Appendix B

HERS Analysis

HERS Analysis

This Appendix describes the methodology used to analyze the performance of Vermont's highway system using the Highway Economic Requirements System (HERS), and summarizes the performance of the road network under a high, medium, and low-budget scenario.

Analysis Methodology

The Highway Economic Requirements System (HERS) was used to analyze the condition and performance of Vermont's highway system over the 10-year analysis period from 2001 to 2010. HERS was developed by Cambridge Systematics for the Federal Highway Administration (FHWA). The HERS model predicts future conditions and performance levels on the highway system given current network conditions and future highway improvement funds. The HERS model is designed to work with Highway Performance Monitoring System (HPMS) sample data. Recently, the HERS model was used in preparing the 2002 *Conditions and Performance* report for the U.S. Congress.[1]

The 2001 HPMS sample data for Vermont were used for the current analysis. This sample includes 17 percent of the state's highway miles overall, with the best representation of the higher functional classes:

- 96 percent of Interstate mileage;
- 38 percent of principal arterial mileage;
- 21 percent of minor arterial mileage;
- 15 percent of urban collector mileage; and
- Seven percent of rural major collector mileage.

Three scenarios, representing different assumptions regarding the annual funds available for highway improvement, were analyzed. Under the first (high-budget) scenario, an annual funding of $200 million was assumed to be available. Under the second (medium-budget) scenario, an annual funding of $100 million was assumed. Under the third (low-budget) scenario, an annual funding of $50 million was assumed.

[1] U.S. Department of Transportation, *2002 Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance*, Washington, D.C., 2003.

Standard HERS default values were used for this analysis. Key inputs to HERS include unit costs for different types of work and standards for what constitutes a deficiency. Table B.1 summarizes the deficiency standards utilized for the analysis; Table B.2 summarizes unit costs.

HERS does not include analysis of bridge needs.

Table B.1 HERS Default Deficiency Standards

Rural/ Urban	Functional/ AADT Class[1]	Terrain	Right Shoulder Width	Lane Width	V/C Ratio	PSR[2]
Rural	Interstate:	Flat	10	12	0.70	3.2
Rural		Rolling	9	12	0.80	3.2
Rural		Mountainous	7	12	0.90	3.2
Rural	OPA ADT>6000:	Flat	9	12	0.70	3.2
Rural		Rolling	9	12	0.80	3.2
Rural		Mountainous	7	12	0.90	3.2
Rural	OPA ADT<=6000:	Flat	9	12	0.70	3.0
Rural		Rolling	9	12	0.80	3.0
Rural		Mountainous	7	12	0.90	3.0
Rural	MA ADT>2000:	Flat	7	12	0.70	2.6
Rural		Rolling	7	12	0.80	2.6
Rural		Mountainous	6	12	0.90	2.6
Rural	MA ADT<=2000:	Flat	7	12	0.70	2.6
Rural		Rolling	7	12	0.80	2.6
Rural		Mountainous	6	12	0.90	2.6
Rural	Coll.'s ADT>1000:	Flat	6	12	0.70	2.4
Rural		Rolling	6	12	0.80	2.4
Rural		Mountainous	6	12	0.90	2.4
Rural	Coll.s ADT=400-1000:	Flat	4	11	0.95	2.4
Rural		Rolling	4	11	0.95	2.4
Rural		Mountainous	4	11	0.95	2.4
Rural	Coll.'s ADT<400:	Flat	2	10	1.00	2.2
Rural		Rolling	2	10	1.00	2.2
Rural		Mountainous	2	10	1.00	2.2
Urban	Interstate		9	12	0.90	3.4
Urban	Other Freeway		9	12	0.90	3.2
Urban	OPA		8	12	0.90	3.0
Urban	MA		8	12	0.90	2.6
Urban	Collectors		6	12	0.90	2.4

