Toll Financing

for

Potomac River Crossings

Washington, D. C.

Wilbur Smith and Associates

265 Church Street

New Haven, Connecticut

April 1955

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TRAFFIC • PARKING • TRANSIT • HIGHWAYS

265 CHURCH STREET
New Haven, Conn.

April 18, 1955

Mr. J. N. Robertson, Director
Department of Highways
Washington, D. C.

Dear Mr. Robertson:

We are pleased to transmit to you and the sponsoring agencies our report on an engineering study to ascertain the feasibility of collecting tolls on Potomac River bridges within the Washington Metropolitan Area. This study was undertaken in accord with Agreement No. D.C.F.-A864, dated February 17th, 1955, entered into with the District of Columbia Department of Highways.

Means of financing additional bridges and approach roads have been given much attention by Congress and other political jurisdictions for many years. The question of revenue bond financing has often been raised. This report has been prepared with a view to exploring the possibilities of toll financing and presenting data to guide legislative and administrative policies.

In developing the background for this report we have been able to use much of the data which we collected and analyzed in our study of "Highway Transportation in the Washington Metropolitan Area of Virginia," prepared for the Virginia Department of Highways in November, 1953, and our investigation of "Traffic and Capacity Needs for Potomac River Crossings," completed for the National Capital Planning Commission earlier this year. Data from these sources have been supplemented by traffic counts and other materials furnished by the District Department of Highways, Fairfax County in Virginia, Montgomery and Prince Georges Counties in Maryland, and the States of Virginia and Maryland.

The report reviews several different combinations of Potomac River bridge improvements which might be considered for development as revenue bond projects. In each instance the feasibility of toll financing has been investigated in terms of the lowest possible toll rate. The results of these studies indicate that it would be possible to finance revenue bonds from Potomac River bridge tolls in amounts sufficient to construct new bridges and access roads and to improve existing crossings. Certain combinations of new bridges could be financed with funds derived from toll schedules based on a ten cent passenger car rate giving preferential treatment to commuters. Other bridge combinations might be financed with revenues based on passenger car tolls ranging from ten cents to twenty-five cents.

Throughout the study our engineers have worked closely with the sponsoring agencies, which include the District of Columbia Department of Highways, the National Capital Planning Commission, the Maryland State Roads Commission, the Virginia Department of Highways, and the Bureau of Public Roads. In addition to numerous individual contacts, all of these organizations have been represented at three general conferences which were held to organize the work and to review progress and findings as the study progressed.

It has been a great pleasure to have participated in developing the information in this report. We would like to again express our appreciation and thanks for the cooperation and assistance which we have received.

Respectfully submitted,

WILBUR S. SMITH

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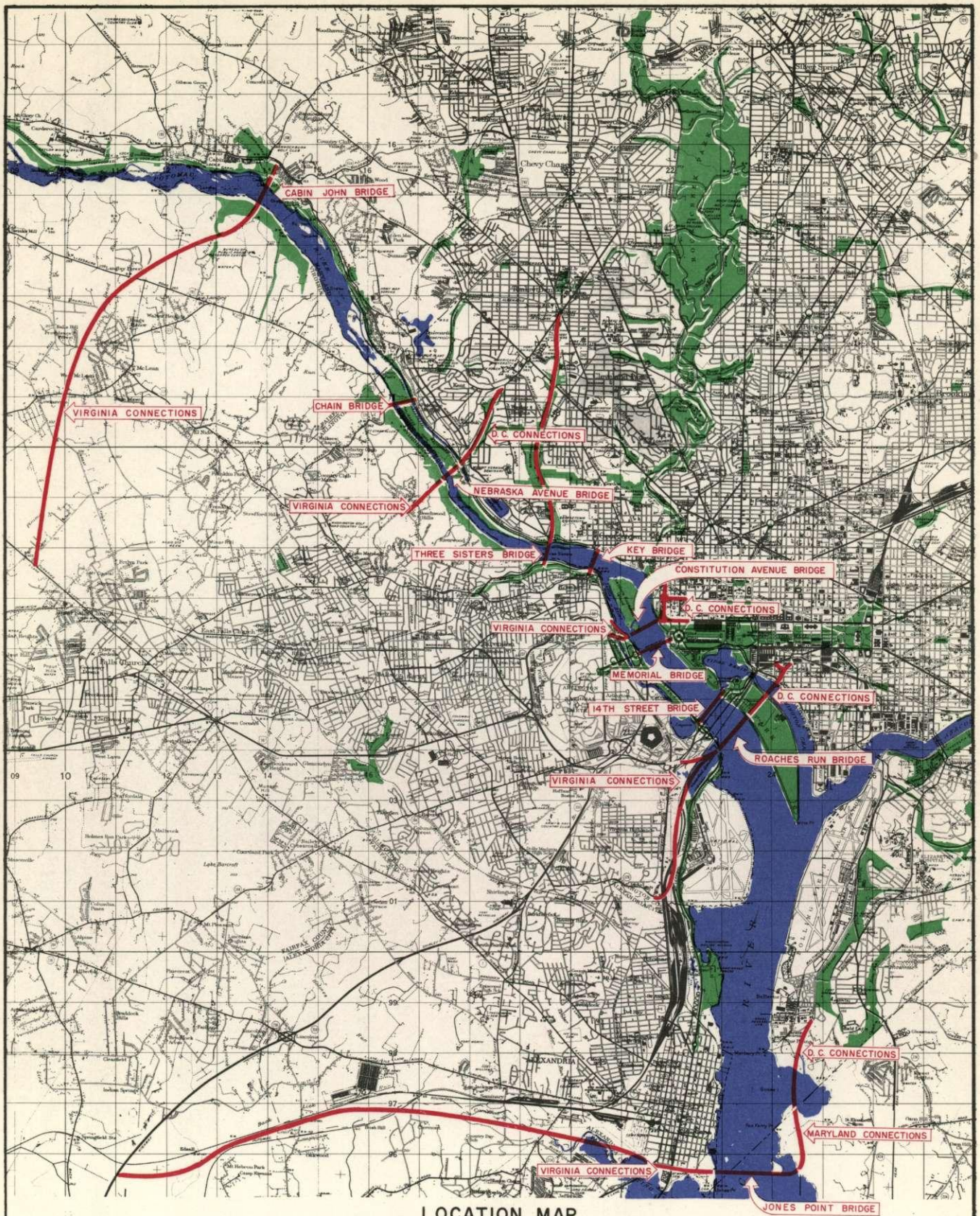


LOCATION MAP

POTOMAC RIVER BRIDGES

EXISTING AND PROPOSED

WASHINGTON, D. C., STUDY AREA

Wilbur Smith & Associates

FIGURE 1

PART I

Introduction

On August 30, 1954, President Eisenhower signed a bill, H. R. 1980, authorizing the construction of two Potomac River bridges to serve the Washington area. One of these bridges would be a four-lane crossing "at or near Jones Point, Virginia." The other would be a six-lane facility extending "from the vicinity of Constitution Avenue in the District of Columbia to the Virginia side" of the Potomac River. Congress has not yet provided funds for construction of the new bridges, however.

Planning and building new bridges in Metropolitan Washington requires the cooperative effort of five principal governmental agencies. These are the Bureau of Public Roads, which is directly concerned in highway facilities at the Federal level; the District of Columbia Department of Highways and the National Capital Planning Commission, which are responsible for location and design of new bridges in the District of Columbia; and the Maryland State Roads Commission and the Virginia Department of Highways which are jointly concerned with Potomac River bridge crossings and their approaches in the urbanized areas just outside the District limits.

Large public works in Washington are usually financed by Congressional appropriations in the form of federal grants. Since no appropriation has been made for the construction of new Potomac River crossings, the several highway planning agencies have undertaken a joint investigation of alternate methods which might be expected to provide the necessary funds. At the state highway level many roads and bridges are financed by borrowing against future gas tax revenues and other sources of highway income. In states where such borrowing is not permitted or where debt limitations prevent further use of the methods, a "pay as you go" policy may prevail. Under the "pay as you go" plan, funds for large projects must be accumulated from regular highway resources until the amount on hand will pay for the project. Neither of these methods is capable of supporting immediate construction of new Potomac River bridges in the Washington area without seriously disrupting current highway improvement programs.

Revenue bonds represent an alternate method of fund raising that has been used extensively to finance new bridge construction at many locations throughout the United States. Revenues derived from the tolls collected of bridge users are the sole source of funds to pay for the facility. This method of financing offers several unique advantages where traffic volumes are large enough to make it feasible. In the first place, the method is popular with taxpayers who do not benefit directly from the new facility since bridge costs are charged only to bridge users, and the bonds do not constitute an obligation against those who do not use the facility. Furthermore, financing

is achieved entirely outside the debt limitations which apply to state or municipal highway agencies. Revenue bonds may thus offer a source of funds for the immediate construction of needed facilities.

Authorization for Study

The following study of possible revenue bond financing of Potomac River bridges has been made in conformance with an agreement dated February 17, 1955, which was approved by the Director of the District of Columbia Department of Highways acting for the five participating agencies noted above. The study explores the feasibility of revenue bond financing of a Potomac River Bridge System which would be paid for from tolls collected on the bridges. The agreement describes the work to be done as follows:

> *"Engineering Study to Ascertain Feasibility of Collecting Tolls to Cross Potomac River Bridges within Washington Metropolitan Area*:

"The Consultant shall:

"Sec. 1. Study the establishment of tolls on all of the Potomac River bridges, including existing bridges and the various combinations of all bridges which the Consultant considers are likely to be required to meet traffic volumes projected to 1970 between the proposed Jones Point Bridge and the proposed Cabin John Bridge. This study shall include the following existing and proposed bridges but shall not be limited thereto in the event the Consultant justifies some other combination of bridges:

Cabin John Bridge
Chain Bridge
Nebraska Avenue Bridge
Francis Scott Key Bridge
24th Street Bridge (in the vicinity of Constitution Avenue)
Memorial Bridge
14th Street Bridge
Roaches Run Bridge
Jones Point Bridge

"Sec. 2. Determine the potential traffic and revenues from the various combinations of bridges and tolls through the year 1970.

"Sec. 3. Determine a toll schedule or schedules which would allow the purchase of tags providing special rate privileges for commuters.

"Sec. 4. Prepare summary tabulations of the costs of existing bridges, the estimated costs of proposed bridges and the rate of retirement of such costs through the collection of tolls.

"Sec. 5. Make recommendations embodying the Consultant's conclusions as to the feasibility of financing various Potomac River bridges in the Washington Metropolitan Area by the collection of tolls."

Toll Bridge Systems

Recent studies have shown that the volume of traffic crossing the Potomac River will soon require more bridge capacity than will be provided by the proposed new bridges at Jones Point and Constitution Avenue.[1] A number of supplementary crossings have been proposed to supply the additional bridge capacity. All of them are related to long-range arterial highway plans which have been developed by the several

[1] "Traffic and Capacity Needs for Potomac River Crossings," Wilbur Smith and Associates; a report for the National Capital Planning Commission, Washington, D. C., 1955.

highway planning agencies in the Washington Metropolitan Area.

An important feature of future traffic plans for Washington is a series of circumferential highways which would complement radial arterials centered in Washington's business district and the governmental center. Three of these circumferential highways have been planned—an "inner loop" around the central business district, an "intermediate loop," and an "outer loop" just beyond the present limits of urbanization. Each of the proposed new bridges is related to one or another of the circumferential routes and would ultimately be incorporated in the basic traffic circulation system of the urban community.

Future bridges must, of course, be located to supplement and relieve existing bridges. In order to relieve the present facilities many of the new bridges would be located so as to provide access to the same areas served by the existing bridges. It would not be possible, therefore, to achieve efficient operation of a toll bridge system unless some or all of the existing Potomac River bridges were made a part of the toll system.

As suggested in the agreement described above, several combinations of bridges have been studied for feasibility as revenue bond projects. The following studies are reported on here:

Scheme I—*Outer Loop Bridges*—Jones Point and Cabin John Bridges have been examined jointly and individually for their toll bridge potential in Part VI of this report. The investigations include study of rate structures and various combinations of bridges and approach roads. The proposed facilities would eventually be incorporated into an outer loop highway extending entirely around the metropolitan area.

Scheme II — *All Potomac River Bridges* A basic system of eight bridges has been examined for feasibility in Part VII. These include the Cabin John and Roaches Run Bridges in addition to existing bridges and the authorized structures at Jones Point and Constitution Avenue. Alternate plans for inclusion of supplementary bridges at Three Sisters or Nebraska Avenue have also been studied.

Scheme III — *All Central Crossings* — Part VIII is devoted to an examination of the eight-bridge system described in Scheme II, but assumes that the Outer Loop Bridges (Cabin John and Jones Point) would be constructed from regular highway funds and would be operated as free facilities. The six central crossings would constitute a toll bridge system serving central Washington and connecting to the inner and intermediate circumferentials.

Scheme IV — *Memorial Bridge Free* — Part IX considers the feasibility of a toll bridge system of five central crossings which would permit the Memorial Bridge and Outer Loop Bridges to operate free and which would be financed from toll revenues collected on the five remaining bridges.

Each of the four toll-feasibility studies has been developed in detail from data which have been collected by the consultant and other agencies during the past few years in the course of a wide variety of engineering studies. Traffic estimates are based on a firm foundation of traffic history in the Washington area.

Description of Potomac River Crossings

Present Potomac River crossing plans contemplate the improvement of some ex-

isting crossings as well as the development of new ones. (Figure1). Cost estimates for new bridges and improvements are developed in Part IV of this report. Following is a brief description of each of the existing and proposed bridges.

Fourteenth Street Bridge (Highway Bridge) — The 14th Street Bridge consists of two structures. The original structure, built in 1903 with a 40-foot pavement, was intended to accommodate two lanes of traffic in each direction. A companion bridge, built in 1950, has a 50-foot pavement and was designed to carry four lanes of traffic one-way (northbound) from Virginia to Washington. The old bridge now carries one-way traffic, southbound, in three lanes. Average traffic on both bridges was about 102,000 vehicles per day in 1954.

Improvements planned for the 14th Street location include the replacement of the old span with a new four-lane bridge to better accommodate traffic from Washington to Virginia. Proposed improved connectors on the Virginia side include revised ramps and connections to accommodate movements now using the old bridge. Improvements on the District side would include ramp connections to the proposed Southwest Freeway sufficient to develop full four-lane capacity on both inbound and outbound bridges.

Memorial Bridge — The Arlington Memorial Bridge, opened to traffic in 1932, accommodates six lanes of traffic on a 60-foot pavement. Traffic on the bridge averaged about 54,000 cars per day in 1954 (heavy trucks are not allowed on the bridge). The use of the bridge is limited more by the capacity of the traffic circles at each approach than by capacity of the bridge itself. However, no improvements to bridge or approaches are contemplated at the present time.

Key Bridge — The Francis Scott Key Bridge was built in 1924 to replace an older stucture originally built in 1888. Four lanes of traffic use the 50-foot pavement in which a double streetcar track is laid. The bridge connects to the George Washington Memorial Parkway and the Lee Highway in Virginia and to the Whitehurst Freeway and "M" Street on the District side of the Potomac River. The bridge carried an average daily travel of 47,000 vehicles in 1954. Bridge and approach roads are saturated at hours of peak use.

The capacity of the Key Bridge can be increased by eliminating the streetcar tracks and by cantilevering the south sidewalk to provide for three moving traffic lanes in each direction. Much needs to be done to improve the bridge approaches.

Chain Bridge — The Chain Bridge, first constructed in 1797, was last rebuilt in 1938. The bridge has a two-lane, 30-foot pavement and was used by some 14,000 vehicles per day in 1954. Sharp curvature on the Washington approach and restricted sight distance on the Virginia side limit the capacity of the bridge. Further development of Canal Road will improve the Washington approach, and intersection redesign at the Virginia terminus will also benefit bridge traffic. Present plans do not contemplate major improvement of this crossing.

Proposed Jones Point Bridge—An outer circumferential route has been approved by the District Department of Highways, the National Capital Planning Commission, and official highway and planning agencies in Maryland and Virginia. A four-lane

river crossing at Jones Point in Alexandria is a part of this circumferential.

The crossing site is located south of Alexandria's central business district where approach roads will create minimum disturbance to existing developments. Several miles of expressway-type approach roads would be required to develop proper access to the crossing. In Virginia, the bridge approaches would connect with the Mount Vernon Memorial Highway, U.S. Route 1, and the Shirley Highway. On the District side of the river the bridge would connect to Overlook Avenue.

Proposed Roaches Run Bridge—The proposed Roaches Run Bridge would be located about one-quarter mile downstream from the 14th Street Bridge and would relieve and supplement that facility. The bridge would provide an additional six lanes across the Potomac River to the periphery of downtown Washington. Streets and highways in the District are presently incapable of absorbing the additional traffic that the bridge would carry, and it would be necessary to coordinate construction of a Roaches Run Bridge with completion of the Southwest Freeway and other access improvements on the Washington side of the river. Financing these improvements would be entirely apart from bridge financing.

On the Virginia side of the Potomac River the Roaches Run Bridge would connect with the Mount Vernon Memorial Highway which would be improved into Alexandria. Direct interchange would also be made with the Pentagon road network. In Washington the most important bridge approaches would consist of an elaborate interchange with the Southwest Freeway.

Proposed Constitution Avenue Bridge—Highway and planning agencies have agreed that there is urgent need for an additional "central crossing" to supplement existing bridges. Studies show that the Roaches Run Bridge alone will not suffice. A number of bridge sites have been studied, including an "E" Street location, a 24th Street bridge, and the Constitution Avenue site, all in the same general vicinity. In 1954, Congress and the President authorized the construction of a bridge in the vicinity of Constitution Avenue. The President made his approval for any structure built on the site. Esthetic considerations are of such importance, however, that thought and study are presently being given to the construction of a tunnel instead of a bridge at this location.

The bridge structure proposed for the Constitution Avenue site would be a six-lane facility providing traffic interchange with Arlington Boulevard and the George Washington Memorial Parkway in Virginia and making connection to Constitution Avenue, the Inner Loop Expressway, and "E" Street in the District.

Proposed Three Sisters Bridge—A Three Sisters site has been suggested as an alternate to the Constitution Avenue Bridge location. A crossing here would introduce traffic into downtown Washington by way of a section of the proposed Arizona Parkway and a portion of the proposed Whitehaven Parkway to Rock Creek Parkway south of Massachusetts Avenue. The bridge would provide direct access to all of Northwest Washington from Virginia. A six-lane stucture at Three Sisters, with proper access, would provide the additional "central crossing" capacity required.

Necessary approaches on the Virginia side of the river would consist of an immediate connection to the George Washington Memorial Parkway. Future access (not a part of the cost estimates) would include interchange with the Spout Run Parkway and an expressway connection to the proposed Outer Circumferential in the Falls Church area. In the District, it would be necessary to construct a section of the Arizona Parkway and Whitehaven Parkway to tie in with the Rock Creek Parkway. Interchange would also be provided with Canal Road.

Proposed Nebraska Avenue Bridge—The Nebraska Avenue Bridge would provide a high-level crossing of the Potomac River about a mile downstream from the Chain Bridge. Although this structure has been proposed to provide relief to existing bridges, it would serve primarily as a bypass around the heavily urbanized section of the metropolitan area and would not attract very much of the traffic generated in central Washington.

An access road of high design standard should be provided from the bridge to a connection with Nebraska Avenue in the District. Interchange should also be made with Canal Road and MacArthur Boulevard. On the Virginia side, the bridge would interchange with an extension of the George Washington Memorial Parkway and would connect to Military Road. An extension would eventually be made to Yorktown Boulevard.

