

Traffic Concepts

CEE 320
Steve Muench

Outline

1. Basic Concepts
   a. Flow Rate
   b. Spacing
   c. Headway
   d. Speed
   e. Density
2. Relationships
3. Example

Concepts

- **Definitions**
- **Volume, Speed, Density relationships**
- **Speed**
  - **Space mean speed**
  - **Time mean speed**

Flow Rate (q)

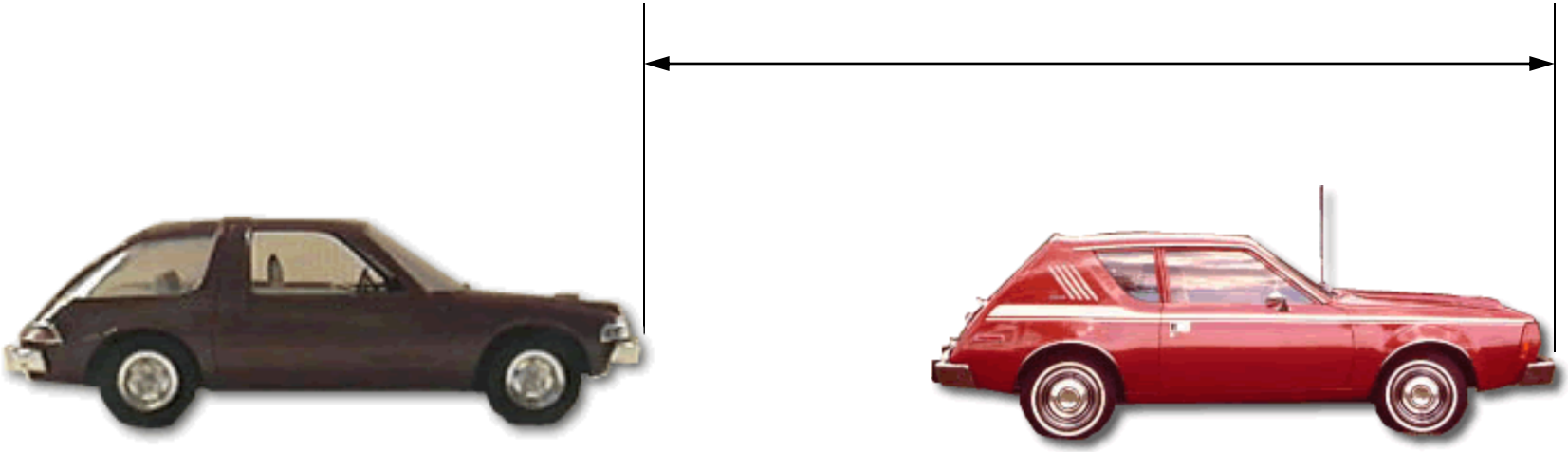
- **The number of vehicles (n) passing some designated roadway point in a given time interval (t)**

$$q = \frac{n}{t}$$

- **Units are typically vehicles/hour**
- **Flow rate is different than volume**

Spacing

- **The distance (ft) between successive vehicles in a traffic stream, as measured from front bumper to front bumper**

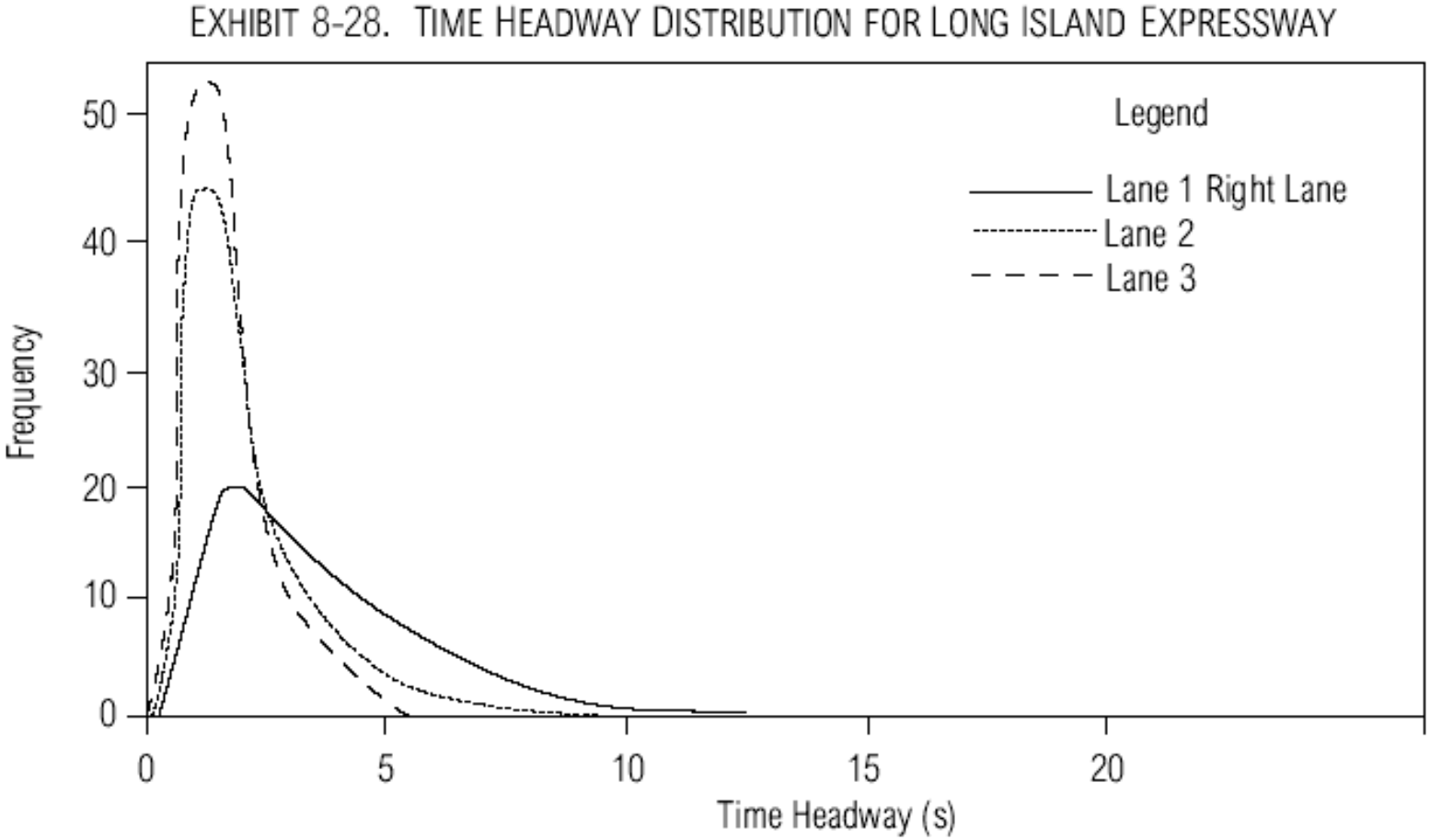


Headway (h)

- **The time (in seconds) between successive vehicles, as their front bumpers pass a given point.**

$$t = \sum_{i=1}^{n} h_i \qquad q = \frac{n}{\sum_{i=1}^{n} h_i} = \frac{1}{\overline{h}}$$

Headway



Source: Berry and Gandhi (*13*).

