that states typically do not categorize every capital dollar when reporting totals to FHWA. This discrepancy was addressed by calculating the percentage of capital spending for each state that went to road repair and preservation projects and to road expansion projects for 2009–2011 using FHWA Table SF-12A. These percents were then applied to the capital spending reported in the full state highway budgets in FHWA Table SF-4. This analysis assumes that the percentages of capital expenditures for each state that went to repair and preservation projects and to expansion projects would also apply to the total capital dollars with unreported expenditure categories.

TABLE A6

Average annual state highway capital expenditures, 2009–2011

		Spending on expansion			**Spending on repair and preservation**		
State	**Total annual expenditures (millions)**	**Annual capital spending (millions)**	**Percent of total capital spending**	**Percent of total spent on road expansion and repair**	**Annual capital spending (millions)**	**Percent of total capital spending**	**Percent of total spent on road expansion and repair**
Alabama	$900	$252	28%	45%	$304	34%	55%
Alaska	$465	$89	19%	35%	$167	36%	65%
Arizona	$1,121	$620	55%	83%	$124	11%	17%
Arkansas	$593	$235	40%	68%	$110	19%	32%
California	$5,280	$940	18%	40%	$1,438	27%	60%
Colorado	$688	$215	31%	53%	$189	27%	47%
Connecticut	$746	$176	24%	56%	$137	18%	44%
Delaware	$359	$113	31%	70%	$48	13%	30%
District of Columbia	$266	$0	0%	0%	$106	40%	100%
Florida	$4,365	$1,223	28%	48%	$1,312	30%	52%
Georgia	$1,701	$486	29%	46%	$569	33%	54%
Hawaii	$247	$88	36%	59%	$63	25%	41%
Idaho	$481	$115	24%	43%	$152	32%	57%
Illinois	$2,658	$543	20%	35%	$1,028	39%	65%
Indiana	$1,421	$735	52%	71%	$293	21%	29%
Iowa	$677	$238	35%	52%	$217	32%	48%
Kansas	$688	$194	28%	46%	$225	33%	54%
Kentucky	$1,291	$527	41%	61%	$343	27%	39%
Louisiana	$2,107	$645	31%	62%	$388	18%	38%
Maine	$344	$35	10%	14%	$221	64%	86%
Maryland	$1,252	$257	21%	68%	$123	10%	32%
Massachusetts	$960	$52	5%	18%	$241	25%	82%
Michigan	$1,298	$95	7%	13%	$662	51%	87%

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State	Total annual expenditures (millions)	Spending on expansion			Spending on repair and preservation		
		Annual capital spending (millions)	Percent of total capital spending	Percent of total spent on road expansion and repair	Annual capital spending (millions)	Percent of total capital spending	Percent of total spent on road expansion and repair
Minnesota	$1,021	$377	37%	60%	$250	25%	40%
Mississippi	$758	$603	79%	97%	$16	2%	3%
Missouri	$1,390	$461	33%	62%	$283	20%	38%
Montana	$477	$132	28%	45%	$161	34%	55%
Nebraska	$392	$20	5%	9%	$196	50%	91%
Nevada	$612	$392	64%	83%	$79	13%	17%
New Hampshire	$287	$76	26%	37%	$130	45%	63%
New Jersey	$2,325	$266	11%	20%	$1,095	47%	80%
New Mexico	$497	$53	11%	23%	$172	35%	77%
New York	$2,861	$297	10%	23%	$975	34%	77%
North Carolina	$2,210	$1,155	52%	83%	$233	11%	17%
North Dakota	$356	$14	4%	6%	$240	68%	94%
Ohio	$1,751	$404	23%	39%	$628	36%	61%
Oklahoma	$1,299	$500	38%	64%	$279	21%	36%
Oregon	$688	$94	14%	37%	$159	23%	63%
Pennsylvania	$4,258	$1,421	33%	62%	$877	21%	38%
Rhode Island	$213	$5	3%	22%	$19	9%	78%
South Carolina	$803	$158	20%	43%	$213	27%	57%
South Dakota	$332	$49	15%	20%	$196	59%	80%
Tennessee	$1,170	$421	36%	72%	$163	14%	28%
Texas	$5,745	$2,765	48%	82%	$612	11%	18%
Utah	$1,140	$700	61%	93%	$50	4%	7%
Vermont	$212	$30	14%	23%	$101	48%	77%
Virginia	$1,110	$402	36%	68%	$192	17%	32%
Washington	$1,975	$849	43%	84%	$166	8%	16%
West Virginia	$818	$312	38%	73%	$113	14%	27%
Wisconsin	$1,307	$544	42%	61%	$349	27%	39%
Wyoming	$409	$46	11%	17%	$224	55%	83%
Average	**$1,295**	**$400**	**31%**	**55%**	**$324**	**25%**	**45%**
Total	**$66,061**	**$20,417**	**31%**	**55%**	**$16,525**	**25%**	**45%**