[1] OPA = Other principal arterial
MA = Minor arterial

[2] PSR = Present Serviceability Rating

Table B.2 HERS Unit Costs

$1,000s per Lane-Mile

Rural/ Urban	Functional System	Terrain	Work Type				
			Reconstruct and Widen	Reconstruct	Resurface and Widen	Resurface and Improve Shoulders	Resurface
Rural	Int.	Flat	633-1585	595	323-1143	221	125
Rural	Int.	Rolling	741-1590	612	346-1232	233	120
Rural	Int.	Mountainous	854-2507	870	475-1677	286	155
Rural	OPA	Flat	609-1199	520	315-1143	153	78
Rural	OPA	Rolling	684-1380	588	348-1232	167	78
Rural	OPA	Mountainous	895-1786	735	495-1489	228	115
Rural	Minor Art.	Flat	469-1041	370	262-1028	155	66
Rural	Minor Art.	Rolling	590-1261	503	275-1030	157	71
Rural	Minor Ar.	Mountainous	920-1551	661	364-1309	195	110
Rural	Major Coll.	Flat	534-1143	379	212-805	108	37
Rural	Major Coll.	Rolling	648-1117	468	223-975	118	43
Rural	Major Coll.	Mountainous	829-1361	646	296-1017	151	54
Urban	Freeways/Expressways	-	2889-9160	1769	1716-9289	513	238
Urban	Other divided	-	1779-5447	1008	946-2554	351	160
Urban	Other undivided	-	1407-3848	922	1001-4347	306	181

Baseline Conditions (2001)

Based on Vermont's HPMS File, the Vermont highway network analyzed by HERS comprises 3,856 miles,[2] of which 320 miles are on the Interstate system, and 709 miles are on the National Highway System (NHS). The network carries 5.9 billion vehicle-miles of travel annually, of which 27 percent is carried by the Interstate system. Some key measures regarding the extent, condition, and performance of the highway network are summarized in Table B.3.

[2] These figures do not include rural minor collectors, rural local roads, and urban local streets as these are not part of HPMS sample data.

Table B.3 Highway Network Conditions in 2001

Performance Measure	System			
	Interstate	Other NHS	Off-NHS	Entire System
Miles	320	389	3,147	3,857
Lane-Miles	1,280	954	6,340	8,575
VMT (Millions)	1,625	1,116	3,163	5,904
Present Serviceability Rating (PSR)	3.6	3.23	3.17	3.30
Average Speed	71.6	41.8	39.8	45.8
Total Delay (hours/1,000 VMT)	0	3.68	2.43	2.00
Congested Link VMT (Percent of Total)	0.50	6.26	3.31	3.09
Congested Link Miles (Percent of Total)	0.19	2.30	0.62	0.75
Deficient Pavement VMT (Percent of Total)	14.33	41.93	19.67	22.41
Deficient Pavement Miles (Percent of Total)	11.18	37.21	20.98	21.81
Deficient Lane Width VMT (Percent of Total)	0.00	18.41	57.39	34.23
Deficient Lane Width Miles (Percent of Total)	0.00	24.57	66.09	56.41
Deficient Shoulder Width VMT (Percent of Total)	0.00	67.81	89.78	60.92
Deficient Shoulder Width Miles (Percent of Total)	0.00	73.56	90.90	81.60
Travel Time Costs ($/1,000 VMT)	295	491	512	448
Operating Costs ($/1,000 VMT)	337	249	231	264
Safety Costs ($/1,000 VMT)	62	192	172	143

Model Predictions

Model predictions for the year 2010 under the high, medium, and low-budget assumptions are summarized in Tables B.4, B.5, and B.6 respectively. Overall, there is a marked deterioration in network condition and performance under the low-budget scenario. Network conditions also get slightly worse under the medium-budget scenario. Under the high-budget scenario, network conditions improve significantly. The Interstate network shows the least improvement under the high-budget scenario, reflecting the high condition and performance standards existing on the network. The NHS network excluding Interstates shows the most improvement under the high-budget scenario. Under the low-budget scenario, the Interstate network shows the most significant deterioration in measures of pavement condition, while the NHS network excluding Interstates shows the most significant deterioration in measures of travel time and congestion.