From HCM 2000

Speed

- **Time mean speed (spot speed)**
  - **Arithmetic mean of all instantaneous vehicle speeds at a given "spot" on a roadway section**
- **Space mean speed (u)**
  - **The mean travel speed of vehicles traversing a roadway segment of a known distance (d)**
  - **More useful for traffic applications**

Space Mean Speed

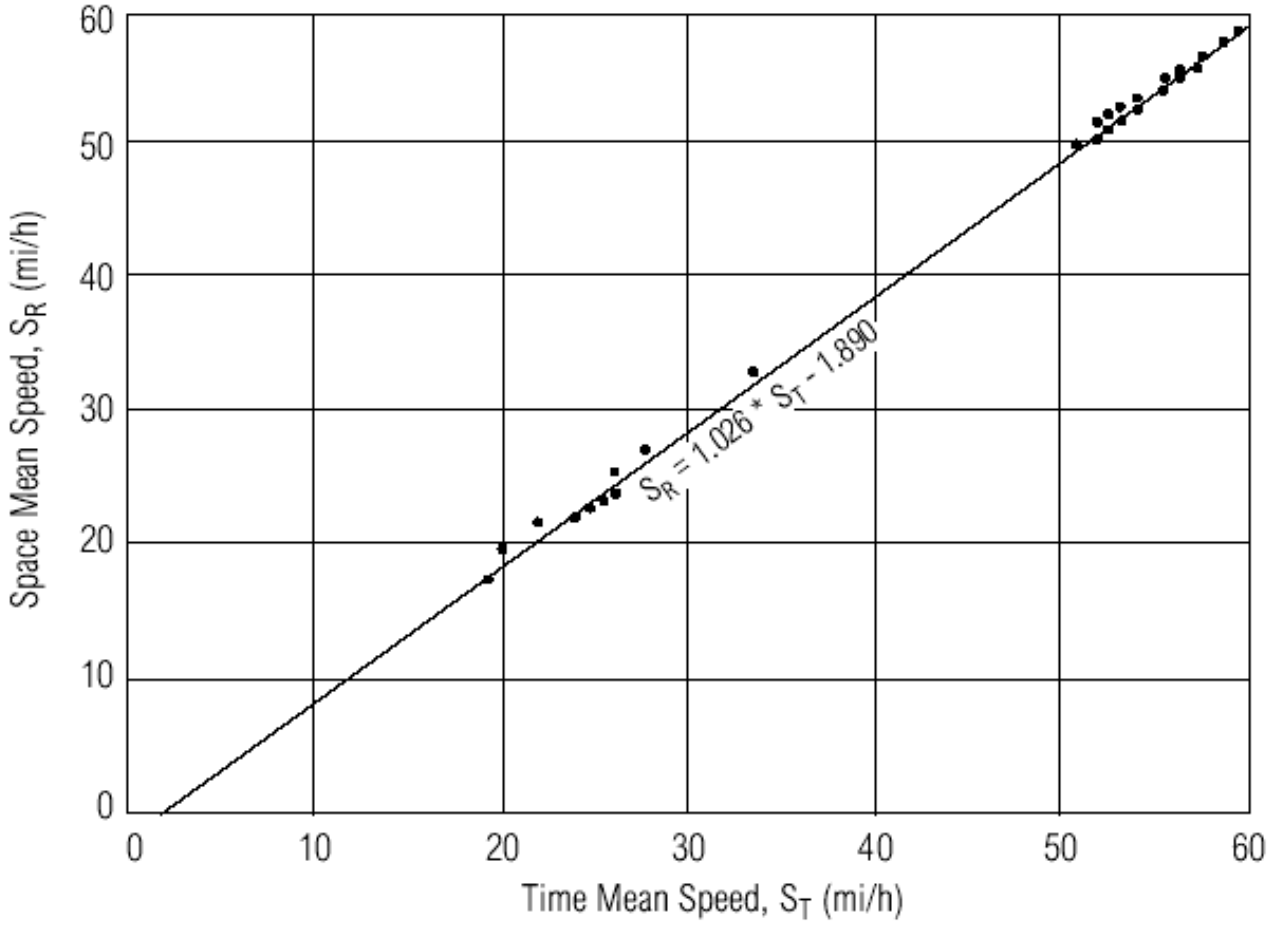
- **It is the harmonic mean (1/H = 1/a + 1/b + …)**

$$u = \frac{\frac{1}{n}\sum_{i=1}^{n} l_i}{\bar{t}} \qquad \bar{t} = \frac{1}{n}\left(t_1 l_1 + t_2 l_2 + \ldots + t_n l_n\right)$$

- **Space mean speed is always less than time mean speed**

Time Mean vs. Space Mean Speed

EXHIBIT 7-1. TYPICAL RELATIONSHIP BETWEEN TIME MEAN AND SPACE MEAN SPEED



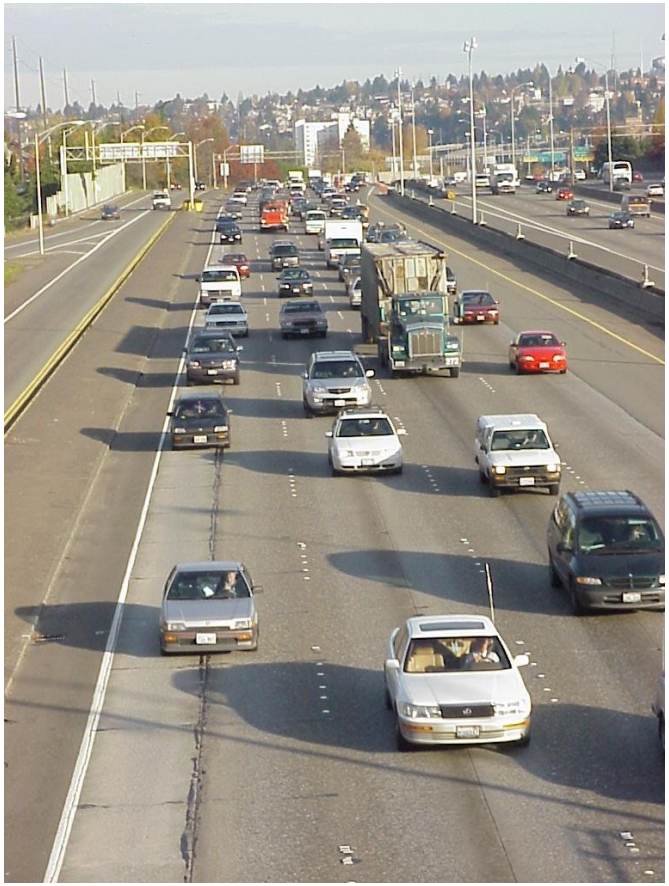
Source: Drake et al. (*1*).

From HCM 2000

Density (k)

- **The number of vehicles (n) occupying a given length (l) of a lane or roadway at a particular instant**
- **Unit of density is vehicles per mile (vpm).**

