

Maryland Work Zone Accidents Comparison 1994-2003

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Introduction

The purposes of this report are to compare Maryland work zone accident characteristics with all types of accident characteristics, and the state figures from the Maryland Automated Accident Reporting System (MAARS) with national figures gathered from the NHTSA FARS. The Maryland Automated Accident Reporting System (MAARS) definition of “work zone” is a one character field called construction-maintenance-zone and is coded “Y” or “N” by the officer completing the MSP-1 accident report form at the scene of the accident. The MUTCD 2000 definition is “A work zone is an area of a highway with construction, maintenance, or utility work activities. Signs, channelizing devices, barriers, pavement markings, and/or work vehicles typically mark a work zone. It extends from the first warning sign or rotating/strobe lights on a vehicle to the END ROAD WORK sign or the last temporary traffic control device.” This may impact the accuracy of work zone data that is collected by Maryland law enforcement agencies because the MAARS manual does not include any national standard definition of work zones.

The work zone definition in the Model Minimum Uniform Crash Criteria (MMUCC) is “A section of road marked to warn motorists that construction, maintenance, repair or utility work is being done. A work zone extends from the first warning sign to the end construction (work) sign or the last traffic control device. Work zones may or may not involve worker or equipment on or near the road. A work zone may be stationary (such as repairing a water line) or moving (such as re-striping the centerline); it may be short term (such as pothole patching) or long term (such as building a new bridge).” Additionally, MMUCC also defines work zone-related accidents as “A crash that occurs in or near a work zone or involves vehicles slowed or stopped because of the work zone even if the first harmful event was before the first warning sign.” With three definitions of work zones being used by various persons, it is easy to see how the numbers for work zone accidents may not reconcile every year.

The main section of this report comprised of four subsections such as work accidents trends and severity, comparison of work zone accidents and all types of accidents, comparison with the U.S. work zone accidents, and relationship among work zone accidents and various Maryland construction/maintenance quantity. Maryland contains 1.9% of the United States total population and total VMT, and has appreciably fewer work zone accidents when compared with all the U.S. work zone accidents. In addition, work zone accidents of Maryland’s neighboring states in NHTSA Region III are compared in this report. As the proxy indicators for Maryland construction/maintenance on highways, the lane-miles resurfaced, the number of contract bids, the amount of contract bids, and the capital program expenditure are used.

Methodology

The data for this report were obtained online from the following three sources: NHTSA FARS System, MAARS, and the National Work Zone Safety Information Clearinghouse. Work zone accident data from the National Work Zone Safety Information Clearinghouse are based on the FARS data. However, the data from FARS and MAARS usually have had some discrepancies in the totals reported. This report is limited by the accuracy of the data collected.

The methodology used in this report includes aggregating and averaging statistics over the latest ten years (1994-2003), and generating rates by using various accident exposure data (population and vehicle miles of travel).

MAARS data are used for analyzing work zone accident trends and severity, and comparing work zone accident with all statewide accident characteristics. Work zone accidents and all statewide accidents are compared by work zone collision type, route type, temporal pattern, District, and county.

For comparing Maryland work zone accidents with the U.S. work zone accidents and the bordering states work zone accidents, the work zone accident data were obtained from the National Work Zone Safety Information Clearinghouse website by Texas Transportation Institute (TTI) and American Road & Transportation Builders Association (ARTBA) (wzsafety.tamu.edu).

In order to analyze dependency relationship among work zone accidents and the indicators measuring highway construction/maintenance quantity, the Pearson correlation coefficients are calculated with yearly data, which are widely used for identifying linear correlation between two random variables. The dependency relationships are analyzed with the proxy indicators by total work zone accidents, fatal work accidents, state-maintained total work accidents, and state-maintained fatal accidents.

Analysis of Findings

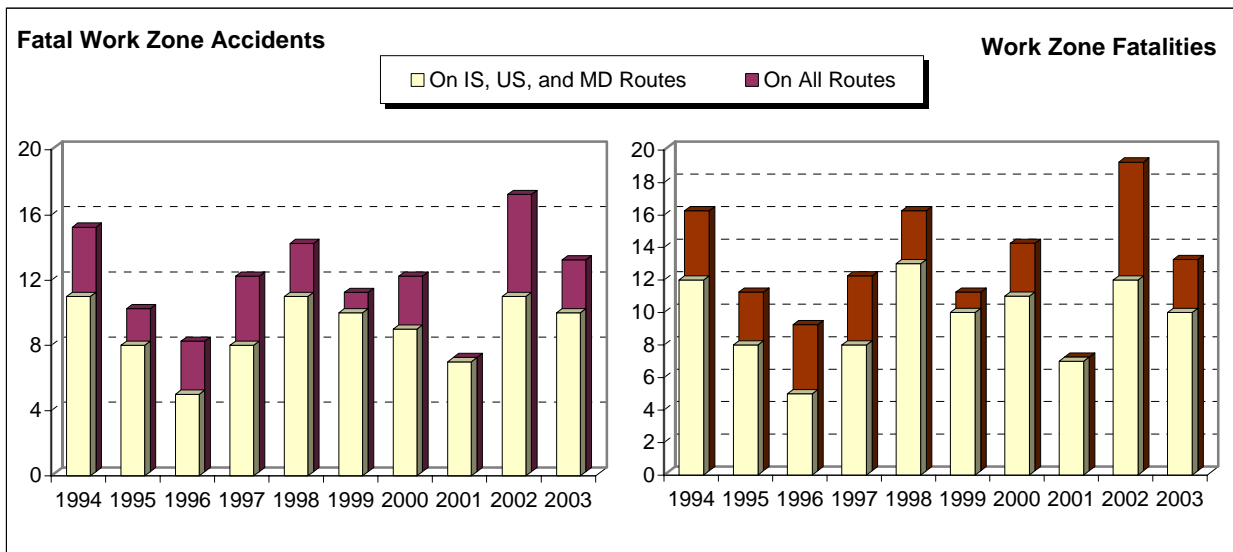
Work Zone Accident Trends and Severity from MAARS

Table 1 shows the fatal work zone accident and work fatalities for 1994-2003 from MAARS reporting. The MAARS data entry at MSP – CDR only provides a “Y” or “N” indication for work zone accidents in field 35 of Maryland Accident Form MSP-1.¹ We can extract the number of fatalities or the number of fatal accidents in construction – maintenance zones using this definition of “work zone”. Over those years, the number of work zone fatalities ranged from 7 to 19 by year, and the numbers for the State-maintained highways ranged from 5 to 13 by year.

Table 1 Work Zone Fatal Accidents and Fatalities by MSP-1 Definition, 1994-2003

Year	Work Zone Fatal Accidents on All Routes	Work Zone Fatalities on All Routes	Work Zone Fatal Accidents on IS, US, and MD Routes	Work Zone Fatalities on IS, US, and MD Routes
1994	15	16	11	12
1995	10	11	8	8
1996	8	9	5	5
1997	12	12	8	8
1998	14	16	11	13
1999	11	11	10	10
2000	12	14	9	11
2001	7	7	7	7
2002	17	19	11	12
2003	13	13	10	10

Figure 1 Maryland Work Zone Fatal Accidents and Fatalities, 1994-2003



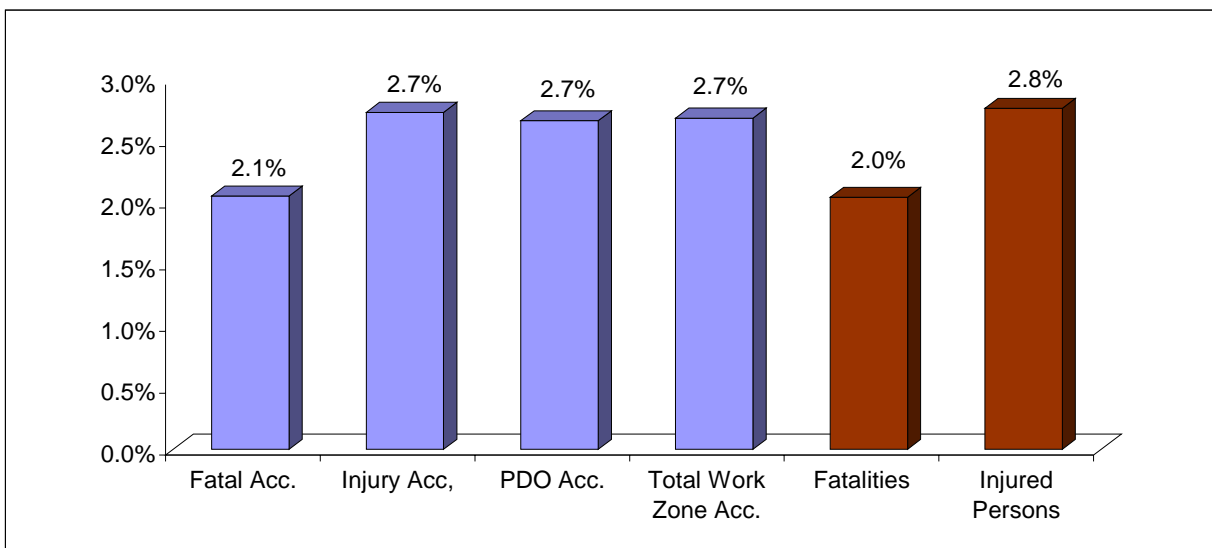
¹ MAARS Instruction and Reference Manual, Page 55.

Table 2 shows work zone accident severity from 1994 to 2003. The data form a random pattern over this time frame that is difficult to interpret. On average, 0.4% of work zone accidents were fatal accidents, while 0.6% of all accidents were fatal accidents. Figure 2 shows the average fraction of work zone accidents among all accidents by accident severity over the last 10 years. Over the last ten years, 2% of all fatalities in Maryland were killed at work zones, and nearly 3% of all statewide accidents occurred at work zones.

