signs to inform freeway drivers of diversion from the freeway to the service road. Phase 2 was designed to route traffic to alternate arterial roads when continuous service roads were not available for diversion. Traffic would be diverted from the freeway via the matrix signs and then guided along the alternate route by trailblazer signs, as described in previous sections. No incidents of sufficient duration occurred in locations that would warrant routing to the alternate arterial route (Phase 2).

Data for the four roadwork studies are presented in Table 1. Case 2 data could not be evaluated because of a system breakdown of the freeway detector system during the study. However, questionnaire data were collected. Flow rates of 5-min duration were averaged prior to the maintenance and during each message. The change during each case is presented as the percent change in the table. The first available downstream entrance ramp was also analyzed to determine the effects on its operation during the maintenance.

In order to allow comparisons between different traffic conditions and volumes during each case, it was necessary to determine the percent of the upstream demand that exited. This measure of the exiting traffic negated any effects the demand might have on the number of drivers who diverted from the freeway.

SUMMARY

Many meaningful comparisons were cited in trends from the data collected for maintenance during the incident management studies. In every case comparison, exit ramp volumes increased for signed (managed) incidents compared to nonsigned (nonmanaged), natural diversion conditions. The results showed that diversion was greater under a managed condition than under a nonmanaged condition. For informational signs only, increases ranged from 125.9 to 324.7 percent for the four case studies. When diversion messages were presented, increases ranged from 147.3 to 343.8 percent.

In all case studies, exit volumes were greater for diversionary signs than for informational signs. This would indicate a preference by motorists for diversionary information. This was indicated in questionnaire results for case 1, where 33 percent of the motorists who responded desired alternate routing when no diversionary information was presented. However, none of the motorists who received alternate routing information cared for this type of information.

Downstream entrance ramp volumes also increased under the signed conditions. Increases were greater for diversionary messages than for informational messages. However, in case 3, results indicate motorists entered the freeway before they had cleared the blockage. Some of the drivers may have thought that this particular ramp would be their last opportunity to enter back on the freeway when, in fact, one more ramp downstream would have cleared them from the blockage. This indicates a need for a supplemental sign, such as trailblazing on the frontage road itself or advisories on the changeable messages signs such as, USE SERVICE ROAD TO CARUTH, to tell drivers where to reenter the freeway.

The management of traffic during maintenance conditions was demonstrated to be feasible and advantageous. The addition of diversion information proved to be a benefit. Although statistically sound data bases for comparison were not achievable, trend data were favorable in virtually every case. Questionnaire data show a preference by the motorists for some type of information along their route during maintenance operations. Motorists' preferences included diversionary information as well as advisory information. This was exemplified by the greater increase in diversion when diversionary signs were used.

Publication of this paper sponsored by Committee on Motorist Information Systems.

**Mr. Carvell was affiliated with the Texas Transportation Institute at the time of this research.*

Pedestrian Movement at the 1980 Winter Olympics Ski Jump

Peter L. Wolf, * Department of City Planning, Harvard University, Cambridge, Massachusetts
David T. Hartgen, Planning and Research Bureau, New York State Department of Transportation

This paper describes and evaluates options for the location of bus staging areas and the movement of pedestrians between bus staging areas and the Intervale ski jump site at the 1980 Winter Olympic Games at Lake Placid, New York. These options are analyzed in terms of impacts on the environment, spectators walking under winter conditions, traffic flow and accidents, cost, maintenance, and post-Olympic implementation considerations. A comparative analysis is made of these impacts on each of four options for pedestrian flow. Results show that either a pedestrian bridge or signal across the main route appears superior, because it minimizes pedestrian-vehicle conflicts, separates spectators from dignitaries and officials, and consolidates bus staging activities in a single adequately sized location. Options that assume joint use of the road by vehicles and pedestrians should be avoided because of the crucial requirement for maximum road capacity to handle bus circulation.

Lake Placid, a small community in the Adirondacks of upstate New York, will be the site of the 1980 Winter Olympic Games. It is located approximately 140 km south of Montreal and 400 km north of New York City (Figure 1). Highway access to Lake Placid is limited to two routes: NY-86 and NY-73. Because of significant capacity and flow problems anticipated from the planned daily influx of spectators, a 450-bus circulation system feeding peripheral parking lots has been proposed as the basic spectator transportation system for the games (1).

The Intervale ski jump, the site of the 70- and 90-m ski jump competitions, is located at the point where NY-73 crosses the west branch of the Ausable River (Figure 2). Estimated peak periods of use of the facility

Figure 1. Olympic transportation region.

