SPR 766 - User's Guide to Identifying Effective Measures to Restrict Vehicle Turning Movements

Purpose

This document guides the analyst responsible for selecting alternative turning treatment configurations for access point locations (driveways and public intersections, as appropriate). The selection of effective turning movement strategies is dependent upon many factors including the traffic volume, roadway cross section (particularly the number of lanes), context of the access point (i.e. land use), acceptable level of non-compliance, access density, and expected corridor speed reductions. In extreme cases the number of observed crashes at a location, in combination with the corridor traffic volume, will require the use of restrictive treatments including longitudinal medians; however, this document identifies alternatives, where practical, to the restrictive median treatment.

Data Needed for Analysis

The following basic information is required to fully evaluate the turning movement treatment at a study location:

Data Requirements
- Design hourly volume (vph) for adjacent road - Hourly volume for access point - Number of lanes (4, 5 with a continuous two-way left-turn lane (TWLTL), 6 lanes) - Adjacent land use type

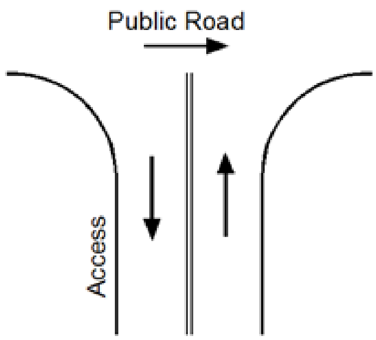
Terminology and Turn-Restriction Scenarios

This document summarizes common turn restriction treatments and their associated characteristics. Included in this analysis are the following **turn restriction options**:

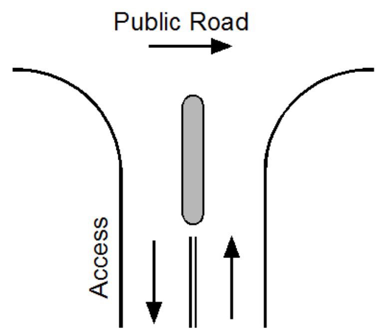
- No restrictions,
- Right-in right-out only (RIRO),
- Right-in right-out left-out (RIROLO), and
- Right-in right-out left-in (RIROLI).

These turn restrictions can be accomplished through the use of the following **turn restriction techniques**:

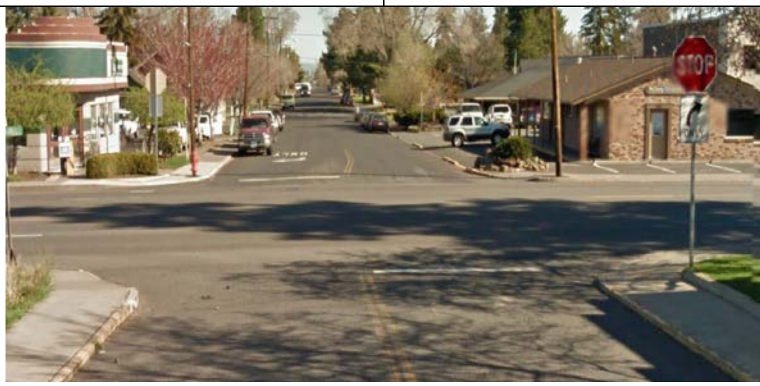
- Use of passive control (signing and marking) at the access point [see Figure 1],
- Incorporation of a directional island at the access point location only [see Figure 2],
- Use of a median-only turn restriction, and
- Inclusion of a directional island (at the access point) and a median turn restriction.



