

**CRASH DATA RESEARCH CENTER**

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**SIDE IMPACT OCCUPANT PROTECTION INVESTIGATION**

**VERIDIAN CASE NO. CA01-013**

**VEHICLE - 2001 GMC YUKON XL K1500 4X4**

**LOCATION - STATE OF NEW JERSEY**

**CRASH DATE - JANUARY, 2001**

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. <i>Abstract</i> This on-site investigation focused on the performance of the side impact air bag system of a 2001 GMC Yukon XL K1500 4x4 sport utility vehicle. The GMC Yukon was equipped with redesigned frontal and side impact air bags for the front seating positions. The left front side impact air bag deployed as a result of an acute angle collision with a 1975 Pontiac Firebird. The driver of the Pontiac Firebird was operating the vehicle in a northeasterly direction when he attempted to turn right (east) at a 3-leg intersection. As the Pontiac entered the intersection, the driver allowed the vehicle to cross the centerline into the path of the westbound GMC. The front left area of the Pontiac impacted the left side surface of the GMC resulting in moderate damage to both vehicles. The restrained 37 year old female driver of the 2001 GMC Yukon initiated a lateral and forward trajectory in response to the 10 o'clock impact force and loaded the manual restraint and deployed side impact air bag. She was uninjured in the collision. The restrained 60 year old female front right passenger of the GMC Yukon initiated a lateral and forward trajectory in response to the 10 o'clock impact force and loaded the manual restraint. She was also uninjured in the collision. The 6 month old infant female passenger of the GMC was restrained in a rear-facing child safety seat which was installed properly in the second row left seating position. At impact, she initiated a lateral and forward trajectory in response to the 10 o'clock impact force and loaded the safety seat harness with no resulting injury reported.			
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**SIDE IMPACT OCCUPANT PROTECTION INVESTIGATION**  
**VERIDIAN CASE NO. CA01-013**  
**VEHICLE - 2001 GMC YUKON XL**  
**LOCATION - STATE OF NEW JERSEY**  
**CRASH DATE - JANUARY, 2001**

***BACKGROUND***

This on-site investigation focused on the performance of the side impact air bag system of a 2001 GMC Yukon XL K1500 4x4 sport utility vehicle. The GMC Yukon was equipped with redesigned frontal and side impact air bags for the front seating positions. The left front side impact air bag deployed as a result of an acute angle collision with a 1975 Pontiac Firebird. The driver of the Pontiac Firebird was operating the vehicle in a northeasterly direction when he attempted to turn right (east) at a 3-leg intersection. As the Pontiac entered the intersection, the driver allowed the vehicle to cross the centerline into the path of the westbound GMC. The front left area of the Pontiac impacted the left side surface of the GMC resulting in moderate damage to both vehicles. The restrained 37 year old female driver of the 2001 GMC Yukon initiated a lateral and forward trajectory in response to the 10 o'clock impact force and loaded the manual restraint and deployed side impact air bag. She was uninjured in the collision. The restrained 60 year old female front right passenger of the GMC Yukon initiated a lateral and forward trajectory in response to the 10 o'clock impact force and loaded the manual restraint. She was also uninjured in the collision. The 6 month old infant female passenger of the GMC was restrained in a rear-facing child safety seat which was installed properly in the second row left seating position. At impact, she initiated a lateral and forward trajectory in response to the 10 o'clock impact force and loaded the safety seat harness with no resulting injury reported.

The crash notification was provided to NHTSA by a local law enforcement agency on Friday, January 26, 2001 and immediately assigned to the Veridian SCI team as an on-site investigative effort. The on-site investigator departed on January 30 and concluded field activities on Wednesday, January 31, 2001.

***SUMMARY***

**Crash Site**

This two vehicle crash occurred during the morning hours of January, 2001. At the time of the crash, it was daylight with no adverse conditions. Although the roads were reported by police as dry, small areas of wet terrain were reported along the curblines from nearby melting snow; which may have contributed to pre-crash circumstances. The crash occurred just east of an urban 3-leg intersection, along the centerline of a (level) two lane east/west roadway (**see Figure 15 - page 10**). The asphalt roadway was bordered by barrier curbs with a narrow paved shoulder to the north. Traffic control consisted of a stop sign for northbound traffic. The posted speed limit at the crash site was 56 km/h (35 mph).

