Federal Railroad Administration
Office of Safety
Headquarters Assigned
Accident Investigation Report
HQ-2008-90

Long Island Railroad (LIRR)
Jamaica, NY
November 23, 2008

Note that 49 U.S.C. §20903 provides that no part of an accident or incident report made by the Secretary of Transportation/Federal Railroad Administration under 49 U.S.C. §20902 may be used in a civil action for damages resulting from a matter mentioned in the report.

DEPARTMENT OF TRANSPORTATION
FEDERAL RAILROAD ADMINISTRATION

FRA FACTUAL RAILROAD ACCIDENT REPORT

FRA File # HQ-2008-90

1.Name of Railroad Operating Train #1: Long Island Rail Road [LI]	1a. Alphabetic Code: LI	1b. Railroad Accident/Incident No.: EQ20081103
2.Name of Railroad Operating Train #2: N/A	2a. Alphabetic Code: N/A	2b. Railroad Accident/Incident No.: N/A
3.Name of Railroad Operating Train #3: N/A	3a. Alphabetic Code: N/A	3b. Railroad Accident/Incident No.: N/A
4.Name of Railroad Responsible for Track Maintenance: Long Island Rail Road [LI]	4a. Alphabetic Code: LI	4b. Railroad Accident/Incident No.: EQ20081103
5. U.S. DOT_AAR Grade Crossing Identification Number:	6. Date of Accident/Incident: Month 11 | Day 23 | Year 2008	7. Time of Accident/Incident: 12:18:00 ☐ AM ☑ PM

8. Type of Accident/Indicent (single entry in code box)					Code
1. Derailment	4. Side collision	7. Hwy-rail crossing	10. Explosion-detonation	13. Other (describe in narrative)	01
2. Head on collision	5. Raking collision	8. RR grade crossing	11. Fire/violent rupture		
3. Rear end collision	6. Broken Train collision	9. Obstruction	12. Other impacts		

9. Cars Carrying HAZMAT	10. HAZMAT Cars Damaged/Derailed	11. Cars Releasing HAZMAT	12. People Evacuated	13. Division
0	N/A	N/A	0	System

14. Nearest City/Town	15. Milepost (to nearest tenth)	16. State Abbr	16. State Code	17. County
Jamaica, Queens	9.7	N/A	NY	QUEENS

18. Temperature (F) (specify if minus)	19. Visibility (single entry) 1. Dawn 2. Day 3.Dusk 4.Dark	Code	20. Weather (single entry) 1. Clear 2. Cloudy 3. Rain 4. Fog 5.Sleet 6.Snow	Code	21. Type of Track 1. Main 2. Yard 3. Siding 4. Industry	Code
35 F	2	2		2		1

22. Track Name/Number	23. FRA Track Class (1-9, X)	Code	24. Annual Track Density (gross tons in millions)	25. Time Table Direction 1. North 2. South 3. East 4. West	Code
Track5, Jamaica	1	1	N/A		3

OPERATING TRAIN #1

26. Type of Equipment Consist (single entry) 1. Freight train 2. Passenger train 3. Commuter train 4. Work train 5. Single car 6. Cut of cars 7. Yard/switching 8. Light loco(s). 9. Maint./inspect.car	A. Spec. MoW Equip.	Code	27. Was Equipment Attended? 1. Yes 2. No	Code	28. Train Number/Symbol
		7	1. Yes	1	LI 7700

29. Speed (recorded speed, if available) R - Recorded E - Estimated			Code
11	MPH	R	

30. Trailing Tons (gross tonnage, excluding power units): N/A

31. Method(s) of Operation (enter code(s) that apply)

a. ATCS; b. Auto train control; c. Auto train stop; d. Cab; e. Traffic; f. Interlocking; g. Automatic block; h. Current of traffic; i. Time table/train orders; j.Track warrant control; k. Direct traffic control; l.Yard limits; m.Special instructions; n. Other than main track; o. Positive train control; p. Other (Specify in narrative)

Code(s)				
d	N/A	N/A	N/A	N/A

31a. Remotely Controlled Locomotive?
0 = Not a remotely controlled
1 = Remote control portable
2 = Remote control tower
3 = Remote control transmitter - more than one remote control transmitter

