TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION

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VERIDIAN ON-SITE AIR BAG/SEATBELT FATALITY INVESTIGATION

VERIDIAN CASE NO. CA99-18

VEHICLE - 1995 FORD ESCORT LX

LOCATION - STATE OF NEW YORK

CRASH DATE - JUNE, 1999

Contract No. DTNH22-94-D-07058

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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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16. *Abstract* This on-site investigation focused on the injury mechanisms and cause of death of an 18 year old female driver of a 1995 Ford Escort LX 4-door sedan. The vehicle was equipped with frontal air bags for the driver and right passenger positions which deployed during the crash. The Escort was northbound on a two lane asphalt roadway when the driver apparently fell asleep following a prom and post-prom activities and allowed the vehicle to depart the right (east) pavement edge. As the vehicle exited the east pavement edge, it impacted a small diameter mailbox post and mailbox. At this point, the vehicle entered a drainage ditch where the front left area struck a concrete culvert resulting in moderate (overlapping) damage. The vehicle came to rest against the culvert facing northwest. The 18 year old female driver was restrained by the available 2-point motorized automatic shoulder belt (manual lap restraint not used) and presumed to be seated out-of-position, forward and to the right. At impact with the culvert, she initiated a forward trajectory in response to the 12 o'clock impact force and loaded the automatic restraint and deployed driver air bag. She submarined the shoulder belt resulting in fractures of the sternum, right 3rd and 4th ribs and a rupture of the right atrium. Additional belt related injuries included contusions of the myocardium, lungs, stomach, pancreas and uterus. She also sustained cerebral edema and a compression of the brain stem which was possibly a result of the forward motion of the head as it jack knifed over the shoulder belt (acceleration injury). Loading of the driver air bag resulted in an abrasion of the chin. Following the collision, she exited the vehicle and reportedly crawled up the ditchbank where she collapsed. The driver was transported to a local hospital for treatment and expired within one hour of the crash.			
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BACKGROUND

This on-site investigation focused on the injury mechanisms and cause of death of an 18 year old female driver of a 1995 Ford Escort LX 4-door sedan. The vehicle was equipped with frontal air bags for the driver and right passenger positions which deployed during the crash. The Escort was northbound on a two lane asphalt roadway when the driver apparently fell asleep following a prom and post-prom activities and allowed the vehicle to depart the right (east) pavement edge. As the vehicle exited the east pavement edge, it impacted a small diameter mailbox post and mailbox. At this point, the vehicle entered a drainage ditch where the front left area struck a concrete culvert resulting in moderate (overlapping) damage. The vehicle came to rest against the culvert facing northwest. The 18 year old female driver was restrained by the available 2-point motorized automatic shoulder belt (manual lap restraint not used) and presumed to be seated out-of-position, forward and to the right. At impact with the culvert, she initiated a forward trajectory in response to the 12 o'clock impact force and loaded the automatic restraint and deployed driver air bag. She submarined the shoulder belt resulting in fractures of the sternum, right 3rd and 4th ribs and a rupture of the right atrium. Additional belt related injuries included contusions of the myocardium, lungs, stomach, pancreas and uterus. She also sustained cerebral edema and a compression of the brain stem which was possibly a result of the forward motion of the head as it jack knifed over the shoulder belt (acceleration injury). Loading of the driver air bag resulted in an abrasion of the chin. Following the collision, she exited the vehicle and reportedly crawled up the ditchbank where she collapsed. The driver was transported to a local hospital for treatment and expired within one hour of the crash.

The crash notification was provided to NHTSA and was forwarded to Veridian's Special Crash Investigation Team on Monday June 7, 1999. Due to the police reported severity of the crash and the belted status of the driver, an on-site investigation was assigned Tuesday June 8, 1999. The Veridian SCI Team departed the morning of Wednesday June 9, 1999 to conduct the local on-site investigation.

