FINAL REPORT

AN ANALYSIS OF SECONDARY ROAD MAINTENANCE PAYMENTS TO HENRICO AND ARLINGTON COUNTIES WITH THE DECEMBER 2001 UPDATE

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DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Virginia Department of Transportation, the Commonwealth Transportation Board, or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

PREFACE: DECEMBER 2001 UPDATE

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BACKGROUND

During discussions with officials from the Henrico County Department of Public Works subsequent to the publication of the May 2001 report (included herein), the officials stated that the estimate of "indirect/overhead" costs provided by Henrico County did not fully account for all such costs related to the construction and maintenance of secondary roads. At the request of the Commonwealth Transportation Board, the Virginia Transportation Research Council updated the study of maintenance payments to Henrico and Arlington counties based on the most recent data available. Specifically, this update:

1. updates the approach described as "Method 1: Allocations Based on Factors Significantly Associated with Maintenance Expenditures" based on new cost data

2. discusses the issue of identifying "indirect" costs incurred as a result of maintaining and constructing secondary roads and reimbursing Henrico and Arlington counties for such costs

3. updates the approach described as "Method 3: Allocations Based on City Street Payments."

METHODOLOGY

The researcher completed two tasks to update the original study:

1. identified and collected revised data, including "indirect" costs

2. updated the appropriate analytical approaches based on the new data.

Identification and Collection of Data

The researcher requested updated secondary road maintenance and construction cost and allocation data as well as moving-lane-mile data from Henrico and Arlington counties. In addition, the researcher obtained from VDOT the FY 02 city street payment rates for moving-lane-miles by functional classification.

Indirect Cost Data

Officials from the Henrico County Department of Public Works provided FY 01 "indirect" cost data and the FY 02 budget for "indirect" costs. In addition, Henrico County provided FY 00 expenditure data for secondary maintenance to document that the Henrico County General Fund provided $2.02 million for operations above the state's allocation from state sources to Henrico County.

Arlington County provided a completed survey containing FY 00 data that they had sent in response to a request from the Weldon Cooper Center for Public Service. However, the data in the survey were not in a useable form. Therefore, the researcher made an additional request for data from Arlington County. However, Arlington County had not yet provided the data when this update was completed.

Moving-lane-mile Data

Henrico and Arlington counties provided estimates of the numbers of secondary road moving-lane-miles by state functional classification (arterial, collector, and local streets). Henrico County provided the "most accurate representation of state functional classification and moving-lane-miles on that classification of Henrico County secondary roads" according to a transportation development engineer (County of Henrico, 2001).

Arlington County provided an estimate of the numbers of moving-lane-miles by functional classification. The Arlington County official said that the estimates of the numbers of secondary arterial and collector moving-lane-miles were based on distances. However, the estimate of the number of moving-lane-miles of local secondary roads was estimated based on the width of the streets and parking polices (County of Arlington, 2001).

Analytical Approaches

The researcher updated the two analytical approaches that were completed in the original study based on the new data provided by Henrico and Arlington counties.

Method 1: Allocations Based on Factors Significantly Associated With Maintenance Expenditures

The researcher applied the appropriate Maintenance Cost Index (MCI) factor to the FY 00 results included in Tables 1 and 2 of the May 2001 report to obtain the estimated FY 02 allocations for Henrico and Arlington counties. For Henrico, the researcher applied the appropriate MCI factor to the results included in Table 1 of the report and added the new indirect/overhead cost data provided by Henrico to obtain the estimated FY 02 maintenance allocation.

Based on the data provided, it was apparent that Henrico classifies and charges "indirect" costs in a manner different than VDOT's. VDOT charges design, inspection, engineering, and planning costs directly to construction projects whenever possible. This is consistent with standard cost accounting principles for distinguishing between direct and indirect costs. As a result, in general, VDOT charges all design and construction inspection and significant portions of environmental inspection, traffic engineering, and transportation planning and development costs against construction allocations. However, Henrico charges much of these costs to "indirect overhead." Therefore, the researcher used the "indirect" cost data provided by Henrico to calculate different cost scenarios. The "indirect" cost data for FY 02 provided by Henrico are presented in Table P1.

For Arlington, since no new indirect cost data were provided, the researcher applied the appropriate MCI factor to the results included in Table 2 of the May 2001 report to obtain the estimated FY 02 maintenance allocation.

Table P1. Henrico County Overhead Costs for FY 02

Overhead Cost Category	FY 02 Budget Amount ($)
Traffic engineering	2,548,954
Administration	2,118,302
Design	1,620,429
Construction inspection	1,383,538
Environmental inspection	861,184
Transportation planning and development	580,790
Technology	221,829
Total	**9,335,026**

Method 3: Allocations Based on City Street Payments

The researcher used the moving-lane-mile data provided by Henrico and Arlington counties along with the FY 02 city and town payment rates for moving-lane-miles by functional classification to estimate the maintenance allocations that Henrico and Arlington would receive if they were paid in accordance with § 33.1-41.1 of the *Code of Virginia*.

RESULTS

Method 1: Allocations Based on Factors Significantly Associated With Maintenance Expenditures

Table P2 presents the estimated FY 02 maintenance allocation determined using the factors significantly associated with maintenance expenditures for Henrico based on three scenarios. The Scenario 1 assumes that Henrico is paid for all "indirect" costs. In Scenario 2, 100% of the construction inspection and 100% of the design costs are treated as direct costs of the secondary construction program. In Scenario 3, 100% of design and construction inspection, 80% of environmental inspection, and 20% of traffic engineering costs are treated as direct costs of the secondary construction program. It is reasonable to argue that Scenario 3 most closely

Table P2. Estimated FY 02 Allocation for Henrico Based on Model Results

Scenario	Maintenance Allocation	Overhead Costs	Total Allocation	Effective Rate Per Lane Mile[1]
1[2]	$13,121,024	$9,335,026	$22,456,050	$7,332
2[3]	$13,121,024	$6,331,059	$19,452,083	$6,351
3[4]	$13,121,024	$5,132,321	$18,253,345	$5,959

[1]Based on 3,062.94 lane miles.
[2]All overhead costs are included.
[3]Overhead costs except 100% construction inspection and 100% design are included.
[4]Overhead costs except 100% construction inspection, 100% design, 80% environmental inspection, and 20% traffic engineering are included.

approximates an allocation that is most consistent with the method VDOT uses to allocate maintenance funds for secondary roads over which it has jurisdiction.