Table 2 Work Zone Accident Severity, 1994-2003

Year	Fatal Accidents	Injury Accidents	PDO	Total Accidents	Fatalities	Injured Persons	Persons Killed or Injured	
Work Zone Acc.	1994	15	1,343	1,519	2,877	16	2,285	2,301
	1995	10	1,173	1,518	2,701	11	1,913	1,924
	1996	8	1,197	1,368	2,573	9	2,036	2,045
	1997	12	915	1,207	2,134	12	1,608	1,620
	1998	14	851	1,176	2,041	16	1,298	1,314
	1999	11	808	1,255	2,074	11	1,274	1,285
	2000	12	1,034	1,709	2,755	14	1,644	1,658
	2001	7	1,122	1,906	3,035	7	1,733	1,740
	2002	17	1,236	1,916	3,169	19	1,956	1,975
	2003	13	1,187	2,161	3,361	13	1,742	1,755
Avg.	12	1,087	1,574	2,672	13	1,749	1,762	
%	0.4	40.7	58.9	100.0	0.7	99.3	100.0	
All Accidents (10 Yr. Avg.)	584	39,786	59,101	99,471	636	63,253	63,889	
%	0.6	40.0	59.4	100.0	1.0	99.0	100.0	

Figure 2 Percentage of Work Zone Accidents among All Accidents by Severity, 10 Year Average



Comparison of Work Zone Accidents and All Statewide Accidents

Table 3 shows that the primary accident type among work zone accidents was rear-end collisions (29.7%) from 1994 to 2003, followed by angle collisions (12.7%), and the fixed object collisions (11.9%). The percentage of rear-end collisions among work zone accidents (29.7%) were higher than among statewide accidents (22.2%). For the fatal work zone accidents, the predominant accident types were the pedestrian, fixed object, angle, rear end, and opposite direction. Those five types accounted for 75% of the fatal work accidents over those 10 years. Pedestrian collisions had the highest percentage of fatal work accidents among the accident types, whereas fixed-object collisions had the highest percentage of statewide fatal accidents.

Table 3 Work Zone Accidents and All Accidents by Accidents Type, 1994-2003

Year		Rear End	Angle	Fixed Objects	Parked Vehicles	Others/unknown	Total
Work Zone Acc.	1994	877	426	335	251	988	2,877
	1995	785	399	330	257	930	2,701
	1996	797	344	280	212	940	2,573
	1997	657	285	236	161	795	2,134
	1998	624	273	236	190	718	2,041
	1999	569	273	218	233	781	2,074
	2000	762	316	331	288	1,058	2,755
	2001	934	358	339	271	1,133	3,035
	2002	920	381	418	270	1,177	3,166
	2003	1,012	326	463	322	1,238	3,361
AVG.		794	338	319	246	976	2,672
%		29.7	12.7	11.9	9.2	36.5	100.0
All Accidents (10 Yr. Avg.)		22,056	17,601	13,111	12,133	34,571	99,471
%		22.2	17.7	13.2	12.2	34.8	100.0

Table 4 Fatal Work Zone Accidents and All Fatal Accidents by Accident Type, 1994-2003

Year		Pedestrian	Fixed Object	Angle	Rear End	Opposite Direction	Other/unknown	Total
Fatal Work Zone Acc.	1994	4	2	3	1	1	4	15
	1995	1	4	0	0	2	3	10
	1996	0	1	0	1	3	3	8
	1997	5	1	2	1	1	2	12
	1998	5	3	2	2	0	2	14
	1999	5	0	3	0	1	2	11
	2000	2	3	1	3	0	3	12
	2001	2	0	1	1	0	3	7
	2002	4	2	2	1	2	3	14
	2003	2	4	0	3	0	4	13
Total		30	20	14	13	10	29	116
%		25.9	17.2	12.1	11.2	8.6	25.0	100.0
All Fatal Accidents (10 Yr. Total)		1,001	1,809	719	363	854	1,090	5,836
%		17.2	31.0	12.3	6.2	14.6	18.7	100.0

Table 5 shows the work zone accidents and all accidents by route type from 1994 to 2003. Both work zone accidents and all accidents occurred most along Maryland-designated routes (MD). However, work zone accidents occurred relatively more on Interstate, US, and MD highways, compared to all statewide accidents. Table 6 shows the work zone accidents on the Maryland State-maintained highway systems (IS, US, and MD). Over those 10 years, 54% of all the work zone accidents occurred on the state-maintained systems, while 45% of all statewide accidents occurred on the state-maintained systems.

Table 5 Work Zone Accidents and All Accidents by Highway System, 1994-2003

Year		Interstate (IS)	US	MD	County	MU	Baltimore City	Others**	Total
Work Zone Acc.	1994	350	280	1025	448	87	574	113	2,877
	1995	327	245	955	384	83	494	213	2,701
	1996	398	245	898	367	69	429	167	2,573
	1997	228	212	717	344	81	431	121	2,134
	1998	171	190	677	337	61	476	129	2,041
	1999	184	204	583	308	81	568	146	2,074
	2000	279	295	761	396	93	714	217	2,755
	2001	387	291	966	476	76	598	241	3,035
	2002	480	272	1021	475	79	596	246	3,169
	2003	579	321	898	500	97	680	286	3,361
Avg.		338	256	850	404	81	556	188	2,672
%		12.7	9.6	31.8	15.1	3.0	20.8	7.0	100.0
All Accidents (10 Yr. Avg.)		7,733	7,985	29,070	23,861	4,606	18,913	7,303	99,471
%		7.8	8.0	29.2	24.0	4.6	19.0	7.3	100.0

Source: MAARS Data, ** Parking Lots, GV, SR, OP, and Unknowns

Table 6 Work Zone Accidents and All Accidents on the Maryland State-Maintained Highways, 1994-2003

Year	State Maintained Highways					Other Routes		Total		
	IS	US	MD	Subtotal		Number	%	Number	%	
				Number	%					
Work Zone Acc.	1994	350	280	1025	1,655	57.5	1,222	42.5	2,877	100.0
	1995	327	245	955	1,527	56.5	1,174	43.5	2,701	100.0
	1996	398	245	898	1,541	59.9	1,032	40.1	2,573	100.0
	1997	228	212	717	1,157	54.2	977	45.8	2,134	100.0
	1998	171	190	677	1,038	50.9	1,003	49.1	2,041	100.0
	1999	184	204	583	971	46.8	1,103	53.2	2,074	100.0
	2000	279	295	761	1,335	48.5	1,420	51.5	2,755	100.0
	2001	387	291	966	1,644	54.2	1,391	45.8	3,035	100.0
	2002	480	272	1,021	1,773	55.9	1,396	44.1	3,169	100.0
	2003	579	321	898	1,798	53.5	1,563	46.5	3,361	100.0
Avg.		338	256	850	1,444	54.0	1,228	46.0	2,672	100.0
All Accidents (10 Yr. Avg.)		7,733	7,985	29,070	44,788	45.0	54,683	55.0	99,471	100.0

Table 7 shows the fatal work zone accidents and all fatal accidents by route type from 1994 to 2003. Both fatal work zone accidents and all fatal accidents occurred most along Maryland-designated routes (MD). Like total work zone accidents, fatal work zone accidents occurred relatively more on state-maintained systems such as Interstate, US, and MD highways, compared to all statewide fatal accidents. Over those 10 years, 77% of statewide fatal work zone accidents occurred on the state-maintained systems, while 68% of statewide fatal accidents occurred on the state-maintained systems.

Table 7 Fatal Work Zone Accidents and All Fatal Accidents by Highway System, 1994-2003

Year	Interstate (IS)	US	MD	County	MU	Baltimore City	Other**	Total	
Work Zone Acc.	1994	5	3	3	2	0	2	0	15
	1995	2	0	6	2	0	0	0	10
	1996	1	2	2	2	0	0	1	8
	1997	1	1	6	2	1	1	0	12
	1998	2	3	6	2	0	1	0	14
	1999	2	2	6	1	0	0	0	11
	2000	2	4	3	3	0	0	0	12
	2001	3	2	2	0	0	0	0	7
	2002	2	3	5	2	1	0	1	14
	2003	3	2	5	2		1		13
Total	23	22	44	18	2	5	2	116	
%	19.8	19.0	37.9	15.5	1.7	4.3	1.7	100.0	
All Fatal Acc. (10Yr. Total)	652	738	2,564	1,272	82	406	122	5,836	
%	11.2	12.6	43.9	21.8	1.4	7.0	2.1	100.0	

Source: MAARS Data, ** Parking Lots, GV, SR, OP, and Unknowns

Table 8 Fatal Work Zone Accidents and All Fatal Accidents on the Maryland State-Maintained Highways, 1994-2003

Year	State Maintained Highways					Other Routes		Total		
	IS	US	MD	Subtotal		Number	%	Number	%	
				Number	%					
Work Zone Acc.	1994	5	3	3	11	73.3	4	26.7	15	100.0
	1995	2	0	6	8	80.0	2	20.0	10	100.0
	1996	1	2	2	5	62.5	3	37.5	8	100.0
	1997	1	1	6	8	66.7	4	33.3	12	100.0
	1998	2	3	6	11	78.6	3	21.4	14	100.0
	1999	2	2	6	10	90.9	1	9.1	11	100.0
	2000	2	4	3	9	75.0	3	25.0	12	100.0
	2001	3	2	2	7	100.0	-	0.0	7	100.0
	2002	2	3	5	10	71.4	4	28.6	14	100.0
	2003	3	2	5	10	76.9	3	23.1	13	100.0
Total	23	22	44	89	76.7	27	23.3	116	100.0	
All Accidents (10 Yr. Avg.)	652	738	2564	3954	67.8	1,882	32.2	5,836	100.0	

Table 9 shows that Maryland work zone accidents were most frequent during the month of October (10.0%) from 1994 to 2003. All statewide accidents also occurred more in October than in other months (9.1%).

Table 9 Maryland Work Zone Accidents by Month of Year, 1994-2003

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
Work Zone Acc.	1994	175	180	175	215	287	275	267	263	230	253	285	272	2,877
	1995	210	202	230	218	219	253	219	244	236	240	220	210	2,701
	1996	157	197	186	205	242	272	222	208	208	295	194	187	2,573
	1997	112	124	186	155	166	163	180	199	207	269	181	192	2,134
	1998	167	132	164	166	211	194	189	154	142	174	196	152	2,041
	1999	144	138	155	160	186	182	197	174	164	231	177	166	2,074
	2000	154	91	136	239	323	286	257	270	253	280	263	203	2,755
	2001	197	216	210	238	293	245	260	302	280	313	263	218	3,035
	2002	202	190	242	274	270	250	299	271	306	325	261	3,169	
	2003	238	225	261	284	323	299	256	316	306	313	286	254	3,361
	Avg.	176	170	195	215	252	242	235	241	230	267	239	212	2,672
	%	6.6	6.3	7.3	8.1	9.4	9.1	8.8	9.0	8.6	10.0	8.9	7.9	100.0
All Accidents (10 Yr. Avg.)	8,095	7,241	7,810	8,015	8,929	8,200	8,158	8,130	8,211	9,005	8,920	8,759	99,471	
%	8.1	7.3	7.9	8.1	9.0	8.2	8.2	8.2	8.3	9.1	9.0	8.8	100.0	

Figure 3 shows the fatal and total work zone accidents and statewide fatal and total accidents by time of day. Work zone accidents were relatively more frequent between 8 AM and 4 PM, compared to all types of accidents. On contrast, fatal work zone accidents were relatively more frequent between 8 PM and 3 AM, compared to all types of accidents.

