# Table of Contents

1.0 INTRODUCTION 1

2.0 CURRENT PRACTICES STANDARDS, AND APPLICATIONS 1  
   2.1 Traffic Control Devices 1  
   2.2 Application of Traffic Control Devices 11  
   2.3 Pre-emption / Interconnection 24

3.0 IDENTIFICATION OF NEW PRACTICES 25  
   3.1 Where are we headed with highway-rail crossing controls? 25  
   3.2 Pre-signals 26  
   3.3 Queue Cutter Flashing-light Beacon 27  
   3.4 Median Separation 28  
   3.5 Four-quadrant Traffic Gate System 28  
   3.6 Barrier System 29  
   3.7 Active Advance Warning Signs with Flashers 30  
   3.8 Active Turn Restriction Signs 30  
   3.9 Quiet Zones 30

4.0 INVENTORY OF RR CROSSINGS IN THE PAG REGION 31  
   4.1 Data Availability and Their Applications 32

5.0 PLANNING, FUNDING AND PROGRAMMING PROCESSES FOR HIGHWAY-RAIL CROSSING IMPROVEMENTS 36  
   5.1 Major Capital Improvements Projects that Address H-R Crossings 36  
   5.2 At Grade Highway-Rail Crossing Improvement Projects 39  
   5.3 The STP-HES 130 Funding Program -RR Crossing Safety and Upgrades 41  
   5.4 The PAG RTA Program Funding for Highway-Rail Crossings 43

6.0 REFERENCES 44

APPENDICES  
Appendix A ADOT and PCDOT Pavement Marking Standards for RR Crossings  
Appendix B FRA Variable Definitions  
Appendix C PAG GIS Railroad Crossing Inventory Spreadsheet  
Appendix D ADOT RR Crossing Inventory for the PAG Region  
Appendix E Sample Inter Governmental Agreement (IGA)
FIGURES

Figure 2.1 - Two-Lane Road with No Stop/Yield Signs 12
Figure 2.2 - Two-lane Roadway with Stop/Yield Signs 13
Figure 2.3 - Parallel Roadway Located Less than 100 Feet from Intersection 14
Figure 2.4 - Parallel Roadway Located More than 100 Feet from Intersection 15
Figure 2.5 - Skewed Railroad Crossing Detail 16
Figure 2.6 - Highway-Rail Crossing with Steep Profile or Bump 17
Figure 2.7 - Required Sight Distance from Stop Line 18
Figure 2.8 - Four-lane Roadway with Active Control Devices 19
Figure 2.9 - Multi-Lane Highway with Active Control Devices 20
Figure 2.10- Sample Traffic Control for Exclusive Right Turn Lanes 21
Figure 2.11- Sample Traffic Control Devices with Pre-signal 22
Figure 2.12- Stopping Sight Distance for Crossings with No Traffic Controls 23
Figure 3.1 - Pre-signal at Highway-Railroad Crossing 26
Figure 3.2 - Four-Quadrant Traffic Gate Systems 29
Figure 3.3 - Stopgate Road Safety Barrier 29
Figure 4.1 - Highway-Railroad Crossings in the Tucson Metropolitan Area 33
Figure 4.2 - Highway-Railroad Crossings with 10 or more Day Thru Train Movements 34
Figure 4.3 - Highway-Railroad Crossings with 4 or more Traffic Lanes Crossing the RR 35

TABLES

Table 2.1 – Traffic Control Devices used for highway-Rail Crossings 3
Table 4.1 – Variables in GIS Database 32
Table 5.1 – Highway-Rail Crossing Improvements 36
Table 5.2 – Improvements Typically Funded by the STP-HES 130 Rail Crossing Program 42
1.0 INTRODUCTION

At the request of member agencies of the Pima Association of Governments (PAG) that reside in Pima County, Arizona, the Pima Association of Governments (PAG) has initiated a project to explore and evaluate various types of controls and applications that can be implemented at Highway-Rail Grade Crossings to further improve the safety of such crossings. As a result, the purpose of this project is two-fold:

- To provide an evaluation of the “pre-signal” traffic signal control application at the Union Pacific Railroad crossing on Prince Road at the Interstate-10 Traffic Interchange in the City of Tucson, Arizona.
- To identify local, national, and international state-of-the-practice highway-rail at-grade crossing strategies.

This Technical Memorandum #2 was produced to fulfill the second purpose noted above. It provides a toolbox of strategies to assist local agency users and others in developing useful applications for Highway-Rail crossings in the PAG region. This paper is the 2nd and final Technical Memorandum produced as part of this project. Technical Memorandum #1 provided a detailed evaluation of a pre-signal installed by the City of Tucson to fulfill the first purpose noted above.

In Summary, Technical Memorandum #2 is divided into four sections to assist the practitioner with information, references, applications and knowledge of processes related to Highway-Rail crossing improvements. These four chapters include the following:

Section 2 – Current Practices, Standards and Guidance
Section 3 – Identification of New Practices
Section 4 – Inventory of Highway-Rail Crossings in the PAG Region
Section 5 – Planning, Funding and Programming Processes for Highway-Rail Crossing Improvements

Most of Section 2 is focused on the current guidelines provided by the 2003 Manual on Uniform Traffic Control Devices (1). To clarify the MUTCD requirements a table of signs and several diagrammatical sketches for different applications are provided. Section 3 focuses on some of the new practices that are being employed and some innovative techniques. Section 4 describes some of the railroad crossing inventories that are available to local agencies in the area and provides a GIS map of the crossings for the PAG Region. Section 5 identifies some of the funding sources that are available for highway-rail crossings and describes the planning and programming processes to implement various types of highway-rail mitigations. Section 5 also describes funding that will be available through the PAG RTA Program.

2.0 CURRENT PRACTICES, STANDARDS AND GUIDANCE

The purpose of this section is to identify current practices and standards for the treatment of highway-rail crossings. In addition, a number of typical applications have been developed and are included in this section to provide guidance to practitioners, engineers and public officials.

2.1 Traffic Control Devices

The purpose of traffic control devices at highway-rail grade crossings is to permit safe and efficient operation of rail and vehicle traffic over such crossings. Since trains are large and cannot easily stop, vehicular traffic must stop at rail-highway crossings to ensure the safe
passage of a train. Therefore, the driver of a vehicle approaching a highway-rail grade crossing must be prepared to yield and stop if necessary if a train is present.

The standard devices required to warn and regulate traffic on the approach to a highway-rail crossing are identified and defined in the 2003 Manual on Uniform Traffic Control Devices (MUTCD). The MUTCD generally defines the treatments that most agencies in the United States use for highway-rail crossings. All users of this guide are encouraged to become familiar with the 2003 MUTCD. However, much information is provided in the MUTCD, and it is not necessarily easy to follow as a practitioner looking for guidance on a particular application.

In addition to the MUTCD, there are state and local policies and standards for applying traffic controls at rail-highway crossings. However, these are typically simplified to show the pavement markings that are typically used on a two-lane roadway. The ADOT and Pima County DOT and City of Tucson Tucson DOT standard drawings are provided in Appendix A.

The MUTCD defines two types of traffic control devices: passive control devices and active control devices.

**Passive traffic control devices** are not activated by the presence of a train and are permanently displayed, such as signs and pavement markings. Examples include:

- Crossbuck sign (R15-1)
- Multiple Tracks sign (R15-2)
- Advance Warning sign (W10-1)
- Stop sign (R1-1)
- Stop Ahead sign (W3-1)
- Yield sign (R1-2)
- Yield Ahead sign (W3-2)
- Pavement Markings

**Active traffic control devices** are those that are activated by the presence of an approaching train to provide adequate warning to motorists, pedestrians and other users. They include the following controls:

- Flashing-Light Signals – Consists of two side-by-side red lights that flash alternately at approaching highway traffic when a train is present.
- Automatic Gates – Consist of a long board that is lowered across the road in front of the railroad tracks when a train approaches and are raised out of the traffic way when the train leaves.
- Train horns – typically mounted on the front of the train, and are activated on the approach to a highway rail crossing to warn motorists, pedestrians and other users that a train is approaching.
- Electronic Signs – are wired to the train pre-emption devices. These signs are activated as a train approaches the tracks and deactivated as the train departs.

To further describe the standard devices that are used at highway-rail crossings, Table 2.1 “Traffic Control Devices for Highway-Rail Crossings” was assembled and is provided in the subsequent pages of this report. This table is based on the Manual of Uniform Traffic Control Devices (MUTCD) Chapter 8, 2003 Edition, and Guidance on Traffic Control at Highway-rail Grade Crossings developed by the Federal Highway Administration (FHWA) (2). The table contains three columns; in the first column signs and their respective MUTCD code are illustrated. The second column provides a description of the application of indication of need of the device. The last column indicates the location at which the devices should be located.
### Table 2.1 Traffic Control Devices used for Highway-Rail Crossings

<table>
<thead>
<tr>
<th>MUTCD Sign and Code</th>
<th>Traffic Control Device</th>
<th>Application or Indication of Need</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>R15-1</td>
<td>CROSSBUCK sign</td>
<td>Required device on each roadway approach for all highway-rail grade crossings. Install on right side. Install additional sign on left side, where restricted sight distance or unfavorable geometry exists.</td>
<td>Install on approach to railroad crossing, typically between stop bar and railroad tracks.</td>
</tr>
<tr>
<td>R15-2</td>
<td>&quot;Multiple Tracks &quot; sign</td>
<td>Standard device, with 2 or more tracks; optional with gate.</td>
<td>Install under CROSSBUCK sign, R15-1, as a supplement.</td>
</tr>
<tr>
<td>R15-3</td>
<td>EXEMPT sign</td>
<td>It may be used when school buses and those commercial vehicles that are usually required to stop at crossings are not required to do it by law or regulation.</td>
<td>Install under CROSSBUCK sign, R15-1, as a supplement. Also install under advanced railroad warning sign W10-1, as a supplement.</td>
</tr>
<tr>
<td>R15-8</td>
<td>LOOK, Supplementary sign</td>
<td>It may be mounted as a supplemental plaque on the CROSSBUCK or as a separate sign in the immediate vicinity of the crossing</td>
<td>Install under CROSSBUCK sign, R15-1, as a supplement.</td>
</tr>
<tr>
<td>W10-1</td>
<td>Advance warning sign</td>
<td>Required device, except: • If a parallel roadway is located within 100 ft from the tracks, and W10-3 signs are installed on both approaches; • On low-volume, low-speed roadways crossing minor spurs or other tracks that are infrequently used and are flagged by train crews; • In business districts where active traffic control devices are in place; • Where physical conditions do not allow effective display of the sign.</td>
<td>Table 2C-4 MUTCD.</td>
</tr>
</tbody>
</table>
Table 2.1 Traffic Control Devices used for Highway-Rail Crossings (Continued)

