HIGHWAY FACTORS GROUP CHAIRMAN FACTUAL REPORT

(46 pages)

NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF HIGHWAY SAFETY
WASHINGTON, DC 20594

HIGHWAY FACTORS GROUP CHAIRMAN FACTUAL REPORT

A. ACCIDENT

LOCATION:	At the intersection of South Garfield Street and the Union Pacific Railroad (UPRR), Mile Post 554.74, DOT grade crossing inventory #796-331L, Midland, Midland County, Texas
VEHICLE 1:	2006 Peterbilt truck-tractor in combination with a 2005 Transcraft Eagle Drop Deck (Flatbed) Semitrailer
OPERATOR:	Smith Industries of Midland, Texas
VEHICLE 2:	Union Pacific Freight Train ZLCAI-14, consisting of 4 locomotives and 84 loaded cars
OPERATOR:	Union Pacific Railroad (UPRR)
VEHICLE 3:	2008 Ford Crown Victoria Police Interceptor
OPERATOR:	Midland County Sheriff's Office
DATE:	November 15, 2012
TIME:	Approximately 4:35 p.m. CST

NTSB #: **HWY-13-MH-003**

B. HIGHWAY FACTORS GROUP

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Eric Johnson City of Midland 1602 E. Orchard Lane	*Asst. Transportation Manager* Midland, Texas 79701	Group Member

C. DETAILS OF THE FACTUAL REPORT

The Highway Factors Group Chairman Factual Report provides the reader with a factual record of the highway conditions that existed at the time of the accident. For a better understanding of all the circumstances and facts of the accident, readers are encouraged to also examine the *Accident Summary Report*, the *Vehicle Factors Group Chairman Factual Report*, the *Human Performance Group Chairman Factual Report*, the *Survival Factors Group Chairman Factual Report*, the *Motor Carrier Operations Group Chairman Factual Report*, the *Railroad Signal Group Chairman Factual Report*, the *Railroad Operations Group Chairman Factual Report*, and the *Railroad Mechanical Group Chairman Factual Report*.

The Highway Factors Group Chairman Factual Report is organized by the following topic areas and page numbers:

List of Tables **Page Number**

List of Figures **Page Number**

1. PREFATORY DATA

1.1 ACCIDENT LOCATION

The accident occurred in the southbound lanes of South Garfield Street at the Union Pacific grade crossing (DOT crossing number 796-331L) at railroad milepost number 554.65. The UP Railroad operates on one main line track crossing South Garfield Street adjacent to the signalized intersections with West Front Avenue and West Industrial Avenue. The signal bungalow that houses the control equipment for the railroad signal system was located at railroad milepost number 554.74. Figure 1 is a vicinity map that illustrates the accident location.

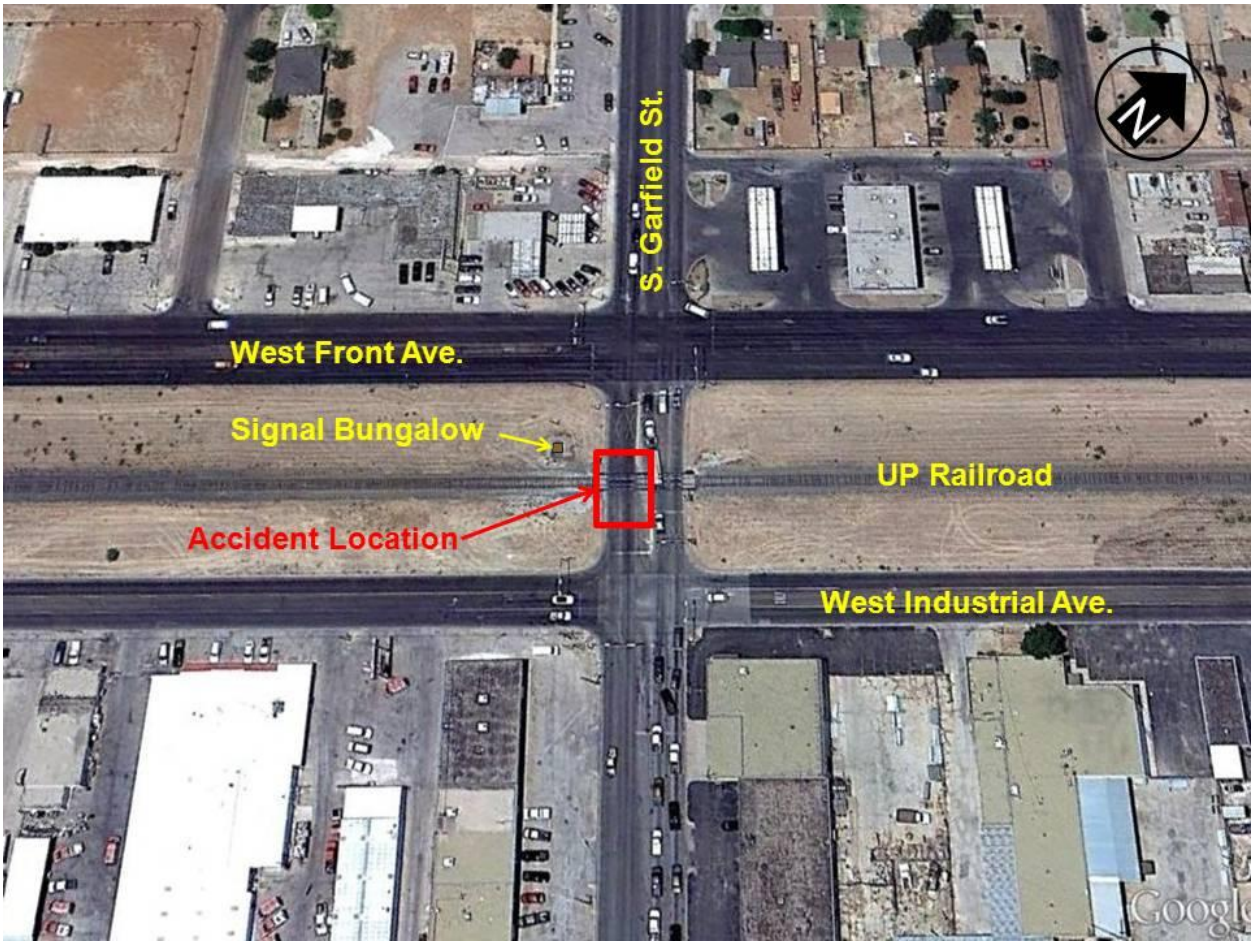

Figure 1 – Vicinity map

1.2 CONSTRUCTION HISTORY

South Garfield Street in the vicinity of the grade crossing was constructed in 1956. The latest rehabilitation project occurred in 2006 that involved constructing a raised median and restriping the roadway to a 5-lane cross section.

1.3 ANNUAL AVERAGE DAILY TRAFFIC

Table 1 summarizes the annual average daily traffic (AADT) on South Garfield Street in the vicinity of the grade crossing in November of 2012.

Table 1 – Annual Average Daily Traffic (AADT) on South Garfield Street in the vicinity of the grade crossing in November of 2012

Lane Assignment	Annual Average Daily Traffic (AADT)
Southbound Left Lane	5,409
Southbound Right Lane	3,375
Total Southbound Lanes	**8,784**
Northbound Left Lane	3,841
Northbound Right Lane	3,607
Total Northbound Lanes	**7,448**

1.4 VEHICLE CLASSIFICATION COUNT

Table 2 summarizes the vehicle classification count on South Garfield Street in the vicinity of the grade crossing in November of 2012.

Table 2 – Vehicle Classification Count on South Garfield Street in the vicinity of the grade crossing in November of 2012

Lane Assignment	Passenger Vehicles	Vans and Pickups	Buses and Trucks	Tractor Trailers
Southbound Left Lane	**3,406** (68% of total)	**1,301** (26% of total)	**222** (4% of total)	**113** (2% of total)
Southbound Right Lane	**2,194** (71% of total)	**712** (23% of total)	**118** (4% of total)	**51** (2% of total)
Northbound Left Lane	**2,401** (67% of total)	**957** (27% of total)	**155** (4% of total)	**50** (1% of total)
Northbound Right Lane	**2,360** (71% of total)	**787** (24% of total)	**125** (4% of total)	**44** (1% of total)

2. HIGHWAY DATA

2.1 HIGHWAY DESIGN

South Garfield Street in the vicinity of the grade crossing consisted of a 5-lane cross section. The 5-lane cross section consisted of two northbound through lanes, two southbound through lanes, and a left turn only lane for each direction. The northbound and southbound lanes were separated by an approximate 2.5 foot wide raised concrete median that contained 3 foot tall yellow delineator posts. The total width of the 5-lane cross section was approximately 62.5 feet.

Figure 2 illustrates the layout of the South Garfield Street and Union Pacific Railroad grade crossing. The distance from the south curb line of West Front Avenue to the nearest rail was approximately 80 feet. The distance from the north curb line of West Industrial Avenue to the nearest rail was approximately 67 feet.

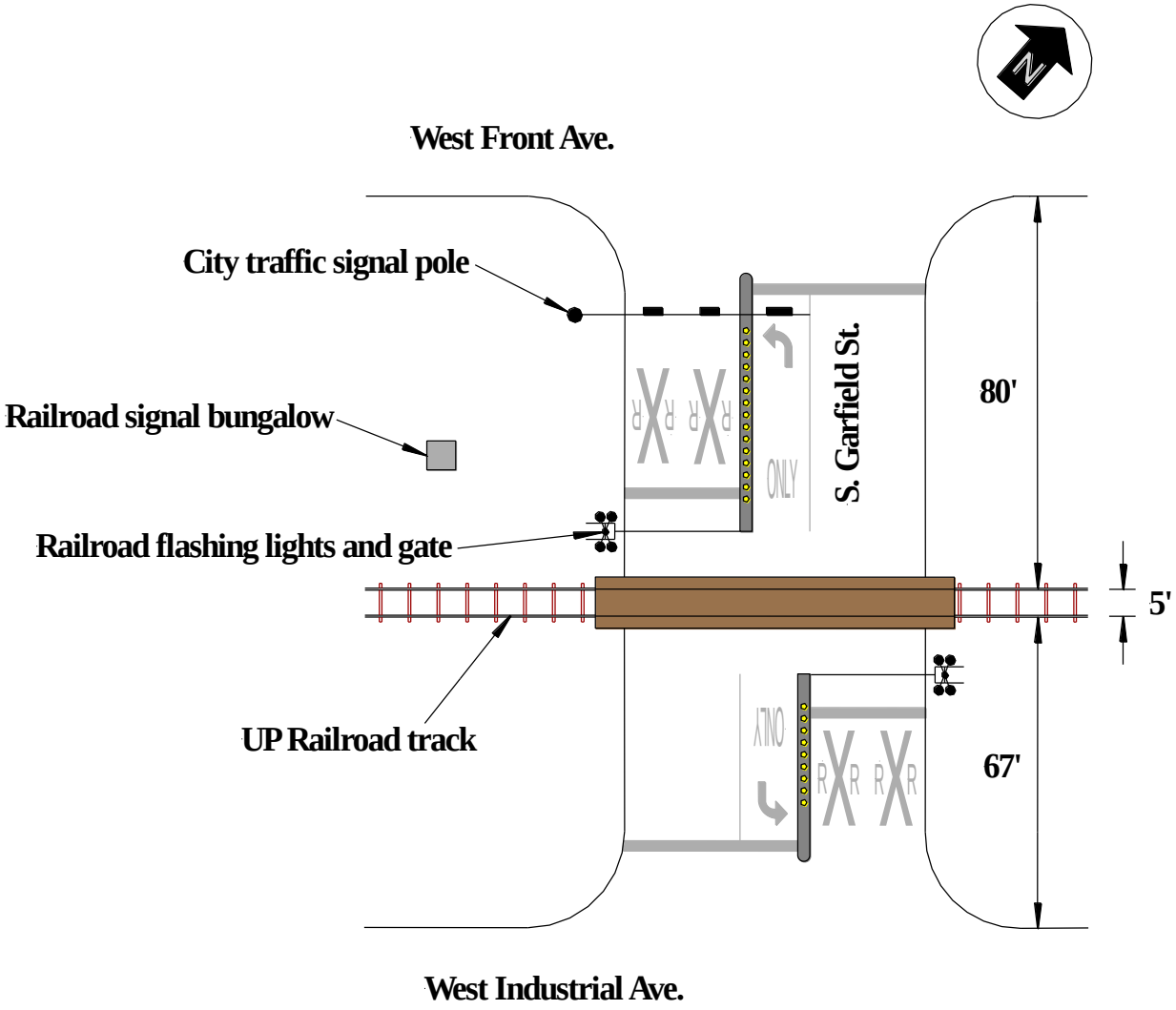

Figure 2 – Layout of the South Garfield Street and Union Pacific Railroad grade crossing

2.2 SPEED LIMIT

The posted speed limit for South Garfield Street was 35 miles per hour (mph). The posted speed limit for West Industrial Avenue was 35 mph. The posted speed limit for West Front Avenue was 45 mph.