$$k = \frac{n}{l} = \frac{q}{u}$$



Other Concepts

- **Free-flow speed (u_f)**
- **Jam density (k_j)**
- **Capacity (q_m)**

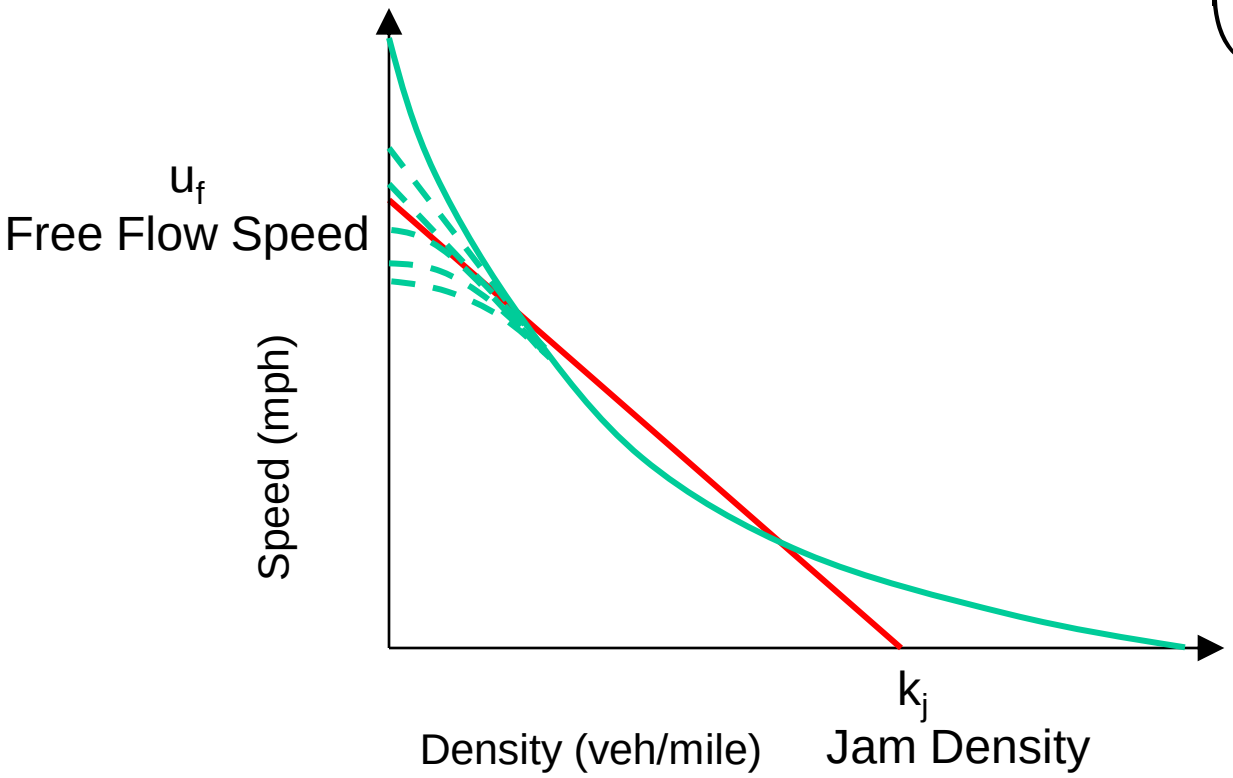
$$Density\ (veh/mi) = \frac{5{,}280}{spacing\ (ft/veh)}$$

