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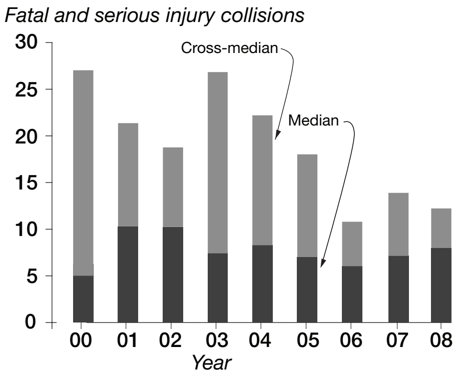
Executive summary

Figure 0.1

Median and cross-median fatal and serious-injury collisions



Source: WSDOT Transportation Data Office and Headquarters Design Office

Introduction

At the end of 2008, the Washington State Department of Transportation (WSDOT) had installed a total of 181 miles of cable median barrier on state highways, and had another 9.6 miles under contract for installation. Our review of another year's collision data and trends shows that cable median barriers continue to be an effective tool for saving lives. From 2000 to 2008, the number of fatal and serious-injury collisions within or across the median decreased by 58 percent.

This report further updates the independent, expert evaluation conducted by Dr. Malcolm Ray of Washington's cable median barrier program, which Governor Gregoire directed in 2007 following a higher-than-average number of crossover collisions on Interstate 5 near Marysville. The results and recommendations from Dr. Ray's review were published in June 2007, "Cable Median Barrier, Reassessment and Recommendation." With another year of collision data for cable median barriers, WSDOT published an update to the 2007 report in September 2008 ("Cable Median Barrier, Reassessment and Recommendations Update"). Previous reports can be found on WSDOT's Web site at **www.wsdot.wa.gov/Projects/CableBarrier**

The 2009 update provides an overview of the changes that have occurred since our last report, including collision trends and cable barrier performance, cross-median collisions in 2008, motorcycle collisions involving cable barrier, median barrier construction in Marysville, and ongoing research and advancements in cable barrier technology.

Cable median barrier trends and performance

Traffic fatality rates in Washington continue to decline, even as traffic volumes increase

From 1990 to 2008 vehicle miles traveled has increased by 29 percent and yet, we saw the highest single-year reduction in fatal and serious injury collisions on state highways since 1990. In 1990 there were 2,491 fatal and serious injury collisions on state highways compared to 1,024 collisions reported in 2008, a reduction of nearly 59 percent. Cable median barriers are one of the engineering strategies that have helped us achieve this overall reduction.

In areas where cable barrier has been installed there has been a 61 percent reduction in the number of cross-median collisions annually

Prior to cable barrier installation, there were 54.8 cross-median incidents per year in the study segments. That number was reduced to 21.6 incidents per year.

Cable barrier stops more vehicles in the median than concrete barrier

Keeping a vehicle in the median, once it has left the roadway, reduces the risk of it colliding with other vehicles. In our 2007 report, we found that 10 percent of the vehicles striking cable barrier were redirected backing into traffic lanes. With the addition of 2008 data, we find that the percentage is now 16 percent. The percentage is still well below what we find with concrete median barriers. In our analysis, 79 percent of vehicles are contained in the median with cable barrier, compared to 34 percent for concrete median barrier.

High-tension cable barrier systems are approaching the effectiveness of concrete barrier in reducing cross-median collisions

An analysis of 58 miles of concrete median barrier reveals that 2.2 percent of the collisions with concrete barrier resulted in vehicles traveling over or through the barrier and reached the opposing traffic lanes compared with 3.7 percent for high-tension cable barrier and 6.0 percent for low-tension cable barrier.

Serious and fatal injury collisions involving cable barriers

While barriers are intended to reduce the overall severity of collisions, there is always a risk of injury when vehicles leave the roadway. Roadside barriers, seat belts, driving tactics and strategies, and vehicle maintenance all play a role in the outcome of an incident. In 2008, there were seven collisions reported in or across the median that resulted in eight fatalities where cable median barrier is installed. There were six collisions in 2008 in or across the median where serious injuries resulted. Speed, alcohol, inattention and sleepy drivers were common behavior factors in these events. See chapter 1 for more details.

WSDOT's evaluation of motorcycle collisions with cable barrier

WSDOT has reviewed collisions involving motorcycles hitting median barrier. We have found no significant difference in injury severity regardless of what type of median barrier motorcyclists struck. Through the end of 2008, there have been seven collisions involving motorcycles and cable median barrier in Washington state. Prior to 2008 we had not experienced any fatalities resulting from motorcycle collisions with cable barrier. Three of the fatal collisions in 2008 were motorcyclists striking cable barriers. Interaction between the barrier system and the rider was vastly different in each of these collisions. See chapter 1 for more details.

WSDOT proposed a national research project, which began in 2009, to identify characteristics involved in serious injury and fatal collisions involving motorcycles and traffic barriers. Results of this research should be available in 2012.

Cable barrier and policy update of WSDOT actions

Washington's policy for cable median barrier usage has been evolving since 1995 when WSDOT's Design Manual first presented guidance on use of cable barrier in highway medians. Our guidance is expected to continue this evolution as cable barrier systems evolve and more is learned about cable barrier placement and performance. In this report we provide further updates to the recommendations made by Dr. Ray, first reported in 2007 and updated in 2008. These include recommendations on:

- installation and placement of barriers
- field inspections of barrier connections
- using crash history as a basis for installing barrier
- research efforts

The Manual on Assessing Safety Hardware (MASH) has been adopted by the American Association of State Highway and Transportation Officials (AASHTO). This manual provides updated guidance on uniform crash testing criteria. The testing requirements for cable barrier are more stringent than they have ever been.

Modifying the median barrier on I-5 in Marysville

The June 2007 Cable Median Barrier report noted a higher-than-average number of crossover collisions on I-5 in Marysville. As a result, Dr. Ray recommended installing concrete median barrier and widening the shoulder along north bound I-5 in Marysville to provide the highest level of protection against crossover collisions.

There haven’t been any cross-median collisions in the segment since February 2007.

Following these recommendations, in December 2007 Gov. Gregoire allocated $26.9 million to replace the existing low-tension cable median barrier with concrete barrier along 10 miles of northbound I-5 in Marysville. The funding was approved by the Legislature in March 2008, allowing WSDOT engineers to begin designing the project.

We advertised the Marysville median barrier project for competitive bids in April 2009, and in June we awarded the contract to Tri-State Construction, Inc. Construction began in late July 2009. Barrier installation is expected to be complete by spring 2010. Total project completion is expected in late 2010. More information is available at: **www.wsdot.wa.gov/Projects/I5/MarysvilleMedianBarrier**

More states using cable barrier systems

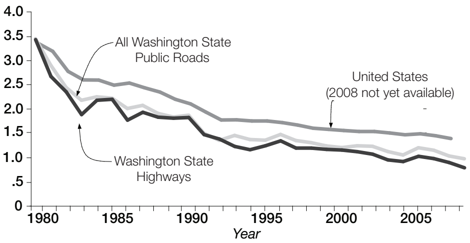
In preparing the June 2007 cable barrier report, we consulted other states regarding their use of cable median barrier systems. At the end of 2006 there were 14 states that had not installed any cable barrier. That equates to 72 percent of states. Now two years later, there are only four states that have no cable barrier in the medians. Ninety-two percent of the country has adopted cable barrier for use as a median barrier. See Figure 4.2 in chapter 4.

Future Planned Installations

There are 25 miles of highway median identified for cable barrier treatment with projects to be advertised in 2010. When all of the planned installations are complete, we expect to have 219 miles of our highway medians treated with cable barrier. Our more recent installations have been four-cable barriers, in contrast to the three-cable barriers that comprise most of our existing inventory. Cable barrier systems have evolved, utilizing four cables to expand the range of height coverage. A higher top cable and lower bottom cable further reduces the probability of vehicles getting under or over the barrier.

