الطرق متعددة الحارات
Multilane Highways

السعة في الظروف المثالية
Ideal Capacity

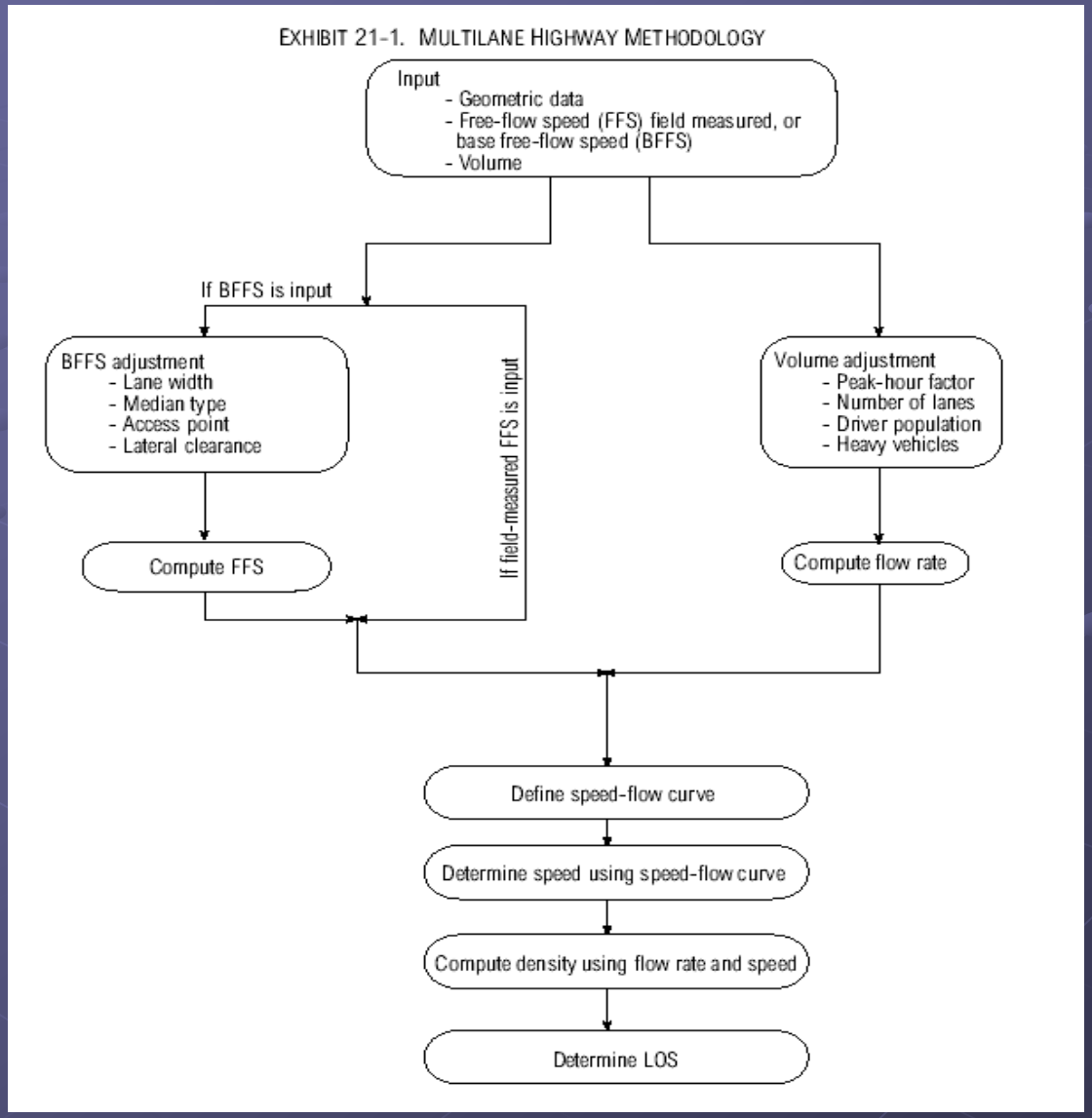
- Multilane Suburban/Rural
  2,200 pcphpl (100 kmph)
  2,100 (90 kmph)
  2,000 (85 kmph)
  1,900 (45 kmph)
- 2-lane rural – 2,800 pcph
- Signal – 1,900 pcphgpl

تتوضع الطرق متعددة حارات المرور عادة في المناطق الريفية rural و ضواحي multilane highways المدن suburban multilane highways وتصل هذه المناطق بمراكز المدن ، كما يوجد هذا النوع في المناطق الرئيسية بين التجمعات الكبيرة ، تتألف هذه الطرق عادة من أربع أو ست حارات مرور مع فاصل وسطي ، وتتراوح الغزارة على هذه الطرق بين ١٥٠٠٠ – ٤٠٠٠٠ عربة / يوم .

الظروف المثالية
Base Conditions

- 1. 3.6m lane widths
- 2. A minimum of 1.8m of lateral clearance in the direction of travel. مسافة رؤية خالية من العوائق في اتجاه الحركة لا تقل عن ١.٨ م
- 3. No direct access points along the highway ليس هنالك إمكانية للوصول المباشر إلى الطريق من الطرق الفرعية
- 4. A divided highway فصل كامل بين اتجاهي الحركة
- 5. **Only passenger cars** السيارات التي تستعمل الطريق هي سيارات سياحية فقط
- 6. A free-flow speed FFS > 100 kmph
- 7. Driver population consisting primarily of commuters جمهور السائقين معتادين على استخدام الطريق

