

# Highways and Property Values: The Washington Beltway Revisited

C. JOHN LANGLEY, JR.

**This study is a continuation of an investigation of the impacts of the Washington Capital Beltway (I-495) on residential property values in the adjacent community of North Springfield, Virginia. A 17-year (1962-1978) time series of property values represents the longest continuous longitudinal data base used in any analysis of highway impacts on residential communities. The results show conclusively that properties near the highway increase in value at a rate less than those more distant. It was found that properties in proximity to I-495 sell for approximately \$3000-\$3500 less than the others.**

Today's society has placed an extremely high priority on the development of transportation systems that will facilitate the movement of both goods and people in a swift and reliable fashion and with the greatest convenience, comfort, and privacy. Although conflicts of interest are inevitable on the design and modification of alternative systems, transportation planners attempt to select those projects that will provide the greatest net benefit to society. As a result, there are a number of tools and techniques available for facilitating the integration of social impacts into the transportation planning process (1). Although efforts to gain a more meaningful understanding of the benefits and costs of transportation improvements have considered a number of modal scenarios, a predominant share of attention has been directed toward the case of highways.

Specific benefits and costs that are likely to be associated with the construction or improvement of a limited-access highway are noted below. Benefits have been divided into two classes--those for which highway users are the principal beneficiaries and those that represent a gain accruing primarily to nonusers; alternatively, because a dichotomy of costs by user status would represent a more narrow, less-meaningful perspective, costs have been considered as being either direct or indirect:

1. Benefits: (a) for the user--accessibility (speed and reliability), fuel cost savings, maintenance cost savings (vehicular), safety, comfort and convenience, and aesthetics of travel; and (b) for the nonuser--reduced congestion in general area, economic efficiency, property value changes, economic development, and income and employment; and

2. Costs: (a) direct--right-of-way acquisition, construction, improvement, maintenance, operation, and relocation; and (b) indirect--loss of tax base, provision of additional community services, degradation of community qualities, property value changes, environmental degradation, and loss of income and employment.

In order to achieve a greater understanding of the extent to which the net of highway benefits and costs is reflected in the values of nearby residential properties, I conducted and reported the results of a time-series analysis of residential property values along a portion of Interstate 495 (the Washington beltway) (2). The research methodology included an analysis of sale-resale data during the period 1962 through 1972 exhibited by 1676 residential properties. A principal finding of that study was that those properties in North Springfield, Virginia, located in proximity to I-495, exhibited a tendency (particularly during the last 3 years of

the time series) to increase in value at a rate significantly less than that for properties more distant from the highway. The study results suggested that highway-related environmental externalities were responsible for a lowering of values of nearby properties compared with those of properties more distant from the highway. Aside from the specific findings of the study, the effort was notable in that it represented the first attempt to analyze the impacts of a highway on residential property values through the construction of a time series of property value index numbers.

The study reported in this paper is a revision and update of the findings of the earlier study, based on the addition of several more years of data to the already-existing time series. As a result, 17 years of data (1962 through 1978) were made available for analysis. This study incorporates a longer time series of residential property sales data than has been used previously in any investigation of the effects of highways on property values. Following a brief review of the recent literature and a profile of the highway-community interface that exists in North Springfield, a summary of the methodological approach and the results achieved is presented.