Figure 1.1

Traffic Fatality Rate in Washington
Compared to National Average
Fatalities per 100 Million VMT, 1980-2008



Provided by: WSDOT-Transportation Data Office (TDO)
Sources: US Fatalities/VMT: FARS Encyclopedia, WA Fatalities; FARS; State Hwy Fatalities: WSDOT-TDO; WA VMT: WSDOT TDO

WSDOT is reducing fatality rates by reducing crossover collisions

WSDOT uses median barriers to reduce the frequency and severity of collisions in or across the median. Reducing the number of vehicles reaching the opposing traffic lanes is one of the objectives of placing barrier in highway medians.

In 2008, approximately one-third of all fatal collisions on Washington highways involved vehicles either crossing the centerline, or in the case of divided highways, crossing the median into opposing traffic lanes. WSDOT is working to reduce serious and fatal injury collisions in Washington. In pursuit of this objective, WSDOT has targeted median crossover collisions as one of the strategies to bring down the overall number of serious and fatal injury collisions on divided highways. In 2002 WSDOT began implementing a system wide approach to focus on cable median barrier as a means to reduce cross-median collisions. The majority of the locations identified for cross-median protection had existing medians widths of 30 to 50 feet.

Our efforts are making a difference. Over the past 18 years, the fatality rate on all Washington public roads (state, city and county) has decreased 49 percent, from 1.85 per 100 million vehicle miles traveled (VMT) in 1990 to 0.94 in 2008. In 2007, the most recently available national data, Washington ranked 9th lowest in the nation. For Washington state highways only, during this same time period, fatal and serious injury collisions have declined 59 percent, from 2,491 collisions in 1990 to 1,024 in 2008, while the state highway VMT increased 29 percent. The year 2008 represents the highest reduction of fatal and serious injury collisions on state highways for a single year since 1990. These improvements are achieved through the efforts of law enforcement agencies, emergency response, engineering, driver education, and automobile manufacturers. Median barriers are one of the engineering strategies that have helped us achieve this overall reduction.

What is included in the 2009 analysis of median collisions?

Before and after comparisons:

This report compares median collision experience in a five-year period before barrier was installed with the collision experience after median barrier was placed. WSDOT analyzed over 3,100 collisions along 181 miles of cable barrier with installations starting in 1995, continuing through December 2008. Collisions occurring during construction of the cable barrier are not normally included, since the traffic control used during construction presents unique traffic conditions that do not offer a fair comparison.

We believe that cross median collisions in the "before" period occurred more frequently than reported in this study. We can easily identify collisions where the vehicle's initial point of impact was across the median. Because the structure of our collision data identifies only the initial point of impact, it does not allow us to identify the sequence of events occurring after that initial impact. It does not allow us to identify cross median events such as a same-direction sideswipe where a vehicle is rebounded across the median, or events where a vehicle crossed the median without hitting anything.

To gather more information about the sequence of events in a collision, we have to go back to the trooper's reports. In many cases, the trooper's reports are no longer available for that time period. Even when the trooper's reports do exist, there is no reliable means to determine which reports to review. In an attempt to identify additional cross-median events with the most severe injuries, we have reviewed trooper's reports for fatal and serious-injury collisions since 2000.

Unreported collisions:

There are instances where drivers did not report a collision, and drove away after striking the barrier. To gain some insight on the frequency of unreported collisions, we reviewed cable barrier repair records from our maintenance offices during 2008. Our review of repair records and a comparison with reported collisions reveals that there are substantial numbers of unreported collisions involving cable barrier. We found 569 cable repair records, compared to 478 reported collisions. We were able to match about 65 percent (368 records) of the 2008 repairs with specific collision reports. From this comparison, we estimate that 20 to 40 percent of collisions with cable barrier are unreported. Because serious injury collisions are normally reported, we presume that none of the unreported collisions involved serious injury.

Comparison with other types of barriers:

We also compared performance of cable barrier, beam guardrail, and concrete barriers used in the median. We conducted a system-wide study and a more detailed segment analysis of 58 miles of concrete barrier installations as a comparison to the 181 miles of cable barrier installations.

Adjustments and corrections made to records in the 2008 report

As we reviewed the collision records we found that a few records (15) presented in the September 2008 "Cable Median Barrier Reassessment and Recommendations Update" report required some adjustment to correct reporting issues such as:

- Records not identified in the 2008 report.
- Corrections made to resolve reporting errors in direction of travel, or impact location.
- More information was obtained.
- Collision record with the wrong highway identifier.
- Better information on construction project dates.
- Updated information on construction project dates.
- Collisions were found to be on undivided highways.

181 miles of cable barrier have been placed on Washington's highways

By the end of 2008, there were 181 miles of cable median barrier in place and another 9.6 miles were under contract for installation. Approximately six miles of new cable median barrier was completed in 2008. Some of the cable barrier mileage presented in the 2007 and 2008 reports was removed during 2008. A roadway widening project has added lanes in the median and is placing concrete barrier between opposing travel lanes. The narrowed median does not provide adequate width for the deflection characteristics of a typical cable barrier system. The maintenance requirements associated with cable barrier repairs would also place our maintenance crews closer to traffic.

Figure 1.2

Miles of Cable Median Barrier Installed by Year End

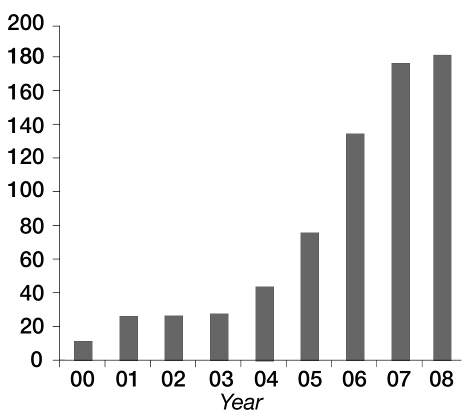


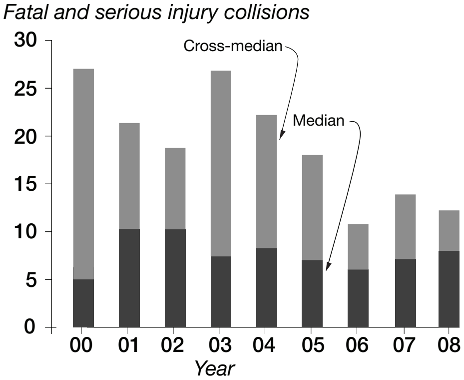
Figure 1.2 provides a year-by-year breakdown of the 181 miles of cable barrier installed between 2000 and 2008.

High-severity collisions continue to decline

The full measure of effectiveness with median barriers is the overall impact on serious and fatal injury collisions. While cross-median collisions are an important component in median barrier performance, engineers must look at all collisions involving a barrier system to fully assess performance. Between 2000 and 2008 there is a dramatic decline in fatal and serious-injury collisions within or across the median. Figure 1.3 illustrates the number of fatal and serious-injury collisions occurring within or across the median where cable barrier has been installed. The decline in serious and fatal injury collisions corresponds to the increase in miles of barrier placed as illustrated in Figure 1.2. Figure 1.3 does not isolate collision

Figure 1.3

Median and cross-median fatal and serious-injury collisions



experience before and after the cable barrier was placed, it simply presents the change in collision experience that we have realized with our median barrier program over time. A before/after comparison is presented later in this report.

Figure 1.3's overall downward trend in fatal and serious injury median collisions is significant considering the increase in miles traveled from 2000 to 2008. Figure 1.4 illustrates traffic volume growth from 2000 through 2008.