Proposed Cabin John Bridge—The Cabin John Bridge would form a link in the proposed Outer Circumferential Highway planned to ring the metropolitan area. A four-lane structure at this location would supplement the Jones Point Bridge as a bypass facility for traffic having neither origin nor destination in central Washington. While there is now relatively little demand for a bridge at this location, construction of the bridge and Outer Circumferential would immediately encourage development of adjacent areas and would create additional crossing demands.

To make the bridge accessible to traffic, a section of the Outer Circumferential should be provided on the Virginia side of the river, extending from the bridge to U.S. Route 29 west of Falls Church, Virginia, a distance of about seven miles. On the Washington side the bridge should connect to MacArthur Boulevard, with eventual extension around the outer limits of the urbanized area as the Outer Loop Circumferential is developed.

PART II

Traffic and Population

Population growth and traffic trends in the Washington Metropolitan Area have been studied for many years. A great deal of information has been compiled about the area which is useful in projecting the probable course of future developments. Several of the more recent studies have been briefly reviewed below.

Traffic Studies

1. *The Washington Metropolitan Area Transportation Study* — The most comprehensive investigation of traffic patterns in the Washington area was the Washington Metropolitan Area Transportation Study of 1948, developed under the joint auspices of the Maryland State Roads Commission, the Commonwealth of Virginia Department of Highways, the District of Columbia Department of Highways, and the U. S. Bureau of Public Roads. The study was initiated with a comprehensive home-interview type origin-destination survey which made use of established sampling techniques, with certain modifications, and was designed to obtain detailed information on travel patterns in the metropolitan area on an average weekday. From five percent of the dwelling units in the area, trained interviewers gathered information regarding trips made the day before the interview by members of each household five years of age or over. A ten percent sample was also obtained directly from the records of taxi and trucking companies to complete the internal portion of the survey.

An external origin-destination survey was conducted concurrently with the internal survey to determine the travel patterns of people entering the study area from points outside. Thirty-four interview stations were established on the cordon line which delimits the survey area, situated so as to intercept traffic on all important roads and interstate trunk highways. The data collected from the internal and external surveys included the basic facts on origin and destination, supplemented by volume counts and traffic classifications by type of vehicle, state of registration, and direction of travel. Survey data were verified by comparing the number of trips reported at the Potomac River screen line against actual counts made on the river crossings. The data were available to the consultants in the form of summarized tabulations of trips between the numerous zones within the survey area.

A final report entitled "A Recommended Highway Improvement Program" was published in the fall of 1952. New Potomac River bridges and improvements to existing bridges were among the highway improvements recommended for the Washington Metropolitan Area. Immediate need was found for a new central crossing ("E" Street) and improvement of the Key Bridge and its approaches. A somewhat lower pri-

ority was given to construction of a new southbound structure at 14th Street. Recognition was also given in the report to an eventual need for bridges at Cabin John and in the vicinity of Alexandria (Shepherds Landing) as essential elements in an outer circumferential highway which would provide for the by-passing of the downtown area, the distribution of traffic and the development of areas adjacent to the already heavily populated districts of Metropolitan Washington.

2. *Harland Bartholomew and Associates Study, 1952*—"A Report on Future Bridge Crossings of the Potomac River, Washington, D. C." (June 1952) by Harland Bartholomew and Associates emphasized the need for application of planning principles to the location of future Potomac River crossings, including the eventual construction of a system of radial expressways and freeways in conjunction with inner, intermediate and outer circumferentials which would intercept the radials to permit traffic to bypass congested areas and disperse itself. The report recommended that the "E" Street Bridge should not be constructed and that improvement of a mass transportation system on a metropolitan basis should be emphasized. Traffic analyses were based on the comprehensive 1948 origin-destination data.

3. *Modjeski and Masters Study, 1952* — In July of 1952, Modjeski and Masters with Lloyd B. Reid, Traffic Consultant, submitted "A Report on Potomac River Bridges, Washington, D. C." which analyzed the 1948 traffic survey in light of more recent information and recommended construction of a central river crossing at "E" Street as a first priority with later construction of an Alexandria Crossing at Jones Point and consideration for a Nebraska Avenue crossing which would provide bypass values for drivers wishing to avoid downtown Washington.

4. *Wilbur Smith and Associates Studies, 1953 and 1955* — A report prepared by Wilbur Smith and Associates for the Virginia State Highway Commission in November, 1953, entitled "Highway Transportation in the Washington Metropolitan Area of Virginia," was based on a projection and re-analysis of the 1948 origin-destination survey. Among the new facilities recommended in the study were four Potomac River crossings, located at Hanes Point (Roaches Run), Three Sisters, Jones Point, and Cabin John. Emphasis was given to the problems of accommodating traffic to and from the bridges on the Virginia approaches.

Just completed is another study by Wilbur Smith and Associates for the National Capital Planning Commission, entitled "Traffic and Capacity Needs for Potomac River Crossings," which is devoted to further evaluation of these sites as traffic facilities and a plan for the coordination of new bridges and bridge improvements with the major arterial plan. Suggested priorities for new bridges have been closely related to new express highway construction to assure sufficient approach road capacity to accommodate vehicles which would use the new structures.

5. *Traffic Counts and Classification Studies* — Records of the District of Columbia Department of Highways which were made available to the consultants provide a history of the annual traffic pattern on the Potomac River crossings since 1940. Total traffic using these crossings is shown in Table I.

Table I

TOTAL VEHICULAR TRAFFIC — POTOMAC RIVER BRIDGES

Year	*Typical Average Daily Traffic*	*Percent of 1940 ADT*
1940	105,627	100
1941	121,332	115
1942	109,206	103
1943	87,868	83
1944	90,339	86
1945	103,150	98
1946	129,231	122
1947	134,840	128
1948	146,649	139
1949	161,623	153
1950	182,190	172
1951	199,659	189
1952	208,281	197
1953	212,886	202
1954	217,000	205

An eleven hour count and classification study of trans-river traffic was also made for the consultants by the District of Columbia Department of Highways in January, 1955. This classification study segregated U. S. Government vehicles from others. It also determined the proportions of passenger cars, trucks, and buses in the daily trans-river traffic. Table II shows the composition of traffic at each bridge as determined by this count.

Table II reveals that 4,080 of the 142,737 total Potomac River crossings (about 2.9 percent) were made by Government vehicles. On the day of the count Government passenger cars constituted about 1.7 percent of all passenger cars, Government trucks accounted for about 11.5 percent of all trucks and 11.6 percent of all bus crossings were made by Government buses. Over 126,000 passenger cars were counted during the 11-hour period, representing over 88 percent of the vehicles using the bridges during that time. Trucks accounted for about 10 percent of the traffic and buses made up 1.7 percent of bridge usage. The composition of traffic using the Potomac River bridges in January, 1955, was found to agree very closely with similar data gathered in 1948 and 1953.

6. *Other Studies* — Both the National Capital Planning Commission and the District of Columbia Department of Highways have made other reports on crossing problems. Among these are official statements of the National Capital Planning Commission recommending against the "E" Street Bridge (March 10, 1954) and recommending construction of a Roaches Run crossing (March 30, 1954). Numerous other reports have also been filed which, although important, have less bearing upon the traffic aspects of the problem.

Other statistical data of much value in these investigations consisted of population statistics, traffic volume records, travel time and distance information, and similar materials used in the projection and analysis of future trends.

Table II

CLASSIFICATION OF VEHICLES CROSSING POTOMAC RIVER

(11 Hour Count, January 1955)

Bridge	Government Vehicles				Private Vehicles				All Vehicles			
	Pass	*Truck*	*Bus*	*Total*	*Pass*	*Truck*	*Bus*	*Total*	*Pass*	*Truck*	*Bus*	*Total*
Chain	29	34	2	65	8,657	846	47	9,550	8,686	880	49	9,615
Key	186	240	81	507	25,756	4,562	436	30,754	25,942	4,802	517	31,261
Memorial	1,040	297	104	1,441	37,347	118	677	38,142	38,387	415	781	39,583
Highway	898	1,080	89	2,067	52,109	7,152	950	60,211	53,007	8,232	1,039	62,278
TOTAL	2,153	1,651	276	4,080	123,869	12,678	2,110	138,657	126,022	14,329	2,386	142,737

Population Growth in the Washington Area

During the past fifteen years metropolitan Washington has expanded far beyond the limits of the District of Columbia. The Washington metropolitan area includes the District, portions of Montgomery and Prince Georges counties in Maryland, portions of Fairfax and Arlington counties, and the independent cities of Falls Church and Alexandria in Virginia. In 1940 this area contained a population of less than one million persons (962,979); by 1950 there were nearly one and one-half million residents in the metropolitan area (1,464,092), and unofficial estimates of population presently in the area approximate 1,800,000 persons. Table III illustrates the population trends for the area and indicates that by 1970 about 910,000 people are expected to reside in the District with about 2,200,000 persons expected for the metropolitan area as a whole. These estimates are in accord with recent extensive studies of future population trends for the Washington area made in the offices of the National Capital Planning Commission.

Most of the population increase since 1940 has been in the Virginia and Maryland counties adjacent to the District. Population increased over 100 percent between 1940 and 1950 in Fairfax and Arlington counties in Virginia and in Prince Georges County in Maryland; Alexandria increased during this period by over 84 percent and the District itself increased by about 21 percent. It is expected that the population growth will continue in the outlying areas — particularly in Fairfax County and other areas in northern Virginia. This expansion is expected to remain largely residential in character, following the non-industrial pattern of development established in the past. Detailed estimates of 1953 population distribution were made by adjusting the 1950 census against an inventory of occupied dwelling units throughout the area, records of new home construction and information concerning

Table III

POPULATION TRENDS — WASHINGTON METROPOLITAN AREA

Area	*1940*	*1950*	*1953*	*1970*
District of Columbia	663,090	802,180	819,500	910,000**
Alexandria	33,520	61,790	75,000	103,000
Arlington County	57,040	135,450	156,000	165,000
Fairfax County*	40,929	98,557	128,000	293,000
Falls Church	.....	7,535	8,200	9,000
Montgomery County*	83,910	164,400	212,600	304,000
Prince Georges County*	84,490	194,180	278,700	416,000
Total Metropolitan Area	962,979	1,464,092	1,678,000	2,200,000

* Populations shown for Fairfax County, Virginia, and Montgomery and Prince Georges Counties in Maryland include only those portions within the revised metropolitan area cordon line shown in the drawing in Figure 7.

** The 1970 population for the District of Columbia has been revised upward from the value reported in our report entitled "Highway Transportation in the Washington Metropolitan Area of Virginia" which was prepared for the Virginia State Highway Commission in November, 1953. This revision is in accord with recent extensive studies of future population trends made by the National Capital Planning Commission.

the number of dwellings removed or destroyed since 1950. Estimates of future population distribution were based on future land use studies made by the several active planning agencies in the Washington area. These studies indicate the amount and distribution of usable land still available in the area. Figure 2 illustrates our estimates of 1953 and 1970 population distribution in the Washington metropolitan area.

Motor Vehicle Ownership Trends

While the population of metropolitan Washington has increased by about 87 percent since 1940 (based on unofficial estimates of present population) motor vehicle registration has increased even more rapidly. Figure 3 illustrates the upward trends in passenger car registration from 1920 to 1953, projected to 1970, for the District of Columbia and its metropolitan area as well as for the states of Maryland and Virginia. Figure 4 illustrates the related trends for these areas in the ratio of persons per passenger car from 1915 to 1953; it is evident that the trend is toward fewer persons per car despite population increases. Even though recent suburban growth in the Washington area is oriented strongly toward the use of the private automobile, there is expected to be a limit to the number of automobiles which the area can support.

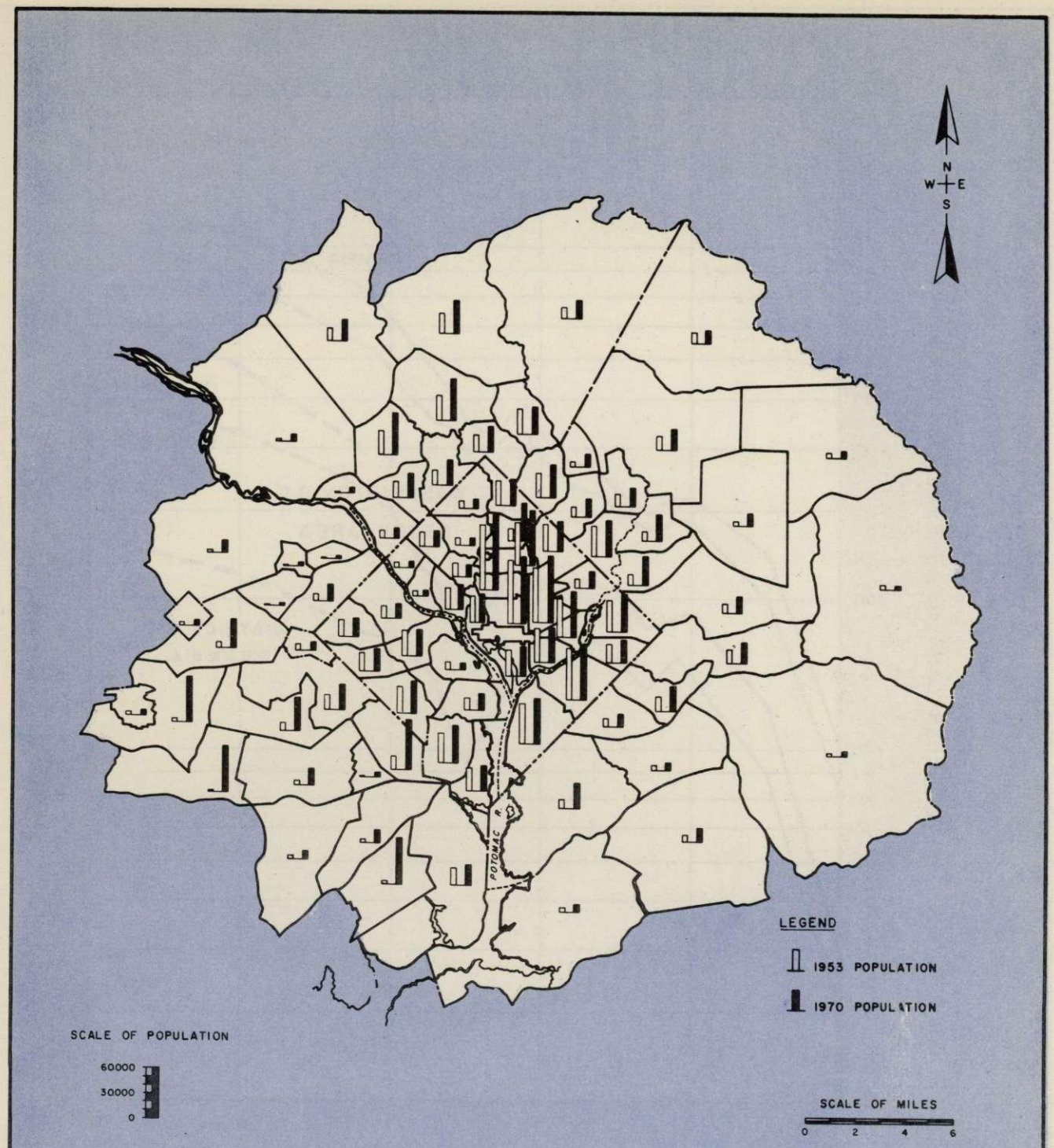
As seen from Figure 4, California, the state with the lowest ratio of persons per car, has about 2.46 persons per car which represents about 1.32 licensed drivers per registered automobile; of the 75 percent of the population in California over 16 years of age, 72 percent are licensed to drive. It is not reasonable to expect that there will ever be an average of a vehicle for each person over 16 years of age and, therefore, California is probably approaching the saturation point in automobile ownership.

Metropolitan Washington is not expected to experience the low ratio experienced in California; highly urbanized areas do not generally support as large a proportion of vehicles to population as do less urbanized locations. Passenger car registrations are expected to continue to increase

Table IV

WASHINGTON METROPOLITAN AREA
AUTOMOBILE REGISTRATION & OWNERSHIP RATIO
1953 & 1970

Area	*Year*	*Population*	*Automobile Registration*	*Persons Per Automobile*
District of Columbia	1953	819,500	176,200	4.65
	1970	910,000	276,000	3.30
Virginia Metropolitan Area	1953	367,200	107,300	3.42
	1970	570,000	219,000	2.60
Maryland Metropolitan Area	1953	491,300	145,300	3.38
	1970	720,000	277,000	2.60
TOTALS	1953	1,678,000	428,800	3.91
	1970	2,200,000	772,000	2.85



