CRASH DATA RESEARCH CENTER

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CALSPAN ON-SITE ROLLOVER CRASH INVESTIGATION

SCI CASE NO.: CA09078

VEHICLE: 2008 HONDA ACCORD EX-L

LOCATION: NORTH CAROLINA

CRASH DATE: OCTOBER 2009

Contract No. DTNH22-07-C-00043

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

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BACKGROUND

This on-site investigation focused on an off-road rollover crash of a 2008 Honda Accord **(Figure 1)**. The vehicle was equipped with four-wheel anti-lock brakes, Electronic Stability Control (ESC), a Certified Advanced 208-Compliant (CAC) frontal air bag system, front seatback mounted side impact air bags and Inflatable Curtain (IC) air bags without rollover sensing capabilities. The manufacturer of the Honda has certified that the vehicle is compliant with the advanced air bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The CAC system included dual-stage frontal air bags for the driver and front right passenger positions, seat track positioning sensors, safety belt buckle switch sensors, retractor pretensioners, and a front right occupant presence sensor. The Honda initiated a counterclockwise (CCW) yaw on a wet roadway, departed the left side and impacted an embankment with its undercarriage. The Honda then initiated a right side leading 8-quarter turn rollover. The IC and side impact air bags on both sides deployed. During the rollover the undercarriage of the Honda impacted a tree that consisted of two 13 cm (5.1 in) tree trunks, which shared the same base and root structure. The Honda's restrained 30-year-old female driver sustained multiple spinal fractures and soft tissue injuries. She was transported by ground ambulance to a local hospital where she was evaluated and stabilized before being transferred, approximately four hours post-crash, to a regional trauma center and admitted for two days.

Figure 1: Front left view of the 2008 Honda Accord.

The Honda was identified through a visit to a regional vehicle salvage facility on November 9, 2009. Based on the rollover of the vehicle and the deployment of the side impact and IC air bags, this case was assigned for an on-site investigation on November 10, 2009. The on-site investigation was initiated on November 11, 2009. The investigation involved the inspection and documentation of the Honda, a detailed interview with the driver of the vehicle, an interview with the homeowner at the location in which the crash occurred, and the documentation of the crash site.

SUMMARY

Crash Site

This crash occurred during the daylight hours of October 2009 on a two-lane east/west rural roadway. The environmental conditions at the time of the crash consisted of heavy rain showers. The wet roadway was comprised of two bituminous travel lanes that measured 2.9 m (9.5 ft) in width. The roadway was bordered by gravel and compacted soil shoulders that measured 2.4 m (7.9 ft) in width that sloped away from the travel lanes. The roadsides were grass surfaced and contained ditch lines that paralleled the roadway. The north roadside was 2.3 m (7.5 ft) in width with a negative grade of 4.9 percent. Located outboard of the north roadside was a ditch that was 3.0 m (9.8 ft) in width. The slopes of the ditch were a negative 31 percent entering the ditch and a positive grade of 30 percent exiting the ditch to the north. An overgrown driveway, surfaced with grass, was located 5.4 m (17.7 ft) east of the reference point and measured 3.8 m (12.5 ft) in width. A culvert pipe was located under the driveway. The pre-crash area of the roadway had a negative grade of 1.6 percent and included a curve to the left with a radius of curvature of 387 m (1269 ft). The grade transitioned to a level surface as the roadway straightened 56.2 m (184.4 ft) west of the reference point. Continuing along the Honda's direction of travel, the grade transitioned again to a positive grade of 1.6 percent. A local resident reported that the level area between the two grades collected standing water at times of heavy rain. This area of standing water was located 40-60 m (131-197 ft) west of the reference point, ending approximately 42 m (138 ft) west of the location in which the Honda departed the roadway. The posted speed limit in the area of the crash was 89 km/h (55 mph). A schematic of the crash is included at the end of this report as **Figure 9**.