Table P3 presents the estimated FY 02 maintenance allocation determined using the factors significantly associated with maintenance expenditures for Arlington.

Table P3. Estimated FY 02 Allocation for Arlington Based on Model Results

Maintenance Allocation	Overhead Costs	Total Allocation	Effective Rate Per Lane Mile[1]
$8,321,925	$5,449,338	$13,771,263	$14,376

[1]Based on 957.96 lane miles.

Method 3: Allocations Based on City Street Payments

Table P4 presents the estimated FY 02 maintenance allocations that Henrico and Arlington would receive if they were treated as cities and paid in accordance with § 33.1-41.1 of the *Code of Virginia.*

Table P4. Estimated FY 02 City Street Payments for Henrico and Arlington Counties

County	Number of Moving-lane-miles	Total Payment	Effective Rate per Lane Mile[1,2]
Henrico	2,617.39	$21,817,382	$7,123
Arlington	672.89	$5,971,816	$6,234

[1]Effective rate is calculated by dividing total payment by total lane miles (not moving-lane-miles).
[2]FY 02 total lane miles are 3,062.94 for Henrico and 957.96 for Arlington.

SUMMARY AND CONCLUSIONS

The researcher updated the analyses for two approaches based on new data to examine the FY 02 maintenance allocations for Henrico and Arlington counties. Table P5 summarizes the results of the updated analyses for Henrico County for FY 02 and presents the FY 02 allocation in accordance with § 33.1-23.5:1 of the *Code*. Table P5 shows that the proportion of

Table P5. Actual and Estimated FY 02 Allocations for Henrico County

Approach	FY 02 Total	FY 02 Per Lane Mile[1]
Actual allocation in accordance with Code[2]	$18,429,783	$6,017
Significantly associated factors with all overhead except 100% construction inspection, 100% design, 80% environmental inspection, and 20% traffic engineering[3]	$18,253,345	$5,959
Significantly associated factors with all overhead except construction inspection and design[4]	$19,452,083	$6,351
City payments for comparison only	$21,817,382	$7,123
Significantly associated factors with all overhead[5]	$22,456,050	$7,332

[1]Lane mile figures are *derived* based on dividing the total allocation by total lane miles for comparison with rates in the *Code.*
[2]Actual allocation in accordance with § 33.1-23.5:1 of the *Code.*
[3]Overhead costs except 100% construction inspection, 100% design, 80% environmental inspection, and 20% traffic engineering are included.
[4]Overhead costs provided by Henrico except 100% construction inspection and 100% design are included.
[5]All overhead costs provided by Henrico are included.

costs that are judged to be appropriate reimbursements for "indirect/overhead" costs significantly influences the estimated allocations. If Henrico were reimbursed for "indirect/overhead" costs according to the scenario that is most consistent with the method used by VDOT to allocate maintenance funds, the resulting allocation to Henrico would be within 1% of the actual allocation presently specified in the *Code*. In comparison, if Henrico were reimbursed for all costs identified as "indirect/overhead" costs, Henrico would receive $4.026 million (approximately 22%) more than the amount currently specified in the *Code*.

Table P6 summarizes the results of the updated analyses for Arlington for FY 02 and presents the FY 02 allocation in accordance with § 33.1-23.5:1 of the *Code*. The results show that treating Arlington County as a city would result in a significant reduction in the total allocation.

Table P6. Actual and Estimated FY 02 Allocations for Arlington County

Approach	FY 02 Total	FY 02 Per Lane Mile[1]
Actual allocation in accordance with Code[2]	$11,478,721	$11,982
City payments for comparison only	$5,971,816	$6,234
Significantly associated factors	$13,771,263	$14,376

[1]Lane mile figures are *derived* based on dividing the total allocation by total lane miles for comparison with rates in the *Code*.
[2]Actual allocation in accordance with § 33.1-23.5:1 of the *Code.*

In conclusion, the statistical model approach that estimates allocations based on population and lane miles is *very* attractive because it is logical and can be used to adjust rates as a county grows. The key issue that significantly affects the allocation when the statistical model approach is used is the determination of the proportion of "indirect/overhead" costs that is judged to be appropriate for reimbursement to Henrico and Arlington. The "city street" approach is included solely for comparison purposes and is not recommended as a basis for establishing allocations for Henrico or Arlington.

REFERENCES

County of Henrico. (November 28, 2001). Telephone conversation with Eric Millirons, Henrico County Department of Public Works, Richmond.

County of Arlington. (December 7, 2001). Telephone conversation with Joe Durkee, Arlington County Department of Public Works, Arlington.

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EXECUTIVE SUMMARY

In 1986, § 33.1-23.5:1 of the *Code of Virginia* established new rates for payments to Henrico and Arlington counties to maintain their secondary roads and specified how the rates were to be adjusted annually. The rates specified for 1986 maintenance payments were $3,616 per lane mile for Henrico County and $7,201 per lane mile for Arlington County. Rates were to be adjusted annually thereafter using a maintenance cost index.