Unrestricted Access



Access with Median Divider



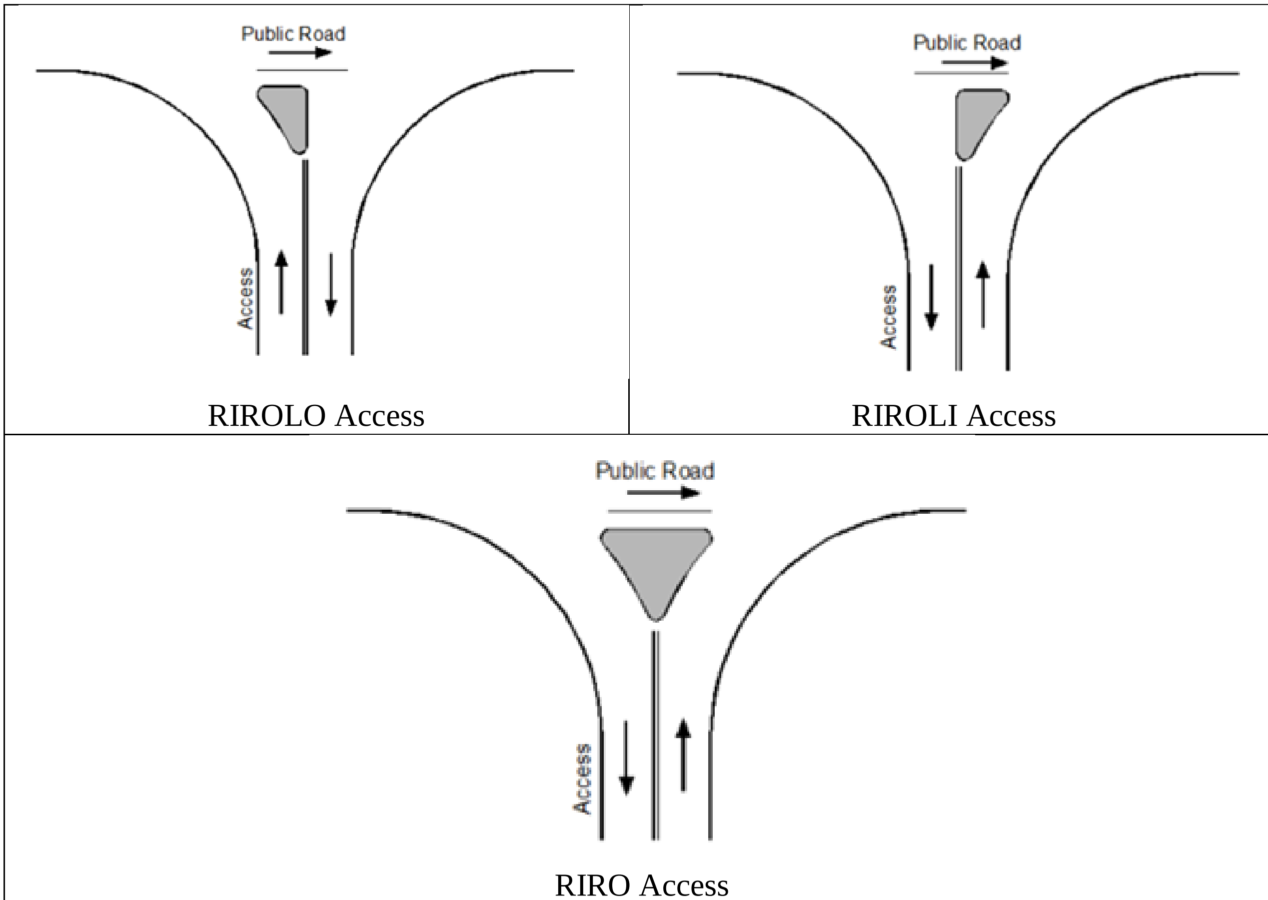
Access with Passive Control

Application:

- Access traffic volume is light (less than 3% of the adjacent road volume)
- Adjacent road volumes can accommodate the friction caused by left-turn activities into and out of the driveways

Figure 1: Access with No Turn Restrictions or Signage Only (Passive Control)

Raised islands that provide the driver of a motor vehicle positive guidance for the successful execution of a turning maneuver are often used at the specific access point location. Figure 2 depicts the three common access island configurations. The decision to exclude or allow left-turn activity depends on the number of access points, adjacent road cross section, and traffic patterns in the area.