2.3 SIGNAGE AND PAVEMENT MARKINGS IN THE VICINITY OF THE GRADE CROSSING

Figure 3 illustrates the signage in the vicinity of the grade crossing. The signage consisted of a parallel railroad crossing T sign with a 'No Train Horn' sign located directly below it on the West Front Avenue and the West Industrial Avenue approaches to the grade crossing for both travel directions. An advance railroad crossing sign with a 'No Train Horn' sign was located on South Garfield Street on both approaches to the grade crossing. A 'Do Not Stop on Tracks' sign was located just prior to the tracks in the northbound and southbound direction.

The pavement markings in the vicinity of the grade crossing consisted of grade crossing pavement marking symbols located in the two northbound through lanes and two southbound through lanes. The left turn lane consisted of left turn-use arrows and 'ONLY' markings.

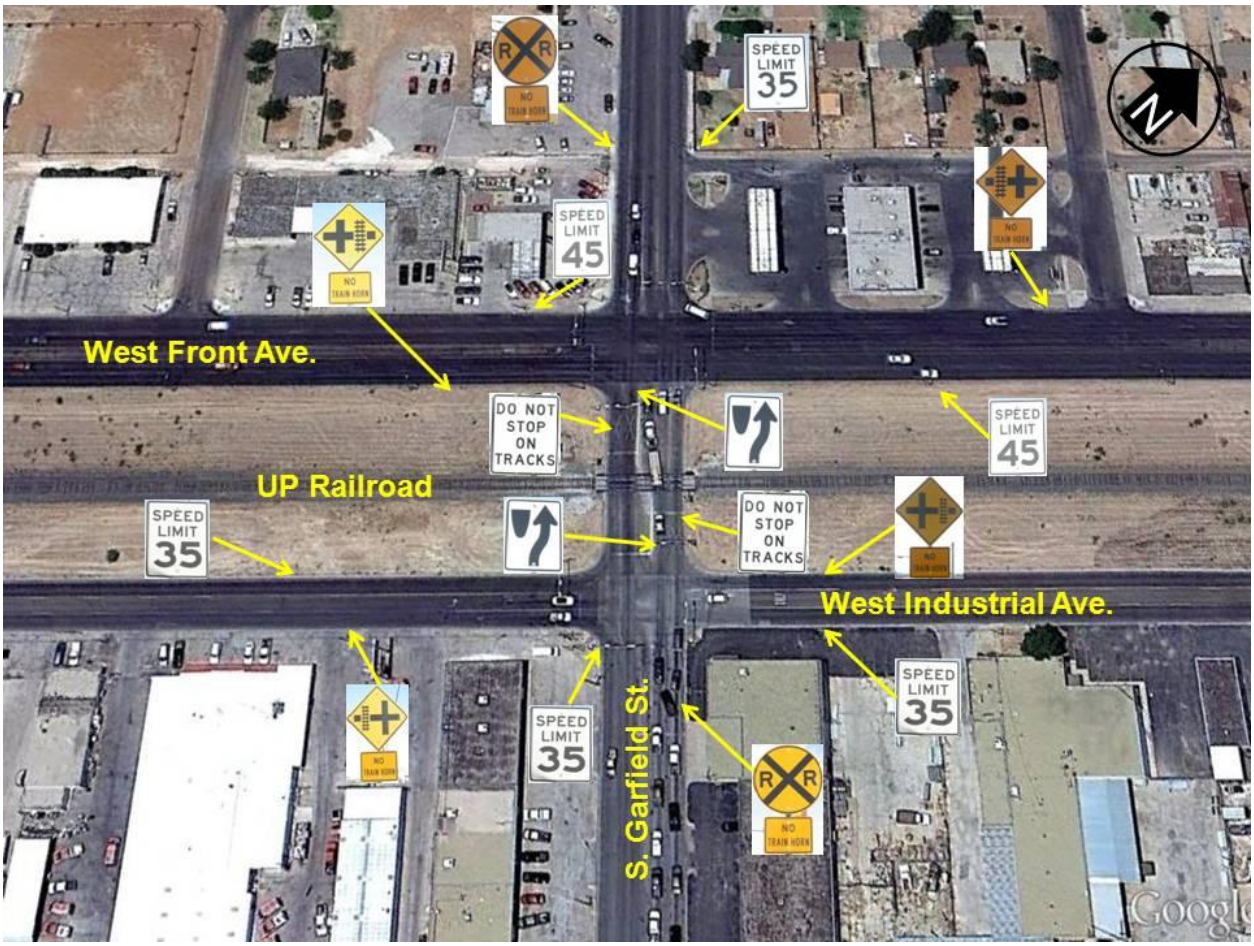

Figure 3 – Signage in the vicinity of the grade crossing

2.4 HUMPED CROSSING

The vertical grade on approach to the grade crossing from West Front Avenue was a positive 5.6% upward slope. The vertical grade on approach to the grade crossing from West Industrial Avenue was a negative 5.4% downward slope. The grade crossing surface was at the same plane as the top of the rails for a distance of 2 feet outside the rails. The vertical grades on approach to the grade crossing were not severe enough for low clearance vehicles to become caught on the tracks. The use of the 'Low Ground Clearance Grade Crossing (W10-5) Warning Sign'[1] was not needed in advance of the grade crossing.

The 2011 AASHTO A Policy on Geometric Design of Highways and Streets (or commonly known as the Green Book) recommended the following regarding vertical alignment at railroad-highway grade crossings[2]:

"***Forward***

The fact that new design values are presented herein does not imply that existing streets and highways are unsafe, nor does it mandate the initiation of improvement projects. This publication is not intended as a policy for resurfacing, restoration, or rehabilitation (3R) projects. For projects of this type, where major revisions to horizontal or vertical curvature are not necessary or practical, existing design values may be retained. Specific site investigations and crash history analyses often indicate that the existing design features are performing in a satisfactory manner. The cost of full reconstruction for these facilities, particularly where major realignment is not needed, will often not be justified. Resurfacing, restoration, and rehabilitation projects enable highway agencies to improve highway safety by selectively upgrading existing highway and roadside features without the cost of full reconstruction. When designing 3R projects, the designer should refer to TRB Special Report 214, Designing Safer Roads: Practices for Resurfacing, Restoration, and Rehabilitation, and related publications for guidance.

9.12.2 Vertical Alignment

It is desirable from the standpoint of sight distance, rideability, braking, and acceleration distances that the intersection of highway and railroad be made as level as practical. Vertical curves should be of sufficient length to provide an adequate view of the crossing.

In some instances, the roadway vertical alignment may not meet acceptable geometrics for a given design speed because of restrictive topography or

[1] *Manual on Uniform Traffic Control Devices for Streets and Highways*, U.S. Department of Transportation, Federal Highway Administration; 2009 Edition; page 763.

[2] *A Policy on Geometric Design of Highways and Streets*, American Association of State Highway and Transportation Officials; 2011 6th Edition; pages xli and 9-184.

limitations of right-of-way. To prevent drivers of low-clearance vehicles from becoming caught on the tracks, the crossing surface should be at the same plane as the top of the rails for a distance of 2 feet outside the rails. The surface of the highway should also not be more than 3 inches higher or lower than the top of nearest rail at a point 30 feet from the rail unless track superelevation makes a different level appropriate, as shown in Figure 9-75. Vertical curves should be used to traverse from the highway grade to a level plane at the elevation of the rails. Rails that are superelevated, or a roadway approach section that is not level, need a site-specific analysis for rail clearances."

The 2007 Railroad-Highway Grade Crossing Handbook recommended the following regarding vertical alignment at railroad-highway grade crossings[3]:

"Track maintenance can result in raising the track as new ballast is added to the track structure. Unless the highway profile is properly adjusted, this practice will result in a "humped" profile that may adversely affect the safety and operation of highway traffic over the railroad."

A humped crossing is defined as a crossing at which the railroad bed is higher than the road it is crossing, causing a hump for the motorist to cross.

Figure 4 illustrates the plan and profile view of the humped crossing at South Garfield Street and the Union Pacific Railroad. The vertical scale is exaggerated to illustrate the humped crossing.

[3]*Railroad-Highway Grade Crossing Handbook*, U.S. Department of Transportation, Federal Highway Administration; August 2007 Revised Second Edition; page 138.

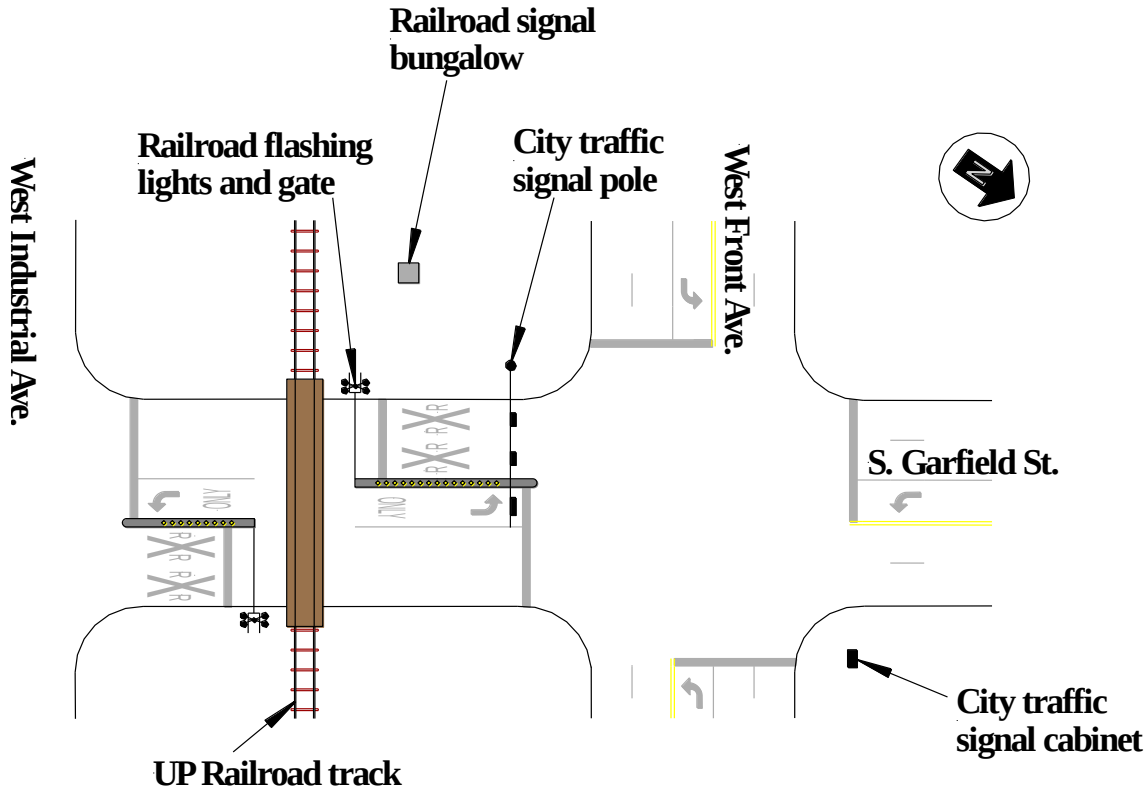

Figure 4 – Plan and profile view of the humped crossing

2.5 CROSSING ANGLE

The crossing of South Garfield Street and the UP Railroad formed an angle that was nearly perpendicular or approximately 90 degrees.

