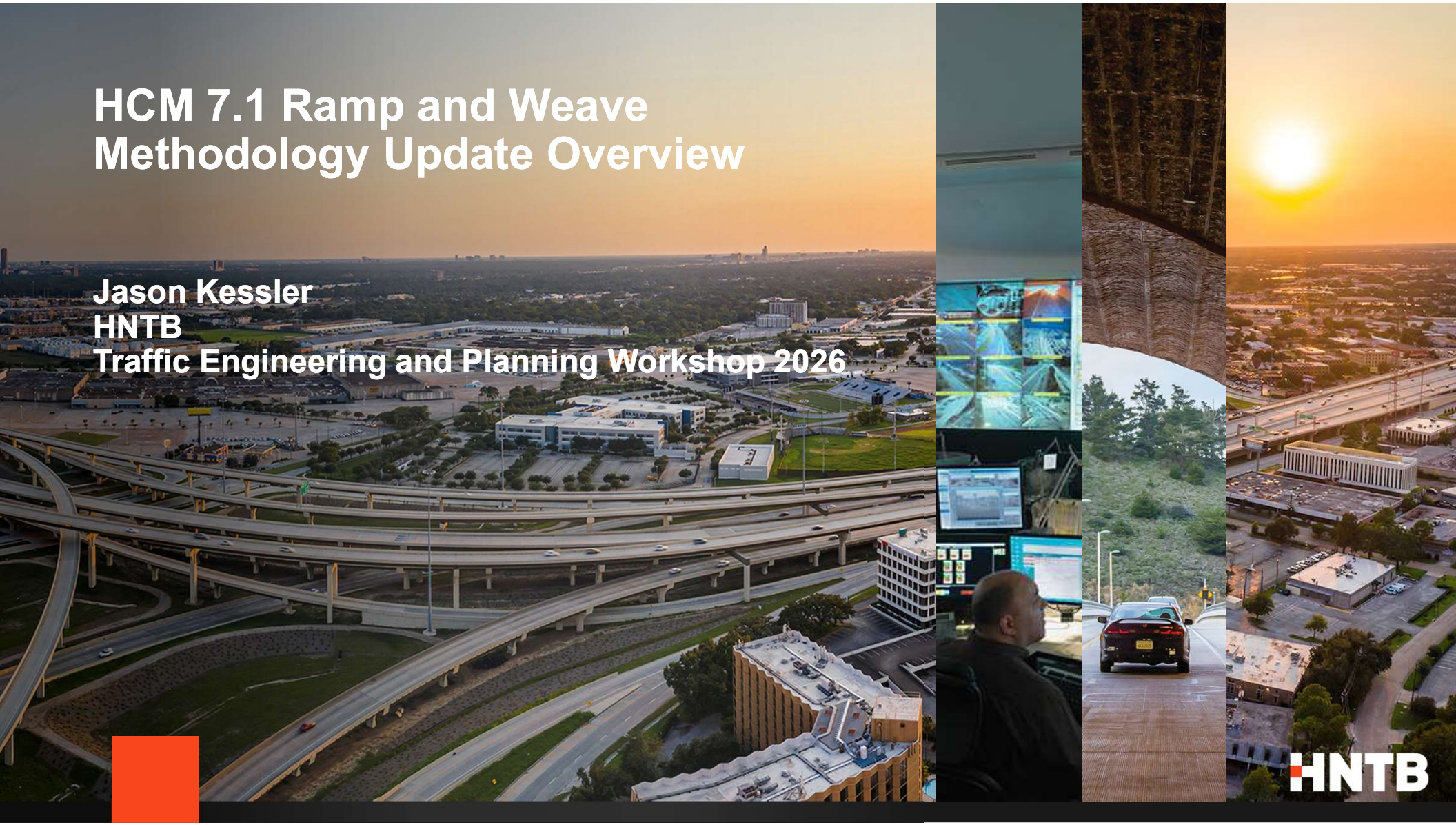
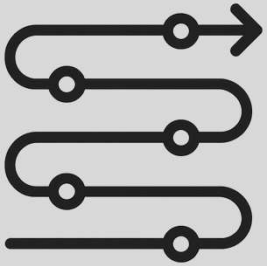
HCM 7.1 Ramp and Weave Methodology Update Overview

Jason Kessler
HNTB
Traffic Engineering and Planning Workshop 2026

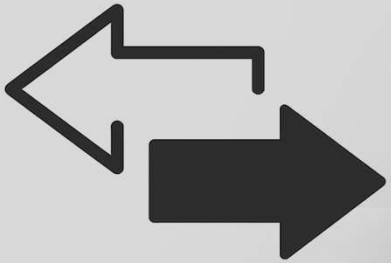


AGENDA

HISTORY TIMELINE



CHANGE



IMPLEMENTATION

History of NCHRP 07-26

Research conducted by Kittelson Associates and the University of Washington

HCM 6th Edition Released – October 2016

HCM 7.0 Released - January 2022

- August 2021: Interim Committee Update
- June 2022: Committee Workshop on Final Products
- January 2023: Follow-up Workshop with STRIDE
- *May 2023: NCHRP Research Report published*
- July-Aug 2023: Committee Review of Draft Chapters
- Nov-Dec 2023: Committee Review of Voting Drafts
- January 2024: Requested Revisions to bring practitioner focus and revised sensitivities
- Jan-Feb 2024: Committee Review of Revised Voting Drafts
- Summer 2024: Electronic Committee Vote on Chapters
- **December 2025: Chapters officially posted on TRB website and Volume 4**

Changes to the HCM

- Chapter 13: Freeway Weaving Segments
- Chapter 14: Freeway Merge and Diverge Segments
- Chapter 27: Weaving Segments Supplemental
- Chapter 28: Merge and Diverge Segments Supplemental

https://nap.nationalacademies.org/resource/26432/Highway_Capacity_Manual_Edition_7.1_Chapters.pdf

Why its changed?