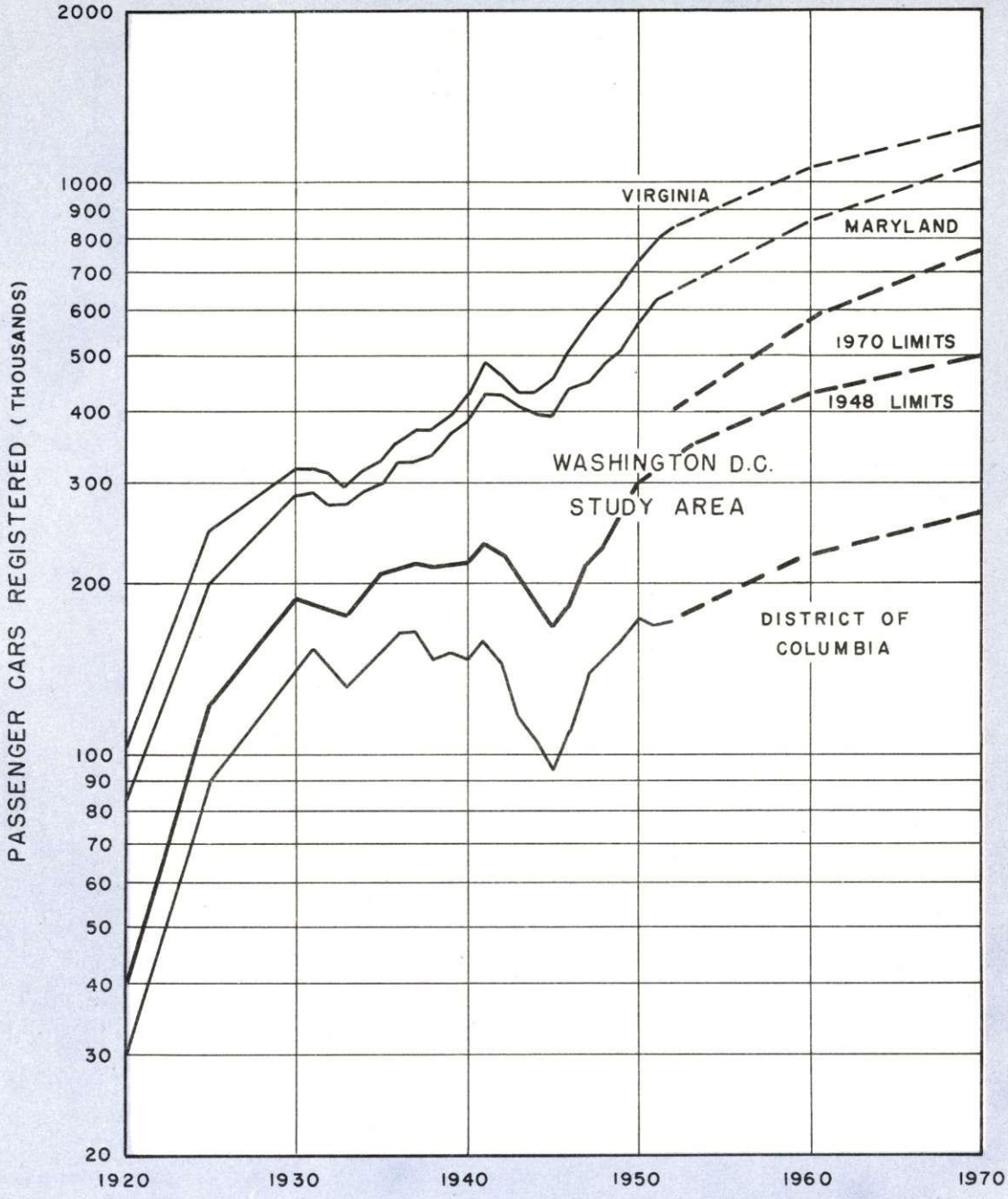
POPULATION DISTRIBUTION

WASHINGTON, D.C. STUDY AREA

1953 - 1970

WILBUR SMITH AND ASSOCIATES

FIGURE 2



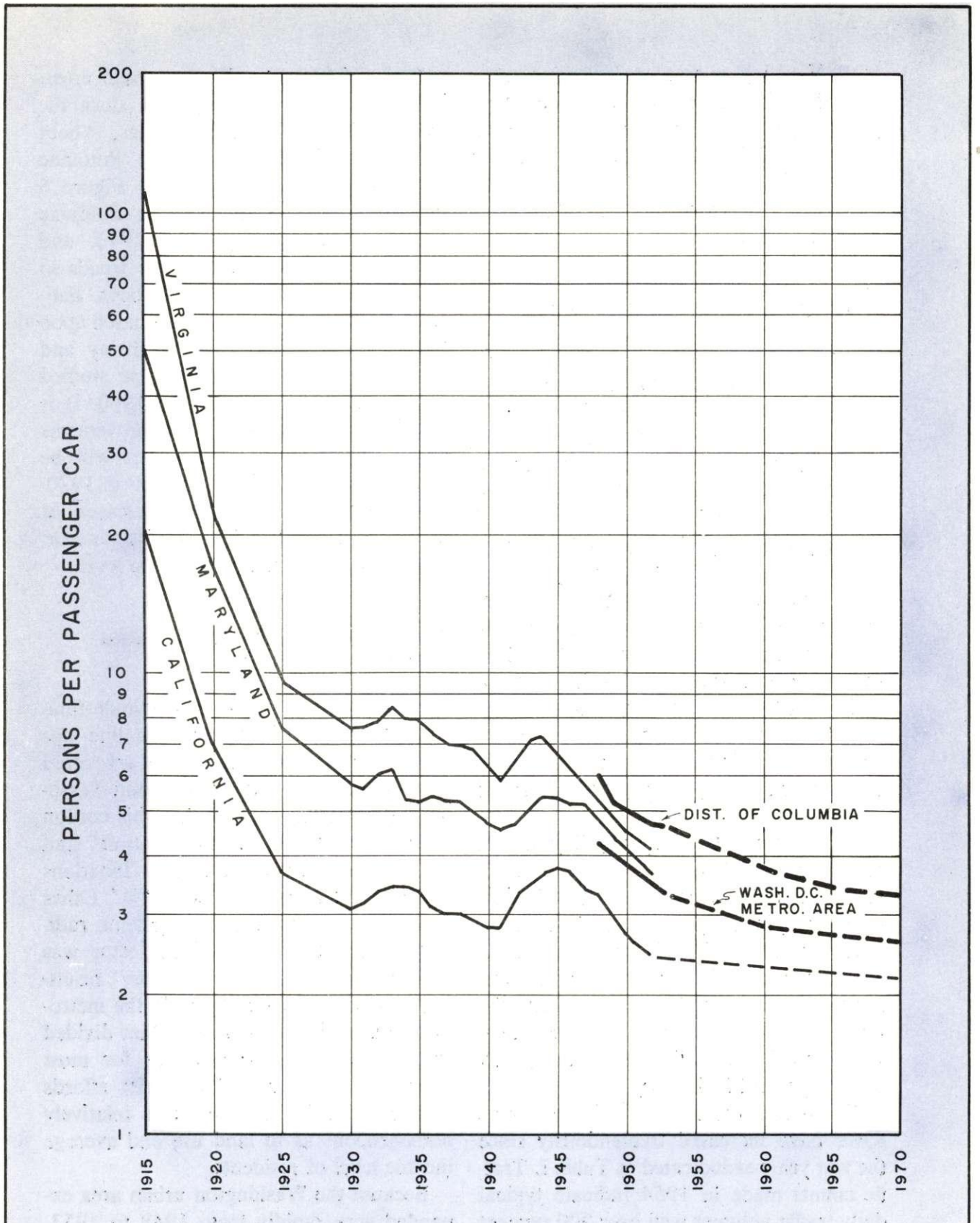
PASSENGER CAR REGISTRATION

WASHINGTON, D.C, STUDY AREA

1920 – 1970

WILBUR SMITH & ASSOCIATES

FIGURE 3



PERSONS PER PASSENGER CAR
1915 – 1970

WILBUR SMITH & ASSOCIATES

FIGURE 4

in the Washington area, at slackening rates, until by 1970 there will be about 2.85 persons per car in the metropolitan area or about 772,000 registered passenger vehicles. Table IV indicates the probable automobile ownership growth for the metropolitan area.

Traffic Growth in the Washington Area

The large increases in motor vehicle registration in the states of Virginia and Maryland and metropolitan Washington are reflected in the continued growth in traffic throughout these states and across the Potomac River. Figure 5 shows the history of annual highway use of motor fuel in Maryland, Virginia and the District of Columbia from 1925 to 1953, projected to 1970; the use of fuel is a broad measure of the trend toward increased highway travel. Traffic volume records obtained by the Virginia State Highway Department and the Maryland State Roads Commission from automatic traffic recorders installed at key locations on their primary systems of highways verify the continued growth in traffic.

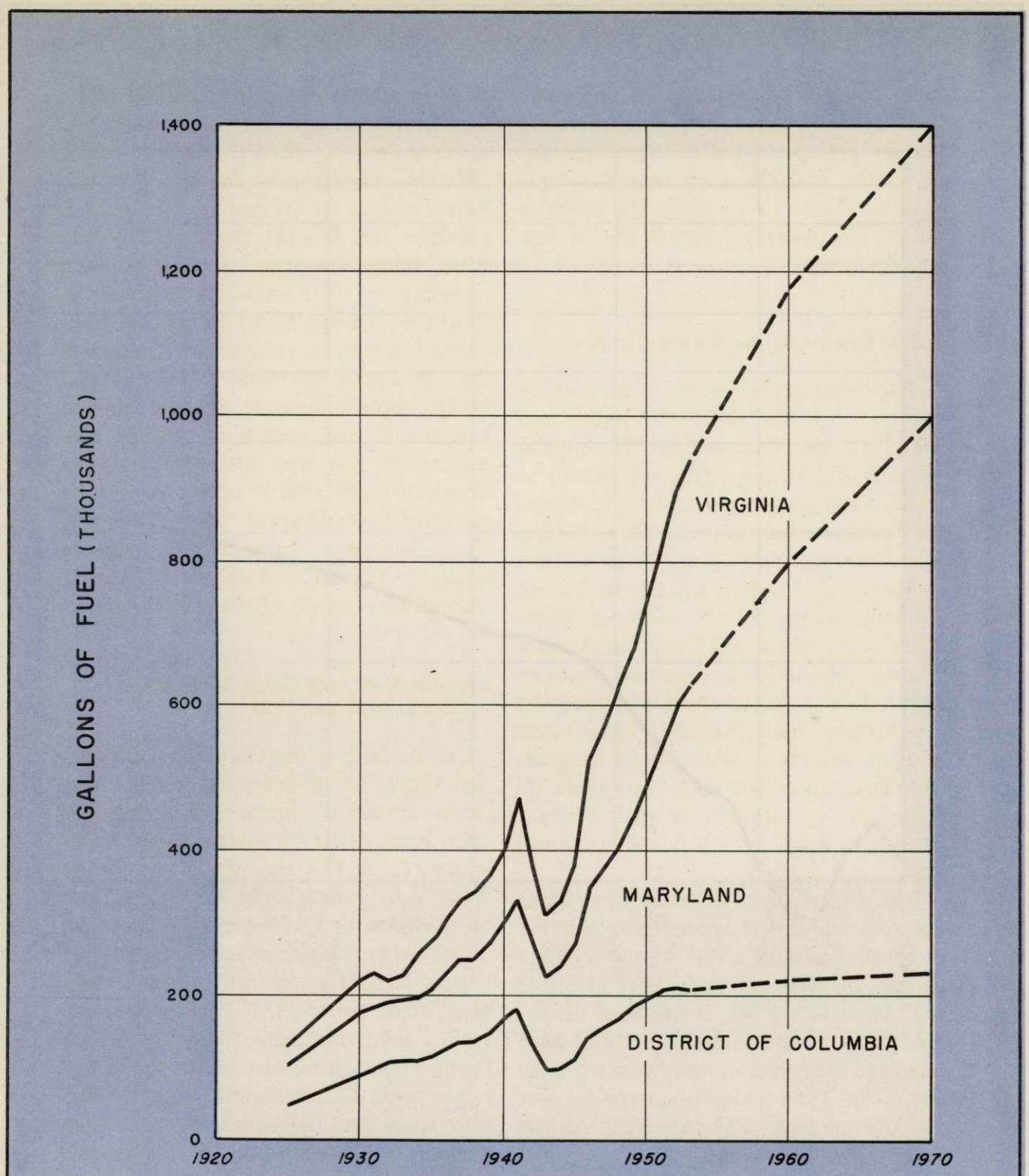
The Virginia State Highway Department has determined the approximate number of vehicle miles of travel on the Virginia primary highway system for each month of each year since 1941. It has been discovered that the vehicle miles of travel have increased every month every year since the war. The 1954 monthly increases over 1953 varied from 1.51 percent in August to 3.74 percent in January.

Trans-river crossings of the Potomac River have increased tremendously since the war years as indicated in Table I. Traffic counts made in 1954 indicate typical daily traffic volumes well over 200 percent of their 1940 levels. These annual crossings have increased every year since the wartime low of 87,868 vehicles. About 220,000 vehicles now use the Potomac River bridges on average days. Figure 6 indicates the upward trend in Potomac River bridge crossings since 1940, and projected to 1970 according to trends in local development mentioned above. Estimated future travel volumes are based upon the assumption that major highway and bridge improvements of the type studied herein will be in existence by 1960. It is anticipated that with such improvements about 267,000 vehicle crossings will be made in 1960 and about 328,000 in 1970. These estimates represent increases of about 23 percent and about 51 percent, respectively, over the 1954 traffic level.

Adjustment of 1948 Origin-Destination Data to 1953 and 1970

At the time of the 1948 origin-destination survey an arbitrary cordon line was drawn around the limits of the urbanized area which made up metropolitan Washington, D. C. The area within this cordon was divided into a series of "sectors" and the business and governmental functions at the center designated sector "O." Other sectors formed pie-shaped segments radiating from sector "O." Each sector was further subdivided into "districts," resulting in a total of 62 districts in the metropolitan area. Districts were further divided into zones and sub-zones, but for most analyses a breakdown by district affords sufficient detail. Each district is relatively homogeneous as to land use and average income level of residents.

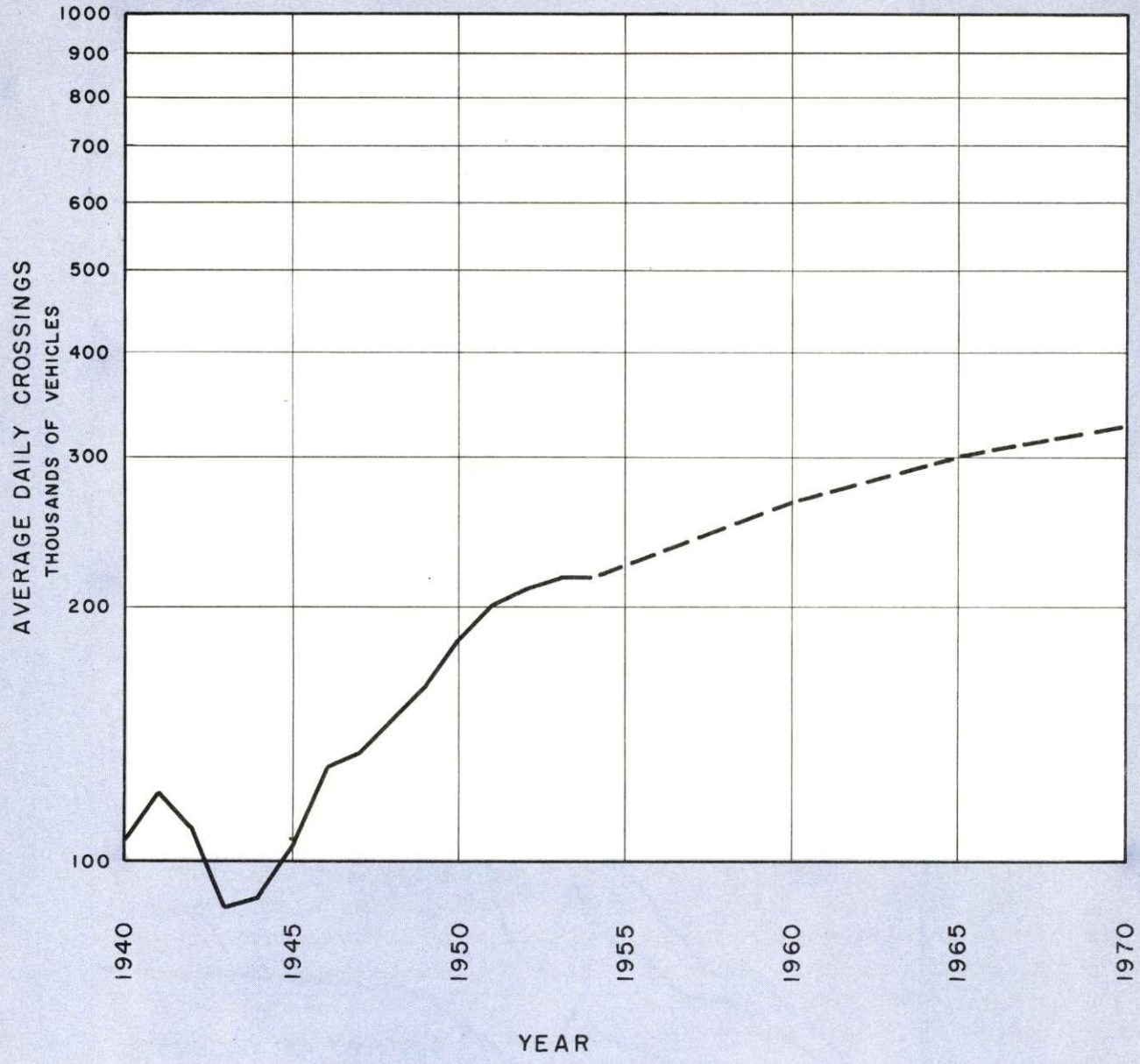
Because the Washington urban area expanded very rapidly from 1948 to 1953,



HIGHWAY USE OF MOTOR FUEL
1925 — 1970

WILBUR SMITH & ASSOCIATES

FIGURE 5



TRAFFIC GROWTH

POTOMAC RIVER CROSSINGS

1940 – 1970

WILBUR SMITH & ASSOCIATES

FIGURE 6

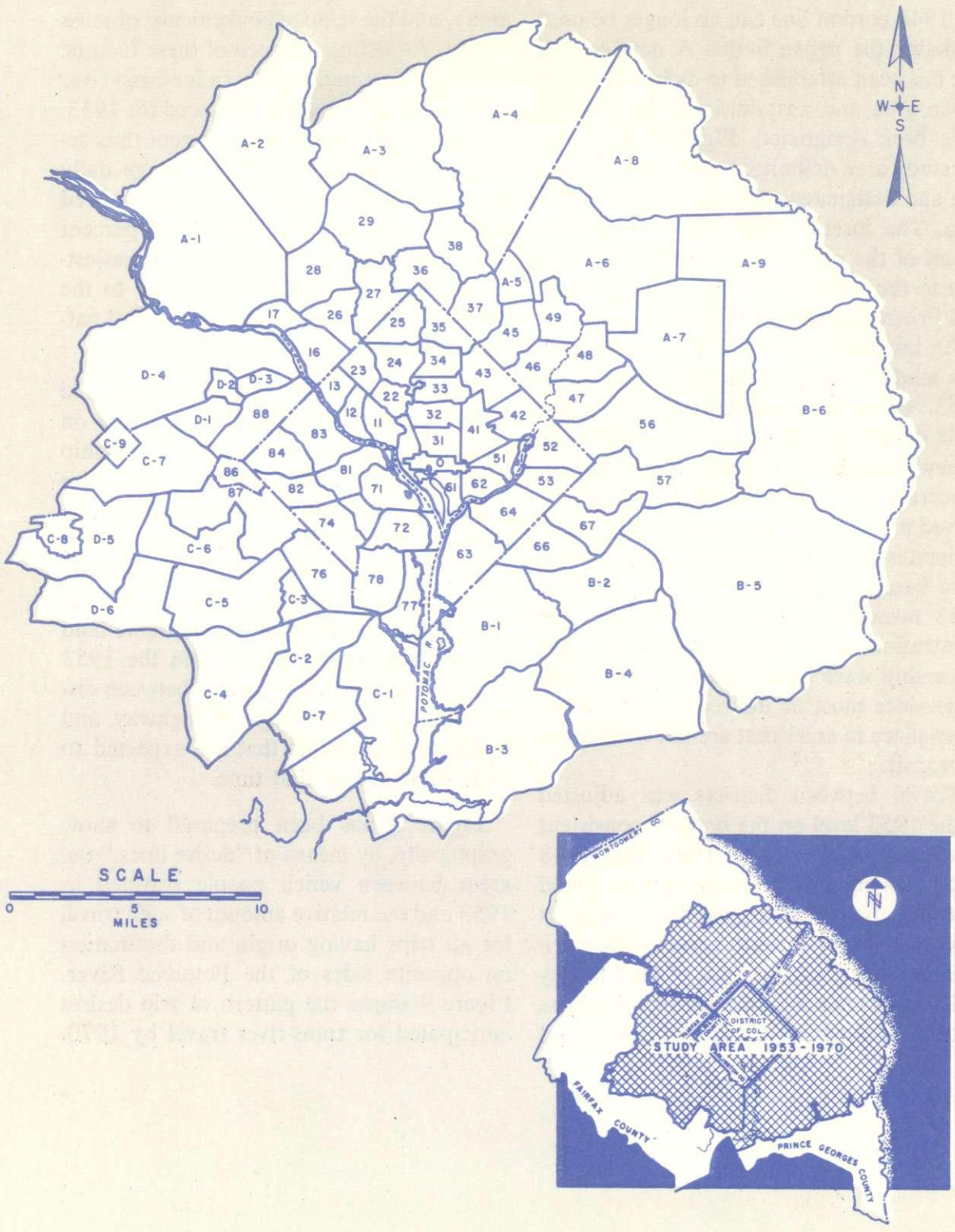
the 1948 cordon line can no longer be used to define the urban limits. A new cordon line has been established to define the 1953 urban area and an additional 31 districts have been designated. Figure 7 indicates the study area delimited by the new cordon line and designates each district within this area. The inset in Figure 7 indicates the extent of the urbanized study area in relation to the whole of Fairfax, Montgomery and Prince Georges Counties.

An inventory of occupied dwelling units was made in each of the new districts in 1953. Occupancy in districts within the 1948 cordon was determined from records of new home construction and information concerning the number of dwellings removed or destroyed since the 1950 census. Estimates of car ownership in each district were based on proportionate increases of 1948 ownership to agree with 1953 car registration data. The highest rates of car ownership were attributed to the new districts since most of the recent growth has taken place in areas that are not well served by transit.