SUMMARY

Crash Site

The crash occurred during the morning hours of June, 1999. At the time of the crash, it was daylight with no adverse conditions as the roads were dry. The crash occurred off the east pavement edge of a level two lane north/south (asphalt) roadway **(see Figure 8 - page 8)**. Environmental features included a 40.0 cm (15.7 in) deep drainage ditch with a 125.0 cm x 40 .0 cm (49.2 in x 15.7 in) "L" shaped concrete storm sewer receiver. No traffic controls were present at the scene which had a posted speed limit of 64 km/h (40 mph).

Pre-Crash

The 18 year old female driver of the 1995 Ford Escort LX was operating the vehicle northbound **(Figure 1)** proceeding straight at a (witness) reported speed of 64 km/h (40 mph). The driver apparently fell asleep following a prom and post-prom activities and allowed the vehicle to depart the right (east) pavement edge, tracking throughout its pre-crash trajectory. Witnesses reported that the vehicle drove off the east pavement edge as if the driver was pulling over but never slowed down (no brake lights observed) prior to entering the drainage ditch.

Figure 1. Northbound approach for the 1995 Ford Escort LX.

Crash

As the Escort departed the right (east) pavement edge of the two lane roadway, the front bumper struck a small diameter mailbox post which resulted in minor damage. The Collision Deformation Classification (CDC) for this impact to the mailbox post was 12-FCEN-1. The post was displaced from the ground as the mailbox struck the hood resulting in minor (non-horizontal) top damage. The CDC for this impact to the mailbox was 00-TFYW-5. At this point, the vehicle traveled 12.0 meters (39.4 feet) and entered a 40.0 cm (15.7 in) deep drainage ditch where the front left area struck a concrete culvert **(Figure 2)** resulting in moderate (overlapping) damage. The bumper overrode the culvert as the vehicle continued forward which engaged the transaxle and fractured the casing. The impact induced deceleration was sufficient to deploy the Escort's air bag system. The WinSMASH damage and trajectory algorithm computed an impact speed of 40.9 km/h (25.4 mph) with a (barrier equivalent) velocity change of 31.4 km/h (19.5 mph). The specific longitudinal component was -31.4 km/h (-19.5 mph). The CDC for the culvert impact was 12-FYEW-3. Following the impact with the culvert, the vehicle rotated counterclockwise 24 degrees and came to rest against the culvert facing northwest.

Figure 2. Impacted concrete culvert.

Post-Crash

The driver of the Escort exited the vehicle under her own power. Police arrived at the crash scene to find her laying face down on the ditchbank unresponsive with labored breathing. Treatment was rendered at the scene by fire department personnel and emergency medical technicians (EMT). The driver was transported to a local hospital for treatment and expired within one hour of the crash. The vehicle was towed from the scene.

VEHICLE DATA

The 1995 Ford Escort LX was identified by the vehicle identification number (VIN): 3FASP13J8SR (production number deleted) and was manufactured on 4/95. The driver's father was listed on the police report as the owner of the vehicle. The vehicle was a 4-door sedan equipped with front wheel

drive and a 1.9 liter, 4 cylinder engine. The vehicle's odometer reading was 114,296 km (71,022 miles) at the time of the crash. The seating was configured with front bucket seats and a folding (back) rear bench. The surrogate interview reported two previous crashes (without air bag deployment) and no maintenance on the Escort's air bag system.

VEHICLE DAMAGE

Exterior

Figure 3. Frontal damage to the 1995 Ford Escort LX.