In spring of the year 2000, in deliberations over the Appropriations Act for the 2000–2002 biennium, Virginia's General Assembly discussed the need for a study of transportation allocations to localities, focusing especially on Henrico and Arlington counties. Subsequently, House Bill 30 directed that "[t]he Department of Transportation shall review the formulas used in determining the financial assistance to localities distributions [*sic*] and make recommendations to the Commonwealth Transportation Board as to the appropriate allocations based on that review."

In April 2000, the director of public works for Henrico County made a presentation to the Commonwealth Transportation Board's Finance Committee in which he argued that the county's secondary maintenance allocation was insufficient (County of Henrico, 2000). In the presentation, maintenance rates for Henrico County were compared with various data sets, including average urban rates in each of VDOT's nine construction districts; the statewide average urban rate; individual urban rates in VDOT's Richmond District; and rates for cities argued to be comparable to Henrico County. In response, the Commonwealth Transportation Board agreed to a temporary increase in Henrico County's rate per lane mile for FY 01 from $5,720 to $8,581. This increased the county's FY 01 total secondary road maintenance allocation from $17.3 million to $25.9 million.

The purpose of the analysis documented in this report was to respond to the requirements set forth in House Bill 30. Because of the legislative history regarding the language in the bill, the analysis was limited to maintenance payments to Henrico and Arlington counties. To complete the analysis, data on maintenance expenditures and allocations, lane miles, population, local economic conditions, and other factors were collected for all counties and cities with a population over 20,000 in the Commonwealth.

The researchers tested three analytical approaches to estimate appropriate maintenance allocations to Henrico and Arlington counties: (1) a statistical analysis based on factors found to be significantly associated with secondary road maintenance expenditures across all counties in Virginia; (2) an analysis that sought to identify counties in the state secondary system that are comparable to Henrico and Arlington counties; and (3) an estimation of allocations based on rates established in the *Code of Virginia* for payments for city streets. After extensive analysis and statistical tests, the comparable localities approach was rejected because it could not account for the urbanization and rural mix found in Henrico County. In addition, no counties were found to be comparable to Arlington County.

Of the three methods tested, the method using factors that were shown to have a strong influence on maintenance expenditures is the most reasonable, accurate, and supportable

approach for estimating maintenance allocations to Henrico and Arlington counties. The advantages of the statistical model are that it is comprehensive (it uses population, lane mile, and secondary road maintenance expenditure data for every county in the Commonwealth) and it is easy to update as new data become available. It is also intuitively logical in that population growth and growth in system size should affect maintenance cost. With this approach, county population from the most recent census and official secondary road lane miles explain almost 95% of the variation in total expenditures for secondary road maintenance across all counties in Virginia. With this approach, the higher the population and the greater the lane miles, the larger the total maintenance allocation. Numerous other growth and economic factors were tested, but none proved significant enough to include as part of the formula. The method also includes amounts for administering the maintenance programs for Henrico and Arlington counties based on annual figures for those counties. For the year 2001, administrative costs for Henrico are estimated to be $5.8 million and for Arlington are approximately $5.2 million. (It should be noted that actual figures on administration costs for Arlington County were not available at the time this report was completed.)

For comparison purposes only, total estimated allocations are provided based on treating Henrico and Arlington as cities. At best, the estimated "city street" allocations shown in Tables A and B are approximations because actual data for "moving-lane-miles" by functional class (required by the *Code of Virginia* to calculate city street payments) were not available.

Tables ES-1 and ES-2 show the estimated allocations for Henrico and Arlington counties using the significantly associated factors (i.e., population and lane miles) approach and the city street payment approach. The tables also show FY 00 and FY 01 allocations in accordance with § 33.1-23.5:1 of the *Code*. For FY 01, a formula based on population and lane miles would

Table ES-1. Estimated and Actual FY 00 and FY 01 Allocations for Henrico County[1]

	FY 00		FY 01	
Approach	**Total**	**Per Lane Mile[2]**	**Total**	**Per Lane Mile[2]**
Significantly associated factors	$17,227,490	$5,774	$18,123,632	$6,005
City payments[3] for comparison only	$18,074,742	$6,058	$19,017,326	$6,301
Actual allocation in accordance with *Code*[4]	$16,409,444	$5,500	$17,263,246	$5,720

[1]Henrico County received a one-year allocation of $25,897,187 in FY 01 ($8,581 per lane mile).
[2]Lane mile figures are *derived* based on dividing the total allocation by total lane miles.
[3]Assumes that 80% of Henrico County's lane miles would be eligible for payment under § 33.1-41.1 of the *Code.*
[4]Actual allocation in accordance with § 33.1-23.5:1 of the *Code.*

Table ES-2. Estimated and Actual FY 00 and FY 01 Allocations for Arlington County

	FY 00		FY 01	
Approach	**Total**	**Per Lane Mile[1]**	**Total**	**Per Lane Mile[1]**
Significantly associated factors	$12,585,129	$13,142	$13,091,264	$13,667
City payments[2] for comparison only	$6,032,127	$6,299	$6,275,271	$6,551
Actual allocation in accordance with *Code*[3]	$10,488,983	$10,953	$10,911,924	$11,392

[1]Lane mile figures are *derived* based on dividing the total allocation by total lane miles.
[2]Assumes that 80% of lane miles would be eligible for payment under § 33.1-41.1 of the *Code.*
[3]Actual allocation in accordance with § 33.1-23.5:1 of the *Code.*

allocate approximately $18.124 million to Henrico County. This is approximately $860 thousand more than the rate specified in the *Code* and approximately $7.774 million less than the temporary allocation of $25.897 million. Arlington County's allocation would be increased by approximately $2.179 million using the population and lane mile approach.