$$Headway\ (s/veh) = \frac{spacing\ (ft/veh)}{speed\ (ft/s)}$$

$$Flow\ rate\ (veh/hr) = \frac{3{,}600}{headway\ (s/veh)}$$

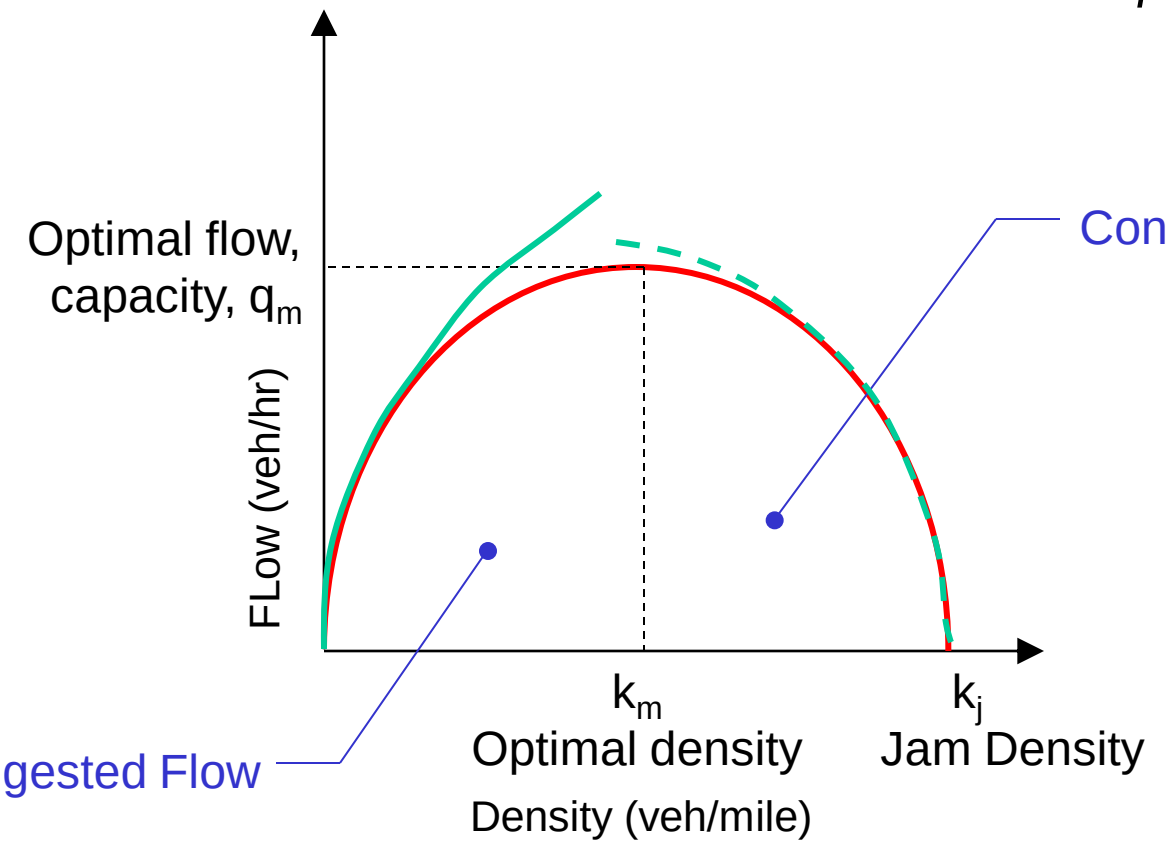
Speed vs. Density

$$u = u_f \left(1 - \frac{k}{k_j}\right)$$



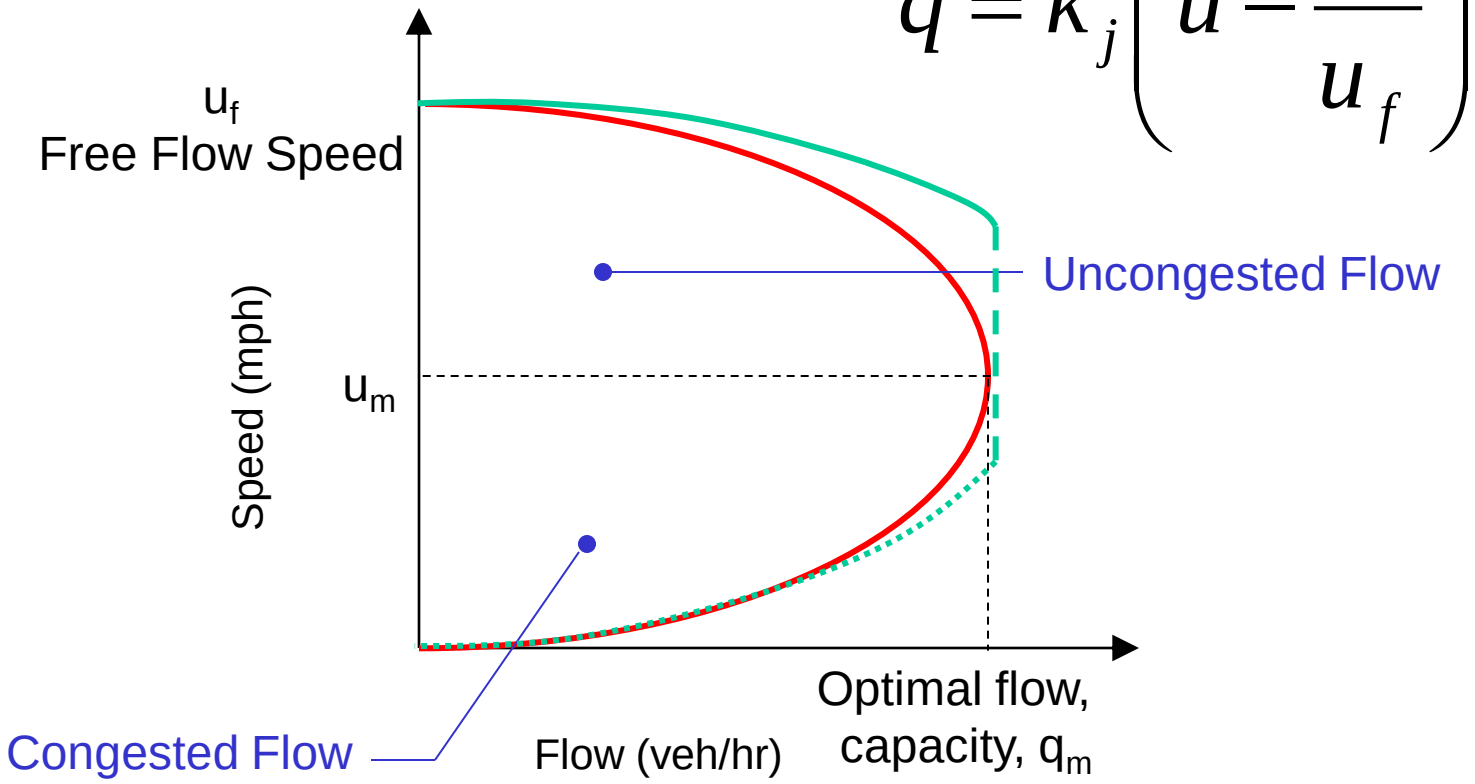
Flow vs. Density

$$q = u_f \left(k - \frac{k^2}{k_j} \right)$$



Speed vs. Flow

$$q = k_j \left(u - \frac{u^2}{u_f} \right)$$



3-D Model

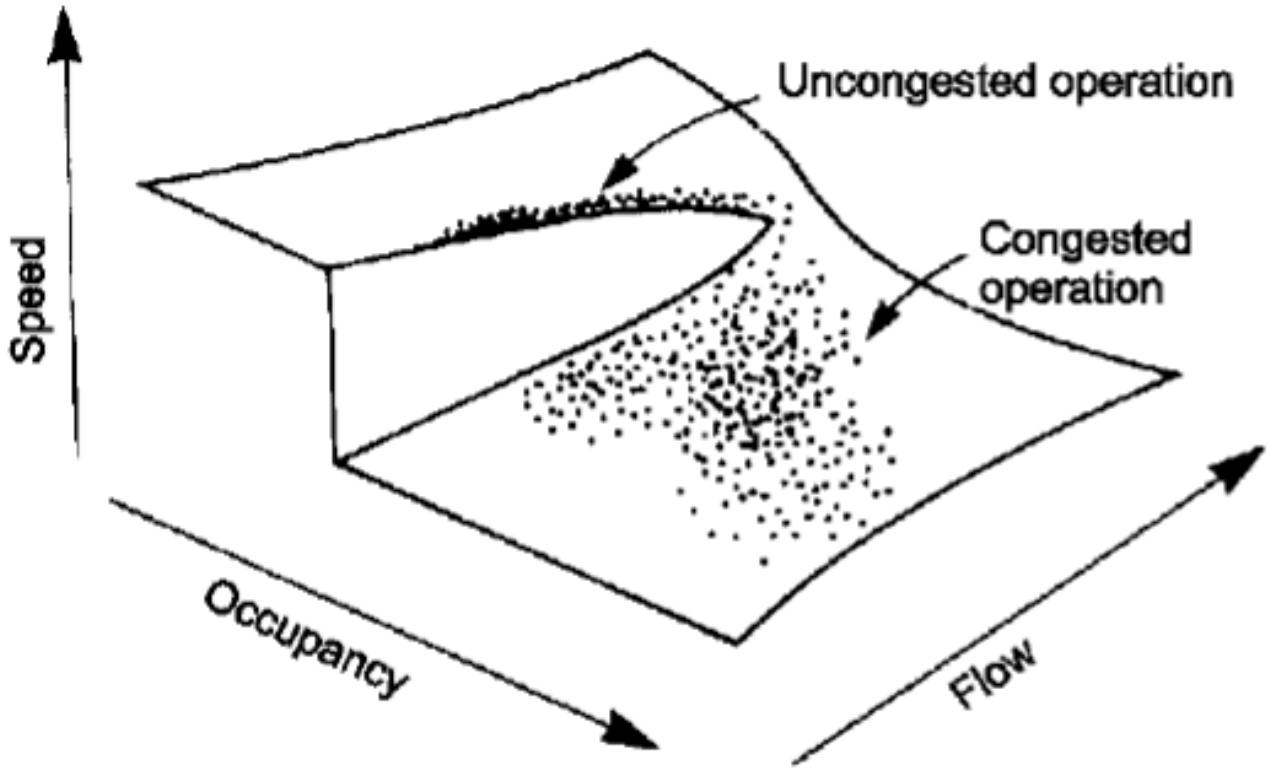


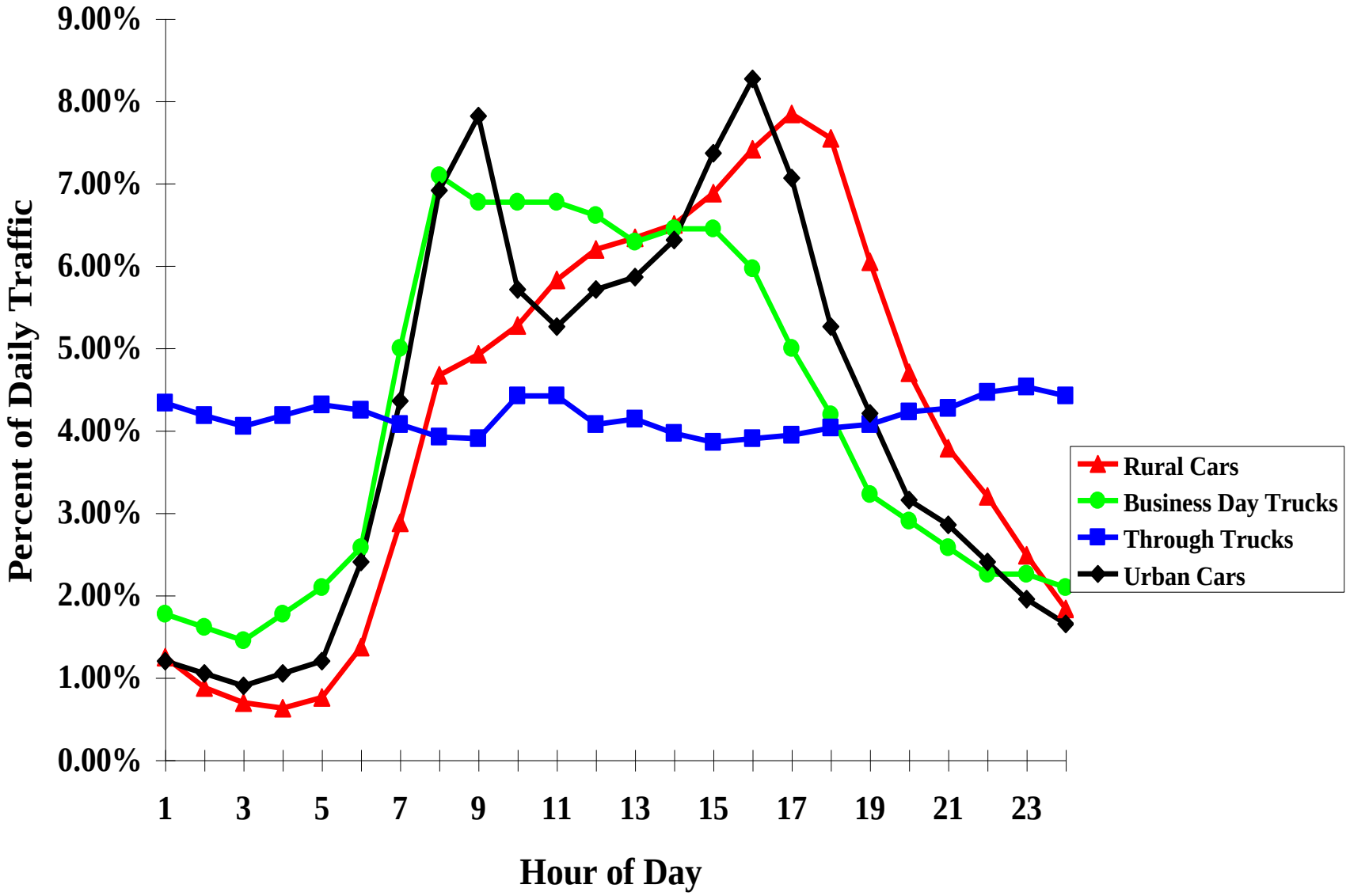
Figure 2.20
Conceptualization of Traffic Operations on a Catastrophe Theory Surface Using the Maxwell Convention (Persaud and Hall 1989).