Figure 3 Maryland Work Zone Fatalities by FARS and MAARS, 10 Year Average

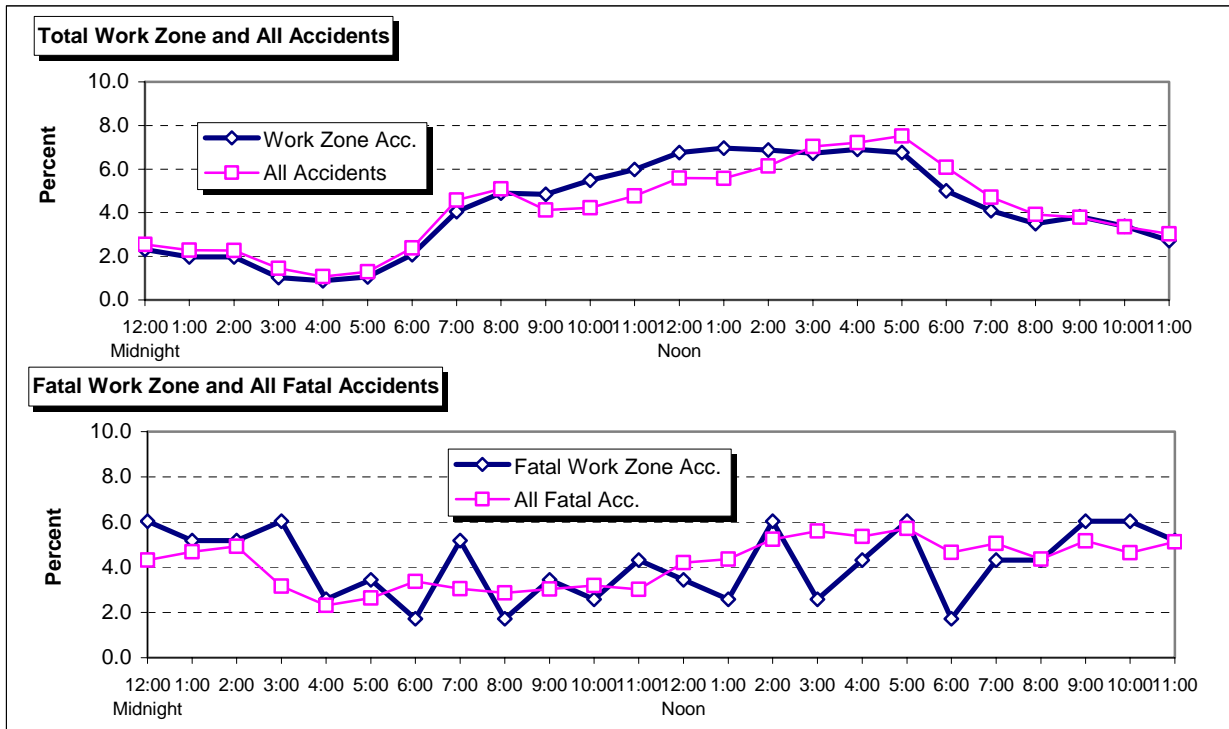


Table 10 shows the work zone accidents and all accidents by SHA Districts for 1994-2003. The District with the highest average number of work zone accidents over the period was District 3 (Montgomery and Prince George's Counties) with an average of 756 accidents, which accounted for an average of 28.3% of statewide work zone accidents. The actual number of work zone accidents was highest in this District for each of the individual years also.

Table 10 Work Zone Accidents and All Accidents by SHA District, 1994-2003

Year		D 1	D 2	D 3	D 4	D 5	D 6	D 7	Balt. City	Total
Work Zone Acc.	1994	30	132	870	474	478	50	253	590	2,877
	1995	30	69	884	470	451	47	231	519	2,701
	1996	33	47	890	492	397	67	185	462	2,573
	1997	35	53	652	424	270	67	185	448	2,134
	1998	22	59	601	330	244	76	209	500	2,041
	1999	37	68	461	376	217	83	247	585	2,074
	2000	38	87	617	339	386	154	374	760	2,755
	2001	50	36	859	461	493	84	412	640	3,035
	2002	59	67	887	484	549	62	337	724	3,169
	2003	46	81	842	619	478	75	304	916	3,361
	Avg.		38	70	756	447	396	77	274	614.4
%		1.4	2.6	28.3	16.7	14.8	2.9	10.2	23.0	100.0
All Accidents (10 Yr. Avg.)		4,064	3,492	29,243	16,325	13,180	4,207	9,114	19,847	99,472
%		4.1	3.5	29.4	16.4	13.2	4.2	9.2	20.0	100.0
% of Work Zone Acc. among All Accidents		0.9	2.0	2.6	2.7	3.0	1.8	3.0	3.1	2.7

Figure 4 shows the percentage of work zone accidents among all accidents by SHA Districts for 1994-2003. 2.7% of all statewide accidents occurred on the work zones. District 4, 5, 7, and Baltimore City had the higher percentage of work accidents than for all statewide accidents. That is, there were relatively more work zone accidents in those three districts and Baltimore City than in other districts.

Figure 4 Percentage of Work Zone Accidents among All Accidents by District, 10 Year Average

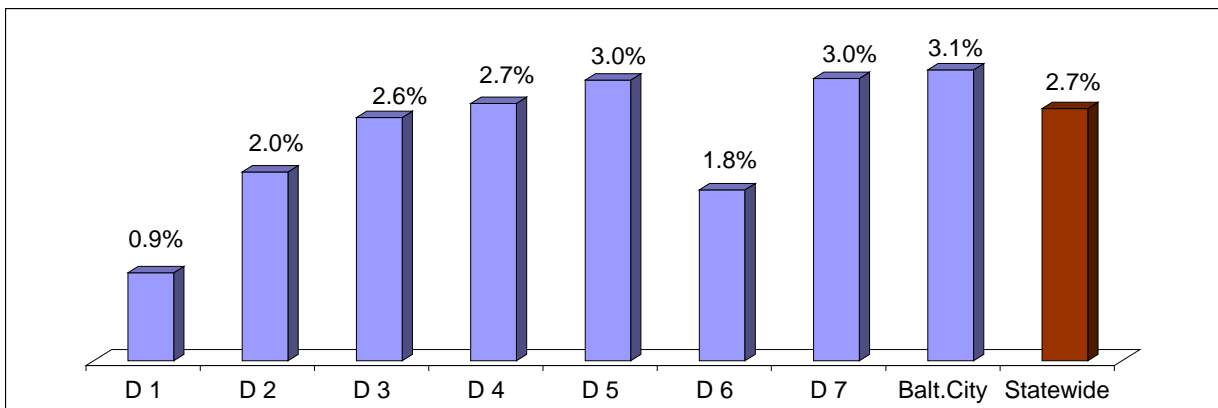


Table 11 shows the fatal work zone accidents and all fatal accidents by SHA Districts for 1994-2003. Over the period, District 3 and 4 accounted for nearly two-thirds of statewide work zone accidents over the period. The actual number of the fatal work zone accidents was highest in those two districts for each of the individual years also.

Table 11 Fatal Work Zone Accidents by SHA District, 1994-2003

Year		D 1	D 2	D 3	D 4	D 5	D 6	D 7	Balt. City	Total
Work Zone Acc.	1994	-	3	2	4	3	-	1	2	15
	1995	-	-	5	2	3	-	-	-	10
	1996	-	-	3	3	-	1	1	-	8
	1997	-	1	4	3	2	-	1	1	12
	1998	1	-	3	6	2	1	-	1	14
	1999	-	1	1	6	1	-	1	1	11
	2000	1	1	5	3	-	1	1	-	12
	2001	1	-	3	1	-	-	2	-	7
	2002	-	1	8	2	1	-	2	-	14
	2003	-	-	5	5	2	-	-	1	13
	Total		3	7	39	35	14	3	9	6
%		2.6	6.0	33.6	30.2	12.1	2.6	7.8	5.2	100.0
All Accidents (10 Yr. Total)		340	494	1,564	988	986	355	644	465	5,836
%		5.8	8.5	26.8	16.9	16.9	6.1	11.0	8.0	100.0
% of Fatal Work Zone Acc. among All Fatal Accidents		0.9	1.4	2.5	3.5	1.4	0.8	1.4	1.3	2.0

Figure 5 shows the percentage of fatal work zone accidents among all fatal accidents by SHA Districts for 1994-2003. 2% of statewide fatal accidents occurred on the work zones. District 3 and 4 had the higher percentage of fatal work accidents (2.5% and 3.5%, respectively) than for statewide fatal accidents. That is, those two districts had the higher relative frequency for fatal work zone accidents than for other districts.