Vehicle Data

2008 Honda Accord

The 2008 Honda Accord EX-L sedan was manufactured in July 2008 and was identified by the Vehicle Identification Number (VIN): 1HGCP36828A (production number deleted). The Honda's odometer reading was 52,994 km (32,929 miles) at the time of the crash. The front-wheel drive Honda was powered by a transverse mounted 3.5-liter, V-6 engine, linked to a 5-speed automatic transmission. The braking system consisted of power-assisted front and rear disc brakes with four-wheel antilock, brake assist and electronic brake force distribution. The Honda was also equipped with ESC, traction control, and a direct Tire Pressure Monitoring System (TPMS). The driver stated that the TPMS instrument panel warning light was off prior to the crash. All four windows were closed at the time of the crash, evidenced by the position of the intact windows at the time of the SCI inspection and glass fragments in the upper area of the weather stripping of the disintegrated windows. The Honda was equipped with a sunroof that was closed at the time of the crash. The vehicle manufacturer recommended tire size was P225/50R17 with a cold pressure recommendation of 221 kPa (32 PSI) for the front and rear tires. The Honda was equipped with Michelin Pilot HX tires, size P225/50R17 mounted on

OEM seven-spoke alloy wheels. The specific tire data at the time of the SCI inspection was as follows:

Position	Measured Tire Pressure	Measured Tread Depth	Damage
Left Front	62 kPa (9 PSI)	3 mm (4/32 in)	None
Left Rear	186 kPa (27 PSI)	2 mm (3/32 in)	None
Right Rear	Tire Flat	2 mm (3/32 in)	De-beaded
Right Front	Tire flat	4 mm (5/32 in)	De-beaded

The interior of the Honda was configured with leather-surfaced five-passenger seating. The front bucket seats were separated by a center console and equipped with adjustable head restraints. The driver's head restraint was adjusted 4.0 cm (1.6 in) above the full-down position. The front right head restraint was in the full-down position. The driver's seat track was adjusted to the full-rear position at the time of the SCI inspection. The driver stated during the interview that the at-crash seat track position was mid-track, consistent with her height of 152 cm (60 in). The front right seat track was adjusted 10.0 cm (3.9 in) forward of the full-rear position. The driver's seatback was reclined 39 degrees aft of vertical post-crash. The front right seatback was adjusted 24 degrees aft of vertical. The second row seat was a split bench with 60/40 folding seat backs and adjustable head restraints for all three seating positions. All three second row head restraints were in the full-down position.

The interior occupant safety systems consisted of 3-point lap and shoulder belts for the five designated positions, front seat safety belt retractor pretensioners, two dual-stage CAC frontal air bags, two side impact air bags mounted in the outboard aspects of the front seat backs and two IC air bags that provide protection to the four outboard seating positions.

Crash Sequence

Pre-Crash

The restrained 30-year-old female driver of the Honda was operating the vehicle eastbound in a shallow left curve on the rural roadway at a driver estimated speed of 97-105 km/h (60-65 mph). It was raining heavily at the time of the crash. **Figure 2** depicts the Honda's pre-crash trajectory. As the Honda entered the straight and level segment of roadway, the vehicle lost traction and initiated a CCW yaw. The Honda's loss of traction was attributed to the vehicle's relative speed in conjunction with the lack of

Figure 2: Pre-crash trajectory of the Honda.

adequate tire tread depth as this vehicle traveled through an area of standing water. The Honda traveled approximately 42 m (138 ft) and yawed approximately 50 degrees CCW through the travel lanes prior to departing the north side of the roadway. The Honda continued to yaw CCW as it crossed the north side ditch line.

Crash

The front aspect of the Honda's undercarriage contacted an earth embankment on the north side of the ditch (Event 1). The Honda continued its path of travel in a northeasterly direction and continued its CCW rotation. The Honda traveled across the grass-surfaced driveway and entered a residential yard. The right side tires de-beaded under the lateral forces from contact with the ground, which caused the Honda to initiate a right side leading rollover (Event 2). At the trip point, the Honda had traveled 28.0 m (91.9 ft) off road and rotated approximately 115 degrees CCW from its initial heading angle. The Honda rolled three-quarter turns and the front aspect of the undercarriage impacted two 13 cm (5.1 in) tree trunks that shared the same base (Event 3). The tree was fractured 35.0 cm (13.8 in) above ground level. The Honda's rollover was considered uninterrupted by the tree impact. The Honda continued to roll about its longitudinal axis across the grass covered ground and completed a total of 8-quarter turns before arriving at final rest on the north side of the road. The Honda came to rest on its wheels partially occupying a gravel driveway facing a northwesterly direction, 29 m (95 ft) from the initial trip point. The three non-horizontal impacts were outside of the scope of analysis by the WinSMASH program.