## RECENT LITERATURE

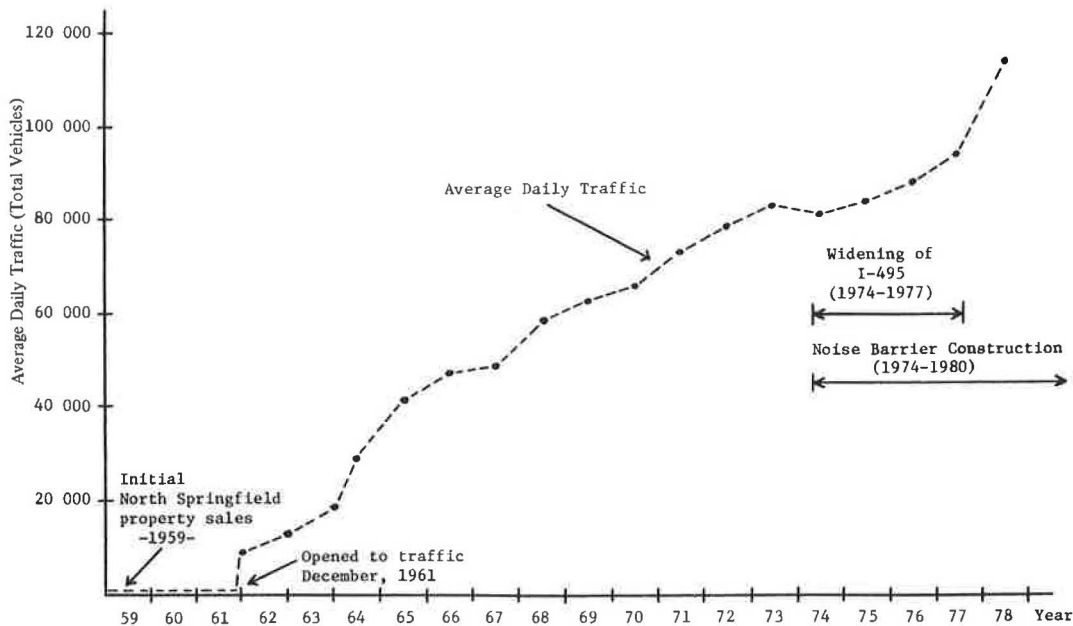
An examination of the published literature indicates that a continuing high level of importance is attached to achieving a greater understanding of the determinants of relative house and land prices. In addition, recent research efforts have placed added emphasis on how neighborhood amenities are valued by people and how such values are translated into prices of land and/or improvements.

Although it preceded publication of the earlier Washington beltway study, a number of empirical efforts into the determinants of relative house prices were surveyed (3). Emphasis was placed on the inclusion of studies that served to isolate and quantify a variety of attributes associated with housing, particularly those that were related to environmental quality in both a physical and a social context. Each of the studies selected for discussion was limited somewhat in that its respective methodological approach incorporated the use of regression analysis (and factor analysis in some cases) as applied to cross-section data. None of those surveyed were based on time series of data.

A recent study analyzed the impact of railway externalities on residential prices (4). Another research effort (5) measured the extent to which variations in levels of local property taxes and public expenditures affect residential property values. Alternatively, the technique of using a time series of property value data was employed in a study on the effects of airports on land values (6). The procedure followed was to measure changes in mean selling prices for various study areas at differing distances from the airport.

Contemporary interest has shifted somewhat from attempting to explain variation in house or land prices, to estimating the implicit valuation of the specific locational features or amenities that have

Figure 1. Traffic profile of I-495, North Springfield, Virginia: 1959-1978.



a major impact on the selling prices of properties (7-10). The major research questions raised collectively focus attention on topics such as the relative usefulness of land only versus the selling prices of land plus improvements; the extent to which hedonic prices (assumed to be equilibrium prices paid by informed, willing buyers) are representative of the more theoretically acceptable willingness-to-pay prices (11); and the development and refinement of models and techniques for estimating price gradients for a number of amenities simultaneously. Finally, a cross section of residential property values was used to determine a set of implicit marginal prices for air quality (12). In combination with income and other variables, the prices are incorporated into a two-equation demand-and-supply model (13). Results are expressed in terms of both price and income elasticity of demand.

#### STUDY AREA DESCRIPTION

The predominantly residential community of North Springfield is located in Fairfax County, Virginia, along the southwest portion of the Washington beltway. The study site is bisected by the highway, and residential structures are limited to single-family dwellings, of which there are nearly 1700. As computed from Fairfax County courthouse records, property sales prices averaged \$22 456 in 1962, \$33 440 in 1970, and \$65 182 for the first quarter of 1978. Numbers of property turnovers per year were typically between 125 and 200. Additional descriptive information regarding the study site may be found in Langley (2).