Figure 5 Percentage of Fatal Work Zone Accidents among All Fatal Accidents by District, 10 Year Average

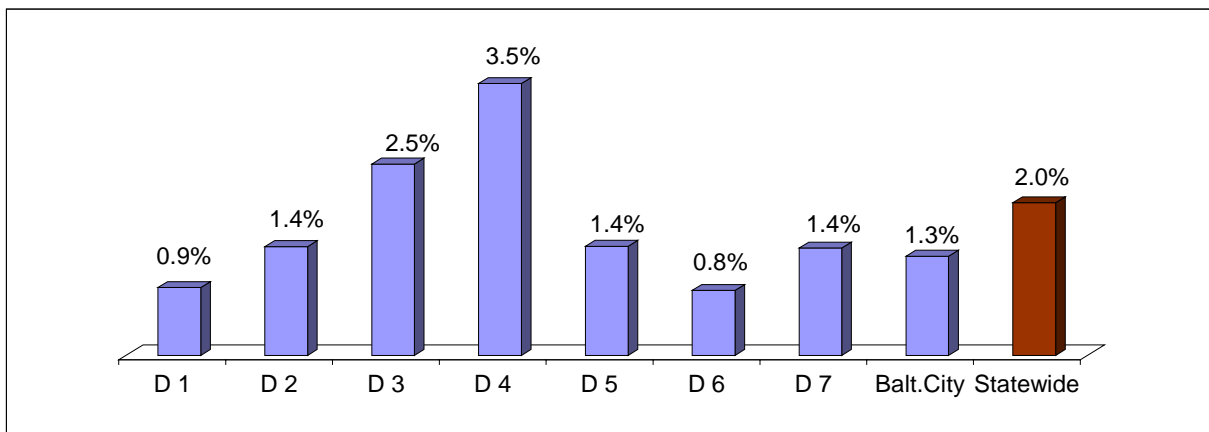


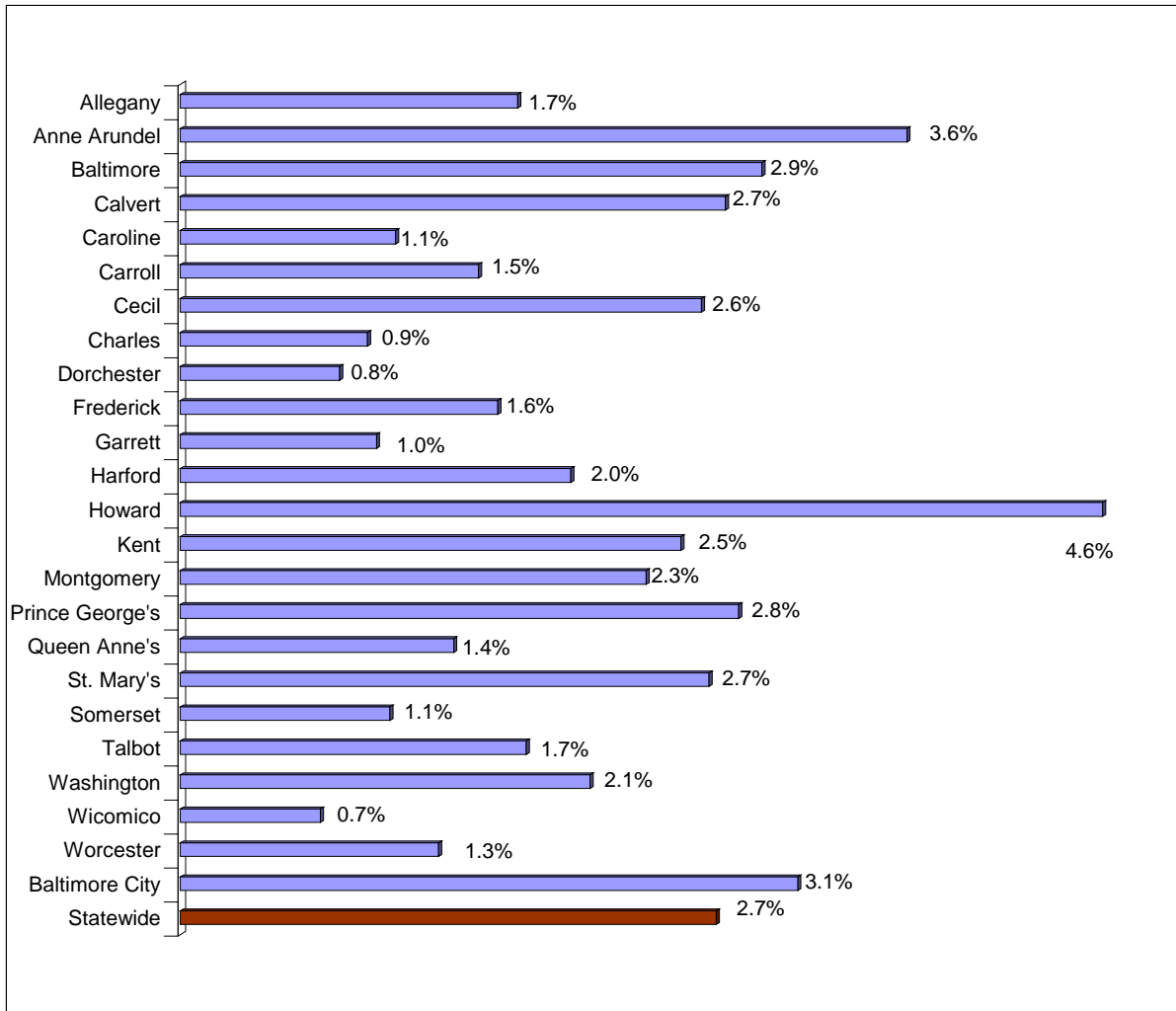
Table 12 shows the Maryland work zone accident frequencies by county for the last 10 years (1994-2003). Note that Baltimore City had the highest number of work zone accidents with an average of 23.0%. Prince George's County was next with 16.6%. Baltimore County was third with 14.3% of all work zone accidents. Note that Anne Arundel, Baltimore, Howard, Prince George's County and Baltimore City had the higher percentage of work zone accidents than of all types of accidents.

Table 12 Work Zone Accidents and All Accidents by County, 1994-2003

County	Work Zone Accidents												All Accidents	
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Avg.	%	10 Yr. Avg.	%
Allegany	6	18	13	16	13	10	19	23	20	24	16	0.6	958	1.0
Anne Arundel	385	398	350	229	191	153	284	373	420	393	318	11.9	8,717	8.8
Baltimore	408	405	429	370	292	333	288	404	406	538	387	14.5	13,279	13.3
Calvert	7	18	12	15	19	21	24	43	52	40	25	0.9	919	0.9
Caroline	1	7	3	1	7	8	1	4	0	11	4	0.2	399	0.4
Carroll	24	19	29	28	45	43	26	23	13	36	29	1.1	1,913	1.9
Cecil	93	17	14	13	27	36	69	24	44	39	38	1.4	1,439	1.4
Charles	30	16	27	23	29	20	27	22	17	10	22	0.8	2,356	2.4
Dorchester	7	4	4	2	4	2	2	6	2	6	4	0.1	488	0.5
Frederick	38	46	38	39	14	50	96	84	30	26	46	1.7	2,896	2.9
Garrett	5	6	7	10	3	3	9	5	2	9	6	0.2	600	0.6
Harford	66	65	63	54	38	43	51	57	78	81	60	2.2	3,046	3.1
Howard	191	166	118	118	150	154	252	305	294	242	199	7.4	4,304	4.3
Kent	10	19	11	5	3	2	2	0	2	1	6	0.2	219	0.2
Montgomery	366	418	398	231	243	200	229	381	332	336	313	11.7	13,421	13.5
Prince George's	504	466	492	421	358	261	388	478	555	506	443	16.6	15,821	15.9
Queen Anne's	17	2	2	13	2	4	10	2	18	20	9	0.3	657	0.7
St. Mary's	56	19	8	3	5	23	51	55	60	35	32	1.2	1,189	1.2
Somerset	4	2	4	3	0	11	7	3	7	1	4	0.2	400	0.4
Talbot	11	24	17	21	20	18	5	6	3	10	14	0.5	779	0.8
Washington	39	23	47	41	60	70	126	56	60	42	54	2.0	2,649	2.7
Wicomico	7	12	10	15	11	11	11	21	22	13	13	0.5	1,893	1.9
Worcester	12	12	15	15	7	13	18	20	28	26	17	0.6	1,283	1.3
Baltimore City	590	519	462	448	500	585	760	640	724	916	614	23.0	19,847	20.0
Total	2,877	2,701	2,573	2,134	2,041	2,074	2,755	3,035	3,169	3,361	2,672	100.0	99,471	100.0

Figure 6 shows the percentage of work zone accidents among all accidents by county for the 10 years (1994-2003). Note that Howard County had a higher percentage of work zone accidents with an average of 4.6% than other counties. The percentages of work zone accidents in Anne Arundel, Baltimore, Price George's County, and Baltimore City were also above the statewide average of 2.7%.

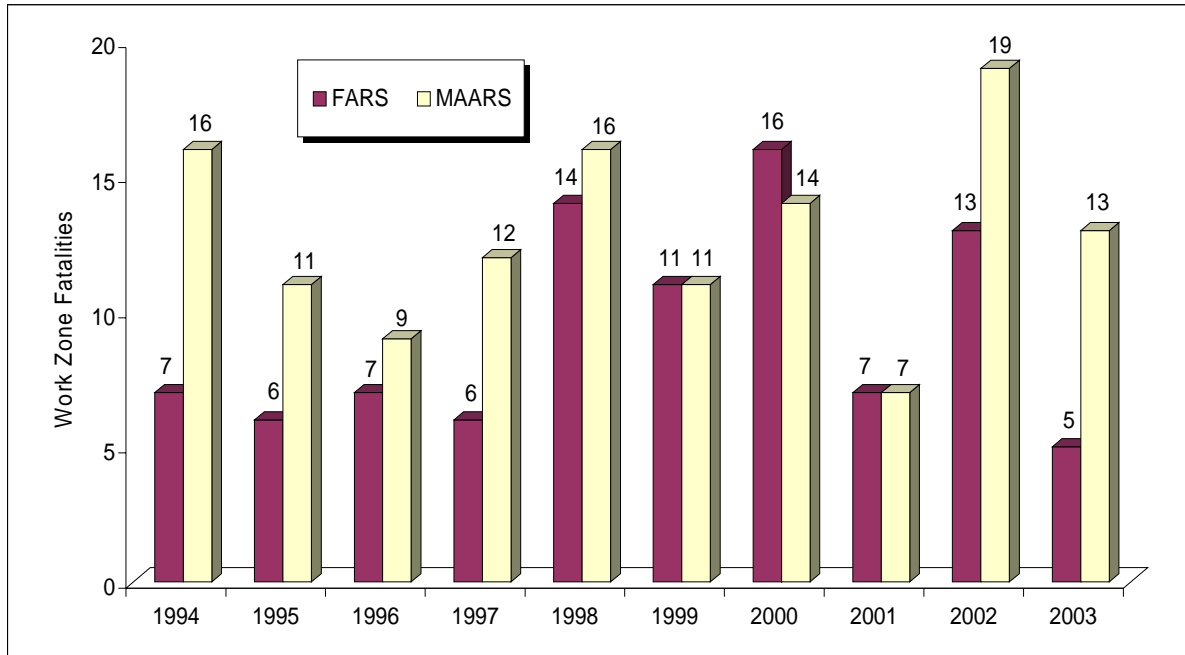
Figure 6 Percentage of Work Zone Accidents among All Accidents by County, 10 Year Average



Comparison of Maryland Work Zone Accidents and the U.S. Work Zone Accidents

Figure 7 shows the Maryland work zone fatalities from 1994 to 2003 according to FARS and MAARS. Note that there is some discrepancy in the number of fatalities reported from the MAARS and FARS as shown at Figure 7. In most years, yearly numbers of work zone fatalities from FARS was less than or equal to those from MAARS except for 2000.