Sources: Total annual spending on capital projects calculated using the following tables:

- Federal Highway Administration. (2011). "Disbursements for State-Administered Highways." Table SF-4. http://www.fhwa.dot.gov/policyinformation/statistics/2011/sf4.cfm.
- Federal Highway Administration. (2010). "Disbursements for State-Administered Highways." Table SF-4.

http://www.fhwa.dot.gov/policyinformation/statistics/2010/sf4.cfm.

- FHWA. (2009). "Disbursements for State-Administered Highways." Table SF-4. http://www.fhwa.dot.gov/policyinformation/statistics/2009/sf4.cfm.

Annual capital spending on road expansion projects and repair and preservation projects calculated using the following tables:

- Federal Highway Administration. (2011). "State Highway Agency Capital Outlay – Classified by Improvement Type." Table SF-12A. http://www.fhwa.dot.gov/policyinformation/statistics/2011/sf12a.cfm.
- Federal Highway Administration. (2010). "State Highway Agency Capital Outlay – Classified by Improvement Type." Table SF-12A. http://www.fhwa.dot.gov/policyinformation/statistics/2010/sf12a.cfm.
- Federal Highway Administration. (2009). "State Highway Agency Capital Outlay – Classified by Improvement Type." Table SF-12A. http://www.fhwa.dot.gov/policyinformation/statistics/2009/sf12a.cfm.

Appendix B

Annual cost of repairing and maintaining states' roads

TABLE B1

Estimated annual funding need for repair and preservation of state-owned roads (in 2010 dollars)

State	State road network preservation need	Repair need for major state roads in poor condition	State road preservation and major road repair need
Alabama	$647,550,906	$26,231,393	$673,782,298
Alaska	$255,612,283	$33,684,428	$289,296,711
Arizona	$432,364,079	$23,730,564	$456,094,643
Arkansas	$827,930,890	$118,276,270	$946,207,160
California	$1,126,173,979	$172,581,802	$1,298,755,781
Colorado	$512,916,187	$46,221,906	$559,138,093
Connecticut	$220,219,745	$46,552,596	$266,772,340
Delaware	$262,550,131	$24,880,688	$287,430,818
District of Columbia	$69,989,567	$32,036,567	$102,026,134
Florida	$940,144,185	$45,782,412	$985,926,597
Georgia	$1,068,017,532	$35,311,645	$1,103,329,177
Hawaii	$56,189,382	$9,811,870	$66,001,252
Idaho	$267,872,316	$21,024,804	$288,897,120
Illinois	$934,724,720	$100,917,192	$1,035,641,911
Indiana	$621,648,891	$63,154,295	$684,803,186
Iowa	$510,216,981	$45,229,754	$555,446,735
Kansas	$536,572,182	$131,345,898	$667,918,080
Kentucky	$1,374,470,628	$46,931,333	$1,421,401,962
Louisiana	$884,987,878	$95,125,341	$980,113,219
Maine	$392,911,512	$51,947,723	$444,859,235
Maryland	$330,449,122	$31,085,024	$361,534,146
Massachusetts	$207,271,767	$11,989,378	$219,261,145
Michigan	$608,902,124	$94,594,631	$703,496,755
Minnesota	$653,772,987	$45,822,336	$699,595,323
Mississippi	$607,415,423	$123,647,772	$731,063,195
Missouri	$1,693,497,222	$50,064,893	$1,743,562,115
Montana	$555,862,591	$17,608,976	$573,471,567
Nebraska	$502,646,152	$26,791,482	$529,437,633