The Ford Escort sustained moderate frontal damage as a result of the impact with the culvert **(Figure 3)**. The direct contact damage began at the front left bumper corner and extended 60.0 cm (23.6 in) inboard. The impact deformed the full frontal width resulting in a combined direct and induced damage length (Field L) of 118.0 cm (46.5 in). Six crush measurements were taken at the level of the bumper: C1= 63.0 cm (24.8 in), C2= 27.0 cm (10.6 in), C3= 18.0 cm (7.1 in), C4= 11.0 cm (4.3 in), C5= 6.0 cm (2.4 in), C6= 1.0 cm (0.4 in). Induced damage was noted to both fenders with the left front wheel restricted and deflated. Reduction in the left side wheelbase measured 21.0 cm (8.3 in). Roof buckling was noted between the B and C-pillars. Grass and mud deposits were documented to all four wheels. Superficial damage was found on the rear aspect of the hood from the mailbox impact along with a red paint transfer to the center portion of the hood lip (forward aspect). The windshield was fractured at the left upper A-pillar from exterior forces and the right lower windshield area from the (interior) front right air bag module cover flap. The transaxle casing was fractured from the culvert override with fluid leaked onto the left front axle and surrounding area.

Interior

Figure 4. Driver area.

Interior damage to the Escort identified through the vehicle inspection was minor and was attributed to occupant contact **(Figure 4)**. Superficial routine wear marks were noted to the latchplate of the manual lap restraint system, but the webbing was found in pristine condition and therefore presumed not used. Routine wear marks were also noted to the aft side of the 2-point motorized automatic shoulder restraint webbing along with (impact related) fabric transfers to the upper and lower sections of the webbing. Blood transfers were identified on the (left) upper and lower quadrants of the driver air bag along with blood spattering on the (right) upper and lower quadrants. Possible scuff marks were documented on the exterior surface of the upper air bag module cover flap. No contact evidence was identified on the front right air bag or exterior surface of the module cover flap, but the windshield was fractured by the flap during the deployment sequence. No loading evidence was found on the knee bolster (rigid plastic type), but a 6.0 cm (2.4 in) scratch mark was documented on the steering column to the right of the centerline. Loading to the lower portion of the steering wheel rim (fixed column) shifted the entire wheel downward 1.5 cm (0.6 in) and compressed the energy absorbing column 3.0

cm (1.2 in). In addition, the left spoke was deformed forward 1.5 cm (0.6 in). A deep scratch mark was noted to the left roof side rail and was located 15.0 cm (5.9 in) rearward of the A-pillar. Possible scuff marks were also noted to the front left roof panel and visor with blood spattering documented on the sun visor. The floor pedals protruded rearward 29.0 cm (11.4 in) into the driver space from 27.0 cm (10.6 in) of toepan intrusion. Additional longitudinal intrusions included 6.0 cm (2.4 in) of left instrument panel displacement and 4.0 cm (1.6 in) of center instrument panel displacement. The floorpan intruded 4.0 cm (1.6 in) vertically into the driver space.

MANUAL RESTRAINT SYSTEMS

The interior of the Ford Escort LX consisted of a five passenger seating configuration with two front bucket seats and three individual rear seat positions. The front seated positions (and rear center position) were equipped with manual lap restraint systems. The driver's lap restraint did not yield evidence of loading (webbing in pristine condition) and the lack of significant routine wear marks to the latchplate supported no belt usage. The rear outboard seated positions were equipped with 3-point manual lap and shoulder belt systems which consisted of continuous loop belt webbings with sliding latchplates (fixed anchorage adjustments). No routine wear marks were noted to the latchplates of the rear right and center positions but superficial routine wear marks were noted to the rear left latchplate; which was an indication of frequent use.

AUTOMATIC RESTRAINT SYSTEMS

The 1995 Ford Escort LX was equipped with 2-point motorized belts for the front outboard positions. The front systems consisted of an upper anchorage point that traveled along a motorized track located in the roof side rail. This mechanism guided the restraint to the forward A-pillar to allow egress from the vehicle. At inspection, the motorized track was found to be inoperative with the upper anchorage point retracted to the B-pillar (used) position. An electrical systems check during the inspection revealed that the motorized track was in fact, inoperative. This was also supported by the on-scene police photos (post-crash) which shows the automatic belt retracted to the B-pillar position. Wear marks were noted to the aft side of the 2-point motorized automatic shoulder restraint webbing with a 13.0 cm (5.1 in) fabric transfer located 42.0 cm (16.5 in) from the upper anchorage point. A possible fabric transfer was documented on the forward side of the restraint webbing which measured 16.0 cm (6.3 in) long and was located 18.0 cm (7.1 in) from the upper anchorage point **(Figure 5)**.