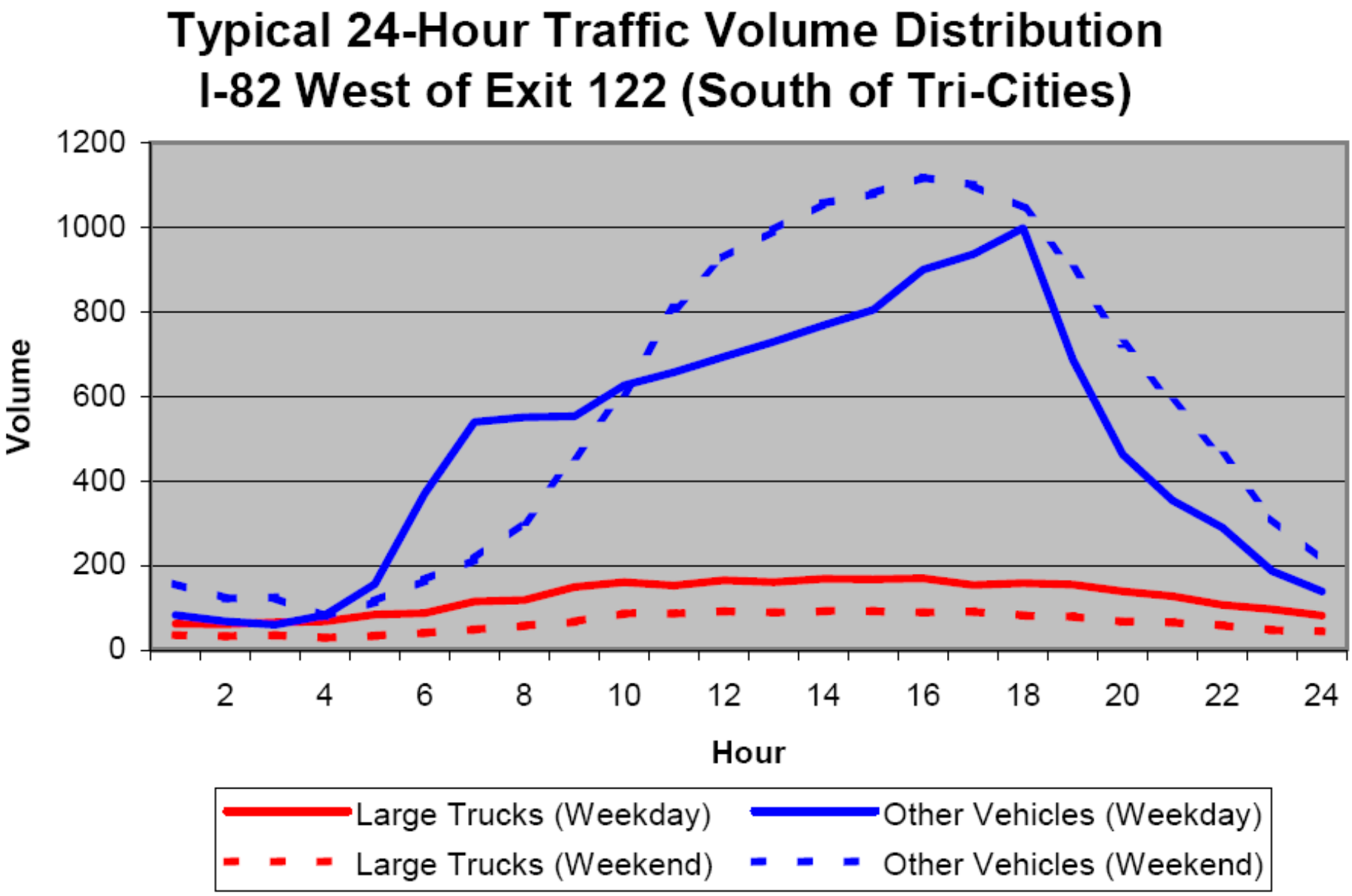
Example

I-5 over the ship canal bridge has 4 lanes in each direction. The northbound capacity is 8200 veh/hr/lane and the free-flow speed is 65 mph. What is the maximum flow rate, maximum density, jam density? If a one-hour vehicle count in the northbound direction for the outside lane gives 7034 vehicles in a non-congested condition, what is the estimated space mean speed of these 7034 vehicles?