- Produce consistent results between Modules
  - Previous Modules developed under independent research,
    - Produces inconsistent results (Ramp with 0 volume ≠ density of a Basic Segment)
    - Merge/Diverge could produce a lower density than an auxiliary lane weave
    - Weaves insensitive to auxiliary lane length
  - fundamental relationship between flow, density, and capacity
- Include additional common ramping configurations
- Larger Sample Size using increasing sensor locations
  - Previous research had very limited data / sites (~1 hour of data per site)
    - Ramp Methodology – 1993 (~60 sites)
    - Weave Methodology – 2008 (14 sites)
  - Latest analysis suggests previous research was overestimating capacity

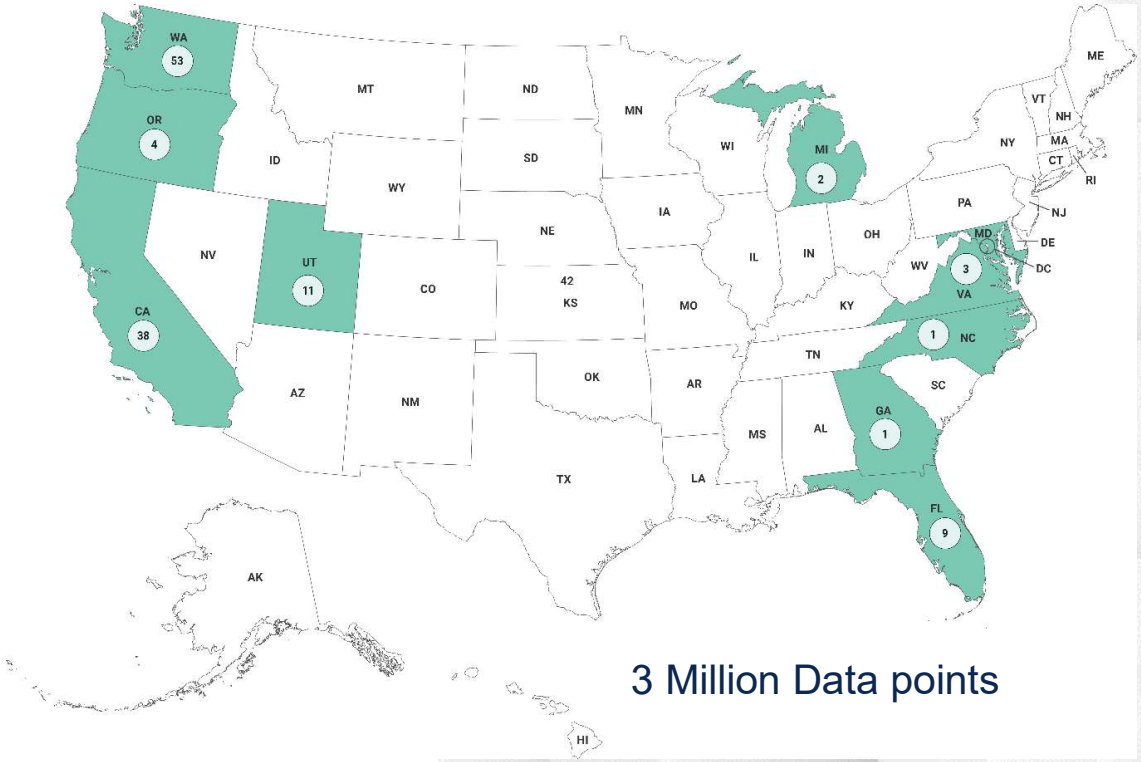
Research

Merge & Diverge Sites

Geometry	Sample Size
Simple Merge	26
Simple Diverge	23
Close Merge	6
Close Diverge	7
Two-Lane On-Ramp	5
Two-Lane Off-Ramp	9
Lane Drop Diverge	6
Ramp Metering	4