Table B.4 Highway Network Conditions in 2010 under the High-Budget Scenario ($200 Million/Year)

	System			
Performance Measure	**Interstate**	**Other NHS**	**Off-NHS**	**Entire System**
Miles	320	389	3,147	3,857
Lane-Miles	1,283	985	6,392	8,663
VMT (Millions)	1,993	1,291	3,664	6,949
PSR	3.66	3.81	3.42	3.54
Average Speed	71.8	42.8	40.2	46.6
Total Delay (hours/1,000 VMT)	0	3.32	2.41	1.88
Congested Link VMT (Percent of Total)	0.25	5.37	1.28	1.54
Congested Link Miles (Percent of Total)	0.13	3.75	0.40	0.67
Deficient Pavement VMT (Percent of Total)	4.87	3.17	1.07	2.91
Deficient Pavement Miles (Percent of Total)	6.37	3.77	3.16	0.67
Deficient Lane Width VMT (Percent of Total)	0.00	14.87	55.26	31.25
Deficient Lane Width Miles (Percent of Total)	0.00	20.58	67.92	57.07
Deficient Shoulder Width VMT (Percent of Total)	0.00	28.67	47.92	30.23
Deficient Shoulder Width Miles (Percent of Total)	0.00	31.06	56.50	49.02
Travel Time Costs ($/1,000 VMT)	294	480	502	441
Operating Costs ($/1,000 VMT)	336	232	223	257
Safety Costs ($/1,000 VMT)	64	190	170	143

Table B.5 Highway Network Conditions in 2010 under the Medium-Budget Scenario ($100 Million/Year)

	System			
Performance Measure	**Interstate**	**Other NHS**	**Off-NHS**	**Entire System**
Miles	320	339	3,147	3,857
Lane-Miles	1,283	970	6,370	8,628
VMT (Millions)	1,992	1,289	3,660	6,942
PSR	3.57	3.32	3.18	3.19
Average Speed	71.8	39	38.8	41.7
Total Delay (hours/1,000 VMT)	0	3.99	2.46	1.98
Congested Link VMT (Percent of Total)	0.25	7.77	2.18	2.46
Congested Link Miles (Percent of Total)	0.13	4.78	0.57	0.91
Deficient Pavement VMT (Percent of Total)	14.03	32.50	16.33	33.25
Deficient Pavement Miles (Percent of Total)	13.91	4.78	27.82	28.22
Deficient Lane Width VMT (Percent of Total)	0.00	15.73	57.36	33.03
Deficient Lane Width Miles (Percent of Total)	0.00	21.19	68.65	58.11
Deficient Shoulder Width VMT (Percent of Total)	0.00	39.28	58.53	35.65
Deficient Shoulder Width Miles (Percent of Total)	0.00	45.54	72.63	60.54
Travel Time Costs ($/1,000 VMT)	294	526	525	459
Operating Costs ($/1,000 VMT)	339	249	232	268
Safety Costs ($/1,000 VMT)	64	191	171	144

Table B.6 Highway Network Conditions in 2010 under the Low-Budget Scenario ($50 Million/Year)

Performance Measure	System			
	Interstate	Other NHS	Off-NHS	Entire System
Miles	320	389	3,147	3,857
Lane-Miles	1,283	959	6,362	8,615
VMT (Millions)	1,992	1,287	3,655	6,936
PSR	3.32	3.12	2.9	2.94
Average Speed	71.2	33.2	34.3	41.7
Total Delay (hours/1,000 VMT)	0	4.61	2.56	2.04
Congested Link VMT (Percent of Total)	0.25	10.99	2.83	3.08
Congested Link Miles (Percent of Total)	0.13	6.79	0.70	1.14
Deficient Pavement VMT (Percent of Total)	44.94	41.19	29.16	45.43
Deficient Pavement Miles (Percent of Total)	42.56	42.07	41.78	42.15
Deficient Lane Width VMT (Percent of Total)	0.00	18.01	57.43	33.57
Deficient Lane Width Miles (Percent of Total)	0.00	23.85	68.67	58.42
Deficient Shoulder Width VMT (Percent of Total)	0.00	43.81	67.21	42.48
Deficient Shoulder Width Miles (Percent of Total)	0.00	50.84	82.38	71.13
Travel Time Costs ($/1.000 VMT)	296	619	593	492
Operating Costs ($/1.000 VMT)	347	264	246	277
Safety Costs ($/1.000 VMT)	64	192	171	144