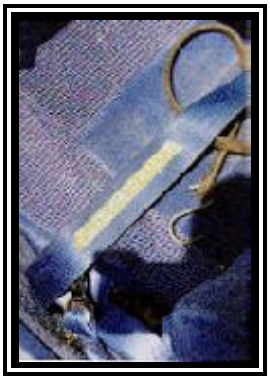

Figure 5. Driver automatic shoulder belt.

The Escort was equipped with front air bags for the driver and right passenger positions. The air bags deployed as a result of the crash. Two electro-mechanical crash sensors were mounted on brackets that were bolted to the forward aspect of the upper radiator support panel, located inboard of the headlamp assembly. The left crash sensor was identified by Ford part number F5CB-14B005-AA with a bar coded identification number of *7A09657151*. This sensor was not damaged or displaced as a

result of the culvert impact. The right crash sensor was identified by part number F5CB-14B004-AA with a bar coded identification number of *6Z06858094*. This sensor was not damaged or displaced as a result of the culvert impact. The labeling on the sensors were different, therefore it was assumed by the SCI investigator that the front left sensor had been replaced. This was confirmed during the subsequent surrogate interview which revealed two previous crashes (without air bag deployment) requiring cosmetic repairs to the front end assembly and replacement of the left crash sensor. The driver air bag module was identified by the Ford part number: F5CB-58043B13-ABJABO with a bar coded identification number of *1P8Z114I10132*.

The driver air bag was housed in the center of the steering wheel with a horizontally oriented flap tear seam (H-configuration). The upper flap measured 23.5 cm (9.3 in) in width and 10.5 cm (4.1 in) in height while the lower flap measured 18.5 cm (7.3 in) in width and 5.5 cm (2.2 in) in height. The flaps were narrower in width at the tear seam and measured 17.0 cm (6.7 in). Two small scuff marks were identified on the exterior surface of the upper module cover flap and measured 2.0 cm (0.8 in) square and 1.0 cm (0.4 in) square. No contact evidence was found on the lower module cover flap. The diameter of the driver air bag measured 56.0 cm (22.0 in) in its deflated state **(Figure 6)**. The bag was tethered by two internal straps and vented by two 4.0 cm (1.6 in) diameter ports located at the 11 o'clock and 1 o'clock sectors on the rear aspect of the air bag. Blood transfers were documented on the (left) upper and lower quadrants of the driver air bag along with blood spattering on the (right) upper and lower quadrants. Black vinyl transfers were noted to the rear aspect of the air bag from expansion within the module.

Figure 6. 1995 Ford Escort LX driver air bag.

Figure 7. 1995 Ford Escort LX passenger air bag.

The front right passenger air bag deployed from the right mid-instrument panel area with a single cover flap design hinged at the top aspect which opened in an upward direction towards the windshield (windshield fractured from flap). There was no contact evidence identified on the exterior surface of the module cover flap which was rectangular in shape and measured 31.7 cm (12.5 in) in width and 17.0 cm (6.7 in) in height. There was no contact evidence identified on the passenger air bag which measured 41.0 cm (16.1 in) in width and 71.5 cm (28.1 in) in height in its deflated state **(Figure 7)**. No internal tether straps were present. The air bag was vented by two ports located below the 10 o'clock and 2 o'clock sectors on the side aspect of the air bag and measured 5.5 cm (2.2 in) each.