<table>
<thead>
<tr>
<th>MUTCD Sign and Code</th>
<th>Traffic Control Device</th>
<th>Application or Indication of Need</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>STOP</td>
<td>STOP sign</td>
<td>It may be used at discretion of the state or local highway agency at crossings that have two or more trains per day and are without automatic control devices. For other crossings, a Stop sign may be used based on engineering studies. If sight distance criterion is not satisfied, a Stop or Yield sign shall be placed.</td>
<td>15 Feet from nearest track (at Crossbuck post) or as near to as practical.</td>
</tr>
<tr>
<td></td>
<td>STOP AHEAD sign</td>
<td>Shall be installed where STOP sign is present at crossing and it is not visible for a sufficient distance to the permit the road user to adequately respond to the device. This sign may be used for additional emphasis even when the visibility of the primary sign is satisfactory.</td>
<td>Table 2C-4 MUTCD.</td>
</tr>
<tr>
<td>YIELD</td>
<td>YIELD sign</td>
<td>It may be used at discretion of the state or local highway agency at crossings that have two or more trains per day and are without automatic control devices. For other crossings, a Yield sign may be used based on engineering studies. If sight distance criterion is not satisfied, a Stop or Yield sign shall be placed.</td>
<td>15 Feet from nearest track (at Crossbuck post) or as near to as practical.</td>
</tr>
<tr>
<td>YIELD AHEAD sign</td>
<td>Shall be installed where YIELD sign is present at crossing and it is not visible for a sufficient distance to the permit the road user to adequately respond to the device. This sign may be used for additional emphasis even when the visibility of the primary sign is satisfactory.</td>
<td>Table 2C-4 MUTCD.</td>
<td></td>
</tr>
</tbody>
</table>
### Table 2.1 Traffic Control Devices used for Highway-Rail Crossings (Continued)

<table>
<thead>
<tr>
<th>MUTCD Sign and Code</th>
<th>Traffic Control Device</th>
<th>Application or Indication of Need</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="NO RIGHT TURN ACROSS TRACKS" /> R3-1a Activated Blank-Out</td>
<td>Turn Restriction sign * (An &quot;active &quot; sign)</td>
<td>Use with interconnected, preempted traffic signals. Install on the nearby parallel highway to control right and left turns toward the tracks.</td>
<td>Stop bar of parallel roadway to railroad tracks.</td>
</tr>
<tr>
<td><img src="image" alt="U-Turn Prohibition sign" /> R3-4</td>
<td>U-Turn Prohibition sign</td>
<td>Use in median of divided highways at highway-rail grade crossings to prohibit turning vehicles from using the track zone for u-turn movements.</td>
<td>In between W10-1 and stop line.</td>
</tr>
<tr>
<td><img src="image" alt="DO NOT STOP ON TRACKS sign" /> R8-8</td>
<td>DO NOT STOP ON TRACKS sign</td>
<td>It should be used whenever engineering judgment determines that the potential for vehicles stopping on the tracks is high.</td>
<td>Near or far side of crossing, depending on visibility.</td>
</tr>
<tr>
<td><img src="image" alt="TRACKS OUT OF SERVICE sign" /> R8-9</td>
<td>TRACKS OUT OF SERVICE sign</td>
<td>Applicable when there is some physical disconnection along the railroad tracks. It should be used when the tracks have been temporary or permanently abandoned. It shall be removed when the tracks have been removed or covered.</td>
<td>Instead of Crossbuck and R15-2 sign.</td>
</tr>
<tr>
<td>MUTCD Sign and Code</td>
<td>Traffic Control Device</td>
<td>Application or Indication of Need</td>
<td>Location</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------------------</td>
<td>----------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>STOP HERE ON RED sign</td>
<td>STOP HERE ON RED sign</td>
<td>It shall be used with pre-signal to discourage vehicle queues onto the track. In addition, it may be used to inform drivers the location of the stop bar.</td>
<td>Locate at or near stop line.</td>
</tr>
<tr>
<td>R10-6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO TURN ON RED sign</td>
<td>NO TURN ON RED sign</td>
<td>It shall be installed with pre-signals where storage space between tracks and a nearby-interconnected traffic signal controlled intersection, is insufficient for a design vehicle or when crossings do not have gates.</td>
<td>Around 15 Feet.</td>
</tr>
<tr>
<td>R10-11a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOW GROUND CLEARANCE CROSSING sign</td>
<td>LOW GROUND CLEARANCE CROSSING sign</td>
<td>It should be installed in advance if the roadway profile is sufficiently abrupt to create a hang-up situation for long-wheel vehicles. It shall be accompanied by an educational plaque “Low Ground Clearance”</td>
<td>Install where a vehicle can detour or at a point wide enough to permit a “u” turn.</td>
</tr>
<tr>
<td>W10-5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TRAINS MAY EXCEED 80 MPH (130 KM/H) sign</td>
<td>TRAINS MAY EXCEED 80 MPH (130 KM/H) sign</td>
<td>It should be installed where train speeds exceed 80 mph (130 km/h).</td>
<td>Between 15’ and W10-1.</td>
</tr>
<tr>
<td>W10-8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Technical Memorandum #2
### Highway/RailRoad Crossings – A Toolbox of Strategies

**Table 2.1 Traffic Control Devices used for Highway-Rail Crossings (Continued)**

<table>
<thead>
<tr>
<th>MUTCD Sign and Code</th>
<th>Traffic Control Device</th>
<th>Application or Indication of Need</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>W10-2</td>
<td>Advance Warning Signs Series</td>
<td>Based upon specific situations with a nearby parallel highway. Required when a parallel roadway is ≤ 100 ft from tracks and may be considered if distance is &gt; 100 ft. If the distance of the parallel roadway to the railroad is less or equal to 100 ft sign W10-1 shall not be installed between the tracks and the parallel roadway.</td>
<td>Install on external approach to tracks and on parallel road. Table 2C-4 MUTCD.</td>
</tr>
<tr>
<td>W10-3</td>
<td>Skewed Crossing Sign</td>
<td>It may be used at skewed crossings to warn drivers that the railroad tracks are not perpendicular to the roadway. It shall not replace W10-1 sign.</td>
<td>After W10-1 sign.</td>
</tr>
<tr>
<td>W10-4</td>
<td>Skewed Crossing Sign</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W10-12</td>
<td>Skewed Crossing Sign</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MUTCD Sign and Code</td>
<td>Traffic Control Device</td>
<td>Application or Indication of Need</td>
<td>Location</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------------------</td>
<td>----------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td><img src="image" alt="NO TRAIN HORN" /> W10-9</td>
<td>NO TRAIN HORN sign</td>
<td>It shall be used only at crossings where FRA authorized trains to not sound a horn.</td>
<td>With W10-1.</td>
</tr>
<tr>
<td><img src="image" alt="100 FEET BETWEEN TRACKS &amp; HIGHWAY" /> W10-11a</td>
<td>Storage Space signs</td>
<td>It should be used when there is an intersection close to railroad crossing and an engineering study determines that adequate space is not available to store a design vehicle. The installation of this sign is supplemented by W10-11a sign. A W10-11b may be mounted beyond the highway-rail crossing to remind drivers of the storage space between the tracks and roadway intersection.</td>
<td>In advance to advise drivers of the space available.</td>
</tr>
<tr>
<td><img src="image" alt="150 FEET BETWEEN HIGHWAY &amp; TRACKS BEHIND YOU" /> W10-11b</td>
<td>NO SIGNAL sign</td>
<td>It may be used at passive controlled crossings (not equipped with automatic signals).</td>
<td>With W10-1.</td>
</tr>
<tr>
<td><img src="image" alt="NO GATES OR LIGHTS" /> W10-13</td>
<td>NO GATES or LIGHTS sign</td>
<td>It may be used at passive controlled crossings (not equipped with automatic signals).</td>
<td>With W10-1.</td>
</tr>
</tbody>
</table>
Table 2.1 Traffic Control Devices used for Highway-Rail Crossings (Continued)

<table>
<thead>
<tr>
<th>MUTCD Sign and Code</th>
<th>Traffic Control Device</th>
<th>Application or Indication of Need</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>REPORT EMERGENCY TO 1-800-555-5555 CROSSED #221-6200 ON WENDOVER ROAD</td>
<td>Emergency Notification sign</td>
<td>It should be posted at all crossings to provide for emergency notification per MUTCD.</td>
<td>In Railroad RW in accordance with UP and local agency.</td>
</tr>
<tr>
<td>TO REPORT STALLED VEHICLE ON TRACKS OR OTHER EMERGENCY CALL 1-800-555-5555 AND REFER TO CROSSED #123-1234 ON CHERRY STREET</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| N/A | RR Pavement Markings | Required on all paved roads, except:  
* When speed is lower than 40 mph. In recent years ADOT has installed these markings for all crossings.  
* In urban areas if engineering studies determine that all other installed devices provide suitable warning and control. | See PCDOT/COT and ADOT standards in appendix A. |
| N/A | Dynamic Envelope Delineation, pavement markings | The Dynamic Envelope Delineation may be used where there is queuing or limited storage space for highway vehicles at a nearby highway intersection. This does not apply to four-quadrant systems | Locate strip 6 ft from the nearest rail, parallel to tracks. |
| N/A | Stop Line | | Approximately 8 Ft from the gate (if present) but no closer than 15 Ft from the nearest track. |
### Table 2.1 Traffic Control Devices used for Highway-Rail Crossings (Continued)