منهجية الطرق المتعددة الحارات
Multilane Highway Methodology

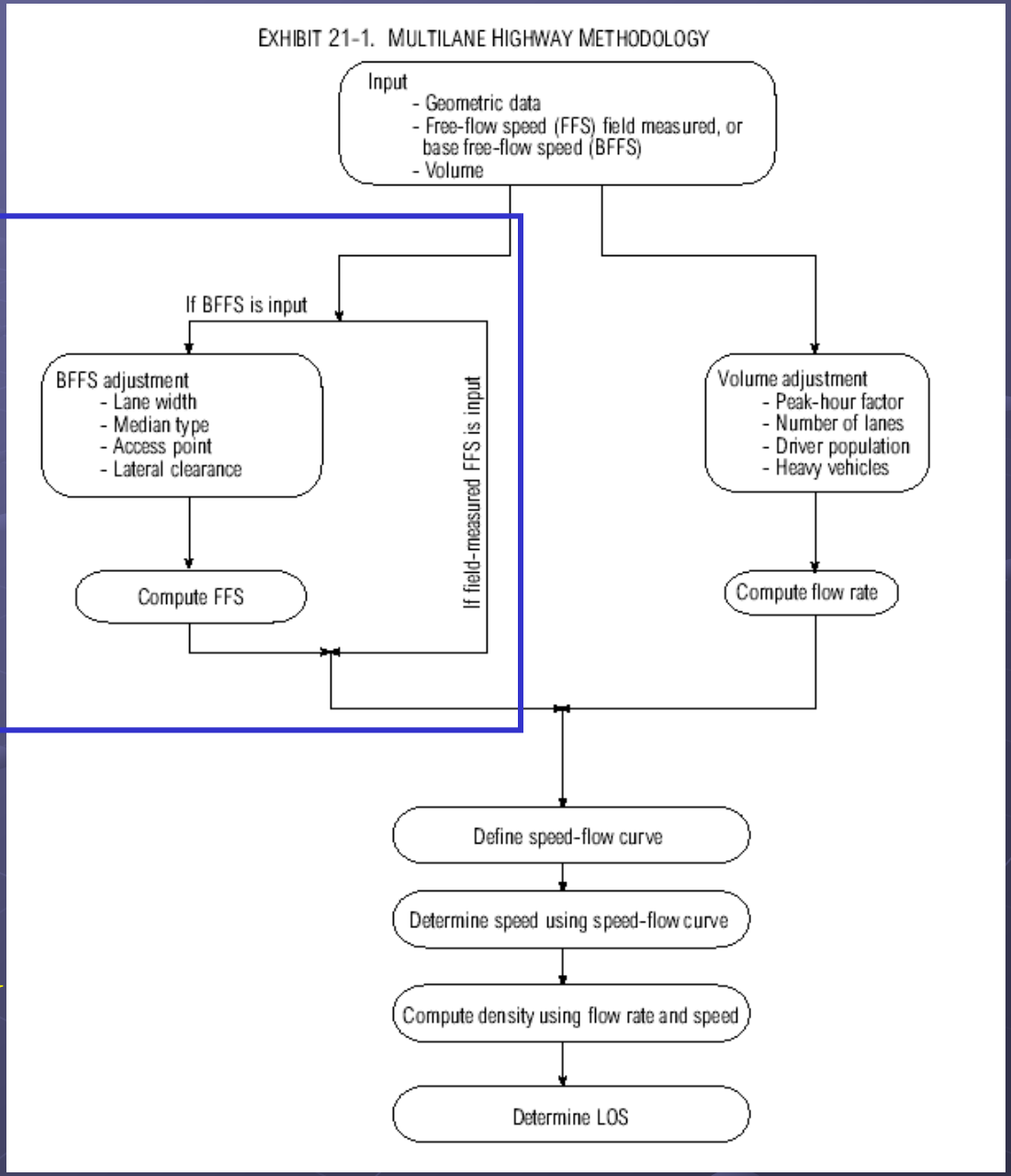


Source: HCM, 2000

The prediction of level of service for a multilane highway involves three steps:

- 1. Determination of free-flow speed
- 2. Adjustment of volume
- 3. Determination of level of service

يتم تحديد مستوى الخدمة على الطرق متعددة حارات المرور وفق ثلاث خطوات :
تحديد سرعة الجريان الحر .
تصحيح الغزارة .
تحديد مستوى الخدمة .



Step 1: Gather data

Step 2: Calculate capacity (Supply)

Source: HCM, 2000

Free Flow Speed سرعة الجريان الحر

يمكن تقدير سرعة الجريان الحر مباشرة في حال عدم وجود القياسات الحقلية كما يلي :

$$FFS = BFFS - F_M - F_{lw} - F_{lc} - F_A$$

حيث : FFS : السرعة التقديرية للجريان الحر .

BFFS : السرعة التقديرية للجريان الحر في الظروف المثالية .

F_M : عامل تصحيح يأخذ بالاعتبار تأثير الجزيرة الوسطية.

F_{LC} : عامل تصحيح يأخذ بالاعتبار تأثير العوائق الجانبية.

F_{LW} : عامل تصحيح يأخذ بالاعتبار تأثير عرض حارة المرور.

F_A : عامل تصحيح يأخذ بالاعتبار تأثير نقاط الطرق الفرعية.

ESTIMATING FFS

The FFS can be estimated indirectly when field data are not available.

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

where

$BFFS$	=	base FFS (mi/h);
FFS	=	estimated FFS (mi/h);
f_{LW}	=	adjustment for lane width, from Exhibit 21-4 (mi/h);
f_{LC}	=	adjustment for lateral clearance, from Exhibit 21-5 (mi/h);
f_M	=	adjustment for median type, from Exhibit 21-6 (mi/h); and
f_A	=	adjustment for access points, from Exhibit 21-7 (mi/h).

عرض حارة المرور
Lane Width

- Base Conditions: 3.6m lanes

EXHIBIT 21-4. ADJUSTMENT FOR LANE WIDTH

Lane Width (m)	Reduction in FFS (km/h)
3.6	0.0
3.5	1.0
3.4	2.1
3.3	3.1
3.2	5.6
3.1	8.1
3.0	10.6

Source: HCM, 2000

المسافة الجانبية
Lateral Clearance

- $TLC = LC_R + LC_L$ المسافة الجانبية تتألف من

TLC = total lateral clearance

LC_R <= 1.8 m from right edge of travel lanes to obstruction ما قيمته أقل أو يساوي ١.٨م من الطرف الأيمن لحارات المرور حتى حاجز الاعاقة

LC_L <= 1.8 m <= 1.8 m from left edge of travel lane to object in median ما قيمته أقل أو يساوي ١.٨م من الطرف الأيسر لحارات المرور حتى منصف الطريق

Source: HCM, 2000

EXHIBIT 21-5. ADJUSTMENT FOR LATERAL CLEARANCE

Four-Lane Highways		Six-Lane Highways	
Total Lateral Clearance[a] (ft)	Reduction in FFS (mi/h)	Total Lateral Clearance[a] (ft)	Reduction in FFS (mi/
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:
a. Total lateral clearance is the sum of the lateral clearances of the median (if greater than 6 ft, use 6 ft) and shoulder (if gr than 6 ft, use 6 ft). Therefore, for purposes of analysis, total lateral clearance cannot exceed 12 ft.

Example: Calculate lateral clearance adjustment for a 4-lane divided highway with milepost markers located 4 feet to the right of the travel lane.

$TLC = LC_R + LC_L = 4 + 6 = 10$

$F_{lc} = 0.4$ mph

Source: HCM, 2000

EXHIBIT 21-5. ADJUSTMENT FOR LATERAL CLEARANCE

Four-Lane Highways		Six-Lane Highways	
Total Lateral Clearance[a] (m)	Reduction in FFS (km/h)	Total Lateral Clearance[a] (m)	Reduction in FFS (km/h)
3.6	0.0	3.6	0.0
3.0	0.6	3.0	0.6
2.4	1.5	2.4	1.5
1.8	2.1	1.8	2.1
1.2	3.0	1.2	2.7
0.6	5.8	0.6	4.5
0.0	8.7	0.0	6.3

Note:

a. Total lateral clearance is the sum of the lateral clearances of the median (if greater than 1.8 m, use 1.8 m) and shoulder (if greater than 1.8 m, use 1.8 m). Therefore, for purposes of analysis, total lateral clearance cannot exceed 3.6 m.

Source: HCM, 2000

شكل الجزيرة الوسطية
Median Type

EXHIBIT 21-6. ADJUSTMENT FOR MEDIAN TYPE

Median Type	Reduction in FFS (km/h)
Undivided highways	2.6
Divided highways (including TWLTLs)	0.0

Source: HCM, 2000

كثافة الطرق الفرعية الواصلة
Access Point Density

EXHIBIT 21-7. ACCESS-POINT DENSITY ADJUSTMENT

Access Points/Kilometer	Reduction in FFS (km/h)
0	0.0
6	4.0
12	8.0
18	12.0
≥ 24	16.0

Source: HCM, 2000

EXHIBIT 21-7. ACCESS-POINT DENSITY ADJUSTMENT

Access Points/Mile	Reduction in FFS (mi/h)
0	0.0
10	2.5
20	5.0
30	7.5
≥ 40	10.0

F_a accounts for interruption due to access points along the facility

Example: if there are 20 access points per mile, what is the reduction in free flow speed?