0

32. Principal Car/Unit	a. Initial and Number	b. Position in Train	c. Loaded (yes/no)
(1) First involved (derailed, struck, etc)	LI7267	8	yes
(2) Causing (if mechanical cause reported)	0	0	N/A

33. If railroad employee(s) tested for drug/alcohol use, enter the number that were positive in the appropriate box.

Alcohol	Drugs
0	0

34. Was this consist transporting passengers? (Y/N): Y

35. Locomotive Units	a. Head End	Mid Train b. Manual	Mid Train c. Remote	Rear End d. Manual	Rear End c. Remote	36. Cars	Loaded a. Freight	Loaded b. Pass.	Empty c. Freight	Empty d. Pass.	e. Caboose
(1) Total in Train	1	0	0	0	0	(1) Total in Equipment Consist	0	9	0	0	0
(2) Total Derailed	0	0	0	0	0	(2) Total Derailed	0	3	0	0	0

37. Equipment Damage This Consist	38. Track, Signal, Way, & Structure Damage	39. Primary Cause Code	40. Contributing Cause Code
$525,000.00	$262,184.00	M405	N/A

Number of Crew Members				Length of Time on Duty	
41. Engineer/ Operators	42. Firemen	43. Conductors	44. Brakemen	45. Engineer/Operator	46. Conductor
1	0	1	1	Hrs 4 Mi 23	Hrs 4 Mi 23

Casualties to:	47. Railroad Employees	48. Train Passengers	49. Other
Fatal	0	0	0
Nonfatal	0	1	0

50. EOT Device? 1. Yes 2. No: N/A

51. Was EOT Device Properly Armed? 1. Yes 2. No: N/A

52. Caboose Occupied by Crew? 1. Yes 2. No: N/A

OPERATING TRAIN #2

53. Type of Equipment Consist (single entry) 1. Freight train 2. Passenger train 3. Commuter train 4. Work train 5. Single car 6. Cut of cars 7. Yard/switching 8. Light loco(s). 9. Maint./inspect.car	A. Spec. MoW Equip.	Code	54. Was Equipment Attended? 1. Yes 2. No	Code	55. Train Number/Symbol
		N/A	N/A	N/A	N/A

56. Speed (recorded speed, if available) R - Recorded E - Estimated			Code
0	MPH	N/A	

58. Method(s) of Operation (enter code(s) that apply)

a. ATCS; b. Auto train control; g. Automatic block; h. Current of traffic; m.Special instructions; n. Other than main track

58a. Remotely Controlled Locomotive?
0 = Not a remotely controlled
1 = Remote control portable

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57. Trailing Tons *(gross tonnage, excluding power units)* N/A

c. Auto train stop; d. Cab; e. Traffic; f. Interlocking; i. Time table/train orders; j.Track warrant control; k. Direct traffic control; l.Yard limits; o. Positive train control; p. Other *(Specify in narrative)* Code(s): N/A N/A N/A N/A N/A

2 = Remote control tower
3 = Remote control transmitter - more than one remote control transmitter: N/A

59. Principal Car/Unit	a. Initial and Number	b. Position in Train	c. Loaded *(yes/no)*
(1) First involved *(derailed, struck, etc)*	0	0	N/A
(2) Causing *(if mechanical cause reported)*	0	0	N/A

60. If railroad employee(s) tested for drug/alcohol use, enter the number that were positive in the appropriate box.

Alcohol	Drugs
N/A	N/A

61. Was this consist transporting passengers? (Y/N) N/A

62. Locomotive Units	a. Head End	Mid Train b. Manual	Mid Train c. Remote	Rear End d. Manual	Rear End c. Remote
(1) Total in Train	0	0	0	0	0
(2) Total Derailed	0	0	0	0	0

63. Cars	Loaded a. Freight	Loaded b. Pass.	Empty c. Freight	Empty d. Pass.	e. Caboose
(1) Total in Equipment Consist	0	0	0	0	0
(2) Total Derailed	0	0	0	0	0

64. Equipment Damage This Consist: $0.00

65. Track, Signal, Way, & Structure Damage: $0.00

66. Primary Cause Code: N/A

67. Contributing Cause Code: N/A

Number of Crew Members

68. Engineer/ Operators	69. Firemen	70. Conductors	71. Brakemen
0	0	0	0

Length of Time on Duty

72. Engineer/Operator: Hrs 0 Mi 0

73. Conductor: Hrs 0 Mi 0

Casualties to:	74. Railroad Employees	75. Train Passengers	76. Other
Fatal	0	0	0
Nonfatal	0	0	0