Travel between districts was adjusted to the 1953 level on the basis of consistent relationships developed from the 1948 data. Among other things, it was found that the ratio of cars to people in a district is a basic factor in auto travel. Other criteria are length of trip, type of land use by which trips are generated (central business district, industrial area, or residential area), and the relative convenience of mass transit. Adjusting for each of these factors, the origin-destination pattern for cross-river automobile travel was determined for 1953, and the total cross-river movement thus derived was compared to the average daily travel across the river in 1953. The derived data were found to be about seven percent short of actual river crossings. An adjustment factor was applied uniformly to the origin-destination data and a corrected pattern developed.

Travel data for 1970 have been prepared in the manner described above, based on estimated population and car ownership values for each district. Estimates of future population distribution were based on future land-use studies made by the several active planning agencies in the Washington metropolitan area. These studies indicate the amount and distribution of usable land yet available in the area within the 1953 cordon. Future travel volumes between districts include evaluation of highway and bridge improvements that are expected to be in existence by that time.

Figure 8 has been prepared to show graphically, by means of "desire lines," the areas between which people traveled in 1953 and the relative amount of such travel for all trips having origin and destination on opposite sides of the Potomac River. Figure 9 shows the pattern of trip desires anticipated for trans-river travel by 1970.



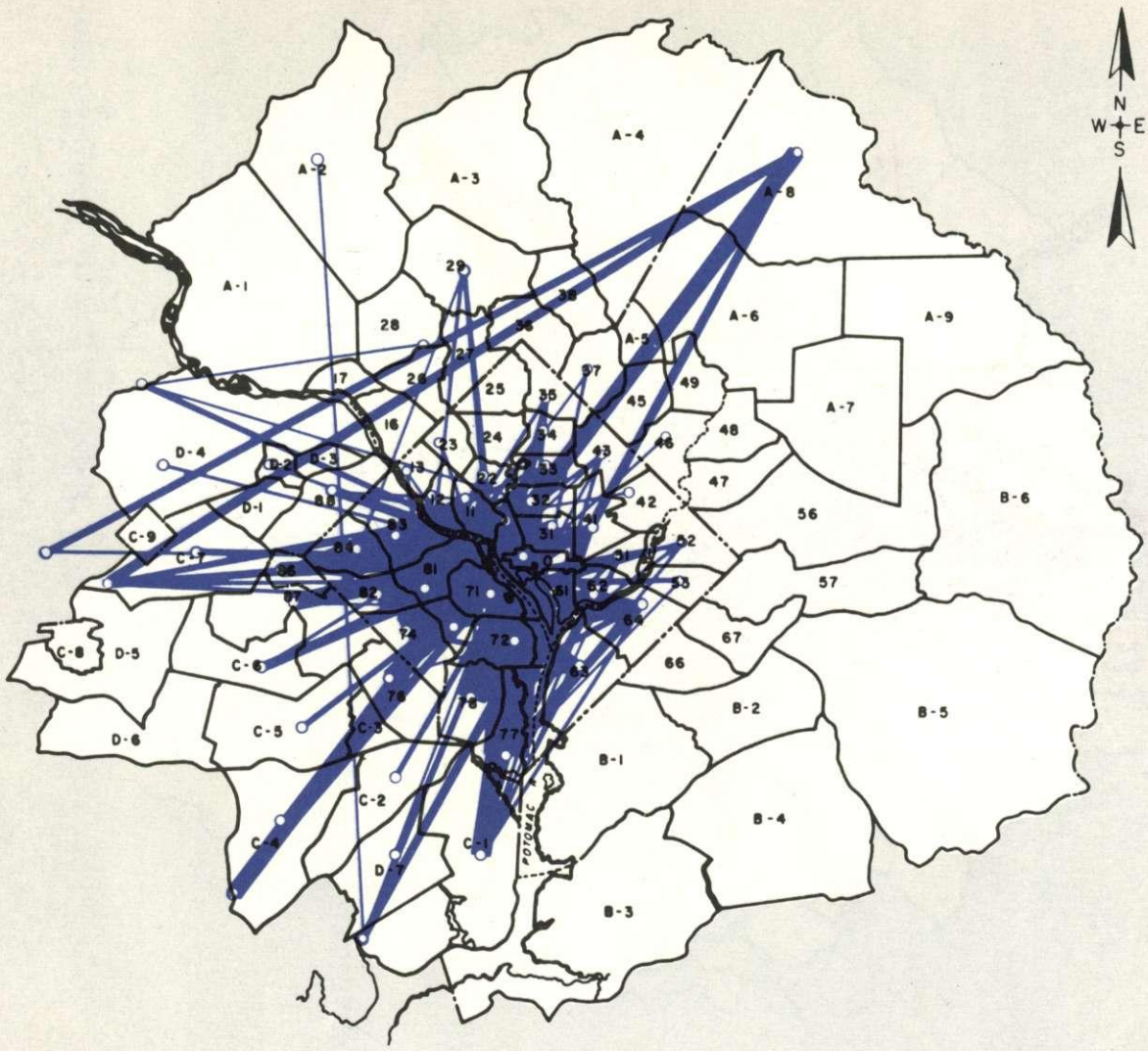
ORIGIN - DESTINATION - ZONES

WASHINGTON, D.C. STUDY AREA

1953 - 1970

WILBUR SMITH AND ASSOCIATES

FIGURE 7



SCALE OF VEHICLE TRIPS

5,000
0

DESIRES OVER 200 VEHICLE TRIPS SHOWN

SCALE

0 5 10

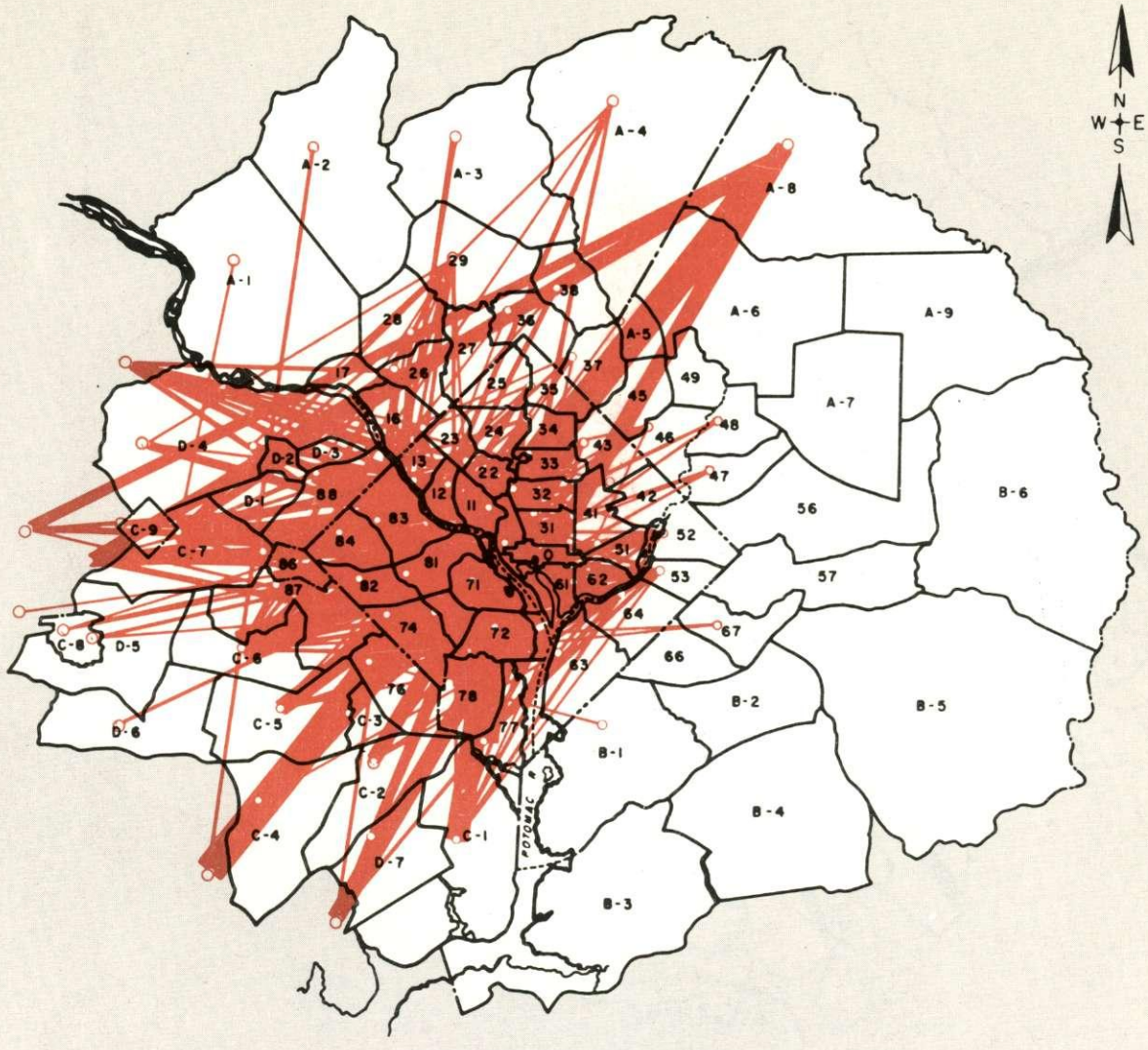
MILES

MAJOR DIRECTIONAL DESIRE LINES OF 1953 TRAFFIC ACROSS THE POTOMAC RIVER

WASHINGTON, D.C.

WILBUR SMITH AND ASSOCIATES

FIGURE 8



SCALE OF VEHICLE TRIPS

5,000
0

DESIRES OVER 200 VEHICLE TRIPS SHOWN

SCALE

0 5 10
MILES

MAJOR DIRECTIONAL DESIRE LINES OF 1970 TRAFFIC ACROSS THE POTOMAC RIVER

WASHINGTON, D.C.

WILBUR SMITH AND ASSOCIATES

FIGURE 9

PART III

Traffic Assignments

The vehicles which cross the Potomac River have a wide variety of origins and destinations, as shown in Figures 8 and 9. The river crossing that a driver chooses is closely related to the pattern of trip desires shown on the drawing, but is modified by topographical restrictions, political boundaries, and the location and capacity limitations of bridges and approach roads.

Choice of Route

The origin-destination survey of 1948 obtained a vast amount of detailed travel information in the Washington area which can be used as a guide in determining the probable future patterns of travel. These data have been analyzed to determine the basic patterns of automobile and truck travel across the Potomac River.

In general, traffic across the Potomac River seeks the shortest and fastest route between points of origin and destination as determined by the location of highways and bridges and the quality of travel afforded on alternate routes. At hours when traffic is relatively light on all routes, it is possible for every driver to select the route he considers most direct. At peak hours, however, the shortest route may not be the fastest due to congestion, and a less direct route might be found to afford considerable time advantage.

Many of the tangible and intangible factors which cause a driver to select a certain route can be interpreted in terms of travel time. If a time saving may be gained by proper choice of route, drivers in general will choose the route having the most time advantage. Although many other factors tend to modify the importance of time saving and may reverse it if monetary considerations such as toll charges are involved, the time measure is a valuable indication of route preference in urban areas. In the case of the Washington study, a time ratio measure was developed from 1947 origin-destination data, bridge-use data, and travel-time information and has yielded satisfactory results.

Average travel time studies for all of the principal highways and streets in the Washington metropolitan area have been developed by the District of Columbia Department of Highways. From these data it is possible to compute the average length of time that would be consumed in traveling between most points in the metropolitan area. Comparison of the travel times required by alternate routes will reveal the route which requires the least time for travel and which is therefore likely to be the route selected for use.

Drivers are not usually aware of the precise time savings that a particular route affords over other possible choices. Therefore, it is not possible to assign all traffic between common points to the shortest route indicated by the time-ratio. If travel times are equal by the principal routes, any

one route will generate about as much of the movement as will the others. If a route has a slight time advantage over others it will tend to attract a slightly higher proportion of travel. If the time advantage is rather large most vehicles will use the shorter route. Empirical studies of such conditions indicate that a route which requires only 80 percent as much travel time as the most attractive alternate will be used by between 80 percent and 90 percent of the drivers performing the trip, all other conditions being equal.

1954 Use of Existing Bridges

Table V indicates the average daily volume of travel on each of the Potomac River bridges in 1954. These average daily traffic (ADT) volumes are based on bridge counts taken at different times during the year which have been reduced to average values on the basis of continuous traffic counts made at selected locations in the Washington area. The ADT values are especially useful in developing the relative traffic demand on the several Potomac River bridges.

It can be seen that almost half of the daily trans-river traffic and about 39 percent of the traffic at peak hours use the Highway Bridge. The Memorial and Chain Bridges carry about 25 percent and six percent of the total daily crossings and greater proportions of peak hour traffic (31 percent and 11 percent, respectively). Travel on the Key Bridge amounts to 22 percent of the average daily volume and accounts for 19 percent of peak hour bridge use.

Effects of Capacity Limitations

Traffic engineers and road designers must give consideration to the amount of traffic that can be handled on the roads and bridges for which they are responsible. Two measures of highway capacity are in common use, both based on volumes of passenger cars per lane. "Practical" capacity refers to a condition of use under which vehicles are able to keep moving with overall speed curtailed somewhat below the levels attained at lower volumes. "Possible" capacity represents complete saturation which involves considerable delay and congestion. These capacity criteria are usually expressed in terms of vehicles per lane in

Table V

1954 TRAFFIC DISTRIBUTION[2]
POTOMAC RIVER BRIDGES

Bridge	*Daily Traffic (Vehicles)*	*Percent of Crossings*	*Inbound Peak Hour*		*Outbound Peak Hour*	
			Vehicles	*Percent*	*Vehicles*	*Percent*
Highway (14th St. Br.)	102,000	47.0	5,400	38.7	5,350	38.4
Memorial	54,000	24.9	4,230	30.3	4,420	31.7
Key	47,000	21.7	2,660	19.1	2,670	19.2
Chain	14,000	6.4	1,660	11.9	1,490	10.7
TOTAL	217,000	100.0	13,950	100.0	13,930	100.0

[2] "Traffic and Capacity Needs for Potomac River Crossings," Wilbur Smith and Associates; a report for the National Capital Planning Commission, Washington, D. C., 1955.

the direction of heaviest travel at peak hours and vary considerably according to road width and alinement and the influence of traffic regulating devices such as stop signs and traffic signals. Since peak-hour traffic generally represents a rather uniform proportion of the average daily traffic, peak-hour capacities are frequently stated in terms of average daily traffic. Daily capacity values are used here in evaluating bridge capacity limitations.

The trans-river traffic volumes for 1953, which were derived by methods described in Part II, have been assigned to most likely routes across the Potomac on the basis of relative time saving, and the results expanded to 1954 ADT levels. These assignments have resulted in theoretical traffic volumes on the Highway and Memorial Bridges which exceed the actual use of the bridges (Table VI). Since actual use of these bridges is considerably greater than the practical capacities computed for them, it is clear that some vehicles have been discouraged from using these bridges and have sought other less direct routes. Most of these re-oriented drivers have chosen to use the Key Bridge, where actual use is about 50 percent greater than the use assigned by the time-ratio technique.

The principal deficiency of the time-ratio method is its inability to distinguish capacity limitations. The time-ratio as used above is based on average conditions, while the capacity deficiency occurs at peak hours. A peak hour time-ratio might be applied to correct this deficiency were it not for the fact that volumes of traffic diverted from the Memorial and Highway Bridges have loaded the Key Bridge beyond its practical capacity, too, as shown in Table VI.

In order to fit traffic assignments to bridge capacity limitations, a method of successive approximations has been applied to the trip assignments determined by the time-ratio method. It is known that as volumes approach capacity limits delay is created rather suddenly. Under these conditions, some drivers seek the next most attractive route. As the alternate route reaches saturation, drivers again seek another route, but probably not the same drivers, since a third alternate may be very much less attractive to the drivers first diverted. This procedure appears to have

Table VI

TRAFFIC USE AND TRAFFIC DESIRES ON EXISTING BRIDGES

1954

Bridge	*Practical Capacity**	*1954 ADT on Bridges*	*Percent of Crossings*	*Time-Ratio Assignment*	*Percent of Crossings*
Highway Bridge (14th St. Br.)	90,000	102,000	47.5	105,700	48.7
Memorial	50,000	54,000	24.2	66,800	30.8
Key	43,000	47,000	22.4	31,000	14.3
Chain	12,000	14,000	5.9	13,500	6.2
TOTAL		217,000	100.0	217,000	100.0

* Capacities are based on the relation of existing peak hour directional volumes to total daily traffic and to theoretical lane capacities.

progressed to a point of almost uniform bridge saturation at peak hours on the Potomac River bridges.

In deriving the origins and destinations of traffic using the Potomac River bridges at the 1954 level, assignments based on time-ratio desires have been adjusted by diverting overloads to the most likely alternate bridge, and, in turn, diverting overloads from that bridge to another alternate.

In developing assignments to new bridges not yet built, the same technique may be applied to the adjustment of trip patterns derived from the time-ratio study.

Assignments to Proposed Facilities—1960

Six proposed Potomac river bridges have been selected for study and analysis, as described in Part I of this report. (See Figure 1.) Each bridge location incorporates sections of access highway which are required to properly integrate the new bridge into the Washington highway system.

The quality of travel on the approach roads will have a great deal to do with the attractive power of the bridges in diverting and generating new travel. Travel time on these approach facilities has been computed at rates similar to time required on existing routes of similar high design standards.

Applying the techniques of time-ratio trip assignment, modified by capacity limitations as described above, an estimate has been prepared to show how traffic would have used the proposed Potomac River crossings if they had been available in 1954. Three separate studies have been made, as shown in Table VII. In all studies, the Jones Point, Roaches Run, Constitution Avenue, and Cabin John Bridges have been assumed to exist. In addition, two alternate plans for central crossings have been examined, the first of which envisions

Table VII

ESTIMATED DISTRIBUTION OF TRAFFIC TO POTOMAC RIVER BRIDGES
1954 ADT

Bridge	*Practical Capacity (Vehicles per day)*	*New Bridges at Jones Point, Roaches Run, Cabin John, and:*		
		Constitution Ave.	*Constitution & Three Sisters*	*Constitution & Nebraska Ave.*
Jones Point	50,000	10,200	10,200	10,200
Roaches Run	75,000	23,400	23,000	23,400
Highway (14th St.)	100,000	54,000	52,000	54,000
Memorial	60,000	40,200	36,000	37,000
Constitution Ave.	75,000	48,000	40,000	43,000
Francis Scott Key	75,000	29,500	20,000	22,300
Three Sisters	75,000	.....	26,600	.....
Nebraska Ave.	75,000	.....	.....	20,000
Chain	20,000	9,700	7,200	5,100
Cabin John	50,000	2,000	2,000	2,000
TOTAL		217,000	217,000	217,000

another crossing at Three Sisters, while the second proposes a supplementary bridge at Nebraska Avenue.

The traffic volumes shown on each of the three schemes indicate the approximate distribution of traffic, assuming that proposed access roads would be a part of each scheme.

Traffic on Bridges, 1960

Recent studies prepared for the National Capital Planning Commission indicate that all of the improvements proposed for existing bridges should be undertaken immediately and that the Jones Point, Roaches Run and one of the central crossings should all be initiated not later than 1960. The Cabin John Bridge might be deferred beyond that date.

If an acceptable plan of revenue bond financing were developed, it is reasonable to expect that a recommended program of new bridges and highway improvements would be complete and ready for operation by 1960. A pattern of traffic distribution has been devised (Table VIII) for the year 1960.