2.6 STOP LINES

White stop lines were located approximately 8 feet from the automatic gate on both approaches to the grade crossing. The white stop lines were approximately 2 feet wide and 24 feet long.

The 2009 Manual on Uniform Traffic Control Devices (MUTCD) recommended the following regarding stop lines[4]:

*"**Section 8B.28 Stop and Yield Lines***

Guidance:

If a stop line is used, it should be a transverse line at a right angle to the traveled way and should be placed approximately 8 feet in advance of the gate (if present), but no closer than 15 feet in advance of the nearest rail."

2.7 JURISDICTION AND MAINTENANCE OF SOUTH GARFIELD STREET

In accordance with City of Midland Resolution No. 2009-059 dated February 24, 2009 and Texas Department of Transportation (TxDOT) Minute Order No. 112740 dated June 30, 2011, the City of Midland and TxDOT placed South Garfield Street onto the state highway system from Wall Street to I-20. South Garfield Street was designated BS 158-B, an approximate distance of 1.8 miles, from Wall Street to I-20. The Union Pacific grade crossing was located on the portion of South Garfield Street designated as a state highway system.

The applicable provisions of the Municipal Maintenance Agreement between the City of Midland and TxDOT dated January 27, 1998 for non-controlled access highways indicated the following:

*"**State's Responsibilities (Non-Controlled Access)***

1. Maintain the traveled surface and foundation beneath such traveled surface necessary for the proper support of same under vehicular loads encountered and maintain the shoulders.

7. Install, operate and maintain traffic signals in cities with less than 50,000 population.

8. In cities equal to or greater than 50,000 population, the State may provide for installation of traffic signals when the installation is financed in whole or in part with federal-aid funds if the City agrees to enter into an agreement setting forth the responsibilities of each party.

[4]*Manual on Uniform Traffic Control Devices for Streets and Highways*, U.S. Department of Transportation, Federal Highway Administration; 2009 Edition; page 766.

City Responsibilities (Non-Controlled Access)

6. Install, maintain and operate all traffic signals in cities equal to or greater than 50,000 population. Any variations will be handled by a separate agreement."

At the time of the accident, South Garfield Street and West Front Avenue were on the state highway system. West Industrial Avenue was a city street. None of the three streets were controlled access highways[5]. Under the Municipal Maintenance Agreement, TxDOT is allowed to perform maintenance between the curb and gutters on non-controlled access highways. However, for cities greater than 50,000 population (Midland had a population of approximately 114,000 in 2011), traffic signals on non-controlled access highways are maintained and operated by the city.

3. TRAIN DATA

3.1 HIGHWAY-RAIL GRADE CROSSING ACCIDENT/INCIDENT REPORTS

Table 3 summarizes the highway-rail grade crossing accident/incident reports at the South Garfield Street and Union Pacific grade crossing for all reported incidents prior to this accident.

Table 3 – Highway-Rail Grade Crossing Accident/Incident Reports

Date	Time	Fatalities	Injuries	Property Damage
12/22/97	01:34 pm	0	1	$2,600
06/18/90	12:01 pm	0	0	$2,000
11/14/89	12:40 pm	0	1	$8,000
12/07/85	10:05 pm	0	0	$500
02/24/85	02:10 am	0	1	$800
02/16/82	04:30 pm	0	1	$8,000
07/23/81	03:25 pm	0	0	$3,000
03/29/81	12:55 am	0	0	$1,000
05/30/79	11:50 am	0	1	$400
02/05/79	07:00 pm	0	1	$750
Totals		**0**	**6**	**$27,050**

[5]A controlled access highway is a highway designed exclusively for high-speed vehicular traffic, with all traffic flow and ingress/egress regulated.

3.2 U.S. DOT CROSSING INVENTORY INFORMATION

Table 4 summarizes the U.S. DOT Crossing Inventory Information at the South Garfield Street and Union Pacific grade crossing.

Table 4 – U.S. DOT Crossing Inventory Information

Subject	Crossing Inventory Information
Crossing Number	796331L
Railroad	Union Pacific (UP)
Type and Position	Public At Grade Crossing
Division	RioGrande
Subdivision	Toyah
Railroad Milepost	554.65
State	Texas
County	Midland
City	Midland
Street or Road Name	South Garfield Street
Highway Type	State Highway
Latitude	31.9856936
Longitude	-102.0935250

3.3 DESIGN SPEED AND MAXIMUM TRACK SPEED

The design speed for the UP track was 79 mph and the maximum track speed was set at 70 mph.

3.4 TRAIN VOLUMES

Table 5 summarizes the average trains per day on the UP track. The Auto[6] and Intermodal[7] trains typically operate at speeds of approximately 70 mph and the Bulk[8] and Manifest[9] trains typically operate at speeds of approximately 50 mph. The Auto, Bulk, and Intermodal trains generally travel to one destination. The Manifest trains generally travel to a destination that requires sorting of the individual cars. The train group involved in the accident on November 15, 2012 was an Intermodal train.

[6]Auto trains typically have cargo that includes automobiles.
[7]Intermodal trains typically have cargo that includes containers and semi-trailers.
[8]Bulk trains typically have cargo that includes coal, grain, sand, and rock.
[9]Manifest trains typically have cargo that includes mixed freight.

Table 5 – Average Trains per Day

Train Group	Trains per Day
Auto	0.5
Bulk	0.6
Intermodal	12.5
Manifest	7.7
Other	1.3
Grand Total	**22.6**

3.5 POST MOUNTED FLASHING LIGHT SIGNAL SYSTEM

The flashing light signal system used at the railroad crossing consisted of a post-mounted flashing light signal (two light units mounted in a horizontal line), a standard Crossbuck sign, and an automatic gate assembly. The flashing light signal was placed to the right of South Garfield Street on both approaches to the grade crossing. The automatic gate arm consisted of a drive mechanism and a fully retroreflectorized red and white striped gate arm with lights. In the down position, the gate arm extended across the approaching lanes of traffic. The gate arm consisted of vertical stripes spaced alternately red and white at 16 inch intervals measured horizontally. The automatic gate arm contained three red lights. When activated, the gate arm light nearest the tip illuminated continuously and the other two lights flashed alternately in unison with the flashing light signals.

The vertical distance from the ground surface to the bottom of the 12 inch diameter flashing light lenses was approximately 9 feet. The 12 inch diameter flashing light lenses were spaced approximately 30 inches apart measured from the center of the lenses.

The center of the post-mounted flashing light system was located approximately 12 feet from the nearest rail on both approaches to the grade crossing. The 2009 Manual on Uniform Traffic Control Devices (MUTCD) and the 2007 Railroad-Highway Grade Crossing Handbook recommend a minimum distance of 12 feet from the center of the post-mounted flashing light system to the center of the railroad tracks. The distance between each rail was approximately 5 feet.

The shunt circuits were located approximately 4,636 feet in either direction of the grade crossing along the UP Railroad.

The 2009 Manual on Uniform Traffic Control Devices (MUTCD) recommended the following regarding flashing light signals, gates, and traffic control signals[10]:

*"**Section 8C.02 Flashing-Light Signals***

Standard:

If used, the flashing-light signal assembly (shown in Figure 8C-1) on the side of the highway shall include a standard Crossbuck (R15-1) sign, and where there is more than one track, a supplemental Number of Tracks (R15-2P) plaque, all of which indicate to motorists, bicyclists, and pedestrians the location of a grade crossing.

If used, flashing-light signals shall be placed to the right of approaching highway traffic on all highway approaches to a grade crossing. They shall be located laterally with respect to the highway in compliance with Figure 8C-1 except where such location would adversely affect signal visibility.

Each red signal unit in the flashing-light signal shall flash alternately. The number of flashes per minute for each lamp shall be 35 minimum and 65 maximum. Each lamp shall be illuminated approximately the same length of time. Total time of illumination of each pair of lamps shall be the entire operating time. Flashing-light units shall use either 8-inch or 12-inch nominal diameter lenses.

Section 8C.04 Automatic Gates

Standard:

The automatic gate (see Figure 8C-1) shall consist of a drive mechanism and a fully retroreflectorized red- and white-striped gate arm with lights. When in the down position, the gate arm shall extend across the approaching lanes of highway traffic.

In the normal sequence of operation, unless constant warning time detection or other advanced system requires otherwise, the flashing-light signals and the lights on the gate arm (in its normal upright position) shall be activated immediately upon detection of approaching rail traffic. The gate arm shall start its downward motion not less than 3 seconds after the flashing-light signals start to operate, shall reach its horizontal position at least 5 seconds before the arrival of the rail traffic, and shall remain in the down position as long as the rail traffic occupies the grade crossing.

[10]*Manual on Uniform Traffic Control Devices for Streets and Highways*, U.S. Department of Transportation, Federal Highway Administration; 2009 Edition; page 769, 771, and 772.

When the rail traffic clears the grade crossing, and if no other rail traffic is detected, the gate arm shall ascend to its upright position, following which the flashing-light signals and the lights on the gate arm shall cease operation.

Gate arms shall be fully retroreflectorized on both sides and shall have vertical stripes alternately red and white at 16-inch intervals measured horizontally.

Standard:

Gate arms shall have at least three red lights as provided in Figure 8C-1.

When activated, the gate arm light nearest the tip shall be illuminated continuously and the other lights shall flash alternately in unison with the flashing-light signals.

The entrance gate arm mechanism shall be designed to fail safe in the down position.

Guidance:

The gate arm should ascend to its upright position in 12 seconds or less.

In its normal upright position, when no rail traffic is approaching or occupying the grade crossing, the gate arm should be either vertical or nearly so (see Figure 8C-1).

The gates should cover the approaching highway to block all highway vehicles from being driven around the gate without crossing the center line."

3.6 FRA FINAL RULE MINIMUM WARNING TIME OF 20 SECONDS

FRA's final rule of a minimum warning time of 20 seconds became effective on January 1, 1995. The final rule establishing a minimum warning time of 20 seconds was contained in 49 CFR Parts 212 and 234 Grade Crossing Signal System Safety. 49 CFR Part 234.225 indicated the following:

*"**Activation of Warning System***

A highway-rail grade crossing warning system shall be maintained to activate in accordance with the design of the warning system, but in no event shall it provide less than 20 seconds warning time for the normal operation of through trains before the grade crossing is occupied by rail traffic."

3.7 OPERATION OF RAILROAD GRADE CROSSING WARNING SYSTEM AND HIGHWAY TRAFFIC SIGNAL PREEMPTION

3.7.1 SITE SPECIFIC FACTS

The grade crossing of South Garfield Street and the Union Pacific Railroad was equipped with an active grade crossing warning system. The intersections of South Garfield Street / West Front Avenue and South Garfield Street / West Industrial Avenue were equipped with traffic control signals. The traffic control signals operated from the same controller assembly. The controller assembly was located in the north-east quadrant of the South Garfield Street / West Front Avenue intersection. The controller assembly was interconnected with the railroad active warning system for advance preemption. The train detection system was a constant warning time system.