Figures B.1 through B.3 summarize differences from the baseline (2001) for the three different budget scenarios. Figure B.1 shows variations in pavement condition (PSR)[3], illustrating that the $100 million scenario would allow Vermont's average pavement condition to stay at the baseline condition.

[3] Present Serviceability Rating (PSR) is a subjective measure of pavement condition, ranging from 0 to 5.

Figure B.1 Average Pavement Condition

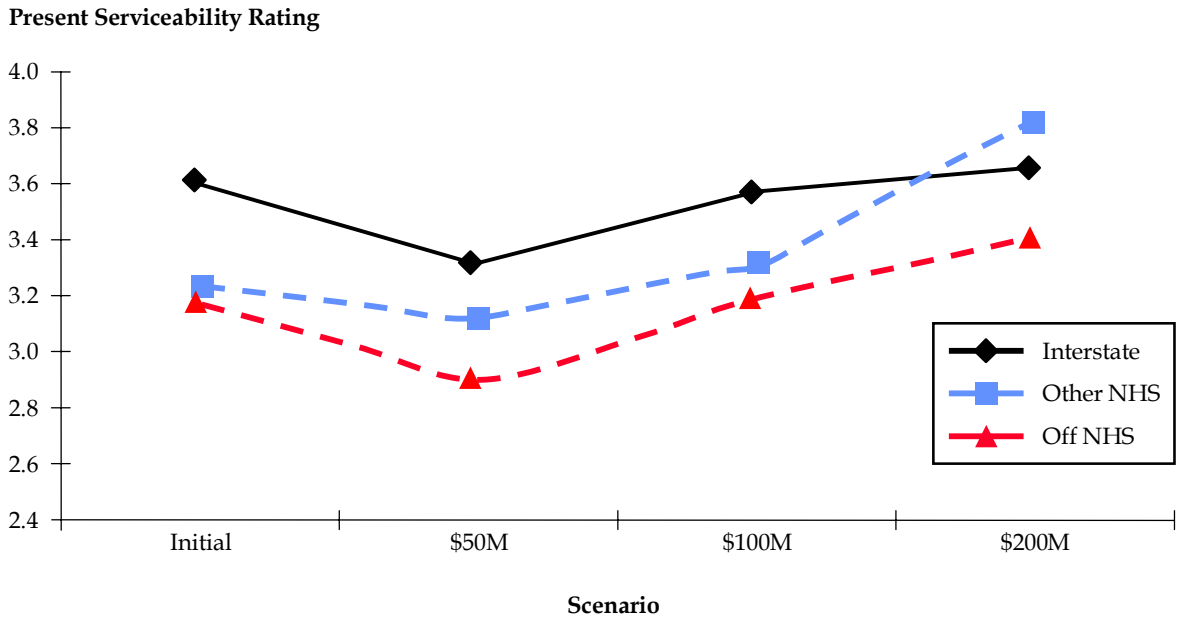

Figure B.2 User Costs

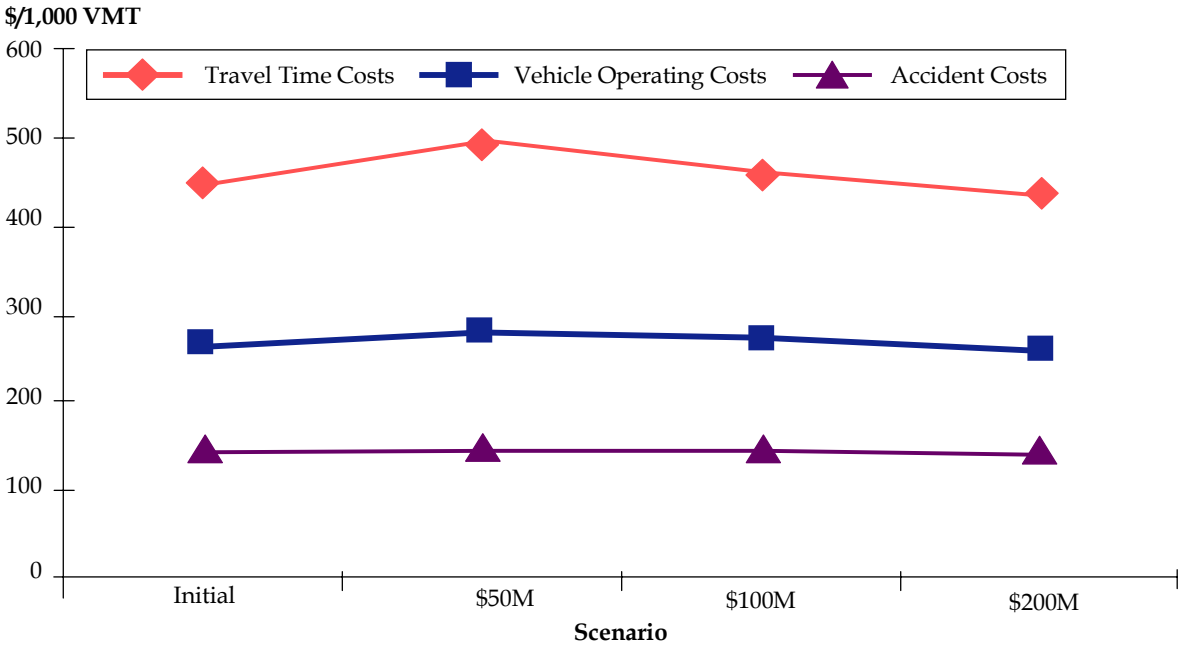

Figure B.3 Percent of Vehicle Miles Traveled (VMT) on Deficient Miles

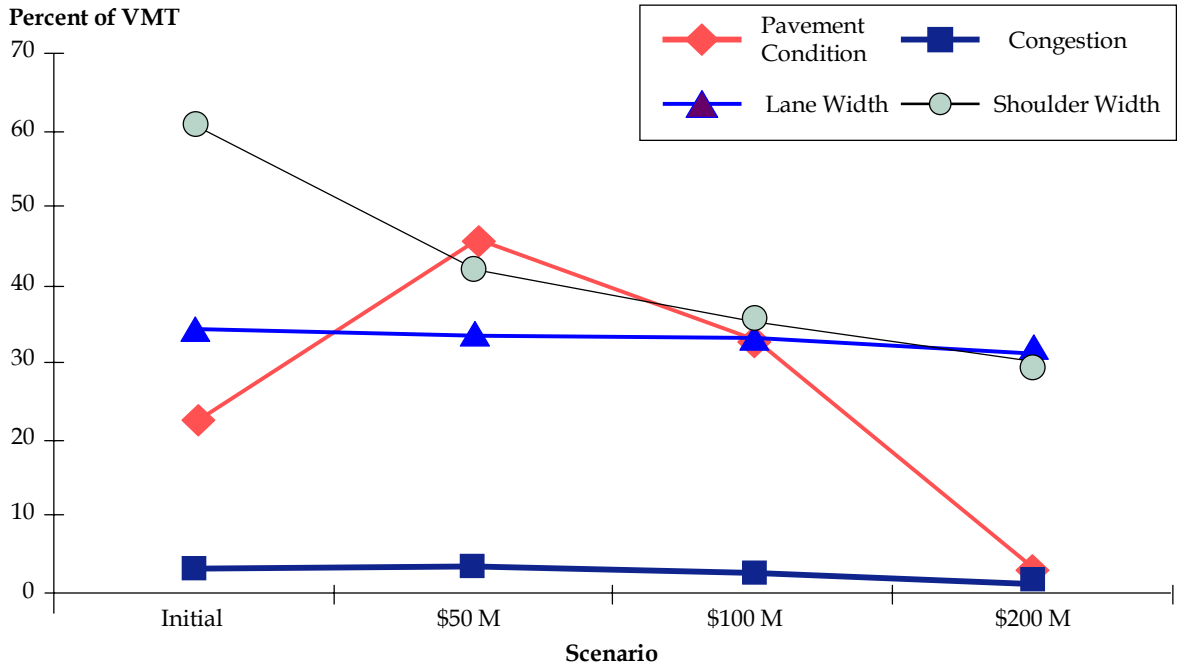

Figure B.2 shows the costs to highway users predicted by HERS for the baseline and the three budget scenarios. The analysis indicates travel time costs are the largest and most sensitive component of user costs, and that the $100 million per year scenario would keep user costs from increasing over the baseline level.

Figure B.3 shows the percentage of travel (VMT) on deficient highways – for different types of deficiencies. Deficiency thresholds vary by functional class, traffic volumes and terrain, as shown in Table B.1. The analysis indicates that a very small percentage of travel is on congested facilities for the initial baseline, and this already small share of congested travel would decline further as the investment level increases. The percent of VMT on highways with deficient pavement condition is very sensitive to the investment level – the results show an increase from 22 percent to over 40 percent at the low investment scenario, dropping back down to 33 percent for the