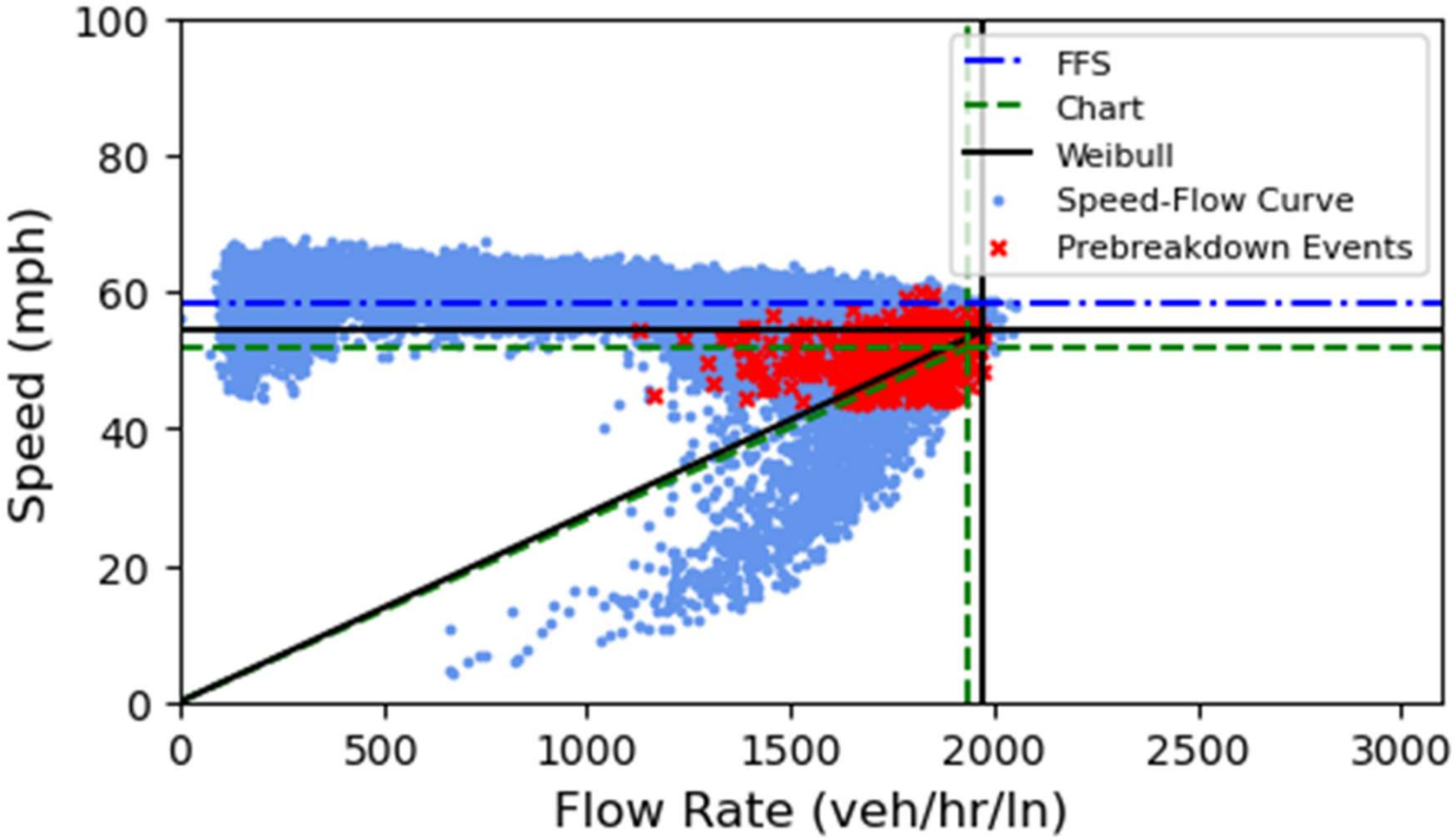
Weave Sites

Geometry	Sample Size
Simple Ramp Weave	15
C-D Weave	8
Complex Weave	12



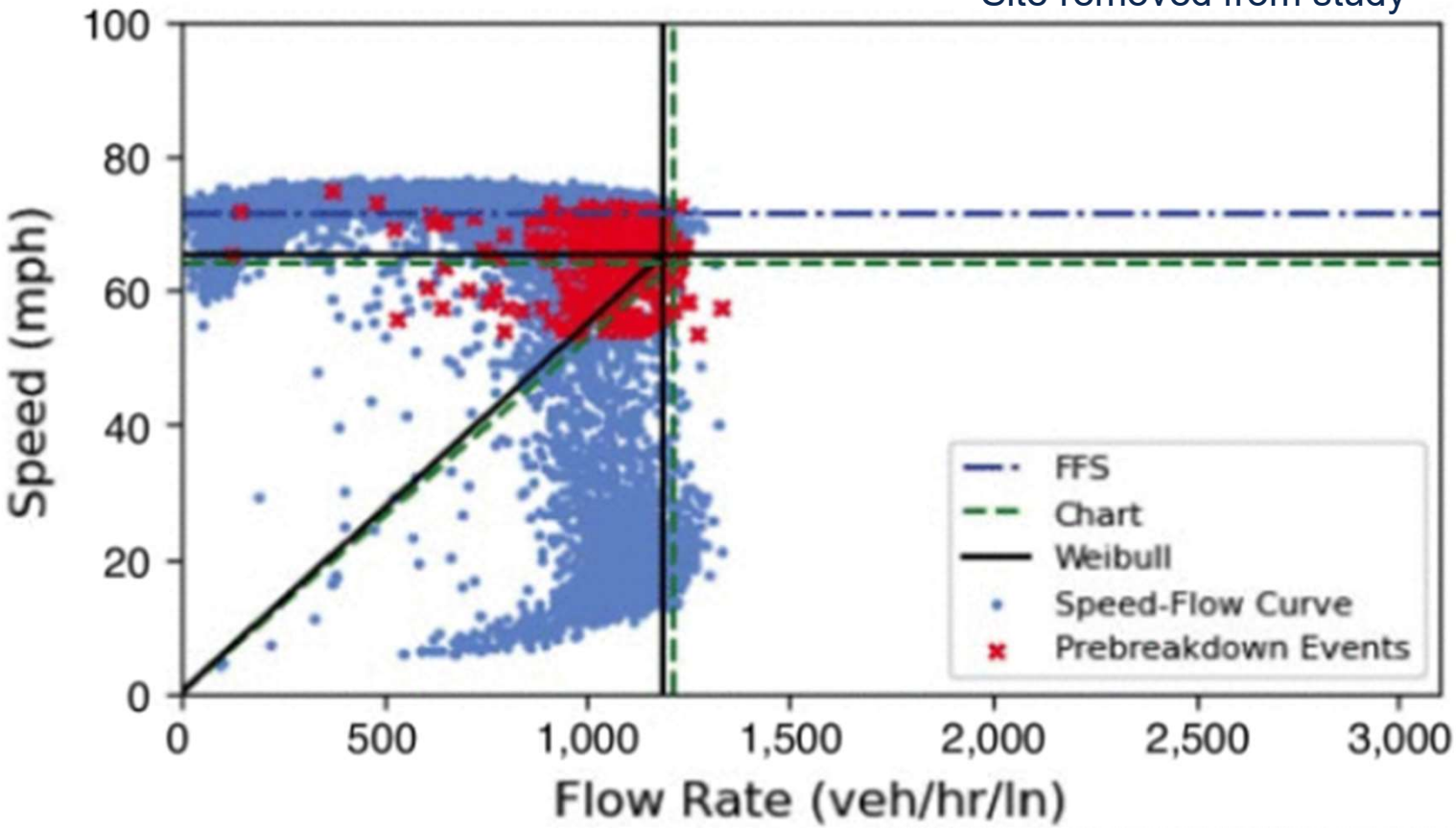
3 Million Data points

Research - Capacity

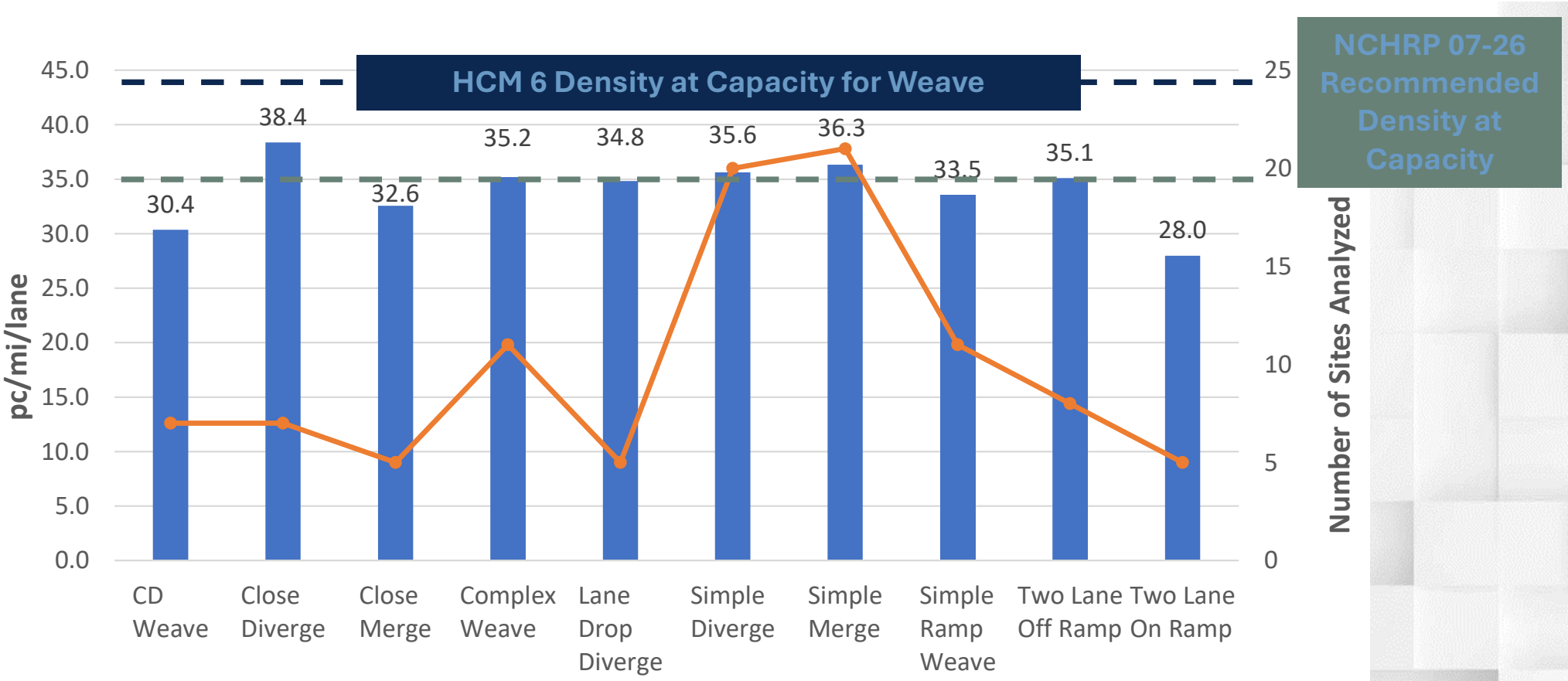


Research - Capacity

Downstream Bottleneck –
Site removed from study



Research - Density Results



Ramp Density Update

HCM 7.0

Exhibit 14-3: LOS Criteria for Freeway Merge and Diverge Segments

LOS	Density (pc/mi/ln)
A	≤10
B	>10–20
C	>20–28
D	>28–35
E	>35
F	Demand exceeds capacity