3.7.2 GRADE CROSSING WARNING SYSTEM

The traffic control system included an active grade crossing warning system (GCWS) consisting of two flashing light signals with automatic gates to provide warning to road users of approaching trains. Each flashing light signal was equipped with a Crossbuck sign and a bell. A constant warning time train detection system provided detection of the approaching train. The combination of these traffic control devices including additional signs, pavement markings and traffic signal preemption is commonly known as a traffic control system as prescribed in the MUTCD. The traffic control system[11] is required to be consistent with Federal, State and local laws and regulations:

> *"**Section 8A.01 Introduction***
>
> *Support:*
>
> *In Part 8, the combination of devices selected or installed at a specific grade crossing is referred to as a "traffic control system."*
>
> ***Standard:***
>
> *The traffic control devices, systems, and practices described in this Manual shall be used at all grade crossings open to public travel, consistent with Federal, State, and local laws and regulations."*

[11] *Manual on Uniform Traffic Control Devices for Streets and Highways*, U.S. Department of Transportation, Federal Highway Administration; 2009 Edition; page 747.

The active grade crossing warning system was designed to provide 20 seconds of minimum warning time for approaching trains as shown on the circuit design plans at train speeds up to 79 MPH in accordance with the following:

- FRA's final rule 49 CFR Part 234.225 – "*A highway-rail grade crossing warning system shall be maintained to activate in accordance with the design of the warning system, but in no event shall it provide less than 20 seconds warning time for the normal operation of through trains before the grade crossing is occupied by rail traffic",*

- MUTCD Section 8C.08[12] – "*Flashing-light signals shall operate for at least 20 seconds before the arrival of any rail traffic",* and

- The American Railway Engineering and Maintenance-of-Way Association (AREMA) Communication and Signal Manual of Recommended Practice Part 3.3.10 B.2.

In addition to the required 20 seconds of minimum warning time, additional time was included as follows:

- 5 seconds of buffer time – per the American Railway Engineering and Maintenance-of-Way Association (AREMA) Communication and Signal Manual of Recommended Practice Part 3.3.10 B.6. "*Buffer Time (BT): buffer time is discretionary and may be provided in addition to MT and CT (EGCT) to accommodate for minor variations in train handling, track circuit variability and allowable tolerances within locomotive speed measurement apparatus."*

- 5 seconds of equipment response time - per the American Railway Engineering and Maintenance-of-Way Association (AREMA) Communication and Signal Manual of Recommended Practice Part 3.3.10 B.7. *"Equipment Response Time (ERT): adjustments shall be made to provide for control circuit equipment response time."*

- 10 seconds of advance preemption time – per the American Railway Engineering and Maintenance-of-Way Association (AREMA) Communication and Signal Manual of Recommended Practice Part 3.3.10 B.8. *"Advance Preemption Time (APT): The period of time specified by the public agency that provides advance notification of an approaching train prior to activation of the highway-rail grade*

[12]*Manual on Uniform Traffic Control Devices for Streets and Highways*, U.S. Department of Transportation, Federal Highway Administration; 2009 Edition; page 775.

crossing warning devices. Buffer time should be considered to be zero when calculating APT. See Manual Part 3.1.10 (Recommended Functional/Operating Guidelines for Interconnection between Highway Traffic Signals and Highway-Rail Grade Crossing Warning Systems), to provide additional guidance in determining advance preemption time."

3.7.3 TRAFFIC CONTROL SIGNAL

The interconnection circuit in the traffic signal controller[13] assembly consisted of an electro-mechanical relay mounted on a panel in the controller cabinet. The relay was connected to the railroad circuits by a two conductor cable which normally energizes when preemption is not in effect. The coil circuit of the preemption relay was connected to a steady source of 120VAC energy. The interconnection circuit supplied the AC neutral return to the preemption relay. When the interconnection is opened by the railroad equipment, the preemption relay de-energizes which applied a logic ground signal to the preemption input to the controller unit. The application of the logic ground signal to the preemption input initiated the railroad preemption special control mode in the controller unit.

3.7.4 PREEMPTION OPERATION

Activating the preemption mode via the railroad interconnection caused the traffic signal to stop the normal operating sequence and transition to a track clearance interval. The track clearance interval displayed a circular green and a green left arrow indication to northbound vehicles on South Garfield Street at West Front Avenue. In addition, a circular green indication was displayed to southbound vehicles on South Garfield Street at West Industrial Avenue. Following the track clearance interval, the preemption mode provided limited operation of movements that did not conflict with the passage of the train.

The preemption mode used various timed intervals in the traffic signal sequence to provide the programmed sequence. The following intervals were used:

- Minimum Green – any minimum green timing in effect when the preemption mode initiated was truncated to zero,

- Yellow Change – the maximum yellow change time used during the transition to the track clearance interval was 3.8 seconds,

- Red Clearance – the maximum red clearance interval used during the transition to the track clearance interval was 1.9 seconds, and

[13]The traffic signal controller unit was a Naztec Model 900 TS2 running firmware version 980–NTCIP Version 61.3q.

- Track Clearance Green – the track clearance green interval was set to be displayed for 25 seconds.

From the time the interconnection is opened due to an approaching train, a maximum of 5.8 seconds was required under the worst case condition prior to the beginning of the track clearance interval. This period of time is known as right-of-way transfer time. Once the track clearance interval begins, 25 seconds of time was provided for the display of green indications to allow vehicles to clear the area over the track, which is known as the minimum track clearance distance. Once the 25 seconds is elapsed, the railroad dwell period begins and remains in effect for the duration of the passage of the train movement. Once the train clears the grade crossing and the automatic gates begin to rise, the interconnection circuit closes and the traffic signal controller unit returns to normal signal operation.

For the UP train involved in the accident, based on the GCP 3000 recorder data, the actual advance preemption time was approximately 9 seconds and the actual warning time was approximately 21 seconds. Figure 5 illustrates the preemption timeline for the UP train involved in the accident.

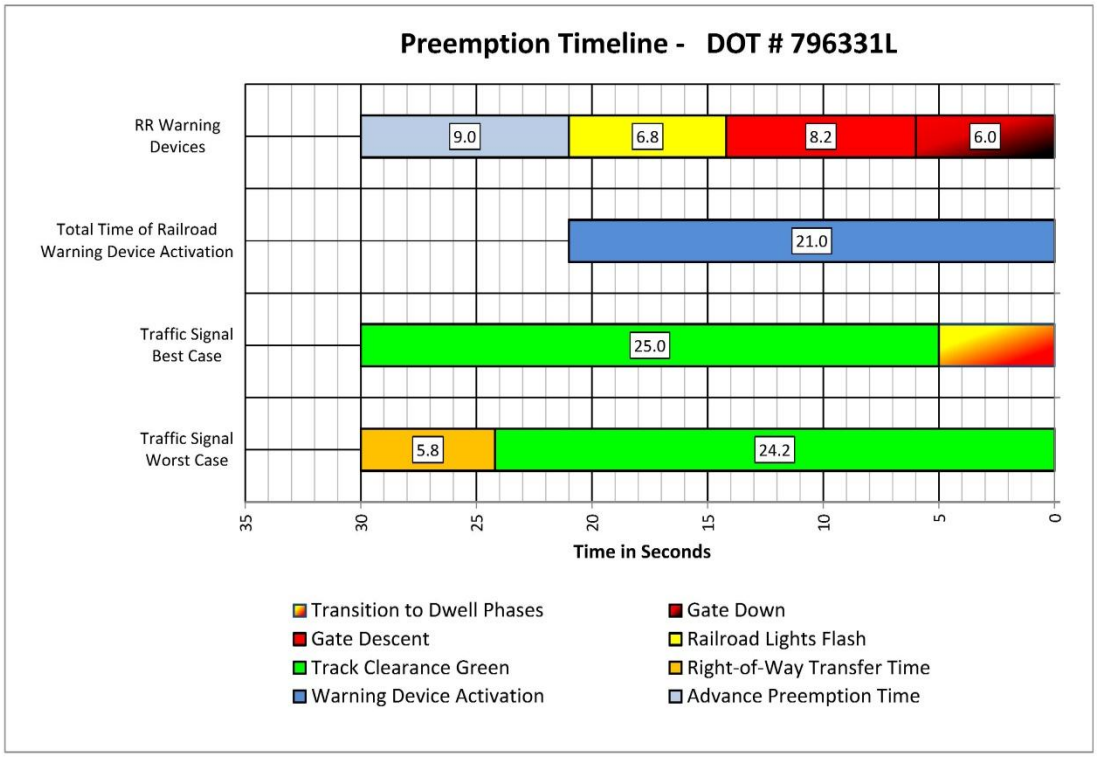

Figure 5 – Preemption timeline for the UP train involved in the accident

3.8 ASSESSMENT OF INTERCONNECTED HIGHWAY-RAIL GRADE CROSSING

3.8.1 PREEMPTION REVIEW

On March 14, 2012, a field inspection was conducted to evaluate the operation of the traffic signal preemption system interconnected with the railroad active warning system. Representatives from the City of Midland (public agency responsible for the traffic signal maintenance and operation), Union Pacific Railroad (railroad) and Campbell Technology Corporation (CTC) were present. The inspection was conducted as a result of Safety Advisory 2010-02 issued by the Federal Railroad Administration on October 1, 2010. The Safety Advisory summary indicated the following:

> *"**SUMMARY:** FRA is issuing Safety Advisory 2010–02 to address Safety Recommendations I–96–10 and I–96–11, issued by the National Transportation Safety Board (NTSB) that relate to railroad and highway signal recording devices at highway-rail grade crossings equipped with active warning systems that are interconnected with highway traffic signal systems. This safety advisory recommends that States, local highway authorities, and railroads install, maintain, and upgrade railroad and highway traffic signal recording devices at these types of grade crossings. This safety advisory also recommends that States, local highway authorities, and railroads conduct comprehensive periodic joint inspections of highway traffic signal pre-emption interconnections and use information obtained from any railroad and highway traffic signal recording devices during those inspections.*
>
> *In order to facilitate the proper functioning of the highway traffic signal pre-emption interconnection, 49 CFR 234.261 requires that railroads test each highway traffic signal pre-emption interconnection at least once each month. Therefore, States, local highway authorities, and railroads should identify which highway-rail grade crossings are equipped, or intended to be equipped, with a highway traffic signal pre-emption interconnection. If so equipped, railroads should ensure that the circuit plan shows the actual interconnection and the designed preemption time. Railroads should also ensure that the interconnection is in place and the train detection device (or equivalent) is programmed or equipped to provide the appropriate designed preemption function."*

During the inspection, various operating criteria of both railroad and the traffic signal were inspected and their operation verified. It was determined that at some time prior to the inspection, a change had been made by unknown persons to the warning time set on the constant warning time system. The change increased the programmed warning time from 20 seconds[14] to 30 seconds[15]. This change also caused the traffic signal preemption to function as simultaneous

[14] 20 seconds does not include a 5 second buffer time.
[15] 30 seconds does not include a 5 second buffer time.

preemption instead of the advance preemption as specified on the circuit plans. As a result of the change, a telephone conversation was conducted between field personnel and Union Pacific signal designers. It was determined that the equipment settings should be in accordance with the circuit plans and the appropriate changes were made. This restored the design warning time of 20 seconds and the advance preemption time of 10 seconds.