medium budget scenario, and to three percent for the high-budget scenario. Lane width deficiencies are relatively insensitive to budget levels (indicating that the model calculates higher benefits from pavement improvement over widening); shoulder width deficiencies on the other hand are fairly sensitive to investment levels, and steadily decrease from the initial baseline of 60 percent (of VMT on highways with deficient shoulder widths) down to 30 percent for the high-budget scenario.

Summary

The HERS analysis indicates that a $100 million per year investment level in the highway system (exclusive of bridge work) would allow Vermont to maintain status quo pavement conditions, improve shoulder widths and keep congestion in check. HERS predicts that an investment level half this size would result in a significant long-term decline in pavement condition, and an increase in user costs of $58 per 1,000 VMT, or roughly $340 million per year (at 5.9 billion VMT per year).

The $100 million level is quite close to the "status quo conditions" scenario investment level of $93 million per year predicted by the pavement management system. However, the pavement management system does not include any reconstruction work on the Interstate, and no widening or shoulder work, whereas much of the work selected in the HERS simulation involved widening and shoulder improvements. Thus, for roughly the same investment level, the HERS simulation model (using standard defaults) appears to indicate that pavement condition can be improved over existing conditions and lane and shoulder widenings can be achieved as well. This could be due to a combination of factors, including differences in work unit costs and in pavement deterioration models in the two systems. Reasons for these differences need to be investigated further.

This rough analysis does indicate, however that HERS produces useful results that provide an understanding of a wide spectrum of impacts associated with different highway investment levels. These impacts include both highway system-level conditions, as well as customer-oriented impacts (i.e., user costs). The order-of-magnitude of the HERS results is consistent with the pavement management system results; therefore HERS provides an independent confirmation as to the scale of Vermont's highway needs.

A number of steps are recommended to better calibrate the HERS model to Vermont conditions and increase the level of confidence in its results:

- Investigate the feasibility of developing a more complete HPMS database, using existing information from the pavement management system and other highway inventory databases. In conjunction with this effort, subsamples representing the three networks analyzed for the Highway System Policy Plan should be prepared to provide better comparability of results.
- Compare the HERS default pavement deterioration curves to those currently used in the VTrans Pavement Management System.
- Compare the HERS unit costs for different work types to those assumed by the pavement management system.
- Modify the HERS PSR deficiency standards to better match the VTrans definitions of "poor" so that better comparability across results for the two models can be assessed.
- Develop a new set of Vermont-specific unit costs and deterioration model parameters for HERS.