With the addition of another year of collision data, we noted the reduction in annual cross-median collisions appears to be less dramatic than reported in 2008. As cable installations for limited-access freeways with medians of 50 feet or narrower are nearing completion, the reduction in collisions that can be expected by installing barrier has been realized and is leveling off.

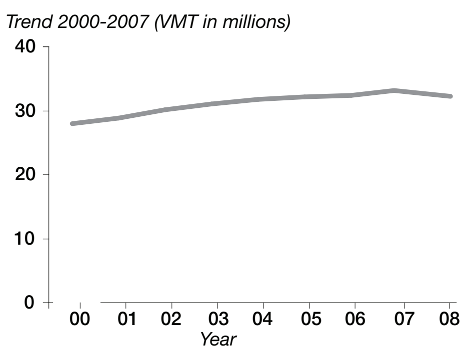
We did see an overall increase in median collisions with the installations of barriers

Once a barrier has been added to a median, errant vehicles no longer have the full width of the median to recover without striking the barrier or other object. Consequently, reportable collisions in the median routinely increase after the installation of any barrier system. This means that WSDOT engineers consider the balance between the benefits of barriers and their associated risks. In the study sections, there were 228 collisions reported annually prior to barrier placement and 594 after placing cable median barrier. That amounts to an increase of 161 percent. Figure 1.5 summarizes this data.

Despite an increase in overall collisions, fatality and serious-injury collision rates have dropped 58 percent

Figure 1.4

Vehicle Miles Traveled (VMT)
Within the Segments Where Cable Median Barriers Were Installed*



*181 miles of cable barriers were installed by the end of 2008.

Expressing collisions as a rate allows us to compare performance on segments with different lengths and traffic volumes. This report presents information on collision rates, expressing the number of collisions for each 100 million vehicle miles of travel (MVMT). Presenting annual collisions is another means to present the data using a common reference point, although it does not account for traffic growth over time,

The overall collision rate jumped from 7.85 collisions per 100 MVMT to 15.99 per 100 MVMT after cable barrier was placed. Despite the overall increase in collisions, we are achieving our objective of reducing serious and fatal injury collisions. The rate of serious-injury collisions was reduced by 64 percent and the rate of fatal collisions was reduced by 44 percent. Collision rate data is presented in Figure 1.5.

If changes in traffic volume are not factored into the analysis, we still see a 48 percent reduction in annual fatal and serious-injury collisions after cable median barrier was placed. There were 24.8 fatal and serious injury collisions per year prior to installation of barrier and 13.0 after.

Figure 1.5
Collision Rate Data "Before" and "After" Cable Barrier Installation

	Before	After	Percent change
Annual median collisions	228	594	+161%
Median collision rate (per 100 million vehicle miles of travel)	7.85	15.99	+104%
Annual serious-injury median collisions	16.8	7.0	-59%
Annual fatal median collisions	8.0	6.0	-25%
Serious-injury median collision rate (per 100 million vehicle miles of travel)	0.58	0.21	-64%
Fatal median collision rate (per 100 million vehicle miles of travel)	0.27	0.15	-44%

We've seen a 61 percent decrease in annual cross-median collisions

Figure 1.6 illustrates cable median barrier's effect on cross-median collisions. Prior to cable barrier installation, there were 54.8 cross-median incidents per year in the study segments. That number was reduced to 21.6 incidents per year after cable barrier was installed. The number of annual cross-median fatal and serious injury collisions was reduced 57 percent, dropping from 13.4 to 5.8.

Figure 1.6

Cross-Median Collisions

	Before	After	Percent change
Annual cross-median incidents	54.8	21.6	-61%
Cross-median collision rate (per 100 million vehicle miles of travel)	1.88	0.66	-65%
Annual serious-injury cross-median collisions	8.6	2.3	-73%
Annual fatal cross-median collision	4.8	3.5	-28%

WSDOT's cable median barrier program began with low-tension (generic) barriers. Over time, cable barrier systems have evolved to offer multiple high-tension systems available from several manufacturers. High-tension systems have dominated Washington's cable median barrier installations since 2004. At the end of 2008, there were 41 miles of generic low-tension barrier in place and 140 miles of high-tension barrier. Washington has not installed any generic low-tension cable barrier since 2005. Although low-tension cable barriers are effective and continue to be used across the country, WSDOT has found high-tension cable barrier systems to be competitively priced and easier to maintain. For new-installations, the WSDOT Design Manual specifies high-tension cable barrier, no longer presenting the generic low-tension cable barrier as an option.

The collision experience with these different systems allows us to compare performance of the low-tension and high-tension cable barrier systems. A direct comparison of experience in Washington is complicated by some policy changes. About the same time that high-tension cable barriers began appearing in Washington, we also implemented changes in our placement guidance. Consequently, it is difficult to draw absolute conclusions regarding whether the high-tension systems are actually performing better or whether changes in cable barrier placement are having a significant influence on the reduction in cross-median collisions. Although we attempted to separate the shift to high tension from the policy change, we found them to be too closely linked to isolate the effects.

Figure 1.7

Comparing low- and high-tension cable median barriers system performance

Barrier type	Barrier performance	Reported collisions	Not stated	No injury	Possible injury	Evident injury	Serious injury	Fatal
Low-tension	Contained in median	742 (85.9%)	16 (1.9%)	598 (69.2%)	68 (7.9%)	50 (5.8%)	8 (0.9%)	2 (0.2%)
	Redirected	70 (8.1%)	3 (0.3%)	58 (6.7%)	4 (0.5%)	4 (0.5%)	1 (0.1%)	0
	Cross-median	52 (6.0%)	0	17 (2.0%)	10 (1.2%)	13 (1.5%)	6 (0.7%)	6 (0.7%)
High-tension	Contained in median	560 (71.5%)	3 (0.4%)	459 (58.6%)	54 (6.9%)	37 (4.7%)	4 (0.5%)	3 (0.4%)
	Redirected	194 (24.8%)	4 (0.5%)	150 (19.2%)	26 (3.3%)	11 (1.4%)	2 (0.3%)	1 (0.1%)
	Cross-median	29 (3.7%)	0	16 (2.0%)	3 (0.4%)	3 (0.4%)	2 (0.3%)	5 (0.6%)

With consideration of the joint effects of system change and policy change, we found that a comparison of low-tension and high-tension cable barrier systems indicate a higher incidence of vehicles being redirected back into traffic

lanes with high-tension cable barrier (see Figure 1.7). The data show that the percentage of cross-median collisions is lower with the high-tension cable barrier installations.

Low-tension cable barrier installation

Cables are mounted with J-bolts to posts placed 16 feet apart, and secured to concrete anchors buried every 2,000 feet. At the anchors, the cables are attached to springs and tightened. The springs are designed to expand and contract with temperature changes. The cables tighten and flex as they bring the vehicle to a stop with a low likelihood for redirecting it back into traffic or allowing it to cross the median. In standard crash tests, at over 60 mph and an impact angle of 25 degrees, the cables flex as much as 12 feet.

Low-tension cable barrier anchor

If a vehicle hits the end of the barrier where the cables are anchored, the cables are designed to release from the anchor, lessening the force of impact transferred to people inside the vehicle. Without the release mechanism, cable anchors were found to increase the frequency of rollovers, and higher numbers of injuries.

High-tension cable barrier installation

After WSDOT began installing cable barrier in the median, private manufacturing companies entered the market with high-tension systems with reduced deflection. Like low-tension systems, high-tension cable median barriers currently in place on Washington highways consist of three strands of steel cable-mounted on posts. Our high-tension barriers string the cables through slots in the middle of the posts, typically spaced 16 feet apart. With high-tensions systems, the cables don't flex laterally as far as their lower-tension predecessors, so they can be used in narrower spaces. When a vehicle strikes the high-tension cable median barrier, the posts are designed to bend down, allowing the cables to slip out of their slots to catch the vehicle. The higher cable tension also increases the likelihood that the cable will remain at a serviceable height prior to repair if a couple of the posts were knocked down.