F_a = 5.0 mph

Default Access-Point Density

Development Type	Default Value	Access Points/mi (One Side)
Rural	8	0–10
Low-density suburban	16	11–20
High-density suburban	25	≥21

Source: TRB, 2000.

Base Free-flow speed also can be estimated from:

يمكن تقدير سرعة الجريان الأساسية من خلال :

1- 85th-percentile speed

السرعة التي تأخذها ٨٥% من السيارات

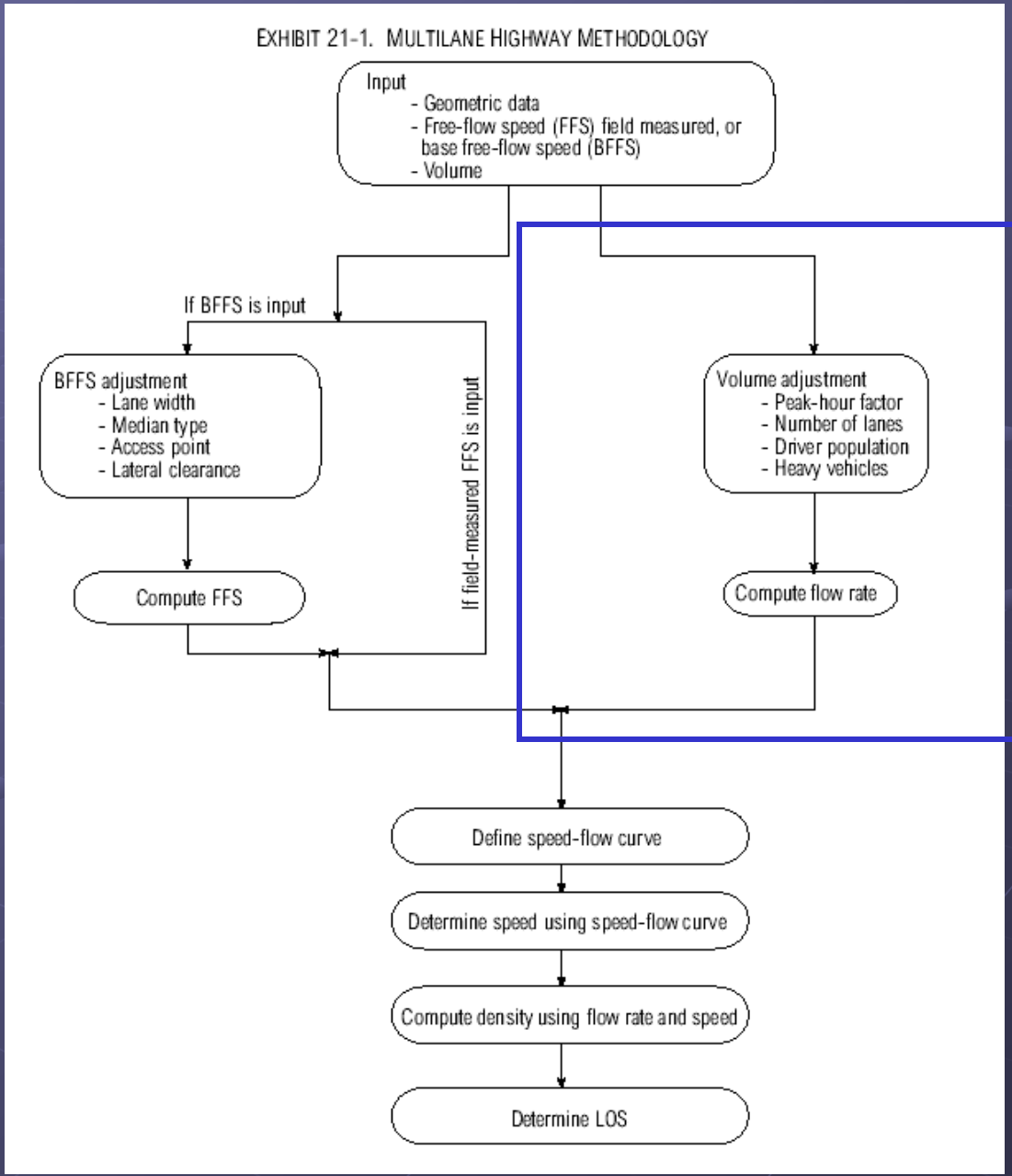
2- posted speed limits,

حدود السرعة المسموحة المعلنة

if it is not possible to measure directly in the field.

إذا لم يكن بالإمكان قياسها مباشرة في الحقل

Step 2: Estimate demand



Source: HCM, 2000

Calculate Flow Rate حساب معدل الجريان

$$v_p = \frac{V}{PHF * N * f_{HV} * f_p}$$

where

v_p = 15-min passenger-car equivalent flow rate (pc/h/ln),
V = hourly volume (veh/h),
PHF = peak-hour factor,
N = number of lanes,
f_{HV} = heavy-vehicle adjustment factor, and
f_p = driver population factor.

Peak Hour Factor (PHF)