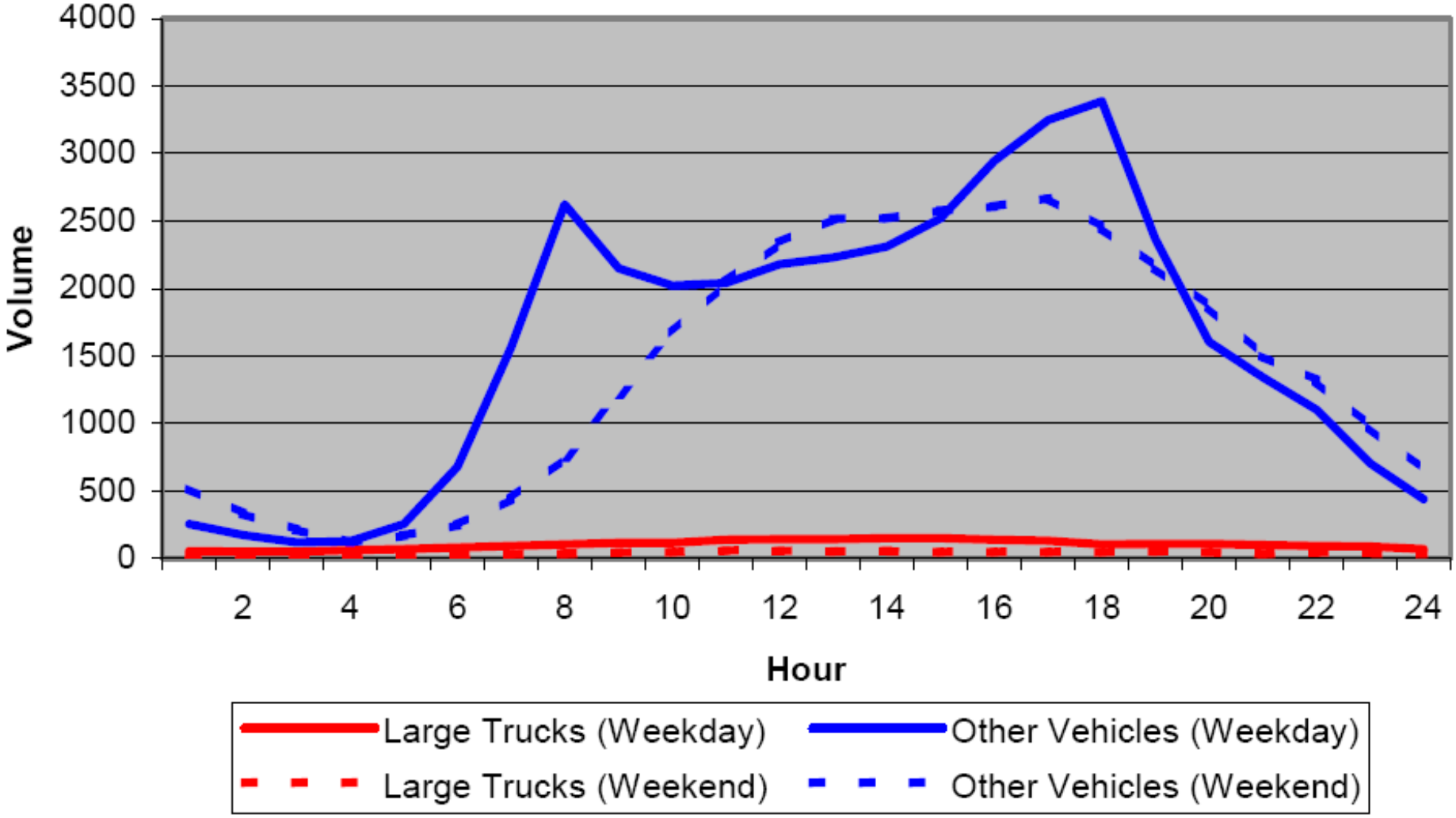
Traffic – Time of Day Patterns





From WSDOT *2003 Annual Traffic Report*

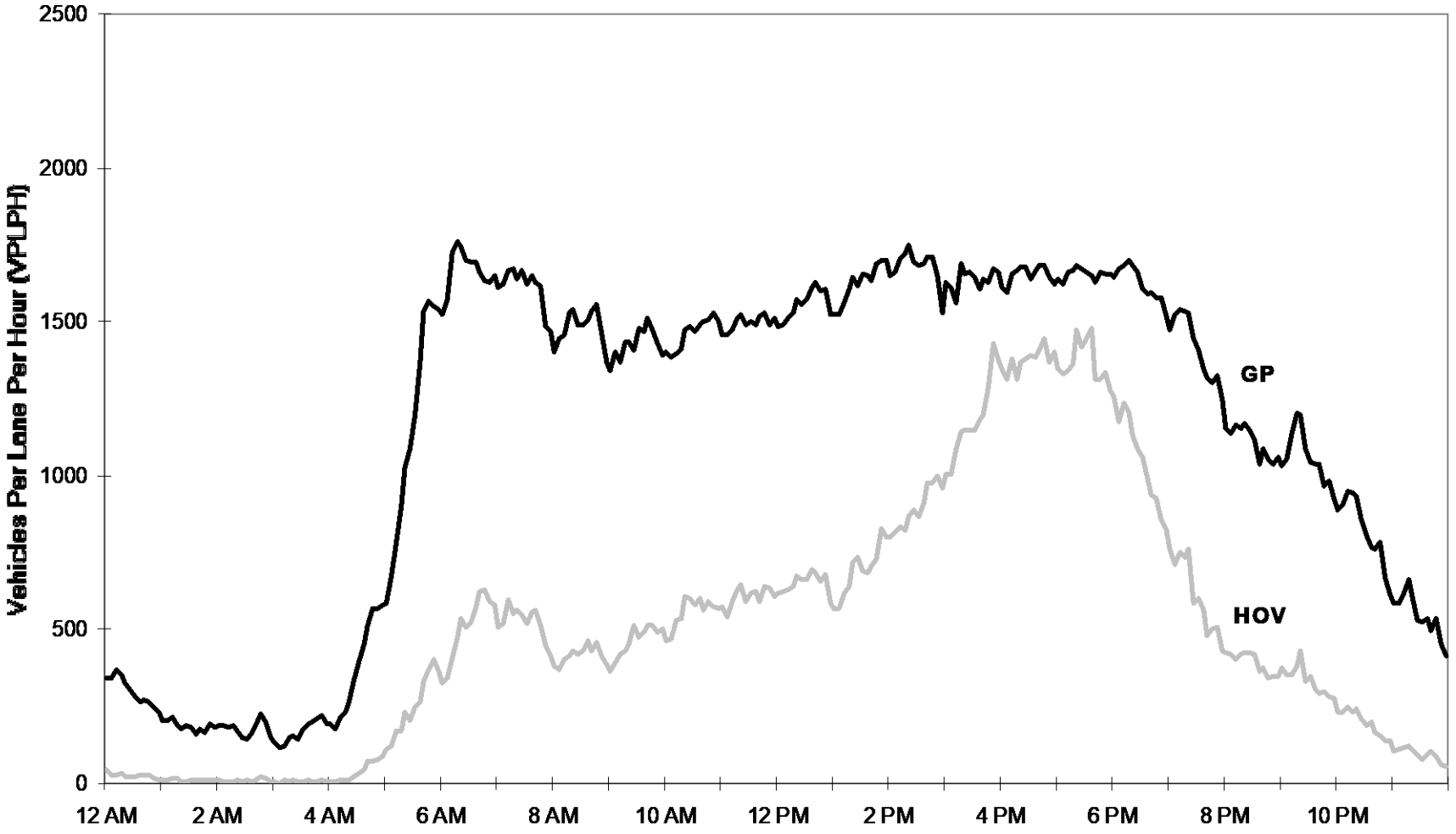
Typical 24-Hour Traffic Volume Distribution
I-5 North of Exit 260 (Near Ferndale)



