mi), subject to minima and maxima given in Step 1; and

v_o = demand flow rate in opposing direction (veh/h); v_o = 1,500 in Passing Constrained segments and v_o = 0 in Passing Lane segments.

For metric units, free-flow speed, along with all the corresponding adjustments, are measured in kilometers per hour. Segment length is measured in kilometers.

Grade Length

The length of the segment, in miles (or kilometers in metric), representing the percent grade

Heavy Vehicles

The percentage of heavy vehicles in the traffic stream. Heavy vehicles are engaged primarily in the transportation of goods and materials or in the delivery of services other than public transportation. Heavy vehicles generally consist of large trucks, buses, and recreational vehicles (RVs).

Horizontal Curve

This is a geometric design that provides a transition between two tangent sections of roadway, allowing a vehicle to complete a turn at a gradual rate than a sharp cut.

Insert Segment

Clicking on the button 'Insert Segment' will add a row of inputs with the default Segment Type 'Passing Constrained' along with the default values for the Passing Constrained segment type above the selected segment. The user can insert an unlimited number of segments and can manually change the inputs to the desired values.

Insert Subsegment

Clicking on the button 'Insert Subsegment' will add a row of inputs with the default Subsegment Type 'Tangent' along with the default values for the Tangent subsegment type above the selected subsegment. The user can insert an unlimited number of subsegments and can manually change the inputs to the desired values.

Jurisdiction

This field is provided to document any jurisdiction convention or project related information.

K-factor

K is the proportion of AADT (annual average daily traffic) that occurs during the peak hour. It is used, along with AADT and the *D*-factor (the proportion of peak-hour volume traveling in the peak direction), in the following equation to determine the demand volume (*V*) or directional peak-hour demand volume (*DDHV*) in a planning and preliminary engineering analysis:

$V = DDHV = AADT \times K \times D$

For many rural and urban highways, this factor falls between 0.09 and 0.10. For highway sections with high peak periods and relatively low off-peak flows, the *K*-factor may exceed 0.10. Conversely, for highways that demonstrate consistent and heavy flows for many hours of the day, the *K*-factor is likely to be lower than 0.09. In general,

- The *K*-factor decreases as the AADT on a highway increases;
- The *K*-factor decreases as development density increases; and
- The highest *K*-factors occur on recreational facilities, followed by rural, suburban, and urban facilities, in descending order.

The *K*-factor should be determined, if possible, from local data for similar facilities with similar demand characteristics.

Lane Width

The lateral distance between stripes for a given lane; measured in feet (or meters in metric)

Lane Width Adjustment

This is an adjustment to Base Free-Flow Speed based on the average lane width. The base condition for lane width is 12 ft or greater. When the average lane width across all lanes is less than 12 ft, the FFS is negatively affected. Adjustments to reflect the effect of narrower average lane width are shown below:

Average Lane Width (ft)	Reduction in FFS, f_{LW} (mi/h)
≥12	0.0
≥11–12	1.9
≥10–11	6.6

For metric units, Average Lane Width is measured in meters, and the corresponding Lane Width Adjustment is measured in kilometers per hour.

Level of Service

Level of Service (LOS) is a quantitative stratification of a performance measure or measures that represent quality of service, measured on an A-F scale, with LOS A representing the best operating conditions from the traveler's perspective and LOS F the worst.

LOS on multilane highway segments is defined by density, which is measured in passenger cars per mile per lane. Although speed is a major concern of drivers related to service quality, it would be difficult to describe LOS by using speed, as it remains constant up to high flow rates (i.e., 1,400 pc/h/ln for multilane highway segments). Density describes a motorist's proximity to other vehicles and is related to a motorist's freedom to maneuver within the traffic stream. Unlike speed, however, density is sensitive to flow rates throughout the range of flows.

The criteria for LOS is shown in the exhibit below:

LOS	Density (pc/mi/ln)
A	≤11
B	>11–18
C	>18–26
D	>26–35
E	>35–45
F	Demand exceeds capacity OR density >45

For metric, density is measured in passenger cars per kilometer per lane. The criteria for LOS is shown in metric below:

LOS	Density (pc/km/ln)
A	≤7
B	>7–11
C	>11–16
D	>16–22
E	>22–28
F	Demand exceeds capacity OR density >28

If the demand-to-capacity ratio is less than or equal to 1.0, follower density is used as the service measure for all two-lane highways. However, two sets of LOS thresholds are used to account for differences in driver perception between driving on higher-speed versus lower-speed highways.