$$PHF = \frac{\text{peak-hour volume}}{4(\text{peak 15-min volume})}$$

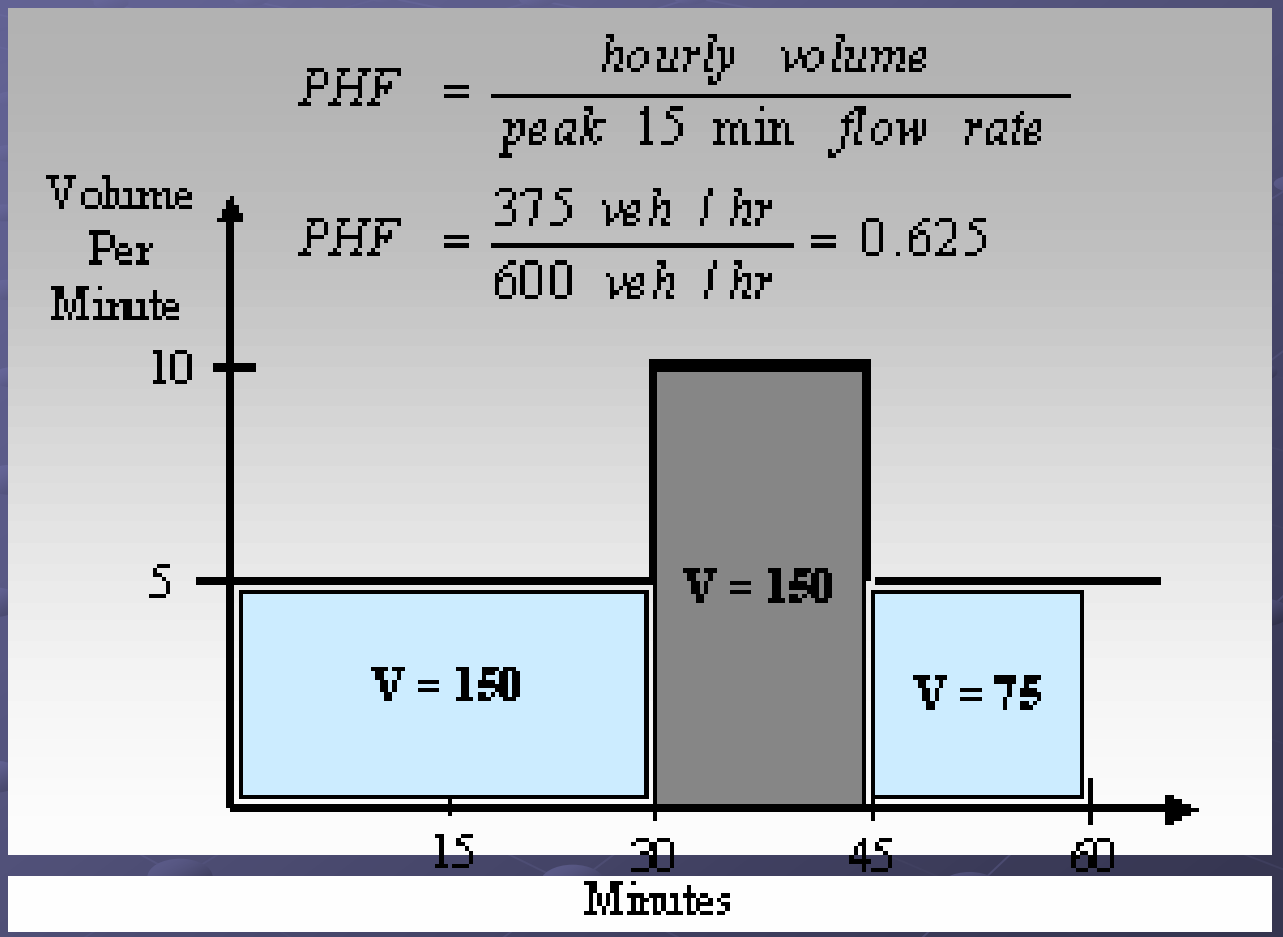
Flow is not uniform throughout an hour

HCM considers operating conditions during most congested 15-minute period of the hour to determine service level for the hour as a whole

Peak Hour Factor

$$PHF = \frac{hourly\ volume}{peak\ 15\ min\ flow\ rate}$$

$$PHF = \frac{375\ veh/hr}{600\ veh/hr} = 0.625$$



إدخال تأثير المركبات الثقيلة

Heavy Vehicle Adjustment

- Heavy vehicles affect traffic
- Slower, larger
- f_{hv} increases number of passenger vehicles to account for presence of heavy trucks

$$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)} \quad (2$$

where

E_T, E_R = passenger-car equivalents for trucks and buses and for recreational vehicles (RVs), respectively;

P_T, P_R = proportion of trucks and buses, and RVs, respectively, in the traffic stream (expressed as a decimal fraction); and

f_{HV} = adjustment factor for heavy vehicles.

إدخال تأثير المركبات الثقيلة
Heavy Vehicle Adjustment

EXHIBIT 21-8. PASSENGER-CAR EQUIVALENTS ON EXTENDED GENERAL HIGHWAY SEGMENTS

Factor	Type of Terrain		
	Level	Rolling	Mountainous
E_T (trucks and buses)	1.5	2.5	4.5
E_R (RVs)	1.2	2.0	4.0

Example: for 10% heavy trucks on rolling terrain, what is F_{hv}?

For rolling terrain, $E_T = 2.5$

$$F_{hv} = \frac{1}{1 + 0.1\,(2.5 - 1)} = \mathbf{0.87}$$

$$f_{HV} = \frac{1}{1 + P_T\,(E_T - 1) + P_R\,(E_R - 1)}$$

العامل الخاص بنوعية السائقين الذين يستخدمون الطريق
Driver Population Factor (f_p)

- Non-familiar users affect capacity
- f_p = 1, familiar users مستخدمون دائمون للطريق
- 1 > f_p >=0.85, unfamiliar users

- Calculate v_p

$$v_p = \frac{V}{PHF * N * f_{HV} * f_p}$$

- **Example:** base volume is 2,500 veh/hour
- PHF = 0.9, N = 2
- f_{hv} from previous, f_{hv} = 0.87
- Non-familiar users, f_p = 0.85

$$v_p = \frac{2{,}500 \text{ vph}}{0.9 \times 2 \times 0.87 \times 0.85} = 1878 \text{ pc/ph/pl}$$

الميول الخاصة
Specific Grade

- عندما يكون ميل الطريق ٣% أو اقل وبطول أكبر من ١.٥ كم أو لدينا طريق بميل يزيد عن ٣% وبطول أكبر من ٠.٨ كم ، عندها يكون التعامل مع هذا النوع من الطرق مختلف ويكون تأثير المركبات الثقيلة بشكل أوضح أيضا .
- هنا يجب حساب المعاملات E_T و E_R من خلال جداول أخرى ويجب التمييز بين حالة الطريق الصاعد Upgrade والطريق الهابط Downgrade

عامل التحويل المكافئ إلى عربات حسابية الخاص بالشاحنات والباصات في منطقة الصعود E_T

EXHIBIT 21-9. PASSENGER-CAR EQUIVALENTS FOR TRUCKS AND BUSES ON UNIFORM UPGRADES

Upgrade (%)	Length (km)	E_T Percentage of Trucks and Buses								
		2	4	5	6	8	10	15	20	25
<2	All	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
≥ 2–3	0.0–0.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	> 0.4–0.8	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	> 0.8–1.2	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	> 1.2–1.6	2.0	2.0	2.0	2.0	1.5	1.5	1.5	1.5	1.5
	> 1.6–2.4	2.5	2.5	2.5	2.5	2.0	2.0	2.0	2.0	2.0
	> 2.4	3.0	3.0	2.5	2.5	2.0	2.0	2.0	2.0	2.0
> 3–4	0.0–0.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	> 0.4–0.8	2.0	2.0	2.0	2.0	2.0	2.0	1.5	1.5	1.5
	> 0.8–1.2	2.5	2.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	> 1.2–1.6	3.0	3.0	2.5	2.5	2.5	2.5	2.0	2.0	2.0
	> 1.6–2.4	3.5	3.5	3.0	3.0	3.0	3.0	2.5	2.5	2.5
	> 2.4	4.0	3.5	3.0	3.0	3.0	3.0	2.5	2.5	2.5
> 4–5	0.0–0.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	> 0.4–0.8	3.0	2.5	2.5	2.5	2.0	2.0	2.0	2.0	2.0
	> 0.8–1.2	3.5	3.0	3.0	3.0	2.5	2.5	2.5	2.5	2.5
	> 1.2–1.6	4.0	3.5	3.5	3.5	3.0	3.0	3.0	3.0	3.0
	> 1.6	5.0	4.0	4.0	4.0	3.5	3.5	3.0	3.0	3.0
> 5–6	0.0–0.4	2.0	2.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	> 0.4–0.5	4.0	3.0	2.5	2.5	2.0	2.0	2.0	2.0	2.0
	> 0.5–0.8	4.5	4.0	3.5	3.0	2.5	2.5	2.5	2.5	2.5
	> 0.8–1.2	5.0	4.5	4.0	3.5	3.0	3.0	3.0	3.0	3.0
	> 1.2–1.6	5.5	5.0	4.5	4.0	3.0	3.0	3.0	3.0	3.0
	> 1.6	6.0	5.0	5.0	4.5	3.5	3.5	3.5	3.5	3.5
> 6	0.0–0.4	4.0	3.0	2.5	2.5	2.5	2.5	2.0	2.0	2.0
	> 0.4–0.5	4.5	4.0	3.5	3.5	3.5	3.0	2.5	2.5	2.5
	> 0.5–0.8	5.0	4.5	4.0	4.0	3.5	3.0	2.5	2.5	2.5
	> 0.8–1.2	5.5	5.0	4.5	4.5	4.0	3.5	3.0	3.0	3.0
	> 1.2–1.6	6.0	5.5	5.0	5.0	4.5	4.0	3.5	3.5	3.5
	>1.6	7.0	6.0	5.5	5.5	5.0	4.5	4.0	4.0	4.0

