The three classes of two-lane highways are defined as follows:

- *Class I two-lane highways* are highways where motorists expect to travel at relatively high speeds. Two-lane highways that are major intercity routes, primary connectors of major traffic generators, daily commuter routes, or major links in state or national highway networks are generally assigned to Class I. These facilities serve mostly long-distance trips or provide the connections between facilities that serve long-distance trips.
- *Class II two-lane highways* are highways where motorists do not necessarily expect to travel at high speeds. Two-lane highways functioning as access routes to Class I facilities, serving as scenic or recreational routes (and not as primary arterials), or passing through rugged terrain (where high-speed operation would be impossible) are assigned to Class II. Class II facilities most often serve relatively short trips, the beginning or ending portions of longer trips, or trips for which sightseeing plays a significant role.
- *Class III two-lane highways* are highways serving moderately developed areas. They may be portions of a Class I or Class II highway that pass through small towns or developed recreational areas. On such segments, local traffic often mixes with through traffic, and the density of unsignalized roadside access points is noticeably higher than in a purely rural area. Class III highways may also be longer segments passing through more spread-out recreational areas, also with increased roadside densities. Such segments are often accompanied by reduced speed limits that reflect the higher activity level.

Exhibit 15-1 shows examples of the three classes of two-lane highway.

The definition of two-lane highway classes is based on their function. Most arterials or trunk roads are considered to be Class I highways, while most collectors and local roads are considered to be Class II or Class III highways. The primary determinant of a facility's classification is the motorist's expectation, which might not agree with the overall functional category of the route. For example, a major intercity route passing through a rugged mountainous area might be described as Class II if drivers recognize that high-speed operation is not feasible due to the terrain, but the route could still be considered to be in Class I.

Even Class III highways incorporate only uninterrupted-flow segments of two-lane highways. Occasional signalized or unsignalized intersections on any two-lane highway must be separately analyzed with the appropriate *Highway Capacity Manual* (HCM) methodologies in Chapter 18, Signalized Intersections, Chapter 20, All-Way STOP-Controlled Intersections, or Chapter 21, Roundabouts. The results must be carefully considered in conjunction with those of uninterrupted-flow portions of the facility to obtain a complete picture of probable operations.

Exhibit 15-1
Two-Lane Highway
Classification Illustrated

(a) Examples of Class I Two-Lane Highways

(b) Examples of Class II Two-Lane Highways

(c) Examples of Class III Two-Lane Highways

Base Conditions

The base conditions for two-lane highways are the absence of restrictive geometric, traffic, or environmental factors. Base conditions are not the same as typical or default conditions, both of which may reflect common restrictions. Base conditions are closer to what may be considered as ideal conditions (i.e., the best conditions that can be expected given normal design and operational practice). The methodology of this chapter accounts for the effects of geometric, traffic, and environmental factors that are more restrictive than the base conditions. The base conditions for two-lane highways are as follows:

- Lane widths greater than or equal to 12 ft,
- Clear shoulders wider than or equal to 6 ft,
- No no-passing zones,
- All passenger cars in the traffic stream,

- Level terrain, and
- No impediments to through traffic (e.g., traffic signals, turning vehicles).

Traffic can operate ideally only if lanes and shoulders are wide enough not to constrain speeds. Lanes narrower than 12 ft and shoulders narrower than 6 ft have been shown to reduce speeds, and they may increase percent time-spent-following (PTSF) as well.

The length and frequency of no-passing zones are a result of the roadway alignment. No-passing zones may be marked by barrier centerlines in one or both directions, but any segment with a passing sight distance of less than 1,000 ft should also be considered to be a no-passing zone.

On a two-lane highway, passing in the opposing lane of flow may be necessary. It is the only way to fill gaps forming in front of slow-moving vehicles in the traffic stream. Restrictions on the ability to pass significantly increase the rate at which platoons form in the traffic stream, since motorists are unable to pass slower vehicles in front of them.

Basic Relationships

Exhibit 15-2 shows the relationships among flow rate, average travel speed (ATS), and PTSF for an extended directional segment of two-lane highway under base conditions. While the two directions of flow interact on a two-lane highway (because of passing maneuvers), the methodology of this chapter analyzes each direction separately.