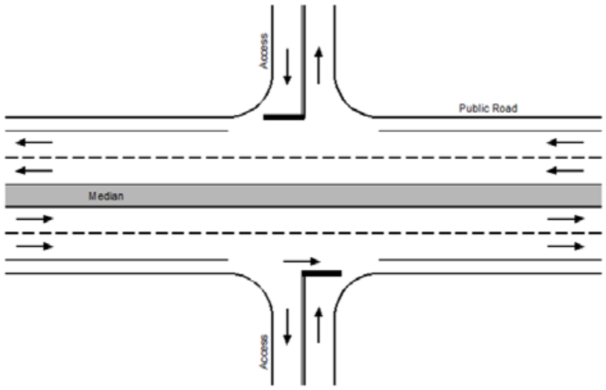
Application:

- Access traffic volume is light to moderate (less than 5% of the adjacent road volume)
- Adjacent road volumes primarily provide access to adjacent properties and so the corridor speed can be marginally reduced due to access activity

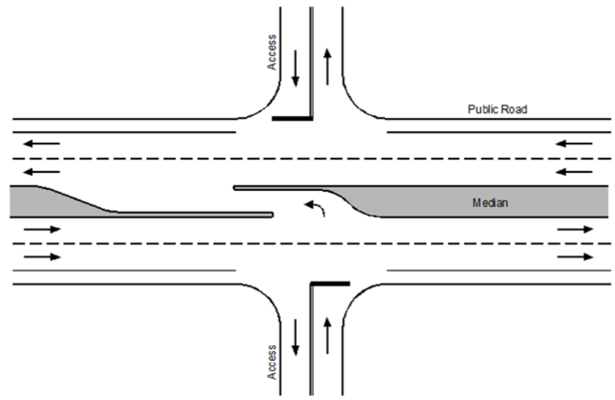
Figure 2: Access with Island Turn Restrictions

An additional strategy to physically restrict turn-movements at an access point is to limit the operations to one-way activities. This turn restriction technique must be integrated into the plan for internal site access and should be constructed so that wrong-way entry does not create safety problems. The application factors for the one-way configuration are similar to those identified for the island turn restrictions.

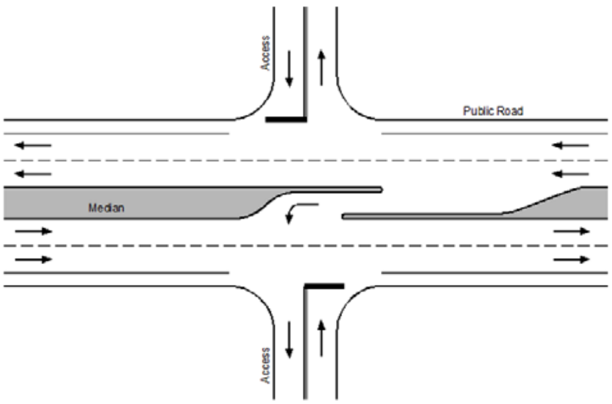
A variety of median-only configurations may be considered. Figure 3 depicts median turn restriction techniques. Though the raised median appears to be continuous along the full length of the corridor, a localized median is also common at locations where direct access needs to be restricted.