It should be noted that the traffic figures developed here are based on projections of present river crossing patterns and volumes and do not take into account additional traffic that new facilities such as those proposed would be expected to generate.

Table VIII

ESTIMATED DISTRIBUTION OF TRAFFIC TO POTOMAC RIVER BRIDGES
1960 ADT

Bridge	*Practical Capacity (Vehicles per day)*	*New Bridges at Jones Point, Roaches Run, Cabin John, and:*		
		Constitution Ave.	*Constitution & Three Sisters*	*Constitution & Nebraska Ave.*
Jones Point	50,000	16,000	16,000	16,000
Roaches Run	75,000	31,000	30,700	31,000
Highway (14th St.)	100,000	65,500	63,000	65,000
Memorial	60,000	44,000	40,000	40,500
Constitution Ave.	75,000	57,500	49,000	52,300
Francis Scott Key	75,000	36,500	23,500	26,500
Three Sisters	75,000	.....	31,800	.....
Nebraska Ave.	75,000	.....	.....	24,800
Chain	20,000	12,000	8,500	6,400
Cabin John	50,000	4,500	4,500	4,500
TOTAL		267,000	267,000	267,000

1970 Traffic on Bridges

Trip desires of the populace expected to reside in the Washington area by 1970 were estimated in the manner described in Part II of this report. The bridge crossings that traffic would use were again determined by the time-ratio method already described and the potential use of each facility thus established (Table IX).

Table IX

ESTIMATED DISTRIBUTION OF TRAFFIC TO POTOMAC RIVER BRIDGES
1970 ADT

Bridge	*Practical Capacity (Vehicles per day)*	*New Bridges at Jones Point, Roaches Run, Cabin John, and:*		
		Constitution Ave.	*Constitution & Three Sisters*	*Constitution & Nebraska Ave.*
Jones Point	50,000	24,300	24,300	24,300
Roaches Run	75,000	43,200	42,000	42,900
Highway (14th St.)	100,000	77,300	76,500	77,000
Memorial	60,000	47,300	42,500	43,000
Constitution Ave.	75,000	68,300	60,000	63,000
Francis Scott Key	75,000	45,000	27,500	31,000
Three Sisters	75,000	.....	37,300	.....
Nebraska Ave.	75,000	.....	.....	30,800
Chain	20,000	14,700	10,000	8,100
Cabin John	50,000	7,900	7,900	7,900
TOTALS		328,000	328,000	328,000

PART IV

Cost of New Bridges and Improvements

An extensive program of bridges and highway improvements has been discussed in the foregoing sections of this report. The feasibility of revenue bond financing of these new facilities depends directly on the amount of money required to build and operate them.

Construction Costs

All estimates of the construction costs of new bridges, bridge improvements, bridge approach roads, and the installation of toll collecting equipment were prepared for the consultant by the District of Columbia Department of Highways, except for cost estimates of the Three Sisters Bridge and approaches which were developed by the consultant. While these estimates are felt to be representative of probable costs, the Director of the Department of Highways has indicated that they should not be construed to indicate the cost of an approved plan at any given location. The estimated costs of proposed new facilities are show in Table X. Cost estimates for the toll plazas shown in Table X for the Highway, Memorial and Key Bridges were prepared by the District of Columbia Department of Highways based upon schematic layouts prepared by the consultant; cost figures used for the toll plazas of all other bridges are figures assumed for the purposes of this study and are not based upon specific designs. Toll plaza costs for the proposed bridges were assumed to be considerably lower than the costs of constucting plazas on existing bridges since in most locations the new bridge approaches would be designed to incorporate the toll plaza.

The construction cost estimates prepared by the Highway Department include property acquisition where new property is required, engineering costs, a contingency reserve, and other usual construction items.

Extensive approach roads and connections to arterial highways would be required to unite each of the new bridges with the principal flows of traffic which they are designed to accommodate. The cost of access facilities would exceed the cost of the bridges in the cases of the Roaches Run, Constitution Avenue, Three Sisters, and Cabin John Bridges.

Maintenance and Operation of Bridges

The Highway Bridge and the Memorial Bridge are low-level structures which must be opened for river traffic. Roaches Run and Constitution Avenue Bridges would be of similar construction. The Key Bridge and all bridges upstream from it would be high-level fixed structures. Annual costs of low-level bridge operations have been developed by the District of Columbia Department of Highways and are shown in Table XI. Also shown in the table are estimated annual maintenance costs for each of the bridges.

Table X

ESTIMATED CONSTRUCTION COSTS — NEW POTOMAC RIVER BRIDGES AND IMPROVEMENTS

Bridge	*Cost of Structure*	*D. C. Approaches*	*Virginia Approaches*	*Maryland Approaches*	*Toll Plazas*	*Toll Equipment*	*Project Cost*
Jones Point	$14,847,000	$ 1,200,000	$ 7,488,000	$ 885,000	$ 500,000	$185,000	$25,105,000
Roaches Run	11,087,000	15,698,000	21,376,000	.....	1,500,000	275,000	49,936,000
Highway (14th St.)	8,850,000	290,000	848,000	.....	1,602,600	460,000	12,050,600
Memorial	.....	.....	.....	.....	6,540,200	275,000	6,815,200
Constitution Ave.	7,457,000	8,388,300	1,884,000	.....	2,000,000	275,000	20,004,300
Francis Scott Key	652,600	2,793,000	1,449,900	.....	6,675,300	275,000	11,845,800
Three Sisters*	5,616,000	4,936,000	750,000	.....	1,500,000	275,000	13,077,000
Nebraska Ave.	5,663,750	1,647,250	1,261,550	.....	1,500,000	275,000	10,347,550
Chain	.....	.....	.....	.....	200,000	100,000	300,000
Cabin John	2,600,000	.....	3,500,000	1,000,000	200,000	185,000	7,485,000

* Estimates for Three Sisters Bridge and approaches prepared by consultant. All other estimates for construction costs were prepared by the District of Columbia Department of Highways; these estimates are felt to be representative of probable costs but should not be construed to indicate the cost of an approved plan at any given location. Cost figures for the toll plazas of the Jones Point, Roaches Run, Constitution Avenue, Three Sisters, Nebraska Avenue, Chain and Cabin John Bridges included above are not based on detailed estimates of any particular design but are assumed figures for the purposes of the feasibility studies included in this report.

Note that all construction costs include the costs of engineering, cost of property acquisition, a contingency reserve, and the other usual construction items.

Toll Collection Costs

The costs of collecting tolls is a major item of expense on all toll facilities. However, the operation of a number of toll bridges as a system will allow certain overhead items to be pro-rated over the several components in the system. Administrative and accounting costs, insurance, toll bridge patrol, and other cost items do not increase in direct proportion to the number of new bridges added to a toll system. The only cost tied directly to the volume of traffic using the bridges is that of toll collection.

In Table XII the estimated annual costs of maintaining and operating toll collection facilities have been set forth for traffic volumes anticipated in 1960 and tabulated with bridge maintenance and operation costs shown in Table XI. Tentative estimates of total annual maintenance and operation costs have been prepared for each of the several toll bridge systems described in Part I of this report (Schemes I to IV).

Other Costs

Revenue bond financing will also involve financing charges and interest during construction. The amount of such costs will depend on the size of bond issue required and the rate of interest that the bonds draw. These costs have been worked out for assumed rates of interest in the following feasibility studies, each of which is tailored to an assumed set of conditions, costs, and revenues.

Table XI

OPERATION AND MAINTENANCE OF POTOMAC RIVER BRIDGES

Bridge	*Annual Operating Cost*	*Annual Bridge Maintenance*	*Total Annual M & O*
Jones Point	$35,000	$24,000	$59,000
Roaches Run	35,000	29,000	64,000
Highway (14th St.)	35,000	18,000	53,000
Memorial	50,000	29,000	79,000
Constitution Ave.	35,000	21,000	56,000
Francis Scott Key	.....	1,000	1,000
Three Sisters	.....	13,000	13,000
Nebraska Ave.	.....	13,000	13,000
Chain	.....	3,000	3,000
Cabin John	.....	13,000	13,000

Table XII

ANNUAL MAINTENANCE AND OPERATION COSTS FOR POTOMAC RIVER TOLL BRIDGE SYSTEMS — 1960

Cost Items	*Scheme I Outer Crossing*	*Scheme I-A Jones Point Bridge Only*	*Scheme II Eight Bridges*	*Scheme II-A Scheme II With Additional Bridge*	*Scheme III Six Central Crossings*	*Scheme IV Five Central Crossings*
Administration & Accounting	$125,000	$ 75,000	$ 325,000	$ 350,000	$ 275,000	$ 235,000
Bridge Maintenance & Operation	72,000	59,000	328,000	341,000	256,000	177,000
Toll Collection	65,000	40,000	650,000	725,000	585,000	470,000
Toll Plaza & Bridge Patrol	20,000	12,000	75,000	80,000	55,000	45,000
Insurance & Miscellaneous	75,000	45,000	250,000	280,000	190,000	165,000
Total Annual Cost	$357,000	$231,000	$1,628,000	$1,776,000	$1,361,000	$1,092,000

PART V

Toll Rates and Potential Revenues

The volume of Potomac River crossing demands expected by 1960 and by 1970 and the manner in which traffic would distribute to the several bridges have been developed in Part III. It should be noted again that the volumes thus developed are based on the assumption that travel time between points of origin and destination would remain substantially as it is today.

Generated Traffic

If new bridges and an extensive network of freeways were constructed which would materially reduce the amount of time presently required for trans-river travel, the volume of trips crossing the Potomac would be considerably increased. A study recently submitted to the National Capital Planning Commission by this consultant found that the construction of a sufficient number of new free bridges with appropriate approach facilities should induce new crossing trips amounting to about 25 percent more than in the amount of traffic anticipated by projecting the normal growth trend described in Part II of this report.

Effect of Toll Charges

On the other hand, if a direct charge were levied against all vehicles which presently use the Potomac River crossings the volume of crossings would be curtailed. The degree of curtailment would depend upon the amount of toll charged and the relation of toll charges to other costs of vehicle operation.

The very purpose of the proposed new Potomac River bridges is to relieve and improve traffic operations across the Potomac River. It follows that toll financing of these new structures ought to be accomplished by using the lowest possible toll-rate structure consistent with revenue requirements to pay for the improvements. Only by keeping toll rates low can the primary purpose of the bridges — to accommodate large volumes of traffic — be realized.

In preparing the several analyses of toll-bridge feasibility, the following toll-rate schedules have been used as a basis for revenue calculations:

TOLL RATES FOR POTOMAC RIVER CROSSINGS

Vehicle-Class	*Basic 10c Toll*	*Basic 15c Toll*
Passenger Cars and Light Trucks (4-tire panels, pickups, etc.)	10c each way	15c each way
Medium Trucks (2-axle, 6-tires)	15c " "	20c " "
Heavy Trucks and Combinations	25c " "	35c " "
Buses	25c " "	35c " "

A basic ten-cent passenger car toll and charges of 15c and 25c for trucks may be considered nominal rates. Although these rates of toll will not seriously discourage drivers from crossing the Potomac River, the toll will depress the amount of trans-river travel to some degree, and to compensate for this loss no allowance has been made for the traffic inducement that would normally be generated by the development of new and improved river crossings and access routes.

At a basic passenger car rate of 15c it would be necessary to anticipate some reduction in trans-river traffic volumes. Commercial vehicles would be affected to a lesser degree than passenger cars, due to the basic nature of commercial trips. In developing traffic volumes expected under the basic 15c schedule, the number of commercial trucks has been reduced by five percent and private passenger cars by 20 percent. Where commuter rates were employed, the proportion of commuters was actually assumed to increase since the higher toll schedule afforded greater relative benefits than the lower rate schedule. It has been assumed that buses and government vehicles would be affected to a negligible degree.

Expected Toll Revenues

If either of the toll schedules noted above were adopted and tolls collected from every bridge user in accordance with these rates, earnings of the bridge system could readily be computed. Revenues which could be expected if all bridge users paid tolls have been developed in Table XIII. With a basic 10c passenger car toll on all bridges, gross income would amount to $10,705,-919 in 1960. If the 15c toll schedule were imposed, 1960 revenues would come to $13,058,278, or about 22 percent more than would be realized if the basic 10c schedule were used.

Free Vehicles:

The most equitable treatment of toll bridge users would require that all vehicles be treated alike in paying for use of the bridges. It is not always possible to achieve this goal, however. Government owned vehicles, as a class, are sometimes granted free use of toll facilities. In the case of the Potomac River bridges, government vehicles were found to number nearly three percent of the total crossing volume. (See Table II). A high proportion of this traffic consists of trucks and buses so that the overall effect on revenues would be considerable if government vehicles were allowed free passage.

In Table XIV potential toll-bridge revenues have been computed for the year 1960, assuming that government vehicles would be allowed to cross the Potomac River without charge and that all bridges would operate as toll facilities. Gross revenues expected to accrue at a 10c basic rate would amount to about $10,288,986 during the course of the year. Gross revenues earned by the basic 15c toll schedule would amount to $12,489,607. Losses due to free use by government vehicles amount to nearly $420,000 on the 10c schedule and $568,000 on the 15c schedule.

Commuters: Ticket Books

Commuters account for a large share of passenger car use on the Potomac River bridges, and commuter fees must be expected to pay a substantial share of bridge

Table XIII

POTENTIAL REVENUES, 1960 — POTOMAC RIVER TOLL BRIDGE SYSTEM
TOLLS ON ALL CROSSINGS; ALL VEHICLES PAY

Vehicle Class	10c Basic Pass. Car Rate: Daily* Vehicles	Toll Rate	Annual Revenues	15c Basic Pass. Car Rate: Daily* Vehicles	Toll Rate	Annual Revenues
Govt. Trucks	3,100	$0.20**	$ 226,300	3,100	$0.25**	$ 282,875
Medium Trucks ..	18,960	0.15	1,038,060	18,012	0.20	1,314,876
Heavy Trucks ...	4,750	0.25	433,438	4,512	0.35	576,408
Govt. Buses	510	0.25	43,538	510	0.35	65,153
Other Buses	3,950	0.25	360,438	3,950	0.35	504,613
Govt. Pass. Cars .	4,030	0.10	147,095	4,030	0.15	220,643
Other Pass. Cars .	231,700	0.10	8,457,050	184,360	0.15	10,093,710
TOTALS	267,000		$10,705,919	218,474		$13,058,278

* Based on Department of Highway's traffic classification counts on all Potomac River Bridges, January, 1955.
** Government trucks are not shown segregated by class. Toll charges would be identical with those paid by commercial vehicles of the same size. These rates are intended to represent the average toll paid by government trucks.

Table XIV

POTENTIAL REVENUES, 1960 — POTOMAC RIVER TOLL BRIDGE SYSTEM
TOLLS ON ALL CROSSINGS; GOVT. VEHICLES FREE; ALL OTHERS PAY

Vehicle Class	10c Basic Pass. Car Rate: Daily* Vehicles	Toll Rate	Annual Revenues	15c Basic Pass. Car Rate: Daily* Vehicles	Toll Rate	Annual Revenues
Govt. Trucks	3,100	$ ...	$.....	3,100	$ ...	$.....
Medium Trucks ..	18,960	0.15	1,038,060	18,012	0.20	1,314,876
Heavy Trucks ...	4,750	0.25	433,438	4,512	0.35	576,408
Govt. Buses	510	...	.....	510	...	.....
Other Buses	3,950	0.25	360,438	3,950	0.35	504,613
Govt. Pass. Cars .	4,030	...	.....	4,030	...	.....
Other Pass. Cars .	231,700	0.10	8,457,050	184,360	0.15	10,093,710
TOTALS	267,000		$10,288,986	218,474		$12,489,607

* Based on Department of Highway's traffic classification counts on all Potomac River Bridges, January, 1955.

costs if non-commuter rates are to be kept low.

Several methods are currently used to favor commuter travel on toll facilities. Most common, perhaps, is the sale of ticket books at a discount. Thus, at the 10c basic rate, a fifty-ride book with a face value of $5.00 might be sold to commuters for $4.00, allowing them a 20 percent advantage. On the 15c schedule it might be possible to offer commuters even greater proportionate saving and still develop an income advantage to the toll system. A 50-ride book for $5.00 would allow the commuter a 33 1/3 percent advantage which would, of course, generate greater use of commuter tickets.

The use of commuter tickets would appreciably reduce annual revenues potential to a toll bridge system. Table XV shows the income which could be expected if commuter tickets were sold at the rates suggested above, and if government vehicles were permitted to cross the river free of charge. Under the basic 10c schedule the toll bridge system would gross $9,443,281 in 1960; with the 15c schedule expected income would amount to $12,121,504. If government vehicles were also required to pay tolls, additional income from them would amount to about $390,000 on the 10c schedule and $495,000 with the 15c schedule.

When the methods of commuter toll collections have been studied and evaluated, the ticket book is found to have considerable appeal. The driver pays for each trip; he realizes a substantial saving on each crossing; tickets can be issued to remain valid for a considerable length of time so that the occasional user can benefit; every ticket holder is treated just alike, so that no one can be said to gain certain advantages by virtue of very frequent use; and an important advantage lies in the fact that the toll collector is required to show evidence for each vehicle that passes through his station, thereby reducing opportunities for toll collecting fraud.

Table XV

POTENTIAL REVENUES, 1960 — POTOMAC RIVER TOLL BRIDGE SYSTEM TOLLS ON ALL CROSSINGS; COMMUTER TICKETS; GOVT. VEHICLES FREE

	10c Basic Pass. Car Rate			*15c Basic Pass. Car Rate*		
Vehicle Class	*Daily* Vehicles*	*Toll Rate*	*Annual Revenues*	*Daily* Vehicles*	*Toll Rate*	*Annual Revenues*
Govt. Trucks	3,100	$ ...	$.....	3,100	$ ...	$.....
Medium Trucks ..	18,960	0.15	1,038,060	18,012	0.20	1,314,876
Heavy Trucks ...	4,750	0.25	433,438	4,512	0.35	576,408
Govt. Buses	510	...	.....	510	...	.....
Other Buses	3,950	0.25	360,438	3,950	0.35	504,613
Govt. Pass. Cars .	4,030	...	.....	4,030	...	.....
Commuters	115,850	0.08	3,382,820	127,435**	0.10	4,651,377
Other Pass. Cars .	115,850	0.10	4,228,525	92,680**	0.15	5,074,230
TOTALS	267,000		$9,443,281	254,229		$12,121,504

* Based on Department of Highway's traffic classification counts on all Potomac River bridges, January, 1955.

** Estimated that the higher single trip rate would encourage 10 percent greater use of commuter tickets and would reduce the remaining potential use by 20 percent.

Commuters: Special Tags

Commuters might also be allowed to purchase a distinctive monthly tag which could be pasted to the windshield where it would be readily recognized by toll collectors. Or the driver might be permitted to purchase an annual plate which could be fastened above his license plate and which need be changed only once a year.

Tags or stickers which are purchased at monthly or annual intervals have certain advantages. Cars so equipped can be passed through a toll station very quickly, thereby reducing the labor and cost of toll collection and reducing congestion on the bridges. They are especially attractive to taxi drivers and others who have occasion to cross the river very frequently.

There are several serious drawbacks to this method of toll collection, however. It is difficult to establish a toll charge that will be attractive to the commuter who crosses the river only for work without allowing unfair advantage to those who use the bridges more often. Allowing for holidays, sick leave, and vacation, the ordinary commuter probably averages about 40 crossings per month to and from work. To be attractive to him under the 10c rate schedule, the tag should cost no more than $3.50 per month. Using the 15c schedule a charge of $5.00 per month might be made. These values were assumed in developing the data in Table XVI.