HCM 7.1

LOS	Density (pc/mi/ln)
A	0–11
B	>11–18
C	>18–25
D	>25–30
E	>30–35
F	>35, or demand exceeds capacity

Exhibit 14-2
LOS Criteria for Freeway
Merge and Diverge Segments

Weaving Density Update

HCM 7.0

Exhibit 13-6: LOS for Weaving Segments

LOS	Density (pc/mi/ln)	
	Freeway Weaving Segments	Weaving Segments on Multilane Highways or C-D Roads
A	0–10	0–12
B	>10–20	>12–24
C	>20–28	>24–32
D	>28–35	>32–36
E	>35–43	>36–40
F	>43, or demand exceeds capacity	>40, or demand exceeds capacity

HCM 7.1

LOS	Density (pc/mi/ln)
A	0–11
B	>11–18
C	>18–25
D	>25–30
E	>30–35
F	>35, or demand exceeds capacity

Exhibit 13-7
LOS Criteria for Weaving Segments

Research – Density Equation

- Weave Density Formula

HCM 7.0

$$D = \frac{(v/N)}{S}$$

HCM 7.1

$$D = \frac{(v/N)}{S_o}$$

S_o = overall mean speed for all vehicles in the weaving segment (mi/h);

Research – Density Equation

- Ramping Density Formula

HCM 7.0

$$D = \frac{v}{S}$$

HCM 7.1

$$D_M = \frac{(v_F + v_R)}{N \times S_M}$$

$$D_D = \frac{v_F}{N \times S_D}$$

Research – Speed Equation

- Speed Formula
  - Speed (S) = Basic Segment (B) speed - speed impedance (SI)

$$S_M = S_b - SIM$$
$$S_D = S_b - SID$$
$$S_W = S_b - SIW$$

- $$\mathrm{SIW} = \boldsymbol{\alpha} * \left(\frac{\frac{v_{rf*}\left(\mathrm{LC_{rf}}+1\right)}{\left(\mathrm{N_{wrf}}+1\right)} + \frac{v_{fr*}\left(\mathrm{LC_{fr}}+1\right)}{\left(\mathrm{N_{wfr}}+1\right)}}{N^{\varepsilon}} \right)^{\boldsymbol{\gamma}} * \left(\frac{1}{L_s} \right)^{\boldsymbol{\delta}} * \left(\frac{v}{N} - 500 \right)$$

Research – Capacity Equation

- Capacity Formula
  - Capacity Estimate and Checks

$$C_M \text{ or } C_D = \frac{-b + \sqrt{b^2 - 4\,ac}}{2a}$$

$$C_W = \frac{-b + \sqrt{b^2 - 4\,ac}}{2a}$$

FFS (mi/h)	Capacity (pc/h) of Upstream or Downstream Freeway Segment			
	2 lanes	3 lanes	4 lanes	>4 lanes
≥70	4,800	7,200	9,600	2,400/ln
65	4,700	7,050	9,400	2,350/ln
60	4,600	6,900	9,200	2,300/ln
55	4,500	6,750	9,000	2,250/ln

Notes: Number of lanes in one direction. Demand in excess of these capacities results in LOS F.

Ramp FFS, S_{FR} (mi/h)	One-Lane Ramps	Two-Lane Ramps
>50	2,200	4,400
>40–50	2,100	4,200
>30–40	2,000	4,000
≥20–30	1,900	3,800
<20	1,800	3,600