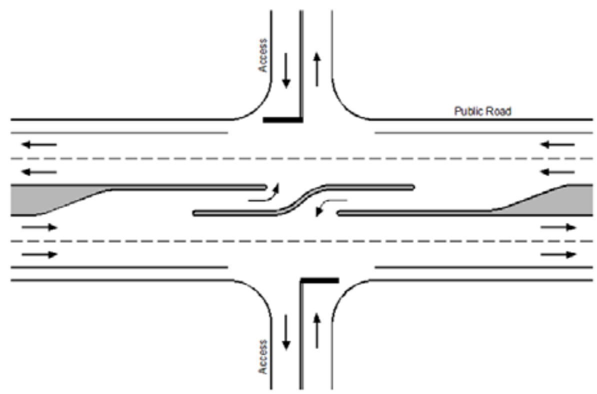
Raised Median RIRO Access



Raised Median RIROLO



Raised Median RIROLI



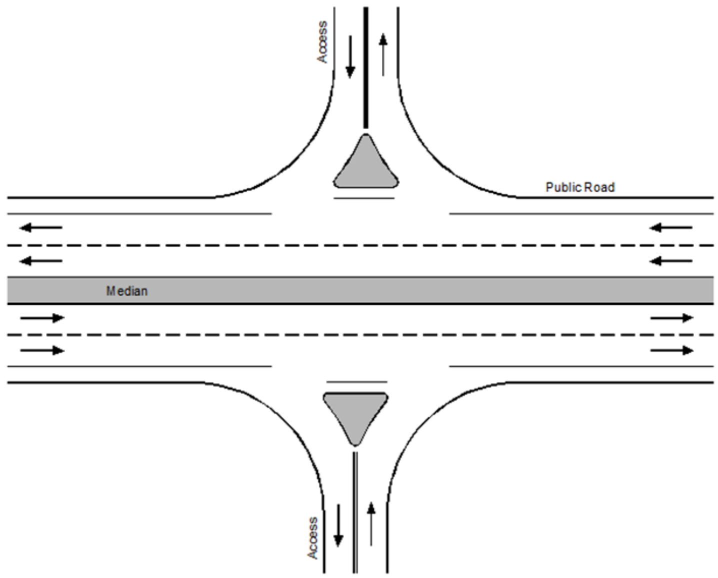
Alternative Raised Median RIROLI

Application:

- Access traffic volume is heavy (up to 10% of the adjacent road volume)
- Adjacent road volumes are higher but within acceptable thresholds for accommodating left-turns as needed by the configuration
- Adjacent road function is primarily traffic movement and access to adjacent properties, though important, is a secondary consideration
- May be required at locations with mid-block angle crashes

Figure 3: Access with Median-Only Turn Restrictions

The combined raised median and RIRO island (see Figure 4) may be observed at locations where additional positive guidance is needed to ensure that drivers do not inadvertently turn left into active oncoming traffic. This configuration is also common at locations where a driveway-only constraint was initially attempted and ultimately supplemented with the median turn constraint.



Median and Driveway Constrained RIRO

Application:

- Access traffic volume is heavy (up to 10% of the adjacent road volume)
- Adjacent road volumes are higher but within acceptable thresholds for facilitating RIRO activities
- Adjacent road function is primarily traffic movement and access to adjacent properties, though important, is a secondary consideration
- May be required at locations with mid-block angle crashes and head-on angle crashes (commonly resulting from vehicles turning left our of the access and into oncoming traffic)

Figure 4: Access with Median and Island Turn Restrictions

Safety Assessment

The number of turning-related crashes located in the vicinity of the access point is a good indicator of the issues related to an existing location; however, new construction locations do not have the benefit of this observed crash information. Similarly, crash reports often do not provide enough detail to determine where a crash occurred. As a result, the safety assessment for an existing facility should focus on the crash types observed along the corridor. When angle crashes become a clear issue, left-turn should not be permitted. In the event that head-on crashes are present at median locations, a directional island may also be advisable to limit driving errors.

When crash data is not available, the corridor safety can be assessed based on key access control items as follows:

- Do not permit left-turn maneuvers at access points located in the functional area of an intersection.
- Facilities where the major road traffic volume (for the future design year) is considerable and the primary corridor function is mobility should restrict left-turn maneuvers to select locations.
- Locations where the adjacent road has low volumes and sizeable gaps in traffic are more suited for full access configurations.
- Driveways with high access volumes are more likely to create friction in the adjacent traffic stream (potentially introducing risky maneuvers by drivers) and so operational recommendations should be considered to limit this risk (see the following operational evaluation summary).

Operational Evaluation

Vehicles turning into and out of driveways and minor public street intersections can be disruptive to the overall traffic operations. As a result, the number of vehicles executing the turn and the number of through vehicles are key factors in determining if a turn restriction is appropriate. As the traffic volume increases, the influence of left-turn vehicles from the road into adjacent access points can be problematic. The operational assessment, therefore must consider several key features of the corridor.