High-tension cable barrier anchor

The anchors for this type of system have been placed as much as three miles apart, although obstacles such as bridges, other barrier systems, or highway hardware often make that length impractical. Each cable is attached to its own anchor post and is designed to break free when struck by a vehicle.

Comparison of barrier systems commonly used in highway medians

WSDOT uses beam guardrail, concrete barrier, and cable barriers to reduce cross-median collisions and bring down the number of serious and fatal injury collisions. Longer installations are typically concrete or cable barrier rather than beam guardrail.

Figure 1.8 presents a comparison of injury severity for the three barrier systems most commonly used in the medians of Washington's highways. We analyzed data for all collisions with cable barrier through the end of 2008 and collisions with beam guardrail and concrete barrier from 2002 through 2008. These data show that 20 percent of collisions involving cable median barrier result in injury or death. Beam guardrail collisions result in injury or death 37 percent of the time, and for concrete barriers it's 38 percent.

Containing vehicles in the median results in fewer multi-vehicle collisions

Our updated analysis resulted in very similar performance comparisons with the 2007 and 2008 cable barrier reports. The increased mileage of high tension

Figure 1.8

Barrier Systems Commonly Used in the Median

Barrier type	Reported collisions	Not stated	No injury	Possible injury	Evident injury	Serious injury	Fatal
Cable barrier	1,647	26 (1.6%)	1298 (78.8%)	165 (10.0%)	118 (7.2%)	23 (1.4%)	17 (1.0%)
Beam guardrail	2,979	59 (2.0%)	1,828 (61.4%)	654 (22.0%)	361 (12.1%)	56 (1.9%)	21 (0.7%)
Concrete barrier	9,708	183 (1.9%)	5,788 (59.6%)	2,394 (24.7%)	1155 (11.9%)	148 (1.5%)	40 (0.4%)
Total	**14,334**	**268 (1.9%)**	**8,914 (62.2%)**	**3,213 (22.4%)**	**1,634 (11.4%)**	**227 (1.6%)**	**78 (0.5%)**

systems and a corresponding increase in overall number of collisions reflects an increase in the number of cross median collisions, and fatal collisions.

Figure 1.9 illustrates that cable barrier collisions involve multiple vehicles 17 percent of the time, while that number increases to 32 percent with concrete barrier and 36 percent with beam guardrail.

Figure 1.10 illustrates the number of injuries per collision event with the various barrier types, with single-vehicle and multi-vehicle collisions. Cable barrier collisions result in lower numbers of injuries per collision than other barrier types.

Figure 1.10

Number of injuries per collision

Collisions	Cable barrier	Concrete barrier	Beam guardrail
Single-vehicle collisions	0.17	0.43	0.49
Multiple-vehicle collisions	0.93	0.66	0.67
All collisions	0.30	0.51	0.56

Comparison of Cable Barrier and Concrete Barrier Performance

WSDOT engineers took a closer look at 58 miles of concrete barrier installations and compared them to 181 miles of cable barrier. These concrete barrier segments were selected because their site characteristics were similar with highway locations where cable median barrier had been placed.

Cable barrier stops more vehicles in the median than concrete barrier

It is desirable to keep vehicles in the median once they have left the roadway. Vehicles that cross the median or are redirected back into traffic have a greater probability of involving additional vehicles which likely result in higher numbers of injuries.

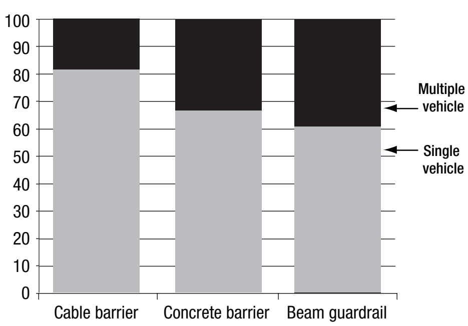
In our 2007 report, we found that 10 percent of the vehicles striking cable barrier were redirected back into traffic lanes. With the addition of 2007 and 2008 collision data, we find that the percentage of redirected vehicles is now 16 percent. In spite of that increase, the percentage is still well below what we find with concrete median barriers. Our analysis indicates that 79 percent of the cable barrier collisions are contained in the median compared with 34 percent for concrete median barrier (Figure 1.11). The high percentage of vehicles redirected by concrete barrier is influenced by the fact that concrete barriers are more frequently used in narrower medians, where the impacting vehicle does not have to travel as far to re-enter the lanes.

Figure 1.9

Percentage of single- and multi-vehicle collisions with barrier types

2002-2008*

Percent



*Time period analyzed for concrete barrier and beam guardrail collisions.

Figure 1.11

Comparison of cable barrier and concrete barrier performance

Barrier performance	Cable barrier	Concrete barrier
Contained in median*	1,302 (79.1%)	441 (34.0%)
Redirected**	264 (16.0%)	828 (63.8%)
Cross-median***	81 (4.9%)	28 (2.2%)
Total	**1,647**	**1,297**

* Contained in median: The vehicle hit the barrier and did not re-enter any lanes of traffic.

** Redirected: The vehicle hit the barrier and rebounded into the lanes of traffic.

*** Cross-median: The vehicle hit the barrier, went across the median, and entered the opposing lanes. To be conservative, WSDOT considered any incident as a cross-median incident whether or not there was a collision with opposing traffic. In our analysis, there were 32 cross-median incidents involving cable barrier where there was not a collision with opposing traffic: 56 percent of the total.

Figure 1.12

Concrete barrier shows a slightly lower percentage of cross-median collisions

	Low-tension cable barrier (41 miles) 1995-2008	High-tension cable barrier (150* miles) 2004-2008	Concrete barrier (58 miles) 2002-2008
Cross-median incidents	52 (6.0%)	29 (3.7%)	28 (2.2%)
Cross-median rate (per 100 million vehicle miles of travel)	0.67	0.64	0.25
Fatal crashes where barrier was impacted	8 (0.9%)	9 (1.1%)	7 (0.8%)
Deaths from collisions where barrier was impacted	12	11	10
Fatal crash rate (per 100 million vehicle miles of travel)	0.10	0.20	0.06

*Marysville section has dual runs of barrier. Southbound collisions after February 2007 are attributed to high-tension cable barrier. All others are low-tension.

High-tension cable barrier systems are approaching the effectiveness of concrete barrier in reducing cross-median collisions.

Adding more collisions to the data yielded results that are very similar to what was reported last year.

- 97.8 percent of the collisions with concrete barrier did not reach the opposing lanes
- 96.3 percent of the collisions with high-tension cable did not reach the opposing lanes
- 94.0 percent of collisions with low-tension cable barrier did not reach the opposing lanes

An analysis of 58 miles of concrete median barrier reveals that 2.2 percent of the collisions with concrete barrier resulted in vehicles traveling over or through the barrier and reached the opposing traffic lanes compared with 3.7 percent for high tension cable barrier and 6.0 percent for low-tension cable barrier.

Cable barrier is effective in reducing rollover collisions in the median

In rollover collisions, vehicle occupants are subjected to a wider range of forces and more frequent impacts with vehicle components, resulting in more severe injuries, particularly at higher speeds and with unrestrained occupants. Figure 1.13 illustrates an overall reduction of 28 percent for all rollover collisions in the median. For serious-injury collisions, the reduction is 67 percent, and a 20 percent reduction was found for fatal collisions.