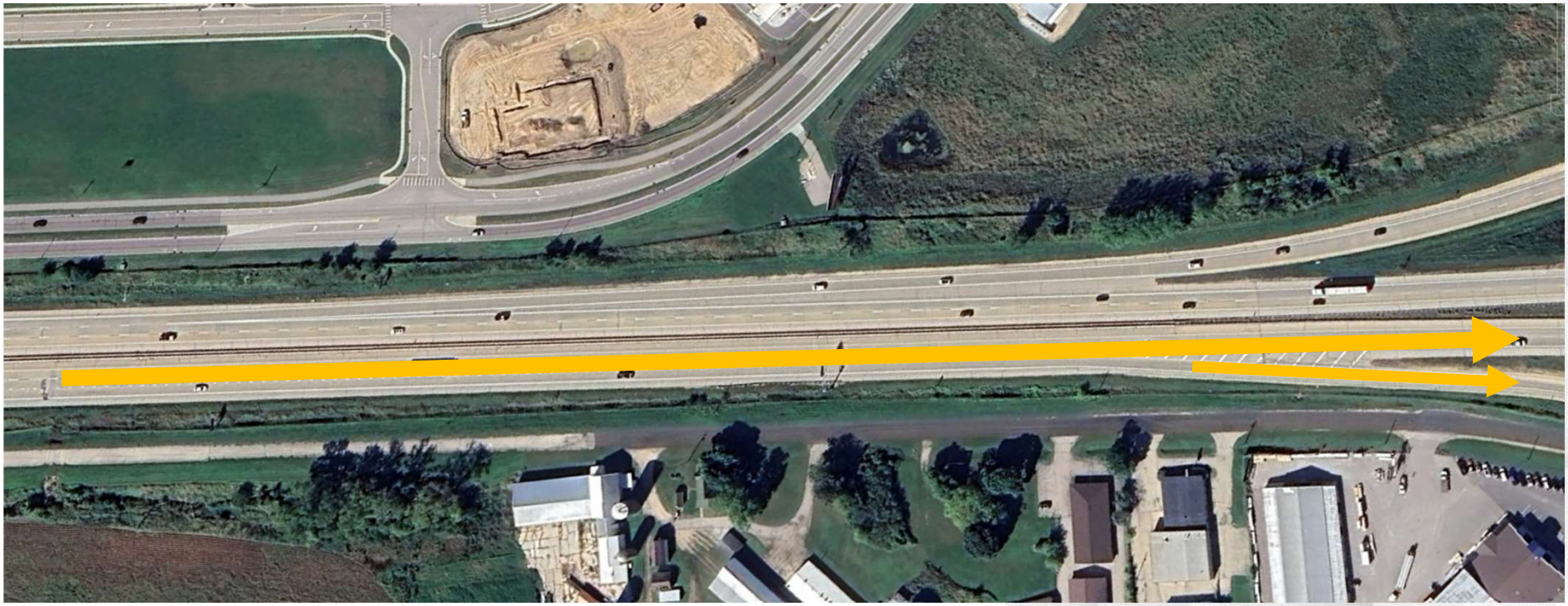
Notes: Capacity of a ramp roadway does not ensure an equal capacity at its freeway or other high-speed junction. Junction capacity must be checked against criteria in Exhibit 14-8 and Exhibit 14-9.

Examples

- Lane Drop
- Merge
- Weave

Lane Drop Diverge

- Northbound 151 at Main Street



Lane Drop

HCM 7.0 opt1	Basic – 3 lane		Basic – 2 lane
	18.5 LOS C		
HCM 7.0 opt2	Basic – 3 lane	Diverge-> Facility Basic	Basic – 2 Lane
		20.2 LOS C	
HCM 7.1	Basic – 3 lane	Diverge	Basic – 2 Lane
		25.5 LOS D	

Close Merge

- Southbound I-39/90 at US 12

Close Merge

HCM 7.0 opt 1	Basic – 2 lane	Merge	Merge	Basic – 2 Lane
		33.8 LOS D	36.3 LOS E	
HCM 7.0 opt 2	Basic – 2 lane	Merge -2 Lane		Basic – 2 Lane
		32.2 LOS D		
HCM 7.0 opt 3	Basic – 2 lane	Basic – 3 lane	Merge	Basic – 2 Lane
		21.7 LOS C	36.3 LOS E	
HCM 7.1	Basic – 2 lane	Merge	Merge	Basic – 2 Lane
		LOS F D/C1.07	LOS F D/C1.11	

Weave

- Southbound I-41 between WIS441 and Ballard Road

Weave

HCM 7.0	Basic – 2 lane	Weave	Basic – 2 Lane
		31.2 LOS D	
HCM 7.1	Basic – 2 lane	Weave	Basic – 2 Lane
		28.8 LOS D	

WisDOT Implementation

- Stay Tuned!
  - Pending WisDOT review and acceptance
- Be on the lookout for TEOpS manual (16-15) update emails
  - QR Sign up
- Available Tools
  - Excel Spreadsheets developed under NCHRP 07-26
  - McTrans HCS2026
    - Includes the methodologies of HCM7.1

Analysis Inputs – Ramps

- # of Lanes
- Length of Accel/Decel Lane
- Free Flow Speed
- Peak Hour Factor
- Heavy Vehicles (%)
- Ramp Capacity (Table)

NCHRP 07-26 Merge Segment Speed and Capacity Calculator

All Inputs in cells are green highlighted
Key outputs are yellow highlights
Other cells are interim calculations

Engine Date 3/7/2023

INPUTS		UNITS
Site Name or ID:		Test
Analyst:		BJS
Length of Acceleration Lane (La)	ft	500
Number of mainline lanes per direction in the merge segment (N)		3
Free flow speed (if unknown use PSL+5 mph)	mph	60
Peak hour factor (PHF)		1
Percent Heavy Vehicle- Mainline (%)		5
Percent Heavy Vehicle- Ramp (%)		5
Equivalent PCE factor (ET)		2
Enter Ramp FFS (mph)		40
Enter Ramp Capacity based on its FFS and N (See Table on bottom)		2,000
Entering freeway mainline flow rate (EF)	vph	2,000
Entering on-ramp flow rate (EONR)	vph	500
Merge segment density at capacity / lane- Default= 35	pc/mi/ln	35

INTERMEDIATE CALCULATIONS		
Heavy Vehicle Factor f HV-Mainline		0.952
Heavy Vehicle Factor f HV-Ramp		0.952
Adjusted Freeway flow rate	pcph	2,100
Adjusted on-ramp flow rate	pcph	525
Adjusted overall flow rate in ramp influence area	pcph	2,625
On a per lane basis	pcphl	875
Ramp capacity check OK?		YES

$$S_o = S_b - \alpha \times (\beta * V_{rf})^{\gamma} \times \left(\frac{V}{N} - 500\right)^{1} \times \left(\frac{1}{\quad}\right)^{\delta}$$