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State	State road network preservation need	Repair need for major state roads in poor condition	State road preservation and major road repair need
Nevada	$295,235,692	$4,577,589	$299,813,282
New Hampshire	$189,058,295	$20,678,114	$209,736,409
New Jersey	$188,500,504	$36,884,161	$225,384,665
New Mexico	$649,093,448	$72,017,798	$721,111,246
New York	$849,819,524	$100,778,943	$950,598,467
North Carolina	$3,789,336,106	$169,197,272	$3,958,533,378
North Dakota	$378,864,290	$10,391,994	$389,256,284
Ohio	$1,118,840,130	$142,946,333	$1,261,786,463
Oklahoma	$673,572,081	$115,878,167	$789,450,248
Oregon	$413,933,660	$11,031,965	$424,965,625
Pennsylvania	$1,966,458,650	$236,482,389	$2,202,941,040
Rhode Island	$64,216,401	$9,271,255	$73,487,657
South Carolina	$2,006,642,342	$92,241,464	$2,098,883,807
South Dakota	$417,031,191	$51,523,561	$468,554,752
Tennessee	$822,938,545	$27,365,827	$850,304,372
Texas	$4,381,245,467	$254,695,540	$4,635,941,007
Utah	$350,586,920	$18,525,612	$369,112,533
Vermont	$134,171,513	$13,794,932	$147,966,445
Virginia	$2,809,312,756	$279,731,298	$3,089,044,054
Washington	$409,964,720	$50,642,099	$460,606,818
West Virginia	$1,592,385,145	$246,701,598	$1,839,086,742
Wisconsin	$657,651,508	$72,090,303	$729,741,810
Wyoming	$351,700,187	$9,719,504	$361,419,690
Average	**$815,949,813**	**$70,971,582**	**$886,921,395**
Total	**$41,613,440,439**	**$3,619,550,687**	**$45,232,991,126**

Determining road preservation and repair costs

This analysis evaluates the funding need based on the average cost of various construction activities compiled by FHWA from DOTs around the country. This study examines the cost and timing of repair and preservation to see how much states would need to spend annually to 1) keep their roads from deteriorating to poor condition; and 2) bring roads in poor condition into good repair over a 20-year period. While it does not capture regional variations attributable to climate or topography, among others, it does offer a big picture assessment.

Preserving the existing network in good condition

Determining the annualized pavement management cost
Once a road is built, a combination of regular repair and preservation along with periodic major rehabilitation is required to keep it in a state of good repair. This section calculates the annualized cost of keeping a state's road network in a state of good repair based on its current asset inventory. The following assumptions went into calculating this cost:

- Asphalt and concrete roads have a 50-year lifecycle from initial construction, a figure based on conversations with representatives from PennDOT and other industry experts. A national approximation is used for this analysis, but road lifecycles actually vary based on a number of factors including traffic flow, climate and pavement type.
- Over the course of 50 years, a regular preventative treatment schedule is required, as outlined in Table B2 below.
- At the end of 50 years, all pavement requires major rehabilitation to address shifting or weakened foundations and other problems.

The treatment schedules below do not include all the techniques that may be used under all situations and different geographic conditions. Though the schedules assume a major rehabilitation at the end of 50 years, a road often needs to be completely reconstructed at the end of its lifecycle, which is significantly more costly than major rehabilitation. Thus, the calculation here for whole network management represents a minimum cost based on a minimum universal treatment schedule applied across all 50 states. A state-customized treatment schedule would yield a more precise network repair and preservation price tag, but this standardized approach is designed to provide a national comparative snapshot.

TABLE B2

Pavement treatment schedules for asphalt and concrete (in 2010 dollars)

Asphalt Treatment Schedule (over 50-year lifecycle)		
Year Applied	**Treatment Type**	**Cost per lane-mile**
0	(Initial Construction)	N/A
5	Crack Sealing	$2,211
6	Microsurfacing	$26,654
10	Crack Sealing	$2,211
14	Mill and Resurfacing	$220,212
14	Chip Seal	$44,124
18	Crack Sealing	$2,211
19	Microsurfacing	$26,654
23	Crack Sealing	$2,211
26	Mill and Resurfacing	$220,212

Concrete Treatment Schedule (over 50-year lifecycle)		
Year Applied	**Treatment Type**	**Cost per lane-mile**
0	Initial Construction	N/A
8	Joint Sealing	$8,375
15	Partial Depth Repair	$25,459
15	Diamond Grinding	$76,892
15	Joint Sealing	$8,375
25	Partial Depth Repair	$25,459
25	Diamond Grinding	$76,892
25	Joint Sealing	$8,375
35	Partial Depth Repair	$25,459
35	Joint Sealing	$8,375