عامل التحويل المكافئ إلى عربات حسابية الخاص بالشاحنات والباصات في منطقة الصعود E_R

EXHIBIT 21-10. PASSENGER-CAR EQUIVALENTS FOR RVS ON UNIFORM UPGRADES

Grade (%)	Length (km)	E_R Percentage of RVs								
		2	4	5	6	8	10	15	20	25
≤2	All	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
> 2–3	0.0–0.8	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
	> 0.8	3.0	1.5	1.5	1.5	1.5	1.5	1.2	1.2	1.2
> 3–4	0.0–0.4	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
	> 0.4–0.8	2.5	2.5	2.0	2.0	2.0	2.0	1.5	1.5	1.5
	> 0.8	3.0	2.5	2.5	2.5	2.0	2.0	2.0	1.5	1.5
> 4–5	0.0–0.4	2.5	2.0	2.0	2.0	1.5	1.5	1.5	1.5	1.5
	> 0.4–0.8	4.0	3.0	3.0	3.0	2.5	2.5	2.0	2.0	2.0
	> 0.8	4.5	3.5	3.0	3.0	3.0	2.5	2.5	2.0	2.0
> 5	0.0–0.4	4.0	3.0	2.5	2.5	2.5	2.0	2.0	2.0	1.5
	> 0.4–0.8	6.0	4.0	4.0	3.5	3.0	3.0	2.5	2.5	2.0
	> 0.8	6.0	4.5	4.0	4.5	3.5	3.0	3.0	2.5	2.0

عامل التحويل المكافئ إلى عربات حسابية الخاص E_T بالشاحنات والباصات في منطقة الهبوط

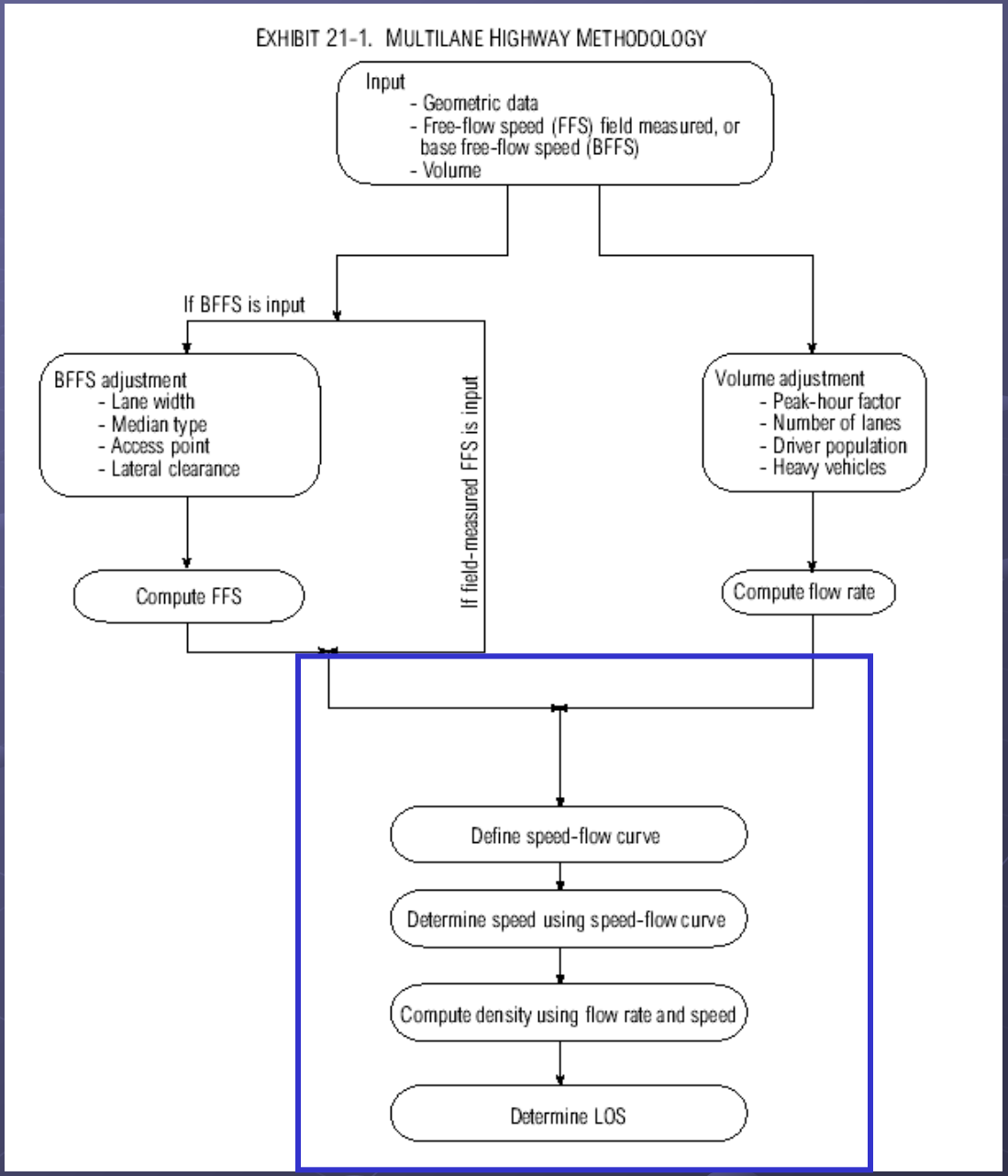
EXHIBIT 21-11. PASSENGER-CAR EQUIVALENTS FOR TRUCKS ON DOWNGRADES

Downgrade (%)	Length (km)	E_T Percentage of Trucks			
		5	10	15	20
< 4	All	1.5	1.5	1.5	1.5
4–5	≤ 6.4	1.5	1.5	1.5	1.5
4–5	> 6.4	2.0	2.0	2.0	1.5
> 5–6	≤ 6.4	1.5	1.5	1.5	1.5
> 5–6	> 6.4	5.5	4.0	4.0	3.0
> 6	≤ 6.4	1.5	1.5	1.5	1.5
> 6	> 6.4	7.5	6.0	5.5	4.5

- في حال كانت الميول اقل من ٤% وطول يساوي أو أقل ٣.٢ كم نستعمل القيم المعطاة في الجدول ٢١-٨ الخاص بالمناطق المنبسطة Level Terrain ، وفي حال الميل ٤% على الأقل وبطول ٣.٢ كم نستعمل القيم المعطاة بالجدول ٢١-١١ .
- أما بالنسبة لقيم E_R فغننا نستعمل القيم المعطاة في الجدول ٢١-٨ الخاص بالمناطق المنبسطة Level Terrain بالنسبة لكل الحالات .