3.8.2 ASSESSMENT REPORT AND RECOMMENDATIONS TO CITY OF MIDLAND AND UNION PACIFIC RAILROAD

As a result of the March 14, 2012 field inspection, a report was prepared by Campbell Technology Corporation entitled Assessment of Interconnected Highway-Rail Grade Crossing April 2012. The recommendations from the report included the following:

*"**Agency Recommendations*** **(City of Midland)*:***

As a result of the on-site inspection, the following proposed recommendations are being presented to the Agency for consideration. The information contained in this report is being provided under the recommendations of Safety Advisory 2010-02 as issued by the FRA. The Railroad acknowledges that its actions are limited to those permitted under the 2009 Manual on Uniform Traffic Control Devices (MUTCD) and that the decision to implement any of the recommendations contained in this report rests with the Agency.

Immediate Recommendations:

- *Increase the track clearance green time from 10 seconds to 25 seconds.*
    - *The agency agreed and made the change on site.*

Short Term Recommendations:

- *Install Storage Space Signs (W10-11a or W10-11b).*
- *Change the interconnection circuitry to double break or supervised operation.*
- *Restrict the right turn movement toward the track during preemption.*
- *Implement a maximum preemption timing circuit.*
- *Implement a traffic signal health circuit in the interconnection.*
- *Implement a Preemption Operation and Maintenance program.*

Long Term Recommendations:

- *Evaluate Advance Preemption Time to clear design vehicle.*

<u>Railroad Recommendations</u>* (UP Railroad)*:

Immediate Recommendations:

- *Program warning time according to the design.*
    - *The Railroad agreed and made the change on site.*

Short Term Recommendations:

- *Follow up with the Agency to review this report and assist with the implementation of the short term recommendations."*

49 CFR Part 234.201 indicated the following:

*"**Location of plans***

Plans required for proper maintenance and testing shall be kept at each highway-rail grade crossing warning system location. Plans shall be legible and correct."

3.9 TEXAS TRANSPORTATION CODE

The Texas Transportation Code indicated the following regarding compliance with traffic control devices[16]:

"***Sec. 544.004 Compliance with Traffic-Control Device***

(a) The operator of a vehicle or streetcar shall comply with an applicable official traffic-control device placed as provided by this subtitle unless the person is:

(1) *otherwise directed by a traffic or police officer*"

[16]Texas Transportation Code, Title 7 Vehicles and Traffic, Subtitle C Rules of the Road, Chapter 544 Traffic Signs, Signals, and Markings, Section 544.004 Compliance with Traffic-Control Device.

The Texas Transportation Code indicated the following regarding obedience to railroad signals[17]:

"***Sec. 545.251 Obedience to Signal Indicating Approach of Train***

(a) An operator approaching a railroad grade crossing shall stop not closer than 15 feet or farther than 50 feet from the nearest rail if:

(1) a clearly visible railroad signal warns of the approach of a railroad train;
(2) a crossing gate is lowered, or a flagger warns of the approach or passage of a train;
(3) a railroad engine approaching within approximately 1,500 feet of the highway crossing emits a signal audible from that distance and the engine is an immediate hazard because of its speed or proximity to the crossing;
(4) an approaching railroad train is plainly visible to the operator and is in hazardous proximity to the crossing; or
(5) the operator is required to stop by:
(A) other law;
(B) a rule adopted under a statute;
(C) an official traffic-control device; or
(D) a traffic-control signal.

(b) An operator of a vehicle required by Subsection (a) to stop shall remain stopped until permitted to proceed and it is safe to proceed.

(c) An operator of a vehicle who approaches a railroad grade crossing equipped with railroad crossbuck signs without automatic, electric, or mechanical signal devices, crossing gates, or a flagger warning of the approach or passage of a train shall yield the right-of-way to a train in hazardous proximity to the crossing, and proceed at a speed that is reasonable for the existing conditions. If required for safety, the operator shall stop at a clearly marked stop line before the grade crossing or, if no stop line exists, not closer than 15 feet or farther than 50 feet from the nearest rail.

(d) An operator commits an offense if the operator drives around, under, or through a crossing gate or a barrier at a railroad crossing while the gate or barrier is closed, being closed, or being opened.

(e) In a prosecution under this section, proof that at the time of the offense a train was in hazardous proximity to the crossing and that the train was plainly visible to the operator is prima facie evidence that it was not safe for the operator to proceed.

[17]Texas Transportation Code, Title 7 Vehicles and Traffic, Subtitle C Rules of the Road, Chapter 545 Operation and Movement of Vehicles, Section 545.251 Obedience to Signal Indicating Approach of Train.

(f) An offense under this section is punishable by a fine of not less than $50 or more than $200."

3.10 POLICE CAMERA DASH VIDEO OF ACCIDENT

3.10.1 ACCIDENT SPECIFICS

On November 15, 2012 at approximately 4:35 p.m. local time, a procession of vehicles in the "Show of Support" parade approached the intersection of South Garfield Street and West Front Avenue. The procession was moving under the direction of law enforcement agencies serving as an escort to the procession. The procession was captured on a video recording made by an escort law enforcement vehicle that was trailing the second procession combination vehicle.

As the procession approached the intersection of South Garfield Street and West Front Avenue, law enforcement officers had taken steps to stop traffic movements in the eastbound and westbound direction of West Front Avenue that would have been in conflict with the procession. Although the traffic control signal was displaying circular red indications for the southbound approach on South Garfield Street, the procession proceeded without stopping and continued to approach and enter the grade crossing. The initial law enforcement vehicle and the first of two procession combination vehicles proceeded onto and across the grade crossing. As the second procession combination vehicle was completing the crossing of the South Garfield Street and West Front Avenue intersection, the flashing light signals began to operate and the bells began to sound. At this point, the front of the truck-tractor pulling the flatbed semitrailer was located at the south curb line of West Front Avenue. The distance from the south curb line of West Front Avenue to the center of the post-mounted flashing light system was approximately 68 feet. The flashing light signals had flashed alternately 12 times from the point at which the front of the truck-tractor crossed the south curb line of West Front Avenue to the point at which the truck-tractor passed the flashing lights.

Figure 6 illustrates the position of the second procession combination vehicle when the flashing light signals began to operate and the bells began to sound.

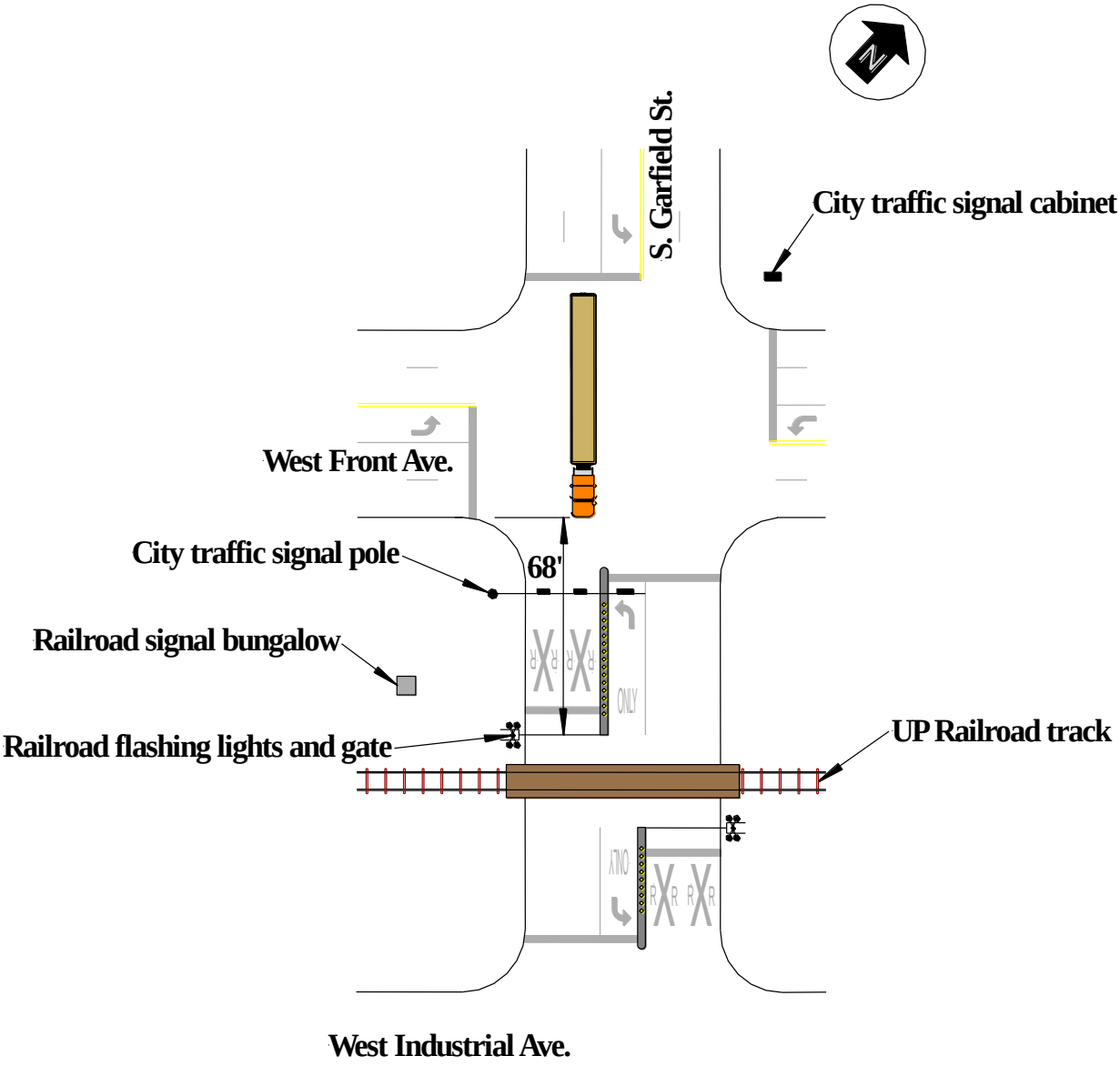

Figure 6 – Position of the second procession combination vehicle when the flashing light signals began to operate and the bells began to sound

In accordance with the Texas Transportation Code, the operator of the combination vehicle was required to stop not closer than 15 feet from the nearest rail and remain stopped until safe to proceed. Despite the visible flashing lights on the railroad signal, the operator of the second procession combination vehicle continued to approach and ultimately enter the grade crossing under police escort.

3.10.2 ADVANCE PREEMPTION SYSTEM OPERATION

Based on the review of the video recording made in the trailing procession escort law enforcement vehicle, the traffic signal for southbound South Garfield Street was and had been displaying circular red indications prior to the second procession combination vehicle entering the intersection with West Front Avenue. From the video, the first point at which the circular red indications could be detected on the traffic signal was approximately 171 feet from the traffic signals cantilevered over the southbound lanes of South Garfield Street at West Front Avenue and approximately 67 feet from the white stop line on the southbound approach to the South Garfield Street and West Front Avenue intersection. Figure 7 illustrates the position of the second procession vehicle at the first point at which the circular red indications could be detected on the traffic signal.