Figure 7 Maryland Work Zone Fatalities by FARS and MAARS, 1994-2003



The FARS definition of “Work Zone Fatality” is more detailed than the MAARS definition. FARS coding allows the following 5 categories to be coded for work zones by the MSP FARS Analyst determination for reporting on HS Form 214 to NHTSA²:

Code 0 – None – This code is used when it is reasonably certain that codes “1-4” do not apply.

Code 1 – Construction – This code indicates that the accident occurred in the vicinity of highway construction activity or within an area marked by signs, barricades or other devices as a highway construction zone. Highway construction includes construction of appurtenances such as guardrails or ditches, surveying activity, installation of utilities within the right-of-way, etc. The use of this code does not imply that the accident was caused by the construction activity or zone.

² FARS Coding Manual, Page 105.

Code 2 – Maintenance – This code indicates that the accident occurred in the vicinity of highway maintenance activity or within an area marked by signs, barricades or other devices as a highway maintenance zone. Highway maintenance includes pavement marking, painting guardrails, cleaning ditches, mowing grass, etc.

Code 3 – Utility – This code indicates that the accident occurred in the vicinity of utility work such as electrical work within the right-of-way. The work must be performed by the utility company.

Code 4 – Work Zone, Type Unknown – This code is used when there is insufficient information to distinguish between construction, maintenance, and utility.

The FARS categories are based on examination of the MSP-1 form by the FARS analyst of the accident description written in freeform English on block 33 called “Describe Accident”. The FARS analyst makes a determination of the HS Form 214 value from the MSP-1 form.

Table 13 shows the FARS work zone fatalities that were disseminated from the NHTSA website and the Work Zone Safety Information Clearinghouse web-site. According to FARS, the number of fatalities has varied from 5 to 16 over those years. The Maryland total VMT has increased from 44.2 billion to 54.7 billion from 1994 to 2003, respectively. This increase in total VMT might include increases in work zone VMT which is not tracked. However, the yearly number of fatalities has varied from 5 to 16, even if VMT have consistently increased over this time frame. It might be due to the variation of VMT in the work zones associated with the number of the work zone projects in Maryland, the work zone size, or the construction period. However, this is very difficult to be calculated due to the temporary nature of work zones.

Table 13 FARS Work Zone Fatalities Breakdown by FARS Definition, 1994-2003

Year	Construction	Maintenance	Utility	Work Zone, Type Unknown	Total
1994	5	0	0	0	5
1995	5	1	0	0	6
1996	3	3	1	0	7
1997	4	1	1	0	6
1998	1	3	0	10	14
1999	1	3	0	7	11
2000	13	2	0	1	16
2001	6	0	0	1	7
2002	10	2	0	1	13
2003	2	3	0	0	5

Source: The National Work Zone Safety Information Clearinghouse Website, American Road & Transportation Builders Association and Texas Transportation Institute (<http://wzsafety.tamu.edu>).

Table 14 shows Maryland and the national work zone fatalities according to FARS, all fatalities, and resident population. The percentages of Maryland work zone fatalities among the national work zone fatalities were calculated for each year. The lowest percentage was 0.49% in 2003, and the highest percentage was 1.81% in 1998. In most years, the percentages of Maryland's work zone fatalities were below those of Maryland's fatalities among the national fatalities except for 1998 and 2000 as shown at Figure 8. It may be noted that Maryland has been well below its expected proportion of work zone fatalities based on its all fatalities and population.

Table 14 Maryland and U.S. Work Zone Fatalities, 1994-2003

Year	Work Zone Fatalities			All Fatalities			Population		
	MD	U.S.	MD's % of U.S. WZ Fatalities	MD*	U.S.	MD's % of U.S. Fatalities	Maryland* (Thousands)	U.S. (Thousands)	MD's % of U.S. Population
1994	7	828	0.85	657	40,716	1.61	5,059	260,327	1.94
1995	6	789	0.76	684	41,817	1.64	5,059	262,803	1.93
1996	7	717	0.98	614	42,065	1.46	5,070	265,229	1.91
1997	6	693	0.87	610	42,013	1.45	5,090	267,784	1.90
1998	14	772	1.81	606	41,501	1.46	5,110	270,428	1.89
1999	11	872	1.26	598	41,717	1.43	5,193	272,691	1.90
2000	16	1,026	1.56	617	41,945	1.47	5,296	282,125	1.88
2001	7	989	0.71	662	42,196	1.57	5,375	284,797	1.89
2002	13	1,181	1.10	661	43,005	1.54	5,418	288,369	1.88
2003	5	1,028	0.49	651	42,643	1.53	5,509	290,810	1.89

Source: The National Work Zone Safety Information Clearinghouse

* Maryland Traffic Safety Facts 2003, SHA, ** Traffic Safety Facts 2003, NHTSA

Figure 8 Percentages of Maryland Work Zone Fatalities and All Fatalities among National Work Zone Fatalities and All Fatalities, respectively, 1994-2003

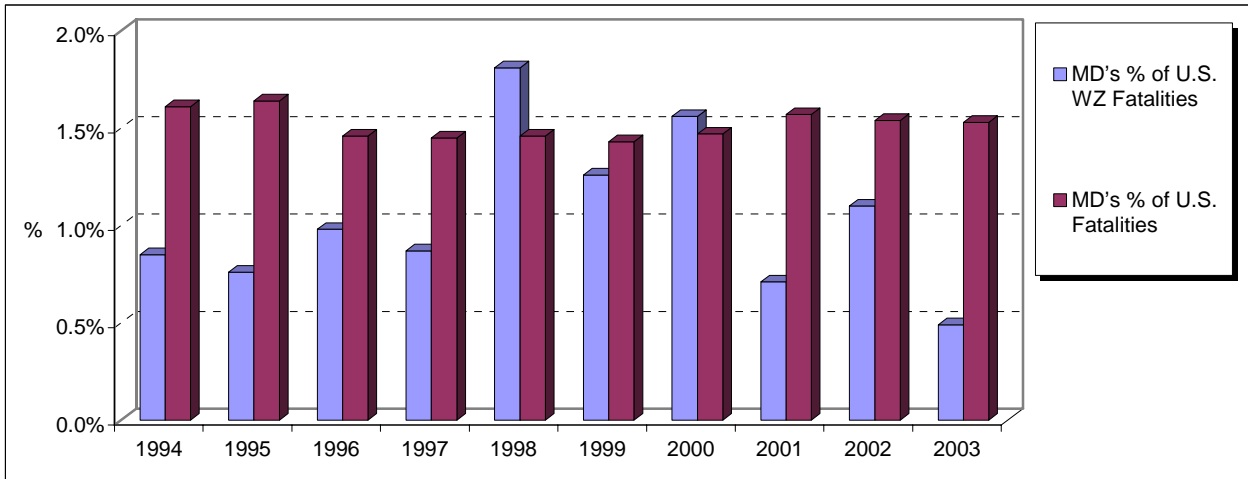


Table 15 shows Maryland and the national work zone fatal accidents, all fatal accidents, and VMT from 1994 to 2003. The percentages of Maryland work zone fatal accidents among the national work zone fatal accidents ranged from 0.49 and 1.81 over those years. In most years, the percentages of Maryland's work zone fatal accidents were below those of Maryland's fatal accidents among the national fatal accidents, and in all years, below those of Maryland's VMT with respect to the national figures.

Table 15 Maryland and U.S. Fatal Work Zone Accidents, 1994-2003

Year	Work Zone Fatal Accidents			All Fatal Accidents			Vehicle Miles Traveled		
	MD	U.S.	MD's % of U.S. WZ Fatal Acc.	MD*	U.S.**	MD's % of U.S. Fatal Accidents	MD* (Billions)	U.S.** (Billions)	MD's % of U.S. VMT
1994	7	828	0.85	605	36,254	1.67	44.2	2,358	1.87
1995	6	789	0.76	614	37,241	1.65	44.9	2,423	1.85
1996	7	717	0.98	563	37,494	1.50	45.9	2,486	1.85
1997	6	693	0.87	570	37,324	1.53	47.0	2,562	1.83
1998	14	772	1.81	551	37,107	1.48	48.4	2,632	1.84
1999	11	872	1.26	555	37,140	1.49	49.1	2,691	1.82
2000	16	1,026	1.56	574	37,526	1.53	50.3	2,747	1.83
2001	7	989	0.71	602	37,862	1.59	52.0	2,797	1.86
2002	13	1,181	1.10	606	38,491	1.57	53.7	2,856	1.88
2003	5	1,028	0.49	596	38,252	1.56	54.7	2,891	1.89

Source: The National Work Zone Safety Information Clearinghouse

* Maryland Traffic Safety Facts 2003, SHA, ** Traffic Safety Facts 2003, NHTSA

Table 16 and 17 show Maryland and U.S. work zone fatality rates. Maryland's work zone fatality rates per 100 million VMT and per 10,000 population have consistently been lower than the national rates for the same years.