<table>
<thead>
<tr>
<th>MUTCD Sign and Code</th>
<th>Traffic Control Device</th>
<th>Application or Indication of Need</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>Crossing illumination:</td>
<td>An engineering study should be conducted based on:</td>
<td>It may be installed at or adjacent to a highway-rail crossing.</td>
</tr>
<tr>
<td>N/A</td>
<td>Flashing-Light Signals, Post-Mounted</td>
<td>They shall include a standard Crossbuck sign. If there is more than one track, include a “supplemental number of tracks” sign. For highway traffic in both directions, back to back pairs of lights shall be placed on each side of the tracks. On multi-lane one-way streets and divided highways flashing-light signals shall be placed on both sides of the roadway or shall be placed above the highway. Audible warning devices may be included.</td>
<td></td>
</tr>
<tr>
<td>N/A</td>
<td>Flashing-Light Signals, Overhead signs</td>
<td>They may be used on multi-lane highways to provide additional emphasis and to improve visibility particularly in highways with profile restriction.</td>
<td></td>
</tr>
<tr>
<td>N/A</td>
<td>Automatic Gates</td>
<td>Automatic gates are traffic control devices used as an adjunct to flashing-light signals. The gate arm shall start its downward motion not less than 3 seconds after the flashing-light signals start to operate and shall reach its horizontal position at least 5 seconds before the arrival of the train. Automatic gates shall remain in the down position as long as the train occupies the crossing. The gate arm should ascend to its right position in not more than 12 seconds.</td>
<td>15 Feet from nearest track</td>
</tr>
<tr>
<td>N/A</td>
<td>Four-Quadrant Gate Systems</td>
<td>They are typically used to discourage drivers from crossing the tracks when gates are down. They may be installed to improve safety when less restrictive measures, such as automatic gates and median islands are not effective.</td>
<td>15 Feet from nearest track or as determined by an engineering study.</td>
</tr>
</tbody>
</table>
2.2 Application of Traffic Control Devices

The 2003 MUTCD provides a significant amount of guidance related to the type and placement of traffic controls that should be used at highway-rail crossings. In order to summarize the guidance provided by the MUTCD, several diagrams were created in this report to illustrate a variety of highway-rail crossing situations. These diagrams are intended to provide guidance to practitioners in the application and placement of signs, signals, and markings that conform to the MUTCD. The highway-rail crossing cases shown are listed in the figures as noted:

- Figure 2.1 - Two-Lane Road with No Stop/Yield Signs
- Figure 2.2 - Two-lane Roadway with Stop/Yield Signs
- Figure 2.3 - Parallel Roadway Located Less than 100 Feet from Intersection
- Figure 2.4 - Parallel Roadway Located More than 100 Feet from Intersection
- Figure 2.5 - Skewed Railroad Crossing Detail
- Figure 2.6 - Highway-Rail Crossing with Steep Profile or Bump
- Figure 2.7 - Required Sight Distance from Stop Line
- Figure 2.8 - Four-lane Roadway with Active Control Devices
- Figure 2.9 – Multi-Lane Highway with Active Control Devices
- Figure 2.10- Sample Traffic Control for Exclusive Right Turn Lanes
- Figure 2.11- Sample Traffic Control Devices with Pre-signal
- Figure 2.12- Stopping Sight Distance for Crossings with No Traffic Controls

These figures show many of the common and recommended applications of traffic control devices; however, the final determination and location of the traffic control devices at any highway-rail crossing shall be based on the MUTCD, local guidelines and the judgment of the practitioner.
Notes:
1. See Table 2.1 for the application of the R15-1, R15-2, R15-3, and R15-8.
2. As a recommended guideline, crossings without Stop or Yield signs should meet the most current AASHTO sight triangle criterion.
3. Signs I-13 and I-13a should be posted at all crossings within the railroad right-of-way per the MUTCD.
4. If the train speed exceeds 80 mph, a W10-8 warning sign shall be installed.
5. Installation of the W10-1 warning sign is required, except as noted in Table 2.1. Location of the W10-1 advanced warning sign shall be determined based on Table 2C-4 of the MUTCD.
6. Application of the W10-1a, W10-9, W10-10, and W10-13 signs shall be determined based on Table 2.1.
7. Pavement markings should meet MUTCD standards. Reference ADOT and PCDOT/TDOT Standards in Appendix A.
8. Reference Figure 7 for the need for automatic gates and flashers.

Typical Applications:
Case 1.
(a) Low traffic volumes
(b) < 2 trains per day
Case 2.
(a) Infrequent use by trains
(b) Flagging operations provided for trains
(c) Low–moderate traffic volumes

Figure 2.1 Two-Lane Roadway with no Stop/Yield Signs

NTS
Notes:
1. See Table 2.1 for the application of the R15-1, R15-2, R15-3, and corresponding WO-1 or R1-2 and corresponding WO-2 signs apply.
2. See Table 2.1 to determine if the R1-1 and corresponding WO-1 or R1-2 and corresponding WO-2 signs apply.
3. Signs L13a and L13 shall be posted at all crossings within the railroad right-of-way per the MUTCD.
4. If the train speed exceeds 80 mph, a WO-3 warning sign shall be installed.
5. Installation of the WO-0-8 warning signs shall be based on Table 2.1.
7. Reference ADOT and PDOT/DOOT Standards in Appendix A.
8. Reference Figure 7 for the need for automatic gates and flashers

Figure 2.2 Two-Lane Road with Stop/Yield Sign.
Notes:
1. See Table 2.1 for the application of the R15-1, R15-2, R15-3, R15-8, and R8-8 signs.
2. See Table 2.1 to determine if the R1-1 and corresponding W3-1 or R1-2 and corresponding W3-2 signs apply.
3. Signs I-13 and I-13a should be posted at all crossings within the railroad right-of-way per MUTCD.
4. See Table 2.1 for applicability of W10-11, W10-11a, and W10-11b.
5. If the train speed exceeds 80 mph, a W10-8 warning sign shall be installed.
6. Installation of W10-1 is required, except as noted in Table 2.1. Location of the W10-1 sign shall be determined based on Table 2.1 of the MUTCD.
7. A W10-1 sign shall not be installed between the railroad tracks and roadway intersections.
8. Application of the W10-1a, W10-9, W10-10 and W10-13 signs shall be determined based on Table 2.1.
9. Dynamic envelope delineation is optional, see Table 2.1.
10. Pavement markings shall meet MUTCD standards, Reference ADOT and PCDOT/TDOT standards in Appendix A.
11. Reference Figure 7 for the need for automatic gates and flashers.

Figure 2.3 Parallel Roadway Located Less than 100 feet, NTS
Notes:
1. See Table 2.1 for the application of the R15-1, R15-2, R15-3, R15-8, and R8-8 signs.
2. See Table 2.1 to determine if the R1-1 and corresponding W3-1 or R1-2 and corresponding W3-2 signs apply.
3. Signs I-13 and I-13a should be posted at all crossings within the railroad right-of-way per MUTCD.
4. Application of the W10-11, W10-11a, and W10-11b signs should be considered, see Table 2.1.
5. If the train speed exceeds 80 mph, a W10-8 warning sign shall be installed.
6. Installation of the W10-1 warning sign is required, except as noted in Table 2.1. Location of the W10-1 advanced warning sign shall be determined based on table 2C-4 of the MUTCD.
7. Application of the W10-1a, W10-3, W10-10, and 10-13 signs shall be determined based on Table 2.1.
8. A W10-3 sign may be placed on parallel roadway based on engineering study.
9. Dynamic envelope delineation is optional, see Table 2.1.
10. Pavement markings shall meet MUTCD standards, Reference ADOT and PCDOT/TDOT standards in Appendix A
11. Reference Figure 7 for the need for automatic gates and flashers
Notes:
1. This figure represents one application. The W10-12 sign may be used in conjunction with all applications provided the RR tracks cross at a skewed angle.
2. See Table 2.1 for the application of the R15-1, R15-2, R15-3, and R15-8 signs.
3. See Figure 1 and Table 2.1 to determine if the R1-1 and corresponding W3-1 or R1-2 and corresponding W3-2 signs apply.
4. Signs I-13 and I-13a should be posted at all crossings within the railroad right-of-way per the MUTCD.
5. W10-12 is an optional sign used at skewed crossings.
6. If the train speed exceeds 80 mph, a W10-8 warning sign shall be installed.
7. Installation of the W10-1 warning sign is required, except as noted in Table 2.1. Location of the W10-1 sign shall be determined based on Table 2C-4 of the MUTCD.
8. Application of the W10-1a, W10-9, W10-10, and W10-13 signs shall be determined based on Table 2.1.
9. Pavement markings shall meet MUTCD standards. Reference ADOT and PCDOT/TDOT standards in Appendix A.
10. Reference Figure 7 for the need for automatic gates and flashing-lights signals.

Figure 2.5 Skewed Railroad Crossing Detail NTS
Notes:
1. See Table 2.1 for the application of the R15-1, R15-2, R15-3, and R15-8 signs.
2. See Table 2.1 to determine if the R1-1 and corresponding W3-1 or R1-2 and corresponding W3-2 signs apply.
3. Signs I-13 and I-13a should be posted at all crossings within the railroad right-of-way per MUTCD.
4. If the train speed exceeds 80 mph, a W10-8 warning sign shall be installed.
5. The W10-5 warning sign should be used in conjunction with all applications provided the RR tracks cross at steep profiles or bumps. This sign shall be accompanied by an educational plaque “Low Ground Clearance”. An WB-1, WB-2, or other warning signs such as AHEAD, NEXT CROSSING or USE NEXT CROSSING may be used when applicable as determined by the engineer.
6. Installation of the W10-1 advance warning sign is required, except as noted in Table 2.1. Location of the W10-1 sign shall be determined based on Table 2C-4 of the MUTCD.
7. Application of the W10-1a, W10-9, W10-10, and W10-13 signs shall be determined based on Table 2.1.
8. Pavement markings shall meet MUTCD standards.
9. Reference ADOT and PCDOT/TDOT standards in Appendix A.
10. The R2-1 may be installed based on engineering judgment.