As indicated in Figure 1, a variety of highway-related changes has taken place in the time period of interest, with the most notable occurring in recent years. The first is that data from the Commonwealth of Virginia (14) indicate that average daily traffic (ADT) volumes have risen from 8845 vehicles/day in 1961-1962 to 113 790/day in 1978. Second, a widening of the relevant section of I-495 from two lanes in each direction to four lanes, begun in 1974, was completed in 1977. Third, noise barriers were constructed beginning in 1974 in a continuous pattern on both the north and south sides

of the highway right-of-way, and minor alterations to the existing walls were being made as recently as 1980. Technically, the barrier type is metal wall on earth berm, and the height of the barrier above the road is 7.6 m. Federal Highway Administration (FHWA) tests have concluded that noise levels in proximity to the highway have been reduced by approximately 15 dB(A), thereby reducing loudness at least by half (15). In addition to measuring the effectiveness of various types of noise barriers, the study evaluated the accuracy of the FHWA Highway Traffic-Noise-Prediction Model. It is interesting to note that the same section of the Washington beltway investigated in the study reported in this paper was also included among the sites selected by FHWA for noise barrier analysis. As a result of personal visits to the study site before, during, and after such construction, it was evident to me not only that noise levels had been lowered as a result, but also that the highway itself was much less obtrusive, and generally less noticeable.

In an overall sense, therefore, North Springfield continues to be the type of community that lends itself appropriately to a study of highway impacts on residential property values. While an inherent stability in the area under study is certainly an attribute from the perspective of research methodology, the general absence of non-highway-related externalities is responsible for a high degree of homogeneity among properties in the area.

#### METHODOLOGY

For purposes of analysis, the 1676 study-area properties were segmented into three groups. The impact zone (consisting of 1056 properties) was defined to include all properties in such proximity to the highway that it could be documented that residents were subjected to a continuing existence of highway-oriented disturbances. The results of the earlier study suggested that a distance of 1125 ft (343 m) represented an appropriate delimiter, and this measure was used once again in this study. Second, the subset of impact zone properties that were located immediately adjacent to the highway were classified as abutting properties (99 in number). Finally,

those properties beyond the boundary of the impact zone were referred to as being located in the nonimpact zone (610 in number).

The research plan included these two major objectives: (a) to construct for each distance-related category a time series of property value index numbers that could be used to describe the behavior of aggregate property values over time and (b) to compare statistically the yearly index numbers among the various property classifications to determine whether any significant differences exist. To the extent that discrepancies are noted, it is accurate to claim that highway-related environmental externalities are the primary contributing factors.

In order to accurately interpret the study results, it is necessary to recognize an important distinction that must be drawn between rate of price appreciation and total or gross impact on property values. The former places no restriction on the actual years to be included in a highway impact study, while the latter would certainly require the measurement of effects on values beginning before construction or even anticipation of the highway. The approach taken in this study emphasizes the rate of price appreciation.

The methodology for price index construction used in this study incorporates only sale-resale pairs of property transaction values, and employs regression analysis to estimate the index numbers (2,16). Courthouse records from Fairfax County indicated that a total of 1322 valid pairs of study area property transactions were recorded for the years 1962 through 1978. Prior to the regression analysis, all property sales values were deflated by using the implicit price deflators for gross national product (17). Although the time series of interest began in the year 1962 (the first full year in which the highway was opened to traffic), the base year for applying the price deflators was selected to be 1959 (the year in which the first property sales were recorded for the study area).

Finally, it is important to understand that the general approach of this study is valid, even when one considers some of the recent findings regarding the appropriateness of methodologies for studying the impact of location dependent amenities on property values. For example, one study suggests that regression studies cannot be used for predictive

purposes except to the extent that the city is small, and there is mobility among cities (18). This means that property values at a particular location depend only on amenities (and other relevant variables) at that location (19). Aside from the fact that the approach of this study is not regression-oriented in the same sense as referred to by those authors, the nature of size and mobility characteristics has no direct bearing on an interpretation of the results. This is because the study findings are expressed in terms of differences in rates of price appreciation among the various North Springfield property groups, and no attempt is made to derive an implicit, generalizable valuation for the existing externalities.

#### FINDINGS

Table 1 summarizes a variety of residential property sales data for North Springfield during the years 1962 through 1978. All valid property transfers are included and, in addition to being presented for all properties, yearly information is subdivided by property category. Two principal observations are notable: (a) the mean selling price of abutting properties tended to be lower on a year-to-year basis than for the other property types in the study area and (b) yearly increases in the mean selling prices of impact zone properties approximated those of the nonimpact zone. The former is explained largely by the fact that abutting properties were priced lower than other properties during the early years of the time series, and the discrepancy has continued throughout the period under consideration. The latter observation could be construed to imply that the existence of highway-associated externalities is not reflected in property values since the averages remain approximately the same throughout the 17 years. As will be indicated subsequently, such a conclusion is not only premature but inaccurate.