DRIVER DEMOGRAPHICS

Age/Sex:	18 year old female
Height:	170 cm (67 in)
Weight:	50 kg (110 lb)
Seat Track Position:	16.0 cm (6.3 in) aft of the forward most position
Automatic Restraint Use:	2-point motorized shoulder belt
Manual Restraint Use:	None
Usage Source:	Vehicle inspection
Eyeware:	None
Type of Medical Treatment:	Transported to a local hospital (expired within 1 hour of crash)

Driver Injuries

	Injury	*Severity (AIS 90)*	*Injury Mechanism*
	Brain stem compression (bilateral uncal grooving with tonsillar coning)	Critical (140202.5,8)	Non-contact injury (acceleration injury)
	Bilateral lung contusion (not further specified)	Severe (441410.4,3)	Shoulder belt webbing/steering wheel rim (lower portion)
	Cerebral edema	Serious (140668.3,9)	Non-contact injury (acceleration injury)
*	Rupture right atrium (not further specified)	Serious (441008.3,4)	Shoulder belt webbing
	Myocardial contusion	Serious (441002.3,4)	Shoulder belt webbing
	Sternum fracture	Moderate (450804.2,4)	Shoulder belt webbing
	Stomach contusion	Moderate (544410.2,7)	Shoulder belt webbing
	Pancreas contusion	Moderate (542810.2,7)	Shoulder belt webbing
	Uterus contusion	Moderate (545210.2,8)	Shoulder belt webbing
*	Fracture right 3rd & 4th ribs	Moderate (450220.2,1)	Shoulder belt webbing
	Chin abrasion	Minor (290202.1,8)	Front left air bag
	Chest abrasion (not further specified)	Minor (490202.1,9)	Shoulder belt webbing
	Right knee abrasion	Minor (890202.1,1)	Steering column
	Bilateral thigh abrasion (anterior/linear)	Minor (890202.1,3)	Steering wheel rim (lower portion)

*A preliminary phone interview was conducted with the medical examiner who revealed the ruptured atrium and specifics of the rib fractures, but they were not listed on the autopsy report. Relaxed procedures may have been in effect during the autopsy given the previous organ harvest.

Driver Kinematics

The 18 year old female driver of the 1995 Ford Escort LX had apparently fallen asleep and was presumed to be seated out-of-position, forward and to the right. The seat back was slightly reclined and the seat track was adjusted 16.0 cm (6.3 in) aft of the forward most position. She was restrained by the 2-point motorized automatic shoulder restraint. Lack of lap belt use was confirmed by the post-crash condition of the manual restraint (pristine condition) relative to the type of injuries sustained.

At impact with the mailbox post and mailbox, the driver probably remained in her pre-impact posture as these minor impacts offered no significant resistance to the vehicle or produce any resulting kinematic response from the occupant. At impact with the culvert (vehicle front pitched slightly downward from the ditch slope), she initiated a forward trajectory in response to the 12 o'clock impact force and loaded the automatic restraint and deployed driver air bag. The driver subsequently submarined the shoulder belt (with counterclockwise torso rotation) resulting in an abrasion of the chest, fractures of the sternum, right 3rd and 4th ribs, and a rupture of the right atrium. Additional belt related injuries included contusions of the myocardium, bilateral lungs, stomach, pancreas, and uterus. These injury mechanisms were evidenced by the loading marks documented on the shoulder belt webbing in conjunction with the lack of manual lap belt use. She also sustained cerebral edema and a compression of the brain stem which was possibly a result of the forward motion of the head as it jack knifed over the shoulder belt (acceleration injury). Loading of the driver air bag resulted in an abrasion to the chin as evidenced by the makeup transfers identified on the right section of the air bag. Contact to the steering column resulted in an abrasion to the right knee as evidenced by the scratch mark documented to this component. No contact evidence was noted to the driver knee bolster. Following the collision, the driver crawled out from under the shoulder restraint and up the ditchbank where she collapsed. Police arrived at the scene to find her laying face down on the ditchbank unresponsive with labored breathing. She was transported via ambulance to a local hospital for treatment and arrived in traumatic cardiopulmonary arrest. The driver expired within one hour of the crash. The autopsy report listed the cause of death as "*severe chest injury*".