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Asphalt Treatment Schedule (over 50 year life cycle)		
Year Applied	**Treatment Type**	**Cost per lane-mile**
26	Chip Seal	$44,124
30	Crack Sealing	$2,211
31	Microsurfacing	$26,654
34	Crack Sealing	$2,210
38	Mill and Resurfacing	$220,212
38	Chip Seal	$44,124
42	Crack Sealing	$2,211
43	Microsurfacing	$26,654
50	Major Rehabilitation	$196,415
Total life cost per lane-mile		**$1,111,516**
Annualized cost per lane-mile		**$22,230**

Concrete Treatment Schedule (over 50 year life cycle)		
Year Applied	**Treatment Type**	**Cost per lane-mile**
35	HMA Overlay	$79,313
36	Chip Seal	$44,124
40	Crack Sealing	$2,211
41	Microsurfacing	$26,654
47	Partial Depth Repair	$25,459
47	Joint Sealing	$8,375
47	Mill and Resurfacing	$220,212
47	Chip Seal	$44,124
50	Major Rehabilitation	$436,933
Total life cost per lane-mile		**$1,150,066**
Annualized cost per lane-mile		**$23,021**

The per-lane-mile cost for each pavement treatment included in the lifecycles above were determined by averaging the costs from different application samples made available in FHWA's 2010 report "Performance Evaluation of Various Rehabilitation and Preservation Treatments." Sample applications were provided from six states (California, Kansas, Michigan, Minnesota, Texas and Washington). Only a subset of the basic preventative treatments provided in the report (see Table B3 below) was used to represent a minimal preservation schedule. It should be noted that FHWA provides cost data for several other treatment types. For concrete roads, FHWA provided cost data for joint sealing, partial depth repair, diamond grinding, hot-mix asphalt (HMA) overlay, chip sealing, crack sealing, microsurfacing, mill and resurfacing, HMA overlay without slab fracturing, crack and seal and unbonded overlays. For asphalt roads, treatment types included chip sealing, crack sealing, microsurfacing, mill and resurfacing, full depth reclamation, structural overlay and whitetopping.

TABLE B3

Per-lane-mile cost of sample pavement treatments (in 2010 dollars)

Preventative preservation treatments (number of cost samples available)	**Average per-lane-mile cost**
HMA overlays (13)	$79,313
Chip seal (15)	$44,124
Microsurfacing (9)	$26,654
Crack sealing (11)	$2,211
Mill and Resurfacing (10)	$220,212
Diamond grinding (8)	$76,892
Partial depth repair (4)	$25,459
Joint sealing (3)	$8,375

Major rehabilitation treatments (number of cost samples)	Average per-lane-mile cost
Concrete	
HMA overlay without slab fracturing (rubblization or crack-and-seal) (7)	$461,805
Crack-and-seal or rubblize and overlay (with HMA) (7)	$332,558
Unbonded Overlay (7)	$516,435
Average concrete major rehabilitation cost	**$436,933**
Asphalt	
Full-Depth Reclamation (12)	$166,058
Structural overlay (mill and fill) (9)	$145,053
Whitetopping (5)	$278,134
Average asphalt major rehabilitation cost	**$196,415**

Source: Costs for preservation, minor rehabilitation and major rehabilitation were found in tables C.1–C.20 from FHWA's 2010 report titled "Performance Evaluation of Various Rehabilitation and Preservation Treatments." (http://www.fhwa.dot.gov/PAVEMENT/pub_details.cfm?id=666).

Treatment costs from sample states were presented as a per-lane-mile dollar figure. These figures varied among sample applications due to geographic, economic and other factors.

Major rehabilitation costs for concrete and asphalt treatments were calculated by averaging sample application cost data from the same FHWA report. The major rehabilitation treatments were aggregated and averaged for an overall major rehabilitation cost (in 2010 dollars).

The per-lane-mile costs for all treatment applications were summed to calculate the total life cost for keeping one lane-mile of pavement in a state of good repair. The total was divided by 50 years (representing the assumed life of a road) to yield the annual cost figure. The annual concrete and asphalt state of good repair costs were then applied to the lane-miles owned by state highway agencies.