77. EOT Device? 1. Yes 2. No N/A

78. Was EOT Device Properly Armed? 1. Yes 2. No N/A

79. Caboose Occupied by Crew? 1. Yes 2. No N/A

OPERATING TRAIN #3

80. Type of Equipment Consist *(single entry)*: 1. Freight train; 2. Passenger train; 3. Commuter train; 4. Work train; 5. Single car; 6. Cut of cars; 7. Yard/switching; 8. Light loco(s); 9. Maint./inspect.car; A. Spec. MoW Equip. Code: N/A

81. Was Equipment Attended? 1. Yes 2. No Code: N/A

82. Train Number/Symbol: N/A

83. Speed *(recorded speed, if available)* Code: R - Recorded; E - Estimated N/A MPH N/A

84. Trailing Tons *(gross tonnage, excluding power units)* N/A

85. Method(s) of Operation *(enter code(s) that apply)*

a. ATCS; b. Auto train control; c. Auto train stop; d. Cab; e. Traffic; f. Interlocking; g. Automatic block; h. Current of traffic; i. Time table/train orders; j.Track warrant control; k. Direct traffic control; l.Yard limits; m.Special instructions; n. Other than main track; o. Positive train control; p. Other *(Specify in narrative)* Code(s): N/A N/A N/A N/A N/A

85a. Remotely Controlled Locomotive?
0 = Not a remotely controlled
1 = Remote control portable
2 = Remote control tower
3 = Remote control transmitter - more than one remote control transmitter: N/A

86. Principal Car/Unit	a. Initial and Number	b. Position in Train	c. Loaded *(yes/no)*
(1) First involved *(derailed, struck, etc)*	N/A	N/A	N/A
(2) Causing *(if mechanical cause reported)*	N/A	N/A	N/A

87. If railroad employee(s) tested for drug/alcohol use, enter the number that were positive in the appropriate box.

Alcohol	Drugs
N/A	N/A

88. Was this consist transporting passengers? (Y/N) N/A

89. Locomotive Units	a. Head End	Mid Train b. Manual	Mid Train c. Remote	Rear End d. Manual	Rear End c. Remote
(1) Total in Train	N/A	N/A	N/A	N/A	N/A
(2) Total Derailed	N/A	N/A	N/A	N/A	N/A

90. Cars	Loaded a. Freight	Loaded b. Pass.	Empty c. Freight	Empty d. Pass.	e. Caboose
(1) Total in Equipment Consist	N/A	N/A	N/A	N/A	N/A
(2) Total Derailed	N/A	N/A	N/A	N/A	N/A

91. Equipment Damage This Consist: N/A

92. Track, Signal, Way, & Structure Damage: N/A

93. Primary Cause Code: N/A

94. Contributing Cause Code: N/A

Number of Crew Members

95. Engineer/ Operators	96. Firemen	97. Conductors	98. Brakemen
N/A	N/A	N/A	N/A

Length of Time on Duty

99. Engineer/Operator: Hrs N/A Mi N/A

100. Conductor: Hrs N/A Mi N/A

Casualties to:	101. Railroad Employees	102. Train	103. Other
Fatal	N/A	N/A	N/A
Nonfatal	N/A	N/A	N/A

104. EOT 1. Yes 2. No N/A

105. Was EOT Device Properly 1. Yes 2. No N/A

106. Caboose Occupied by Crew? 1. Yes 2. No N/A

Highway User Involved

107. Code: A. Auto; B. Truck; C. Truck-Trailer.; D. Pick-Up Truck; E. Van; F. Bus; G. School Bus; H. Motorcycle; J. Other Motor Vehicle; K. Pedestrian; M. Other *(spec. in narrative)*: N/A

108. Vehicle Speed *(est. MPH at impact)*: N/A

109. *geographical)* Code: 1.North 2.South 3.East 4.West: N/A

Rail Equipment Involved

111. Equipment Code: 1.Train *(units pulling)*; 2.Train *(units pushing)*; 3.Train *(standing)*; 4.Car(s) *(moving)*; 5.Car(s) *(standing)*; 6.Light Loco(s) *(moving)*; 7.Light(s) *(standing)*; 8.Other *(specify in narrative)*: N/A