The results of residential property price index construction are exhibited in Table 2 by distance category. In addition to the yearly index numbers, the logarithms and standard errors of the logarithms of the index numbers are shown, as well as the total number of initial plus final sales in each year. The three time series of index numbers are depicted in Figure 2. Major observations of interest include

Table 1. North Springfield, Virginia, property sales data: 1962-1978.

Year	All Properties <sup>a</sup>			Abutting <sup>b</sup>			Impact <sup>c</sup>			Nonimpact <sup>d</sup>		
	N	$\bar{x}$ (\$)	Deflated <sup>e</sup> $\bar{x}$ (\$)	N	$\bar{x}$ (\$)	Deflated $\bar{x}$ (\$)	N	$\bar{x}$ (\$)	Deflated $\bar{x}$ (\$)	N	$\bar{x}$ (\$)	Deflated $\bar{x}$ (\$)
1962	226	22 456	21 489	10	20 719	19 827	87	22 584	21 611	139	22 375	21 411
1963	238	22 774	21 485	21	22 857	21 563	94	23 432	22 106	144	22 345	21 080
1964	214	23 222	21 562	16	24 544	22 789	84	24 396	22 652	130	22 464	20 858
1965	162	24 224	22 002	11	24 733	22 464	69	24 914	22 629	93	23 712	21 537
1966	162	25 319	22 268	13	24 557	21 598	62	25 534	22 457	100	25 186	22 151
1967	147	26 189	22 384	11	25 441	21 744	52	26 460	22 615	95	26 041	22 257
1968	143	28 730	23 491	6	31 633	25 865	58	29 625	24 223	85	28 120	22 993
1969	129	31 257	24 343	5	28 683	22 339	51	31 324	24 396	78	31 213	24 309
1970	127	33 440	24 715	8	30 521	22 558	42	33 329	24 633	85	33 495	24 756
1971	161	35 517	24 977	16	34 985	24 603	57	36 247	25 490	104	35 117	24 695
1972	157	39 290	26 529	9	40 272	27 192	56	39 808	26 879	101	39 003	26 336
1973	133	46 897	29 928	12	47 216	30 131	44	47 919	30 580	89	46 393	29 606
1974	135	52 009	30 273	6	49 658	28 905	43	51 245	29 828	92	52 366	30 481
1975	121	56 449	29 978	9	55 416	29 430	45	56 688	30 105	76	56 307	29 903
1976	112	58 905	29 735	5	57 667	29 110	35	58 075	29 316	77	59 282	29 925
1977	159	62 817	29 956	9	57 800	27 562	52	62 541	29 824	107	62 952	30 020
1978	33	65 182	29 914	1	65 000	29 830	13	67 446	30 953	20	63 711	29 239
Total	2559			168			944			1615		

<sup>a</sup> Within 1676 ft.  
<sup>b</sup> Within 99 ft.  
<sup>c</sup> Within 620 ft.

<sup>d</sup> Within 1056 ft.