Table 16 Maryland and U.S. Work Zone Fatality Rates (per 100 million VMT), 1994-2003

Year	Maryland			U.S.		
	Work Zone Fatalities*	VMT** (billions)	Fatality Rate (per 100M VMT)	Work Zone Fatalities*	VMT** (billions)	Fatality Rate (per 100M VMT)
1994	7	44.2	0.016	828	2,358	0.035
1995	6	44.9	0.013	789	2,423	0.033
1996	7	45.9	0.015	717	2,486	0.029
1997	6	47.0	0.013	693	2,562	0.027
1998	14	48.4	0.029	772	2,632	0.029
1999	11	49.1	0.022	872	2,691	0.032
2000	16	50.3	0.032	1,026	2,747	0.037
2001	7	52.0	0.013	989	2,781	0.036
2002	13	53.7	0.024	1,181	2,830	0.042
2003	5	54.7	0.009	1,028	2,891	0.036

Source: *: Work Zone Safety Information Clearinghouse

** *: Maryland Traffic Safety Facts 2003, SHA

Table 17 Maryland and U.S. Work Zone Fatality Rates (per 100,000 population)

Year	Maryland			U.S.		
	Work Zone Fatalities*	Population (thousand)**	Fatality Rate (per 100,000 population)	Work Zone Fatalities*	Population (1000)**	Fatality Rate (per 100,000 population)
1994	7	5,059	0.138	828	260,327	0.318
1995	6	5,059	0.119	789	262,803	0.300
1996	7	5,070	0.138	717	265,229	0.270
1997	6	5,090	0.118	693	267,784	0.259
1998	14	5,110	0.274	772	270,428	0.285
1999	11	5,193	0.212	872	272,691	0.320
2000	16	5,296	0.302	1,026	282,125	0.364
2001	7	5,375	0.130	989	284,797	0.347
2002	13	5,418	0.240	1,181	288,369	0.410
2003	5	5,509	0.091	1,028	290,810	0.353

Source: * Work Zone Safety Information Clearinghouse

** Maryland Traffic Safety Facts 2003, SHA

Table 18 shows the work zone fatalities and fatality rates of Maryland and bordering states around Maryland (the NHTSA Region III mid-Atlantic area) for 2003. Delaware and West Virginia had slightly less work zone fatalities than Maryland; Virginia and Pennsylvania experienced more work zone fatalities; No work zone fatalities occurred in Washington DC in the year. Maryland had the lowest work zone fatality rate per 100 million VMT excluding Washington DC. Virginia and Delaware had higher work zone fatality rates than U.S. work zone fatality rates. As noted previously, data are not yet available to quantify the level of work zone activity such as VMT in work zones for the involved states. This calculation is dynamically changing for every state every week during maintenance season.

Table 18 Maryland and Bordering States Comparison in Work Zone Fatalities and Fatality Rates, 2003

State	Work Zone Fatalities *	VMT (Million)**	Work Zone Fatality Rate per 100M VMT	Population (thousands)**	Work Zone Fatality Rate per 100,000 Population
Delaware	4	9,013	0.044	817	0.490
Maryland	5	54,678	0.009	5,509	0.091
Pennsylvania	38	106,554	0.036	12,365	0.307
Virginia	33	76,830	0.043	7,386	0.447
Washington DC	-	4,161	-	563	-
West Virginia	4	19,174	0.021	1,810	0.221
U.S.	1,028	2,891,000	0.036	290,810	0.353

Source: *: National Work Zone Safety Information Clearinghouse

** Maryland Traffic Safety Facts 2002, SHA

Relationships among Work Zone Accidents and Construction/Maintenance Quantity

This part addresses the relationship among work zone accidents and a few indications showing construction / maintenance intensity of Maryland. As such indications, the lane-miles resurfaced, the annual number of contracts, the amount of contract bids, and the capital program expenditure were used in this subsection.

Table 17 shows the number of Maryland lane-miles resurfaced and tons of hot mix asphalts used for pavement (HMA) from 1996 to 2003, showing a construction / maintenance intensity. These indications are peaked in 1999, and were lowest in 2001. The lane-miles resurfaced and the HMA are linearly dependent of each other with the correlation of coefficient of 0.89. Figure 9 shows fatal work zone accidents, lane-miles resurfaced, and HMA produced from 1996 to 2003. Figure 10 shows work zone accidents, the lane-miles resurfaced, and the HMA produced from 1996 to 2003.

Table 17 Maryland Lane-Miles Resurfaced and HMA* Produced, 1996-2003

Year	Lane-Miles Resurfaced	HMA Produced
1996	1,090	2,298
1997	994	1,990
1998	1,190	2,295
1999	1,546	2,638
2000	1,242	2,546
2001	758	1,975
2002	975	2,100
2003	867	1,700

Source: 2003 Pavement System Preservation Report, Office of Material & Technology, SHA, May 2004

* HMA: Tons of Hot Mix Asphalt

Figure 9 Fatal Work Zone Accidents, Lane-Miles Resurfaced, and HMA Produced, 1996-2003

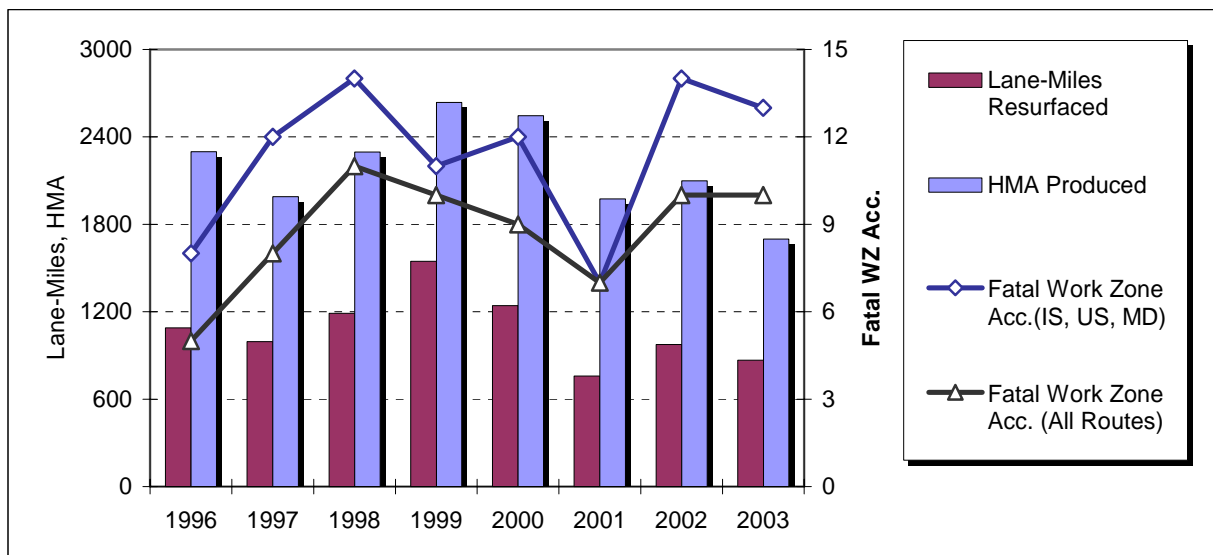


Figure 10 Work Zone Accidents, Lane-Miles Resurfaced, and HMA Produced, 1996-2003

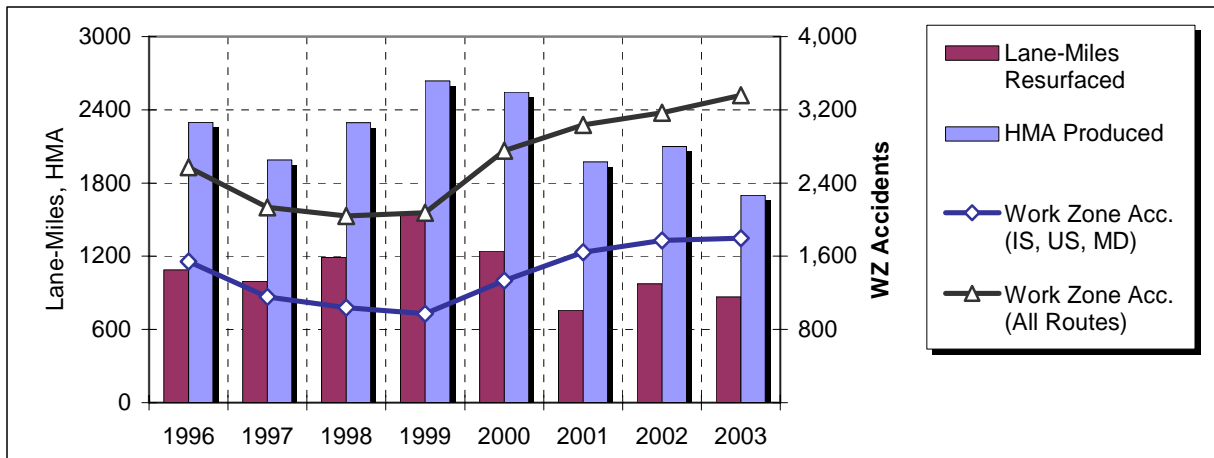


Table 18 shows the number of all contracts awarded by state fiscal year quarters. These numbers include contracts for highway construction/maintenance projects. Fiscal year 2000 had the highest number of contracts with a total of 304.

Table 18 Number of Contracts per State Fiscal Year by SHA, 1996-2003

Fiscal Year	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
1996	8	37	83	63	191
1997	27	50	106	67	250
1998	32	67	84	51	234
1999	49	99	69	55	272
2000	56	79	113	56	304
2001	35	64	72	97	268
2002	49	66	84	84	283
2003	48	62	93	79	282