Calculating number of asphalt and concrete lane-miles

FHWA does not report state highway agency-owned lane-miles by surface type (concrete versus asphalt) within the publicly available FHWA Highway Statistics dataset. To calculate the total asphalt and concrete lane-miles owned by each state, the percentages of public centerline miles in each state (regardless of owner) that are asphalt versus concrete were calculated and then applied to the total centerline miles in the state-owned road network (as reported in FHWA Table HM-80) to estimate how much of the state-owned network is concrete and how much is asphalt.

FHWA reports road surface type characterized by functional system type in FHWA Table HM-51. The percentages of asphalt versus concrete roads within the public road network were determined for each functional system type with the exception of rural minor collectors, rural locals and urban locals, which are excluded from this FHWA dataset. These lower functionality roads were assumed to be asphalt in order to maintain a more financially conservative estimate of total cost. Asphalt roads included the surface type categories bituminous and composite. Unpaved roads were not taken into account.

The percentages for each road functionality type that were asphalt versus concrete were applied to the number of state highway agency–owned centerline miles to create the number of state highway agency–owned asphalt and concrete centerline miles.

Converting state-owned centerline miles to lane-miles

Next, the asphalt and concrete state-owned centerline miles calculated using the methodology described above were converted into lane-miles. To do this, multipliers were created for each functionality type using public roads data on total centerline miles (as reported in FHWA Table HM-20) and total lane-miles (as reported in FHWA Table HM-60). For each functionality type of public road, the number of lane-miles in each state was divided by the number of centerline miles. These numbers represented the approximate number of lane-miles that exist for every centerline mile within each functionality type. This calculation assumes that the estimate would also be similar for the state-owned network. Using these multipliers, the number of state-owned asphalt and concrete centerline miles were converted to asphalt and concrete lane-miles.

Generating the road network management cost

The number of asphalt lane-miles was multiplied by the annual pavement management cost for asphalt roads ($22,230), and the number of concrete lane-miles was multiplied by the average annual preservation cost for concrete roads ($23,021) for each functionality type. These costs were summed to create a total pavement management cost for each functionality type. The annual preservation cost for state highway agency-owned roads was then generated by the sum of each functionality type cost.

Data sources

Costs for preservation and major rehabilitation of asphalt and concrete roads were determined based on the following report:

- FHWA. (2010). "Performance Evaluation of Various Rehabilitation and Preservation Treatments." Tables C.1 – C.20. http://www.fhwa.dot.gov/PAVEMENT/pub_details.cfm?id=666.

The portions of public centerline miles that are asphalt versus concrete for each state were calculated based on the following table:

- FHWA Highway Statistics. (2011). "Functional System Length - 2011 Miles by Type of Surfaces." Table HM-51. http://www.fhwa.dot.gov/policyinformation/statistics/2011/hm51.

Centerline miles of state-owned road were calculated based on the following table:

- FHWA Highway Statistics. (2011). "State Highway Agency-Owned Public Roads – 2011 Miles by Functional System." Table HM-80. http://www.fhwa.dot.gov/policyinformation/statistics/2011/hm80.cfm.

Multipliers for the conversion from centerline miles to lane-miles were calculated based on the following tables:

- FHWA Highway Statistics. (2011). "Public Road Length - 2011 Miles by Functional System." Table HM-20. http://www.fhwa.dot.gov/policyinformation/statistics/2011/hm20.cfm.
- FHWA Highway Statistics. (2011). "Functional System Lane-Length - 2011 Lane-Miles." Table HM-60. http://www.fhwa.dot.gov/policyinformation/statistics/2011/hm60.cfm.

Backlog of state-owned roads in poor condition

Creating a lane-mile cost for major rehabilitation

The unfortunate consequence of deferred preservation and repair is that roads will eventually deteriorate to the point that they need to be majorly rehabilitated or reconstructed. Roads in poor condition as of 2011 were assumed to require major rehabilitation in order to bring them up to a state of good repair.