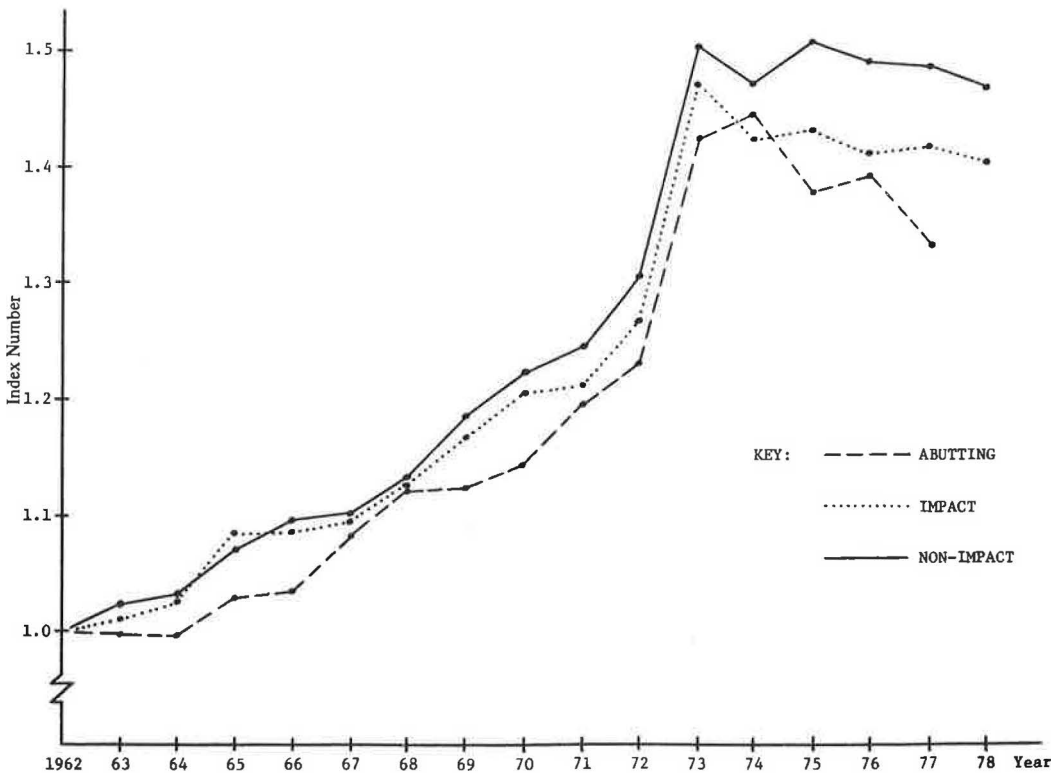
<sup>e</sup> Mean sales values were deflated to base year = 1959 by using the implicit price deflator for gross national product (17).

Table 2. Real estate price indexes, North Springfield, Virginia: 1962-1978.

Abutting Properties <sup>a</sup>					Properties in Impact Zone <sup>b</sup> (within 1125 ft from highway)					Properties in Nonimpact Zone <sup>c</sup> (>1125 ft from highway)				
Year	Index	Log of Index	S <sub>e</sub> Log	N	Year	Index	Log of Index	S <sub>e</sub> Log	N	Year	Index	Log of Index	S <sub>e</sub> Log	N
1962	1.000	0.000 00	0.000 00	8	1962	1.000	0.000 00	0.000 00	62	1962	1.000	0.000 00	0.000 00	96
1963	0.987	-0.005 83	0.015 78	12	1963	1.011	0.004 81	0.006 32	68	1963	1.024	0.010 42	0.005 31	107
1964	0.990	-0.004 33	0.014 19	18	1964	1.031	0.013 10	0.006 14	70	1964	1.033	0.014 14	0.005 03	108
1965	1.030	0.012 66	0.015 52	10	1965	1.084	0.035 08	0.005 48	78	1965	1.071	0.029 71	0.005 49	83
1966	1.037	0.015 82	0.015 75	13	1966	1.088	0.036 51	0.006 23	71	1966	1.097	0.040 10	0.004 97	107
1967	1.082	0.034 08	0.013 90	15	1967	1.096	0.039 93	0.006 38	57	1967	1.101	0.041 87	0.005 08	118
1968	1.122	0.049 83	0.017 49	8	1968	1.124	0.050 69	0.006 40	66	1968	1.132	0.053 90	0.005 16	112
1969	1.122	0.050 06	0.018 77	6	1969	1.167	0.067 19	0.006 37	65	1969	1.185	0.073 76	0.005 19	107
1970	1.142	0.057 82	0.017 09	9	1970	1.207	0.081 56	0.006 70	56	1970	1.222	0.087 20	0.005 25	113
1971	1.197	0.077 93	0.014 09	24	1971	1.213	0.083 71	0.006 13	74	1971	1.245	0.095 33	0.005 09	123
1972	1.233	0.090 99	0.016 13	11	1972	1.268	0.103 09	0.006 49	67	1972	1.307	0.116 44	0.005 03	131
1973	1.427	0.154 56	0.014 21	13	1973	1.471	0.167 65	0.006 98	47	1973	1.504	0.177 20	0.005 27	114
1974	1.444	0.159 67	0.019 20	6	1974	1.422	0.152 86	0.007 05	46	1974	1.472	0.167 90	0.005 42	98
1975	1.378	0.139 32	0.015 13	12	1975	1.434	0.156 60	0.006 90	51	1975	1.507	0.178 21	0.005 82	79
1976	1.392	0.143 79	0.020 03	5	1976	1.411	0.149 58	0.007 80	31	1976	1.491	0.173 47	0.006 07	69
1977	1.333	0.124 88	0.018 88	6	1977	1.419	0.152 06	0.007 34	44	1977	1.487	0.172 33	0.005 43	96
1978 <sup>d</sup>					1978	1.403	0.146 92	0.011 06	13	1978	1.466	0.166 13	0.010 08	17