From WSDOT *2003 Annual Traffic Report*

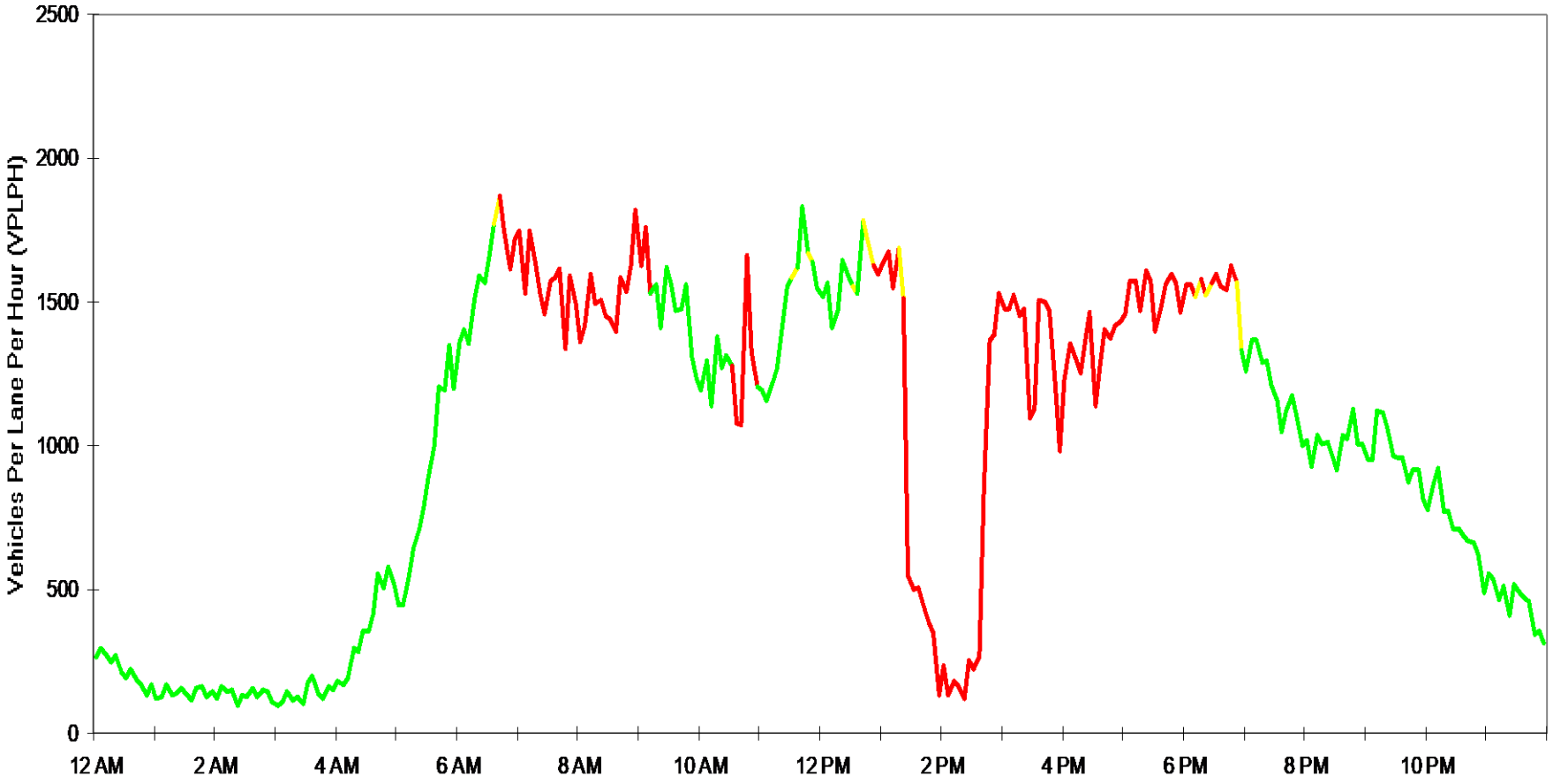
Estimated Weekday Volume Profile: GP and HOV Lanes (Nov 98)

I-405 NE 37th St GP SB



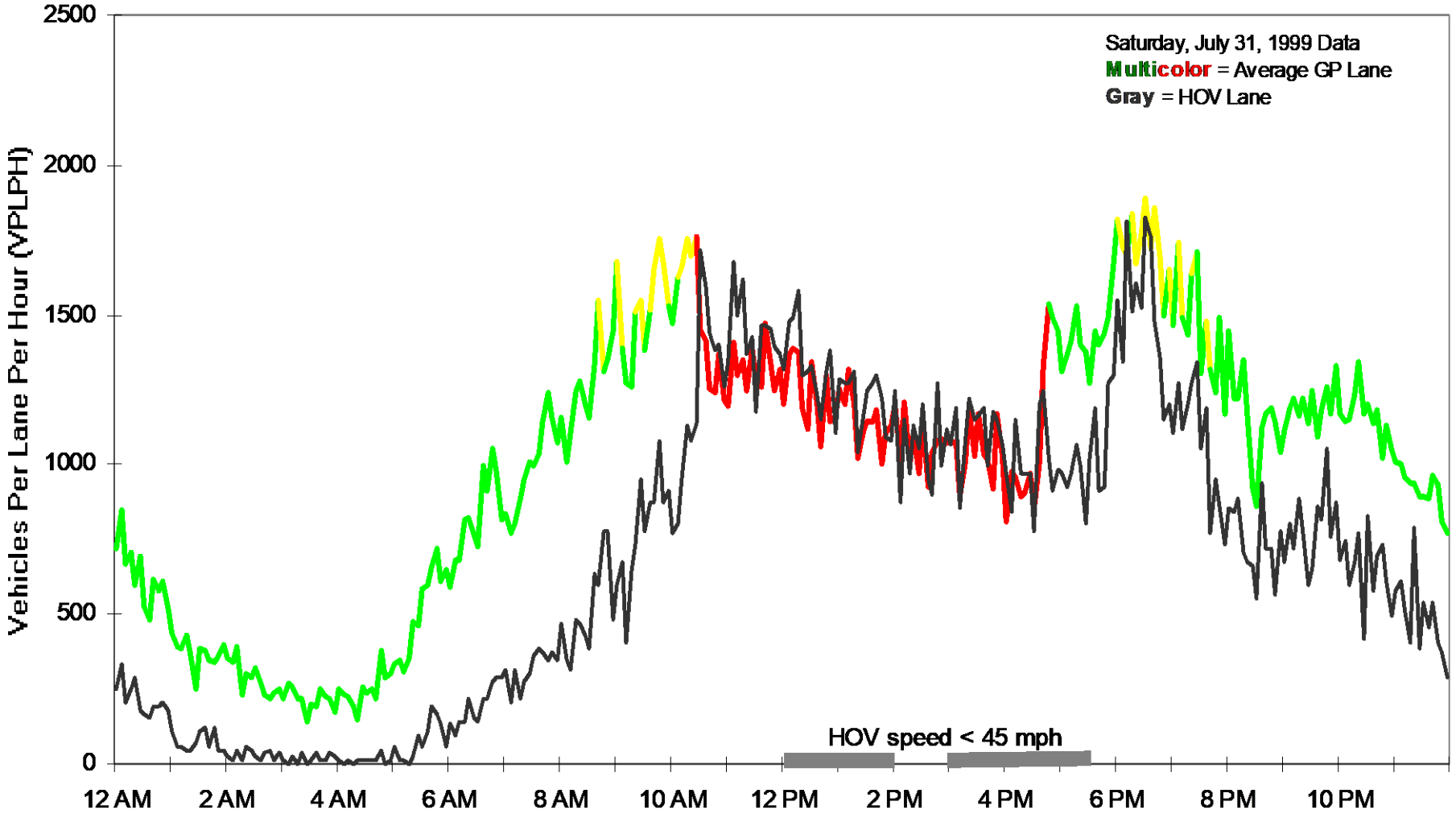
Estimated Volume and Speed Conditions (2/17/00)