FHWA identifies six major rehabilitation treatments in its 2010 report "Performance Evaluation of Various Rehabilitation and Preservation Treatments." These treatments are applied to either "hot mix asphalt" pavement or "Portland cement concrete" pavement. FHWA provides cost data from sample applications of the six types of major rehabilitation treatments in six states (California, Kansas, Michigan, Minnesota, Texas and Washington). For each of the treatment types, the average cost per lane-mile was calculated. Next, the average costs of all three asphalt treatment types and all three concrete treatment types were averaged to generate a per-lane-mile cost for the major rehabilitation of poor asphalt and concrete roads (see Table B3 on page 32 for more information). Note that these major rehabilitation costs are in 2010 dollars. This number was later applied to the sum of state-owned roads in poor condition to determine what it would cost to bring the poor roads back to a state of good repair.

Generating annualized cost to rehabilitate state-owned major roads in poor condition

The state-owned lane-miles of road in poor condition were estimated as of 2011 (see Appendix A, Table A4). Then the numbers of these poor roads that were asphalt versus concrete were estimated based on the percentage of all public roads that were asphalt versus concrete. FHWA does not publicly report pavement condition data categorized by surface type, so this required making the assumption that the percentage of total public roads that are asphalt versus concrete (based on FHWA Table HM-51) would also apply to state-owned lane-miles of road in poor condition.

The total centerline miles of public roads that are asphalt and the total centerline miles of public roads that are concrete were calculated by summing asphalt and concrete roads for each state and functionality type in FHWA Table HM-51. Based on these calculations, 93 percent of all public roads were found to be asphalt and 7 percent were found to be concrete as of 2011. These percentages were then applied to the estimated state-owned lane-miles of road in poor condition to determine the number of asphalt and concrete lane-miles of road in poor condition as of 2011.

The calculated costs for asphalt and concrete major rehabilitation were applied to the estimated number of lane-miles of asphalt and concrete roads in poor condition. The resulting costs were summed to determine the total cost to rehabilitate all the roads in poor condition owned by each state. Recognizing that states would be unable to rehabilitate all of these roads at once, it was assumed that states would rehabilitate these roads over a 20-year period. The total cost, therefore, was divided by 20 years to create an annualized cost to bring major road lane-miles currently in poor condition to a state of good repair.

The calculations described above required two assumptions:

- The ratio of asphalt roads versus concrete roads for all public roads would also apply to state-owned lane-miles of road in poor condition.

- These calculations do not take into account that the number of roads in poor condition is likely to change over this 20-year period.

Data sources

Costs for major rehabilitation of asphalt and concrete roads were determined based on the following report:

- FHWA. (2010). "Performance Evaluation of Various Rehabilitation and Preservation Treatments." Tables C.1 – C.20. http://www.fhwa.dot.gov/PAVEMENT/pub_details.cfm?id=666.

The percentages of public centerline miles in poor condition for each state were calculated based on the following tables:

- FHWA Highway Statistics. (2011). "Functional System Length - 2011 Miles By Measured Pavement Roughness." Table HM-64. http://www.fhwa.dot.gov/policyinformation/statistics/2011/hm64.cfm.
- FHWA Highway Statistics. (2011). "Functional System Length - 2011 Miles By Measured Pavement Roughness/Present Serviceability Rating." Table HM-63. http://www.fhwa.dot.gov/policyinformation/statistics/2011/hm63.cfm.

Lane-miles of state-owned road were found in the following table:

- FHWA Highway Statistics. (2011). "State Highway Agency-Owned Public Roads - 2011 1/Rural and Urban Miles; Estimated Lane-Miles and Daily Travel." Table HM-81. http://www.fhwa.dot.gov/policyinformation/statistics/2011/hm81.cfm.

The percentage of public centerline miles that are asphalt versus concrete were calculated based on the following table:

- FHWA Highway Statistics. (2011). "Functional System Length - 2011 Miles by Type of Surfaces." Table HM-51. http://www.fhwa.dot.gov/policyinformation/statistics/2011/hm51.

Appendix C

Lane-miles in poor condition that could be brought into good repair by redirecting annual investment from expansion

States collectively spent an average of $20.4 billion per year on road expansion for 2009–2011 based on the analysis in this report (see Table A6 beginning on page 26). To determine how many roads in poor condition could be brought into a state of good repair per year if those funds were instead invested in repair, the cost of bringing a lane-mile of road in poor condition into good repair through major rehabilitation treatment was estimated. That cost was then used to determine the number of lane-miles that could be rehabilitated with an investment of $20.4 billion per year. The methodology below contains some repetition of the calculations described in previous appendices.