Figure 2.6 Highway-Railroad Crossing with Steep Profiles or Bumps

NTS
**TABLE 2.4 Unobstructed Viewing Distance (Feet)**

<table>
<thead>
<tr>
<th>Train Speed (MPH)</th>
<th>Passenger Car</th>
<th>Single Unit Truck</th>
<th>Bus</th>
<th>WB-50 Semi-Truck</th>
<th>85ft Double Truck</th>
<th>Pedestrian</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>105</td>
<td>185</td>
<td>200</td>
<td>225</td>
<td>240</td>
<td>180</td>
</tr>
<tr>
<td>20</td>
<td>205</td>
<td>365</td>
<td>400</td>
<td>450</td>
<td>485</td>
<td>355</td>
</tr>
<tr>
<td>25</td>
<td>255</td>
<td>455</td>
<td>500</td>
<td>580</td>
<td>805</td>
<td>440</td>
</tr>
<tr>
<td>30</td>
<td>310</td>
<td>550</td>
<td>600</td>
<td>675</td>
<td>725</td>
<td>530</td>
</tr>
<tr>
<td>40</td>
<td>410</td>
<td>730</td>
<td>785</td>
<td>886</td>
<td>965</td>
<td>705</td>
</tr>
<tr>
<td>50</td>
<td>515</td>
<td>910</td>
<td>995</td>
<td>1123</td>
<td>1205</td>
<td>800</td>
</tr>
<tr>
<td>60</td>
<td>615</td>
<td>1065</td>
<td>1195</td>
<td>1345</td>
<td>1445</td>
<td>1080</td>
</tr>
<tr>
<td>70</td>
<td>715</td>
<td>1275</td>
<td>1395</td>
<td>1570</td>
<td>1680</td>
<td>1235</td>
</tr>
<tr>
<td>80</td>
<td>820</td>
<td>1460</td>
<td>1590</td>
<td>1790</td>
<td>1925</td>
<td>1410</td>
</tr>
<tr>
<td>90</td>
<td>920</td>
<td>1640</td>
<td>1790</td>
<td>2015</td>
<td>2165</td>
<td>1685</td>
</tr>
</tbody>
</table>

Source: Guidance on Traffic Control Devices at Highway-rail Grade Crossings by FHWA

---

**FIGURE 2.7 Required Sight Distance from Stop Line**

Note:
1. If the actual viewing distance is less than D, then automatic gates and flashing lights shall be installed at the crossing.
Notes:
1. The arrow symbol at the entrance of the turn lane is mandatory.
2. The arrow symbol nearest the crosswalk on the turn lane should be located at the point of curvature (PC).
3. The arrow symbol closest to the crosswalk shall be installed 20 feet behind the stop bar.
4. The active turn restriction sign must be only visible when the turn prohibition is in effect.

Figure 2.10 Sample Traffic Control for Exclusive Right Turn Lanes
NTS
FIGURE 2.11 Sample Traffic Control Devices with Pre-signal
Notes:
1. D is the minimum stopped sight distance required for a driver to stop before reaching the crossing.
2. Adequate Stopping Sight Distance allows roadway users to bring their vehicles to a safe controlled stop at least 15' short of the nearest rail.
3. If the crossing does not have adequate stopping sight distance, a stop sign (R1-1) or yield sign (R1-2) should be placed.
4. See subsequent figures for applications of traffic control devices.

<table>
<thead>
<tr>
<th>Design Speed (MPH)</th>
<th>Length of Leg</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>70</td>
</tr>
<tr>
<td>20</td>
<td>90</td>
</tr>
<tr>
<td>25</td>
<td>115</td>
</tr>
<tr>
<td>30</td>
<td>140</td>
</tr>
<tr>
<td>35</td>
<td>165</td>
</tr>
<tr>
<td>40</td>
<td>195</td>
</tr>
<tr>
<td>45</td>
<td>220</td>
</tr>
<tr>
<td>50</td>
<td>245</td>
</tr>
<tr>
<td>55</td>
<td>285</td>
</tr>
<tr>
<td>60</td>
<td>326</td>
</tr>
<tr>
<td>65</td>
<td>365</td>
</tr>
<tr>
<td>70</td>
<td>405</td>
</tr>
<tr>
<td>75</td>
<td>445</td>
</tr>
<tr>
<td>80</td>
<td>485</td>
</tr>
</tbody>
</table>

Source: A policy on Geometric Design of Highways and Streets by AASHTO

FIGURE 2.12 Stopping Sight Distance for Crossings with No Traffic Controls

Typical Applications:
Case 1.
- a) Low traffic volumes
- b) < 2 trains per day

Case 2.
- a) Frequent use by trains
- b) Flagging operations provided for trains
- c) Low moderate traffic volumes (5000 vpd)
2.3 Traffic Signal Pre-emption/Interconnection

Traffic signal railroad pre-emption refers to a wired system that enables a traffic signal to change in color when a train approaches. The system consists of a wired connection between the train detection system and the traffic signal controller at an intersection located near the railroad crossing. The idea of railroad pre-emption is to coordinate the operations of the highway-railroad crossing with a traffic signal at an adjacent intersection so that traffic safely clears the highway-rail crossing area before the train arrives. In other words, the objective of railroad pre-emption is to avoid the entrapment of vehicles at the highway-rail road crossing.

According to the MUTCD 2003 Edition, Highway traffic control signals located at intersections within 200 feet of a highway-railroad crossing should be preempted by the approach of a train. Signals located at intersections further than 200 feet from a highway-railroad crossing may be preempted if traffic volume, vehicle mix, vehicle and train approach speeds, frequency of trains and queue lengths create a safety concern such as vehicles queuing across at the highway-rail crossing. The effects of these factors on safety should be determined by an engineering study.

In order to clear vehicles queued on the tracks, the traffic signal is pre-empted to provide a short green interval to the respective intersection approach. In other words, when the traffic control signal is pre-empted by the train movements, the traffic signal provides the proper change intervals follow by a green interval to the approach crossing the track. Once the track is cleared, the traffic signal is programmed to provide red indications that prevent vehicles from entering the track area, while at the same time, it allows the other traffic movements that do not conflict with the railroad movements to operate on a semi-regular basis. When possible and practical, turning movements from the intersection towards the highway-rail crossing should be prohibited through the use of blank out signs that display “NO Right Turn” or “NO Left Turn” as appropriate (see table 2.1 for more information).

Historically, traffic signals were pre-empted to provide a flashing red indication on all approaches that would conflict with the train and a flashing yellow signal on the approaches that would not. This practice is still employed today in special cases where operational issues result from the green, yellow and red signal pre-emption indications.

In designing pre-emption, the following elements should be considered: intersection geometries, vehicular volumes, queue lengths and dissipation rate, proximity of the crossing to the intersection, train movements, approach speeds for trains and motor vehicles, public transportation vehicles, school buses, trucks carrying hazardous materials and other long vehicles that may pose a problem.

Detection systems

Consistent warning times are important because they encourage driver compliance with the traffic controls. False activations in train detection systems affect the system credibility which can affect driver behavior. According to the MUTCD (1), flashing-light signals shall operate for at least 20 seconds before the arrival of any train. Note that trains may run at different speeds, and therefore, special devices or circuits should be strategically located to provide adequate notice to the crossing system. An engineering study should be conducted to determine the amount of extra warning time that the system should provide. According to the US DOT (2), the engineering study should take into account the following elements:

- Track clearance distances due to multiple tracks and/or angled crossings
- Close proximity of a highway intersection controlled by a stop sign where vehicles have a tendency of stopping on the crossing.
• Long tractor-trailer vehicle activity
• Activity of vehicles required to make a mandatory stop before proceeding over the crossing.
• Control devices connected to other highway traffic signal systems
• Five seconds should be provided between the time the gates are fully lowered and when the train reaches the crossing.
• Pedestrian activity
• Difference in level between the crossing and the approaches
• Additional time needed to accommodate a four-quadrant gate system.

Different types of detection systems are used for signal pre-emption as follows:
• DC, AC-DC or AFO Grade crossing island and approach circuits. They consist of two components a battery or transmitter at one end of the affected track and a relay, receiver or diode at the other end. The system works when a train on the section of the affected track will shunt the circuit and de-energize the relay.
• Motion Sensitive Devices (MS). MS devices activate the traffic control devices for all the train located within the approach circuit.
• Constant Warning Time (CWT) Systems. These systems detect trains and have the capability of determining the distance from the position of the train to the crossing and the speed of the train.

In addition to these systems, video detection can be used to detect trains approaching the crossing as well as to surveillance vehicle, bicycle and pedestrian intrusion at the crossings.

At locations where multiple or successive pre-emption may occur from differing modes, train actuation shall receive first priority and emergency vehicles second priority.

When a crossing is located only a few car lengths from the signalized intersection’s stop line, it is likely that vehicles will queue across the tracks during the red interval of each cycle. Although the track clearance interval of the preemption sequence may provide sufficient time to allow vehicles in the track area to proceed through the intersection, occasionally an anxious driver may stall the vehicle and not clear the crossing. Additionally, when a crossing is located a significant distance away from a signalized intersection, providing pre-emption can be complicated because it requires long approach circuits along the tracks which become complex and expensive to implement. As a solution to these issues, a pre-signal or a queue cutter flashing-light beacon may be used. Pre-signals and queue cutter flashing-light beacons are described in Section 3 of this report.

3.0 IDENTIFICATION OF NEW PRACTICES

This section of the report identifies some of the new practices that are being used by different agencies abroad, and some new techniques that are still being tested. This section is intended to provide practitioners with information and insight into these new practices. It is also intended to assist and/or encourage practitioners in developing new and better techniques to apply to highway-rail crossings when special circumstances allow experimentation.