I-5 NE 45th St-SB GP SB



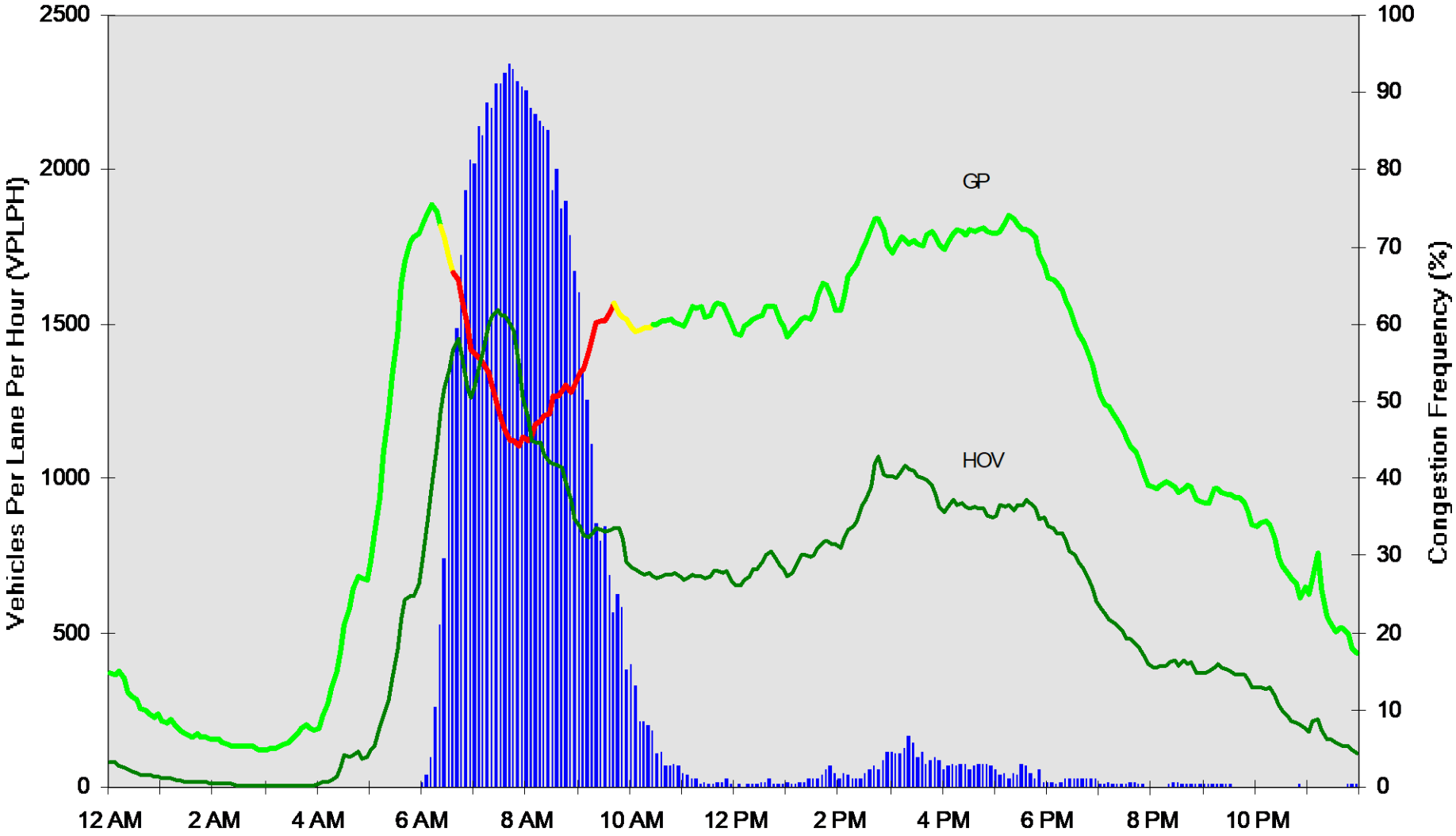
Estimated GP and HOV Volume and Speed Conditions

I-5 S Spokane St GP NB

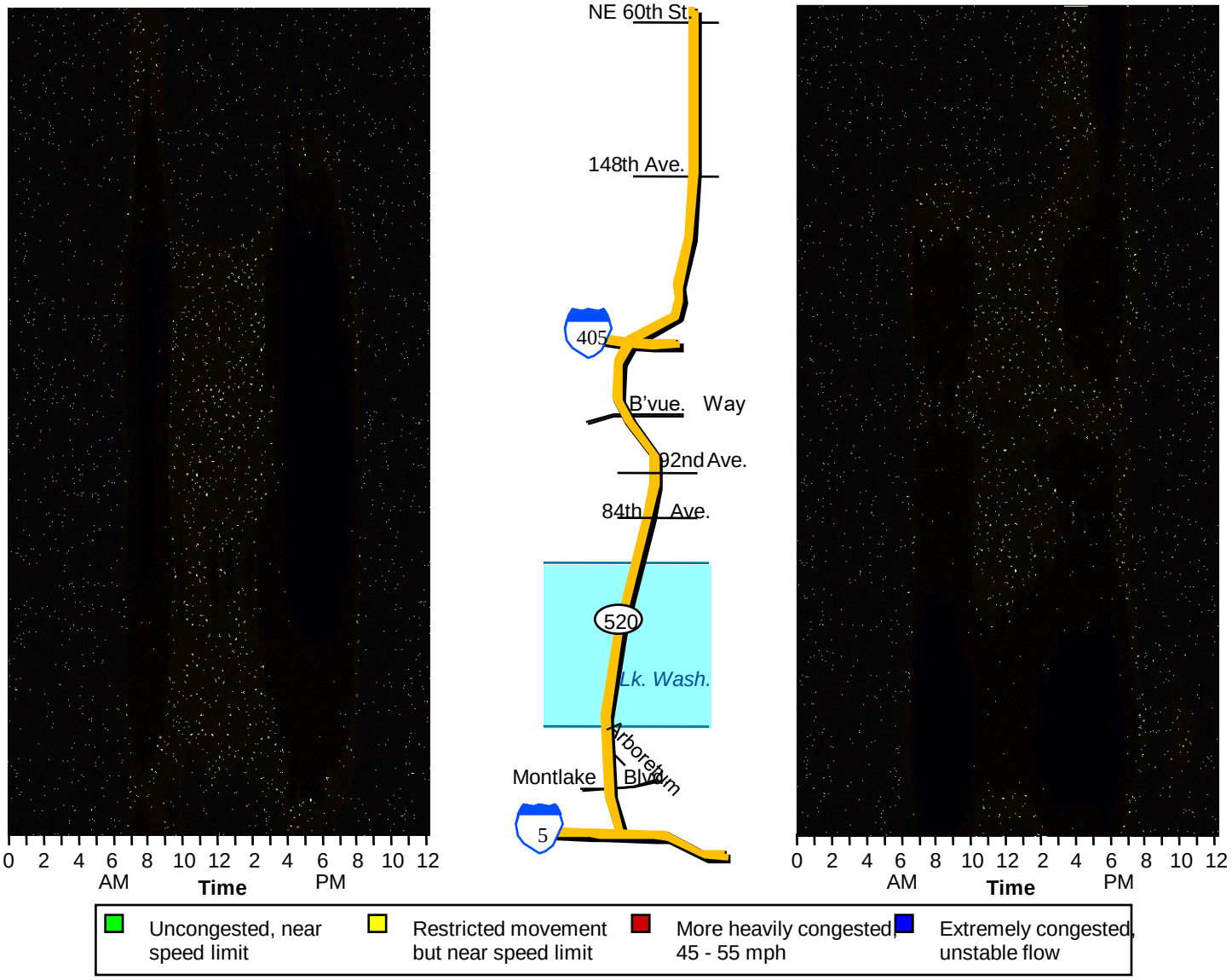


Estimated Weekday Volume, Speed, and Reliability Conditions (1999)

I-405 NE 37th St GP NB



SR 520 Traffic Profile
General Purpose Lanes
1997 Weekday Average



Primary References

- Mannering, F.L.; Kilareski, W.P. and Washburn, S.S. (2005). *Principles of Highway Engineering and Traffic Analysis*, Third Edition. Chapter 5

- Transportation Research Board. (2000). *Highway Capacity Manual 2000*. National Research Council, Washington, D.C.