Exhibit 15-2(b) illustrates a critical characteristic that affects two-lane highways. Low directional volumes create high values of PTSF. With only 800 pc/h, PTSF ranges from 60% (with 200 pc/h opposing flow) to almost 80% (with 1,600 pc/h opposing flow).

In multilane uninterrupted flow, typically acceptable speeds can be maintained at relatively high proportions of capacity. On two-lane highways, service quality (as measured by PTSF) begins to deteriorate at relatively low demand flows.

CAPACITY AND LOS

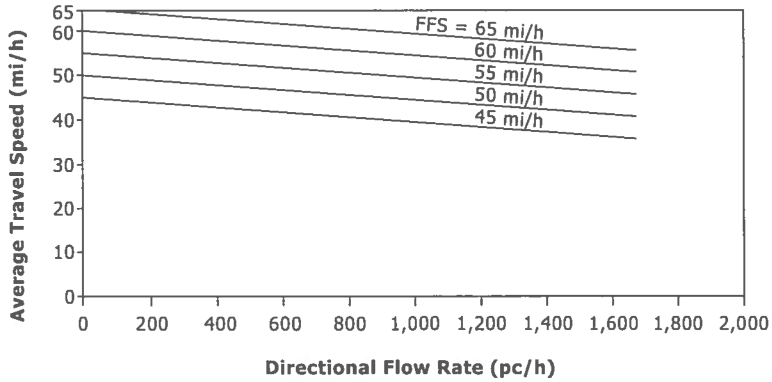
Capacity

The capacity of a two-lane highway under base conditions is 1,700 pc/h in one direction, with a limit of 3,200 pc/h for the total of the two directions. Because of the interactions between directional flows, when a capacity of 1,700 pc/h is reached in one direction, the maximum opposing flow would be limited to 1,500 pc/h.

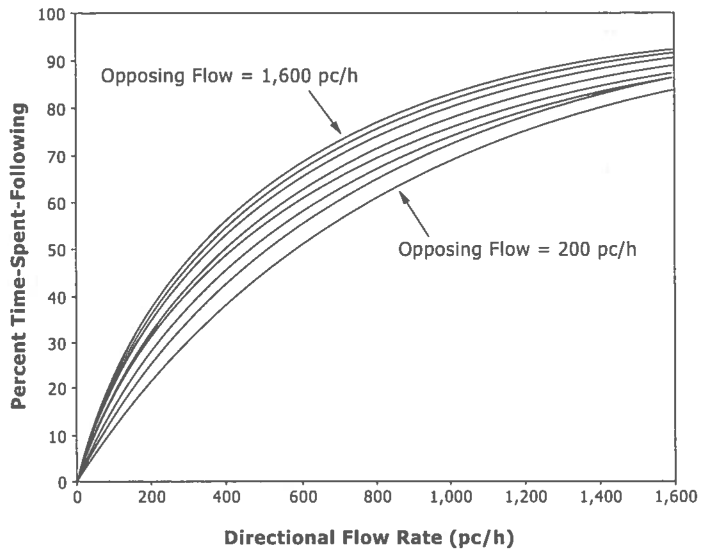
Capacity of a two-lane highway under base conditions is 1,700 pc/h in one direction, with a maximum of 3,200 pc/h in the two directions.

Capacity conditions, however, are rarely observed—except in short segments. Because service quality deteriorates at relatively low demand flow rates, most two-lane highways are upgraded before demand approaches capacity.

Exhibit 15-2
Speed–Flow and PTSF Relationships for Directional Segments with Base Conditions



(a) ATS Versus Directional Flow Rate



(b) PTSF Versus Directional Flow Rate

Capacity is important for evacuation and special event planning.

However, estimation of capacity conditions is important for evacuation planning, special event planning, and evaluation of the downstream impacts of incident bottlenecks once cleared.

Two-way flow rates as high as 3,400 pc/h can be observed for short segments fed by high demands from multiple or multilane facilities. This may occur at tunnels or bridges, for example, but such flow rates cannot be expected over extended segments.

Capacity is not defined for bicycles on two-lane highways because of lack of data. Bicycle volumes approaching capacity do not often occur on two-lane highways except during special bicycle events, and little information is available on which to base a definition.