Cost of bringing a lane-mile of road in poor condition into good repair
The average costs of major rehabilitation for a single lane-mile of asphalt road ($196,405) and a single lane-mile of concrete road ($436,933) were estimated. These cost estimates were developed using a methodology described in Appendix B and were reviewed by an advisory team of former state DOT chief executives, senior infrastructure system managers and engineers at PennDOT.

Lane-miles that could be brought into good repair with an investment of $20.4 billion
Determining how many lane-miles in poor condition could be brought into good repair annually with an investment of $20.4 billion assumed the percentage of lane-miles repaired each year that would be asphalt versus concrete. FHWA does not publicly report pavement condition data categorized by surface type; it was assumed that the percentage of total public roads that are asphalt versus concrete (as reported in FHWA Table HM-51) would also apply to the public roads in poor condition that would be repaired each year. These costs were developed based on a report released by FHWA in 2010 and are in 2010 dollars.

The total centerline miles of public roads that are asphalt and the total centerline miles of public roads that are concrete were calculated by summing asphalt and concrete roads for each state and functionality type in FHWA Table HM-51. Asphalt roads included the surface type categories bituminous and composite. Based on these calculations, 93 percent of all public roads were found to be asphalt and 7percent were found to be concrete as of 2011.

The number of roads in poor condition that could be brought into a state of good repair each year through major rehabilitation was determined by assuming that 93 percent of the roads were asphalt (requiring major rehabilitation costing $196,405 per lane-mile) and 7 percent were concrete (requiring major rehabilitation costing $436,933). Based on an investment of $20.4 billion per year in major rehabilitation, 95,742 lane-miles in poor condition could be brought into a state of good repair per year.

Estimating impact on the backlog of state-owned roads in poor condition
The time it would take to eliminate the backlog of state-owned roads in poor condition was estimated based on an additional investment of $20.4 billion in repair per year. As described in Appendix A, FHWA reports pavement conditions data for public roads, a category that includes and does not distinguish between roads owned by states, federal agencies, counties and towns and municipalities. To estimate the backlog of state-owned lane-miles in poor condition, the

percentage of centerline miles of public road in poor condition as of 2008 (17 percent), calculated using the methodology described in Appendix A, was applied to the total lane-miles of road owned by the states (see Table A4 beginning on page 21). This calculation required making the assumption that the percentage of public centerline miles in poor condition as of 2008 was equivalent to the percentage of state-owned lane-miles of road in poor condition. Based on these assumptions, an estimated 321,542 lane-miles of state-owned road were in poor condition as of 2008, and this backlog of roads in poor condition could have been brought into a state of good repair in less than four years with a $20.4 billion annual investment in repair.

Data sources

Costs for major rehabilitation of asphalt and concrete roads were determined based on the following report:

- FHWA. (2010). "Performance Evaluation of Various Rehabilitation and Preservation Treatments." Tables C.1 – C.20. http://www.fhwa.dot.gov/PAVEMENT/pub_details.cfm?id=666.

The portion of public centerline miles that are asphalt versus concrete were calculated based on the following table:

- FHWA Highway Statistics. (2011). "Functional System Length - 2011 Miles by Type of Surfaces." Table HM-51. http://www.fhwa.dot.gov/policyinformation/statistics/2011/hm51.

The percentages of public centerline miles in poor condition for each state were calculated based on the following tables:

- FHWA Highway Statistics. (2011). "Functional System Length - 2011 Miles By Measured Pavement Roughness." Table HM-64. http://www.fhwa.dot.gov/policyinformation/statistics/2011/hm64.cfm.
- FHWA Highway Statistics. (2011). "Functional System Length - 2011 Miles By Measured Pavement Roughness/Present Serviceability Rating." Table HM-63. http://www.fhwa.dot.gov/policyinformation/statistics/2011/hm63.cfm.

Lane-miles of state-owned road were found in the following table:

- FHWA Highway Statistics. (2011). "State highway Agency-Owned Public Roads - 2011 1/Rural and Urban Miles; Estimated Lane-Miles and Daily Travel." Table HM-81. http://www.fhwa.dot.gov/policyinformation/statistics/2011/hm81.cfm.

Endnotes

1 Smart Growth America and Taxpayers for Common Sense. (2011). *Repair Priorities: Transportation spending strategies to save taxpayer dollars and improve roads*. Available at http://www.smartgrowthamerica.org/repair-priorities.