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BACKGROUND

In 1932, Virginia's General Assembly authorized the establishment of the state secondary road system. The Byrd Road Act, as the legislation was called, also permitted each county, if it wished, to hand over responsibility for constructing and maintaining its secondary roads to the State Highway Commission. Four counties—Arlington, Henrico, Nottoway, and Warwick—chose to keep the responsibility. In 1933, Nottoway reversed its earlier decision and joined the state secondary road system. Years later, Warwick gave up its county status to become a city that eventually merged with Newport News. Today, of the 95 counties in Virginia, only Henrico and Arlington counties continue to construct and maintain their own local roads.

Until 1986, the funds Henrico and Arlington counties received for their secondary roads were based on the formula established in 1932. The formula was based on the distribution of funds in 1930, which allocated 30% of gas tax receipts to the counties for maintenance and construction of local roads and had little relationship to transportation needs (Joint Legislative Audit and Review Commission [JLARC], 1984). As part of the 1982 Appropriations Act, Virginia's General Assembly directed JLARC to conduct a study of the "reasonableness, appropriateness, and equity" of the statutory provisions for allocating highway construction funds. The General Assembly subsequently directed that the study be expanded to include other major programs of the Highway Maintenance and Construction Fund. In 1984, JLARC published the results of their study (JLARC, 1984), which included recommendations concerning the allocations of funds for Henrico and Arlington counties.

To assess the equity of the allocations for these counties, JLARC conducted an analysis based on the premise that the allocations should be equivalent to the allocations for counties in the state secondary system. However, the allocations for Henrico and Arlington included funding for all the secondary system programs, including construction, maintenance, and administration, whereas allocations to counties in the state's secondary road system were for construction only. Maintenance and other secondary activities were budgeted separately by the Department of Highways and Transportation. In order to come up with amounts for Henrico and

Arlington counties to compare with the amounts received by counties in the state-maintained secondary road system, JLARC staff estimated maintenance costs; administration, traffic engineering, design, and inspection costs; and construction allocations for the two counties. The estimated maintenance costs were based on the county allocations prepared by VDOT for maintenance on the secondary system. Arlington County's cost was based on that for Fairfax County, and Henrico County's cost was based on that for Chesterfield County. The estimates for the administrative, engineering, design, and inspection costs were based on direct estimates from Henrico and Arlington. As the result of their analysis, JLARC recommended that the General Assembly adopt new rates for allocating funds to Henrico and Arlington counties.

In 1986, these changes were codified in § 33.1-23.5:1 of the *Code of Virginia* (see the Appendix). The rates specified for 1986 maintenance payments were $3,616 per lane mile for Henrico County and $7,201 per lane mile for Arlington County. Rates were to be adjusted annually thereafter using a maintenance cost index (MCI).

In spring of the year 2000, in deliberations over the Appropriations Act for the 2000-2002 biennium, Virginia's General Assembly discussed the need for a study of transportation allocations to localities, focusing especially on Henrico and Arlington counties. Subsequently, House Bill 30 directed that "[t]he Department of Transportation shall review the formulas used in determining the financial assistance to localities distributions *[sic]* and make recommendations to the Commonwealth Transportation Board as to the appropriate allocations based on that review."

In April 2000, the director of public works for Henrico County made a presentation to the Commonwealth Transportation Board's Finance Committee in which he argued that the county's secondary maintenance allocation was insufficient (County of Henrico, 2000). In the presentation, maintenance rates for Henrico County were compared with various data sets, including average urban rates in each of VDOT's nine construction districts; the statewide average urban rate; individual urban rates in VDOT's Richmond District; and rates for cities argued to be comparable to Henrico County. In response, the Commonwealth Transportation Board agreed to a temporary increase in Henrico County's rate per lane mile for FY 01 from $5,720 to $8,581. This increased Henrico County's FY 01 total secondary road maintenance allocation from $17.3 million to $25.9 million.

PURPOSE AND SCOPE

The purpose of this analysis was to respond to the requirements set forth in House Bill 30 from the 2000 Session of Virginia's General Assembly. Because of the legislative history regarding the language in the bill, the analysis was limited to maintenance payments to Henrico and Arlington counties.

METHODOLOGY

The researchers conducted the study in three steps:

1. JLARC's 1984 study, Henrico County's April 2000 presentation to the Commonwealth Transportation Board, and the relevant sections of the *Code* were reviewed.

2. Required data were identified and obtained.

3. Appropriate analytical approaches were developed and used.

Identification and Collection of Data

To gain a complete picture of the issues at hand, the researchers gathered the following data for all counties in Virginia: full maintenance expenditures, including basic costs (labor, equipment, materials) and overhead; secondary road data; and demographic data. Data were collected from a number of sources including the Weldon Cooper Center for Public Service of the University of Virginia, VDOT central office divisions and districts, and Henrico and Arlington counties.

Maintenance Expenditure Data

VDOT's Maintenance Division provided FY 99 and FY 00 secondary system maintenance expenditures from VDOT's financial management system (FMS II) for each county VDOT maintains. These expenditures included overhead costs and other adjustments as follows:

- direct and indirect labor costs were loaded with a 60% additive for fringe benefits

- equipment costs were loaded with overhead values ranging from 25% to 50% (approximately) depending on the type of equipment and its location throughout the state

- materials costs were loaded with an approximate 16% overhead rate for materials obtained from VDOT's Central Warehouse or an approximate 27% overhead rate for most items obtained through the National Automotive Parts Association.

Detailed maintenance expenditure data for VDOT's Northern Virginia District (NOVA) from FY 95 through FY 97 (the most recent readily available detailed data) were obtained to determine the proportion of maintenance expenditures that are labor related, since VDOT pays a differential to workers in NOVA. These data indicated that labor and the labor portion of contract expenditures were approximately 50% of total expenditures. The NOVA pay differential for equipment operators (now called maintenance team members) and area supervisors is 12 steps (approximately 30%), and the differential for area superintendents is 8 steps (approximately 20%). Since equipment operators perform a substantial percentage of the labor on the secondary system, a conservative differential of 25% was applied to the 50% of the expenditures that were labor related in NOVA. Secondary road maintenance expenditures and allocations for localities in NOVA were adjusted by 12.5% to reflect the labor differential.