Levels of Service

Automobile Mode

Because of the wide range of situations in which two-lane highways are found, three measures of effectiveness are incorporated into the methodology of this chapter to determine automobile LOS.

1. *ATS* reflects mobility on a two-lane highway. It is defined as the highway segment length divided by the average travel time taken by vehicles to traverse it during a designated time interval.
2. *PTSF* represents the freedom to maneuver and the comfort and convenience of travel. It is the average percentage of time that vehicles must travel in platoons behind slower vehicles due to the inability to pass. Because this characteristic is difficult to measure in the field, a surrogate measure is the percentage of vehicles traveling at headways of less than 3.0 s at a representative location within the highway segment. PTSF also represents the approximate percentage of vehicles traveling in platoons.
3. *Percent of free-flow speed* (*PFFS*) represents the ability of vehicles to travel at or near the posted speed limit.

Average Travel Speed

On Class I two-lane highways, speed and delay due to passing restrictions are both important to motorists. Therefore, on these highways, LOS is defined in terms of both ATS and PTSF. On Class II highways, travel speed is not a significant issue to drivers. Therefore, on these highways, LOS is defined in terms of PTSF only. On Class III highways, high speeds are not expected. Because the length of Class III segments is generally limited, passing restrictions are also not a major concern. In these cases, drivers would like to make steady progress at or near the speed limit. Therefore, on these highways, PFFS is used to define LOS. The LOS criteria for two-lane highways are shown in Exhibit 15-3.

Exhibit 15-3
Automobile LOS for Two-Lane Highways

LOS	Class I Highways ATS (mi/h)	Class I Highways PTSF (%)	Class II Highways PTSF (%)	Class III Highways PFFS (%)
A	>55	≤35	≤40	>91.7
B	>50–55	>35–50	>40–55	>83.3–91.7
C	>45–50	>50–65	>55–70	>75.0–83.3
D	>40–45	>65–80	>70–85	>66.7–75.0
E	≤40	>80	>85	≤66.7

Because driver expectations and operating characteristics on the three categories of two-lane highways are quite different, it is difficult to provide a single definition of operating conditions at each LOS.

Two characteristics, however, have a significant impact on actual operations and driver perceptions of service:

- *Passing capacity*: Since passing maneuvers on two-lane highways are made in the opposing direction of flow, the ability to pass is limited by the opposing flow rate and by the distribution of gaps in the opposing flow.
- *Passing demand*: As platooning and PTSF increase in a given direction, the demand for passing maneuvers increases. As more drivers are caught in a

platoon behind a slow-moving vehicle, they will desire to make more passing maneuvers.

Both passing capacity and passing demand are related to flow rates. If flow in both directions increases, a difficult trend is established: as passing demand increases, passing capacity decreases.

At LOS A, motorists experience high operating speeds on Class I highways and little difficulty in passing. Platoons of three or more vehicles are rare. On Class II highways, speed would be controlled primarily by roadway conditions. A small amount of platooning would be expected. On Class III highways, drivers should be able to maintain operating speeds close or equal to the free-flow speed (FFS) of the facility.

At LOS B, passing demand and passing capacity are balanced. On both Class I and Class II highways, the degree of platooning becomes noticeable. Some speed reductions are present on Class I highways. On Class III highways, it becomes difficult to maintain FFS operation, but the speed reduction is still relatively small.

At LOS C, most vehicles are traveling in platoons. Speeds are noticeably curtailed on all three classes of highway.

At LOS D, platooning increases significantly. Passing demand is high on both Class I and II facilities, but passing capacity approaches zero. A high percentage vehicles are now traveling in platoons, and PTSF is quite noticeable. On Class III highways, the fall-off from FFS is now significant.

At LOS E, demand is approaching capacity. Passing on Class I and II highways is virtually impossible, and PTSF is more than 80%. Speeds are seriously curtailed. On Class III highways, speed is less than two-thirds the FFS. The lower limit of this LOS represents capacity.

LOS F exists whenever demand flow in one or both directions exceeds the capacity of the segment. Operating conditions are unstable, and heavy congestion exists on all classes of two-lane highway.

Bicycle Mode

Bicycle LOS is based on a traveler-perception model.