3.1 Where are we headed with Highway-Rail Crossing Controls?
This is an interesting question. If one considers the origin of the controls that are used today, it is easy to see that highway-rail crossing controls have evolved over time to adapt to changing needs and conditions. It is important to note, that the railroad companies are responsible for maintaining the active controls in the railroad right-of-way, such as gates and flashers. Each
railroad company has a large system of these crossing controls that are spread out over several states. As a result, it is in their interest to standardize these controls to minimize costs, simplify their inventory of parts and tools, simplify training and equipment for staff, and to maximize the reliability of their systems. Therefore, any changes to these controls will naturally meet some resistance. However, if there are clear advantages and funding sources available, there may be reason for change. With significant technology advances over the past few decades, there are some off-the-shelf type equipment that could easily be integrated in the railroad right-of-way. These include:

Video Detection – Traffic Signal Detection cameras could be used or modified to detect oncoming trains. Advantages that they may offer include:
- The ability to set more than one detector, and therefore provide advance detection.
- The ability to mount the unit on the railroad signal post, this negates long conduit runs.
- The ability to provide a video signal to a control center.
- Reliability

Flashing-Lights that display both yellow and red indications - The flashing yellow indication could be used to introduce a change interval prior to the flashing red indication. This practice would be consistent with the change intervals employed at all traffic signals.

Advance Detection and Signal Cycling – A recent study performed by the Northern Arizona University identifies benefits that can be realized by using the advance detection of trains in conjunction with traffic signals that operate with railroad pre-emption. The benefits are realized by clearing the traffic movements that will be prohibited during a train crossing prior to the train arriving. This minimizes the queuing of traffic while the train is present and reduces the occurrence of vehicles that may need to be cleared from the tracks.

3.2 Pre-Signals
A simple definition of a “Pre-Signal” is a typical traffic signal that displays red, yellow and green lights and is installed on the approach to a railroad crossing for the purpose of stopping traffic in advance of the railroad tracks. Figure 3.1 provides an illustration of a pre-signal.

![Figure 3.1 Pre-signal at Highway-railroad crossing (2)](image-url)
The 2003 MUTCD defines a “pre-signal” and its use in the following terms:

Guidance:
If a highway-rail grade crossing is located within 15 m (50 ft) (or within 23 m (75 ft) for a highway that is regularly used by multi-unit vehicles) of an intersection controlled by a traffic signal, the use of pre-signals to control traffic approaching the grade crossing should be considered.

Standard:
If used, the pre-signals shall display a red signal indication during the track clearance portion of the signal preemption sequence to prohibit additional vehicles from crossing the railroad track.

Guidance:
Consideration should be given to using visibility-limited signal faces (see section 4A.02) at the intersection for the downstream signal faces that control the approach that is equipped with the pre-signal.

Option:
The pre-signal phase sequencing may be timed with an offset from the signalized intersection such that the railroad track area and the area between the railroad and the downstream signalized intersection is generally kept clear of stopped vehicles.

Standard:
If a pre-signal is installed at an interconnected highway-rail grade crossing near a signalized intersection, a STOP HERE ON RED (R10-6) sign shall be installed near the pre-signal or at the stop line if used. If there is a nearby signalized intersection with insufficient clear storage distance for a design vehicle, or the highway-rail grade crossing does not have gates, a NO TURN ON RED (R10-11) sign shall be installed for the approach that crosses the railroad tracks.

Option:
At locations where a highway-rail grade crossing is located more than 15 m (50 ft) (or more than 23 m (75 ft) for a highway regularly used by multi-unit vehicles) from an intersection controlled by a traffic control signal, a pre-signal may be used if an engineering study determines a need.

If highway traffic signals must be located within close proximity to the flashing light signal system the highway traffic signals may be mounted on the same overhead structure as the flashing light signals.

The offset of the start of green between the pre-signal and the intersection is typically zero when the highway-rail crossing is close to the intersection. In other words, the pre-signal and intersection approach signal turn green at the same time. However, the offset of the end of green is such that the pre-signal turns yellow and then red first while the intersection stays green to clear any traffic that may queue in the track area.

In order to avoid driver confusion, the downstream green signal indication should only be visible from the immediate approach and should not be visible at the approach to the pre-signal. To accomplish this, it is highly recommended to equip the downstream green signal with programmable visibility indicators or louvers.

For a more detailed account of the use of Pre-Signals, the reader should reference Technical Memorandum #1 Before and After Evaluation of the Pre-Signal Control at the Prince Road/I-10 UPRR Railroad Crossing, May 2006 (3).

3.3 Queue Cutter Flashing-Light Beacon
The queue cutter flashing-light beacon is located on the departure side of the highway-railroad crossing and is typically activated by a loop or video detection system. When growing queue
between the highway crossing and the highway-railroad crossing is detected, the system activates the beacon to inform motorists not to stop on the tracks. Its purpose is to minimize the queuing of traffic over railroad tracks. The queue cutter flashing-light beacon should be used in conjunction with the “Do Not Stop on Track” sign (R8-8). It is recommended to activate the queue cutter flashing-light beacon only when the traffic signal indication at the intersection approach is not green. The queue cutter flashing-light beacon system may be an alternative for pre-signals, particularly when the railroad crossing is too far away from a traffic signal to consider a pre-signal.

3.4 Median Separation
At many highway-rail crossings, motorists are able to drive around the gate when it is down by crossing the center of the roadway, thereby committing a “crossing gate” violation. In order to decrease the number of crossing gate violations, access to opposing lanes can be restricted with the placement of different median types at the crossing. These median countermeasures are described below:

- **Barrier wall systems** – These consist of concrete barriers and/or guardrails installed in advance of the crossing to prevent drivers from driving around gates and crossing into opposing lanes. These systems work as deterrents for crossing gate violations.

- **Wide Raised medians** – consist of curbed medians that discourage drivers from driving around gates and into opposing lanes. While these are not true barriers, and are not true barriers, drivers would have significant difficult trying to cross into the opposing lanes. Wide raised medians combined with landscaping may be aesthetically pleasing and also provide space for gates and flashing lights to be installed in the median.

- **Non-Mountable curb islands** – consist of a curbed median with vertical, non-mountable curbing. They are very effective in discouraging violators and can be relatively small in size and narrow in width. Therefore, they provide a cost effective solution that can be installed in a minimum of width and length. They tend to be more of an urban/suburban application.

- **Mountable raised curb islands** - provide drivers with a visual barrier for driving around gates and crossing into opposing lanes. They are designed to allow emergency vehicles to cross and, as a result, they are more susceptible to violations than other median treatments.

The choice of the median countermeasures above may be partly based on the level of violations that occur. A median separation may be applicable where there is a greater risk for accidents such as a rail crossing with several tracks and heavy traffic volumes. In other words, if there is a serious violation rate or safety issue, a barrier wall system may be the best application. For most locations, a curbed median is adequate to improve compliance and/or address safety.

3.5 Four-Quadrant Traffic Gate Systems
Four-quadrant traffic gate systems were created to improve safety and compliance at highway-rail crossings where median grade separations are not feasible or effective. The four-quadrant gate system consists of gates on each side of the road on both sides of the highway-rail crossing resulting in four gates for the crossing. With this system, the gates block the approach lane as well as the opposing lane, which results in an obstruction all the way across the roadway to deter violators from attempting to cross the tracks when the gates are down. A typical application for four quadrant gates are two-lane roadways where there is no space for a
median and a violation or complex situation, such as a wide crossing of several tracks exists. Figure 3.2 illustrate a crossing equipped with a Four-Quadrant gate system.

![Figure 3.2 Four-Quadrant Traffic Gate Systems (4)](image)

3.6 Barrier System
Barrier systems are moveable barriers designed to prevent the intrusion of vehicles onto the railroad tracks at highway-rail road crossings. These barriers should be designed based on NCHRP Report 350. Vehicle arresting barriers are a type of barrier system consisting of flexible netting across the highway approach that is attached to an energy absorption system. Vehicle arresting barriers are raised and lowered by a tower lifting mechanism. Another barrier system is the safety barrier gate which is a gate consisting of three steel cables that fit into a locking assembly. Electro-mechanical components lower and raise the gate arm.

![Figure 3.3 Stopgate Road Safety Barriers (4)](image)

Barrier systems are relatively expensive and more complicated to maintain than railroad crossing gates; therefore, these treatments are not normally employed unless there is a demonstrated problem at a crossing.
3.7 Active Advance Warning Signs with Flashers
Active advance warning signs are electronic signs with an illuminated message that is activated by the presence of a train. These signs include two flashing-light indications. These signs may be used at locations where sight distance is restricted on the approach to a crossing and drivers cannot see the flashing-light signals in time to make a safe stop.

3.8 Active Turn Restriction Signs
An active turn restriction sign (R3-1a or R3-1b) should be used if the intersection is located within 200 feet of the highway-rail crossing and the intersection traffic control is pre-empted by the approach of a train. Turning movements toward the highway-rail crossing shall be prohibited during pre-emption; therefore, these signs shall be visible only when a train activates the highway-rail crossing controls.

3.9 Quiet Zones
A growing concern related to railroad crossings is the noise associated with the train approaching a highway/rail crossing. For many years, it has been required by law that a train activates its horn when approaching a railroad crossing as a safety measure to warn motorists, pedestrians and others of the approaching train. While a train’s engine and wheels typically generate a significant level of noise, the sound of their horn is much louder. In response to this, some communities have pursued what has been termed “Quiet Zones” in an effort to improve their quality of life. A quiet zone is an area where trains do not use their horn on the approach to a crossing; however, additional safety devices need to be installed to protect and warn the public of the arrival of a train to the crossing.

A recent revision to the federal laws that require the use of horns at highway/rail crossings was published in the Federal Register, Volume 70, No. 80 on April 27, 2005 entitled Part II Department of Transportation, Federal Rail Road Administration, 49 CFR Parts 222 and 229 Use of Locomotive Horns at Highway-Rail Grade Crossings; Final Rule (6). This Final Rule of the use of locomotive horns at highway-rail grade crossings establishes the application of quiet zones. This Rule preempts any State statutory or common law, local ordinance or State or local regulatory agency from governing locomotive horn use at public highway-railroad crossings. The effective date of the final rule was June 24 of 2005.

The Final Rule of the use of locomotive horns at highway-rail grade crossings establishes two types of quiet zones: partial quiet zones and quiet zones (complete quiet zones). Partial quiet zones require train horns to be silenced for a portion of the day (typically during night time hours). For complete quiet zones horns are silenced during the whole day.