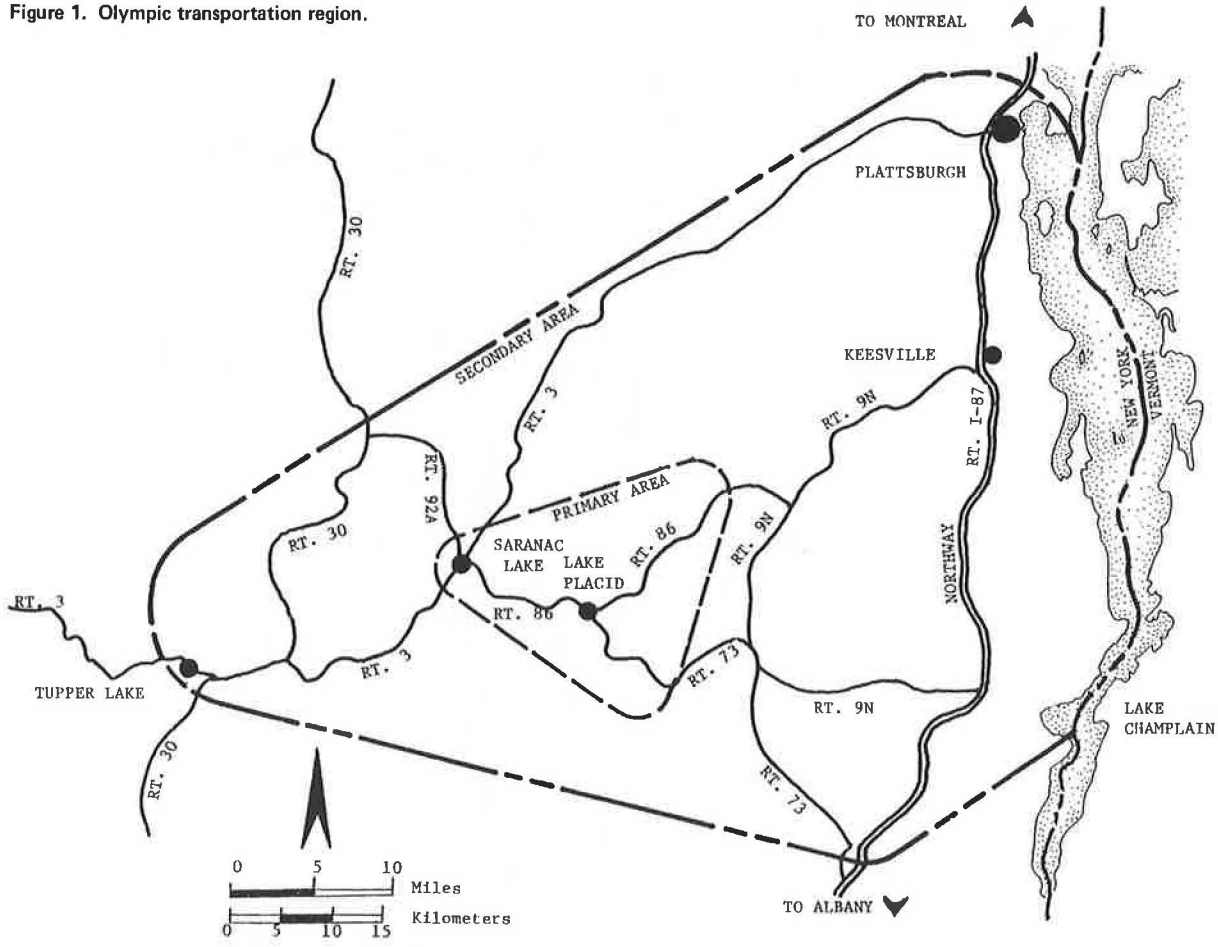


Figure 2. Olympic primary area.