Figure 1.13

Cable barrier is effective in reducing rollover collisions in the median

	Before	After	Percent change
Annual median rollover collisions	84.0	60.7	-28%
Median rollover collision rate (per 100 million vehicle miles of travel)	2.99	1.62	-46%
Annual serious-injury median rollover collisions	8.6	2.7	-69%
Annual fatal median rollover collisions	2.8	2.2	-20%

Serious and fatal injury collisions in 2008 involving cable barriers

While the placement of cable and other barriers is intended to reduce the overall severity of collisions, there is always a risk of injury when vehicles leave the roadway. Roadside barriers, vehicle restraint systems, driving tactics and strategies, and vehicle maintenance practices, all play a role in the outcome of an incident.

Not all cross-median collisions resulted in a fatality, however in 2008, there were seven collisions reported in or across the median that resulted in eight fatalities where cable median barrier is installed. All of these collisions involved the cable median barrier. Those collisions and serious injury cross-median collisions are summarized below:

Summary of fatal median and cross-median collisions in 2008

SR 512, Milepost 7, Puyallup - March 13, 2008: The driver of a westbound truck and semi-trailer was reaching for a compact disc from the floor of the truck when he drifted into the median and over the cable barrier. The truck continued across the eastbound lanes, where the trailer was struck by a second vehicle, shearing the roof off the second vehicle. A third vehicle also struck the trailer. The driver of the second vehicle died at the scene. Driver inattention was a factor in this collision.

SR 16, Milepost 15, - May 23, 2008: The driver of a Ford Expedition was westbound, and drifted off the road to the right. The driver then over-corrected and crossed both lanes and entered the median where it struck the cable barrier. The SUV went over the cable barrier, rolled several times and came to rest on its side, blocking both eastbound lanes. The driver died at the scene. Speed and driver inattention were factors in this collision.

I-5, Milepost 88, Grand Mound - October 3, 2008: The driver of a southbound truck and semi-trailer observed slowing traffic and made a lane change to the right. A southbound Subaru Legacy was in the right lane when the truck moved over. The Subaru turned to the left and crossed both southbound lanes and entered the median. The Subaru went under the cable barrier and crossed into the northbound lanes where it struck a truck and semi-trailer head-on. The driver and front seat occupant in the Subaru died at the scene.

SR 512, Milepost 9, Puyallup - November 3, 2008: The driver of an eastbound Acura left the roadway to the left, entered the median, struck the cable barrier, and rode over the top. The Acura crossed the median, entered the westbound lanes and struck a Toyota pickup. Both vehicles then struck a semi-truck and trailer. The driver of Acura died at the scene.

Three other fatal collisions are listed in the summary of motorcycle collisions.

Summary of serious-injury median and cross-median collisions in 2008

I-5, Milepost 114, Nisqually - January 11, 2008: A Toyota pickup was traveling southbound (wrong way) in the northbound lanes and sideswiped a northbound Ford pickup. The Toyota continued southbound and struck northbound Honda Civic nearly head on. The Toyota came to rest in the median on the cable barrier. The driver of the Honda suffered a broken leg. Alcohol was a factor in this collision.

I-5, Milepost 22, Vancouver- March 20, 2008: Two vehicles collided in the northbound lanes. One vehicle swerved left into the median and was restrained by the cable barrier. The other vehicle lost control, left the road to the right and struck a tree. The driver of the vehicle striking the tree suffered a broken ankle, broken collarbone, and chest and neck pain. Inattention and drowsy driving were factors in this collision.

I-90, Milepost 298, East of Spokane - March 30, 2008: A westbound Chevy sedan lost control on the ice, slid into the median, and rolled over. The Chevy came to rest on the cable barrier. The driver suffered head injuries. Speed was a factor in this collision.

US 12, Milepost 15, Montesano to Elma - April 20, 2008: An eastbound Chevy van struck the rear of an eastbound Oldsmobile. The Oldsmobile spun to the right, struck the guardrail, rotated and re-entered the lanes, where it was struck by a Kenworth tractor/trailer combination. The Oldsmobile was pushed back to the right shoulder striking the guardrail a second time. The Chevy van left the roadway to the left, struck the cable barrier, veered to the right crossing the lanes and struck the guardrail on the right shoulder. The van continued approximately 1/4 mile, where the driver fled the scene. The van had been stolen. The driver of the Oldsmobile suffered internal injuries. Speed was a factor in this collision.

SR 3, Milepost 52, Silverdale - June 4, 2008: A northbound Isuzu SUV left the roadway to the left, struck the cable barrier, and rolled multiple times. The SUV came to rest in the median. The driver suffered head and neck injuries. Alcohol and speed were factors in this collision.

182, Milepost 13, Pasco - October 1, 2008: An eastbound Mercury sedan, lost control and drifted to the right, striking the rear trailer tires of a Peterbuilt tractor/trailer combination. The Mercury bounced off, went through the cable median barrier, across the westbound lanes, and came to rest on the westbound shoulder. The driver of the Mercury suffered injuries to the head, back, neck, and wrist. Alcohol was a factor in this collision.

WSDOT's evaluation of motorcycle collisions with cable barrier

Some motorcyclists have expressed concern that cable barrier systems present a high risk for severe lacerations, or even dismemberment from contact with the cables. While motorcyclists are at greater risk of injury in a collision than occupants in most other vehicles, there is little evidence that these types of injuries are occurring. WSDOT has reviewed collisions involving motorcycles hitting median barrier. We have found no significant difference in injury severity regardless of what type of median barrier motorcyclists struck.

Collisions involving motorcycles and cable barrier

Through the end of 2008, there have been seven collisions involving motorcycles and cable median barrier in Washington State. Prior to 2008 we had not experienced any fatalities resulting from motorcycle collisions with cable barrier. Unfortunately that trend changed dramatically, with three fatal collisions in 2008. It is important to note that concern about severe lacerations or dismemberment resulting from contact with the cables has not been an issue in Washington. Contact with pavement was the source of injury in two of the 2008 collisions. Contact with the post was the method of injury in the third event.

I-90, Milepost 184, Moses Lake – Oct. 26, 2008: An inexperienced driver was entering I-90 westbound at MP 184 east of Moses Lake, when he left the paved on-ramp to the left, crossed through a gravel area between the ramp and the interstate, crossed the interstate traffic lanes, entered the median, and struck the cable barrier. The driver was upright on the motorcycle when it struck the barrier, was subsequently ejected, striking the ground with his head. The driver was dead at the scene from a broken neck. Driver inattention was a factor in this collision.

SR 99, Milepost 25, Seattle - Aug. 24, 2008: A northbound motorcycle on SR 99 between Tukwila and Seattle was traveling at high speed, lost control, and overturned in the lane. Witnesses reported the driver was doing wheelies prior to the crash. The driver separated from the motorcycle and struck a cable barrier post with his back. The driver was dead at the scene from spinal injuries. Speed was a factor in this collision.

SR 512, Milepost 10, Puyallup - June 27, 2008: A westbound motorcycle on SR 512 was observed traveling at high speed, passing vehicles on both shoulders. The driver lost control, overturning in the lanes, and slid into the cable barrier. The driver suffered broken bones and a broken neck resulting from pavement contact and was pronounced dead at the scene. The investigating officer reported that the driver came to rest against a post of the barrier system. The driver was found to be under the influence of alcohol. Alcohol was a factor in this collision.

Motorcycle collision research continues

As mentioned in the 2008 cable barrier report, a WSDOT proposed research project titled "Identification of Factors Related to Serious Injuries in Crashes of Motorcyclists into Traffic Barriers," was selected for funding as part of the National Cooperative Highway Research Program (NCHRP). This study began in 2009 and the results should be available in 2012.