The criteria for LOS is shown in the exhibit below:

LOS	Follower Density (followers/mi/ln)	
	Higher-Speed Highways Posted Speed Limit ≥ 50 mi/h	Lower-Speed Highways Posted Speed Limit < 50 mi/h
A	≤ 2.0	≤ 2.5
B	> 2.0 – 4.0	> 2.5 – 5.0
C	> 4.0 – 8.0	> 5.0 – 10.0
D	> 8.0 – 12.0	> 10.0 – 15.0
E	> 12.0	> 15.0
F	Demand exceeds capacity	

For metric, follower density is measured in followers per kilometer per lane. The criteria for LOS is shown in metric below:

LOS	Follower Density (followers/km/ln)	
	Higher-Speed Highways Posted Speed Limit ≥ 80 km/h	Lower-Speed Highways Posted Speed Limit < 80 km/h
A	≤ 1.2	≤ 1.6
B	> 1.2 – 2.5	> 1.6 – 3.1
C	> 2.5 – 5.0	> 3.1 – 6.2
D	> 5.0 – 7.5	> 6.2 – 9.3
E	> 7.5	> 9.3
F	Demand exceeds capacity	

Level Terrain

Any combination of grades and horizontal or vertical alignment that permits heavy vehicles to maintain the same speed as passenger cars. This type of terrain typically contains short grades of no more than 2%.

Measured Free-Flow Speed

The measured free-flow speed is the FFS measured in the field and provided by the user. If the FFS is measured directly, no adjustments are applied to the measured value.

Median (Left) Side Clearance

Left-side lateral clearance is measured from the edge of the travel lanes to the nearest periodic or continuous obstruction in the median. If such obstructions are farther than 6 ft (or 1.8 m in metric) from the edge of the pavement, a value of 6 ft (or 1.8 m in metric) is used.

Left-side lateral clearances are subject to some judgement. Many types of common median barriers do not affect driver behavior if they are no closer than 2 ft (or 0.6 m in metric) from the edge of the travel lane, including concrete and W-beam barriers. A value of 6 ft (or 1.8 m in metric) would be used in such cases. Also, when the multilane highway segment is undivided or has a TWLTL, no left-side lateral clearance restriction is assumed, and a value of 6 ft (or 1.8 m in metric) is applied.

Median Type

Multilane highways have three median types:

- Undivided (with only a centerline separating the directions of flow)
- Divided (with a physical median separating the directions of flow)
- TWLTL (two-way left-turn lane)

Median type is used in determining the adjustment for median type f_M, which is used in the calculation of free-flow speed.

Median Type Adjustment

The adjustment for type of median is given in the following exhibit:

Median Type	Reduction in FFS, f_N (mi/h)
Undivided	1.6
TWLTL	0.0
Divided	0.0

For metric units, Median Type Adjustment is measured in kilometers per hour.

Mixed-Flow Model

The mixed-flow model is one of two distinct methodologies offered to assess the effect of heavy vehicles on capacity and LOS. The model directly assesses the capacity, speed, and density of traffic streams that include a significant percentage of heavy vehicles operating on a single or composite grade. When using the mixed-flow models, no PCEs are needed, as the passenger car, SUT, and TT volumes are used directly in the estimation of mixed-flow speed and density.

Number of Lanes

This specifies the number of lanes on the roadway in the specified direction.

Opposing Demand

The demand volume for the opposing direction (V_o), in vehicles per hour, at the entrance of the segment being analyzed. This is then adjusted to account for the peak 15-min volume within the analysis hour.

Outside Lane Width

The width of the outside through lane is measured in feet. This is denoted as W_{OL} and is used in the calculation of effective width.

If V is greater than 160 veh/h:

$$W_v = W_{OL} + W_s$$

Otherwise,

$$W_v = (W_{OL} + W_s) \times (2 - 0.005V)$$

where

W_v = effective width as a function of traffic volume (ft);

W_{OL} = outside lane width (ft);

W_s = paved shoulder width; and

V = hourly directional volume per lane (veh/h).

For metric units, the width of the outside through lane is measured in meters. All widths listed in the calculations above are measured in meters. However, they are converted to feet for calculations and then converted to meters for end results.

Pavement Condition Rating

A description of the road surface in terms of ride quality and surface defects. The pavement condition is rated from 2 to 5 based on the Federal Highway Administration (FHWA) 5-point rating scale.