The allocation information from the JLARC study (JLARC, 1984) was employed to subtract out the administration, traffic engineering, design, and inspection costs of the allocations paid to Henrico and Arlington counties. As described previously, JLARC staff combined ordinary maintenance and maintenance replacement costs from the respective comparable county (Chesterfield County for Henrico County and Fairfax County for Arlington County) to Henrico and Arlington counties' expenditures for administration, traffic engineering, design, and inspection to determine a base rate for Henrico and Arlington counties. The researchers used the ratio of the maintenance costs to the combined costs of maintenance and administration, traffic engineering, design, and inspection for Henrico and Arlington counties to determine the FY 00 allocation for maintenance that each of the two counties received. Subtracting out Henrico and Arlington counties' costs for administration, traffic engineering, design, and inspection resulted in all maintenance expenditure and allocation data only, including expenses and allocations for ordinary maintenance and maintenance replacement activities.

As in the JLARC study, officials from Henrico and Arlington counties were contacted to obtain their actual FY 00 expenditures for administration, traffic engineering, design, and inspection. Arlington County's actual expenditures were not available when this report was written. Therefore, the researchers estimated the allocation that Arlington County received in FY 00 for these activities based on the data included in the JLARC study, updated by the MCI. Arlington County's estimated cost for administration, traffic engineering, design, and inspection for FY 00 was $5.0 million (this means that administrative costs are estimated to be almost $5,200 on a per lane mile basis). Henrico County data indicated that the county expended $5.5 million ($1,858 per lane mile) on these activities in FY 00 (based on 2,983.57 secondary lane miles). As an internal check on the reasonableness of the data on administrative costs, the researchers also estimated Henrico County's allocation for these activities using the data in the JLARC report. The estimated cost for Henrico County for FY 00 was $5.7 million, which is within approximately 3% of Henrico County's actual FY 00 expenditures.

MCI values and maintenance payment data for Henrico and Arlington counties for FY 00 and FY 01 were obtained from VDOT's Maintenance Division. The MCI is based on a fixed "basket" of unit costs for labor, equipment, and materials that is updated annually to reflect changes in these costs. The MCI is used by VDOT to adjust base rate maintenance allocations to counties and cities on an annual basis.

Secondary Road Data

Secondary road mile and lane mile data as of December 31, 1999, were obtained from VDOT road mileage books for VDOT-maintained counties. Henrico and Arlington counties each provided the lane mileage data and the number of lane miles by functional classification (principal arterials, minor arterials, collector and local roads) for their county. VDOT's Urban Division supplied the city street payment rates and the maintenance payments to urban localities.

Until the early 1980s, VDOT collected traffic count data every other year on every section (connection between two intersections or an intersection and the end of the road) of secondary road maintained by VDOT. Since then, VDOT has sampled only a small percentage

of the hard-surfaced roads in each county. Traffic counts on road sections without a hard surface are made every other year. Since hard-surfaced traffic count sites are not randomly selected, the researchers did not use secondary road traffic count data in the analyses.

Demographic and Economic Data

In order to be able to identify localities that are comparable to Henrico and Arlington counties, the researchers obtained the most recent demographic and economic data for all counties and cities with a population over 20,000 from the Weldon Cooper Center for Public Service at the University of Virginia. The data included:

- population (1990 census data)
- estimated population (1998 data)
- population growth (1990-1998 data)
- population density (calculated from 1998 population projections and 1990 area data)
- geographic area (1990 data)
- number of households (1990 data)
- median household income (1995 data)
- number of residential building permits (1999 data)
- number of private non-farm business establishments (1997 data)
- gross retail sales (1997 data)
- retail sales per capita (1997 data)
- sales and use tax (1999 data)
- manufacturing shipments (1997 data)
- public works expenditures for each major urban locality (1999 data).

At the request of Henrico County representatives, data from the 2000 census and taxable sales (rather than gross retail sales) were collected, specifically:

- population (2000 census data)

- population density (calculated from 2000 census data and 1990 area data)
- population growth (1990-2000 data)
- taxable sales (1999 data).

Analytical Approaches

The researchers identified three approaches to estimate secondary road maintenance allocations for Henrico and Arlington counties. The approaches estimated allocations based on the following:

1. factors significantly associated with secondary road maintenance expenditures
2. secondary road maintenance expenditures of comparable localities
3. city street payments.

Method 1: Allocations Based on Factors Significantly Associated with Maintenance Expenditures

The first approach used to analyze Henrico and Arlington counties' secondary road maintenance allocations was statistical modeling (i.e., multiple regression equations). Regression models are a statistical tool that can be used to explain the relationship between an independent variable (such as maintenance expenditures in this case) and explanatory variables (such as population, number of lane miles, land area, etc., in this case). That is, regression models can be used to identify which variables explain, or do not explain, the variability in the independent variable. In this case, statistical models were developed to estimate maintenance expenditures (or allocations in the case of Henrico and Arlington counties) for all of Virginia's counties based on a number of factors that were shown to influence these expenditures.

All counties were included in the model in order to obtain an objective picture of secondary road maintenance expenditures throughout the Commonwealth. Once a good statistical model for maintenance allocations across the Commonwealth was developed, it was used to estimate maintenance payments for Henrico and Arlington.