112. Position of Car Unit in: N/A

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110. Position 1.Stalled on Crossing 2.Stopped on Crossing 3.Moving Over Crossing 4. Trapped	Code N/A	113. Circumstance 1. Rail Equipment Struck Highway User 2. Rail Equipment Struck by Highway User	Code N/A
114a. Was the highway user and/or rail equipment involved in the impact transporting hazardous materials? 1. Highway User 2. Rail Equipment 3. Both 4. Neither	Code N/A	114b. Was there a hazardous materials release 1. Highway User 2. Rail Equipment 3. Both 4. Neither	Code N/A
114c. State here the name and quantity of the hazardous materials released, if any. N/A			

115. Type Crossing Warning 1.Gates 2.Cantilever FLS 3.Standard FLS 4.Wig Wags 5.Hwy. traffic signals 6.Audible 7.Crossbucks 8.Stop signs 9.Watchman 10.Flagged by crew 11.Other *(spec. in narr.)* 12.None	116. Signaled Crossing *(See instructions for codes)*	Code	117. Whistle Ban 1. Yes 2. No 3. Unknown	Code
Code(s) N/A N/A N/A N/A N/A N/A N/A	N/A	N/A	N/A	N/A

118. Location of Warning 1. Both Sides 2. Side of Vehicle Approach 3. Opposite Side of Vehicle Approach	Code N/A	119. Crossing Warning with Highway Signals 1. Yes 2. No 3. Unknown	Code N/A	120. Crossing Illuminated by Street Lights or Special Lights 1. Yes 2. No 3. Unknown	Code N/A

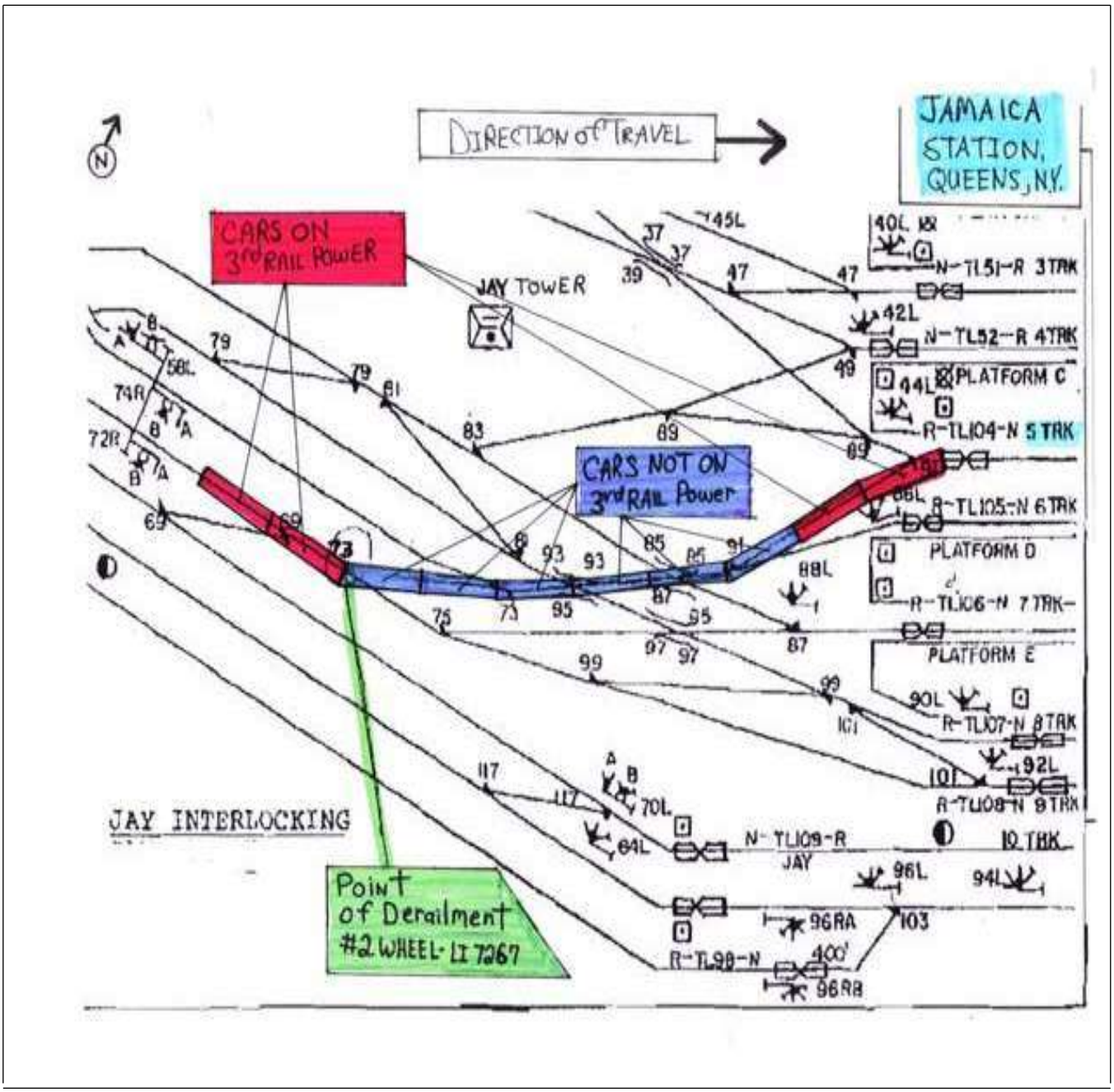
121. Age N/A	122. Driver's Gender 1. Male 2. Female	Code N/A	123. Driver Drove Behind or in Front of and Struck or was Struck by Second Train 1. Yes 2. No 3. Unknown	Code N/A	124. Driver 1. Drove around or thru the Gate 2. Stopped and then Proceeded 3. Did not Stop 4. Stopped on Crossing 5. Other *(specify in narrative)*	Code N/A