Step 3: Determine LOS

Demand Vs. Supply



Source: HCM, 2000

حساب الكثافة
Calculate Density

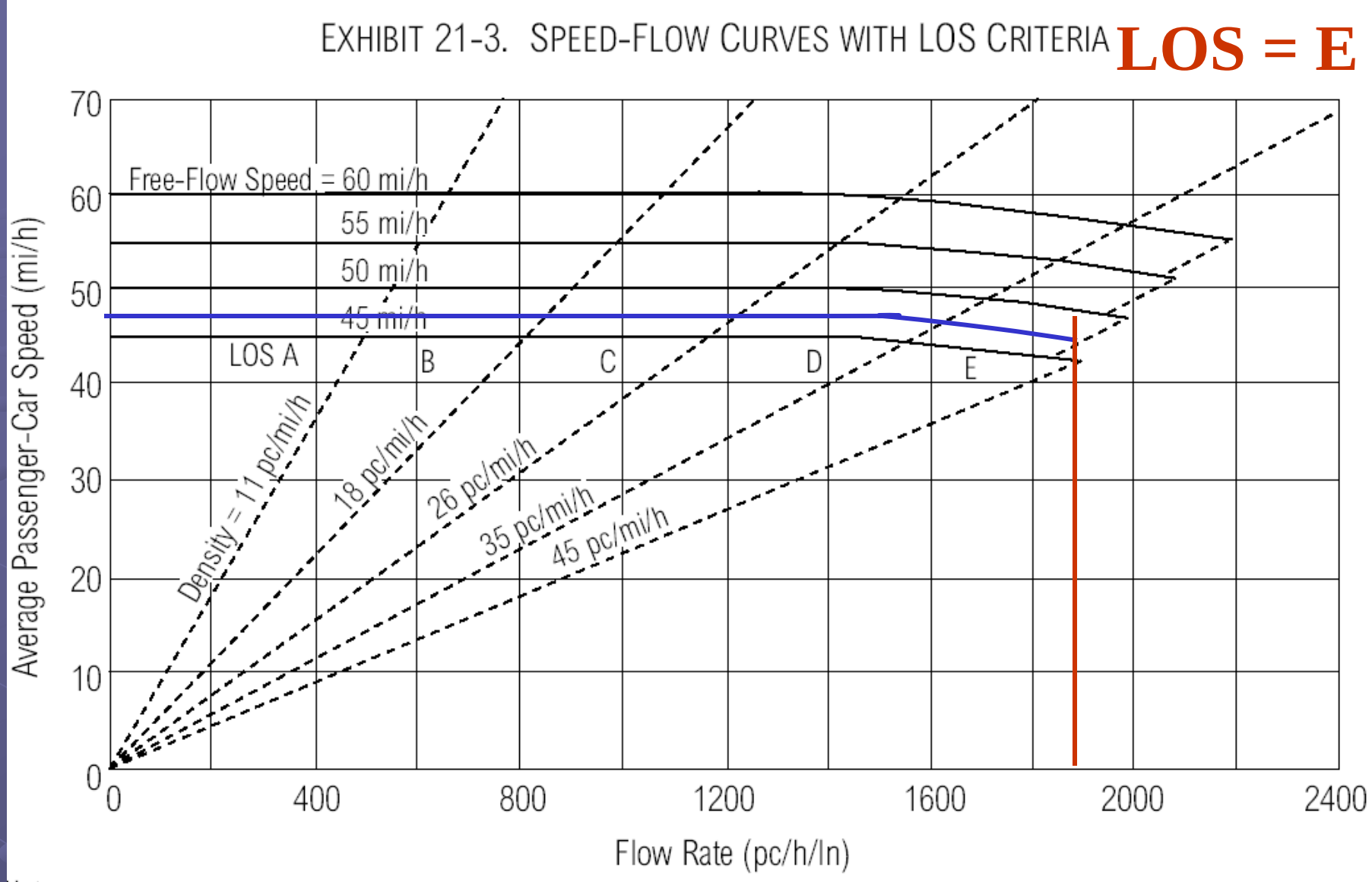
$$D = \frac{v_p}{S} \qquad (21\text{-}5)$$

where

D = density (pc/mi/ln),
v_p = flow rate (pc/h/ln), and
S = average passenger-car travel speed (mi/h).

Example: for previous

$$D = \frac{1878 \text{ vph}}{48 \text{ mph}} = \mathbf{39.1 \text{ pc/mi/lane}}$$



Also, D = 39.1 pc/mi/ln, LOS E

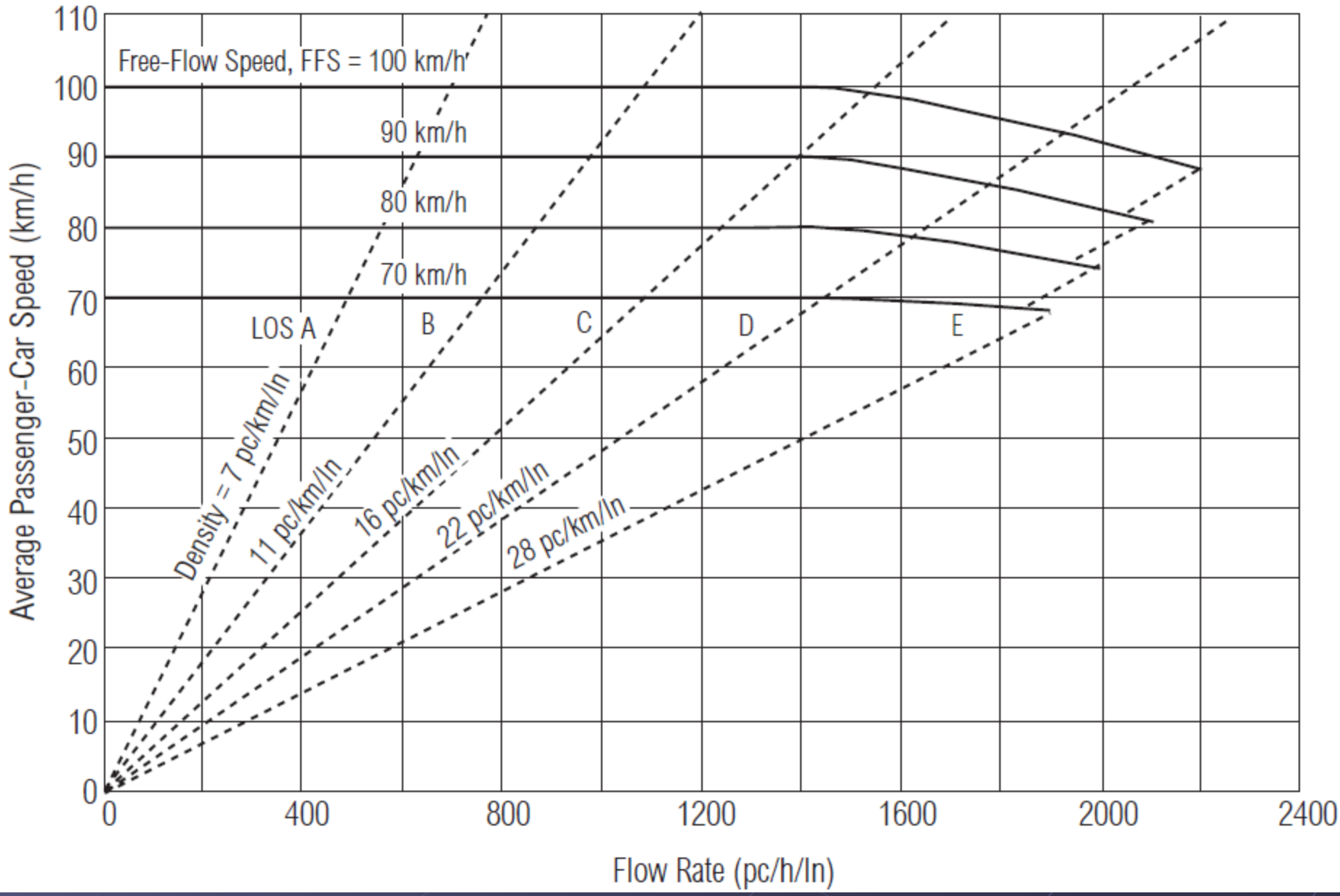
EXHIBIT 21-2. LOS CRITERIA FOR MULTILANE HIGHWAYS