Post-Crash

The resident of a nearby house heard the crash and called the 9-1-1 emergency response system. Police and medical personnel responded to the crash site. The driver was found approximately 15 m (50 ft) north of where the Honda came to rest. There was no evidence of ejection and she could not recall how she exited the vehicle. The driver of the Honda sustained serious level injuries and was transported by ground ambulance to a regional hospital where she was evaluated and stabilized. Due to a need for services not available at that facility, the driver was transferred to a regional trauma center approximately four hours post-crash. She was admitted to the trauma center for two days, during which time she received treatment for fractured cervical and thoracic vertebrae and soft tissue injuries to her chest, face and lower extremities. The Honda was towed from the crash site due to disabling damage and was transferred to a regional vehicle salvage facility where it was inspected for this investigation.

2008 Honda Accord

Exterior Damage

The exterior of the Honda sustained severe damage to the top plane and moderate-severity damage to the left and right planes as a result of this multiple impact crash. The front bumper fascia and front aspect of the undercarriage was damaged in the initial impact with the ditch's north side embankment. **Figure 3** depicts the deformation to the panel concealing the forward

aspect of the undercarriage. There was dirt and grass embedded into the undercarriage. The Collision Deformation Classification (CDC) assigned for the initial impact with the embankment was 00UFDW1

Figure 3: Undercarriage damage to the Honda, from lower right.

The rollover event resulted in two separate surface abrasion patterns on the left rear aspect of the roof, indicating that the Honda's top plane had contacted the ground on two separate occasions **(Figure 4)**. The longitudinal direct contact damage to the top plane began at the leading edge of the hood and extended rearward 448.0 cm (176.4 in) to the rear of the trunk lid. Laterally, the direct contact damage extended 112.0 cm (44.1 in) between roof side rails. The maximum vertical crush measured 40 cm (15.7 in), which was located on the windshield header 21 cm (8.3 in) inboard of the left roof side rail. The maximum lateral crush was located at the junction of the windshield header and the left A-pillar, which measured 18 cm (7.1 in). During the rollover, the right rear wheel impacted the ground, resulting in deformation and separation of the suspension components that allowed for the wheel to be displaced under the vehicle. **Figure 5** depicts the maximum roof crush to the Honda. The CDC assigned for the rollover event was 00TDDO6.

Figure 4: Overhead view of the rollover damage to the Honda.

Figure 5: Vertical crush to the windshield header and left roof side rail.

During the rollover event, the front aspect of the Honda's undercarriage impacted a tree that consisted of a two 13 cm (5.1 in) tree trunks, which shared the same base. This impact resulted in minimal damage to the undercarriage and overlapped the initial impact damage from the embankment. The CDC assigned for this non-horizontal impact was 00UFD999 (99 = unknown values).

The windshield glazing was completely fractured with a laminate tear that extended from the windshield header adjacent to the left A-pillar to the lower aspect of the windshield at the right A-pillar. The left front door, left rear door quarter glazing, the backlight and the sunroof glazing all disintegrated during the crash. The rear left door glazing and all right side glazing were undamaged. The left front, left rear and right rear doors were closed and operational; however, the right front door was jammed closed at the time of the SCI inspection.

Interior Damage

The Honda sustained interior damage that was attributed to passenger compartment intrusion, occupant contact and air bag deployment. The intruding left A-pillar contacted the steering wheel rim and deformed the wheel rim 2.0 cm (0.8 in) at the 10 o'clock position. A scuff mark was located on the top aspect of the center console that measured 5.0 cm (2.0 in) diagonally. This scuff mark was attributed to the right side of the driver's abdomen. There were two additional scuff marks attributed to contact with the driver's head. The first was an 8 cm (3.1 in) scuff mark on the headliner located 17.0 to 25.0 cm (6.7 to 9.8 in) aft of the windshield header and 5.0 cm (2.0 in) right of the left side of the sunroof opening, extending left 8.0 cm (3.1 in). The second scuff mark was located on the lower aspect of the left roof side rail located 5.0 to 8.0 cm (2.0 to 3.2 in) above the lower edge of the roof side rail and extended 8.0 to 18.0 cm (3.1 to 7.1 in) aft of the left A-pillar.