The advantage gained by the 40-ride commuter is less than the discount he might

Table XVI

POTENTIAL REVENUES, 1960 — POTOMAC RIVER TOLL BRIDGE SYSTEM
TOLLS ON ALL CROSSINGS; MONTHLY COMMUTER PASSES; GOVT. VEHICLES FREE

	10c Basic Pass. Car Rate			*15c Basic Pass. Car Rate*		
Vehicle Class	*Daily* Vehicles*	*Toll Rate*	*Annual Revenues*	*Daily* Vehicles*	*Toll Rate*	*Annual Revenues*
Govt. Trucks	3,100	$ ...	$.....	3,100	$ ...	$.....
Medium Trucks ..	18,960	0.15	1,038,060	18,012	0.20	1,314,876
Heavy Trucks ...	4,750	0.25	433,438	4,512	0.35	576,408
Govt. Buses	510	...	.....	510	...	.....
Other Buses	3,950	0.25	360,438	3,950	0.35	504,613
Govt. Pass. Cars .	4,030	..	.....	4,030	...	.....
Commuters	115,850**	3.50 per mo.	1,596,000	127,435***	5.00 per mo.	2,508,000
Other Pass. Cars .	115,850**	0.10	4,228,525	92,680***	0.15	5,074,230
TOTALS	267,000		$7,656,461	254,229		$9,978,127

* Based on Department of Highway's traffic classification counts on all Potomac River Bridges, January, 1955.

** Estimated that 38,000 monthly passes would account for 115,850 trips each day—averaging a little over three trips per day per commuter. This rather liberal estimate is based on the assumption that most of the drivers who average more than two trips a day would buy the passes while many of those who make only two trips per day would not. Many of the pass holders would be taxis and other heavy users of the bridges.

*** Estimated that the higher single trip rate would encourage 10 percent greater use of commuter passes (41,800 tickets per month) and would reduce the remaining potential use by 20 percent.

enjoy using a ticket book, yet the effect on toll collections is much more drastic. The 10c schedule, using a $3.50 monthly commuter ticket, would be expected to produce gross revenue amounting to $7,656,461 in 1960, about $1,787,000 less than a commuter ticket system charging $4.00 for 50 rides. The 15c basic toll schedule, using a $5.00 monthly commuter ticket would realize revenues amounting to $9,978,127 in 1960, or about $2,143,377 less than the corresponding commuter ticket system.

A further disadvantage of the commuter tag is the difficulty of controlling revenues collected at the toll stations. Even the best toll collection systems are subject to theft in some degree. Classes of vehicles which pass free coupled with adoption of commuter tags would increase the difficulties inherent in the money-handling problem.

Feasibility Studies

The feasibility studies which follow have been developed on the basis of revenues derived from commuters by the use of commuter ticket books. The earnings which would be obtained by charging government vehicles at the same rate imposed on private operators have also been included as potential revenues, and the amount of such earnings identified in each study.

Feasibility has been computed for the various systems of toll bridges using both 10c and 15c basic toll schedules in order to compare their relative attractiveness.

PART VI

Scheme I - The Outer Bridges

These studies of revenue bond feasibility were undertaken to determine which, if any, of the proposed Potomac River bridges could be financed from toll revenues. Analysis of the origins and destinations of traffic which would use each of the bridges shows that the bridges can logically be segregated into two groups, based on traffic desires. Through trips, and trips generated across the Potomac River between suburban zones near the river would be potential users of the Outer Bridges — especially if long sections of the Outer Circumferential are constructed to provide good access to the bridges. The remaining Central Crossings serve traffic generated primarily within the heavily built-up portions of the city.

The Jones Point and Cabin John Bridges are both about four miles removed from the nearest Central Crossings and may be considered somewhat isolated from them. It is not unreasonable to consider separate schemes for financing the Outer Bridges and the Central Crossings. The Cabin John Bridge is of principal concern only to Virginia and Maryland, but the Jones Point Bridge and its approaches is the joint responsibility of both states and the District of Columbia.

Under the plan considered here, both the Outer Crossings would be built to four-lane standards although immediate traffic potential does not require that amount of bridge capacity. These bridges would serve the sparsely-settled outlying areas and would doubtless provide a strong stimulus to their further development.

Possible revenue bond financing of the Outer Bridges was studied by this consultant in 1953, and the proposed project was found infeasible at that time.[3] The present study contemplates a somewhat postponed construction of the bridges, with 1960 the first year of the toll bridge operation. Since metropolitan area traffic is expected to show large increases in the years 1953 to 1960, it would seem worthwhile to re-examine bridge feasibility in terms of 1960 potentials.

Basic Considerations

In order to develop a practical approach to the study of bridge feasibility, it is necessary to make certain assumptions regarding conditions which are expected to prevail in 1960, the first year of toll bridge operation. Among the most important of these considerations, it is assumed:

That the pattern of population and vehicle registration increase in the Washington Metropolitan area will continue, but at a decreasing rate of growth, during the years prior to opening of the bridges.

[3] "Highway Transportation in the Washington Metropolitan Area of Virginia," a report prepared for the Virginia Department of Highways, 1953.

That the Outer Bridge approach roads illustrated in Figure 1 will be completed and opened for traffic by the beginning of the year 1960.

That new Central Crossings will be built and operated free of toll at Roaches Run and Constitution Avenue, together with the approach roads and other access facilities illustrated on Figure 1, and that the existing Highway Bridge (14th Street Bridge) will be improved.

That no new bridge will be built between the site of the proposed Roaches Run Bridge and the proposed Jones Point Bridge.

That no new bridge will be built between the Chain Bridge and the proposed Cabin John Bridge.

That toll charges made for use of the bridges will be as set in each of the alternate studies reported here.

Both Bridges — 10c Toll Schedule

The volumes and classes of traffic expected to use each of the Outer Bridges during the first year of operation are shown in Table XVII. It has been assumed that commuters using the bridges would use tickets sold to them at 80 percent of face value. Under the assumed conditions, first year gross income on the Jones Point Bridge would amount to $596,411 and on the Cabin John Bridge would be $166,222 if no tolls were charged against government vehicles; another $10,985 would be earned by the bridges if all government vehicles were required to pay the designated rates.

The toll revenues that would be earned by the Outer Bridges in 1970 (Table XVIII) have been developed from projections of 1970 trans-river travel, based on expected population distribution and car ownership. By 1970 the Jones Point Bridge would be expected to earn about $909,643 annually and Cabin John tolls would amount to $291,811 with an additional $10,985 received if government vehicles were charged for use of the bridges. (It was assumed that there would be no change in the volume of government vehicles using the bridges during the years 1960-1970.)

Table XIX shows the pattern of earnings that the bridges would be expected to develop during the years following the opening if government vehicles are permitted to travel free and also if they are tolled the designated rates. This table also shows the estimated cost of maintaining and operating the bridges and toll collection facilities during these years and the amount of net revenues that would be available for debt service.

It should be understood, of course, that the estimates of revenue shown in Table XIX, as income expected to accrue to the Outer Bridges in years after they have been opened to traffic, are intended to represent the general trend of earnings over a period of years. Earnings for specific years might exceed or fall short of the values shown.

Feasibility — In order to be acceptable for revenue bond financing, a toll facility should usually earn sufficient net revenues during its first full year of operation to cover bond interest by a factor of approximately 1.5 times or more and to cover interest and amortization of bonds (level debt service) by a factor of 1.0. Debt service coverage should average about 1.5 over the life of the bonds. A major proportion of level debt service consists of interest on outstanding bonds during the early years of toll operations. The feasibility of a proj-

Table XVII

SCHEME I — OUTER BRIDGES
FIRST YEAR TRAFFIC AND REVENUES — 1960

(10c Passenger Car Tolls)

Vehicle Class	Toll Rate	Jones Point Bridge — Daily Traffic	Jones Point Bridge — Annual Revenues	Cabin John Bridge — Daily Traffic	Cabin John Bridge — Annual Revenues	Total Revenue 1960
Govt. Trucks	$ ..	90	$	....	$	$ .....
Med. Trucks	0.15	1,210	66,248	360	19,710	85,958
Heavy Trucks ...	0.25	300	27,375	90	8,213	35,588
Govt. Buses	...	10	.....	....	.....	.....
Other Buses	0.25	310	28,288	90	8,213	36,501
Govt. Pass.	...	120	.....	....	.....	.....
Commuters	0.08	4,800	140,160	1,980	57,816	197,976
Other Pass.	0.10	9,160	334,340	1,980	72,270	406,610
TOTALS		16,000	$596,411	4,500	$166,222	$762,633

Note: If tolls were collected from government vehicles at the average rate of 20c per trip for trucks, 25c per trip for buses, and 8c per trip for passenger cars (assuming all government cars to take advantage of the commuter rate), the additional income would amount to $10,985 annually.

Table XVIII

SCHEME I — OUTER BRIDGES
ESTIMATES TRAFFIC AND REVENUES — 1970

(10c Passenger Car Tolls)

Vehicle Class	Toll Rate	Jones Point Bridge — Daily Traffic	Jones Point Bridge — Annual Revenues	Cabin John Bridge — Daily Traffic	Cabin John Bridge — Annual Revenues	Total Revenue 1970
Govt. Trucks	$ ..	90	$	....	$	$ .....
Med. Trucks	0.15	1,847	101,123	632	34,602	135,725
Heavy Trucks ...	0.25	462	42,158	158	14,418	56,576
Govt. Buses	...	10	.....	....	.....	.....
Other Buses	0.25	462	42,158	158	14,418	56,576
Govt. Pass.	...	120	.....	....	.....	.....
Commuters	0.08	7,339	214,299	3,476	101,499	315,798
Other Pass.	0.10	13,970	509,905	3,476	126,874	636,779
TOTALS		24,300	$909,643	7,900	$291,811	$1,201,454

Note: If tolls were collected from government vehicles at the average rate of 20c per trip for trucks, 25c per trip for buses, and 8c per trip for passenger cars (assuming all government cars to take advantage of the commuter rate), the additional income would amount to $10,985 annually.

Table XIX

SCHEME I — OUTER BRIDGES

TRAFFIC AND REVENUE SUMMARY

(10c Passenger Car Tolls)

Year	Average Daily Traffic	Govt. Vehicles Free			Govt. Vehicles Tolled		
		Annual Revenues	Maint. & Oper.	Net Avail. for Debt Service	Annual Revenues	Maint. & Oper.	Net Avail. for Debt Service
1960	20,500	$ 761,902	$357,000	$ 404,902	$ 772,887	$357,000	$ 415,887
1961	21,670	805,856	360,570	445,286	816,841	360,570	456,271
1962	22,840	849,810	364,176	485,634	860,795	364,176	496,619
1963	24,010	893,765	367,818	525,947	904,750	367,818	536,932
1964	25,180	937,720	371,496	566,224	948,705	371,496	577,209
1965	26,350	981,675	375,211	606,464	992,660	375,211	617,449
1966	27,520	1,025,630	378,963	646,667	1,036,615	378,963	657,652
1967	28,690	1,069,585	382,753	686,832	1,080,570	382,753	697,817
1968	29,860	1,113,541	386,580	726,961	1,124,526	386,580	737,946
1969	31,030	1,157,497	390,446	767,051	1,168,482	390,446	778,036
1970	32,200	1,201,454	394,350	807,104	1,212,439	394,350	818,089
Next 27 yrs.	32,200	1,201,454	394,350	807,104	1,212,439	394,350	818,089
Total 38 yrs.				28,460,880	.....	.....	28,878,310
Avg. 38 yrs.				748,971	.....	.....	759,956

ect may thus depend very heavily on the interest rate at which bonds are sold.

Interest rates on revenue bonds have ranged between three percent and four percent on recent projects. In order to illustrate the relative attractiveness of the several schemes considered in this report, an interest rate of 3½ percent has been used throughout. For those schemes which appear to be only marginally attractive, the assumed interest rate might be lower than could actually be achieved on the bond market. On the other hand, it might be possible to finance those combinations of bridges which show very satisfactory earnings potential at interest rates somewhat lower than the one assumed.

Table XX has been developed to determine the degree to which toll revenues earned on the Outer Bridges would be able to finance their construction. A 40-year bond issue at 3½ percent interest has been assumed in the computations since it is generally not advisable to consider bond issues of greater life for projects of this nature. Bond interest has been capitalized for a two-year construction period and an additional sum has been included to cover financing costs.

Toll revenues available for debt service during the first year of toll bridge operation have been applied to two sets of conditions. First, earnings have been measured against a $36,500,000 bond issue required to finance both bridges and the approach roads necessary to serve them. If government vehicles are not subject to tolls, the net earnings can be expected to meet interest charges by only 32 percent during the first year of operation. Level debt service coverage over the life of the bonds would be only 0.43. Even if government vehicles are required to pay the designated toll charges, first year earnings would amount to only 33 percent of the interest charges with practically no change in average debt service coverage.

If revenues are applied to the cost of the bridge structures only, Table XX indicates that first year interest charges would be covered by a factor of only 0.57 even if government vehicles are subject to the tolls; level debt service would be covered by a factor of only 0.41 during the first year. It is clear that a toll schedule based upon a 10c passenger car rate will not earn enough to finance the Outer Bridges.

Both Bridges — 15c Toll Schedule

Traffic and revenue data have been developed for the Outer Bridges based on the 15c toll schedule. While the higher toll schedule yields greater returns than the 10c schedule just examined, the increased revenue is not sufficient to develop a feasible project.

First year net revenues (1960) would amount to about $625,000 if tolls from government vehicles were included in bridge earnings. This amount of revenue would cover 3½ percent interest on a $21,000,000 investment for bridge structures alone by a factor of 0.85. A sum of $1,007,580 would be required to cover annual debt service on 40-year bonds (38 years of earnings), which would be covered only 0.62 times by first year's income.

Average net earnings of the bridges during the life of the bonds would amount to about $1,024,000, which would cover annual debt service 1.06 times.

Scheme 1-A — The Jones Point Bridge

Although a toll schedule based on 10c or 15c passenger car tolls is not sufficient

Table XX

SCHEME I — OUTER BRIDGES

FEASIBILITY OF TOLL FINANCING

(10c Passenger Car Tolls)

	Outer Bridges and Approaches		*Bridge Structures*	
	Govt. Veh. Free	*Govt. Veh. Tolled*	*Govt. Veh. Free*	*Govt. Veh. Tolled*
Gross Earnings — First Year	$ 761,902	$ 772,887	$ 761,902	$ 772,887
Maintenance and Operation Costs	357,000	357,000	357,000	357,000
Net Available for Debt Service	404,902	415,887	404,902	415,887
Cost of Structures	17,447,000	17,447,000	17,447,000	17,447,000
Approaches	14,073,000	14,073,000	.....	.....
Toll Plazas and Equipment	1,070,000	1,070,000	1,070,000	1,070,000
Total Capital Costs	32,590,000	32,590,000	18,517,000	18,517,000
3½% Interest During Const. (2 Year Period)	2,555,000	2,555,000	1,470,000	1,470,000
Financing Costs, Legal Fees, etc.	1,355,000	1,355,000	1,013,000	1,013,000
Bonds Required	36,500,000	36,500,000	21,000,000	21,000,000
First Year Interest (3½%)	1,277,500	1,277,500	735,000	735,000
Interest Coverage — First Year	0.32	0.33	0.55	0.57
40 Year Bonds @ 3½%				
Interest and Amortization — 38 Years Earnings	1,751,270	1,751,270	1,007,580	1,007,580
Level Debt. Service, First Year Coverage	0.23	0.24	0.40	0.41
Level Debt Service Coverage over Life of Bonds	0.43	0.43	0.74	0.75

to finance the Outer Bridges, a larger toll might be found sufficient if applied to the Jones Point Bridge alone (the Jones Point Bridge would earn more than 3½ times as much as the Cabin John Bridge — see Table XVII).

Table XXI has been developed to show the volume of traffic expected to use the Jones Point Bridge when toll schedules are based on passenger car rates of 25c and 50c without provision for special commuter rates. It is interesting to note that bridge earnings would be greater under the 25c schedule. Proximity to the free Central Crossings would overcome the advantages of increased toll rates in the 50c schedule.

In Table XXII the 1970 traffic and earnings on a Jones Point Toll Bridge have been determined for tolls based on a 25c passenger car rate. Additional revenue in the amount of $25,915 would be earned each year if government vehicles were also required to pay tolls. Table XXIII shows the pattern of earnings that the bridge would be expected to develop during the years following the opening. The table also shows maintenance and operating costs and the amount of net revenues available for debt service. Again, traffic and revenue estimates for years after 1960 are intended to indicate a general trend of earnings rather than precise estimates of earnings for specific years.

Feasibility — Table XXIV has been developed to determine the feasibility of the Jones Point Bridge as a revenue bond project. The net revenues earned from tolls based on a 25c passenger car rate schedule have been applied against the cost of a bridge and approaches and against the cost of the bridge alone. In the latter case it is assumed that the approach facilities would be constructed with funds derived from other sources and would be opened to traffic at the same time the bridge is put in use.

Table XXI

SCHEME I-A — JONES POINT BRIDGE

FIRST YEAR TRAFFIC AND REVENUES — 1960

(25c and 50c Passenger Car Tolls)

	25c Passenger Car Schedule			*50c Passenger Car Schedule*		
Vehicle Class	*Toll Rate*	*Daily Traffic*	*Annual Revenues*	*Toll Rate*	*Daily Traffic*	*Annual Revenues*
Govt. Trucks	$ ...	90	$	$ ...	90	$ .....
Medium Trucks	0.35	839	107,182	0.75	388	106,215
Heavy Trucks	0.50	211	38,508	1.00	97	35,405
Govt. Buses	...	10	.....	...	10	.....
Other Buses	0.50	218	39,785	1.00	105	38,325
Govt. Pass.	...	120	.....	...	120	.....
Other Pass.	0.25	9,912	904,470	0.50	4,940	901,550
TOTALS		11,400	$1,089,945		5,750	$1,081,495

Note: If tolls were collected from government vehicles at the average rate of 40c per trip for trucks, 50c per trip for buses, and 25c per trip for passenger cars, the bridge would earn additional income amounting to $25,915 annually.

Under the above conditions, the anticipated earnings are not sufficient to cover the annual debt service required for a 40 year bond issue at 3½ percent interest for construction of both the bridge and the approaches. Table XXIV indicates that the bridge alone might be financed with a 40-year bond issue, although the interest coverage for the first year appears to be a little low at 1.40 (if government vehicles are not subject to tolls) and first year coverage of debt service is barely met with a factor of 1.02. Average coverage of debt service during the 40-year life of 3½ percent bonds would amount to only 1.40 times average requirements, if government vehicles are permitted free use of the bridge.

Assuming that the coverage values shown are satisfactory for bond financing, the feasibility of this project would depend very largely on the accuracy of construction cost estimates. The cost estimates used in this analysis were those furnished the consultant by the District of Columbia Department of Highways. A cost estimate for this bridge, prepared for the consultant in 1953 by the Virginia Department of Highways was nearly $900,000 greater. If the revenue figures developed here were applied to that estimate a less favorable result would be obtained.

On the other hand, the traffic estimate is believed to be a conservative one. If government vehicles were charged tolls instead of crossing free, toll revenues would be increased by a small amount as shown in the tables. If new Central Crossings were not built at Roaches Run and Constitution Avenue by the time this bridge is opened to traffic, the bridge would get more use than these estimates show. If all Central Crossings were to be operated as toll facilities (at the 10c rate), the Jones Point Bridge (operated at the 25c passenger car rate) would attract considerable volume that has been considered lost to it under the assumed conditions of free Central Crossings.