<sup>a</sup>R<sup>2</sup> = 0.8278.      <sup>b</sup>R<sup>2</sup> = 0.7824.      <sup>c</sup>R<sup>2</sup> = 0.8085.      <sup>d</sup>Insufficient sales of abutting properties.

Figure 2. Property value price indexes: 1962-1978.



the following: (a) the time series of index numbers for abutting properties consistently shows less-than-comparable figures for impact and nonimpact zone properties (aside from the slight aberration of data in the year 1974), (b) with the exception of one year early in the time series, index numbers for impact zone properties are less in magnitude than those for nonimpact zone properties, and (c) the apparent divergences among index numbers of various property types are the greatest in years subsequent to 1973. It is evident, therefore, that properties nearer the highway exhibit a very definite tendency to increase in value at a rate less than those more distant from the highway.

One-tailed student-t tests were used to test for statistical significance among the various index number differences noted above. Table 3 notes those pairs of index numbers for which the differences were found to be significantly different at the 10 percent level, or better. While 12 of the 17 years in the time series are represented in Table 3, a preponderance of attention is focused obviously on the years from 1970 to 1978. These findings lend conclusive support to the contention that highway-related environmental externalities from I-495 are responsible for an adverse impact on nearby residential property values in North Springfield. It is quite likely, however, that the widening construc-

**Table 3. Significant differences among index numbers and conversion to value differences in dollars.**

Year	Price Deflator	Index Numbers			Difference Among Indexes	Difference Expressed in Dollars <sup>a</sup>
		Abutters	Impact	Nonimpact		
1965	1.101	1.030	1.084		-0.054 <sup>b</sup>	1278
1966	1.137	1.037	1.088		-0.051 <sup>b</sup>	1246
1970	1.353	1.142	1.207		-0.065 <sup>b</sup>	1890
1977	2.097	1.333	1.419		-0.086 <sup>b</sup>	3875
1964	1.077	0.990		1.033	-0.043 <sup>b</sup>	995
1966	1.137	1.037		1.097	-0.060 <sup>b</sup>	1466
1970	1.353	1.142		1.222	-0.080 <sup>b</sup>	2326
1971	1.422	1.197		1.245	-0.048 <sup>b</sup>	1467
1972	1.481	1.233		1.307	-0.074 <sup>b</sup>	2355
1973	1.567	1.427		1.504	-0.077 <sup>b</sup>	2593
1975	1.883	1.378		1.507	-0.129 <sup>d</sup>	5220
1976	1.981	1.392		1.491	-0.099 <sup>b</sup>	4214
1977	2.097	1.333		1.487	-0.154 <sup>c</sup>	6940
1971	1.422		1.213	1.245	-0.032 <sup>b</sup>	978
1972	1.481		1.268	1.307	-0.039 <sup>b</sup>	1241
1974	1.718		1.422	1.472	-0.050 <sup>b</sup>	1846
1975	1.883		1.434	1.507	-0.073 <sup>d</sup>	2954
1976	1.981		1.411	1.491	-0.080 <sup>c</sup>	3406
1977	2.097		1.419	1.487	-0.068 <sup>c</sup>	3064
1978	2.179		1.403	1.466	-0.063 <sup>b</sup>	2950

<sup>a</sup> Dollar differences have been inflated to reflect real value in each respective year. Computation: \$22 456 x price deflator x difference among indexes.

<sup>b</sup> Indicates significance at 10 percent level.

<sup>c</sup> Indicates significance at 2.5 percent level.

<sup>d</sup> Indicates significance at 1 percent level.

tion from 1974 through 1977 was responsible for a portion of the differences in recent years that are apparent in Table 3.