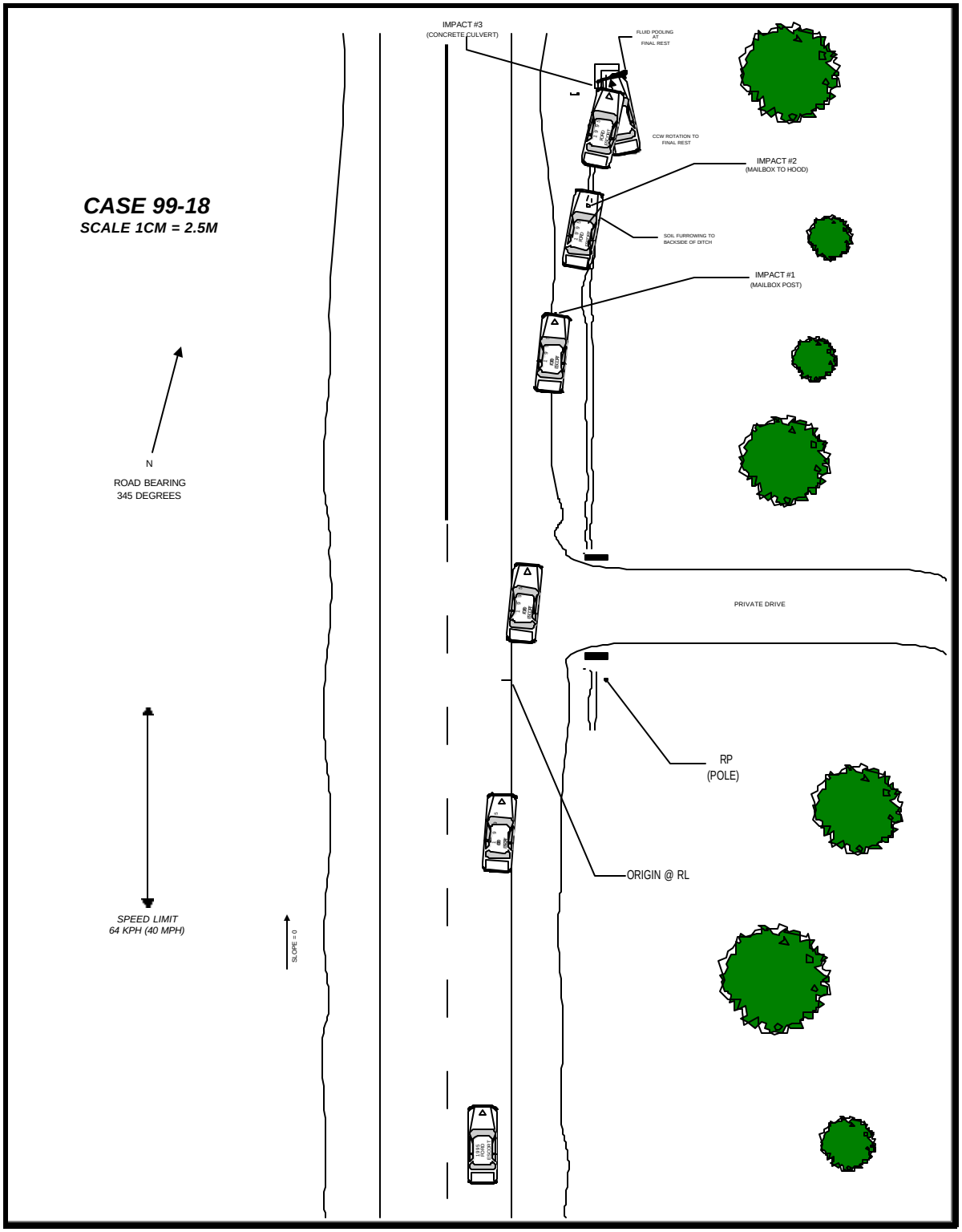

Figure 8. Scene Diagram