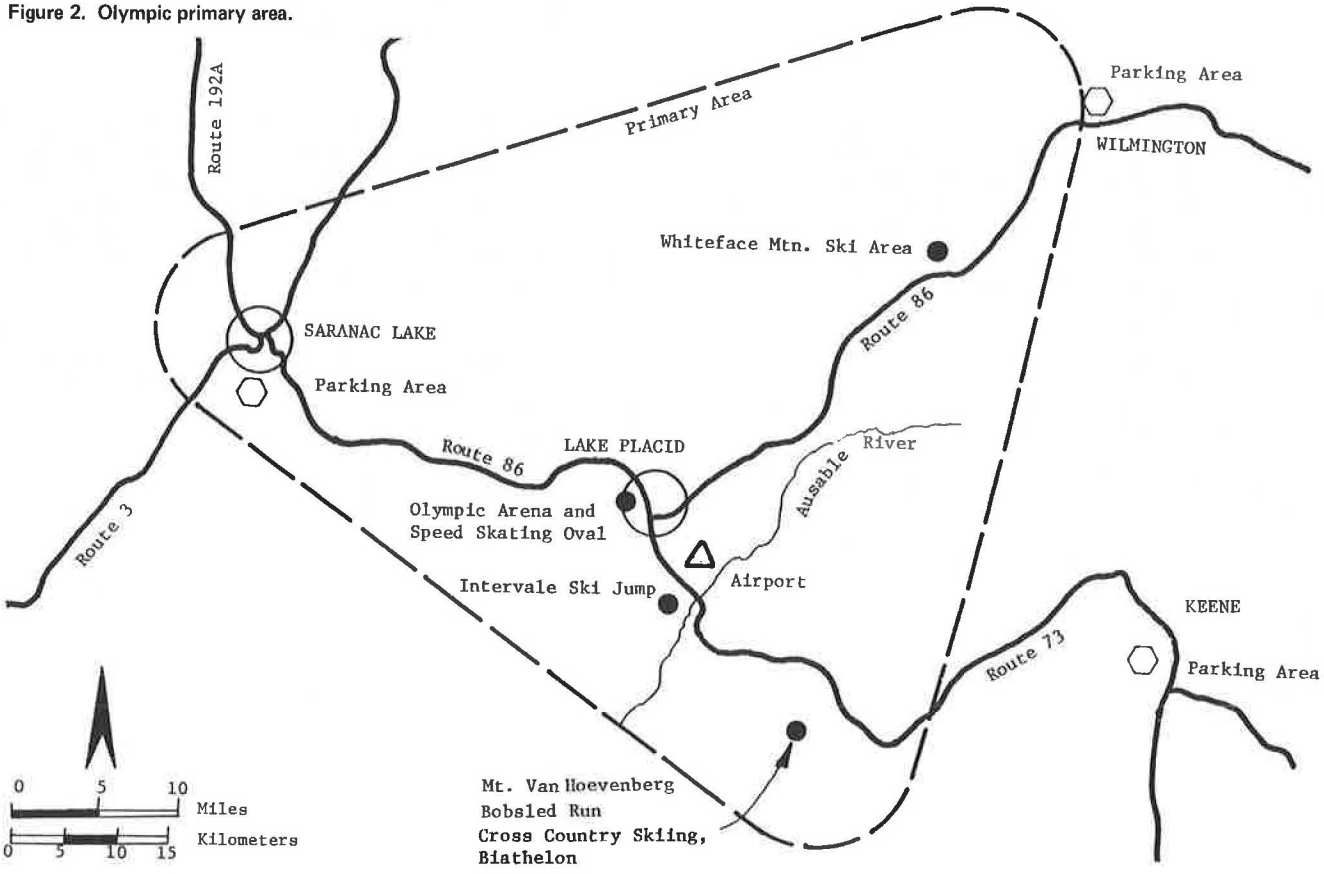
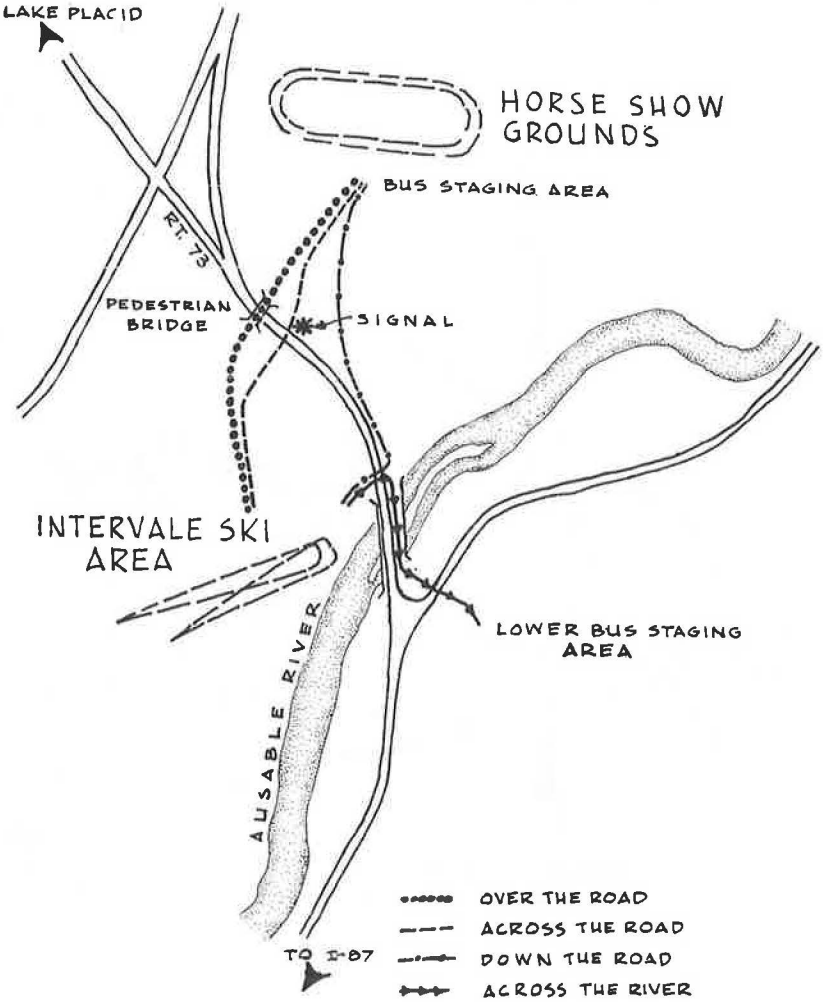