The left roof side rail intruded laterally and vertically until it contacted the driver's head restraint located in a position 4.0 cm (1.6 in) above the seatback. The seatback was displaced longitudinally rearward in a deformed condition approximately 15 degrees aft of its original recline position. The left roof side rail compressed 5.0 cm (2.0 in) into the front left head restraint, which was also deformed from this intrusion. The intrusion to the Honda is listed on the following table:

Position	Component	Direction	Magnitude
Row 1 Left	Windshield header	Vertical	35.0 cm (13.8 in)
Row 1 Left	Roof	Vertical	30.0 cm (11.8 in)
Row 1 Left	A-pillar	Vertical	28.0 cm (11 in)
Row 1 Left	Roof side rail	Lateral	26.0 cm (10.2 in)
Row 1 Left	B-pillar	Vertical	20.0 cm (7.9 in)
Row 1 Center	Windshield header	Vertical	25.0 cm (9.8 in)
Row 1 Center	Roof	Vertical	23.0 cm (9.1 in)
Row 1 Right	Windshield header	Vertical	8.0 cm (3.1 in)
Row 1 Right	Roof	Vertical	11.0 cm (4.3 in)
Row 2 Left	Roof	Vertical	25.0 cm (9.8 in)
Row 2 Left	Backlight header	Vertical	8.0 cm (3.1 in)
Row 2 Left	C-pillar	Lateral	10.0 cm (3.9 in)

Position	Component	Direction	Magnitude
Row 2 Left	Roof side rail	Vertical	36.0 cm (14.2 in)
Row 2 Center	Roof	Vertical	20.0 cm (7.9 in)
Row 2 Center	Backlight header	Vertical	9.0 cm (3.5 in)
Row 2 Right	Roof	Vertical	7.0 cm (2.8 in)
Row 2 Right	Backlight header	Vertical	3.0 cm (1.2 in)

Manual Restraint Systems

The Honda was equipped with 3-point manual lap and shoulder safety belts for the five designated seating positions. The driver's safety belt system consisted of continuous loop webbing, a sliding latch plate, an adjustable D-ring, a retractor-mounted pretensioner and an Emergency Locking Retractor (ELR). The D-ring was located in the full-down position. The safety belt webbing was found in an extended position, measuring 158.0 cm (62.2 in) in length and locked in place by the actuated pretensioner. A frictional abrasion was located on the belt webbing near the latch plate 65.0 to 69.0 cm (25.6 to 27.2 in) above the lower seat anchor point. Based upon the post-crash condition of this safety belt system, the driver was restrained at the time of the crash.

The front right and second row safety belt systems utilized switchable ELR/Automatic Locking Retractors (ALR) with sliding latch plates. The front right adjustable D-ring was found in the full-down position with the safety belt webbing stowed within its retractor, indicating that retractor mounted pretensioner did not actuate during the crash.

Frontal Air Bag System

The Honda was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system that consisted of dual stage driver and front right passenger air bags, seat track positioning sensors, and a front right occupant presence sensor. The manufacturer of the Honda had certified that this vehicle was compliant to the advanced air bag portion of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208.

The driver position CAC air bag was concealed within the center hub of a four-spoke steering wheel. The front right passenger position CAC air bag was concealed within the upper aspect of the right instrument panel. The CAC air bag system did not deploy as a result of impact forces.

Side Impact Air Bag System

The Honda was equipped with front seatback mounted side impact air bags and roof side rail mounted IC air bags. Both IC air bags and both side impact air bags deployed during this multiple impact crash.