		LOS				
Free-Flow Speed	Criteria	A	B	C	D	E
60 mi/h	Maximum density (pc/mi/ln)	11	18	26	35	40
	Average speed (mi/h)	60.0	60.0	59.4	56.7	55.0
	Maximum volume to capacity ratio (v/c)	0.30	0.49	0.70	0.90	1.00
	Maximum service flow rate (pc/h/ln)	660	1080	1550	1980	2200
55 mi/h	Maximum density (pc/mi/ln)	11	18	26	35	41
	Average speed (mi/h)	55.0	55.0	54.9	52.9	51.2
	Maximum v/c	0.29	0.47	0.68	0.88	1.00
	Maximum service flow rate (pc/h/ln)	600	990	1430	1850	2100
50 mi/h	Maximum density (pc/mi/ln)	11	18	26	35	43
	Average speed (mi/h)	50.0	50.0	50.0	48.9	47.5
	Maximum v/c	0.28	0.45	0.65	0.86	1.00
	Maximum service flow rate (pc/h/ln)	550	900	1300	1710	2000
45 mi/h	Maximum density (pc/mi/ln)	11	18	26	35	45
	Average speed (mi/h)	45.0	45.0	45.0	44.4	42.2
	Maximum v/c	0.26	0.43	0.62	0.82	1.00
	Maximum service flow rate (pc/h/ln)	490	810	1170	1550	1900

Note:
The exact mathematical relationship between density and volume to capacity ratio (v/c) has not always been maintained at LOS boundaries because of the use of rounded values. Density is the primary determinant of LOS. LOS F is characterized by highly unstable and variable traffic flow. Prediction of accurate flow rate, density, and speed at LOS F is difficult.

Source: HCM, 2000

EXHIBIT 21-3. SPEED-FLOW CURVES WITH LOS CRITERIA



Example Problem 2 (Part I)

The Highway A 3.4-km segment of an east-west five-lane highway with two travel lanes in each direction separated by a two-way left-turn lane (TWLTL). The highway includes a 4 percent grade, 1830-m in length, followed by level terrain of 1570 m.

The Question What is the LOS of the highway on level terrain during the peak hour?

The Facts

- √ Level terrain,
- √ 3.6-m lane width,
- √ 6 percent trucks and buses,
- √ 6 access points/km (eastbound),
- √ 3.6-m and greater lateral clearance for westbound and eastbound,
- √ 83.0-km/h 85th-percentile speed,
- √ 1,500-veh/h peak-hour volume,
- √ 8 access points/km (westbound), and
- √ 0.90 PHF.

Comments

- √ Assume base FFS to be 3.0 km/h less than 85th-percentile speed.
  BFFS = 83.0 – 3.0 = 80.0 km/h
- √ Assume no RVs, since none is indicated.

Steps

1. Find f_{HV} (EB and WB) (use Exhibit 21-8).	$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$ $f_{HV} = \frac{1}{1 + 0.06(1.5 - 1) + 0}$ $f_{HV} = 0.971$
2. Find v_p (EB and WB) (use Equation 21-3).	$v_p = \frac{V}{PHF * N * f_{HV} * f_p}$ $v_p = \frac{1,500}{0.90 * 2 * 0.971 * 1.00}$ $v_p = 858$ pc/h/ln
3. Compute EB and WB free-flow speeds (use Exhibits 21-4, 21-5, 21-6, 21-7, and Equation 21-1).	$FFS = BFFS - f_{LW} - f_{LC} - f_A - f_M$ $FFS = 80 - 0.0 - 0.0 - 4.0 - 0.0$ FFS = 76.0 km/h (EB) $FFS = 80 - 0.0 - 0.0 - 5.3 - 0.0$ FFS = 74.7 km/h (WB)
4. Determine LOS (use Exhibit 21-3).	LOS C (EB and WB)

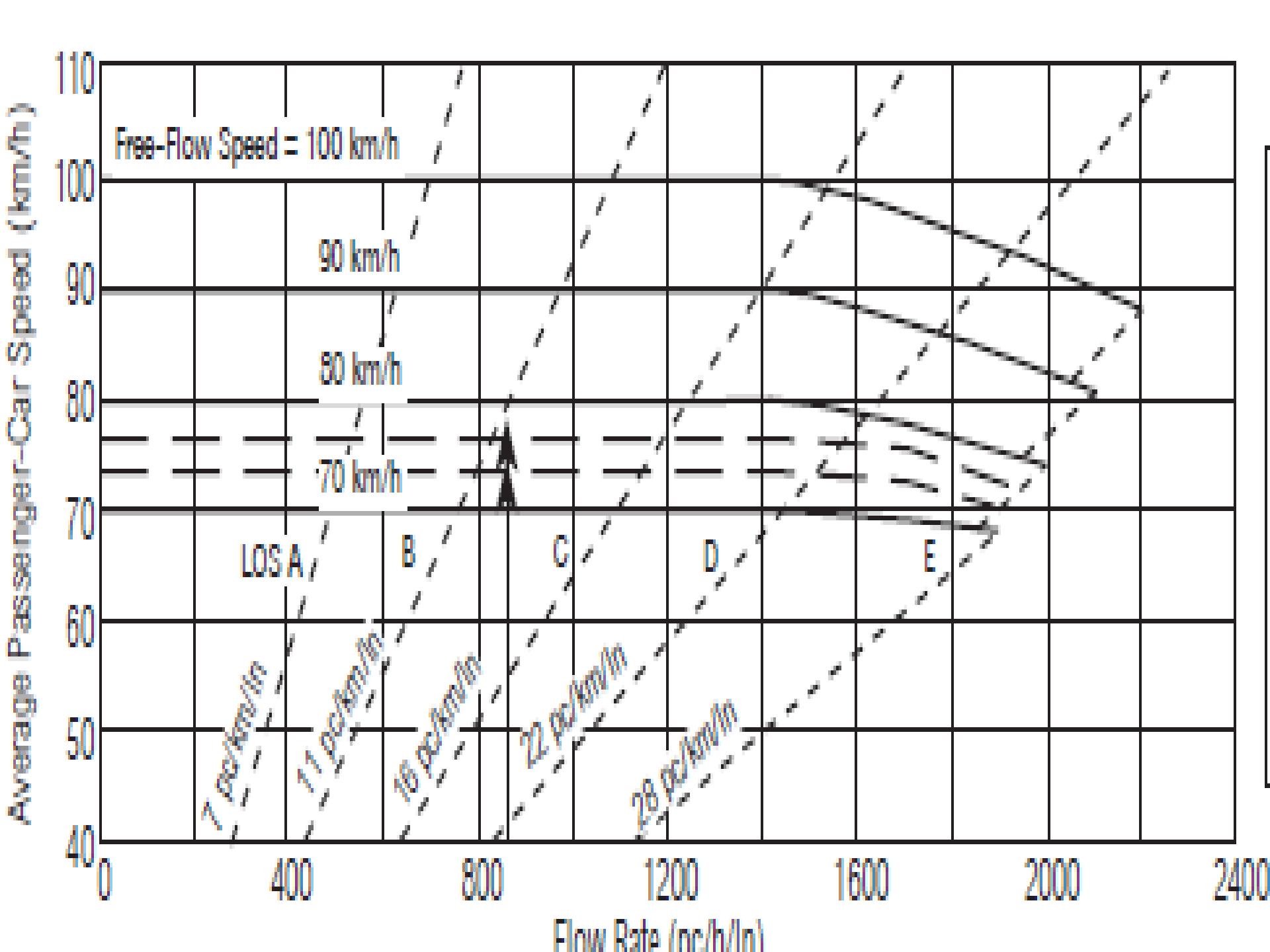
The Results

Eastbound:

- LOS C,
- Speed = 76.0 km/h, and
- Density = 11.3 pc/km/ln.