This study will identify characteristics involved in serious-injury and fatal collisions involving motorcycles and traffic barriers. The research will investigate characteristics related to the drivers involved, the collision types, the barrier types, the roadway geometry and conditions, the vehicle types, and the environmental conditions. The study will also identify specific characteristics that could be studied further to develop potential ways of improving motorcycle safety. A WSDOT employee is on the project panel for this research.

Chapter 2: Cable barrier policy and update of WSDOT actions

Washington's policy for cable median barrier usage has been evolving since 1995 when WSDOT's Design Manual first presented guidance on use of cable barrier in highway medians. Our guidance is expected to continue this evolution as cable barrier systems evolve and more is learned about cable barrier placement and performance. In 2007, WSDOT hired Dr. Malcolm Ray, PE, Ph.D., to conduct an independent evaluation of our cable median barrier policy and program. Dr. Ray presented his findings in the 2007 "Cable Median Barrier Reassessment and Recommendations" report to Governor Christine Gregoire. In that report, Dr. Ray submitted several recommendations regarding WSDOT's policy on cross median protection. In the updated 2008 report, Dr. Ray reviewed and commented on WSDOT's progress toward implementing his recommendations and offered updated recommendations for the future. Although Dr. Ray was not consulted in this report, this chapter presents an update to his policy and research recommendations published in the 2008 report.

Policy Recommendations

Policy Recommendation No. 1 - Installation of cable barrier

I recommend that WSDOT continue its use of cable median barrier. The cable median barrier program has been very effective statewide in reducing the number and severity of median cross-over crashes and has doubtless saved many lives.

2008 recommendations/conclusion - WSDOT has adopted my recommendation that the cable median barrier continue to be used in Washington State.

Progress since 2008 report - WSDOT continues to install cable barrier in the medians.

Policy Recommendation No. 2 - Placement of barrier on slopes

When cable barriers must be placed near the breakpoint between a nominal 10:1 and nominal 6:1 slope in the median, the following options should be considered:

a. *For single-runs of cable median barrier, if there is at least 13 feet from edge of the nearest traveled lane to the slope breakpoint, the cable median barrier should be placed at least one foot in front of (i.e., between the breakpoint and the traveled lane) the slope breakpoint. Any crash tested cable median barrier can be used in this situation (i.e., low-tension or high-tension). This arrangement will allow 12 feet of dynamic deflection distance for back-side hits, provide an adequate emergency lane, minimize the chance of bumper height problems associated with SUV's and pickup trucks traversing slopes prior to contacting the barrier and provide some recovery space for vehicles leaving the near lanes of travel.*

b. *For double-runs of cable median barrier, if there is at least 11 feet from edge of the nearest traveled lane to the slope breakpoint, the cable median barrier should be placed at least one foot in front of the slope breakpoint. Any crash tested cable median barrier can be used in this situation (i.e., low-tension or high-tension). This arrangement will provide an adequate emergency lane, minimize the chance of bumper height problems associated with SUV's and pickup trucks traversing slopes prior to contacting the barrier and provide some recovery room for vehicles leaving the near lanes of travel. Deflection distance for back-side hits are not as much of a concern in this situation since the back of one barrier is shielded by the barrier on the other side of the median.*

c. *When there is not sufficient space to position the barrier in front of the slope breakpoint, a cable median barrier with a wider window of protection should be used to minimize the chance of newer SUV and pickup trucks from over-riding the barrier. Other types of cable median barriers that can be used behind the slope break point are:*

   i. *Any test level four-cable median barrier or*

   ii. *A cable median barrier that is designed and crash tested such that its successful performance with newer SUVs and pickup trucks on terrains with typical slope breakpoints has been established.*

   While I do not believe that test level four barriers are appropriate for general highway conditions, the higher rail height of typical test level four barriers should provide additional protection for SUV's in the interim period between the new full-scale crash testing guidelines being adopted and the development of new test level three hardware. I also encourage WSDOT to perform full-scale crash testing of cable median barriers on typical median cross-sections to develop barrier options with established performance on typical median cross-sections.

2008 recommendations/conclusion - Implementation of this recommendation is still in progress. There are several development efforts aimed at developing four-cable median barriers for use on 4:1 slopes and test level four barrier may also help address this need. If these new barriers are successfully tested on 4:1 slopes the placement on the slope should be less critical. WSDOT is in the process of revising its cable median barrier policy as reflected in Chapter 700 (Traffic Barriers) of the WSDOT Design Manual. The revision is expected to (1) removed the low-tension cable median barrier as an option for new installations, (2) add the slope placement details described in parts a and b of my recommendations and (3) recommend the use of test level four cable median barriers or four-cable median barriers. The revisions to the Design Manual should address this recommendation.

Progress since 2008 report - WSDOT has pursued Dr. Ray's recommendations. We have modified the Design Manual to: preclude low-tension cable barrier as an option for new installations, added slope placement guidance, and recommend four cable barriers systems. We have contracts in progress that will install some of the four cable systems approved for use on 4H:1V slopes. We will continue to monitor the evolution of cable barrier systems to identify systems that offer enhanced performance.

Policy Recommendation No. 3 - Field inspection of connections

WSDOT should develop a field inspection procedure to ensure that all wedge-and-socket connections are sound and the wedges are firmly seated into the sockets. All such connections on the low-tension cable median barriers should be field checked in a reasonable period of time to ensure that the cable forces are correctly transmitted to the foundation.

2008 recommendations/conclusions - WSDOT has adopted my recommendation and quickly performed the field inspections to ensure the socket-and-wedge connection in the low-tension cable median barrier were properly seated.

Progress since 2008 report - WSDOT checks the wedge-and-socket connections of low-tension cable barrier during maintenance and repairs of the low-tension cable barrier systems. Projects advertised and awarded in the summer of 2009 will replace nearly all of the existing low-tension cable barriers installations with four cable high-tension systems. With high-tension cable barrier systems, the constant cable tension keeps any wedges seated firmly in the sockets.

Policy Recommendation No. 4 - Crash history as a basis for installing barrier

WSDOT should develop install recommendations based on a periodic review of crash history for installing both cable median barrier and concrete median barrier. Currently, installation recommendations are based primarily on the median characteristics such as median width and traffic volume. Engineering judgment and installation recommendations based on highway geometry should be the first criteria in deciding on locations for median barrier but crash history should also play a role for locations like Marysville where the site geometry are simply not accurate predictors of the magnitude of the cross-median problem.

2008 recommendations/conclusion - In reviewing the screening criteria I would like to make one small suggestion for a change. Currently, the note on Table 6 reads " crash rates should be calculated on sections that are at least two miles long and, where data are available, the section has experienced at least 100 MVMT." ……… I believe it would be more accurate and realistic to not calculate the rate until the vehicle miles travelled exceed 200 MVMT. I also believe the section length criterion can be dropped since a short section will simply take longer to meet the vehicle miles travelled criteria. I suggest that the note be changed to "crash rates should be calculated only on sections where the section has experienced at least 200 MVMT.

The quick comparison of the "old" WSDOT cable median barrier policy versus the "new" cable median barrier policy discussed earlier in this report raises very interesting questions about the evolution of median barrier policy. I recommend that WSDOT use the data assembled for this review and perform a more comprehensive review of the pre-2004 and post-2004 policies to see if it is possible to determine the effectiveness of low-tension versus high-tension cable median barrier and the effectiveness of the different versions of the placement policy. It may not be possible to separate these two effects but it should be possible to demonstrate that the post-2004 policy is an incremental improvement over the earlier policy.