Figure 3. Options for pedestrian movement.



will occur on Sunday, February 17, between 1:00 and 3:00 p.m.; Monday, February 18, between 12:30 and 3:00 p.m.; and Sunday, February 24, between 12:30 and 3:30 p.m. (2). These three peak periods will involve, respectively 15 000, 10 000, and 15 000 spectators—15 000 is the largest number of spectators expected at any of the athletic events of the 1980 Winter Olympic Games (3). Approximately 44 percent of this traffic will approach the site from the south, up NY-73 (4).

The ski jump site is bordered by the Ausable River on the east, NY-73 on the north, and steep ridges on the south (Figure 3). The spectator area at the base of the jump is about 212 x 60 m. Since adequate space does not exist for the loading and unloading of spectators at the immediate site, it will be necessary for spectators to to move on foot between bus staging areas and the ski jump site. At peak periods this will involve the flow of 15 000 pedestrians within a desired time period of 1.5 h, or at a rate of 10 000 pedestrians/h.

ISSUES

The issues involved in the implementation of a pedestrian system at Intervale can best be made clear through a discussion of the impacts that fall into each issue category. Thus each issue will be broken down into individual impacts.

Environmental

As stated by the Olympic Transportation Committee, all transportation work and development must be performed with an extreme sensitivity to environmental impacts (1). Although the site-related impacts at Intervale that fall into this category are not great, they must be considered in order to gain an environmental perspective of the pedestrian options. The impacts of the environmental category are explained below.

1. Trees, shrubs—This involves the degree to which implementation of an option (say, by widening a pedestrian path) would necessitate the removal of surrounding trees and shrubs.
2. Salt, sand—The degree to which salt or sand will be needed to properly maintain the road and walkways and the resulting average walking rates from such maintenance.
3. Staging areas—The number of and total area of staging areas used in each option. The less area used and maintained, the less the environmental impact. Different staging area options also differ in impact.

Walking

The conditions of the walk pedestrians must undertake between spectator facilities and the bus staging areas constitute the second issue. Harsh winter weather conditions of mid-February could severely jeopardize the proper functioning of the pedestrian system. The average February temperature is -8 °C, and temperatures of -26 °C occur nearly every February. It is speculated, however, that the colder temperatures will have little

significant effect on average walking speeds. Average February snowfall is 0.5 m; the seasonal average is 2.8 m (1). It is also assumed that proper maintenance of the pedestrian system will keep it free of snow and ice obstacles, which would decrease system capacity and pedestrian speed. The impacts included in the walking category are explained below.