2 Calculated based on the Federal Highway Administration's Highway Statistical Series, for years 2004–2008. This data refers to the network of the nation's roads owned by state highway agencies. A "lane-mile" is a unit of measurement used to determine the size of a road network and accounts for road capacity as well as road length (for example, one mile of a six-lane highway would be measured as six lane-miles).

3 Smart Growth America and Taxpayers for Common Sense. (2011). *Repair Priorities: Transportation spending strategies to save taxpayer dollars and improve roads.* Available at http://www.smartgrowthamerica.org/repair-priorities. Calculated based on the Federal Highway Administration's Highway Statistical Series, for years 2004-2008.

4 Federal Highway Administration. (2011). Highway Statistics Series. Available at http://www.fhwa.dot.gov/policyinformation/statistics/2011.

5 Calculated based on the Federal Highway Administration's Highway Statistical Series, for years 2009–2011. See Appendix A on page 14 for full methodology.

6 Calculated based on the Federal Highway Administration's Highway Statistical Series for 2008. See Appendix A on page 14 for full methodology.

7 Calculated based on the Federal Highway Administration's Highway Statistical Series, for years 2009–2011. See Appendix A on page 14 for full methodology.

8 Estimated based on the Federal Highway Administration's (FHWA) Highway Statistics Series for years 2008 and 2011. FHWA reports pavement conditions for "public roads," a category that includes and does not distinguish between roads owned by states, federal agencies, counties and towns and municipalities. This means that there is not enough information to determine how the pavement condition of roads owned exclusively by states have changed over time, and these figures represent estimates based on available data for all public roads. More information about how state road conditions were estimated is available in Appendix A on page 14.

9 Calculated based on the Federal Highway Administration's Highway Statistical Series, for years 2009–2011 and 2004–2008. See Appendix A on page 14 for full methodology.

10 Calculated based on the Federal Highway Administration's Highway Statistical Series, for years 2009–2011 and 2004–2008. See Appendix A on page 14 for full methodology.

11 American Association of State Highway and Transportation Officials (AASHTO) and the Road Information Project. (2009). "Rough Roads Ahead: Fix Them Now or Pay for It Later." Available at http://www.ttap.mtu.edu/library/RoughRoadsAhead.pdf.

12 Calculated based on the Federal Highway Administration's Highway Statistical Series, for years 2004–2008.

13 Calculated based on the Federal Highway Administration's Highway Statistical Series, for years 2009–2011. This figure is in 2010 dollars. See Appendix B on page 29 for full methodology.

14 Calculated based on the Federal Highway Administration's Highway Statistical Series, for years 2009–2011, based on the assumption that the 1.9 million lane-miles of state-owned roads have the same portion in poor condition as public roads—17 percent as of 2008. The road repair treatment costs used in this calculation are in 2010 dollars. See Appendix C on page 37 for full methodology.

15 Calculated based on the Federal Highway Administration's Highway Statistical Series, for years 2009–2011. See Appendix C on page 37 for full methodology.

16 Calculated based on the Federal Highway Administration's Highway Statistical Series, for years 2009–2011. See Appendix A on page 14 for full methodology.

17 Texas Transportation Institute. (2012). *2012 Urban Mobility Report.* Available at http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/mobility-report-2012.pdf.

18 American Society of Civil Engineers. (2013). *2013 Report Card for America's Infrastructure*. Available at http://www.infrastructurereportcard.org/a/#p/roads/conditions-and-capacity.

19 Wyoming Department of Transportation. (2013, September 3). "19 Projects Planned for Additional Fuel Tax Revenue in FY 2014." Retrieved January 13, 2014, from http://www.dot.state.wy.us/news/19-projects-planned-for-additional-fuel-tax-revenue-in-fy-2014.

20 Michigan Department of Transportation. https://www.michigan.gov/mdot/0,4616,7-151-9621_15757---,00.html.

21 TRIP. (2013, October). Bumpy Roads Ahead: America's roughest rides and strategies to make our roads smoother. Available at http://www.tripnet.org/docs/Urban_Roads_Report_Oct_2013.pdf.

22 Estimated state-owned lane-miles in poor condition as of 2011 is the product of state-owned lane-miles and percent of public centerline miles in poor condition (see Table A2 for full centerline mile calculations).

23 See note 22.

24 See note 22.