The IC air bags deployed from their respective roof side rails. The IC air bags measured 202.0 cm (79.5 in) in length. The IC's measured 41.0 cm (16.1 in) in height at the front seating position and 40.0 cm (15.7 in) at the rear seating positions and provided complete longitudinal coverage across the entire side glazing. Vertically, the IC air bags extended 6.0 cm (2.4 in) below the beltline at the front and rear seating positions. Both IC's were free of occupant contacts and crash related damage.

Figure 6 depicts the deployed left IC air bag. The left IC was labeled with the following nomenclature: *2420364 2006082701 250608GL31 S.* **Figure 7** depicts the right IC air bag. The right IC was labeled with the following nomenclature: *2420364 2406082706 260608GL32 S.*

Figure 6: Interior view of the deployed left IC air bag.

Figure 7: Interior view of the right IC air bag.

The side impact air bags deployed from panels in the outboard aspects of the front seatbacks. These panels measured 45.0 cm (17.7 in) in height. The seatback mounted air bags measured 28.0 cm (11 in) in width and 57 cm (22.4 in) in height in the deflated state. These side air bags contained one vent port located on the outboard aspect of forward most top corner. There was no damage or contact evidence on either side impact air bag. **Figure 8** depicts the left side impact air bag.

Figure 8: Left side impact air bag.

Driver Demographics/Data

Age/Sex:	30-year old/Female
Height:	152.0 cm (60.0 in)
Weight:	54.0 kg (118.0 lb)
Eyewear:	None
Seat Track Position:	Mid-track
Manual Safety Belt Use:	Lap and shoulder belt
Usage Source:	Vehicle Inspection
Egress from Vehicle:	Exited vehicle without assistance
Mode of Transport from Scene:	Ground ambulance
Type of Medical Treatment:	Transported by ground ambulance to a local hospital, then transferred to a regional trauma center and admitted for two days.

Driver Injuries

Injury	Injury Severity (AIS90/Update 98)	Injury Source
C1 pedicle fracture	Serious (650224.3,6)	Intruding roof
C6 pedicle fracture	Serious (650226.3,6)	Intruding roof
T5 chip fracture of the lamina (small)	Serious (650426.3,7)	Induced flexion from roof intrusion
C3 right transverse process fracture	Moderate (650220.2,6)	Intruding roof
C6 right transverse process fracture	Moderate (650220.2,6)	Intruding roof
Left high parietal scalp hematoma	Minor (190402.1,2)	Intruding roof
Epistaxis	Minor (251090.1,4)	Possibly self inflicted
Left ear (pinna) superficial laceration	Minor (290602.1,2)	Flying glass
Right cheek abrasion	Minor (290202.1,1)	Flying glass
Left cheek abrasion	Minor (290202.1,2)	Flying glass
Left upper arm contusion	Minor (790402.1,2)	Safety belt webbing
Left hand abrasion	Minor (790202.1,2)	Unknown
Bilateral knee and right lower leg abrasions	Minor (890202.1,3)	Knee bolster

Source - Medical records

Driver Kinematics

The 30-year-old female driver of the Honda was seated in a mid-track position and was restrained by the manual 3-point lap and shoulder belt system. The Honda lost traction on the

wet roadway and initiated a CCW yaw, which caused this vehicle to depart the north side of the roadway. The combination of the CCW yaw and the initial impact to the undercarriage displaced the driver to the right and slightly forward within the front left seating position. The safety belt retractor locked and the driver loaded the belt system.

During the rollover event, the driver's pretensioner actuated and the side impact and IC air bags deployed. The left roof and left roof side rail intruded vertically and laterally towards the driver. The driver's head contacted the headliner and left roof side rail, which created scuff marks on both components. She sustained fractures of the C1, C3 and C6 cervical vertebrae from the roof contact and a T5 chip fracture from the flexion induced by the intrusion. Glass fragments from the disintegrated side windows traveled through the passenger compartment resulting in lacerations and abrasions to the driver's face and left ear. The driver's loading of the shoulder belt resulted in a contusion of the upper left arm. She sustained bilateral knee and lower right leg abrasions from knee bolster contact. Her right hip contacted the center console; however, this contact did not result in injury.