1. Distance—The distance each pedestrian must walk between the Intervale and spectator facilities and the bus staging areas.
2. Capacity—The walking area available for each system. The options using NY-73 as pedestrian access have greater capacity.
3. Slope—The relative degree to which a pedestrian will encounter slope difficulties on a walk between Intervale and the bus staging areas.
4. Pedestrian walking speed—The average pedestrian walking speed is dependent on the area available to each pedestrian, termed the module. A high speed is desirable.
5. Pedestrian delays—The delay caused to pedestrians by stops at signals located at crosswalks.
6. Pedestrian safety—The relative degree of safety to pedestrians on the different systems, taking account of use of NY-73 by both pedestrians (along or crossing) and vehicular traffic.
7. Bus Loading—The degree to which bus loading facilities and ease of pedestrian loading can be sited and arranged.

Traffic Flow on NY-73

The use of NY-73 for access to Intervale by pedestrians or the crossing of NY-73 by pedestrians will cause significant delays to bus traffic along NY-73 as well as impede official and emergency vehicle access to the ski jump site. For these reasons, options that use the road as a walkway may not be feasible.

1. Vehicle delay—The delay caused to vehicular traffic on NY-73 by signals located at pedestrian crosswalks or by pedestrian use of the road itself.
2. Emergency access—The degree of ease and speed at which emergency vehicles can enter the Intervale area, given pedestrian and vehicular queuing at or near the site.

Cost

The relative construction and maintenance costs of pedestrian access systems must be considered.

Post-Olympic Use

The impact of permanence is considered as well as the use of a system in the post-Olympic period by 5000 spectators.

1. Permanence—The degree to which components of each option will remain after the games and continue to produce impacts, environmental and otherwise.
2. Use of existing facilities—The degree to which existing facilities at or near the Intervale site are used (NY-73, existing Intervale entrance).
3. Post-Olympic usage—The degree to which a facility will be used for expected post-Olympic flow volumes (5000 spectators) and to what degree any changes will be necessary.

Maintenance

Since it is assumed that the pedestrian system will be properly maintained in order to ensure planned capacity and flow rates and the highest degree of safety possible, a comparison of how much maintenance each option would require is made. Degree of need is the amount of maintenance necessary to prevent pedestrian obstacles from snow and ice, which would reduce capacity and average walking rates.

OPTIONS

Four options exist as to where the buses will unload the 15 000 spectators who will attend the ski jump events. Each option is comprised of several components, some of which are unique to a specific system, others overlap in two or more of the options (Table 1 and Figure 3).

Over the Road and Through the Woods

Option 1 entails a bus staging area located at the Horse Show Grounds (HSG) north and upgrade of the Intervale site. The three components of this system are the staging area, the pedestrian bridge over NY-73 with stairway access 5.5-m wide, and the path through the woods.

The HSG is located on the opposite side of NY-73 from Intervale; approximately 360 m separates their entrances along NY-73. In this option, a pedestrian bridge over NY-73 would provide access to HSG. Assuming that the pedestrians enter the system at a flow rate of 10 000/h or 167/min, and the system will operate at a level of service D, as defined by Fruin (5), the stairway that connects ground level to the above-grade crossing will need to be about 5.5-m wide. The shortage of space would render a stairway access more feasible than ramp access, but ramps would permit easy light-truck maintenance.

Across the Road and Through the Woods

Option 2 also makes use of the HSG as a bus staging area and a path through the woods to provide access to Intervale. However, pedestrians would cross the road on a crosswalk, rather than on a bridge. A signal system and perhaps a warming shelter and traffic control people would be necessary to allow pedestrians to cross the road, and a pedestrian queuing area will be necessary on each end of the crosswalk. The queuing area will have to provide each pedestrian with 2.1 m^2 of area, given a level of service D. Since 2.78 pedestrians/s will be entering the queuing area, a queuing area of 5.8 m^2/s of pedestrian delay will be needed.

Down the Road

Option 3 makes use of NY-73 for pedestrian flow between the Intervale site and the bus staging area, again located at HSG. The width of NY-73 at this point (two lanes plus two shoulders) is 8.5 m (6). Therefore, one lane plus one shoulder (4.25 m) could easily handle a flow of 10 000 pedestrians/h.

This option may be broken into two options for eastside and westside use of NY-73. A double signal system will also be necessary to allow pedestrians to cross one of the lanes to keep the lane used by the pedestrians clear of traffic during the critical period. Even with such precautions, impacts on traffic flow would be high, as would be impacts on pedestrian safety. Because of the long length of the walkway and stragglers, NY-73 would have to be closed to traffic for significant periods.

Table 1. Components of options.