NCHRP 07-26 Merge Segment Speed and Capacity Results

SPEED AND CAPACITY CALCULATIONS

BASIC SEGMENT

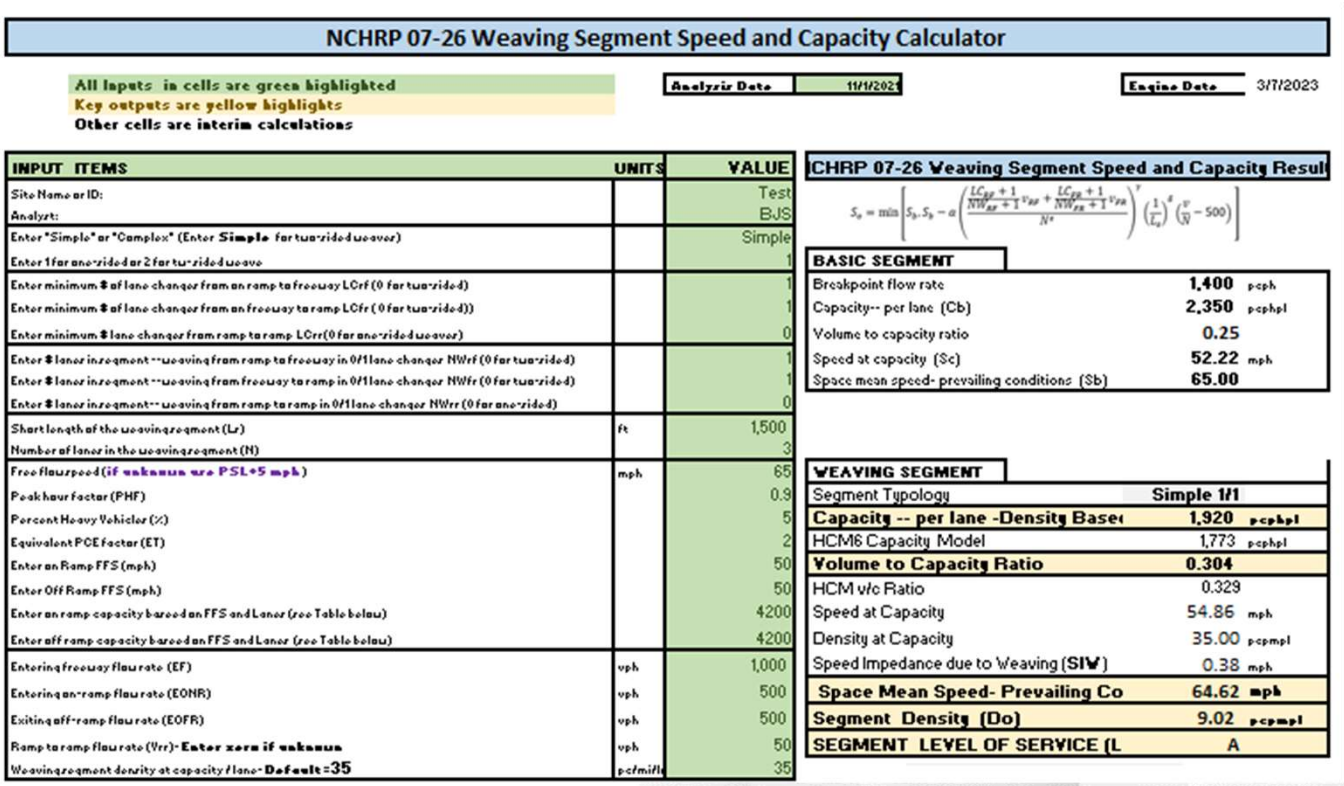
Breakpoint flow rate	1,600	pcph
Capacity-- per lane	2,300	pcphpl
Volume to capacity ratio	0.38	
Speed at capacity	51.11	mph
Space mean speed	60.00	mph

MERGE SEGMENT

Capacity -- per lane ---Density Based	1,891	pcphpl
HCM6 Capacity Model	2,300	pcphpl
HCM6 volume to capacity ratio	0.38	
Volume to Capacity (v/c) Ratio	0.463	
Speed at capacity	54.03	mph
Density at Capacity	35.00	pcpmpl
Speed Impedance due toMerging (SIM)	1.61	mph
Space mean speed	58.39	
Density	14.98	
LEVEL OF SERVICE (LOS)	B	

Analysis Inputs – Weaves

- # of Weaving Lanes
- Lane Changes
- Length of Weaving Segment
- # of Lanes
- Free Flow Speed
- Peak Hour Factor
- Heavy Vehicles (%)
- Ramp Capacity (Table)



NCHRP 07-26 Weaving Segment Speed and Capacity Calculator

All inputs in cells are green highlighted
Key outputs are yellow highlights
Other cells are interim calculations