The vehicle came to final rest on its wheels. The driver was found outside the Honda by a local resident. There was no evidence of ejection. The driver could not recall how she exited the vehicle. She was transported by ground ambulance to a local hospital where she was evaluated and transferred to a regional trauma center approximately four hours post-crash. She was then admitted to the trauma center where she received medical care for two days.

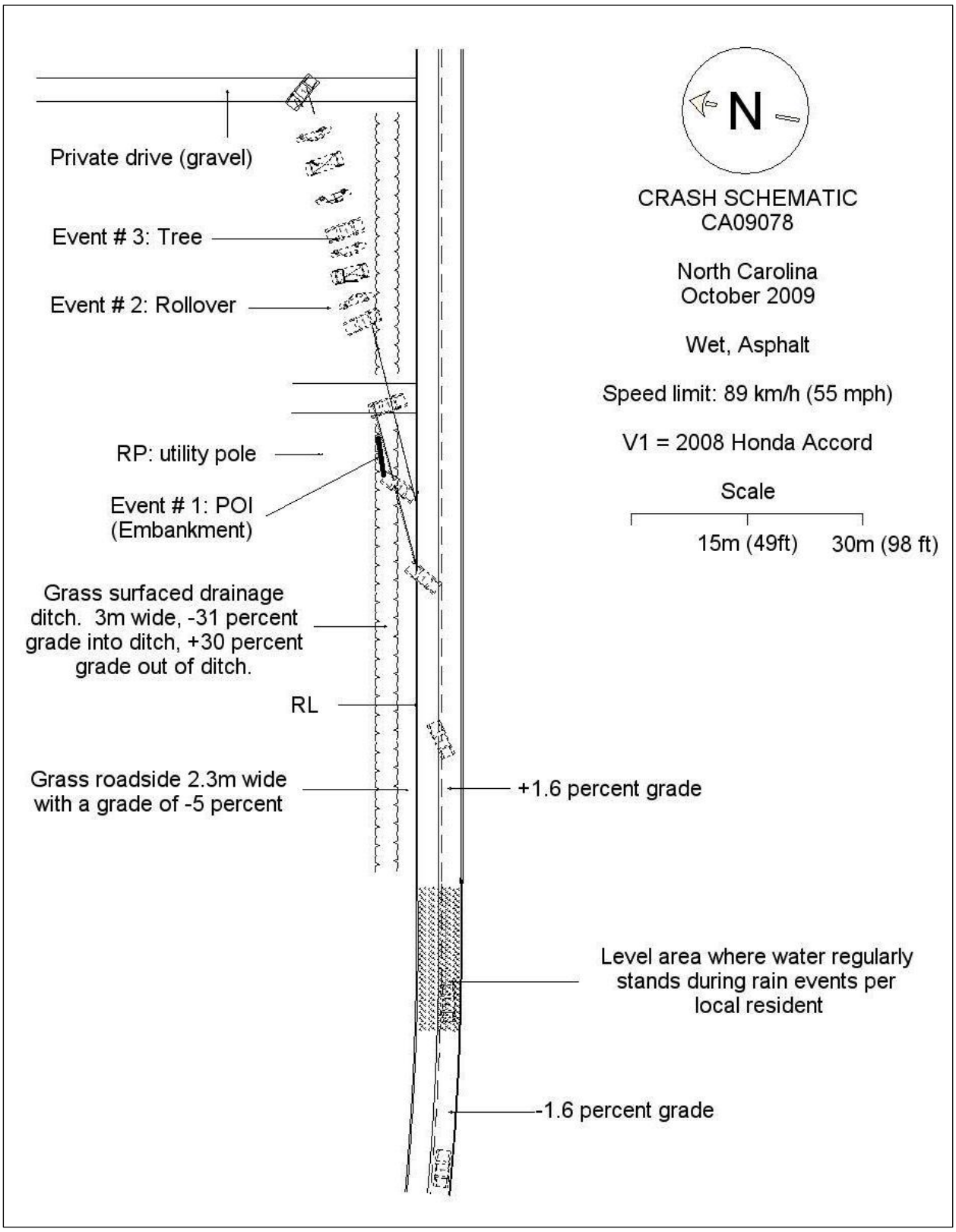

Figure 9: Crash Schematic