**Pre-Crash**

The 37 year old female driver of the 2001 GMC Yukon XL was operating the vehicle westbound (**Figure 1**) at a (vehicle recorded) speed of 71 km/h (44 mph) when she observed the eastbound Pontiac Firebird "fishtail" into her lane of travel. The GMC driver further stated that the left rear section of the Pontiac encroached into the westbound lane during his (*Pontiac driver's*) attempts to regain

control of the vehicle following the right turn. At this point, multiple steering maneuvers by the Pontiac driver re-directed the vehicle's rotation as the front left area of the Pontiac re-entered the westbound lane into the path of the GMC. Although the GMC driver recalled no avoidance maneuvers in anticipation of the impending crash, the GMC's Event Data Recorder (EDR) logged active braking up to the point of impact (*as a near deployment event; see Figures 13 & 14 - page 9*).

The 26 year old male driver of the 1975 Pontiac Firebird was operating the vehicle in a northeasterly direction when he exited a service station adjacent to the 3-leg intersection and attempted a right turn (east) onto the two lane roadway (**Figure 2**). The Pontiac driver reported to police that he encountered a wet spot in the road which allowed the vehicle to spin out and subsequently enter the westbound lane.



**Figure 1. Westbound approach for the 2001 GMC Yukon XL.**



**Figure 2. Northeasterly approach for the 1975 Pontiac Firebird.**

### **Crash**

As the Pontiac Firebird entered the westbound lane, the front left area impacted the left side surface of the GMC Yukon resulting in moderate damage to both vehicles. The GMC's EDR logged a vehicle speed of 55 km/h (34 mph) one second prior to the crash. The missing vehicle algorithm of the WinSMASH reconstruction program computed total velocity changes of 11.0 km/h (6.8 mph) for the subject vehicle and 16.1 km/h (10.0 mph) for the Pontiac. The latitudinal component for the subject vehicle was 8.4 km/h (5.2 mph). The longitudinal component for the Pontiac was -15.9 km/h (-9.9 mph). The impact was sufficient to deploy the GMC's left front side impact air bag. At this point, the GMC Yukon rotated approximately 170 degrees counterclockwise and came to rest in the westbound lane facing southeast. The Pontiac Firebird rotated approximately 70 degrees counterclockwise and came to rest perpendicular to the centerline facing north.

### **Post-Crash**

The driver and front right passenger of the 2001 GMC Yukon XL exited the vehicle through the right front door under their own power as the infant was removed through the right rear door with assistance from the driver. The exit status (and *any* subsequent treatment) of the Pontiac Firebird driver was unknown, however, he was reported by police as uninjured. No fire department personnel were summoned to the crash site. Although police were on-scene, the GMC's On-Star system summoned the driver and asked if any assistance was needed. Both vehicles were towed from the crash site due to disabling damage.

## **VEHICLE DATA**

The 2001 GMC Yukon XL K1500 4x4 was manufactured in July, 2000 and identified by the vehicle identification number (VIN): 3GKFK16T21G (production number deleted). The leased vehicle was a 4-door sport utility equipped with four-wheel drive, ABS and a 5.3 liter, V-8 engine. The vehicle was also equipped with the On-Star response system. At the time of the crash, the odometer had recorded 12,601 km (7,830 miles). The seating was configured with front bucket, a second row split bench (with folding backs), and a bench (with folding back) for the third row seating positions. The driver reported no previous crashes or maintenance on the GMC's frontal or side impact air bag system.