Progress since 2008 report - In addition to existing state and federal guidance, WSDOT did conduct a performance analysis of existing cable barrier installations, incorporating the modifications to the screening criteria recommend by Dr. Ray in the 2008 report. That analysis revealed that there were 12 locations where the rate of cross-median collisions exceeded the 0.75 collisions per 200 million vehicle miles threshold suggested by Dr. Ray. Eight of these sections did not meet the minimum exposure (200 million vehicle miles traveled) for the barrier. One of these sections did not meet the minimum average daily traffic volume suggested by Dr. Ray. One of the remaining segments (Puyallup River to Fife on I-5) is mostly within the limits of a programmed project that will replace the cable with concrete barrier as part of a larger HOV lane project. Because of permitting issues, the remaining portion (0.99 mile) of this installation could not be included in the recent federal stimulus-funds projects. The remaining segment near the Puyallup River will be slated for retrofit or replacement when project funding is identified. The remaining two sections are as follows:

> **I-5, Nisqually:** This section has a cross-median collision rate of 1.19. This installation currently has a low-tension cable barrier system and is included in the federal stimulus funded contracts that will place a four-cable high tension system in the median.
>
> **SR-512, Puyallup:** This section has a cross-median collision rate of 0.95. This installation currently has a high-tension cable barrier system in place. WSDOT is evaluating this location for an appropriate barrier system to improve the performance.

[1] 4H:1V refers to a slope ratio of four feet horizontal distance for each one foot of elevation change.

In the 2008 cable barrier report Dr. Ray recommended that WSDOT perform a more comprehensive review of their pre-2004 and post-2004 placement guidance - if that analysis could be separated from the low-tension and high-tension barrier comparison. We revised our placement policy in May 2004, identifying locations within the median cross-section where cable barrier placement should be avoided. Prior to May 2004 all of our installations were low-tension cable barrier. After May 2004, 97.6 percent of the mileage installed was high-tension cable barrier. Looking more closely at collisions with the low-tension cable barrier installations we find that 8.7 percent of those collisions occurred in segments that were completed after the placement policy changed. Comparing those collisions, we find insignificant differences (fractions of a percentage) in the percentages of vehicles contained in the median, cross median, or redirected. The cross median percentage was 6.1 percent of the total prior to the policy change and 5.3 percent after the policy change. Changes in injury severities were also insignificant with fractions of a percentage difference in injury severity We concluded that the shift in policy is so closely linked to the shift in barrier type, that we are unable to isolate the impacts of the policy change.

Research Recommendations

Research Recommendation No. 1 - Placement in the median

Research on the proper placement of cable median barriers is desperately needed. The only guidance in this area is either outdated or never completed. Recently some crash tests of high-tension cable median barriers have been performed on 4:1 slopes but a comprehensive study of vehicle behavior when traversing typical depressed medians is needed to determine exactly where barriers should and should not be located. A new NCHRP project is programmed for this year that will look at the issue of guardrail and median barrier placement on slopes. NCHRP 22-22, Placement of Traffic Barriers on Roadside and Median Slopes," will examine a variety of types of guardrails and median barriers placed on slopes so it should be possible for WSDOT personnel to encourage the project team to include the issues of cable median barrier placement in the project scope. NCHRP 17-22, "Identification of Vehicular Impact Conditions Associated with Serious Ran-Off-Road Crashes," is examining real-world impact conditions to try and re-examine the most relevant crash test conditions. This project has been active since 2001 and has recently been expanded.

2008 recommendations/conclusion - WSDOT has implemented my recommendation and is both participating in and observing research efforts on cable median barrier taking place nationally.

Progress since 2008 report - WSDOT is awaiting the completion of NCHRP Project 17-22 in late 2009. Project 22-22 has not moved forward over the past year. NCHRP Project 22-25 "Development of Guidance for the Selection, Use and Maintenance of Cable Barrier Systems was proposed by WSDOT, funded by NCHRP, and is in progress with a WSDOT employee on the panel. This project is scheduled for completion in March 2010.

Research Recommendation No. 2 - Higher bumper heights of pickups and SUVs

As discussed earlier, pickup trucks and SUVs have continued to become larger resulting in increasing bumper heights. Newer pickup trucks and SUVs may not perform well in impacts with some types of roadside hardware due to the miss-match between the barrier heights and bumpers. NCHRP 22-14(3), Evaluation of Existing Roadside Safety Hardware Using Updated Criteria, is a new project that will perform crash tests of existing hardware like cable median *barriers using the new proposed updated crash test procedures. Since the new crash test procedures recommend the use of newer pickup trucks with higher bumpers, some of the questions regarding bumper and barrier compatibility should be resolved. The Midwest Roadside Safety Facility at the University of Nebraska is also developing a new four-cable median barrier system that may provide some insight into the interaction of newer pickups and SUVs and cable median barriers.*

2008 recommendations/conclusion - There are many activities going on nationally in this regard but some that particularly impact cable median barriers are Midwest Roadside Safety Facilities on-going efforts to design and crash test a four-cable median barrier, testing by several of the proprietary cable median barrier manufacturers to develop test level four cable median barriers and efforts to perform crash tests of several types of common roadside hardware with the new MASH 2008 pickup truck test vehicle. All these efforts are continuing and WSDOT personnel are monitoring these efforts.

Progress since 2008 report - The Manual on Assessing Safety Hardware (MASH) was adopted by AASHTO in mid-2009 through a review and comment process. An FHWA implementation plan is included in this manual. The final guidance will be published in late 2009. This document provides revised guidance on standardized crash test criteria including updated information on test vehicles. The large pickup selected as the standard test vehicle has a bumper height that is approximately four inches higher than the previous guidance. The criteria also provide more guidance on the testing of cable barrier systems than the previous guidance under NCHRP Report 350.

Midwest Roadside Safety Facility continues work on their four-cable-high tension design, sponsored by several states in a pooled fund research project. There was a setback in the crash testing during 2008, which required a redesign of the cable to post attachment bracket. The states involved in the pooled fund effort continue to support this project with funding contributions, and design guidance. The bracket redesign is well under way and if all goes well, the system will be crash tested in fall 2009.

Research Recommendation No. 3 - Traffic conditions that promote median crossovers

The conditions that promote cross-median crashes are not well understood. Traffic conflicts and impaired drivers seem to initiate most cross-median crashes but it has been difficult to predict which sites will respond well to treatment with cable median barriers and which should use concrete median barriers. Traffic conditions like volume, mixing, interchange spacing, land use and speed limits appear to be related to the likelihood of cross-median crashes. Research should be performed to find good ways of predicting locations where cross-median crashes will be a problem. Such research would enable engineers to be pro-active and create designs that address a problem before fatal and disabling crashes occur.

2008 recommendations/conclusion - WSDOT acted on my recommendation and was able to get a new NCHRP project funded to investigate this issue.

Progress since 2008 report - This project resulted in a research contract awarded to Midwest Research Institute in Kansas City, MO. The contract was awarded in March 2009 with a scheduled completion in mid-2011. A WSDOT employee serves on the project panel to help guide the direction of this research.

Implementing recommendations to modify the I-5 median barrier system in Marysville

The June 2007 Cable Median Barrier report noted a higher-than-average number of crossover collisions on I-5 in Marysville. As a result, independent expert Dr. Malcolm Ray recommended installing concrete median barrier and widening the shoulder along north-bound I-5 in Marysville to provide the highest level of protection against crossover collisions. There haven't been any cross-median collisions in the segment since February 2007.

Following these recommendations, in December 2007 Gov. Gregoire allocated $26.9 million to replace the existing low-tension cable median barrier with concrete barrier along 10 miles of northbound I-5 in Marysville. The funding was approved by the Legislature in March 2008, allowing WSDOT engineers to begin designing the project.

Following environmental processes, permit acquisition, and project design, we advertised the Marysville median barrier project for competitive bids in April 2009, and in June awarded the contract to Tri-State Construction, Inc., who submitted the most competitive bid at $18.9 million. Construction began in late July and is expected to be complete by late 2010. Barrier installation is expected to be complete by spring 2010. Total project completion is expected in late 2010. More information is available at: **www.wsdot.wa.gov/Projects/I5/MarysvilleMedianBarrier**

How will the new median barrier system help to reduce crossover collisions?