The researchers tested all of the variables identified in the data section of the report for which data were available for every county in order to construct a statistical model that best explained the variation in maintenance payments in all counties in the Commonwealth. The best performing model was used to estimate FY 00 ordinary maintenance and maintenance replacement allocations for Henrico and Arlington counties. Arlington County's estimate was subsequently readjusted to reflect the labor differential in NOVA. Arlington County's estimated and Henrico County's actual FY 00 costs for administration, traffic engineering, design, and inspection were added to obtain estimated FY 00 allocations for each county. The researchers

applied the appropriate MCI factor to the FY 00 estimated allocations to obtain the estimated FY 01 allocations.

Method 2: Allocations Based on Maintenance Expenditures in Comparable Localities

The researchers sought to identify the Virginia counties and cities most comparable to Henrico County and Arlington County in order to compare their secondary maintenance allocations per lane mile. The researchers used measures of economic activity, demographics, and secondary road system factors in this effort.

Method 3: Allocations Based on City Street Payments

For comparison purposes, a third method was included. This method estimated the upper bound of secondary road maintenance dollars Henrico and Arlington counties would receive if they were treated as cities, as specified in § 33.1-41.1 of the *Code* (see the Appendix). These calculations were undertaken because Henrico County's presentation to the Commonwealth Transportation Board in April 2000 argued the county's comparability to several Virginia cities (County of Henrico, 2000).

RESULTS

Method 1: Allocations Based on Factors Significantly Associated with Maintenance Expenditures

The best model, based on the data obtained, used population and lane miles to predict secondary road expenditures and allocations. The model is shown as:

Total allocation for FY 00 ($) = 355,565.09 + (25.456 x population) + (1,541.081 x lane miles).

where

population = 2000 census population

lane miles = actual secondary lane miles as of December 31, 1999.

The adjusted R^2 (an indicator of the explanatory power) of this approach was very high—0.94 of a maximum value of 1.00. This means that the model explained 94% of the variation in secondary road expenditures among counties.

Population was by far the strongest predictor of maintenance expenditures and allocations; the number of secondary lane miles was second. Both population and lane miles were statistically significant predictors of maintenance allocations and expenditures. At the

request of Henrico County, lane miles per road mile was tested as a predictor but was not used in the final model because it added little explanatory power and varied little among counties.

Table 1 presents the best model's estimated total allocations for maintenance activities for Henrico and Arlington counties for FY 00 and FY 01. Allocations per lane mile are derived by dividing the total allocation based on the model by total secondary lane miles. This provides an easy comparison to the lane mile rates in the *Code*. Again, Arlington County's estimate for maintenance was readjusted to reflect NOVA's labor differential.

Table 1. FY 00 and FY 01 Estimated Maintenance Allocations and Allocations per Lane Mile for Henrico and Arlington Counties Based on Model Results Excluding Administrative Costs[1]

County	Allocation	FY 00	FY 01
Henrico	Total	$11,683,844	$12,291,612
	Per lane mile[2]	$3,916	$4,073
Arlington	Total	$7,605,144	$7,911,004
	Per lane mile[2]	$7,941	$8,259

[1]Allocations presented include only costs for ordinary maintenance and maintenance replacement activities.
[2]Derived for comparison with rates in the *Code*.

Table 2 presents the estimated total FY 00 and FY 01 allocations for Henrico and Arlington counties (including maintenance, administration, traffic engineering, design, and inspection costs) and the estimated per lane mile allocation based on the estimates from the statistical model. Henrico County's actual and Arlington County's estimated costs for administration, traffic engineering, design, and inspection were added to the estimates in Table 1.

Table 2. FY 00 and FY 01 Estimated Total Maintenance Allocations and Allocations per Lane Mile for Henrico and Arlington Counties Based on Model Results Including All Administrative Costs[1]

County	Allocation	FY 00	FY 01
Henrico	Total	$17,227,490	$18,123,632
	Per lane mile[2]	$5,774	$6,005
Arlington	Total	$12,585,129	$13,091,264
	Per lane mile[2]	$13,142	$13,667

[1]Allocations presented include cost of administration, traffic engineering, design, and inspection and ordinary maintenance and maintenance replacement activities. These costs for FY 01 were approximately $5.83 million for Henrico and approximately $5.2 million for Arlington.
[2]Derived for comparison with rates in the *Code*.

Method 2: Allocations Based on Maintenance Expenditures in Comparable Localities

The researchers explored extensively using demographic, economic, and secondary road system factors to identify comparable localities for Henrico and Arlington. In the analyses, the researchers found that many of these factors were highly correlated and, thus, could not be used as independent measures to determine comparable localities. In addition, the comparable localities approach could not recognize pockets of urbanization and growth, such as those in Henrico County. Further, no counties were identified as being comparable to Arlington County.

Ultimately, the researchers determined that the comparable localities approach could not be used to estimate allocations for Henrico and Arlington counties and rejected this approach in favor of the stronger logic associated with Method 1, which was based on population and lane miles.

Method 3: Allocations Based on City Street Payments

Some of the localities identified in the preliminary review of the demographic and economic data as being somewhat comparable to Henrico and Arlington counties were cities. However, unlike Henrico and Arlington counties, urban areas (cities) in Virginia receive city street payments for their lane miles as specified in § 33.1-41.1 of the *Code* (see the Appendix).

Although the total number of secondary lane miles is known for Henrico and Arlington counties, the total number of moving-lane-miles and the number of moving-lane-miles by functional classification as defined in the *Code* for city street payments are not known (or at least could not be obtained during the course of this study). A *moving-lane-mile* is defined in the *Code* as a lane mile that is "available to peak-hour traffic" (i.e., not available for peak hour parking). It was, therefore, not possible to calculate exactly what payments Henrico and Arlington counties might receive if they were treated as cities and received payments in accordance with § 33.1-41.1 of the *Code*. In addition, at the time this report was written, Henrico County did not have available the number of lane miles by functional classification so that the researchers could estimate the allocation for FY 00 by the city street payments method. The researchers applied the ratio of arterial lane miles to local and collector lane miles from the FY 01 data to the FY 00 lane mile total to estimate Henrico County's number of lane miles by functional classification for FY 00.