Peak Hour Factor

Peak Hour Factor (PHF) is the hourly volume during the analysis hour divided by the peak 15-min flow rate within the analysis hour. It is a measure of traffic demand fluctuation within the analysis hour.

Percent Grade

The longitudinal slope of a roadway; provided by the user as a percentage.

Percent Occupied Parking

This refers to the percent of the segment with occupied on-highway parking. On-highway parking reduces effective width, because parked vehicles take up shoulder space and bicycles leave some shy distance between themselves and the parked cars.

Project Description

This field is provided for the user to document the analysis with any information for identification purposes.

Radius

Curve radius is a horizontal curve specific input. The curve radius, along with the central angle, of the curve will automatically adjust the segment length and control points accordingly.

Right Side Clearance

Right-side lateral clearance is measured from the right edge of the travel lanes to the nearest periodic or continuous roadside obstruction. If such obstructions are farther than 6 ft (or 1.8 m in metric) from the edge of the pavement, a value of 6 ft (or 1.8 m in metric) is used.

Fixed obstructions with lateral clearance effects include light standards, signs, trees, abutments, bridge rails, traffic barriers, and retaining walls. Standard raised curbs are not considered to be obstructions.

Rolling Terrain

Any combination of grades and horizontal or vertical alignment that causes heavy vehicles to reduce their speed below those of passenger cars, but that does not cause heavy vehicles to operate at crawl speeds for any significant length of time or at frequent intervals.

Segment Length

This field is provided to document the length of the segment being analyzed; measured in feet (or meters in metric)

Segment Name

This field is provided for each segment to identify the segment or specify the start point and end point of the segment under analysis.

Shoulder Width

In Multilane, this is the width of the shoulder, measured in feet (or meters in metric).

In TwoLane, this is the average shoulder width for both sides of the highway, measured in feet (or meters in metric).

Single-Unit Trucks (SUT)

Single-Unit Trucks (SUT) are defined as one of two categories of heavy vehicles. Buses and RVs are treated as SUTs in the HCM. SUTs include the following:

- Other Two-Axle, Four-Tire Single-Unit Vehicles: Two-axle, four-tire vehicles, other than passenger cars. Generally pickup trucks, sports utility vehicles, and vans.
- Buses: All vehicles manufactured as traditional passenger-carrying buses with two axles and six tires or three or more axles. Excludes modified buses no longer capable of mass passenger transport.
- Two-Axle, Six-Tire, Single-Unit Trucks: All vehicles on a single frame with two axles and dual rear wheels. Includes some trucks, camping and recreational vehicles, and motor homes.
- Three-Axle Single-Unit Trucks: All vehicles on a single frame with three axles. Includes some trucks, camping and recreational vehicles, and motor homes.
- Four or More Axle Single-Unit Trucks. All trucks on a single frame with four or more axles.

Specific Grade

A single grade of roadway segment or extended roadway segment expressed as a percentage.

Speed Adjustment Factor

The Speed Adjustment Factor (SAF) is the factor used to allow the user to adjust speed based on a combination of different sources, including weather and work zone effect. The SAF may also be used to calibrate the estimated FFS for local conditions or other effects that contribute to a reduction in FFS. For example, poor pavement conditions or sun glare may result in drivers reducing their speed even under low-volume conditions.

Speed Limit

The speed limit, in miles per hour (or kilometers per hour in metric), posted on the highway segment in the analysis direction. In Multilane, the posted speed limit is used to calculate the effective speed factor.

Subsegment Length

This field is provided to document the length of the subsegment being analyzed. For tangent subsegments, the link length is entered. For curves, the link length will be based on the curve radius and central angle.

Subsegment Type

There are two subsegment types: Tangent and Horizontal Curve. Tangent sections are either straight or have horizontal curves with radii greater than 2,550 ft (or 777.24 m in metric).

Super 2

The 2+1, sometimes referred to as “Super 2”, design typically extends for many miles, with several changes of direction for the passing lane provided within this distance.

Superelevation

Superelevation is a horizontal curve specific input. It is the banking of a roadway in a curve to counteract lateral acceleration.

Target LOS

Target LOS is used in a planning and preliminary engineering analysis. This is the Level of Service (LOS) the analyst wishes to achieve based on other parameters, such as Number of Lanes and FFS.

See also *Level of Service.*

Terrain Type

An extended length of highway containing a number of upgrades and downgrades where no single grade is long enough or steep enough to have a significant impact on the operation of the overall segment. There are three types of terrain: Level, Rolling, and Specific Grade.