The new Marysville median barrier system will include 10 miles of concrete median barrier and a widened 10-foot shoulder along the northbound lanes of I-5 from State Route 528 to State Route 530. Wider shoulders will give northbound drivers who lose control of their vehicle additional room to slow down, regain control, and re-enter traffic, while increasing their chances of avoiding a collision with the median barrier. If a northbound vehicle leaves the roadway and collides with the concrete median barrier, the barrier should reduce the frequency of vehicles crossing the freeway median.

The existing high-tension cable barrier system along the southbound lanes will remain in place to provide redundant protection against southbound drivers crossing into northbound lanes. Southbound drivers who run off the freeway will hit cable median barrier on that side of I-5, which will absorb much of the force of impact, reduce the risk of a rollover, and reduce the risk of rebound collisions that involve other vehicles. If the cable median barrier does not restrain the vehicle within the median, it will likely decelerate and redirect upon impact with the concrete median barrier along the northbound lanes.

Federal stimulus funding broadened the scope of the Marysville barrier project

In February 2009 WSDOT received an additional $2.5 million from the American Recovery and Reinvestment Act (ARRA) to install Intelligent Transportation Systems (ITS) along I-5 in Marysville. This funding will be used to install 11 traffic cameras, an overhead message sign, 10 miles of fiber communications conduit, and traffic data detectors along I-5 in Marysville. These ITS components will improve freeway operations and provide real-time traffic information for motorists.

What has happened on I-5 in Marysville since the last report?

In 2008, a total of 46 collisions involving cable median barrier occurred in Marysville. None of these collisions resulted in fatalities, and only six resulted in an injury.

Chapter 4: Next steps

The median locations identified by WSDOT in 2002 for barrier treatment are either complete or under contract. These locations targeted full access-controlled highways with medians up to 50 feet in width. In addition to these locations, we have identified partial access-controlled highways that we predict will benefit from similar installations.

Future planned installations

There are projects planned to install cable barrier on segments of US 195, US 395, and SR 8. These installations are planned within the next two years. When all of the planned installations are complete, we expect to have 219 miles of our highway medians treated with cable barrier.

In addition to treating medians where no barrier exists, we are addressing cable barrier systems in most of the locations where we first installed cable barrier systems. The American Recovery & Reinvestment Act of 2009 (ARRA) offered funding opportunities for WSDOT projects that will place four-cable high-tension barrier system in locations where three-cable low-tension barrier currently exist. The four-cable systems planned for these locations will provide a higher top cable and lower bottom cable than the system currently in place. The expanded range of cable heights reduce the probability of vehicles getting under or over the barrier. The ARRA projects are expected to be under contract in 2009.

We will consider new developments in cable barrier technology for future designs and installations

Ongoing research and development of cable barrier systems have been directed towards high-tension cable barriers, systems with a broader range of cable heights, and systems tested on steeper slopes. We anticipate that these efforts will continue, and we will monitor future developments and adopt as appropriate design guidance that reflects those developments.

One such effort that we are aware of is evaluating a retrofit of the three-cable high-tension cable system currently in place in many of our medians. The focus of the retrofit effort is conversion of those installations to a four-cable system with a higher top cable and lower bottom cable. WSDOT is engaged in the development of this retrofit and anticipates a system that complies with crash test guidance and is deemed acceptable to FHWA. To help offset the cost of such a retrofit, our ARRA funded contracts removing the low tension cable systems are salvaging the cables for use as the fourth cable in the high tension retrofits.

Cable barrier is being tested in narrow medians and in other applications

In the 2008 report, we noted that the Oregon Department of Transportation (ODOT) installed cable barrier in a paved median that is only eight-feet wide as an experimental installation on US 26 (Mt. Hood highway). This location had experienced several centerline crossover collisions. ODOT plans to monitor this installation for a five-year period to determine the effectiveness of the barrier and potential for use in similar conditions. After approximately two years in service, ODOT reports, that there haven't been any injury accidents associated with collisions to this barrier (as of June 2009). It's estimated that 30 to 40 percent of hits to this installations are instances where the impacting vehicles simply drive off.

More states are using cable barrier systems

In preparing the June 2007 cable barrier report, we had consulted other states regarding their use of cable median barrier systems. At the end of 2006 there were 14 states that had not installed any cable barrier. That equates to 72 percent of states. Now two years later, there are only four states that have no cable barrier the medians. 92 percent of the country has adopted cable barrier for use as a median barrier. Figure(s) 4-1 & 4-2 provide a comparison of states using cable barrier as of 2006 versus 2008.

Figure 4-1 **Cable Median Barrier Usage in 2006**

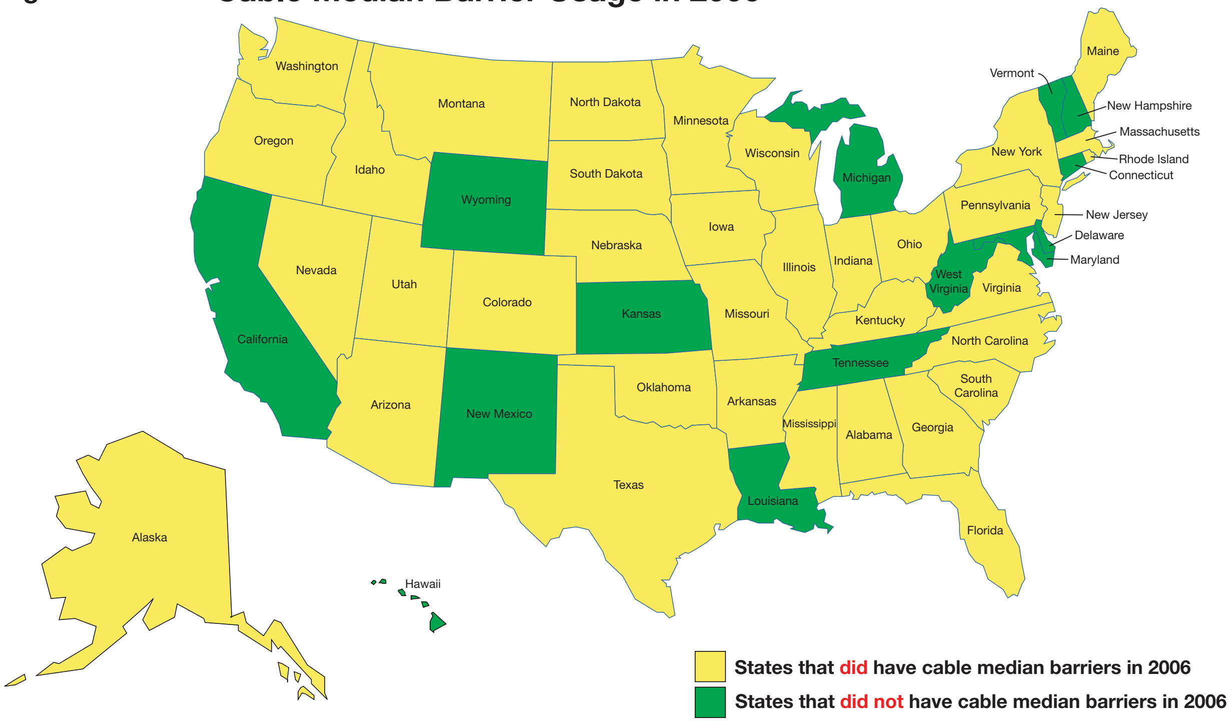


Figure 4-2 **Cable Median Barrier Usage in 2008**