The allocations presented in Tables 3 and 4 represent the maximum maintenance allocations that could be paid in accordance with § 33.1-41.1 of the *Code* for FY 00 and FY 01 if Henrico and Arlington were treated as cities. Tables 3 and 4 also include the estimated maintenance allocations for FY 00 and FY 01 for Henrico and Arlington counties if 80% of each county's lane miles were eligible for payment under § 33.1-41.1 of the *Code*.

Table 3. Estimated FY 00 City Street Payments for Henrico and Arlington Counties

County	Assumption	Number of Moving-Lane-Miles	Total Payment	Effective Rate per Lane Mile[1,2]
Henrico	100% of lane miles are moving	2,983.57	$22,593,427	$7,573
	80% of lane miles are moving	2,386.86	$18,074,742	$6,058
Arlington	100% of lane miles are moving	957.66	$7,540,159	$7,874
	80% of lane miles are moving	766.13	$6,032,127	$6,299

[1]Effective rates are calculated by dividing total payment by total lane miles (not moving-lane-miles).
[2]Derived for comparison with rates in the *Code*.

Table 4. Estimated FY 01 City Street Payments for Henrico and Arlington Counties

County	Assumption	Number of Moving-Lane-Miles	Total Payment	Effective Rate per Lane Mile[1,2]
Henrico	100% of lane miles are moving	3,018[3]	$23,771,658	$7,876
	80% of lane miles are moving	2,414[3]	$19,017,326	$6,301
Arlington	100% of lane miles are moving	958	$7,844,089	$8,189
	80% of lane miles are moving	766	$6,275,271	$6,551

[1]Effective rates are calculated by dividing total payment by total lane miles (not moving-lane-miles).
[2]Derived for comparison with rates in the *Code*.
[3]Henrico County lane mile data by functional classification are 0.03 lane mile higher than certified lane mile data.

SUMMARY AND CONCLUSIONS

The researchers investigated three approaches to examine the FY 00 and FY 01 maintenance allocations for Henrico and Arlington counties. After extensive statistical testing and analysis, the comparable counties approach was rejected because it could not account for pockets of urbanization and growth found in Henrico County and because no county was comparable to Arlington County.

Table 5 summarizes the results of each method for Henrico County for FY 00 and FY 01 and presents the FY 00 and FY 01 allocations in accordance with § 33.1-23.5:1 of the *Code*. The results show that the estimated allocations were relatively consistent regardless of the approach used.

Table 5. Estimated and Actual FY 00 and FY 01 Allocations for Henrico County[1]

	FY 00		FY 01	
Approach	Total	Per Lane Mile[2]	Total	Per Lane Mile[2]
Significantly associated factors	$17,227,490	$5,774	$18,123,632	$6,005
City payments[3] for comparison only	$18,074,742	$6,058	$19,017,326	$6,301
Actual allocation in accordance with *Code*[4]	$16,409,444	$5,500	$17,263,246	$5,720

[1]Henrico County received a 1-year allocation of $25,897,187 in FY 01 ($8,581 per lane mile).
[2]Lane mile figures are *derived* based on dividing the total allocation by total lane miles for comparison with rates in the *Code*.
[3]Assumes that 80% of Henrico County's lane miles would be eligible for payment under § 33.1-41.1 of the *Code.*
[4]Actual allocation in accordance with § 33.1-23.5:1 of the *Code.*

Table 6 summarizes the results of each method for Arlington County for FY 00 and FY 01 and presents the FY 00 and FY 01 allocations in accordance with § 33.1-23.5:1 of the *Code* that Arlington County actually received. The results show that treating Arlington County as a city would result in a significant reduction in the total allocation.

Table 6. Estimated and Actual FY 00 and FY 01 Allocations for Arlington County

	FY 00		FY 01	
Approach	**Total**	**Per Lane Mile[1]**	**Total**	**Per Lane Mile[1]**
Significantly associated factors	$12,585,129	$13,142	$13,091,264	$13,667
City payments[2] for comparison only	$6,032,127	$6,299	$6,275,271	$6,551
Actual allocation in accordance with *Code*[3]	$10,488,983	$10,953	$10,911,924	$11,392

[1]Lane mile figures are *derived* based on dividing the total allocation by total lane miles for comparison with rates in the *Code*.
[2]Assumes that 80% of lane miles would be eligible for payment under § 33.1-41.1 of the *Code.*
[3]Actual allocation in accordance with § 33.1-23.5:1 of the *Code.*

In conclusion, the statistical model approach that estimates allocations based on population and lane miles is *very* attractive because it is logical and can be used to adjust rates as a county grows. The "city street" approach is included solely for comparison purposes and is not recommended as a basis for establishing allocations for Henrico or Arlington.

REFERENCES

County of Henrico. (2000). *Presentation to the Commonwealth Transportation Board Finance Committee.* Henrico County Department of Public Works, Richmond.

Joint Legislative Audit and Review Commission of the Virginia General Assembly. (1984). *Equity of the Current Provisions for Allocating Highway and Transportation Funds in Virginia.* House Document Number 11. Richmond.

APPENDIX

RELEVANT SECTIONS OF THE *CODE OF VIRGINIA*

§ 33.1-23.5:1. Funds for counties which have withdrawn or elect to withdraw from the secondary system of state highways.