The two basic requirements to establish quiet zones are:
- Quiet zones shall be at least one half mile in length along the railroad right-of-way, as shorter zones would be ineffective.
- Advance warning signs shall be posted that advise motorists and pedestrians that trains do not sound their horns. These signs typically consist of (W10-9) “NO TRAIN HORN”, and if applicable (S4-1) “10 p.m. to 7 a.m.”

A quiet zone may be implemented by installing one or more of the following supplementary safety measures (SSMs):
- Temporary closure of a public crossing (close the crossing during the designated quiet periods).
- Four-quadrant gate system.
- Gates with medians or channelization devices.
Another way to implement quiet zones is by estimating the Quiet Zone Risk Index (QZRI). The QZRI shall be at or lower than the National Significant Risk Threshold which is 17,030. The QZRI is the average of the risk index of all the crossings in the quiet zone. “The risk index is basically the predicted cost to society of the causalties that are expected to result from the predicted collisions at a crossing” (6). Note that the implementation of SSMs reduce the QZRI. In addition to supplementary safety measures (SSMs), other safety measures that may be considered while establishing quiet zones are alternative safety measures (ASMs).

The procedures to implement a quiet zone are described in the Final Rule of the Federal Register referenced above. These procedures are complex and too detailed to describe in this report. Therefore, any local agency wishing to pursue the implementation of a quiet zone should obtain a copy of the Final Rule, which is available on-line at:

http://a257.g.akamaitech.net/7/257/2422/01jan20051800/edocket.access.gpo.gov/2005/pdf/05-3285.pdf

More information and electronic calculators related to establishments of quiet zones are available at: http://www.fra.dot.gov/us/content/1318

4.0 INVENTORY OF HIGHWAY-RAIL GRADE CROSSINGS IN THE PAG REGION

The US Department of Transportation has a program called “US DOT National Highway-Rail Crossing Inventory Program”. This program is administrated by the Federal Railroad Administration (FRA) and collects data throughout the country related to highway-railroad crossing features such as location, physical data, vehicular data, train data and safety data. A list of these variables within the FRA dataset, as well as their definitions, is shown in Appendix B.

According to the National Highway-Rail Crossing Inventory, there are 205 highway-railroad crossings in Pima County. The majority of these highway-railroad crossings are located along the two main lines that are operated by Union Pacific Railroad Company. In an effort to make this inventory data more accessible, a set of variables gathered from the Federal Railroad Administration website (7) and another set of variables collected by Pima Association of Governments were imported into a Geographic Information System (GIS). GIS is a system of hardware and software that stores, retrieves, analyzes and displays geographic data. Figure 4.1 was generated by the GIS system and illustrates the Highway-Railroad crossings in the PAG Region, as well as the main Railroad lines.

The data imported into GIS include some of the variables available in the Highway-Railroad Crossing inventory database. The variables were selected based on their importance for users of public agencies and private sector (consultants). The variables are described in Table 4.1.

The variables collected by Pima Association of Governments in previous years contain detail data features at the crossing. These variables provide information of 205 highway-Railroad crossings located in Pima County. A sample of this dataset is provided in Appendix C.
Table 4.1 Variables in the GIS database

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CROSSING</td>
<td>Crossing No.</td>
</tr>
<tr>
<td>CITYCD</td>
<td>City</td>
</tr>
<tr>
<td>STREET</td>
<td>Street or Road Name</td>
</tr>
<tr>
<td>TYPEXING</td>
<td>Type of Crossing</td>
</tr>
<tr>
<td>POSXING</td>
<td>Position of Crossing</td>
</tr>
<tr>
<td>DAYTHRU</td>
<td>Day Thru Train Movements</td>
</tr>
<tr>
<td>DASYWT</td>
<td>Switching</td>
</tr>
<tr>
<td>NGHTTHRU</td>
<td>Night Thru Train Movements</td>
</tr>
<tr>
<td>NGHTSWT</td>
<td>Night Switching Movements</td>
</tr>
<tr>
<td>MAXTTSPD</td>
<td>Maximum Timetable Speed</td>
</tr>
<tr>
<td>MAINTRK</td>
<td>Main</td>
</tr>
<tr>
<td>HWYPVED</td>
<td>Is Highway Paved?</td>
</tr>
<tr>
<td>SURFACE</td>
<td>Crossing Surface:</td>
</tr>
<tr>
<td>TRAFICLN</td>
<td>No. of Traffic Lanes Crossing</td>
</tr>
<tr>
<td>TRUCKLN</td>
<td>Are Truck Pullout Lanes Present (Y/N)?</td>
</tr>
<tr>
<td>HWYCLASS</td>
<td>Functional Classification of Road at Crossing:</td>
</tr>
<tr>
<td>AADT</td>
<td>AADT</td>
</tr>
<tr>
<td>PCTTRUK</td>
<td>Estimate Percent Trucks:</td>
</tr>
<tr>
<td>LATITUDE</td>
<td>Latitude</td>
</tr>
<tr>
<td>LONGITUD</td>
<td>Longitude</td>
</tr>
<tr>
<td>SCHLBUS</td>
<td>Avg. No. of School Buses Passing Over the Crossing on a School Day</td>
</tr>
<tr>
<td>XINGOWNR</td>
<td>Crossing Owner</td>
</tr>
<tr>
<td>AADTYEAR</td>
<td>Year for AADT</td>
</tr>
<tr>
<td>RRCONT</td>
<td>Railroad Contact</td>
</tr>
<tr>
<td>HWYCONT</td>
<td>State Contact</td>
</tr>
<tr>
<td>POLCONT</td>
<td>Emergency Contact</td>
</tr>
<tr>
<td>TOTALTRN</td>
<td>Total Trains</td>
</tr>
<tr>
<td>TOTALSWT</td>
<td>Total Switching Trains</td>
</tr>
<tr>
<td>GATES</td>
<td>Gates</td>
</tr>
</tbody>
</table>

4.1 Data Availability and Their Applications

By incorporating these data sets into a GIS, a shape file was created. This shape file will be available at the PAG website: http://www.pagnet.org/RDC/ under “GIS Interactive”. Due to the visualization limitation on the PAG website, not all of the variables and data included in the FRA and PAG datasets will be available on this site. However, a user will have the capability of visually locating a Highway-Railroad crossing, zooming in on it on a street map and obtaining information related to train and vehicular traffic as well as location characteristics.

In addition, the shape file with the complete set of railroad crossing variables is available from PAG. Key contacts for this information are Don Freeman, Manny Rosas and Paul Casertano. The advantage of using the shape file is that the user would have the ability to query data for all of the Highway-Railroad crossings at the same time. In other words, the user will be able to visually identify a particular attribute and only show those crossings with that particular crossing on the GIS map. To illustrate, Figure 4.2 shows the Highway-Railroad crossings in the Tucson metropolitan region with 10 or more thru train movements, and Figure 4.3 displays the Highway-Railroad crossings with 4 or more traffic lanes crossing the railroad.
Figure 4.1 Highway-Railroad Crossings in the Tucson Metropolitan Region
Figure 4.2 Highway-Railroad Crossings with 10 or more Day Thru Train Movements
Figure 4.3 Highway-Railroad Crossings with 4 or more Traffic Lanes Crossing the RR
The Arizona Department of Transportation also maintains a database of Highway-rail crossing data. A sample list of the ADOT inventory is included in Appendix D.

5.0 PLANNING, FUNDING AND PROGRAMMING PROCESSES FOR HIGHWAY-RAIL CROSSING IMPROVEMENTS

The purpose of this Section is to provide an overview of the planning and programming processes and funding sources available for highway-rail crossing improvement projects. The planning of improvements depends somewhat on the magnitude of the improvement that is needed. For the purposes of this report, two categories of improvements are identified to discuss the planning and programming of highway-rail crossings. They are Major Capital Improvements and At-Grade Improvements. These categories follow different planning and programming processes.

Major Capitol Improvements refer to improvements that either remove, relocate, reconfigure, or grade separate the rail and highway facilities. These types of improvements typically remove the conflict of traffic crossing the railroad tracks and tend to have a very high cost. They typically take a considerable amount of time such as 5 or more years to program, fund, design and construct. At-grade Improvements are relatively much lower in cost and are focused on improving the conditions of an existing highway-rail crossing. Some of these types of improvements can be implemented quickly, such as signing and striping improvements, and others may take a few years to implement if they involve the railroad company and federal funding sources. The following Table provides a summary of highway-rail crossing improvement types.

<table>
<thead>
<tr>
<th>Improvement Category</th>
<th>Strategy</th>
<th>Cost</th>
<th>Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major Capitol Improvement Projects</td>
<td>Realign Railroad</td>
<td>Very High</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Realign Highway</td>
<td>Very High</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Grade Separation</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Roadway Projects with Highway-Rail Issues</td>
<td>Moderate</td>
<td>Low-High</td>
</tr>
<tr>
<td>At-Grade Crossing Improvements</td>
<td>Geometric and Physical Improvements</td>
<td>Low-Moderate</td>
<td>Low-Moderate</td>
</tr>
<tr>
<td></td>
<td>Gates</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Flashing Lights</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Surface Treatments</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Signing and Striping</td>
<td>Very Low</td>
<td>Very Low</td>
</tr>
<tr>
<td></td>
<td>Pre-Signal</td>
<td>Low</td>
<td>Low-Moderate</td>
</tr>
<tr>
<td></td>
<td>Signal Timing and Pre-emption</td>
<td>Low</td>
<td>Low-Moderate</td>
</tr>
<tr>
<td></td>
<td>Electronic Signs</td>
<td>Low-Moderate</td>
<td>Low-Moderate</td>
</tr>
<tr>
<td></td>
<td>New/Innovative Improvements</td>
<td>Low-Moderate</td>
<td>Low-Moderate</td>
</tr>
</tbody>
</table>

The following subsections describe these improvements in more detail, the funding sources that can be used and the processes that apply to different types of improvements.