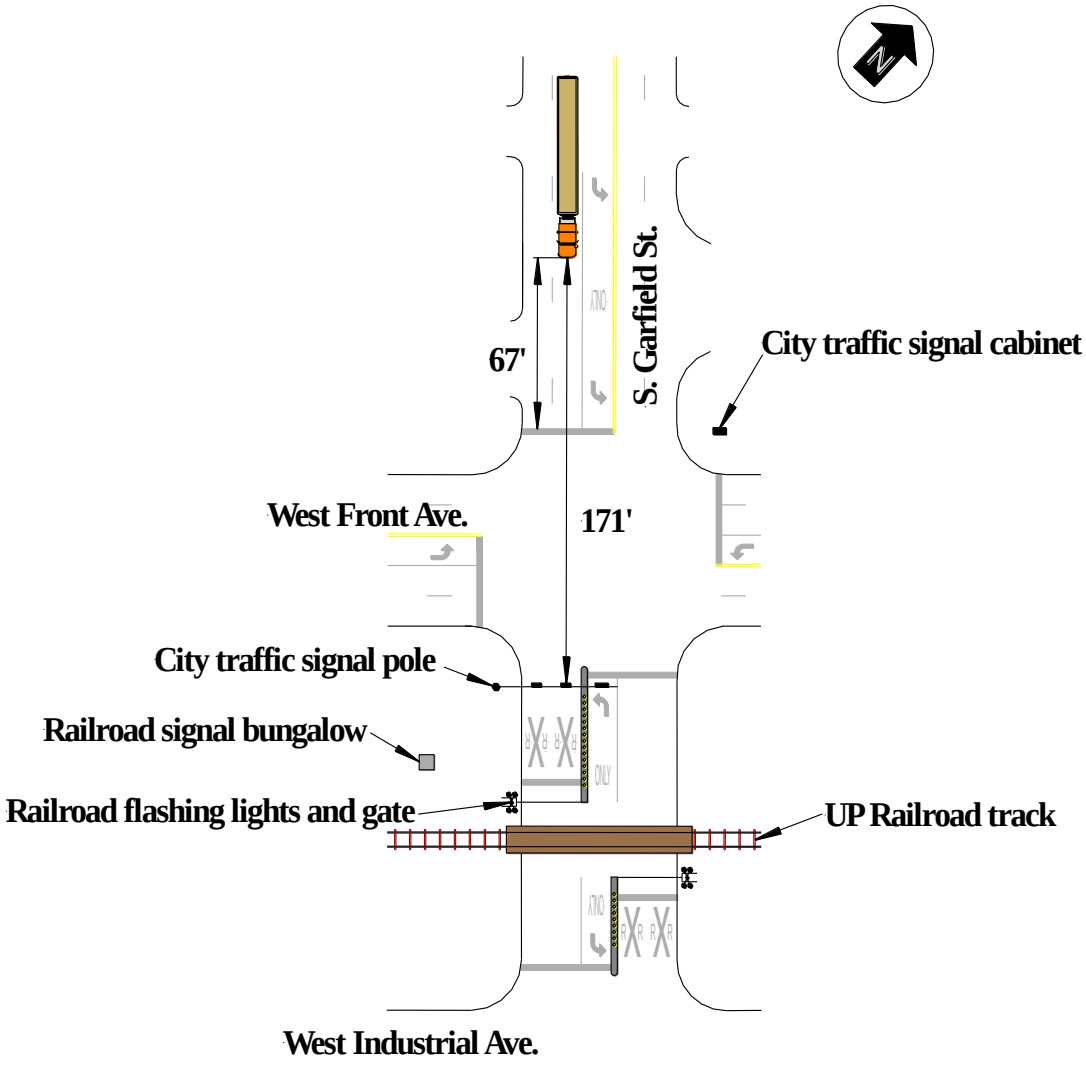

Figure 7 – Position of the second procession combination vehicle at the first point at which the circular red indications could be detected on the traffic signal

The traffic signal at the intersection of South Garfield Street and West Front Avenue was in advance preemption prior to the second procession combination vehicle entering the intersection. The advance preemption time provides additional time before the flashing lights begin to activate for vehicles to clear the track, and is an integral part of the functioning of the overall warning provided to road users. The second procession combination vehicle entered the intersection of South Garfield Street and West Front Avenue under police escort while the traffic signal displayed circular red signal indications. The advance preemption system is designed for vehicles entering and departing the grade crossing to comply with the traffic signal indications and clear the track before the railroad flashing lights begin to operate. The additional clearance time provided by the advance preemption operation was negated resulting in the loss of the effectiveness of the advance preemption time provided by the railroad active warning system. This served to shorten the overall warning provided of the approaching train.

4. DAMAGE TO AUTOMATIC GATE ARM AND POST MOUNTED SIGNAL

NTSB investigators documented the damage to the automatic gate arm in the northbound lanes of South Garfield Street. The automatic gate arm was removed from its drive mechanism and found on the earthen grass surface in the south-east quadrant of the grade crossing (see *HWY Photo-01, View of automatic gate arm removed from its drive mechanism in the northbound lanes of South Garfield Street* and *HWY Photo-02, View of final rest of the automatic gate arm found on the earthen grass surface in the south-east quadrant of the grade crossing*). A new automatic gate arm was attached to the drive mechanism after the accident on November 16, 2012.

NTSB investigators also documented damage to the traffic signal mounted to the post that supported the traffic signals cantilevered over the northbound lanes of South Garfield Street at West Industrial Avenue. A research effort using Google Earth revealed the traffic signal was mounted vertically to the post (see *HWY Photo-03, View of vertically mounted traffic signal before the accident obtained from Google Earth*). The purpose of the vertically mounted traffic signal is to provide a different orientation of the traffic signal unit for view by motorists traveling in the northbound lanes due to sun glare of the traffic signals positioned horizontally on the cantilever structure. The damage consisted of the vertically mounted traffic signal being dislodged from the post and supported by a wire conduit (see *HWY Photo-04, View of vertically mounted traffic signal dislodged from the post and supported by a wire conduit*). The vertically mounted traffic signal consisted of three lenses, one of which was broken from the traffic signal unit and found on the roadway pavement (see *HWY Photo-05, View of portion of traffic signal unit found on the roadway pavement*). The distance from the ground surface to the point at which the traffic signal was mounted vertically to the post was approximately 9 feet. The damaged post mounted traffic signal was removed after the accident on November 16, 2012. The City of Midland installed a new traffic signal mounted vertically to the post on November 26, 2012.

5. DIRECTION OF TRAVEL FOR UNION PACIFIC (UP) TRAIN AND SHOW OF SUPPORT PARADE

Figure 8 illustrates the direction of travel for the UP train and the "Show of Support" parade. The UP train was headed in an easterly direction and the "Show of Support" parade was headed in a southerly direction on South Garfield Street.

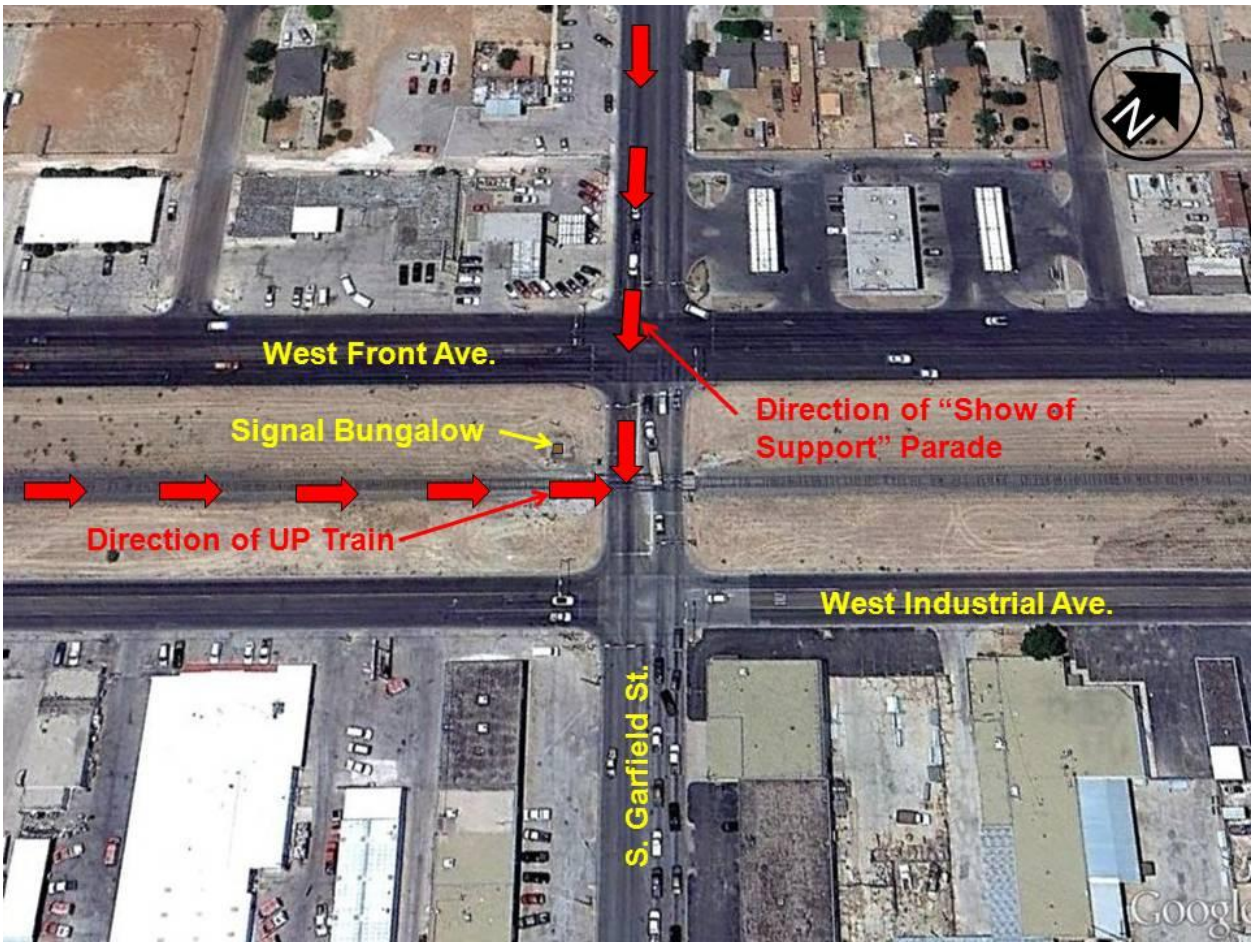

Figure 8 – Direction of travel for the UP train and "Show of Support" parade

6. QUIET ZONES

In response to a legislative mandate, FRA issued a Final Rule on the Use of Locomotive Horns at Highway-Rail Grade Crossings. This final rule, which requires that locomotive horns be sounded as a warning to highway users at public highway-rail crossings, took effect on June 24, 2005. The final rule provides an opportunity, not available until that time, for thousands of localities nationwide to mitigate the effects of train horn noise by establishing new "quiet zones." The rule also details actions communities with preexisting "whistle bans" can take to preserve the quiet they have become accustomed to.

FRA provided information on the procedure for creating a new quiet zone or new partial quiet zone:

> ***"Chart 3, Creating a New Quiet Zone or New Partial Quiet Zone using Supplemental Safety Measures (SSM's)***
>
> *1. Select the crossings to be included in the New Quiet Zone.*
>
> *2. A Quiet Zone may include highway-rail grade crossings on a segment of rail line crossing more than one political jurisdiction, or there may be roads within a particular area that are the responsibility of different entities (State or county roads within a town, for example). If the selected crossings are the responsibility of more than one entity, obtain the cooperation of all relevant jurisdictions.*
>
> *3. A New Quiet Zone must be at least ½ mile in length along the railroad tracks.*
>
> *4. A New Quiet Zone must have, at a minimum, flashing lights and gates in place at each public crossing. These must be equipped with constant warning time devices where reasonably practical, and power out indicators. Any necessary upgrades must be completed before calculating risk for the quiet zone.*
>
> *5. Are there any private or pedestrian crossings within the proposed Quiet Zone? If any private crossings allow access to the public or provide access to active industrial or commercial sites, or if there are any pedestrian crossings, you must conduct a diagnostic team review of those crossings. Following the diagnostic review, you must comply with the diagnostic team's recommendations concerning those crossings.*
>
> *6. Update the USDOT Grade Crossing Inventory Form to reflect conditions at each public and private crossing; this update should be complete, and accurate3. For instructions on how to complete the update, see the FRA website at http://www.fra.dot.gov/us/content/801.*
>
> *7. Submit notification of your intent to create a New or New Partial Quiet Zone in accordance with the rule. (Refer to rule section 222.43 for details.)*
>
> *8. Using the FRA's Quiet Zone Calculator, a web-based tool that can be found at http://safetydata.fra.dot.gov/quiet/ , determine whether the Quiet Zone Risk Index (QZRI) of the proposed Quiet Zone is less than or equal to the Nationwide Significant Risk Threshold (NSRT). If the QZRI is less than or equal to the NSRT, you can establish the Quiet Zone through public authority designation by completing the following steps:*
>
> *a. Install required signage at each crossing. (Refer to rule sections 222.25, 222.27, and 222.35 for details.)*
>
> *b. Submit notification in accordance with the rule. (Refer to rule section 222.43 for details.)*

Note: Quiet Zones established by comparison to the NSRT are subject to annual FRA review. (Refer to rule section 222.51 for details.)