Notwithstanding the provisions of § 33.1-23.5, pursuant to § 33.1-23.1 A, the Commonwealth Transportation Board shall make the following payments to counties which have withdrawn or elect to withdraw from the secondary system of state highways under the provisions of § 11 of Chapter 415 of the Acts of Assembly of 1932, and which have not elected to return: to any county having withdrawn prior to June 30, 1985, and having an area greater than 100 square miles, an amount equal to $3,616 per lane-mile for fiscal year 1986, and to any county having an area less than 100 square miles, an amount equal to $7,201 per lane-mile for fiscal year 1986; to any county that elects to withdraw after June 30, 1985, the Commonwealth Transportation Board shall establish a rate per lane-mile for the first year using (i) an amount for maintenance based on maintenance standards and unit costs used by the Department of Transportation to prepare its secondary system maintenance budget for the year in which the county withdraws, and (ii) an amount for administration equal to five percent of the maintenance figure determined in (i) above. The payment rates shall be adjusted annually by the Board in accordance with procedures established for adjusting payments to cities and towns under § 33.1-41.1, and lane mileage shall be adjusted annually to include (i) streets and highways accepted for maintenance in the county system by the local governing body, or (ii) streets and highways constructed according to standards set forth in the county subdivision ordinance or county thoroughfare plan, and being not less than the standards set by the Department of Transportation. Such counties shall, in addition, each receive for construction from funds allocated pursuant to § 33.1-23.1 B 3 an annual amount calculated in the same manner as payments for construction in the state secondary highway system are calculated.

Payment of the funds shall be made in four equal sums, one in each quarter of the fiscal year, and shall be reduced, in the case of each such county, by the amount of federal-aid construction funds credited to each such county.

§ 33.1-41.1. Payments to cities and certain towns for maintenance of certain highways.

The Commonwealth Transportation Commissioner, subject to the approval of the Commonwealth Transportation Board, shall make payments for maintenance, construction or reconstruction of highways, as hereinafter provided, to: (i) all incorporated towns having more than 3,500 inhabitants according to the last preceding United States census; (ii) all incorporated towns which, according to evidence satisfactory to the Commonwealth Transportation Board, have attained a population of more than 3,500 since the last preceding United States census; (iii) all incorporated towns which, on June 30, 1985, maintained certain streets under § 33.1-80 as then in effect; (iv) all cities operating under charters designating them as cities, regardless of their populations; and (v) the Town of Wise, the Town of Lebanon, and the Town of Blackstone.

Such payments, however, shall only be made if those highways functionally classified as principal and minor arterial roads are maintained to a standard satisfactory to the Department of Transportation.

No payments shall be made by the Commissioner to any such city or town unless the portion of the highway for which such payment is made either (a) has (i) an unrestricted right-of-way at least fifty feet wide and (ii) a hard-surface width of at least thirty feet; or (b) has (i) an unrestricted right-of-way at least eighty feet wide, (ii) a hard-surface width of at least twenty-four feet, and (iii) approved engineering plans for the ultimate construction of an additional hard-surface width of at least twenty-four feet within the same right-of-way; or (c) (i) is a cul-de-sac, (ii) has an unrestricted right-of-way at least forty feet wide, and (iii) has a turnaround that meets applicable standards set by the Department of Transportation; or (d) either (i) has been paved and has constituted part of the primary or secondary system of state highways prior to annexation or incorporation or (ii) has constituted part of the secondary system of state highways prior to annexation or incorporation and is paved to a minimum width of sixteen feet subsequent to such annexation or incorporation and with the further exception of streets or portions thereof which have previously been maintained under the provisions of § 33.1-79 or § 33.1-82; or (e) was eligible for and receiving such payments under the laws of the Commonwealth in effect on June 30, 1985; or (f) is a street established prior to July 1, 1950, which has an unrestricted right-of-way width of not less than thirty feet and a hard-surface width of not less than sixteen feet; or (g) is a street functionally classified as a local street and constructed on or after January 1, 1996, which at the time of approval by the city or town met the criteria for pavement width and right-of-way of the then-current edition of the subdivision street requirements manual for secondary roads of the Department of Transportation (24 VAC 30-90-10 et seq.); (h) is a street previously eligible to receive street payments that is located in a city having a population of at least 200,000 but no more than 250,000 and is closed to public travel, pursuant to legislation enacted by the governing body of the city in which it is located, for public safety reasons, within the boundaries of a publicly funded housing development owned and operated by the local housing authority; or (i) is a local street, otherwise eligible, containing one or more physical protuberances placed within the right-of-way for the purpose of controlling the speed of traffic.

However, the Commissioner may waive the requirements as to hard-surface pavement or right-of-way width for highways where the width modification is at the request of the local governing body and is to protect the quality of the affected local government's drinking water supply or, for highways constructed on or after July 1, 1994, to accommodate some other special circumstance where such action would not compromise the health, safety, or welfare of the public. The modification is subject to such conditions as the Commissioner may prescribe.

For the purpose of calculating allocations and making payments under this section, the Department shall divide affected highways into two categories, which shall be distinct from but based on functional classifications established by the Federal Highway Administration: (i) principal and minor arterial roads and (ii) collector roads and local streets. Payments to affected localities shall be based on the number of moving-lane-miles of highways or portions thereof available to peak-hour traffic in each category of highways in that locality. For the fiscal year 1986, payment to each city and town shall be an amount equal to $7,787 per moving-lane-mile

for principal and minor arterials and $4,572 per moving-lane-mile for collector roads and local streets.

The Department of Transportation shall establish a statewide maintenance index of the unit costs for labor, equipment, and materials used on roads and bridges in the fiscal year 1986, and use changes in that index to calculate and put into effect annual changes in the base per-lane-mile rate payable under this section.

The fund allocated by the Board shall be paid in equal sums in each quarter of the fiscal year, and no payment shall be made without the approval of the Board.

The city or town receiving this fund shall make annual reports, in such form as the Board may prescribe, accounting for all expenditures and certifying that none of the money received has been expended for other than maintenance, construction or reconstruction of the streets. Such reports shall be included in the scope of the annual audit of each municipality conducted by independent certified public accountants.