Bicycle levels of service for two-lane highway segments are based on a bicycle LOS (BLOS) score, which is in turn based on a traveler-perception model. This score is based, in order of importance, on five variables:

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

The LOS ranges for bicycles on two-lane highways are given in Exhibit 15-4. The same LOS score is used for multilane highways, as described in Chapter 14.

LOS	BLOS 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

Exhibit 15-4
Bicycle LOS for Two-Lane Highways

REQUIRED INPUT DATA AND DEFAULT VALUES

Exhibit 15-5 lists the information necessary to apply the methodology. It also contains suggested default values for use when segment-specific information is not available. The user is cautioned, however, that every use of a default value instead of a field-measured, segment-specific variable makes the analysis results more approximate and less related to the specific conditions that describe the study site. Defaults should be used only when field measurements cannot be collected.

Exhibit 15-5
Required Input Data and Default Values for Two-Lane Highways

Required Data	Recommended Default Value	Relevant Modes
	Geometric Data	
Highway class	Must select as appropriate	Auto
Lane width	12 ft	Auto, bicycle
Shoulder width	6 ft	Auto, bicycle
Access-point density (one side)	Classes I and II: 8/mi, Class III: 16/mi	Auto
Terrain	Level or rolling	Auto
Percent no-passing zone[a]	Level: 20%, rolling: 40%, more extreme: 80%	Auto
Speed limit	Speed limit	Bicycle
Base design speed	Speed limit + 10 mi/h	Auto
Length of passing lane (if present)	Must be site-specific	Auto
Pavement condition	4 on FHWA 5-point rating scale (good)	Bicycle
	Demand Data	
Hourly automobile volume	Must be site-specific	Auto, bicycle
Length of analysis period	15 min (0.25 h)	Auto, bicycle
Peak hour factor	0.88	Auto, bicycle
Directional split	60/40	Auto, bicycle
Heavy vehicle percentage[b]	6% trucks	Auto, bicycle
Percent occupied on-highway parking	0%	Bicycle

Notes: [a] Percent no-passing zone may be different in each direction.
[b] See Chapter 26 in Volume 4 for state-specific default heavy vehicle percentages.

The use of some default values is less problematic than others. Lane and shoulder widths of 12 and 6 ft, respectively, are common, particularly on Class I highways. However, these variables have large impacts on bicycle LOS, increasing the importance of segment-specific data. A general assessment of terrain is usually straightforward and requires only general knowledge of the area through which the highway is built. Access-point densities are more difficult and tend to vary widely on a site-by-site basis. Estimating the percent no-passing zones on the basis of a generalized assessment of terrain is also challenging, since the details of vertical and horizontal alignment can have a significant impact on this factor.

FFS is best measured at the site or at a similar site. While adjustments to a base free-flow speed (BFFS) are provided as part of the methodology, no firm guidance on determining the BFFS is given. The default suggestions of Exhibit 15-5 are highly approximate.

In terms of demand data, the length of the analysis period is a recommended HCM standard of 15 min (although longer periods can be examined). The peak hour factor (PHF) is typical but could vary significantly on the basis of localized trip generation characteristics. The directional split is best observed directly, since it can vary widely over time, even at the same location. The recommended default for heavy vehicle presence is also highly approximate. This factor varies widely with local conditions; Chapter 26, Freeway and Highway Segments: Supplemental, provides state-specific default values (4).

As is the case with all default values, these values should be used with care, and only when site-specific data cannot be acquired by any reasonable means.

DEMAND VOLUMES AND FLOW RATES

Demand volumes are generally stated in vehicles per hour under prevailing conditions. They are converted in the methodology to demand flow rates in passenger cars per hour under base conditions. The PHF, in particular, is used to convert hourly volumes to flow rates.

If demand volumes are measured in 15-min increments, use of the PHF to convert to flow rates is unnecessary. The worst 15-min period is selected, and flow rates are the 15-min volumes multiplied by 4. When this is done, the PHF is set at 1.00 for the rest of the application.

In measuring demand volumes or flow rates, flow may be restricted by upstream bottlenecks or even signals that are more than 2 mi away from the study site (if they are closer, this methodology is not applicable). Downstream congestion may also affect flows in a study segment. Insofar as is possible, demand volumes and flow rates should reflect the situation that would exist with no upstream or downstream limiting factors.