An added feature of Table 3 is that the significantly different index numbers are transformed into dollar differences that have been inflated to reflect real dollar values in the respective years. These are shown in column 7 of Table 3. Although the value differences are greatest for abutting versus nonimpact zone properties, the recent differences between impact and nonimpact area properties are more representative of the impact on nearby properties in general. With reference to the dollar differences shown in the bottom portion of column 7 of Table 3, therefore, it can be stated that properties in proximity to the highway (within 1125 ft) sell for approximately \$3000-\$3500 less than equivalent properties located farther from the highway.

#### EVALUATION

This study proves conclusively that highway-originated environmental externalities are the major cause of an inverse relationship between yearly increases in North Springfield property resale values and proximity to I-495. Aside from simply revising and updating the results of the earlier study, the current effort found significant differences among distance-related property value index numbers in 12 of the 17 years under study. Although significant differences were found in each of the latest nine years in the time series under study, it is likely that the highway widening construction from 1974 through 1977 had some impact on the magnitude of such differences in those particular years. In general, therefore, the overall results justify a much stronger statement concerning highway impacts on property values than did the findings of the 1962-1972 analysis. An additional contribution of this study is that the length of the time series (17 years) was unprecedented in previous highway impact investigations.

Although the study findings are valid in a statistical sense, caution should be exercised regarding their overall generalizability. It would be misleading to attempt to apply the results of this study directly to the situations of other highway-community interfaces. It would be very useful, how-

ever, to employ the methodology and procedures of this study for the purpose of gaining insight into the net economic impact of highways on property values in other areas.

It was interesting to note that noise barriers had been constructed along the right-of-way boundaries of the Washington beltway in North Springfield and that reductions of up to 15 dB(A) in noise levels were estimated. As a result, the loudness of traffic noise has been reduced by at least one-half. Unfortunately, such improvements occurred so recently that any possible impact on property sales values could not have been detected. Perhaps a future study may investigate this. While it is well documented that highway-originated disturbances can have adverse impacts on the values of nearby residential properties, it will be interesting to see if such a trend reverses, given that the level of disturbance has been reduced significantly.

Finally, it is appropriate to mention that the findings of this study are quite consistent with generally accepted theories of capital asset pricing. That is, each yearly deflated housing price actually represents the present value of a stream of anticipated housing services and locational amenities. If such anticipations were to have remained constant over time, no changes in deflated housing prices could have been expected. Property sales prices in North Springfield did change throughout the period under observations, however. This phenomenon can be attributed to two general factors: (a) changes in the level or degree of an externality and (b) changes in consumer attitudes (preference or tastes) toward an externality. Traffic volumes on I-495 (level of externality) have increased quite dramatically and, without any doubt, people have become much more cognizant and concerned about environmental issues, including traffic-generated noise and air pollutants, since the environmental movement began approximately with Earth Day in 1969. Also, the construction that took place in order to widen the highway and the erection of noise barriers must be regarded as having been annoying sources of environmental externalities. These had an adverse impact on those residents in proximity to the highway.

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## Highway Noise, Noise Mitigation, and Residential Property Values

GARY R. ALLEN

This paper presents the findings of a study of the relationship between different noise levels and market values for a sample of 206 single-family residences abutting Interstate-495 in Northern Virginia and for a sample of 207 residences along two heavily traveled urban streets in the Tidewater area of Virginia. Estimates of the influence of noise on the market price of houses sold in 1978-1979 at these sites, where barriers have since been completed, were then used to estimate economic benefits received by property owners. By using these estimates, it was concluded that recent public expenditures on highway noise abatement per household far exceed reasonable economic benefit levels, even for noise reductions of 10 dB(A).

Part 772 of Title 23 of the Code of Federal Regulations emphasizes that final decisions about highway noise mitigation are not to be made without serious consideration of the costs of abatement. Paraphrasing the law, there may be sections of highways where the costs of abatement are so high in relation to the benefits received that it would be impractic-

able to apply noise abatement measures.

At least one author has attempted to provide evidence regarding the social impacts of noise (1); yet, economic data are necessary as an aid in decisions about noise mitigation. Early empirical evidence on the effects of highway noise was provided by Gamble and others (2) and Nelson (3); however, the results of these and more recent studies appear to have had only marginal influence on noise mitigation policies.

### OBJECTIVES AND SCOPE

The objectives of this study were (a) to empirically estimate the effect of highway-generated noise on residential housing values and (b) to suggest financial criteria for the construction of noise barriers consistent with the estimated benefits that noise