5.1. Major Capital Improvement Projects that Address Highway-Rail Crossings

The best solutions for addressing the conflicts that potentially occur at a highway-rail crossing are those that eliminate the crossing itself. These types of improvements are generally very high in cost and therefore can be categorized as Major Capital Improvement Projects that
address highway rail crossings. These types of improvements typically include grade separations between the railroad and street system, such as a bridge over the tracks, and sometimes can involve the realignment of the railroad or highway to avoid or minimize crossings.

a. Highway-Rail Grade Separations
Grade separations between highways and the railroad tracks involve the construction of bridges or underpasses to allow the highway to go over or under the railroad tracks for the primary purpose of removing the highway-rail crossing conflict. Typically, the grade of the highway is less expensive and easier to change than the grade of the railroad tracks. This is primarily due to the allowable grades and differential in grades of rail which have significantly more impacts than those for streets and highways. In other words, to change the grade of a railroad, several miles of track reconstruction may be involved compared to thousands of feet of street or highway. Other reasons that may preclude the change of the grade of railroad tracks include the willingness of the railroad company to allow such a change, the lack of public funding sources that can be used for the railroad tracks, noise, safety, cost, operation, project schedule, and other impacts.

In the PAG Region which is primarily the Tucson Metropolitan Area, several examples of grade separations between railroad tracks and highway facilities exist. These include the underpasses with the UPRR tracks such as the 4th Avenue underpass north of downtown area of Tucson and the Orange Grove Road underpass at the I-10/Orange Grove Road interchange. Overpasses include the 22nd Street bridge over the UPRR/Barraza-Aviation Highway and the Houghton Road bridge over the UPRR tracks north of I-10.

Specific Grade Separation projects have been programmed for design and construction in the past few years. Examples include the I-10/Ina Road interchange which is currently programmed for construction in 2011.

b. Highway Projects that Address Highway-Rail Grade Separations
Most projects that involve highway-rail grade separations are projects that were programmed with the primary intent of improving the highway and have the added element of addressing a highway-rail crossing. In the development of the purpose and need of the project, it becomes evident that an important element of improving the roadway is eliminating the highway-rail crossing. As a result, the grade separation improvement is funded as part of the roadway project. A grade separation is not always a feasible solution, as they are costly to construct. However, the planning and design process of major streets and highways should consider the possibility of a grade separation for roadway facilities that run parallel to or cross railroad tracks.

Programmed highway projects present a valuable opportunity and a funding source to improve or eliminate highway-rail crossings. It is usually far more economical and feasible to construct a grade separation as part of a major roadway project than as a stand alone project.

c. Highway Realignment Projects
Highway Realignment projects developed for the primary purpose of eliminating rail-highway crossings are a viable solution, but these types of projects are rare. Typically the roadway is easier to realign as vehicles can turn horizontally and climb vertical grades much easier than trains can; therefore, a roadway is usually more feasible to realign than railroad tracks are.

A current example of redesigning a major road with an at grade crossing is the I-10, Prince Road to Ruthrauff Road project. The purpose of this project is to widen I-10 from 3 to 4 lanes in
each direction. Currently, Prince Road crosses the Union Pacific Railroad track at grade and proceeds under the I-10Mainline, forming a typical diamond interchange below the grade of the interstate. To address the rail crossing on Prince Road adjacent to the I-10/Prince Road interchange, the project was modified to vertically realign I-10 to match the grade of the railroad tracks and design Prince Road with structures over both the interstate highway and the railroad tracks, resulting in a grade separation. In this case, both Prince Road and I-10 will be realigned to facilitate the grade separation. This project is also a good example of a Highway Project that was used as an opportunity to provide a grade separation at a busy highway-rail crossing.

d. Rail Realignment Projects
As mentioned previously, rail realignment projects are somewhat rare as they present many challenges. First, it is typically not in the interest of a rail company to realign a track or set of tracks, as it is very costly, requires the purchase of new right-of-way, and may have significant impacts on adjacent properties. In addition, unlike highways, introducing a curve or grade change to a set of railroad tracks often involves several miles of railroad track, as the curves and grades used for railroads are much slighter and longer than those accepted for roadways.

e. How to Program a Major Capital Improvement for Highway-Rail Crossings
If a local agency desires a major capital improvement for a highway-rail crossing, such as a grade separation, the project needs to be programmed into the PAG Transportation Improvement Program (TIP). The process to program a major capital improvement project is a lengthy process with several steps. To provide an overview of this process, the following basic steps are described:

Step 1 The local agency identifies the need for the project – In this step the local agency typically provides a preliminary cost estimate of the improvement to be considered. In addition, the local agency must decide how to fund the project. If the local agency decides to fund the project with its own resources, then the project will be entered into the TIP automatically. If the local agency wants to fund the project with regional funds received by PAG, then Step 2 applies.

Step 2 The local agency requests regional funding – To request regional funding the local agency must submit factual data regarding the need for the project. This factual data may be in the form of the amount of users that will benefit by the project, the strategic location of the project, the safety benefits of the project and any other benefits that may be realized. Requests are typically submitted once a year at the beginning of the PAG TIP process.

Step 3 The PAG TIP committee receives all requests from the local agencies – Once received the TIP Committee reviews all requests and compares projects based on several factors. These factors include the number of users that will benefit by the improvement, proximity to key destinations, safety concerns, environmental improvements, etc. For each of these factors, the PAG TIP assigns a score and determines a total score for each project. The projects are then ranked in order of their score and a preliminary TIP is formulated based on ranked score.

Step 4 PAG TIP reconsiders the preliminary TIP to ensure that each agency receives a fair share of the funding. If there is an unbalance of funding, the Committee will ask one or more of the local agencies with a higher share of the funding to withdraw a project or two from the program. The funding is then redistributed to a project or projects within the local agencies that have a lower share of the funding.
Technical Memorandum #2
Final Report
Highway/Railroad Crossings – A Toolbox of Strategies

Step 5 The TIP is Revised for final review – the final review consists of a public review of the document, where comments are received. In addition, the TIP improvements are input into PAG’s Transportation Model and checked. The Tip improvements are also entered into an air quality model. Based on the comments from the public and the findings of the modeling efforts, the TIP is revised to a final form.

Step 6 The Final TIP is sent to the Regional Council for approval. Once approved the TIP is sent to ADOT and then the FHWA for final approvals. Once the final approval from the FHWA is received the plan becomes official and the funding sources are binding.

5.2 At-Grade Highway-Rail Crossing Improvement Projects

At-grade rail-highway crossing improvements include a wide variety of relatively low cost improvements as identified in Table 5.1. Several ways to fund and implement these improvements are described in this subsection. They include:

- Roadway Projects that Address Rail-Highway Crossings
- Emergency Projects through the ACC.
- Local Agency Funding
- Local Agency Implementation
- Private Development Funded Projects.

A specific funding source known as the STP-HES 130 Program, which is available at the state level, is described in subsection 5.3.

a. Emergency Projects through the ACC

In special cases, the Arizona Corporation Commission (ACC) has the authority to make the railroad pay for highway crossing improvements. In emergency situations, such as an extreme accident trend or an unusual emergency, the ACC may require that the railroad improve a crossing. A hearing will be held by the ACC to determine a course of action to rectify a problem. The ACC will commit an opinion and approve an order for the railroad to make the necessary improvements. Typically the railroad will be responsible for ½ the cost of the improvements and the local agency will be responsible for ½ of the funding.

b. Roadway Improvement Projects that include RR Crossings

Funding earmarked for roadway projects is normally used to pay for highway-rail crossing upgrades if the crossing is located within the project limits and if the crossing needs to be improved to coincide with the roadway improvements. For example, a roadway being widened from three to five lanes would require that the pavement at the railroad tracks be widened, and new gates and flashers be installed outside the new edge of pavement. In such a case, the funding for the railroad crossing improvements comes from the project budget.

The process to implement the highway-rail crossing improvements in the railroad right-of-way starts during the design process. The railroad crossing approval process may dictate the critical path of the design of a project as it involves the formulation of legal documents that follow specific approval procedures. The process to implement improvements inside railroad right-of-way is described in the following steps:

Process to Improve Railroad Crossings when HES-TP 130 Funding is not Used

Step 1 The rail-highway crossing improvements that need to be made must be identified on a conceptual basis.

Step 2 A written, legal Agreement between the railroad and the lead agency is made that indicates that the lead agency will pay for construction of the improvements within the
railroad right-of-way and that the railroad will maintain the improvements. This step takes 18-24 months on average.

Step 3 Once there is an Agreement, then the proposed changes to the crossing must be approved by the Arizona Corporation Commission. The ACC will review the requested changes and hold a public hearing to determine if the recommended changes are acceptable. Upon determining if they are acceptable, the ACC will issue a legal opinion and order for the work. This step typically takes 3-4 months.

Step 4 If the lead agency and/or its contractor must perform work within the railroad right-of-way as part of the construction project, an Easement must be processed with the railroad. This typically entails a description of the work involved and a payment by the lead agency to enter the railroad right-of-way.

**ADOT cannot bid a project for construction unless it has an Agreement with the railroad and an Opinion and Order from the ACC.** This is stated in the Special Provisions of all ADOT contracts.

To facilitate the railroad approval process, ADOT meets the Union Pacific Railroad Representative each month in Phoenix to discuss project issues and the progress of different projects. The State Railroad Liaison, Mr. Michael Delleo, schedules this meeting and has indicated that local agencies are welcome to schedule time to meet with the UPRR representative, Mr. Jim Smith, after the ADOT projects meeting. This presents an opportunity to local agencies to discuss project issues that they may have involving railroad crossings and railroad right-of-way.