Source: Office of Construction, SHA, 2004

Figure 11 Fatal Work Zone Accidents and Number of Contracts, 1996-2003

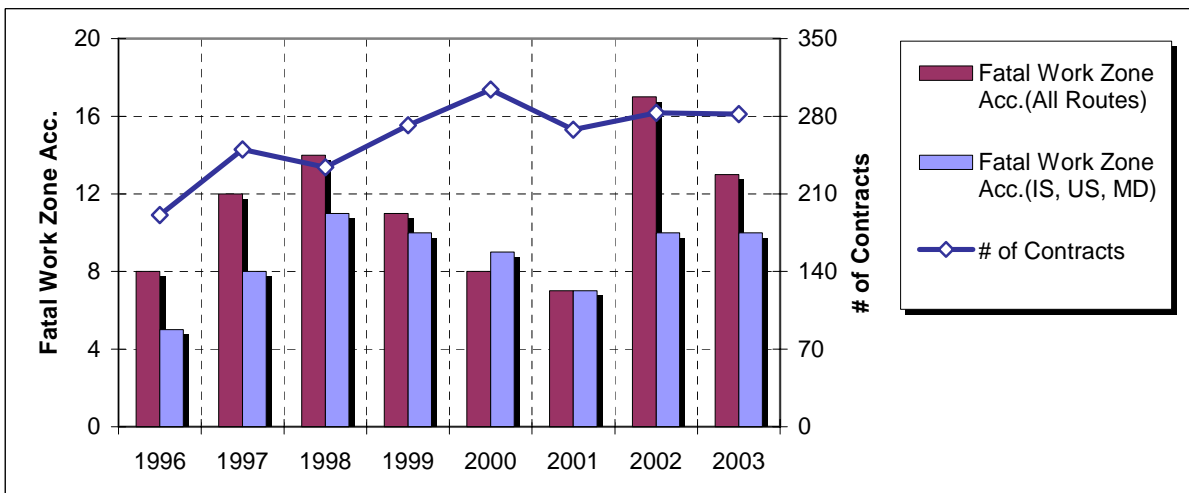


Figure 12 Work Zone Accidents and Number of Contracts, 1996-2003

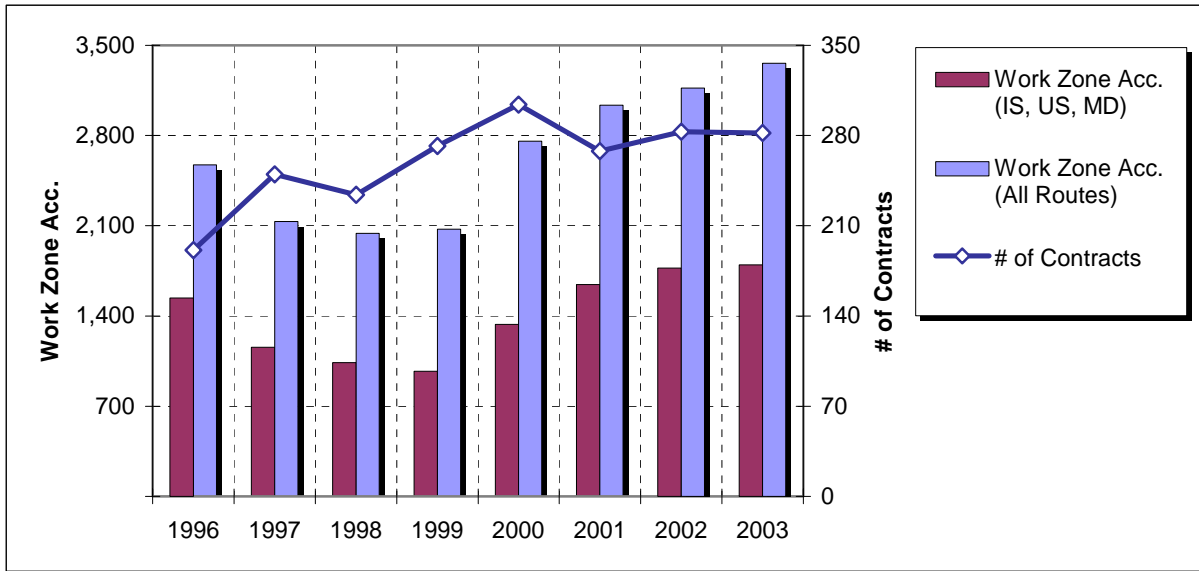


Table 19 shows the amount of contract bids by state fiscal quarter and yearly total at SHA. This includes highway construction/maintenance projects. Fiscal year 2003 had the highest amount of bids. Figure 13 and 14 shows the work zone accidents and the amount of contract bids which shows a steady increase in expenditures for every consecutive year since 1996, excluding 2002.

Table 19 Total Amount of Contract Bids by State Fiscal Year by SHA, 1996-2003

(unit: \$)

Fiscal Year	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Totals
1996	69,101,738	69,389,367	80,572,008	59,830,406	278,893,519
1997	34,663,062	78,780,081	111,082,758	61,532,143	286,058,044
1998	20,437,168	39,093,076	82,240,426	68,728,315	210,498,985
1999	28,467,984	171,967,168	113,982,481	49,081,401	363,499,034
2000	76,769,165	70,228,324	189,944,998	114,856,850	451,789,337
2001	126,412,301	66,811,301	269,751,629	217,422,909	680,398,135
2002*	88,929,487	89,512,515	119,209,198	64,641,642	362,292,842
2003	102,268,081	287,409,204	206,756,416	371,232,189	967,665,890

Source: Office of Construction, SHA, 2004

* Adjustment without PG3455173 (Woodrow Wilson Bridge) Figures

Figure 13 Fatal Work Zone Accidents and Contract Bid Amounts, 1996-2003

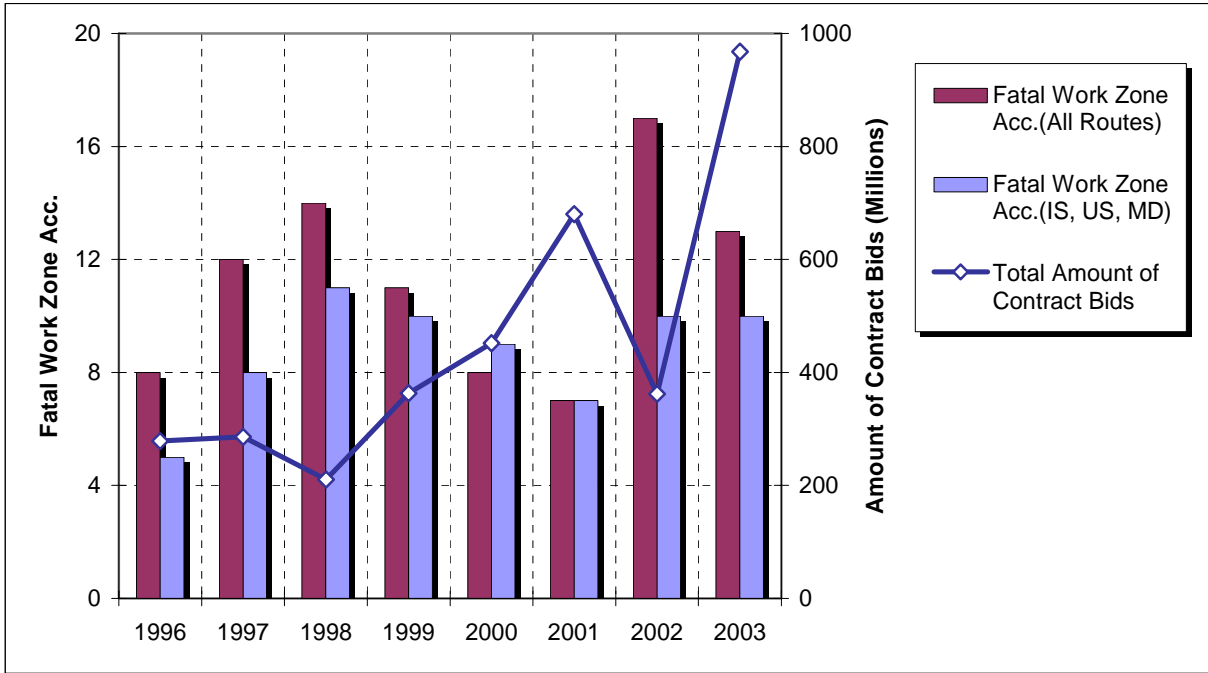


Figure 14 Work Zone Accidents and Contract Bid Amounts, 1996-2003

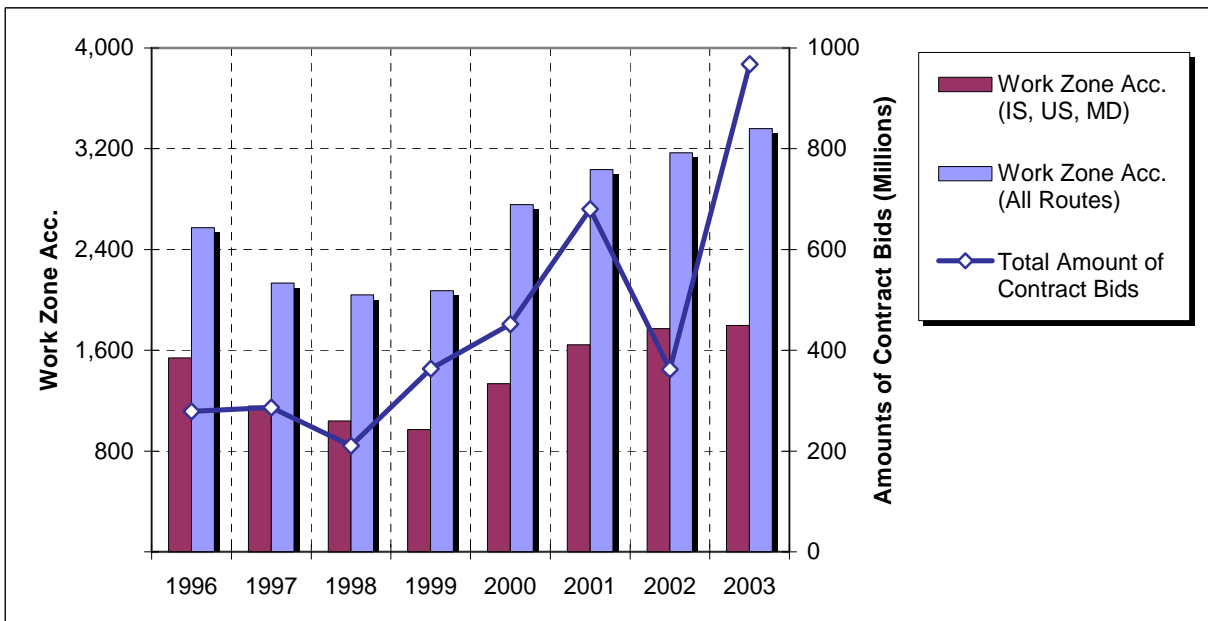


Table 20 shows the actual dollars spent on the SHA capital program. The capital program expenditure is classified into three categories such as major projects, operations and maintenance, and system preservation. The Woodrow Wilson Bridge project has been separately added in capital program since 1999. Fiscal Year 2002 had the highest dollar amounts spent.