Note: Periodic updates, including updated USDOT Grade Crossing Inventory Forms, must be submitted to FRA every 2.5-3 years. (Refer to rule section 222.47 for details.)

9. The step described above involves qualifying a quiet zone without implementing any Supplementary Safety Measures (SSMs) or Alternative Safety Measures (ASMs). If FRA's Quiet Zone Calculator indicates that the proposed quiet zone will not qualify on that basis, install any measures that are needed. To qualify for Public Authority Designation, you must implement SSMs, build grade separations, close crossings, or install wayside horns.

Note: If you would like to implement any ASMs, their use must be approved in advance by FRA, in accordance with Appendix B of the rule. For guidance on ASM use, see Chart 4B, Creating a Quiet Zone using Modified SSMs, Chart 4C, Creating a Quiet Zone using Engineering ASMs, or Chart 4C, Creating a Quiet Zone using Non-engineering ASMs.

10. If every public crossing in the proposed Quiet Zone is equipped with one or more SSMs, you can establish the Quiet Zone through public authority designation by completing the following steps:

a. Install required signage at each crossing. (Refer to rule sections 222.25, 222.27, and 222.35 for details.)

b. Update the National Grade Crossing Inventory to reflect current conditions at each public and private crossing within the Quiet Zone.

c. Submit notification in accordance with the rule. (Refer to rule section 222.43 for details.)

Note: Periodic updates, including updated USDOT Grade Crossing Inventory Forms, must be submitted to FRA every 4.5-5 years. (Refer to rule section 222.47 for details.)"

The City of Midland submitted to the FRA a Notice of Establishment dated May 1, 2007 and a Notice of Affirmation dated May 14, 2010 to establish a 24 hour quiet zone for the following public highway rail grade crossings operated by the Union Pacific Railroad. The quiet zone will restrict the routine sounding of locomotive horns 24 hours a day.

Crossing ID #	**Street Name**
796328D	Eisenhower Drive
796329K	Warehouse Road
796330E	Midkiff Road
796331L	South Garfield Street
796332T	K Street
796334G	G Street
796335N	South Marienfeld Street
796337C	South Main Street
796338J	North Terrell Street
448430B	North Lamesa Road
796340K	North Carver Street

Figure 9 illustrates an aerial map of the quiet zone corridor in the City of Midland from Eisenhower Drive to North Carver Street. The quiet zone corridor was approximately 5 miles in length. The South Garfield Street grade crossing was located approximately 2.8 miles north-east from the beginning of the quiet zone (at Eisenhower Drive).

Figure 9 – Aerial map of the quiet zone corridor in the City of Midland

The Union Pacific Railroad System Special Instructions[18] indicated the following:

*"**Item 9 Use of Engine Horns – Quiet Zone***

Quiet Zone

Quiet zones are designated in the timetable. Do not sound the horn for grade crossings within limits or at locations designated on the subdivision page.

Sounded Horn

Horn may be sounded to provide a warning to animals, vehicle operators, pedestrians, trespassers or crews on other trains in an emergency situation when engineer believes such action is appropriate in order to prevent injury, death, or property damage.

[18]Union Pacific Railroad System Special Instructions, Effective Friday, April 20, 2012, page 41.

Horn must be sounded when:

- *Employees are working on or near the track.*
- *Meeting or passing the head end or rear end of a train in the vicinity of a grade crossing.*
- *Notified that automatic warning devices are malfunctioning or disabled or crossings require additional precautions. Sound whistle signal 5.8.2(7) regardless of any prohibition."*

The Union Pacific Railroad Sunset Area Timetable #3[19] indicated the following:

"SI-08 RULES ITEMS

Rule 5.8.2(7): *Item 9 of the System Special Instructions applies at and between:*

Carver Street, MP 552.2 and Eisenhower Street, MP 557.5, Midland, Texas"

7. SIGNAL BUNGALOW AT GRADE CROSSING

The signal bungalow was located in the north-west quadrant of the grade crossing. The signal bungalow was located approximately 35 feet from the west curb line of South Garfield Street and 22 feet from the nearest rail. The dimensions of the signal bungalow were 6 feet by 6 feet by 8 feet (width x length x height).

Figure 10 illustrates the signal bungalow was in the sight triangle of the grade crossing. The sight triangle was developed using a train speed of 62 mph and truck tractor speed of 5 mph corresponding to a distance along the UP Railroad from the grade crossing of 1,008 feet and the distance along South Garfield Street from the grade crossing of 80 feet.

[19]Union Pacific Railroad Sunset Area Timetable #3, Effective 0900 Monday, November 22, 2010, page 35.

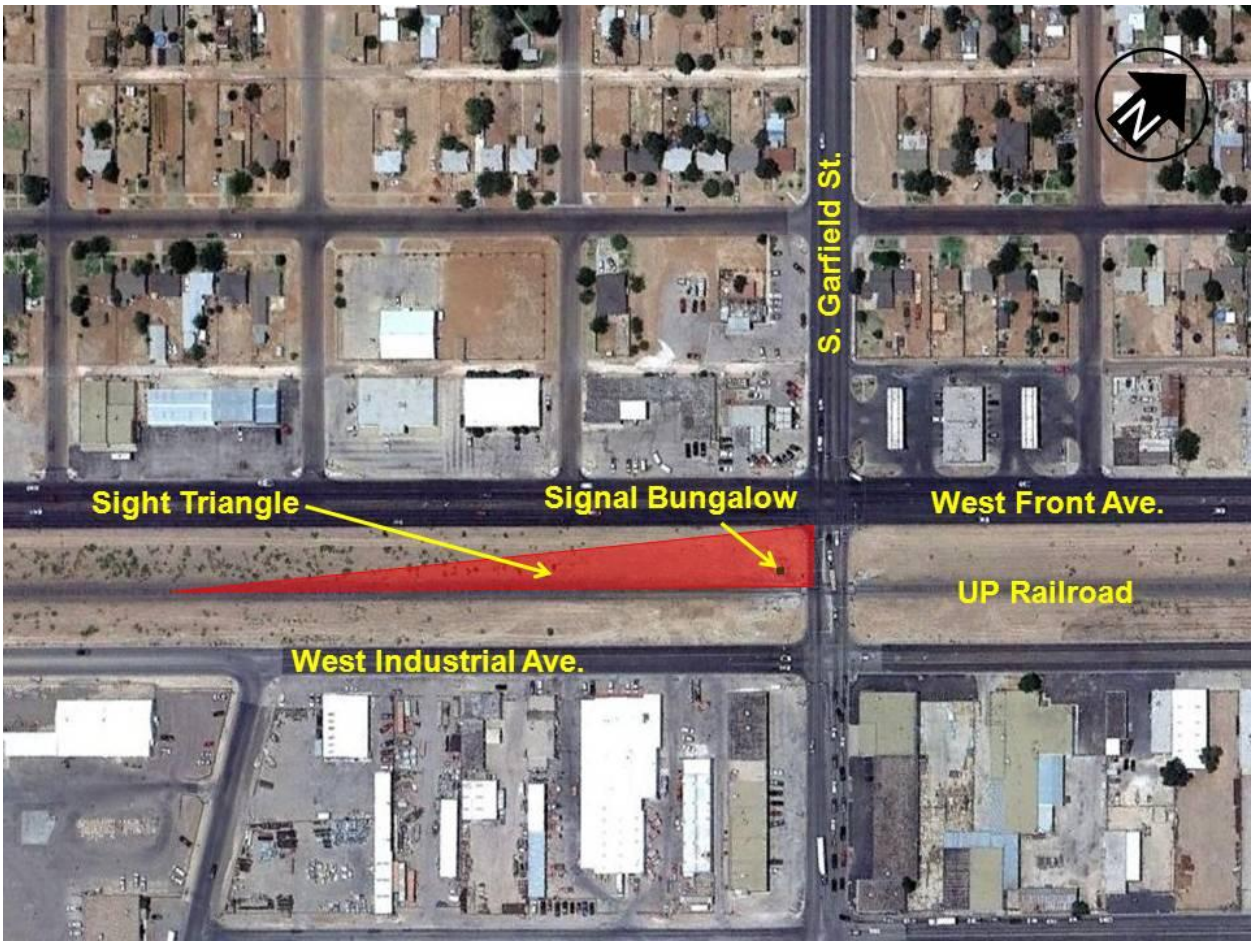

Figure 10 – Signal bungalow was in the sight triangle of the grade crossing

Table 6 summarizes the location of the signal bungalow at 10 grade crossing locations along West Front Avenue.

Table 6 – Location of the signal bungalow at 10 grade crossing locations along West Front Avenue

Grade Crossing	Signal Bungalow Location
Midkiff Road	North-east quadrant
South Garfield Street	North-west quadrant
K Street	North-east quadrant
G Street	North-east quadrant
South Marienfeld Street	North-east quadrant
South Main Street	South-west quadrant
North Terrell Street	North-east quadrant
North Lamesa Road	North-east quadrant
North Carver Street	North-east quadrant
North Fairgrounds Road	North-east quadrant

8. GLOSSARY OF TERMS USED IN THE FACTUAL REPORT

Definitions taken from the 2009 Manual on Uniform Traffic Control Devices[20] (MUTCD):

Active Grade Crossing Warning System—the flashing-light signals, with or without warning gates, together with the necessary control equipment used to inform road users of the approach or presence of rail traffic at grade crossings.

Advance Preemption—the notification of approaching rail traffic that is forwarded to the highway traffic signal controller unit or assembly by the railroad or light rail transit equipment in advance of the activation of the railroad or light rail transit warning devices.

Advance Preemption Time—the period of time that is the difference between the required maximum highway traffic signal preemption time and the activation of the railroad or light rail transit warning devices.

Clear Storage Distance—the distance available for vehicle storage measured between 6 feet from the rail nearest the intersection to the intersection stop line or the normal stopping point on the highway. At skewed grade crossings and intersections, the 6-foot distance shall be measured perpendicular to the nearest rail either along the center line or edge line of the highway, as appropriate, to obtain the shorter distance. Where exit gates are used, the distance available for vehicle storage is measured from the point where the rear of the vehicle would be clear of the exit gate arm. In cases where the exit gate arm is parallel to the track(s) and is not perpendicular to the highway, the distance is measured either along the center line or edge line of the highway, as appropriate, to obtain the shorter distance.

Constant Warning Time Detection—a means of detecting rail traffic that provides relatively uniform warning time for the approach of trains or light rail transit traffic that are not accelerating or decelerating after being detected.

Controller Assembly—a complete electrical device mounted in a cabinet for controlling the operation of a highway traffic signal.

Controller Unit—that part of a controller assembly that is devoted to the selection and timing of the display of signal indications.

[20] *Manual on Uniform Traffic Control Devices for Streets and Highways*, U.S. Department of Transportation, Federal Highway Administration; 2009 Edition; page 11.

Design Vehicle—the longest vehicle permitted by statute of the road authority (State or other) on that roadway.