125. Driver Passed Highway Vehicle 1. Yes 2. No 3. Unknown	Code N/A	126. View of Track Obscured by *(primary obstruction)* 1. Permanent Structure 2. Standing Railroad Equipment 3. Passing Train 4. Topography 5. Vegetation 6. Highway Vehicle 7. Other *(specify in narrative)* 8. Not obstructed	Code N/A

Casualties to:	Killed	Injured	127. Driver 1. Killed 2.Injured 3. Uninjured	Code N/A	128. Was Driver in the Vehicle? 1. Yes 2. No	Code N/A
129. Highway-Rail Crossing Users	N/A	N/A	130. Highway Vehicle Property Damage *(est. dollar damage)*	N/A	131. Total Number of Highway-Rail Crossing Users *(include driver)*	N/A

132. Locomotive Auxiliary Lights? 1. Yes 2. No	Code N/A	133. Locomotive Auxiliary Lights Operational? 1. Yes 2. No	Code N/A
134. Locomotive Headlight Illuminated? 1. Yes 2. No	Code N/A	135. Locomotive Audible Warning Sounded? 1. Yes 2. No	Code N/A

136. DRAW A SKETCH OF ACCIDENT AREA INCLUDING ALL TRACKS, SIGNALS, SWITCHES, STRUCTURES, OBJECTS, ETC., INVOLVED.



137. SYNOPSIS OF THE ACCIDENT

On November 23, 2008 at 12:18 p.m. EST eastbound Long Island Railroad (LIRR) Passenger Train No. 7700 operating from Penn Station, N.Y. to Huntington, N.Y. derailed the three west cars of a ten car train at milepost 9.7, west of Jamaica Train Station at the Jay Interlocking. LIRR Train # 7700 was operating on Main Track # Four into Jamaica station track five. There were no reported injuries to the crew members however one minor passenger injury was reported.

Equipment damage is $ 525,000. Track and signal damages are $ 262,184.

At the time of the derailment it was daylight and cloudy. The temperature was 35 ° F.

The cause of this derailment is determined to be low speed wheel climb. The FRA and the Long Island Railroad Officials concur on the cause of the derailment. A low speed wheel climb derailment is not caused by a single factor, but a combination of multiple factors working together to create the potential for derailment.