Westbound:

- LOS C,
- Speed = 74.7 km/h, and
- Density = 11.5 pc/km/ln.


Free-Flow Speed = 100 km/h
90 km/h
80 km/h
70 km/h
LOS A
B
C
D
E
7 pc/km/ln
11 pc/km/ln
16 pc/km/ln
22 pc/km/ln
28 pc/km/ln
Average Passenger-Car Speed (km/h)
Flow Rate (pc/h/ln)
110
100
90
80
70
60
50
40
0
400
800
1200
1600
2000
2400

Example Problem 2 (Part II)

The Highway A 3.4-km segment of an east-west five-lane highway with two travel lanes in each direction separated by a TWLTL. The highway characteristics include a 4 percent grade, 1830 m in length, followed by level terrain of 1570 m.

The Question What is the LOS of the 4 percent grade segment during the peak hour?

Additional Facts

- √ 4.0 percent grade (EB downgrade, WB upgrade),
- √ 87.0-km/h eastbound 85th-percentile speed,
- √ 77.0-km/h westbound 85th-percentile speed,
- √ 3.6-m lane width,
- √ 6 access points/km (EB), and
- √ 0 access points (WB).

Comments

- √ Assume base FFS to be 3.0 km/h less than 85th-percentile speed.
  BFFS (EB) = 87.0 – 3.0 = 84.0 km/h
- √ BFFS (WB) = 77.0 – 3.0 = 74.0 km/h
- √ Assume no RVs, since none indicated.

Steps

1. Find f_{HV} (EB and WB) (use Exhibits 21-9 and 21-11).	$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$ $f_{HV} = \frac{1}{1 + 0.06(1.5 - 1) + 0} = 0.971$ (EB) $f_{HV} = \frac{1}{1 + 0.06(3.0 - 1) + 0} = 0.893$ (WB)
2. Find v_p (EB and WB).	$v_p = \frac{V}{PHF * N * f_{HV} * f_p}$ $v_p = \frac{1,500}{0.90 * 2 * 0.971 * 1.00} = 858$ pc/h/ln (EB) $v_p = \frac{1,500}{0.90 * 2 * 0.893 * 1.00} = 933$ pc/h/ln (WB)
3. Compute EB and WB FFS (use Exhibits 21-4, 21-5, 21-6, and 21-7).	$FFS = BFFS - f_{LW} - f_{LC} - f_A - f_M$ FFS = 84.0 – 0.0 – 0.0 – 4.0 – 0.0 = 80.0 km/h (EB) FFS = 74.0 – 0.0 – 0.0 – 0.0 – 0.0 = 74.0 km/h (WB)
4. Determine LOS (use Exhibit 21-3).	LOS B (EB) LOS C (WB)

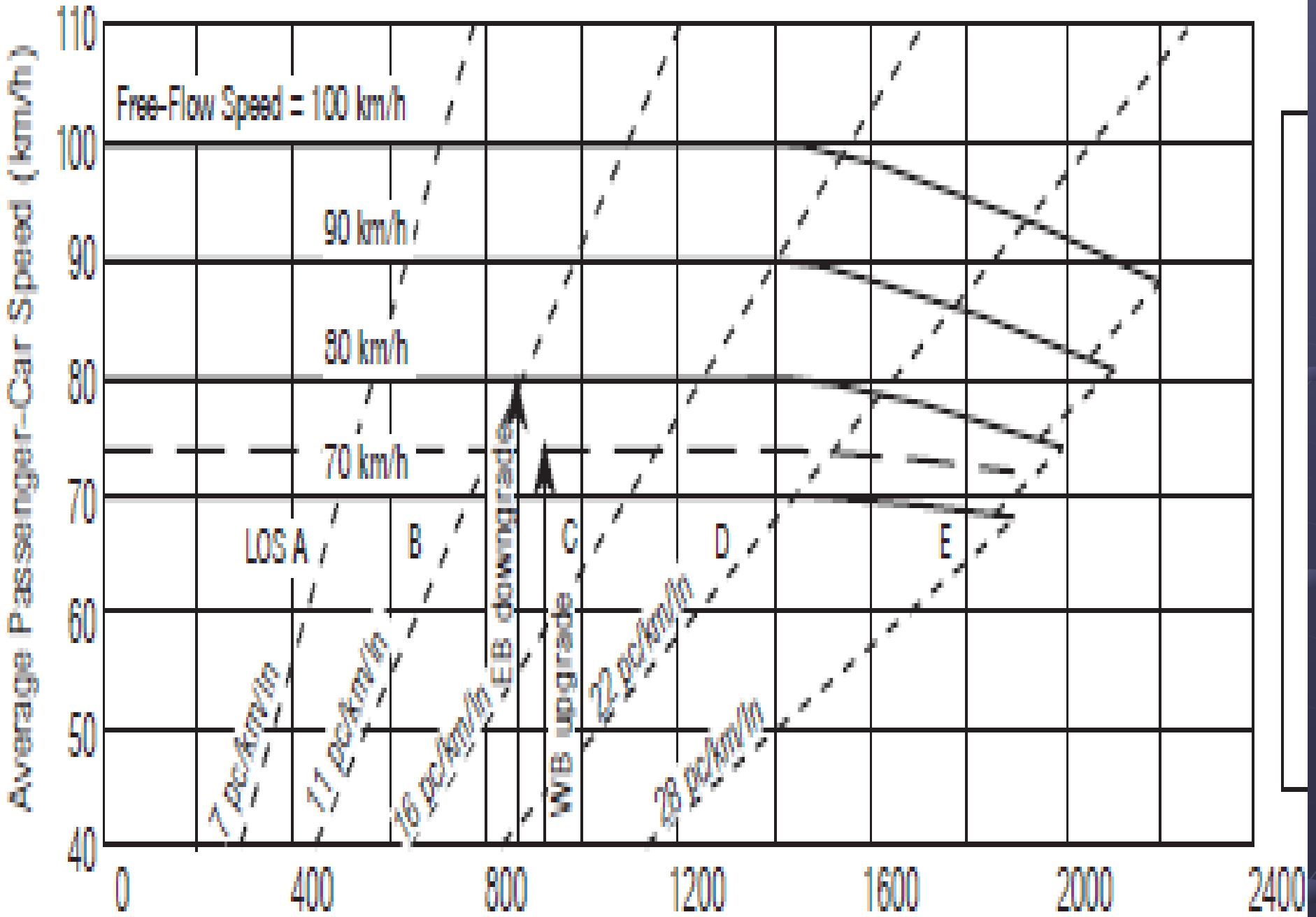
The Results

Eastbound:

- LOS B,
- Speed = 80.0 km/h, and
- Density = 10.7 pc/km/ln.

Westbound:

- LOS C,
- Speed = 74.0 km/h, and
- Density = 12.6 pc/km/ln.


Free-Flow Speed = 100 km/h
90 km/h
80 km/h
70 km/h
LOS A
B
C
D
E
7 pc/km/ln
11 pc/km/ln
16 pc/km/ln
EB downgrade
WB upgrade
22 pc/km/ln
28 pc/km/ln
Average Passenger-Car Speed (km/h)
110
100
90
80
70
60
50
40
0
400
800
1200
1600
2000
2400