Engineering Judgment—the evaluation of available pertinent information, and the application of appropriate principles, provisions, and practices as contained in this Manual and other sources, for the purpose of deciding upon the applicability, design, operation, or installation of a traffic control device. Engineering judgment shall be exercised by an engineer, or by an individual working under the supervision of an engineer, through the application of procedures and criteria established by the engineer. Documentation of engineering judgment is not required.

Engineering Study—the comprehensive analysis and evaluation of available pertinent information, and the application of appropriate principles, provisions, and practices as contained in this Manual and other sources, for the purpose of deciding upon the applicability, design, operation, or installation of a traffic control device. An engineering study shall be performed by an engineer, or by an individual working under the supervision of an engineer, through the application of procedures and criteria established by the engineer. An engineering study shall be documented.

Entrance Gate—an automatic gate that can be lowered across the lanes approaching a grade crossing to block road users from entering the grade crossing.

Flashing-Light Signals—a warning device consisting of two red signal indications arranged horizontally that are activated to flash alternately when rail traffic is approaching or present at a grade crossing.

Gate—an automatically-operated or manually-operated traffic control device that is used to physically obstruct road users such that they are discouraged from proceeding past a particular point on a roadway or pathway, or such that they are discouraged from entering a particular grade crossing, ramp, lane, roadway, or facility.

Grade Crossing—the general area where a highway and a railroad and/or light rail transit route cross at the same level, within which are included the tracks, highway, and traffic control devices for traffic traversing that area.

Highway-Rail Grade Crossing—the general area where a highway and a railroad cross at the same level, within which are included the railroad tracks, highway, and traffic control devices for highway traffic traversing that area.

Highway Traffic Signal—a power-operated traffic control device by which traffic is warned or directed to take some specific action. These devices do not include power-operated signs, steadily-illuminated pavement markers, warning lights, or steady burning electric lamps.

Interconnection—the electrical connection between the railroad or light rail transit active warning system and the highway traffic signal controller assembly for the purpose of preemption.

Locomotive Horn—an air horn, steam whistle, or similar audible warning device mounted on a locomotive or control cab car.

Maximum Highway Traffic Signal Preemption Time—the maximum amount of time needed following initiation of the preemption sequence for the highway traffic signals to complete the timing of the right-of-way transfer time, queue clearance time, and separation time.

Minimum Track Clearance Distance—for standard two-quadrant warning devices, the minimum track clearance distance is the length along a highway at one or more railroad or light rail transit tracks, measured from the highway stop line, warning device, or 12 feet perpendicular to the track center line, to 6 feet beyond the track(s) measured perpendicular to the far rail, along the center line or edge line of the highway, as appropriate, to obtain the longer distance.

Minimum Warning Time—the least amount of time active warning devices shall operate prior to the arrival of rail traffic at a grade crossing.

Preemption—the transfer of normal operation of a traffic control signal to a special control mode of operation.

Queue Clearance Time—the time required for the design vehicle of maximum length stopped just inside the minimum track clearance distance to start up and move through and clear the entire minimum track clearance distance.

Quiet Zone—a segment of a rail line, with one or a number of consecutive public highway-rail grade crossings at which locomotive horns are not routinely sounded.

Rail Traffic—every device in, upon, or by which any person or property can be transported on rails or tracks and to which all other traffic must yield the right-of-way by law at grade crossings, including trains, one or more locomotives coupled (with or without cars), other railroad equipment, and light rail transit operating in exclusive or semi-exclusive alignments.

Right-of-Way Transfer Time—the maximum amount of time needed for the worst case condition, prior to display of the track clearance green interval. This includes any railroad or light rail transit or highway traffic signal control equipment time to react to a preemption call, and any traffic control signal green, pedestrian walk and clearance, yellow change, and red clearance intervals for conflicting traffic.

Road User—a vehicle operator, bicyclist, or pedestrian, including persons with disabilities, within the highway or on a private road open to public travel.

Separation Time—the component of maximum highway traffic signal preemption time during which the minimum track clearance distance is clear of vehicular traffic prior to the arrival of rail traffic.

Signal Face—an assembly of one or more signal sections that is provided for controlling one or more traffic movements on a single approach.

Signal Lens—that part of the signal section that redirects the light coming directly from the light source and its reflector, if any.

Signal Louver—a device that can be mounted inside a signal visor to restrict visibility of a signal indication from the side or to limit the visibility of the signal indication to a certain lane or lanes, or to a certain distance from the stop line.

Signal Phase—the right-of-way, yellow change, and red clearance intervals in a cycle that are assigned to an independent traffic movement or combination of movements.

Signal Section—the assembly of a signal housing, signal lens, if any, and light source with necessary components to be used for displaying one signal indication.

Signal System—two or more traffic control signals operating in signal coordination.

Signal Timing—the amount of time allocated for the display of a signal indication.

Simultaneous Preemption—notification of approaching rail traffic is forwarded to the highway traffic signal controller unit or assembly and railroad or light rail transit active warning devices at the same time.

Stop Line—a solid white pavement marking line extending across approach lanes to indicate the point at which a stop is intended or required to be made.

Supplemental Signal Face—a signal face that is not a primary signal face but which is provided for a given approach or separate turning movement to enhance visibility or conspicuity.

Traffic Control Device—a sign, signal, marking, or other device used to regulate, warn, or guide traffic, placed on, over, or adjacent to a street, highway, private road open to public travel, pedestrian facility, or shared-use path by authority of a public agency or official having jurisdiction, or, in the case of a private road open to public travel, by authority of the private owner or private official having jurisdiction.

Traffic Control Signal (Traffic Signal)—any highway traffic signal by which traffic is alternately directed to stop and permitted to proceed.

Train—one or more locomotives coupled, with or without cars, that operates on rails or tracks and to which all other traffic must yield the right-of-way by law at highway-rail grade crossings.

Vehicle—every device in, upon, or by which any person or property can be transported or drawn upon a highway, except trains and light rail transit operating in exclusive or semi-exclusive alignments.

Wayside Equipment—the signals, switches, and/or control devices for railroad or light rail transit operations housed within one or more enclosures located along the railroad or light rail transit right-of-way and/or on railroad or light rail transit property.

D. ATTACHMENTS

Attachment 1 – Highway-Rail Grade Crossing Accident/Incident Reports at the South Garfield Street and Union Pacific Railroad Grade Crossing

Attachment 2 – 49 Code of Federal Regulations (CFR) Part 234.225 Minimum 20 Second Warning Time

Attachment 3 – 49 Code of Federal Regulations (CFR) Parts 212 and 234 Grade Crossing Signal System Safety

Attachment 4 – Federal Register Federal Railroad Administration Safety Advisory 2010-02

Attachment 5 – Average Daily Traffic and Vehicle Classification Count on South Garfield Street in the Vicinity of the Union Pacific Railroad Grade Crossing

Attachment 6 – City of Midland Ordinance No. 9064 Establishing Speed Limit of 35 MPH on Garfield Street and Industrial Avenue

Attachment 7 – Plan and Profile of Humped Crossing on South Garfield Street at the Union Pacific Railroad Grade Crossing

Attachment 8 – 2006 Rehabilitation Project on South Garfield Street in the Vicinity of the Union Pacific Railroad Grade Crossing

Attachment 9 – Texas Department of Transportation and City of Midland Municipal Maintenance Agreement dated January 27, 1998

Attachment 10 – Texas Transportation Commission Minute Order No. 112740 Transferring South Garfield Street to the Texas State Highway System

Attachment 11 – City of Midland Resolution No. 2009-059 Intent to Transfer South Garfield Street to the Texas State Highway System

Attachment 12 – Notice of Establishment of a Railroad Quiet Zone in Midland, Texas dated May 1, 2007

Attachment 13 – Notice of Affirmation for a Railroad Quiet Zone in Midland, Texas dated May 14, 2010

Attachment 14 – Union Pacific Railroad Standard Drawing of Signal Bungalow

E. PHOTOGRAPHS

HWY Photo-01 – View of automatic gate arm removed from its drive mechanism in the northbound lanes of South Garfield Street

HWY Photo-02 – View of final rest of the automatic gate arm found on the earthen grass surface in the south-east quadrant of the grade crossing

HWY Photo-03 – View of vertically mounted traffic signal before the accident obtained from Google Earth

HWY Photo-04 – View of vertically mounted traffic signal dislodged from the post and supported by a wire conduit

HWY Photo-05 – View of portion of traffic signal unit found on the roadway pavement

HWY Photo-06 – View of final rest of second procession combination vehicle on South Garfield Street and damage to vertically mounted traffic signal and automatic gate arm in background

HWY Photo-07 – View of grade crossing sign on signal bungalow

HWY Photo-08 – View of automatic gate arms lowering in anticipation of eastbound train, looking to the north on South Garfield Street

HWY Photo-09 – View of automatic gate arms fully lowered in anticipation of eastbound train, looking to the north on South Garfield Street

HWY Photo-10 – View of eastbound train occupying the grade crossing looking to the north on South Garfield Street

HWY Photo-11 – View of the humped crossing in the direction of the parade in the southbound lanes of South Garfield Street

HWY Photo-12 – View of the humped crossing in the direction of the parade in the left southbound lane of South Garfield Street

HWY Photo-13 – View of eastbound train occupying the grade crossing looking to the south on South Garfield Street

HWY Photo-14 – View of southbound lanes of South Garfield Street approaching the West Front Avenue intersection looking to the north

HWY Photo-15 – View of UP Railroad track looking to the west from the left southbound lane of South Garfield Street approximately 9 feet from the nearest rail

HWY Photo-16 – View of UP Railroad track looking to the west from the left southbound lane of South Garfield Street approximately 15 feet from the nearest rail

HWY Photo-17 – View of UP Railroad track looking to the west from the left southbound lane of South Garfield Street approximately 20 feet from the nearest rail

HWY Photo-18 – View of UP Railroad track looking to the west from the left southbound lane of South Garfield Street approximately 26 feet from the nearest rail

HWY Photo-19 – View of UP Railroad track looking to the west from the left southbound lane of South Garfield Street approximately 33 feet from the nearest rail

HWY Photo-20 – View of UP Railroad track looking to the west from the left southbound lane of South Garfield Street approximately 41 feet from the nearest rail

HWY Photo-21 – View of UP Railroad track looking to the west from the left southbound lane of South Garfield Street approximately 48 feet from the nearest rail

HWY Photo-22 – View of UP Railroad track looking to the west from the left southbound lane of South Garfield Street approximately 56 feet from the nearest rail

HWY Photo-23 – View of UP Railroad track looking to the west from the left southbound lane of South Garfield Street approximately 63 feet from the nearest rail

HWY Photo-24 – View of UP Railroad track looking to the west from the left southbound lane of South Garfield Street approximately 70 feet from the nearest rail

HWY Photo-25 – View of UP Railroad track looking to the west from the left southbound lane of South Garfield Street approximately 77 feet from the nearest rail

HWY Photo-26 – View of UP Railroad track looking to the west from the east curb line of South Garfield Street approximately 6 feet from the nearest rail

HWY Photo-27 – View of UP Railroad track looking to the west from the east curb line of South Garfield Street approximately 15 feet from the nearest rail

HWY Photo-28 – View of UP Railroad track looking to the west from the east curb line of South Garfield Street approximately 20 feet from the nearest rail

HWY Photo-29 – View of UP Railroad track looking to the west from the east curb line of South Garfield Street approximately 26 feet from the nearest rail

HWY Photo-30 – View of UP Railroad track looking to the west from the east curb line of South Garfield Street approximately 33 feet from the nearest rail

HWY Photo-31 – View of UP Railroad track looking to the west from the east curb line of South Garfield Street approximately 41 feet from the nearest rail

HWY Photo-32 – View of UP Railroad track looking to the west from the east curb line of South Garfield Street approximately 56 feet from the nearest rail

Dan Walsh /S/

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Senior Highway Accident Investigator