Option	Pedestrian Bridge Over NY-73	HSG Staging Area	Lower Staging Area	Path Through Woods	Pedestrian Crosswalk	Pedestrian-Traffic Conflict For Use on NY-73
1. Over the road	x	x		x		
2. Across the road		x		x	x	
3a. Down the road (east-side)		x			x[a]	x[b]
3b. Down the road (west-side)		x			x[a]	x[b]
4a. Across the bridge (east-side)			x		x[a]	x[b]
4b. Across the bridge (west-side)			x		x[a]	x[b]

[a]Two crosswalks required. [b]Conflict along NY-73.

Table 2. Comparative analysis.

	Option					
			3		4	
Impacts	1	2	a	b	a	b
Environmental						
Tree, shrubs	4	4	10	10	10	10
Salt, sand	5	5	2	2	2	2
Staging area	8	8	8	8	1	1
Average	5.7	5.7	6.7	6.7	4.3	4.3
Walking						
Distance	4	4	4	4	7	7
Capacity	7	7	10	10	10	10
Slope	5	6	7	7	8	8
Pedestrian walking speed	5	6	7	7	7	7
Pedestrian delay	10	5	6	6	6	6
Pedestrian safety	10	8	1	1	1	1
Average	6.8	6.0	5.8	5.8	6.5	6.5
Traffic on NY-73						
Vehicle delay	10	8	1	1	2	2
Emergency access	10	9	2	2	2	2
Average	10.0	8.5	1.5	1.5	2.0	2.0
Cost						
Construction	2	5	8	8	8	8
Maintenance						
Degree of need	3	4	2	2	2	2
Post-implementation						
Permanence	5	6	9	9	9	9
Use of existing facilities	3	4	8	8	8	8
Post-Olympic use	4	5	5	5	5	5
Average	3.0	4.0	7.1	7.1	7.1	7.1

Note: 0 = very high (negative) impact and 10 = very low (positive) impact.

Table 3. Comparative scores.

Option	Score	Positive Impacts	Negative Impacts
1. Pedestrian bridge	95	Vehicle delay and pedestrian safety	Cost and post-Olympic use
2. Crosswalk	94	Vehicle delay and pedestrian safety	Maintenance and post-Olympic use
3. Down the road	90	Cost and post-Olympic use, environmental	Vehicle delay
4. Lower staging area	88	Cost, walking, post-Olympic use	Vehicle delay

Across the River

The river referred to here is the Ausable River, just below the Intervale entrance. Option 4 also makes use of NY-73 as pedestrian access to the Intervale entrance, but from the south direction. This option is also broken down into two options for eastside and westside use of NY-73. The staging area is located approximately 180 m south of the Intervale entrance, on the opposite side of NY-73. The two options also necessitate a double signal system to allow pedestrians to cross one of the lanes and to keep the lane used by pedestrians clear of traffic during the critical period. As above, traffic impacts are high. The proposed staging area is steeper, smaller, and generally less accessible than the HSG area.

ANALYSIS AND CONCLUSION

The analysis of the different options must begin with a statement of assumptions to be made about the options and the situations each option is designed to handle. The assumptions made are as follows:

1. Pedestrians will enter the system from buses at a rate of 10 000/h or 167/min.
2. There will be little or no reverse traffic flow during high-volume periods. Pedestrian flow entering Intervale at the beginning of an event and leaving Intervale at the end of an event will be one directional. During the event, however, two-directional flow will occur.
3. There will be no pedestrian cross-conflicts or interference between pedestrians and vehicular flow, except when pedestrians cross or walk on NY-73.
4. A minimum number of handicapped persons will be in the flow.
5. Pedestrians in the flow will carry only lightweight, hand-carried items of small bulk.
6. An exercise of control in the form of signs and barriers will ensure orderly flow.
7. There is an assumed dead width of 0.3 m on each side of a pedestrian walkway and of 0.15 m on stairways to account for railings and containment barriers. Therefore, the net effective width will be assumed to be equal to the gross width minus 0.6 m on the pedestrian walkway and gross width minus 0.3 m on stairways.
8. Flow will be steady and even, with no minipeaks (except where caused by signaling).
9. Isolated signaling is assumed, except for the interconnected signals for use of NY-73 as a pathway.
10. The signaling at pedestrian crosswalks would be activated only for the 1.5-h critical periods, and then would follow a preplanned pattern. However, it should be able to be activated for individual crossing during a noncritical period.
11. There will be proper maintenance of the system so walking speeds and system capacity will not be decreased.