The demand for the land use will increase as land use density and type increases.

- Light retail/commercial/residential (access point volume ≤ 60 vph during peak conditions),
- Moderate retail/commercial/residential (access point volume ranging from 61 to 139 vph during peak conditions), and
- Heavy retail/commercial/residential (access point volume ≥ 140 vph during peak conditions).

The indication of “light”, “moderate”, and “heavy” represents driveway or minor roadway traffic demand. In general, the “light” land use designation represents access to a site with a single or only a few businesses. The “moderate” description generally applies to mixed use developments with at least one active traffic generator such as a fast food restaurant or a gas station. Sites with “light” or “moderate” access point traffic volumes are expected to have volumes that are **five percent** or less of that on the adjacent road.

A “heavy” description refers to a retail/commercial site that includes a major store that generates considerable traffic. An example of this type of store would be a grocery store. The heavy access point traffic volume is approximately **ten percent** or more of the volume for the adjacent road.

Table 1 represents the expected speed reduction for light to moderate land development adjacent to a four-lane road. Similarly, Table 2 presents a similar speed reduction for heavy land development access point configurations for a four-lane road. Because it is not practical to fully evaluate congestion separately from the turn restriction scenario, each of these tables also includes the expected percent of speed reduction based on no access points. This information can then be used to make a relative comparison of the impact that the turn lane scenarios do have on the overall corridor operations. The maximum volume thresholds for each configuration are where the corridor operations begin to deteriorate. When volumes exceed the maximum values within the tables, **a continuous median is strongly recommended**.

The expected speed reduction thresholds depicted in these tables are defined as follows:

- Less than or equal to ten percent speed reduction from target corridor speed,
- Speed reductions that are less than or equal to 20 percent but greater than ten percent,
- Speed reductions that are less than or equal to 30 percent but greater than 20 percent, and
- Speed reductions that are greater than 30 percent.

Table 1: Expected Performance for 4-Lane Light to Moderate Land Use Access

<table>
<tr><th>Test Scenario Description</th><th>1500 vph</th><th>2000 vph</th><th>2500 vph</th><th>3000 vph</th><th>3500 vph</th><th>4000 vph</th><th>4500 vph</th></tr>
<tr><td>No Access Points</td><td colspan="6">≤ 10% SR</td><td>20% ≤ SR < 10%</td></tr>
<tr><td colspan="8">20 Access Points per Mile</td></tr>
<tr><td>All</td><td colspan="2" rowspan="4">≤ 10% SR</td><td colspan="3" rowspan="2">20% ≤ SR < 10%</td><td rowspan="2">30% ≤ SR < 20%</td><td rowspan="2">> 30%</td></tr>
<tr><td>RIROLI</td></tr>
<tr><td>RIROLO</td><td colspan="2" rowspan="2">≤ 10% SR</td><td colspan="3" rowspan="2">20% ≤ SR < 10%</td></tr>
<tr><td>RIRO</td></tr>
<tr><td colspan="8">40 Access Points per Mile</td></tr>
<tr><td>All</td><td colspan="4" rowspan="2">20% ≤ SR < 10%</td><td colspan="2" rowspan="2">30% ≤ SR < 20%</td><td rowspan="2">> 30%</td></tr>
<tr><td>RIROLI</td></tr>
<tr><td>RIROLO</td><td colspan="4" rowspan="2">≤ 10% SR</td><td colspan="3" rowspan="2">20% ≤ SR < 10%</td></tr>
<tr><td>RIRO</td></tr>
<tr><td colspan="8">Legend: SR = Speed Reduction (Simulated Speed Compared to Target Speed)</td></tr>
</table>

As shown in Table 1, the percent of expected speed reduction is ten percent or less when there are no access points and adjacent road traffic volumes are 4000 vph or less. At locations with 40 access points, a RIROLI turn restriction, and a traffic volume of 4000 vph, the expected speed reduction is between 20 and 30 percent. This finding indicates that a 10 to 20 percent speed reduction occurs primarily due to the observed access at locations where the land use is heavily developed.