## **VEHICLE DAMAGE**

### **Exterior**

The 2001 GMC Yukon XL sustained moderate left side surface damage as a result of the impact with the Pontiac Firebird (**Figures 3 & 4**). The direct contact damage began 19.0 cm (7.5 in) forward of the left rear axle and extended 220.0 cm (86.6 in) forward. The combined direct and induced damage length (Field L) began 5.0 cm (2.0 in) forward of the left rear axle and extended 285.0 cm (112.2 in) forward. Six crush measurements were documented at the level of the lower door: C1= 0 cm, C2= 17.0 cm (6.7 in), C3= 19.0 cm (7.5 in), C4= 17.0 cm (6.7 in), C5= 12.0 cm (4.7 in), C6= 0 cm. A maximum crush value of 21.0 cm (8.3 in) was identified 19.0 cm (7.5 in) aft of the C3 position. The Collision Deformation Classification (CDC) for this impact to the GMC was 10-LZEW-2 with a principal direction of force of (-)50 degrees. Red paint transfers were noted along the direct contact damage. A rubber transfer was documented along the level of the frame attributed to the left front tire of the opposing Pontiac. Both left side doors were jammed as all tempered glazing (and laminated windshield glazing) remained undamaged. The left rear tire was deflated (not restricted) with contact damage noted to the rim. Induced contact damage produced 6.0 cm (2.4 in) of outward buckling to the left rear door upper window frame.



**Figure 3.** Left side surface damage to the 2001 GMC Yukon XL K1500 4x4.



**Figure 4.** Close up view of the direct contact damage.

### **Interior**

Interior damage to the GMC Yukon identified through the vehicle inspection was minimal and was attributed to occupant contact and component intrusion (**Figures 5 & 6**). Small scuff marks were documented on the left front door panel/armrest from driver contact and upper left door panel area from the side impact air bag deployment. Lateral intrusions into the driver space involved 8.0 cm (3.1 in) of B-pillar, 7.0 cm (2.8 in) of door panel, 3.0 cm (1.2 in) of sill and 3.0 cm (1.2 in) of seat back intrusion. Lateral intrusions into the second row left passenger space involved 8.0 cm (3.1 in) of sill and 7.0 cm (2.8 in) of door panel intrusion.



**Figure 5. Interior view of the 2001 GMC Yukon front seating positions.**



**Figure 6. Interior view of the 2001 GMC Yukon rear seating positions.**

### ***MANUAL RESTRAINT SYSTEMS***

The interior of the GMC Yukon consisted of a eight passenger seating configuration with front bucket, a second row split bench (with folding backs), and a bench (with folding back) for the third row seating positions. The driver 3-point manual lap and shoulder belt system was integrated into the seat back and consisted of a continuous loop belt webbing with a sliding latchplate and a dual mode retractor (inertial lock/belt sensitive). The front right 3-point manual lap and shoulder belt system was also integrated into the seat back and consisted of a continuous loop belt webbing with a sliding latchplate and a retractor equipped with an inertial and switchable lock mechanism. Although slight dimpling was noted to the shoulder portions of the front restraints attributed to frequent usage, no obvious loading marks were found. No restraint pretensioners were identified. The second row outboard seated positions were equipped with 3-point manual lap and shoulder belt systems which consisted of a continuous loop belt webbing with a sliding latchplate that retracted into an inertial sensitive and switchable locking retractor. The restraints for these seating positions were also equipped with energy management loops at the lower anchorage points. Loading marks were documented on the shoulder portion of the second row left restraint (**Figures 7 - 9**) along with child safety seat locking clip marks along the upper shoulder portion indicative of frequent usage. The third row outboard seating positions were equipped with 3-point manual lap and shoulder belt systems integrated into the seat backs and consisted of a continuous loop belt webbing with a sliding latchplate that retracted into an inertial sensitive and switchable locking retractor. The second and third row *center* seats were equipped with a 2-point manual lap belt with a locking latchplate.





Figure 7. Loading marks to the second row left shoulder belt webbing.

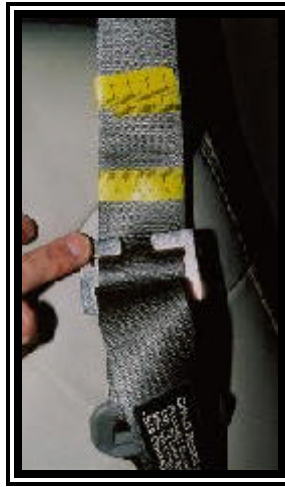


Figure 8. Close-up view of restraint webbing and CSS locking clip.