Table XXII

SCHEME I-A — JONES POINT BRIDGE
ESTIMATED TRAFFIC AND REVENUES — 1970

(25c Passenger Car Tolls)

Vehicle Class	*Toll Rate*	*Daily Traffic*	*Annual Revenues*
Govt. Trucks	$ ...	90	$ .....
Medium Trucks	0.35	1,160	148,190
Heavy Trucks	0.50	290	52,925
Govt. Buses	...	10	.....
Other Buses	0.50	298	54,385
Govt. Pass.	...	120	.....
Other Pass.	0.25	13,432	1,225,670
TOTALS		15,400	$1,481,170

Note: If tolls were collected from government vehicles at the average rate of 40c per trip for trucks, 50c per trip for buses, and 25c per trip for passenger cars, the bridge would earn additional income amounting to $25,915 annually.

Table XXIII

SCHEME I-A — JONES POINT BRIDGE
TRAFFIC AND REVENUE SUMMARY

(25c Passenger Car Tolls)

Year	Average Daily Traffic	Government Vehicles Free			Government Vehicles Tolled		
		Annual Revenues	Maint. & Oper.	Net Avail. for Debt Service	Annual Revenues	Maint. & Oper.	Net Avail. for Debt Service
1960	11,400	$1,089,945	$231,000	$ 858,945	$1,115,860	$231,000	$ 884,860
1961	11,840	1,129,068	233,310	895,758	1,154,983	233,310	921,673
1962	12,280	1,168,190	235,643	932,547	1,194,105	235,643	958,462
1963	12,720	1,207,313	237,999	969,314	1,233,228	237,999	995,229
1964	13,160	1,246,435	240,379	1,006,056	1,272,350	240,379	1,031,971
1965	13,600	1,285,558	242,783	1,042,775	1,311,473	242,783	1,068,690
1966	13,960	1,324,680	245,211	1,079,469	1,350,595	245,211	1,105,384
1967	14,320	1,363,803	247,663	1,116,140	1,389,718	247,663	1,142,055
1968	14,680	1,402,925	250,140	1,152,785	1,428,840	250,140	1,178,700
1969	15,040	1,442,048	252,641	1,189,407	1,467,963	252,641	1,215,322
1970	15,400	1,481,170	255,167	1,226,003	1,507,085	255,167	1,251,918
Next 27 Years	15,400	1,481,170	255,167	1,226,003	1,507,085	255,167	1,251,918
Total 38 Years				44,571,280	.....	.....	45,556,052
Avg. 38 Years				1,172,928	.....	.....	1,198,843

Table XXIV

SCHEME I-A — JONES POINT BRIDGE
FEASIBILITY OF TOLL FINANCING

(25c Passenger Car Tolls)

	Bridges and Approaches		*Bridge Only*	
	Govt. Veh. Free	*Govt. Veh. Tolled*	*Govt. Veh. Free*	*Govt. Veh. Tolled*
Gross Earnings — First Year	$ 1,089,945	$ 1,115,860	$ 1,089,945	$ 1,115,860
Maintenance and Operation Costs	231,000	231,000	231,000	231,000
Net Available for Debt Service	858,945	884,860	858,945	884,860
Cost of Structures	14,847,000	14,847,000	14,847,000	14,847,000
Approaches	9,573,000	9,573,000	.....	.....
Toll Plazas and Equipment	685,000	685,000	685,000	685,000
Total Capital Costs	25,105,000	25,105,000	15,532,000	15,532,000
Interest During Const. (2 Year Period)	1,995,000	1,995,000	1,225,000	1,225,000
Financing Costs, Legal Fees, etc.	1,400,000	1,400,000	743,000	743,000
Bonds Required	28,500,000	28,500,000	17,500,000	17,500,000
First Year Interest (3½%)	997,500	997,500	612,500	612,500
Interest Coverage — First Year	0.86	0.89	1.40	1.43
40 Year Bonds @ 3½%				
Interest and Amortization — 38 Years Earnings	1,367,430	1,367,430	839,650	839,650
Level Debt Service, First Year Coverage	0.63	0.65	1.02	1.05
Level Debt Service Coverage over Life of Bonds	0.86	0.88	1.40	1.44

PART VII

Scheme II - All Potomac River Bridges

Although the Jones Point Bridge may be able to earn sufficient revenues to finance the structure itself from toll revenues, it does not appear likely that tolls earned by the Outer Bridges alone would support construction of both bridges and the approach roads necessary to serve them. The Outer Bridges might, however, be incorporated in a complete system of Potomac River Toll Bridges.

Basic Considerations

If tolls were to be charged on all bridges, traffic volumes across the Potomac River would be reduced to some extent, no matter how small the toll. On the other hand, as previously pointed out, the contemplated improvements to the arterial highway system which would accompany the construction of new bridges would tend to induce much new trans-river traffic. It has been quite arbitrarily assumed that the effects of a nominal toll charge, such as the proposed schedule based on a 10c passenger car rate, would cancel the inducement due to new improvements. This is believed to be a very conservative view.

The toll schedule based on a 15c passenger car charge would have greater adverse influence than the 10c schedule, of course. Certain vehicle categories would react more strongly than others. The higher rates would be expected to have a negligible effect on the volume of government vehicles and buses crossing the Potomac River. Commercial truck volume has been reduced five percent, which is believed to be a generous allowance. Commuters have not been reduced, but more passenger car drivers would be expected to take advantage of the greater cost differential between the single trip rate and the commuter ticket rate. The remaining non-commuters have been reduced by 20 percent to adjust for the higher toll rate. These values are believed to be conservative.

Other Basic Considerations

Other important considerations upon which this phase of the study is based are the assumptions:

That the patterns of population growth and vehicle registration increases will continue upward at a slowly decreasing rate during the years prior to 1960, the year upon which first year estimates of toll revenues are based.

That the approach roads and interchange facilities illustrated in Figure 1 will be incorporated in the final development of new bridges and will be available for use by 1960.

That at least eight bridges will be available for traffic use during the first year of operation of a toll system.

Toll Revenues

Revenues which would be earned by a complete system of Potomac River Toll

Bridges have been computed for both the 10c and the 15c schedules of charges. Revenues earned by the 10c schedule appear to be sufficient to pay for new bridges and bridge approaches. However, estimated earnings over the 40-year bond life are not sufficiently in excess of debt service requirements to make the project attractive to investors.

The amount of revenues that would be earned from toll charges applied to all Potomac River Bridges in 1960 is shown in Table XXV. Although three different conditions of central crossing are to be considered, the total volume of river crossings has been assumed to be the same for all studies. Therefore, revenues would be the same under each set of conditions.

Table XXV

SCHEME II — ALL POTOMAC RIVER BRIDGES
FIRST YEAR TRAFFIC AND REVENUES (1960)

	10c Basic Pass. Car Rate			*15c Basic Pass. Car Rate*		
Vehicle Class	*Daily Vehicles*	*Toll Rate*	*Annual Revenues*	*Daily Vehicles*	*Toll Rate*	*Annual Revenues*
Govt. Vehicles Free						
Govt. Trucks	3,100	$ ...	$.....	3,100	$ ...	$.....
Medium Trucks ..	18,960	0.15	1,038,060	18,012*	0.20	1,314,876
Heavy Trucks ...	4,750	0.25	433,438	4,512*	0.35	576,408
Govt. Buses	510	...	.....	510	...	.....
Other Buses	3,950	0.25	360,438	3,950	0.35	504,613
Govt. Pass. Cars .	4,030	...	.....	4,030	...	.....
Commuters	115,850	0.08	3,382,820	127,435*	0.10	4,651,377
Other Pass. Cars .	115,850	0.10	4,228,525	92,680*	0.15	5,074,230
TOTALS	267,000		$9,443,281	254,229		$12,121,504
Govt. Vehicles Tolled						
Govt. Trucks ...	3,100	$0.20	$ 226,300	3,100	$0.25	$ 282,875
Govt. Buses	510	0.25	46,538	510	0.35	65,153
Govt. Pass. Cars .	4,030	0.08	117,676	4,030	0.10	147,095
Sub-totals	7,640	...	$ 390,514	7,640	...	$ 495,123
Other Vehicles ..	259,360	...	9,443,281	246,489	...	12,121,504
TOTALS	267,000		$9,833,795	254,129		$12,616,627

* Volume of commuters increased 10%, other passenger cars reduced 20% and trucks reduced 5% due to the higher toll rates.

Toll bridge earnings have been computed on the bases of government vehicles free and government vehicles tolled. In each case, all government passenger cars have been assumed to cross at commuter rates. At the 10c rate, tolls on government vehicles would be expected to net over $390,000 in 1960; on the 15c schedule these vehicles would return over $495,000. Gross revenues earned by the Toll Bridge System under the 10c schedule would amount to $9,833,795 in 1960; under the 15c schedule 1960 gross revenue would amount to $12,616,627, or about 28 percent greater income due to the increased toll rates.

Table XXVI shows the revenues which would be derived from traffic anticipated on all of the bridges by 1970. Again, the 15c toll schedule would produce about 28 percent more revenue than the 10c schedule.

Table XXVI

SCHEME II — ALL POTOMAC RIVER BRIDGES
ESTIMATED TRAFFIC AND REVENUES — 1970

	10c Basic Pass. Car Rate			*15c Basic Pass. Car Rate*		
Vehicle Class	*Daily Vehicles*	*Toll Rate*	*Annual Revenues*	*Daily Vehicles*	*Toll Rate*	*Annual Revenues*
Govt. Vehicles Free						
Govt. Trucks	3,100	$ ...	$.....	3,100	$ ...	$.....
Medium Trucks ..	23,910	0.15	1,309,073	22,715*	0.20	1,658,195
Heavy Trucks ...	5,970	0.25	544,763	5,672*	0.35	724,598
Govt. Buses	510	...	.....	510	...	.....
Other Buses	5,120	0.25	467,200	5,120	0.35	654,080
Govt. Pass. Cars .	4,030	...	.....	4,030	...	.....
Commuters	142,680	0.08	4,166,256	156,948*	0.10	5,728,602
Other Pass. Cars .	142,680	0.10	5,207,820	114,144*	0.15	6,249,384
TOTALS	328,000		$11,695,112	312,239		$15,014,859
Govt. Vehicles Tolled						
Govt. Trucks ...	3,100	$0.20	$ 226,300	3,100	$0.25	$ 282,875
Govt. Buses	510	0.25	46,538	510	0.35	65,153
Govt. Pass. Cars .	4,030	0.08	117,676	4,030	0.10	147,095
Sub-totals	7,640		$ 390,514	7,640		$ 495,123
Other Vehicles ..	320,360		11,695,112	304,599		15,014,859
TOTALS	328,000		$12,085,626	312,239		$15,509,982

* Volume of commuters increased 10%, other passenger cars reduced 20% and trucks reduced 5% due to the higher toll rates.

Table XXVII

SCHEME II — ALL POTOMAC RIVER CROSSINGS
TRAFFIC AND REVENUE SUMMARY (GOVT. VEHICLES TOLLED) — 15c BASIC PASSENGER CAR TOLL

Year	Average Daily Traffic	Annual Revenues	New Bridges at Jones Point, Roaches Run, Cabin John and: System A Constitution Ave. Maint. & Oper. Costs	System A Constitution Ave. Net Avail. for Debt Service	System B Const. Ave. & Three Sisters Maint. & Oper. Costs	System B Const. Ave. & Three Sisters Net Avail. for Debt Service	System C Const. & Nebraska Aves. Maint. & Oper. Costs	System C Const. & Nebraska Aves. Net Avail. for Oper. Costs
1960	254,229	$12,616,627	$1,628,000	$10,988,627	$1,766,000	$10,840,627	$1,776,000	$10,840,627
1961	259,940	12,899,393	1,644,280	11,255,113	1,793,760	11,105,633	1,793,760	11,105,633
1962	265,751	13,189,458	1,660,723	11,528,735	1,811,698	11,377,760	1,811,698	11,377,760
1963	271,562	13,479,524	1,677,330	11,802,194	1,829,815	11,649,709	1,829,815	11,649,709
1964	277,373	13,769,589	1,694,103	12,075,486	1,848,113	11,921,476	1,848,113	11,921,476
1965	283,184	14,059,655	1,711,044	12,348,611	1,866,594	12,193,061	1,866,594	12,193,061
1966	288,995	14,349,720	1,728,154	12,621,566	1,885,260	12,464,460	1,885,260	12,464,460
1967	294,806	14,639,786	1,745,435	12,894,351	1,904,113	12,735,673	1,904,113	12,735,673
1968	300,617	14,929,851	1,762,889	13,166,962	1,923,154	13,006,697	1,923,154	13,006,697
1969	306,428	15,219,917	1,780,518	13,439,399	1,942,385	13,277,532	1,942,385	13,277,532
1970	312,239	15,509,982	1,798,323	13,711,659	1,961,809	13,548,173	1,961,809	13,548,173
Next 26 Years	312,239	15,509,982	1,798,323	13,711,659	1,961,809	13,548,173	1,961,809	13,548,173
Total 37 Years				492,335,837		486,373,299		486,373,299
Avg. 37 Years				13,306,374		13,145,224		13,145,224

In Table XXVII is shown the amount of net revenues that the entire system of toll bridges would be expected to produce over the life of a 40-year bond issue. The income shown is based on the 15c toll schedule and includes revenues which would be derived from tolls charged against government vehicles. The costs of maintenance and operation have been deducted from gross earnings to show the amount of money that would be available for debt service each year.

Three different plans for the central crossings are shown in Table XXVII. Maintenance and operating expenses are least for the basic plan which includes only eight bridges. These expenses are greatest for the scheme which includes bridges at both Constitution Avenue and Three Sisters.

Estimates of revenues which are expected to accrue in years following the opening of the Potomac River Toll Bridge System to traffic represent the expected earnings trend of the bridge system over a period of years. Actual earnings might, of course, exceed or fall short of the values shown for a particular year.

Table XXVIII

SCHEME II—ALL POTOMAC RIVER BRIDGES—GOVT. VEHICLES TOLLED
FEASIBILITY OF TOLL FINANCING BY 15c BASIC PASS. CAR TOLL

	New Bridges at Jones Point, Roaches Run Cabin John and:		
	System A Const. Ave.	*System B Const. Ave. & Three Sisters*	*System C Const. and Nebraska Aves.*
Gross Earnings — First Year	$ 12,616,627	$ 12,616,627	$ 12,616,627
Maintenance & Operation Costs	1,628,000	1,776,000	1,776,000
Net Available for Debt Service	10,988,627	10,840,627	10,840,627
Cost of Structures	45,493,600	51,109,600	51,157,350
Approaches	66,800,200	72,486,200	69,709,000
Toll Plazas & Equipment	21,248,100	23,023,100	23,023,100
Total Capital Costs	133,541,900	146,618,900	143,889,450
Interest During Construction (3 Year Period)	16,275,000	17,850,000	17,535,000
Financing Costs, Legal Fees, etc.	5,183,100	5,531,000	5,575,550
Bonds Required	155,000,000	170,000,000	167,000,000
First Year Interest (3½%)	5,425,000	5,950,000	5,845,000
Interest Coverage — First Year	2.03	1.82	1.86
40 Year Bonds @ 3½%			
Interest and Amortization — 38 Years Earnings	7,535,015	8,264,210	8,118,371
Level Debt Service, First Year Coverage	1.46	1.31	1.34
Level Debt Service, Average Over Life of Bonds	1.77	1.59	1.62

Feasibility

Table XXVIII examines the feasibility of the alternate Central Crossing plans on the basis of tolls earned at the 15c schedule. The eight-bridge scheme which incorporates new crossings at Jones Point, Roaches Run, Constitution Avenue, and Cabin John is the least expensive, since each of the alternate plans includes another bridge in addition to those named. On the basis of available cost estimates, all schemes are eligible for revenue bond financing. First year net earnings cover interest by factors of 2.03, 1.82, and 1.86, for the three bridge systems analyzed. Debt service is earned 1.46, 1.31, and 1.34 times, respectively, during the first year of operation. Over the life of the project average earnings would cover debt service by 1.77, 1.59, and 1.62 times for the three bridge systems.

Listed below are the several coverage factors which would be realized if the 10c toll schedule formed the basis of toll earnings, and for conditions by which government vehicles would be allowed free passage.

INTEREST AND DEBT SERVICE COVERAGE — 10c and 15c BASIC TOLL SCHEDULES

40-Year Bonds 3½ percent	*Times Interest Earned — 1st Year*			*Times Debt Service Earned — First Year*			*Times Debt Service Earned — Average Year*		
	System			*System*			*System*		
	A	*B*	*C*	*A*	*B*	*C*	*A*	*B*	*C*
10c toll schedule									
Govt. Veh. Free	1.44	1.29	1.31	1.04	0.93	0.94	1.27	1.14	1.16
Govt. Veh. Toll	1.51	1.36	1.38	1.09	0.98	0.99	1.32	1.19	1.21
15c toll schedule									
Govt. Veh. Free	1.98	1.74	1.77	1.39	1.25	1.28	1.70	1.53	1.56
Govt. Veh. Toll	2.03	1.82	1.86	1.46	1.31	1.34	1.77	1.59	1.62

It should be noted that all of the alternate Potomac River bridge systems studied involve very large expenditures for approach roads and interchange facilities which are not a part of the bridge structures. Higher toll rates might finance even larger expenditures unless rates were placed so high that the majority of present users could not afford to cross the river.

PART VIII

Scheme III - The Central Crossings

All of the trans-river traffic in the Washington area must presently use a centrally located crossing. Although new Outer Bridges would divert some of those vehicles which were not destined to central locations, the majority of traffic would continue to gravitate to the Central Crossings. Since these bridges accommodate most of the vehicles crossing the river, their earnings potential is very great.

The four existing bridges must of course be incorporated in any toll bridge plan that is to provide effective relief to present congestion. Inasmuch as the modernization and adaptation of the existing bridges will be relatively inexpensive, they can be expected to earn considerably more revenue than is required for their development, and in this way assume some of the costs of the new bridges and their approaches.

Basic Assumptions

In developing the pattern of traffic use and earnings on the Central Crossings certain arbitrary conditions have been established. Among these are assumptions:

That population growth and vehicle registration increases in the Washington Metropolitan Area will continue upwards at a decreasing rate during the years prior to 1960, the year for which revenue estimates have been developed in this report.

That the Outer Bridges will be constructed from other sources of revenue and will be available for free use, together with the approaches shown in Figure 1, during the entire first year of full bridge operation (1960). If these bridges are not built or if they are built as toll structures, the use and earnings of the Central Crossings would be increased.

That toll charges used on the Central Crossings will conform to the schedules set forth earlier in this report.

Traffic and Revenues

The amount of revenues which would be expected from toll charges applied to traffic using the Central Crossings (all bridges except the Jones Point and Cabin John Bridges on the Outer Circumferential) are shown in Table XXIX for the assumed first year of opening in 1960.

Data have been developed to show the amount of revenue which would be earned at either a 10c or 15c basic toll schedule, and for government vehicles tolled and free under each schedule. The 15c toll schedule would produce about 32% more revenue than the 10c schedule.

Table XXX shows the revenues that the Central Crossings would be expected to earn by 1970.

Table XXXI shows an estimate of the amount of revenues that a system of Cen-

tral Crossings would earn on toll bridges during 1960 and years following, assuming that government vehicles would pay to use the bridges. Data have been developed for both 10c and 15c toll schedules. Estimated costs of maintaining and operating the bridges and toll collection facilities have been deducted from gross revenues to show the estimated amount of net income that would be available for debt service each year. These costs are based on new central crossings at Roaches Run and Constitution Avenue. If a central crossing were also constructed at Three Sisters or at Nebraska Avenue, operating and maintenance costs would be somewhat larger than the values shown in the table while gross revenues would be about the same.