Table 2: Expected Performance for 4-Lane Heavy Land Use Access

<table>
<tr><th>Test Scenario Description</th><th>1500 vph</th><th>2000 vph</th><th>2500 vph</th><th>3000 vph</th><th>3500 vph</th><th>4000 vph</th><th>4500 vph</th></tr>
<tr><td>No Access Points</td><td colspan="6">≤ 10% SR</td><td>20% ≤ SR < 10%</td></tr>
<tr><td colspan="8">20 Access Points per Mile</td></tr>
<tr><td>All</td><td rowspan="2"></td><td colspan="3" rowspan="2">20% ≤ SR < 10%</td><td colspan="2" rowspan="2">30% ≤ SR < 20%</td><td rowspan="2">> 30%</td></tr>
<tr><td>RIROLI</td></tr>
<tr><td>RIROLO</td><td colspan="4" rowspan="2">≤ 10% SR</td><td colspan="3" rowspan="2">20% ≤ SR < 10%</td></tr>
<tr><td>RIRO</td></tr>
<tr><td colspan="8">40 Access Points per Mile</td></tr>
<tr><td>All</td><td colspan="4" rowspan="2">20% ≤ SR < 10%</td><td colspan="2" rowspan="2">30% ≤ SR < 20%</td><td rowspan="2">> 30%</td></tr>
<tr><td>RIROLI</td></tr>
<tr><td>RIROLO</td><td colspan="4" rowspan="2">≤ 10% SR</td><td colspan="3" rowspan="2">20% ≤ SR < 10%</td></tr>
<tr><td>RIRO</td></tr>
<tr><td colspan="8">Legend: SR = Speed Reduction (Simulated Speed Compared to Target Speed)</td></tr>
</table>

In addition to the four-lane simulations, Table 3 and Table 4 present similar speed reduction summaries for five-lane cross-sections. Table 5 and Table 6 similarly demonstrate the six-lane values for light and moderate as well as heavy land development, respectively.

Table 3: Expected Performance for 5-Lane Light to Moderate Land Use Access

<table>
<tr><th>Test Scenario Description</th><th>2000 vph</th><th>2500 vph</th><th>3000 vph</th><th>3500 vph</th><th>4000 vph</th><th>4500 vph</th><th>5000 vph</th><th>5500 vph</th><th>6000 vph</th></tr>
<tr><td>No Access Points</td><td colspan="4">≤ 10% SR</td><td colspan="5">20% ≤ SR < 10%</td></tr>
<tr><td colspan="10">20 Access Points per Mile</td></tr>
<tr><td>All</td><td rowspan="2">≤ 10% SR</td><td colspan="3" rowspan="2">20% ≤ SR < 10%</td><td colspan="2" rowspan="2">30% ≤ SR < 20%</td><td colspan="3" rowspan="2">> 30%</td></tr>
<tr><td>RIROLI</td></tr>
<tr><td colspan="10">40 Access Points per Mile</td></tr>
<tr><td>All</td><td colspan="3" rowspan="2">20% ≤ SR < 10%</td><td colspan="2" rowspan="2">30% ≤ SR < 20%</td><td colspan="4" rowspan="2">> 30%</td></tr>
<tr><td>RIROLI</td></tr>
<tr><td colspan="10">Legend: SR = Speed Reduction (Simulated Speed Compared to Target Speed)</td></tr>
</table>