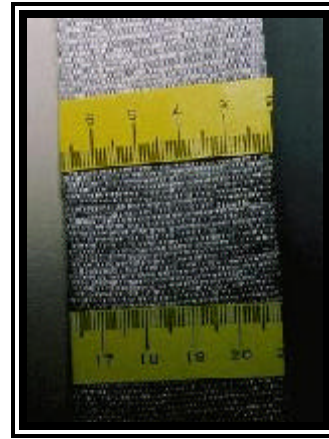


Figure 9. Close-up view of marks produced by CSS locking clip.

### ***CHILD SAFETY SEAT (CSS)***

The infant passenger of the 2001 GMC Yukon XL was positioned in a rear-facing child safety seat (RFCSS) in the second row left seat of the vehicle. The child safety seat was manufactured by Century Products on 03/21/2000 and was identified as a Smartfit Plus (**Figure 10**) with a model number of 41321STD. The RFCSS consisted of a molded plastic shell with a folding carrying handle, fabric covered padding, and an integral 3-point harness system. A detachable base was provided with the RFCSS and was in use at the time of the crash. Warning labels were affixed to the shell of the seat with additional warning labels found on the vehicle sunvisors and restraint systems. There was no residual damage to the RFCSS as the shell did not yield evidence of contact (i.e., abrasions, fracture sites).



Figure 10. Century Smartfit Plus RFCSS.

### ***SUPPLEMENTAL RESTRAINT SYSTEMS***

The 2001 GMC Yukon XL was equipped with redesigned frontal air bags for the driver and front right passenger positions which did not deploy as a result of the crash. The driver air bag was housed in the center of the steering wheel with a vertically oriented flap tear seam (I-configuration). The front right passenger air bag was housed in the right mid-instrument panel area with a rectangular flap design hinged at the top aspect. The vehicle's Sensing and Diagnostic Module (SDM) was located on the floor under the driver's seat cushion.

The GMC was also equipped with side impact air bags for the front seated positions. The air bag modules were housed in the outboard side aspect of the front seat backs with a vertically oriented flap tear seam which measured 9.3 cm (3.7 in) in width and 19.8 cm (7.8 in) in height. The left front side impact air bag deployed as a result of the crash (**Figure 11**). The air bag was rectangular in shape and

measured 42.3 cm (16.7 in) in width and 27.3 cm (10.7 in) in height in its deflated state (**Figure 12**). No vent ports or internal tether straps were present. A scuff mark was documented at the lower right quadrant of the air bag along with multiple striations at the upper right quadrant from expansion within the module. In addition, bag interaction by the driver produced the noted scuff marks to the upper door panel area. The side impact air bag sensors were located in the front door cavities just below the armrest area.



**Figure 11. 2001 GMC Yukon XL deployed side impact air bag.**



**Figure 12. Close-up view of the deployed side impact air bag.**

### **Event Data Recorder (EDR)**

The 2001 GMC Yukon XL SDM was located under the driver's seat as the event data was retrieved via the J1962 connector found to the left of the steering column. The EDR records deployment and near-deployment events for the frontal air bag system. In this crash, the EDR recorded a near deployment event at ignition cycle number 1406. The system status at near deployment reflected the driver's belt switch circuit status as "buckled". As the vehicle and engine speed decreased during the five second pre-crash interval, the brake switch circuit status went from "off" to "on" two seconds prior to algorithm activation.