**Contact Information:**

- Mr. Michael F. Delleo, Jr., P.E.
  ADOT – State Railroad Liaison
  205 S. 17th Avenue, Room 357, MD 618E
  Phoenix, AZ 85007
  (602) 712-8648
  e-mail: Mdelleo@azdot.gov

- Mr. James Smith
  Manager Industry & Public Projects
  Union Pacific Railroad
  10031 Foothills Boulevard
  Roseville, CA 95747
  (916) 789-6352
  e-mail: jhsmith@up.com

c. Local Agency Funding

Local agencies are able to fund and perform At-grade railroad crossing improvements. All work performed outside of the railroad right-of-way is the responsibility of the local agency. Work performed within the railroad right-of-way may or may not be the responsibility of the local agency. If an agency desires improvements such as an upgrade of gates, flashers and crossing surface treatments, STP-HES 130 funds are available (See Section 5.3 of this report for a description of this funding source). If this is the case, the process described in Section 5.3 for HES-STP 130 Funding applies.
In addition, a local agency can pay for improvements within the railroad right-of-way; however, it must enter into an Agreement with the railroad. If the local agency is willing to pay or has an improvement project that includes a railroad crossing, the process that a local agency must follow is essentially the same as the steps outlined in the Process to Improve Railroad Crossings when HES-SP 130 Funding is not Used in Section 5.1.b. of this report.

d. Private Development Contributions
New housing and/or commercial developments occasionally impact rail-highway crossings necessitating improvements to the crossing to accommodate the traffic that will be generated by the development. In such cases where the developer has agreed to fund or construct transportation improvements to mitigate impacts from his/her development, developers must work through the local, county or state agency when addressing highway-rail crossings. The railroad companies require that all agreements regarding highway-rail crossings be made with local, county or state government. Therefore, the local government is responsible for taking the lead when a private developer is funding the improvements.

As a result, the process to improve the railroad crossing with funding from private developers requires that the appropriate agency collect monies from the private developer. Once the local agency receives funding from the developer, the steps outlined in the Process to Improve Railroad Crossings when HES-SP 130 Funding is not Used in Section 5.1.b. of this report applies.

5.3 The STP-HES 130 Funding Program – Railroad Crossing Safety and Upgrades
The STP-HES Funding Source is part of the Federal Transportation Efficiency Act. This funding source has two components, one is the STP-HES 150 Hazard Elimination Program for streets and highways and the other is the STP-HES 130 Rail Crossing Program for the purpose of upgrading existing highway-rail crossings.

The typical Improvements funded by the STP-HES 130 Rail Crossing Program include the installation of new gates, flashing lights, and crossing surface treatments. A typical crossing that requires gates, flashing lights and a concrete surface currently costs approximately $250,000 to construct (2005). Given the program budget of $1.5 million per year, approximately 6 locations are programmed each year for improvement. This funding is available to all local agencies for use in addressing highway-rail crossings. Historically, no local match was required with the STP-HES 130 funds; however, according to Section 23 of USC 120(c) a match of 10% local funds will be required as part of the new Federal legislation. The only exceptions are crossing that only require flashing lights, which will still be funded 100% through the STP-HES 130 program. There are approximately 800-900 public highway-rail crossings statewide.

In addition to the standard gates, flashing lights, cross-bucks and surfacing, this program will also fund overhead flashing lights on cantilever structures for streets with multiple lanes and concrete headers on the approach side of the tracks where heavy traffic volumes exist. Therefore, roadways that have been widened with multiple lanes may qualify for overhead cantilever flashing lights.

The STP-HES 130 funding source will not cover certain types of improvements. Signing and Striping are the responsibility of the State, County or local agency. Similarly, traffic signal controls associated with railroad crossings, including pre-signals, are not covered. The items that are and that are not funded by this program are summarized in Table 5.2.
Table 5.2: Improvements Typically Funded by the STP-HES 130 Rail Crossing Program

<table>
<thead>
<tr>
<th>Items Funded by Program</th>
<th>Items Not Funded by Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>o Gates</td>
<td>o Signing</td>
</tr>
<tr>
<td>o Flashing Lights</td>
<td>o Stripping</td>
</tr>
<tr>
<td>o Surface Treatments</td>
<td>o Traffic Signals and Pre-signals</td>
</tr>
<tr>
<td>o Cantilever Flashing Lights</td>
<td>o Roadway and Intersection Geometry</td>
</tr>
<tr>
<td>o Approach Headers</td>
<td></td>
</tr>
</tbody>
</table>

a. Identifying and Prioritizing Crossings for Improvement

To determine which crossings should be addressed, the Arizona Department of Transportation has created an inventory of railroad crossing characteristics. From this inventory, a reference point index (RPI) is calculated based on the following criteria:

- Train Speed
- Average Daily Train Traffic
- Roadway Speed Limit
- Average Daily Vehicular Traffic

The RPI is calculated for each crossing statewide in a database by ADOT. A sample of the RPI Inventory List sorted for the Tucson area is included in Appendix D. The inventory for the whole State is then sorted in descending order of RPI. The top third of the list for the whole State is reviewed in detail and the crossings that do not require upgrades in terms of gates, flashing lights, and surface treatments are removed from the list.

While the RPI list is generally used to generate rail-highway crossing upgrade projects each year, ADOT also considers other locations suggested by local agencies. The local agencies are encouraged to use accident data and other statistics to identify crossings for improvement. In particular, ADOT requires 24-hour traffic count data at each crossing prior to considering it for improvement. Once a preliminary list of candidate projects is developed, ADOT sets up field reviews for each location to determine the specific improvements that are applicable. Agencies that participate in the field review are the FHWA, the representative local agency, the UPRR, the ACC, and ADOT. ADOT is the facilitator of this process. Based on the field reviews, the final projects to be programmed for the next fiscal year are determined.

b. Implementation of Programmed Projects

Once a list of projects is identified, including the location and type of improvements, the projects are entered into the STP-HES 130 Rail Crossing Project Program. Once in the program, a number of agreements need to be made for each project.

a. IGA - An Intergovernmental Agreement (IGA) is typically made between the State and the local agency. The IGA states that the State will administer federal funds to pay for the applicable improvements such as gates, flashing lights and surface treatments and that the local government is responsible for maintaining and installing the appropriate signing and striping, and resolving right-of-way issues and utility conflicts. A sample IGA is included in Appendix E for reference.

b. JPA – For Class I Railroads, such as UPRR and BNSF, who perform the improvements with their own forces, a Joint Project Agreement (JPA) is drafted between the State of Arizona and the corresponding railroad company. The document is prepared by the Utilities and Railroad Section of ADOT. The JPA includes a Scope of Work and the procedures for the railroad to bill ADOT for the work when completed. For smaller railroad companies that contract out the improvement services, a similar Joint Project Agreement (JPA) is drafted, including the scope of work and the procedures for billing.
Agreement is made between the State of Arizona and the railroad company after the railroad calls for bids according to the ADOT bidding process or the railroad may contract with a contractor with whom it has an ongoing maintenance contract, at a reasonable price. The railroad company is responsible for maintaining and paying for the electrical power to operate the controls, and the equipment is the property of the railroad company once installed.

Once the IGA and JPA are processed, the railroad company may move forward with constructing the improvements in the programmed year of the project.

To effectively manage the program and its funding, ADOT typically adjusts the Program each year based on funding limits and project readiness. For example, if an IGA is not processed by the programmed year, ADOT will push the corresponding project back in the schedule, and move another project up in its place that is ready to go to construction. In other words, the projects that have the IGA and JPA processes completed ahead of time are more likely to be moved up in the schedule.

The entire process for railroad crossing upgrade projects using STP-HES 130 funds from the diagnostic tour through the construction of the improvements ranges from 2-5 years.

c. The STP-HES 150 Safety Program
The STP-HES 150 Program can be used for any type of roadway safety improvement, including rail-highway crossings. However, this program normally has a funding limit per project of $3 Million. It also requires that the proposed improvement result in a benefit-to-cost ratio of 1.0 or greater. Typically, an engineering study is required that documents the safety problem, identifies a solution, estimates the accident reduction of the improvement and determines the benefit-to-cost ratio. The benefit is the reduction in accidents and the cost is the cost of construction and maintenance of the improvement. This program is administered through the ADOT Traffic Engineering Section and the ADOT Local Governments Section. A local match of 10% of the funding for the project is required by the local agency. A local agency that wishes to pursue this funding source for a rail-highway project or another type of safety project is encouraged to contact the ADOT Local Government Section at (602) 712-7545.

5.4 The PAG RTA Program Funding for Highway-Rail Crossings
Recently, voters in Pima County passed an initiative to form a Regional Transportation Authority (RTA) and fund roadway improvements within the PAG region via a ½ cent sales tax. The PAG RTA Program includes an element of funding that can be used for both at-grade railroad crossings and bridge deficiencies. The line item for at-grade railroad crossings and bridge deficiencies will include $15,000,000 that will be available over the 20 year life of the RTA plan. The following description outlines this line item in the RTA Program and the funding:

Project: At-Grade Railroad Safety and Bridge Deficiencies

**Scope:** To provide funding for design and construction of (1) at-grade highway/rail intersection improvements for intersections experiencing congestion and safety issues and (2) roadway, pedestrian and other transportation bridges in need of repairs or upgrades due to bridge deficiencies. Proposals for improvements to address safety issues of at-grade rail intersection or bridges will be given the highest priority. Selection of improvement locations will be based on safety and other criteria established by the oversight committee discussed below. Identification and selection of candidate improvements will be done on an on-going basis to ensure that upgrades reflect current needs and are supported by current data.
Project Costs: $15,000,000, including Design, Right-of-Way and Construction.

Funding:  
- Sales Tax Revenues: $15,000,000
- Other Revenues: 0
- Total Revenues: $15,000,000

Implementation Period: 1 – 4

Benefits: Improved safety at at-grade railroad crossings and bridges

Implementation: The Regional Transportation Authority or Pima Association of Governments will establish an oversight committee to develop priorities to evaluate eligible projects, to make recommendation on project funding to the Board of Regional Transportation Authority or the Pima Association of Governments, and to provide regular reports to the public on the implementation of the program.

The jurisdiction with ownership and operational responsibility for the roadway at the rail intersection or bridge will be responsible for management of design and construction.

6.0 REFERENCES:

5. Don Freeman, P. E. Transportation Engineer, Pima Association of Governments (PAG). Discussion and information on PAG programming process and PAG Railroad crossing Inventory.
6. David Gibson, Railroad Inventory Specialist, MVD Traffic Records Section, Discussion and Information on ADOT HES-STP 130 Funding and ADOT Railroad Crossing Inventory.
7. Michael F. Delleo, Jr., P.E., State Railroad Liaison, Utility and Railroad Engineering Section, Arizona Department of Transportation. Discussion on Process to Improve Railroad Crossing when HES-STP Funding is not used.