138. NARRATIVE

CIRCUMSTANCES PRIOR TO THE ACCIDENT

The crew of LIRR Commuter Train 7700 consisted of a locomotive engineer, a conductor, an assistant conductor, and a collector. The engineer, conductor, and assistant conductor went on duty at 7:55 a.m. at Port Washington N.Y. The collector went on duty at 8:31 a.m. at Long Beach N.Y. All crew members received the required statutory off-duty rest period prior to reporting for duty.

The engineer, conductor, and assistant conductor worked on LIRR Passenger Train # 6417 en route from Port Washington to Penn Station at 8:10 a.m. on November 23, 2008. Subsequently they worked on LIRR Commuter Train # 7700 en route from Penn station to Huntington N.Y. at 11:54 a.m. the same day. The collector worked on LIRR Train # 6812 from Long Beach to Penn Station at 8:46 a.m. the same day, and then worked on LIRR Passenger Train # 7700 from Penn station to Huntington at 11:54 a.m. LIRR Train # 7700 received a 2B (daily) inspection at Westside Yard in Manhattan N.Y. at 8:30 a.m. on November 23, 2008 and received a class one brake test at Westside yard at 11:15 a.m. on that same day. LIRR Train # 7700 consisted of ten M-7 passenger coach cars. The train was approximately 850 feet long. LIRR Train # 7700 departed Penn station on time at 11:54 a.m. The crew took no exceptions to the mechanical condition of the train or the required accompanying paperwork. LIRR Train # 7700 made its first scheduled station stop at Woodside, N.Y. on time. The next scheduled station stop was Jamaica N.Y. As the train came by the Van Wyck signal bridge, which is approximately 1100 feet from Jamaica station and approximately 400 feet from the point of derailment, the engineer was positioned in the lead car # 7702, the conductor was in car # 7101 (the second car), the assistant conductor was in car # 7267 (the eighth car), and the collector was in car # 7237 (the sixth car). LIRR Train # 7700 was operating on Main Track Four into Jamaica station track five. The train was now operating in the Jay Interlocking which is made up of grades, curves, and complex switch layouts.

THE ACCIDENT

LIRR Passenger Train # 7700 was being operated at 11 mph through the Jay Interlocking. At approximately

12:18 p.m. EST the engineer pulled into Jamaica station track five from Main Track # 4. The crew pulled the train approximately one half car length onto the west end of the platform and stopped because an existing train occupying track five which was performing a normal station stop was blocking their way. At this point LIRR Train # 7700 was not derailed. When the stopped train ahead departed track five the engineer of LIRR Train # 7700 proceeded to pull the train into track five for the normal Jamaica station stop. The train derailed as it began to move. Approximately seven cars, or 595 feet, onto the platform the engineer reportedly heard an audible over the radio instructing "7700 stop your train." The engineer stopped the train with maximum brake application and said he didn't feel, hear, or see anything abnormal. The engineer then heard "7700 you are on the ground." When the crew went back to investigate they discovered that the rear three cars were derailed. There were no reported crew injuries however one train passenger reported a minor injury. Most of the approximate 300 passengers were escorted from the train and onto the track five platforms at Jamaica station. At 12:55 p.m. third rail power was de-energized and the remaining seven passengers, who were at the rear of the train, were escorted off of the train and up to ground level. At 1:20 p.m. passenger evacuation was concluded without incident. The cause of this derailment was low speed wheel climb.

ANALYSIS AND CONCLUSION

ANALYSIS - EQUIPMENT AND TRACK

The cause of this derailment was a result of low speed wheel climb of the number two wheel on passenger coach car # 7267 positioned the eighth car in the consist. A low speed wheel climb derailment is not caused by a single factor, but a combination of multiple factors working together to create the potential for the derailment. Factors that contributed to the low speed wheel climb were a high ratio of lateral wheel force as it relates to the vertical wheel force (L/V ratio) and a high coefficient of friction (COF) between the wheel and the rail at the point of derailment. The point of derailment (POD) was at the # 73 switch. The way the switch was lined caused a tight radius crossover. Just prior to the derailment the number two wheel of the first derailed car was stopped on the heel block of the # 73 switch. This stop was due to an existing train on track five at Jamaica station. While the first derailed car was situated on the crossover it mirrored the angle of the crossover. The car behind the first derailed car was not on the crossover. The difference in how these two cars were situated caused significant coupler angularity. Additionally, as the train was stopped at this position, only the first two and the last two cars of the train were on third rail power. The middle six cars were not on third rail power. Third rail power is necessary for traction effort. Without third rail power the cars cannot move under their own power and must rely on neighboring powered cars to move them. The first derailed car was not on third rail power; however the two cars behind it were on third rail power. When the engineer began to move the train and called for full throttle, only the third rail powered cars began making traction effort. In effect, the two cars behind the first derailed car began pushing the train. This generated a significant longitudinal compressive (buff) force which converted to lateral force because of coupler angularity and the way the first derailed car was situated on the crossover. The lateral force from the coupler created an elevated lateral wheel force which increased the L/V ratio at the point of derailment which contributed to the low speed wheel climb.