Table 4: Expected Performance for 5-Lane Heavy Land Use Access

<table>
<tr><th>Test Scenario Description</th><th>2000 vph</th><th>2500 vph</th><th>3000 vph</th><th>3500 vph</th><th>4000 vph</th><th>4500 vph</th><th>5000 vph</th><th>5500 vph</th><th>6000 vph</th></tr>
<tr><td>No Access Points</td><td colspan="4">≤ 10% SR</td><td colspan="5">20% ≤ SR < 10%</td></tr>
<tr><td colspan="10">20 Access Points per Mile</td></tr>
<tr><td>All</td><td colspan="3" rowspan="2">20% ≤ SR < 10%</td><td rowspan="2">30% ≤ SR < 20%</td><td colspan="5" rowspan="2">> 30%</td></tr>
<tr><td>RIROLI</td></tr>
<tr><td colspan="10">40 Access Points per Mile</td></tr>
<tr><td>All</td><td colspan="2" rowspan="2">20% ≤ SR < 10%</td><td colspan="2" rowspan="2">30% ≤ SR < 20%</td><td colspan="5" rowspan="2">> 30%</td></tr>
<tr><td>RIROLI</td></tr>
<tr><td colspan="10">Legend: SR = Speed Reduction (Simulated Speed Compared to Target Speed)</td></tr>
</table>

Table 5: Expected Performance for 6-Lane Light to Moderate Land Use Access

<table>
<tr><th>Test Scenario Description</th><th>4000 vph</th><th>4500 vph</th><th>5000 vph</th><th>5500 vph</th><th>6000 vph</th><th>6500 vph</th></tr>
<tr><td>No Access Points</td><td colspan="5">≤ 10% SR</td><td>20% ≤ SR < 10%</td></tr>
<tr><td colspan="7">20 Access Points per Mile</td></tr>
<tr><td>All</td><td colspan="2" rowspan="2">20% ≤ SR < 10%</td><td colspan="2" rowspan="2">30% ≤ SR < 20%</td><td colspan="2" rowspan="2">> 30%</td></tr>
<tr><td>RIROLI</td></tr>
<tr><td>RIROLO</td><td colspan="3" rowspan="2">≤ 10% SR</td><td colspan="3" rowspan="2">20% ≤ SR < 10%</td></tr>
<tr><td>RIRO</td></tr>
<tr><td colspan="7">40 Access Points per Mile</td></tr>
<tr><td>All</td><td rowspan="2">20% ≤ SR < 10%</td><td colspan="3" rowspan="2">30% ≤ SR < 20%</td><td colspan="2" rowspan="2">> 30%</td></tr>
<tr><td>RIROLI</td></tr>
<tr><td>RIROLO</td><td colspan="3" rowspan="2">≤ 10% SR</td><td colspan="3" rowspan="2">20% ≤ SR < 10%</td></tr>
<tr><td>RIRO</td></tr>
<tr><td colspan="7">Legend: SR = Speed Reduction (Simulated Speed Compared to Target Speed)</td></tr>
</table>

Table 6: Expected Performance for 6-Lane Heavy Land Use Access

Test Scenario Description	4000 vph	4500 vph	5000 vph	5500 vph	6000 vph	6500 vph
No Access Points	≤ 10% SR					20% ≤ SR < 10%
20 Access Points per Mile						
All	30% ≤ SR < 20%			> 30%		
RIROLI						
RIROLO	≤ 10% SR	20% ≤ SR < 10%			30% ≤ SR < 20%	
RIRO						
40 Access Points per Mile						
All	30% ≤ SR < 20%			> 30%		
RIROLI						
RIROLO	≤ 10% SR		20% ≤ SR < 10%			30% ≤ SR < 20%
RIRO						
Legend: SR = Speed Reduction (Simulated Speed Compared to Target Speed)						

Selecting the Appropriate Treatment

The basic safety considerations and the operational performance tables in the previous section can collectively be used to assist with the turn-restriction selection. There are three basic evaluation questions that can be used to help identify an access point turn restriction that best fits the facility. These questions are as follows:

1) Does the location provide adequate corner clearance?
2) Will any level of driver non-compliance be acceptable if turn restrictions are needed (for existing sites, do crash types include mid-block angle and head-on collisions)?
3) What additional speed reduction is acceptable if this and similar access points are constructed along the corridor?

The following examples demonstrate this procedure.

Example Problem #1 – Four-lane Light to Moderate Land Development Access

Question: A transportation agency has been asked to permit a new driveway that will be located approximately 1000 feet from the nearest intersection. The traffic volume along the corridor is approximately 4000 vph during the peak period. The number of approximate access points per mile (this includes both sides of the road) is 20. Is it appropriate to permit construction of this driveway and are any supplemental turn restrictions recommended?