See also *Level Terrain*, *Rolling Terrain*, and *Specific Grade*.

Time Analyzed

This field is provided to document the time frame of the analysis as morning peak, afternoon peak, existing conditions, future projections, etc.

Total Lateral Clearance Adjustment

The adjustment for total lateral clearance (TLC) on multilane highway segments is based on TLC at the roadside (right side) and at the median (left side). Fixed obstructions with lateral clearance effects include light standards, signs, trees, abutments, bridge rails, traffic barriers, and retaining walls. Standard raised curbs are not considered to be obstructions.

The following equation is used to determine TLC:

$TLC = LC_R + LC_L$

where

TLC = total lateral clearance (ft) (maximum value 12 ft);

LC_R = right-side lateral clearance (ft) (maximum value 6 ft); and

LC_L = left-side lateral clearance (ft) (maximum value 6 ft).

The following exhibit shows the reduction of FFS due to lateral obstructions on the multilane highway:

Four-Lane Highways		Six-Lane Highways	
TLC (ft)	Reduction in FFS (mi/h)	TLC (ft)	Reduction in FFS (mi/h)
12	0.0	12	0.0
10	0.4	10	0.4
8	0.9	8	0.9
6	1.3	6	1.3
4	1.8	4	1.7
2	3.6	2	2.8
0	5.4	0	3.9

Note: Interpolation to the nearest 0.1 is recommended.

For metric units, Total Lateral Clearance, along with Right-Side Lateral Clearance and Left-Side Lateral Clearance, are measured in meters. The corresponding Total Lateral Clearance Adjustment is measured in kilometers per hour.

Total Trucks

The percentage of trucks in the traffic stream. Trucks are heavy vehicles engaged primarily in the transport of goods and materials or in the delivery of services other than public transportation. All heavy vehicles are classified as single-unit trucks (SUTs) or tractor-trailers (TTs).

Tractor-Trailers (TT)

Tractor-Trailers (TT) are defined as one of two categories of heavy vehicles. TTs include the following:

- Four or Fewer Axle Single-Trailer Trucks: All vehicles with four or fewer axles consisting of two units, one of which is a tractor or straight truck power unit.
- Five-Axle Single-Trailer Trucks: All five-axle vehicles consisting of two units, one of which is a tractor or straight truck power unit.
- Six or More Axle Single-Trailer Trucks: All vehicles with six or more axles consisting of two units, one of which is a tractor or straight truck power unit.
- Five or Fewer Axle Multi-Trailer Trucks: All vehicles with five or fewer axles consisting of three or more units, one of which is a tractor or straight truck power unit.
- Six-Axle Multi-Trailer Trucks: All six-axle vehicles consisting of three or more units, one of which is a tractor or straight truck power unit.
- Seven or More Axle Multi-Trailer Trucks: All vehicles with seven or more axles consisting of three or more units, one of which is a tractor or straight truck power unit. Includes triple-trailer combinations.

Units

This specifies the units of the analysis file (i.e., U.S. Customary or Metric).

Vehicle Hours of Delay (VHD)

VHD is the vehicle hours of delay during time period *t*. In TwoLane, the facility VHD is the sum of each segment VHD, which is calculated using the equation below:

$$VHD = \sum_{t} \left[\left(\left(V_i \times \frac{L_i}{S_i} \right) - \left(V_i \times \frac{L_i}{S_i} \right) \right) \times T \right]$$

where

VHD	=	Vehicle Hours of Delay (hours/time period)
V_i	=	Segment Volume (veh/h)
L_i	=	Segment Length (mi)
S_i	=	Segment Average Speed (mi/h)
FFS	=	Free-Flow Speed (mi/h)
T	=	Length of time period (h)

For metric units, Segment Length is measured in km, while Segment Average Speed and Free-Flow Speed are measured in km/h.

Vehicle Miles Traveled (VMT)

VMT is the vehicle miles traveled during time period *t*. In TwoLane, The facility VMT is the sum of each segment VMT, which is calculated using the equation below:

$$VMT = \sum_{t} [V_i \times L_i \times T]$$

where

VMT = Vehicle Miles Traveled (veh-miles/time period)

V_i = Segment Volume (veh/h)

L_i = Segment Length (mi)

T = Length of time period (h)

For metric units, Vehicle Miles Traveled (VMT) is converted to vehicle-kilometers per time period and is then denoted as VkmT, which stands for Vehicle Kilometers Traveled.

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