Contributing to the high coefficient of friction was the fact that the rail lubricators had been turned off in this area due to the accelerated leaf accumulation. Another factor contributing to the high coefficient of friction was that traces of Sandite were present. Sandite is a wheel/rail adhesive additive used to prevent wheel slip. The Long Island Railroad has a Sandite train which travels throughout the system, cleans the rail, and applies Sandite where slippery conditions exist during the leaf and snow seasons. The high coefficient of friction did not allow the wheel to slide. The high COF, along with the high L/V ratio and the train starting from a stopped position, caused the number L-two wheel of LIRR coach car # 7267 to climb the number 73 switch and derail.

No other contributing factors were found in the condition of the cars or track. The contact angle of the wheel and the rail was not found to be a causal factor in this derailment. The first wheel to derail, according to LIRR records, had approximately 8000 miles wear on it. The rail was within 49 CFR 213 regulations and both were in good condition.

The overall configuration of Jay Interlocking, including grades, curves, and the complex switch layout, was determined to be a significant aspect of the derailment as it related to third rail contact loss and coupler angularity. The general design and layout of Jay Interlocking have reportedly been the same for approximately 100 years.

The Long Island Railroad hired the consulting firm of Rail Sciences Inc. to conduct an inspection of the track and the equipment involved in the derailment. Vehicle/track interaction computer simulation software called VAMPIRE™ was used to simulate the derailment and find the root cause. A re-enactment was conducted by the Long Island Railroad on December 4, 2008.

ANALYSIS--TOXICOLOGICAL TESTING

Four crew members of LIRR Commuter Train # 7700 and two tower operators from Jay Tower in Jamaica, Queens were tested for drugs and alcohol as per FRA 49 CFR Rule 219 Subpart C-Post-Accident Toxicological Testing. In a memo, FRA Alcohol and Drug Program Manager stated "Federal Railroad Administration Post-accident Forensic Toxicology Result Report indicate that the six employees tested (from the LIRR accident of November 23, 2008) had negative results.

CONCLUSION:

Drugs and alcohol played no part in the derailment.

OVERALL CONCLUSION AND ACTION TAKE BY THE LIRR:

The cause of the derailment was the low speed wheel climb of number L-two wheel of car # 7267 (eighth car in train). Contributing factors to the low speed wheel climb were a high L/V ratio, a high coefficient of friction and the train starting from a stopped position.

The Long Island Railroad has taken the following steps to assure derailments of this nature do not re-occur. LIRR has stopped all train movement through the number 73 switch in the reverse position. LIRR has developed policies to assure Sandite is not applied on any switches, turnouts, crossovers, or high degree curves. The LIRR will maintain rail lubrication on year round basis and refrain from discontinuing the process during the winter months and leaf season. Some of the Long Island Railroad's long term recommendations include revised operational changes that will reduce the risk of derailments in the Jay Interlocking area, review infrastructure changes that will reduce the risk of derailments, and review other locations to ascertain similar derailment risks.

The cause of this derailment is determined to be low speed wheel climb. The FRA and the Long Island Railroad Officials concur on the cause of the derailment. A low speed wheel climb derailment is not caused by a single factor, but a combination of multiple factors working together to create the potential for derailment.

CONCLUSION:

The cause of this derailment was the low speed wheel climb of the number L-two wheel of LIRR coach car # 7267 (eighth car in train). Contributing factors to the low speed wheel climb were a high L/V ratio, a high coefficient of friction, and the train starting from a stopped position.