Table 20 Capital Program Summary (in Millions of Dollars), 1996-2003

Year	Major Project	Operations & Maintenance	System Preservation	Woodrow Wilson Bridge	Total
1994	264.1	167.4	210	-	641.5
1995	275.0	149.1	294.6	-	718.7
1996	281.7	189.7	253.9	-	725.3
1997	329.4	163.2	242.9	-	735.5
1998	243.5	159.4	290.6	-	693.5
1999	277.0	182.3	314	5.2	778.5
2000	271.4	184.5	292.2	16	764.1
2001*	346.1	179.7	294.1	42.3	862.2
2002*	352.1	186	276.7	189.9	1004.7
2003*	270.9	192.5	303.6	190.2	957.2

Source: Highway Indicators Statistical Report, 2000, SHA

* Projected expenditure

Figure 15 Fatal Work Zone Accidents and Capital Program Expenditures, 1996-2003

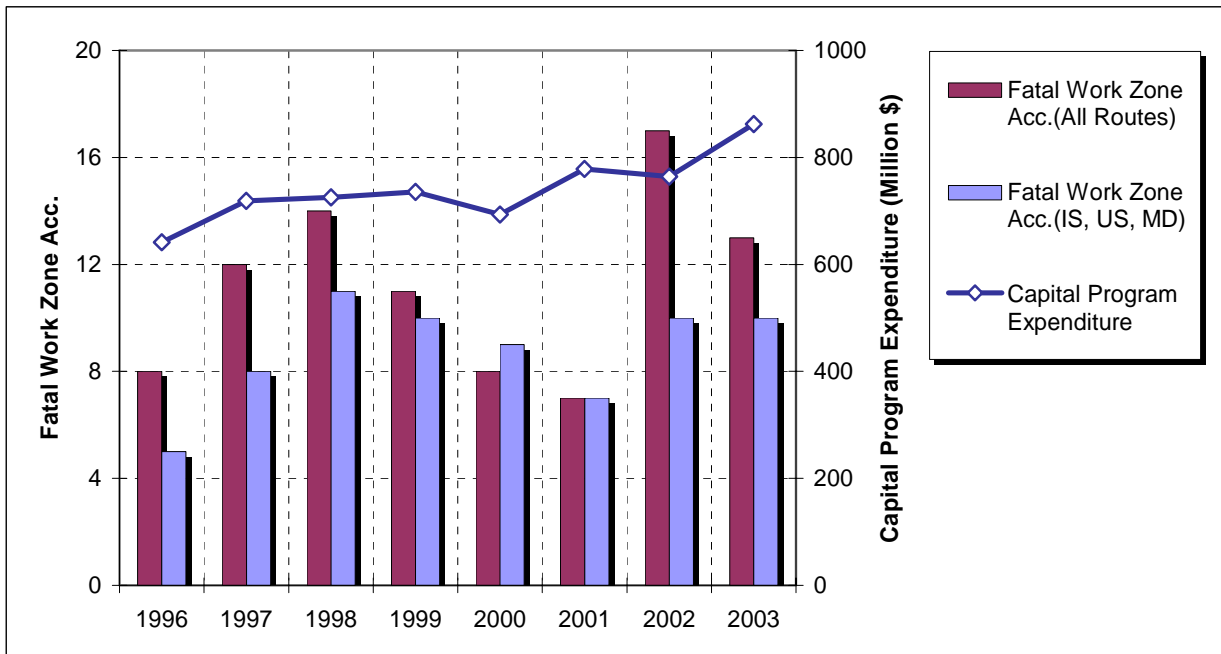


Figure 16 Work Zone Accidents and Capital Program Expenditures, 1996-2003

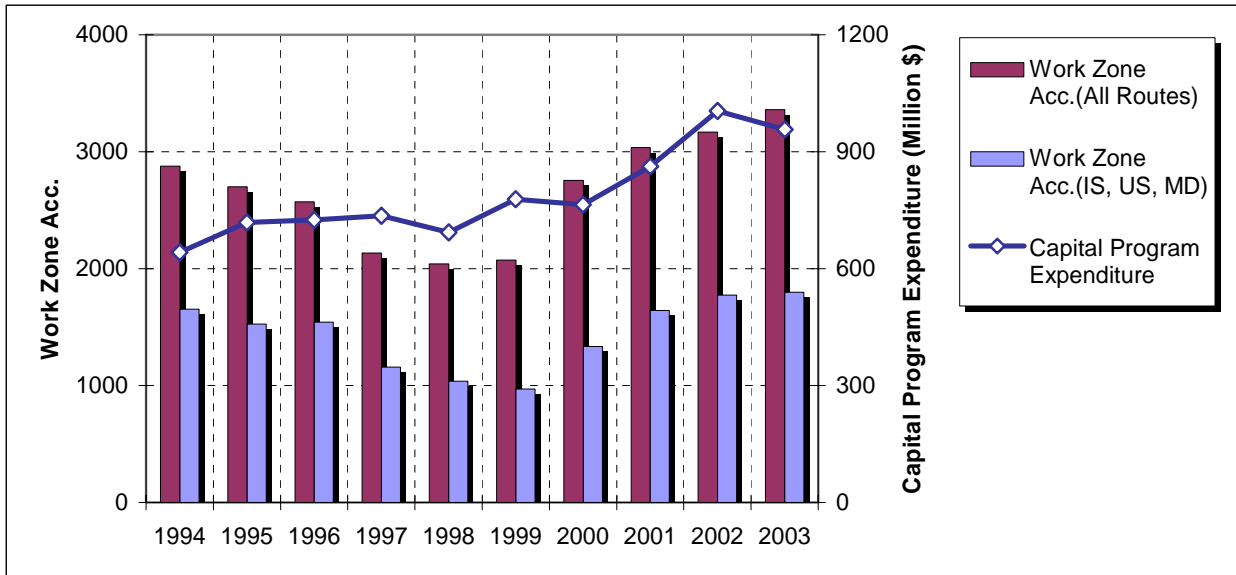


Table 21 shows the dependency relationship among the work accidents and the indicators representing construction/maintenance project intensity. For the purpose of measuring the dependence among the variables, each of the correlation coefficients was calculated based on the yearly data from 1996 to 2003. The correlation coefficient between total statewide work zone accidents and the capital program expenditure was highest at 0.85. In addition, from these correlation coefficients calculated, work zone accidents are fairly and positively associated with the capital program expenditure and total amount of contract bids. There are negative correlation coefficients for work zone accidents and the lane-miles resurfaced, and fatal work zone accidents and amount of contract bids. In general, negative coefficients between two variables indicate that they might be negatively associated with each other. However, in this situation, it must be appropriate explanation that those variables do not have linear dependence relationship rather than are negatively associated with each other.

Table 21 Correlation Coefficients among Work Zone Accidents and Construction/Maintenance Indicators

Indicators	Fatal Work Zone Accidents (All Routes)	Fatal Work Zone Accidents (State-Maintained Systems)	Total Work Zone Accidents (All Routes)	Total Work Zone Accidents (State-Maintained Systems)
Lane-miles Resurfaced	0.203	0.312	-0.673	-0.762
Number of Contract	0.376	0.565	0.425	0.165
Amount of Contract Bids	-0.111	0.072	0.761	0.633
Capital Program Expenditure	0.209	0.250	0.850	0.793

Conclusions and Summary

Maryland work zone accidents include the following trends in NHTSA FARS, Work Zone Information Clearinghouse, and Maryland MAARS data:

From the MAARS data, Maryland work zone accidents had the following characteristics as follows.

- The number of Maryland work zone fatalities ranged from 7 to 19 by year from 1994 to 2003, and the numbers for the State-maintained highways did from 5 to 13 by year.
- On the whole, the severity of work zone accidents has been lower than that of all types of accidents. Over the latest ten years, 2% of all fatalities in Maryland were killed at work zones, and nearly 3% of all statewide accidents occurred at work zones.
- For the fatal work zone accidents, the predominant accident types were the pedestrian, fixed object, angle, rear end, and opposite direction, which accounted for 75% of the fatal work accidents from 1994 to 2003.
- Work zone accidents occurred relatively more on Interstate, US, and MD highways, compared to all statewide accidents. Over the 10 years, 54% of all the work zone accidents occurred on the state-maintained systems, while 45% of all statewide accidents occurred on the state-maintained systems. 77% of statewide fatal work zone accidents occurred on the state-maintained systems, while 68% of statewide fatal accidents occurred on the state-maintained systems.
- Work zone accidents were relatively more frequent between 8 AM and 4 PM, compared to all types of accidents. On contrast, fatal work zone accidents were relatively more frequent between 8 PM and 3 AM, compared to all types of accidents.
- District 4, 5, 7, and Baltimore City had the higher percentage of work accidents than for all statewide accidents. That is, there were relatively more work zone accidents in those three districts and Baltimore City than in other districts.
- District 3 and 4 had the higher percentage of fatal work accidents (2.5% and 3.5%, respectively) than for statewide fatal accidents. That is, those two districts had the higher relative frequency for fatal work zone accidents than for other districts.
- Howard County had higher fraction of work zone accidents than other counties. The fractions of work zone accidents in Anne Arundel, Baltimore, Prince George's County, and Baltimore City were also above the statewide average of 2.7%.

From the FARS and Work Zone Information Clearinghouse data, Maryland work zone accidents were compared with the U.S. work zone accidents as follows.

- In most years, yearly numbers of work zone fatalities from FARS were less than or equal those from MAARS except for 2000.
- In most years, the percentages of Maryland's work zone fatalities among the national work zone fatalities were below those of Maryland's fatalities among the national fatalities except for 1998 and 2000.
- There were fewer fatal work zone accidents and fatalities than expected according to population, VMT ratios of Maryland to the United States, assuming that state population and VMT are exposure measures for work zone accidents.

- Maryland's work zone fatality rates per 100 million VMT and per 10,000 population have consistently been below the national rates for the latest 10 years.
- Among the bordering states, Maryland had the lowest work zone fatality rate per 100 million VMT excluding Washington DC.

The following statistical observations can be concluded from this report by using multiple Tables. These are derived from Figures 9 -16, which are used for estimating the correlations between the number of work zone accidents and various indicators for construction / maintenance of Maryland highway. As the proxy indicators for construction/maintenance along Maryland highways, the lane-miles resurfaced, the number of contract bids, the amount of contract bids, and the capital program expenditure were used.

- There is a strong, positive correlation between work zone accidents and capital program expenditure ($\rho=0.85$).
- Work zone accidents are fairly and positively associated with the capital program expenditure and total amount of contract bids.

Recommendations

The following recommendations are made from the study of these findings:

- The Maryland State Police FARS Analyst and the Central Records Division Fatality Analyst should reconcile numbers for work zone fatalities before finalizing any fatality totals in FARS or MAARS. SHA should be included in this process. This would avoid problems with the discrepancies in the counts of work zone fatalities.
- The Maryland State Police Central Records Division should issue a MAARS Advisory that discusses the valid definition of a construction zone according to the MUTCD and MMUCC that officers can use when completing the MSP-1 accident form. This will help make officers aware of the problem with the coded field of data. This could be supplemented by additional training on work zone definitions to the police officers.
- If the MAARS Manual or the MSP-1 Form is revised, consideration should be given to making it consistent with the MMUCC definition of work zone accidents.
- Comparisons could be made to a state/states that have similar characteristics to Maryland.
- Valid and/or more accurate estimate of VMT data for work zones by year would be helpful in calculating work zone accident rates.
- 46% of work zone accidents occur on non-state maintained routes. A local work zone inspection rating program (similar to SHA program) for these routes by county and municipal traffic engineers would greatly help lower the work zone accidents on these highways.

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Any errors in this report are solely the responsibility of the editor/author(s).

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