### **DRIVER DEMOGRAPHICS**

Age/Sex:	37 year old female
Height:	157 cm (62 in)
Weight:	52 kg (115 lb)
Seat Track Position:	Full forward position [22.0 cm (8.7 in) forward of the full rearward position]
Manual Restraint Use:	3-point lap and shoulder belt system
Usage Source:	Vehicle inspection, driver interview, police report
Eyewear:	None
Type of Medical Treatment:	None

### **Driver Injuries**

<i>Injury</i>	<i>Severity (AIS 90)</i>	<i>Injury Mechanism</i>
None	N/A	N/A

### **Driver Kinematics**

The 37 year old female driver of the 2001 GMC Yukon XL was restrained by the available 3-point manual lap and shoulder belt system, seated in an upright posture with her hands placed at the 10 o'clock and 2 o'clock positions on the steering wheel rim. The seat track was adjusted to the full forward position with the seat back angled 23 degrees off vertical. Restraint usage was evidenced by the lack of interior contacts and injury in conjunction with the vehicle's event data recorder summary.

At impact, the driver initiated a lateral and forward trajectory in response to the 10 o'clock impact force and loaded the manual restraint and deployed side impact air bag. Contact to the deployed side impact air bag was evidenced by the scuff marks documented to the lower right quadrant of the air bag face. In addition, driver interaction with the bag produced the noted scuff marks to the upper door panel area. The manual belt system restrained her body as the subsequent counterclockwise vehicle rotation re-directed the kinematic pattern to the right. Following the impact, she exited the vehicle through the right front door (behind the front right passenger) and attended to the infant passenger. The driver was uninjured in the crash. The deployed side impact air bag provided protection against left side components, and potential injury.

### ***FRONT RIGHT PASSENGER DEMOGRAPHICS***

Age/Sex:	60 year old female
Height:	175 cm (69 in)
Weight:	57 kg (125 lb)
Seat Track Position:	Mid-to-rear position [15.5 cm (6.1 in) aft of the full forward position or 6.5 cm (2.6 in) forward of the full rearward position]
Manual Restraint Use:	3-point lap and shoulder belt system
Usage Source:	Vehicle inspection, driver interview, police report
Eyewear:	None
Type of Medical Treatment:	None

### **Front Right Passenger Injuries**

<i>Injury</i>	<i>Severity (AIS 90)</i>	<i>Injury Mechanism</i>
None	N/A	N/A

### **Front Right Passenger Kinematics**

The 60 year old female front right passenger of the 2001 GMC Yukon XL was restrained by the available 3-point manual lap and shoulder belt system, seated in an upright posture with her hands

resting on her lap (holding a purse). The seat track was adjusted to the mid-to-rear position with the seat back angled 22 degrees off vertical. The driver stated the passenger was belted, further evidenced by the lack of interior contacts and injury as a result of this moderate severity crash.

At impact, the front right passenger initiated a lateral and forward trajectory in response to the 10 o'clock impact force and loaded the manual restraint. She was uninjured in the crash.

**SECOND ROW LEFT INFANT PASSENGER DEMOGRAPHICS**

Age/Sex: 6 month old female  
 Height: 64 cm (25 in)  
 Weight: 7 kg (15 lb)  
 Seat Track Position: Fixed  
 Manual Restraint Use: 3-point lap and shoulder belt system  
 Child Safety Seat Use: Century Smartfit Plus Model #41321STD  
 Usage Source: Vehicle inspection, driver interview, police report  
 Eyeware: None  
 Type of Medical Treatment: None

**Second Row Left Infant Passenger Injuries**

<i>Injury</i>	<i>Severity (AIS 90)</i>	<i>Injury Mechanism</i>
None	N/A	N/A

**Second Row Left Infant Passenger Kinematics**

The 6 month old female infant passenger of the 2001 GMC Yukon XL was positioned in a Century Smartfit Plus child safety seat (CSS). This child restraint was designed exclusively as a rear-facing restraint and was engineered with a detachable base. The driver's spouse secured the restraint shell and base with the vehicle's 3-point manual lap and shoulder belt system in the second row left seat which was used in the switchable mode. It should be noted that this restraint can be used with or without the detachable base. The driver stated during the SCI interview that the infant was restrained within the CSS by the integral 3-point harness system. The harness utilized a plastic harness positioning clip that was positioned at the level of the armpits and adjusted to fit the infant with no more than a finger's thickness of slack in the straps at the shoulder level. Although a locking clip was used, it was not required with the switchable retractor.