Responses to Questions: The following responses to the analysis questions will be used to determine the recommended driveway turn constraint recommendation:

1. A corner clearance of 1000 feet should be adequate.

2. Safety is very important, but the agency does recognize that minor non-compliance could occur and accepts this potential risk.

3. The corridor is part of a larger network that must maintain good operations during the peak period. The total allowable reduction in speed (due to the increased peak hour traffic as well as friction due to turning maneuvers) is 15 percent.

Solution: Based on the response to the three questions, the agency notes that corner clearance is adequate. If there had not been adequate corner clearance and an alternative driveway site could not be accommodated, then a localized island that would restrict left-turn traffic into and out of the driveway would have been needed. The agency would like to have a location where drivers comply with all requested turn restrictions. This expectation rules out the use of passive turn protection if needed. Finally, the light to moderate land use for a corridor with 4000 vph and 20 access points per mile will be expected to have speed reductions of less than ten percent if no access points are present (see Table 1). If a RIROLO or a RIRO turn restriction is constructed, the combined speed reduction would be ten to20 percent – an additional 10 percent speed reduction due to the turn restriction. Finally, if no turn restriction of a RIROLI design is selected, the speed reduction for 4000 vph would be 20 to 30 percent – equivalent to an additional 20 percent speed reduction on average due to the turn constraint.

The need to limit speed reductions to 15 percent means that a turn restriction is advisable and that a RIROLO or RIRO option may be suitable. Because some minor non-compliance issues would be acceptable, the use of passive turn control only is not recommended. This means that the initial turn restriction recommendation could be a directional island and that the agency should then monitor compliance to determine if an additional median is needed. The determination between the RIROLO and the RIRO can vary. If there is a destination to the left that should be accommodated, then the RIROLO directional island is acceptable. In all cases, the design of the directional island should maintain geometry that aids in channelization of the traffic and is not easily violated.

Example Problem #2 – Five-lane Heavy Land Development Access

Question: A transportation agency has been asked to approve a new driveway that will be located approximately 480 feet from the nearest intersection. The traffic volume along the corridor is approximately 3000 vph during the peak period. The number of approximate access points per mile (this includes both sides of the road) is 40. Is it appropriate to permit construction of this driveway and are there any supplemental turn restrictions that should be recommended?

Responses to Questions: The following responses to the questions will be used to determine the recommended driveway turn constraint recommendation:

1. A corner clearance of 480 feet is adequate.

2. The propose five-lane section consists of four general use lanes and one TWLTL. This means that there is an expectation of left turn maneuvers into the adjacent sites (due to the presence of

the continuous turn lane). This type of corridor requires flexibility and it is expected that a few drivers may not comply fully with any recommended turn restrictions.

3. One goal of the corridor is to provide easy access to the adjacent businesses. Consequently an allowable reduction in speed up to 25 percent would be acceptable.

Solution: Based on the response to the three questions, the corner clearance is adequate, some non-compliance is acceptable, and speed reductions up to 25 percent would still meet the corridor objectives. Upon review of Table 4 the 3000 vph volume for up to 40 access points per mile will result in a ten to 20 percent speed reduction simply due to the increased traffic volume (i.e. no access point option). For the 3000 vph threshold, the total speed reduction would then be greater than 30 percent of which ten to 20 percent of the reduction is due to the driveway placement. Since the 30 percent exceeds the allowable 25 percent speed reduction, it is advisable not to construct a driveway at this location. The construction of a median treatment, however, would effectively convert the road to a four lane facility with a median and then Table 2 would be applicable and the expected total speed reduction would be within the acceptable speed reduction levels (with a ten to 20 percent speed reduction for no turn restriction or a RIROLI configuration). The construction of a RIRO or a RIROLO would have a total speed reduction of less than ten percent.

Additional Note: If the corner clearance had a value of 80 feet instead of 480 feet, the turn restrictions would be extended to prohibiting left-turns into or out of an access. This would therefore limit the restriction to a RIRO only.