Analyzir Date: 11/1/2023 | Engine Date: 3/7/2023

INPUT ITEMS	UNITS	VALUE
Site Name or ID:		Test
Analyzt:		BJS
Enter "Simple" or "Complex" (Enter **Simple** for two-sided weaves)		Simple
Enter 1 for one-sided or 2 for two-sided weave		1
Enter minimum # of lane changes from an ramp to freeway LCrf (0 for two-sided)		1
Enter minimum # of lane changes from an freeway to ramp LCfr (0 for two-sided))		1
Enter minimum # lane changes from ramp to ramp LCrr(0 for one-sided weaves)		0
Enter # lanes in segment -- weaving from ramp to freeway in 0/1 lane changes NWrf (0 for two-sided)		1
Enter # lanes in segment -- weaving from freeway to ramp in 0/1 lane changes NWfr (0 for two-sided)		1
Enter # lanes in segment -- weaving from ramp to ramp in 0/1 lane changes NWrr (0 for one-sided)		0
Short length of the weaving segment (Lr)	ft	1,500
Number of lanes in the weaving segment (N)		3
Free flow speed (**if unknown use PSL+5 mph**)	mph	65
Peak hour factor (PHF)		0.9
Percent Heavy Vehicles (%)		5
Equivalent PCE factor (ET)		2
Enter on Ramp FFS (mph)		50
Enter Off Ramp FFS (mph)		50
Enter on ramp capacity based on FFS and Lanes (see Table below)		4200
Enter off ramp capacity based on FFS and Lanes (see Table below)		4200
Entering freeway flow rate (EF)	vph	1,000
Entering on-ramp flow rate (EONR)	vph	500
Exiting off-ramp flow rate (EOFR)	vph	500
Ramp to ramp flow rate (Vrr) - **Enter zero if unknown**	vph	50
Weaving segment density at capacity / lane - **Default =35**	pc/mi/l	35

CHRP 07-26 Weaving Segment Speed and Capacity Result

$$S_o = \min\left[S_b, S_b - a\left(\frac{\frac{LC_{RF}+1}{NW_{RF}+1}v_{RF} + \frac{LC_{FR}+1}{NW_{FR}+1}v_{FR}}{N^x}\right)^y \left(\frac{1}{L_r}\right)^d \left(\frac{v}{N} - 500\right)\right]$$

BASIC SEGMENT

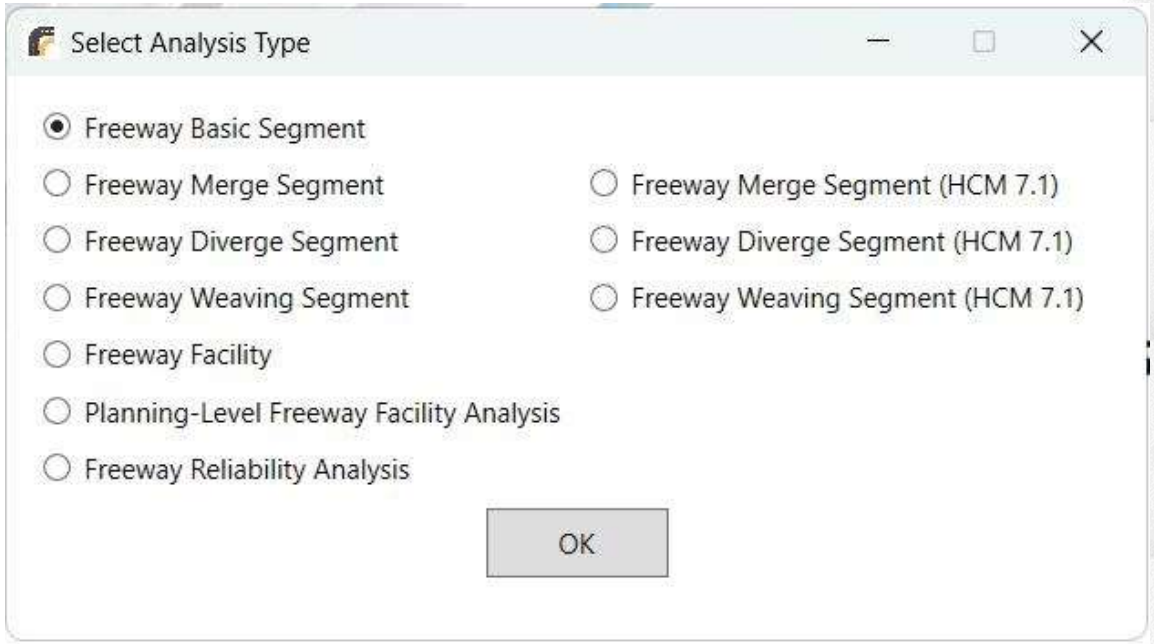
Breakpoint flow rate	1,400	pcph
Capacity-- per lane (Cb)	2,350	pcphpl
Volume to capacity ratio	0.25	
Speed at capacity (Sc)	52.22	mph
Space mean speed- prevailing conditions (Sb)	65.00	

WEAVING SEGMENT

Segment Typology	Simple 1/1	
Capacity -- per lane -Density Base	1,920	pcphpl
HCM6 Capacity Model	1,773	pcphpl
Volume to Capacity Ratio	0.304	
HCM v/c Ratio	0.329	
Speed at Capacity	54.86	mph
Density at Capacity	35.00	pcpmpl
Speed Impedance due to Weaving (SIW)	0.38	mph
Space Mean Speed- Prevailing Co	64.62	mph
Segment Density (Do)	9.02	pcpmpl
SEGMENT LEVEL OF SERVICE (L	A	

HCS 2026

- Available now (released 10/2025)
- Facilities utilize HCM 7.0



Questions

Jason Kessler
jrkessler@hntb.com