At impact, the infant passenger initiated a lateral and forward trajectory in response to the 10 o'clock impact force and loaded the harness system. She was uninjured in the crash.

3GKFK16T21G102686 System Status At Near Deployment	
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Passenger Front Air Bag Suppression Switch Circuit Status	ON
Ignition Cycles At Near Deployment	1406

PRE-CRASH DATA					Electronic Data Validity Check Status = VALID
Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status	
-5	44	1344	9	OFF	
-4	44	1344	16	OFF	
-3	44	1280	2	OFF	
-2	41	1152	0	ON	
-1	34	1024	0	ON	

Figure 13. 2001 GMC Yukon XL EDR report (near deployment event).

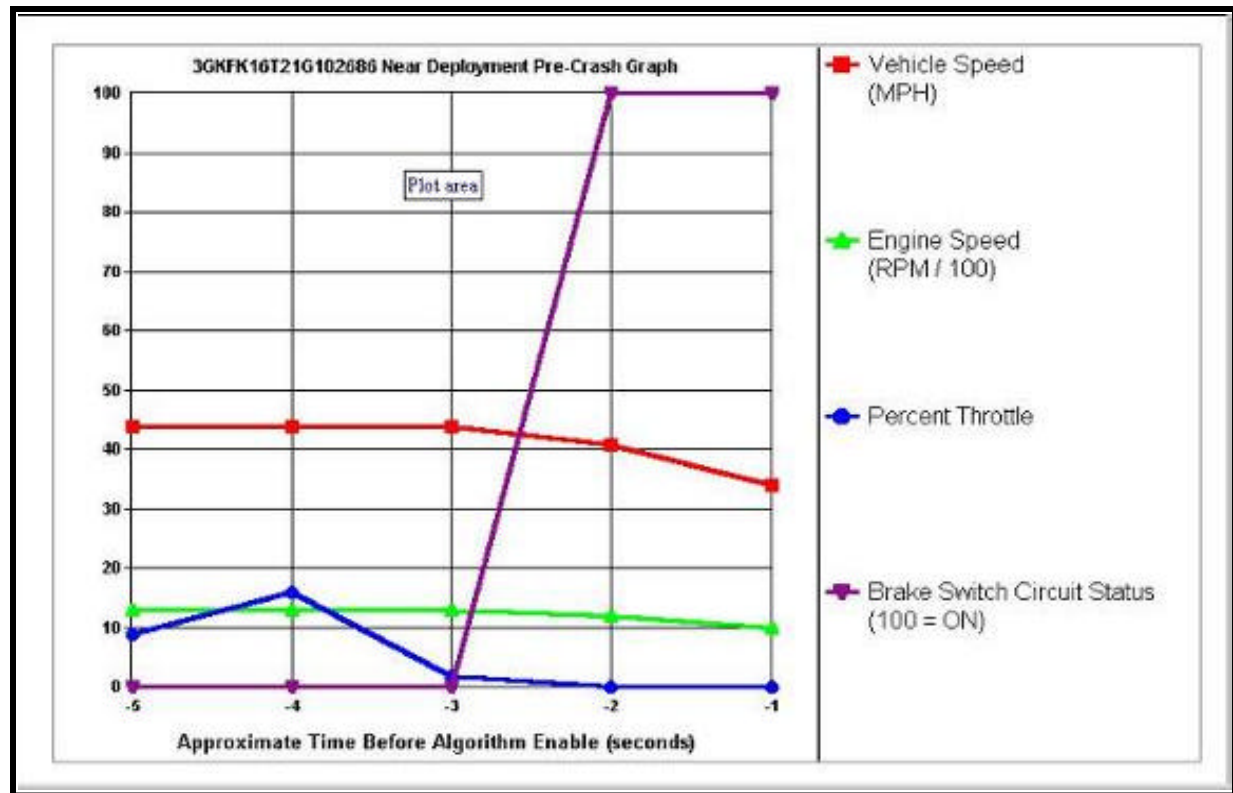


Figure 14. 2001 GMC Yukon XL EDR report (near deployment event).

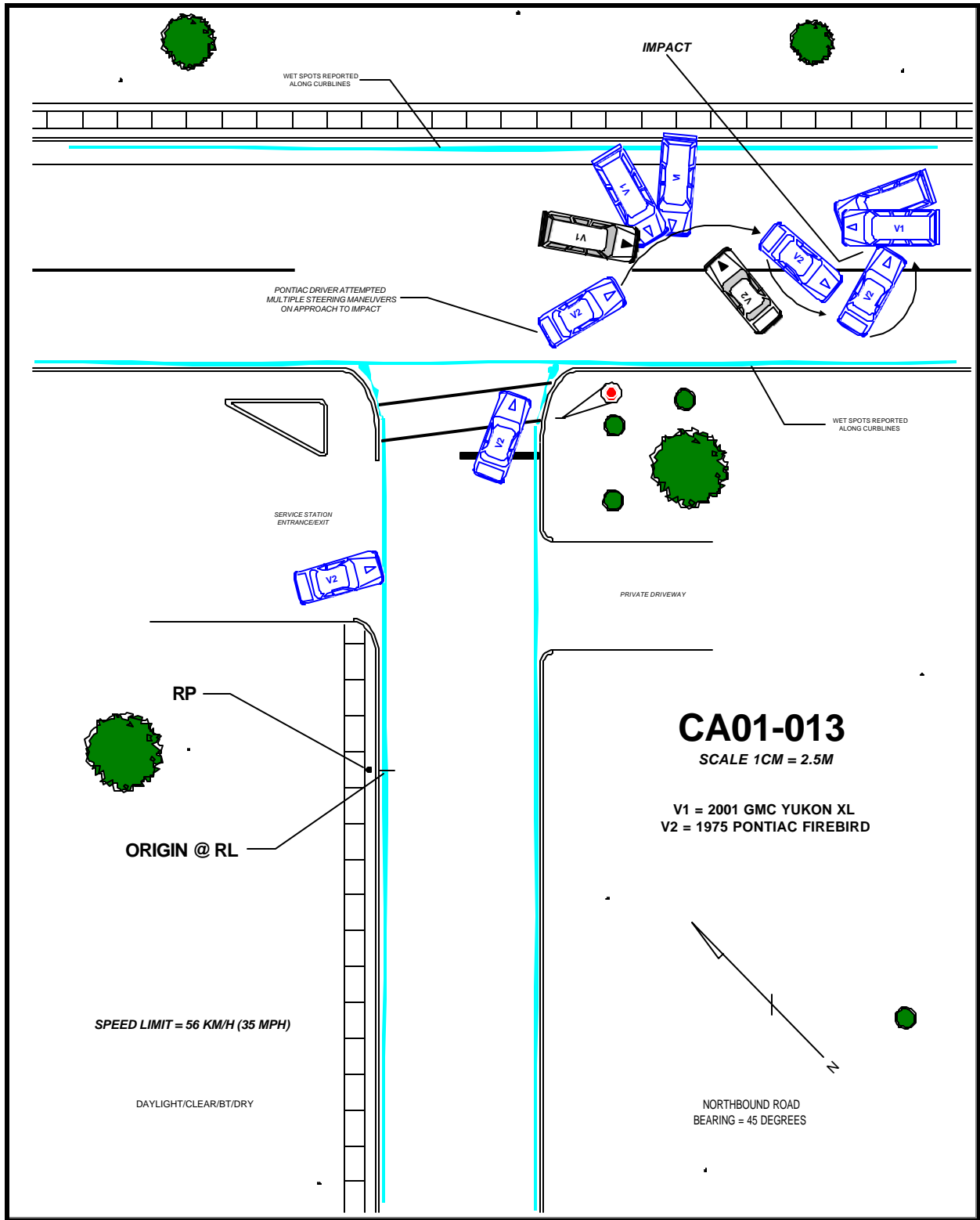


Figure 15. Scene Diagram.