Again, the estimates of revenues set forth in Table XXXI, as income expected to accrue to the operation of the Central Crossings as a toll system in years following its opening, are intended to represent the general earnings trend of the system of bridges over a period of years. It must be expected that earnings for specific years will in some degree exceed or fall short of the values shown.

Feasibility

Table XXXII examines the feasibility of all Central Crossings operated as a system of toll bridges. The 1960 earnings of a system of crossings which include all exist-

Table XXIX

SCHEME III — CENTRAL CROSSINGS ONLY

FIRST YEAR TRAFFIC AND REVENUES — 1960

	10c Basic Pass. Car Rate			15c Basic Pass. Car Rate		
Vehicle Class	*Daily Vehicles*	*Toll Rate*	*Annual Revenues*	*Daily Vehicles*	*Toll Rate*	*Annual Revenues*
Govt. Vehicles Free						
Govt. Trucks	3,010	$ ...	$.....	3,010	$ ...	$.....
Medium Trucks ..	17,390	0.15	952,103	16,620*	0.25	1,516,575
Heavy Trucks ...	4,360	0.25	397,850	4,142*	0.35	529,141
Govt. Buses	500	...	.....	500	...	.....
Other Buses	3,550	0.25	323,938	3,550	0.35	453,512
Govt. Pass. Cars .	3,910	...	.....	3,910	...	.....
Commuters	109,070	0.08	3,184,844	119,977*	0.10	4,379,161
Other Pass. Cars .	104,710	0.10	3,821,915	83,768*	0.15	4,586,298
TOTALS	246,500		$8,680,650	235,377		$11,464,687
Govt. Vehicles Tolled						
Govt. Trucks	3,010	$0.20	$ 219,730	3,010	$0.25	$ 274,662
Govt. Buses	500	0.25	45,625	500	0.35	63,875
Govt. Pass. Cars .	3,910	0.08	114,172	3,910	0.10	142,715
Govt. Sub-totals .	7,420		$ 379,527	7,420		$ 481,252
Other Vehicles ..	239,080		$8,680,650	227,957		11,464,687
TOTALS	246,500		$9,060,177	235,377		$11,945,939

* Volume of commuters increased 10%, other passenger cars reduced 20% and trucks reduced 5% due to the higher toll rates.

ing bridges and new bridges at Roaches Run and Constitution Avenue have been reviewed for their ability to cover interest and debt service on a $117,500,000 loan secured by revenue bonds. The net revenues available for debt service under the 10c toll schedule are sufficient to cover bond interest at 3½ percent by 1.87 times the first year of toll bridge operation. Debt service on 40-year bonds drawing 3½ percent interest would be covered 1.35 times from first year revenues. Average coverage over the life of the bonds would amount to 1.59 times the annual debt service costs.

A larger issue and considerably lower coverage would result if a Three Sisters or Nebraska Avenue Bridge were built in addition to Roaches Run and Constitution Avenue Bridges.

The revenues which would be derived from a 15c toll schedule would be sufficient to cover the costs of such additional facilities as a Three Sisters or Nebraska Avenue Bridge, or could be used to amortize bonded indebtedness at a more rapid rate than could be realized from lower toll rates. As shown in Table XXXII, earnings from the 15c toll schedule would cover bond interest by 2.57 times the first year of toll bridge operation (1960) and, applied to a 30-year series of 3½ percent bonds, would cover debt service 1.56 times. Over the life of the bonds annual debt service would be covered an average of 1.78 times.

Table XXX

SCHEME III — CENTRAL CROSSING ONLY

ESTIMATED TRAFFIC AND REVENUES — 1970

Vehicle Class	*10c Basic Pass. Car Rate*			*15c Basic Pass. Car Rate*		
	Daily Vehicles	*Toll Rate*	*Annual Revenues*	*Daily Vehicles*	*Toll Rate*	*Annual Revenues*
Govt. Vehicles Free						
Govt. Trucks	3,010	$ ...	$.....	3,010	$ ...	$.....
Medium Trucks	21,430	0.15	1,173,292	20,359*	0.20	1,486,207
Heavy Trucks	5,350	0.25	488,188	5,082*	0.35	649,225
Govt. Buses	500	...	.....	500	...	.....
Other Buses	4,500	0.25	410,625	4,500	0.35	574,875
Govt. Pass. Cars	3,910	...	.....	3,910	...	.....
Commuters	131,865	0.08	3,850,458	145,051*	0.10	5,294,361
Other Pass. Cars	125,235	0.10	4,571,077	100,188*	0.15	5,485,293
TOTALS	295,800		$10,493,640	282,600		$13,489,961
Govt. Vehicles Tolled						
Govt. Trucks	3,010	$0.20	$ 219,730	3,010	$0.25	$ 274,662
Govt. Buses	500	0.25	45,625	500	0.35	63,875
Govt. Pass. Cars	3,910	0.08	114,172	3,910	0.10	142,715
Govt. Sub-totals	7,420	...	$ 379,527	7,420	...	$ 481,252
Other Vehicles	288,380	...	10,493,640	275,180	...	13,489,961
TOTALS	295,800		$10,873,167	282,600		$13,971,213

* Volume of commuters increased 10%, other passenger cars reduced 20% and trucks reduced 5% due to the higher toll rates.

Table XXXI

SCHEME III — CENTRAL CROSSINGS ONLY
TRAFFIC AND REVENUE SUMMARY*

Year	10c Basic Pass. Car Rate			15c Basic Pass. Car Rate		
	Annual Revenues	*Maint. & Oper. Costs*	*Net Avail. Debt Service*	*Annual Revenues*	*Maint. & Oper. Costs*	*Net Avail. Debt Service*
1960	$ 9,060,177	$1,361,000	$ 7,699,177	$11,945,939	$1,361,000	$ 10,584,939
1961	9,241,935	1,374,610	7,867,325	12,148,466	1,374,610	10,773,856
1962	9,423,183	1,388,356	8,034,827	12,350,993	1,388,356	10,962,637
1963	9,604,431	1,402,239	8,202,192	12,553,520	1,402,239	11,151,281
1964	9,785,679	1,416,261	8,369,418	12,756,047	1,416,261	11,339,786
1965	9,966,927	1,430,424	8,536,503	12,958,574	1,430,424	11,528,150
1966	10,148,175	1,444,728	8,703,447	13,161,101	1,444,728	11,716,373
1967	10,329,423	1,459,175	8,870,248	13,363,628	1,459,175	11,904,453
1968	10,510,671	1,473,767	9,036,904	13,566,155	1,473,767	12,092,388
1969	10,691,919	1,488,505	9,203,414	13,768,682	1,488,505	12,280,177
1970	10,873,167	1,503,390	9,369,777	13,971,213	1,503,390	12,467,823
Next 26 yrs.	10,873,167	1,503,390	9,369,777	13,971,213	1,503,390	12,467,823
Total 27 yrs.			243,809,664	.....	.....	326,287,031
Average 27 yrs.			9,029,988	.....	.....	12,084,705
Total 37 yrs.			337,507,434	.....	.....	450,965,261
Average 37 yrs.			9,121,823	.....	.....	12,188,250

* Based on a toll-bridge system with new bridges at Roaches Run and Constitution Avenue.

Annual Revenues include income from government-vehicle tolls.

Table XXXII

SCHEME III — CENTRAL CROSSINGS ONLY
FEASIBILITY OF TOLL FINANCING

	10c Basic Pass. Car Rate	*15c Basic Pass. Car Rate*
Gross Earnings — First Year	$ 9,060,177	$ 11,945,939
Maintenance and Operation	1,361,000	1,361,000
Net Available for Debt Service	7,699,177	10,584,939
Cost of Structures	28,046,600	28,046,600
Approaches	52,727,200	52,727,200
Toll Plazas & Equipment	20,178,100	20,178,100
Total Capital Costs	100,951,900	100,951,900
3½% Interest During Construction (3 yrs.)	12,337,500	12,337,500
Financing Costs, Legal Fees, etc.	4,210,600	4,210,600
Bonds Required	117,500,000	117,500,000
First Year Interest (3½%)	4,112,500	4,112,500
Interest Coverage, First Year	1.87	2.57
30 Year Bonds @ 3½%		
Interest and Amortization — 27 Years Earnings	.....	6,797,610
Level Debt Service, First Year Coverage	.....	1.56
Level Debt Service, Coverage Over Life of Bonds	.....	1.78
40 Year Bonds @ 3½%		
Interest and Amortization — 37 Years Earnings	5,712,027	.....
Level Debt Service, First Year Coverage	1.35	.....
Level Debt Service, Coverage Over Life of Bonds	1.59	.....

PART IX

Scheme IV - Free Memorial Bridge

The most difficult task of adapting an existing bridge for toll collection exists at the Memorial Bridge. Not only is extensive construction involved, but esthetic considerations are of great importance at this location. It will be very difficult to develop toll plazas at this site which will not appear intrusive.

The Memorial Bridge is presently operating under near-capacity traffic loads during several hours of the day. Access to the bridge is somewhat restrictive and cannot well be improved. It is not likely that many more vehicles could conveniently use the bridge even if it were left free and all other Central Crossings operated as a toll bridge system.

Basic Considerations

The conditions which were assumed for the study of the Memorial Bridge were the same as those assumed for the Central Crossings in Scheme III with the exception that the Memorial Bridge would remain free. Traffic volumes using the bridge in 1954 amounted to about 54,000 vehicles per day. Daily volumes would be expected to increase to a maximum of about 61,000 vehicles per day if the Memorial Bridge became the only free crossing in the central area. It is important to note that two new bridges would be available to serve downtown Washington before the Memorial Bridge would gain its unique position as the only free bridge. The availability of fine alternate routes would tend to minimize the advantages of the free but overcrowded Memorial Bridge.

Traffic and Revenue Estimate

The revenues which would be expected from toll charges applied to traffic using the five bridges in the Central Crossing system (Free Memorial Bridge) are shown in Table XXXIII for the first year of operation (1960).

Data are shown for revenues earned under a 10c basic toll schedule and from a 15c basic schedule. The amount that would be earned if government vehicles were charged for use of the bridges is also shown for each toll schedule. In deriving earnings potential to this system it has been assumed that all commercial vehicles (all trucks and buses) will be prohibited from using the Memorial Bridge.

Table XXXIV shows the revenues that the toll bridges would be expected to earn by 1970.

Table XXXV shows an estimate of the amount of revenues that a system of Central Crossings would earn over the life of revenue bonds which might be sold to finance bridge construction. The estimates of revenue shown in the table are intended to develop the general earnings trend of the toll bridge system over a period of years. Earnings for specific years might exceed or fall short of the values shown.

Table XXXIII

SCHEME IV — FREE MEMORIAL BRIDGE
FIRST YEAR TRAFFIC AND REVENUES (1960)

	10c Basic Pass. Car Toll			15c Basic Pass. Car Toll		
	Daily Vehicles	*Toll Rate*	*Annual Revenues*	*Daily Vehicles*	*Toll Rate*	*Annual Revenues*
Govt. Vehicles Free						
Govt. Trucks	3,010	$ ...	$	3,010	$ ...	$ .....
Medium Trucks	17,390	0.15	952,102	16,520*	0.20	1,205,960
Heavy Trucks	4,360	0.25	397,850	4,142*	0.35	529,140
Govt. Buses	500	...	.....	500	...	.....
Other Buses	3,550	0.25	323,938	3,550	0.35	453,512
Govt. Pass. Cars	3,410	...	.....	3,410	...	.....
Commuters	78,500	0.08	2,292,200	86,350*	0.10	3,151,775
Other Pass. Cars	75,780	0.10	2,765,970	60,624*	0.15	3,319,164
TOTALS	186,500		$6,732,060	178,106		$8,659,551
Govt. Vehicles Tolled						
Govt. Trucks	3,010	$0.20	$ 219,730	3,010	$0.25	$ 274,662
Govt. Buses	500	0.25	45,625	500	0.35	63,875
Govt. Pass. Cars	3,410	0.08	99,572	3,410	0.10	124,465
Govt. Sub-totals	6,920	...	$ 364,927	6,920	...	$ 463,002
Other Vehicles	179,580	...	6,732,060	171,186	...	8,659,551
TOTALS	186,500		$7,096,987	178,106		$9,122,553

* Volume of commuters increased 10%, other passenger cars reduced 20% and trucks reduced 5% due to the higher toll rates.

Table XXXIV

SCHEME IV — FREE MEMORIAL BRIDGE
ESTIMATED TRAFFIC AND REVENUES — 1970

	10c Basic Pass. Car Toll			15c Basic Pass. Car Toll		
	Daily Vehicles	*Toll Rate*	*Annual Revenues*	*Daily Vehicles*	*Toll Rate*	*Annual Revenues*
Govt. Vehicles Free						
Govt. Trucks	3,010	$ ...	$.....	3,010	$ ...	$.....
Medium Trucks ..	21,430	0.15	1,173,292	20,359*	0.20	1,486,207
Heavy Trucks ...	5,350	0.25	488,187	5,082*	0.35	649,225
Govt. Buses	500	...	.....	500	...	.....
Other Buses	4,500	0.25	410,625	4,500	0.35	574,875
Govt. Pass. Cars .	3,410	...	.....	3,410	...	.....
Commuters	100,250	0.08	2,927,300	110,275*	0.10	4,025,037
Other Pass. Cars .	96,550	0.10	3,524,075	77,240*	0.15	4,228,890
TOTALS	235,000		$8,523,479	224,376		$10,964,234
Govt. Vehicles Tolled						
Govt. Trucks ...	3,010	$0.20	$ 219,730	3,010	$0.25	$ 274,662
Govt. Buses	500	0.25	45,625	500	0.35	63,875
Govt. Pass. Cars .	3,410	0.08	99,572	3,410	0.10	124,465
Govt. Sub-totals .	6,920	...	$ 364,927	6,920	...	$ 463,002
Other Vehicles ..	228,080	...	8,523,479	217,456	...	10,964,234
TOTALS	235,000		$8,888,406	224,376		$11,427,236

* Volume of commuters increased 10%, other passenger cars reduced 20% and trucks reduced 5% due to the higher toll rates.

Table XXXV

SCHEME IV — FREE MEMORIAL BRIDGE
TRAFFIC AND REVENUE SUMMARY*

Year	10c Basic Pass. Car Rate			15c Basic Pass. Car Rate		
	Annual Revenues	*Maint. & Oper.*	*Net Avail. Debt Service*	*Annual Revenues*	*Maint. & Oper.*	*Net Avail. Debt Service*
1960	$7,096,987	$1,092,000	$ 6,004,987	$ 9,122,553	$1,092,000	$ 8,030,553
1961	7,276,129	1,102,920	6,173,209	9,353,021	1,102,920	8,250,101
1962	7,455,271	1,113,949	6,341,322	9,583,489	1,113,949	8,469,540
1963	7,634,413	1,125,088	6,509,325	9,813,958	1,125,088	8,688,870
1964	7,813,555	1,136,339	6,677,216	10,044,427	1,136,339	8,908,088
1965	7,992,697	1,147,702	6,844,995	10,274,895	1,147,702	9,127,193
1966	8,171,839	1,159,179	7,012,660	10,505,364	1,159,179	9,346,185
1967	8,350,981	1,170,771	7,180,210	10,735,832	1,170,771	9,565,061
1968	8,530,123	1,182,479	7,347,644	10,966,300	1,182,479	9,783,821
1969	8,709,265	1,194,304	7,514,961	11,196,768	1,194,304	10,002,464
1970	8,888,406	1,206,247	7,682,159	11,427,236	1,206,247	10,220,989
Next 26 years	8,888,406	1,206,247	7,682,159	11,427,236	1,206,247	10,220,989
Total 32 years			236,614,027			315,033,634
Avg. 32 years			7,394,188			9,844,801
Total 37 years			275,024,822			366,138,579
Avg. 37 years			7,433,103			9,895,637

* Based on a toll bridge system with new bridges at Roaches Run and Constitution Avenue. Annual revenues include revenue for government vehicle tolls.

Table XXXVI

SCHEME IV — FREE MEMORIAL BRIDGE
FEASIBILITY OF TOLL FINANCING

	10c Basic Pass. Car Rate	*15c Basic Pass. Car Rate*
Gross Earnings — First Year	$ 7,096,987	$ 9,122,553
Maintenance and Operation Costs	1,092,000	1,092,000
Net Available for Debt Service	6,004,987	8,030,553
Cost of Structures	28,046,600	28,046,600
Approaches	52,727,200	52,727,200
Toll Plazas and Equipment	13,362,900	13,362,900
Total Capital Costs	94,136,700	94,136,700
3½% Interest During Construction (2 years)	11,497,500	11,497,500
Financing Costs, Legal Fees, etc.	3,865,800	3,865,800
Bonds Required	109,500,000	109,500,000
First Year Interest (3½%)	3,832,500	3,832,500
Interest Coverage, First Year	1.57	2.10
35 Year Bonds @ 3½%		
Interest and Amortization — 32 Years Earnings	.....	5,742,344
Level Debt Service, First Year Coverage	.....	1.40
Level Debt Service Coverage over Life of Bonds	.....	1.72
40 Year Bonds @ 3½%		
Interest and Amortization — 37 Years Earnings	5,323,151	.....
Level Debt Service, First Year Coverage	1.13	.....
Level Debt Service Coverage over Life of Bonds	1.40	.....

Feasibility

Table XXXVI develops the feasibility of the Central Crossings toll bridges operated without the Memorial Bridge. First-year revenues for a 10c basic toll schedule are estimated to be sufficient to cover bond interest by 1.57 times and amortization costs on 40-year bonds by 1.13 times. Earnings during the life of the bonds would cover debt service 1.40 times.

First year revenues from a 15c toll schedule would cover bond interest by 2.10 times and amortization costs on 35-year bonds by 1.40 times. Earnings during the life of the bonds would cover debt service by 1.72 times.

From the foregoing analysis it would appear possible to develop a system of Central Crossings operated as a Toll Bridge System without placing tolls on the Memorial Bridge.

PART X

Summary and Conclusions

All of the Potomac River crossings in the Washington metropolitan area are presently used to capacity during peak hours on most days. There is an urgent need for additional river crossing capacity in terms of new bridges and bridge approaches and improvements to existing bridges.

Means of financing additional bridges and approach roads have been given much attention by Congress and other political jurisdictions for many years. The question of revenue bond financing has often been raised. This report has been prepared with a view to exploring the possibilities of toll financing and presenting data to guide legislative and administrative policies.

Revenue bond financing of bridges and other traffic facilities has long been an accepted means of deriving funds for immediate use. Tolls charged against traffic using the facilities provide funds to amortize the bonds. The money borrowed by pledging future toll revenues can be used for the immediate construction of those needed facilities for which other revenue cannot be found or the construction of which would have to be postponed indefinitely.

This study has developed from a number of basic assumptions which grew out of conferences with various members of the Regional Highway Planning Committee. These assumptions include the extent to which approach roads and other highway improvements must be made a part of the plan, the amount of repairs and improvements to existing facilities which must be made, the scale of toll plaza development involved at the approaches to existing bridges, and the extent to which existing facilities should be accepted as part of the overall plan.

Toll schedules have been tentatively established upon which to base estimates of traffic likely to use the Potomac River crossings if they are operated as a toll system. Toll rates have been investigated which represent the lowest possible charges that can be made against bridge users consistent with the need for revenues sufficient to finance proposed improvements.

Tentative cost estimates of new bridges and approach roads have been prepared by the District of Columbia Department of Highways. The costs of developing toll plazas at existing bridges and of installing toll collection equipment at all locations have also been developed by the Department of Highways. The consultant has supplied cost estimates only where such data were not available from the Department of Highways. The cost estimates supplied by the Department of Highways, with a small amount of supplementary data, form the basis for the feasibility studies in this report.

Basic 10c and 15c passenger car toll rates have been investigated for each of the bridge combinations studied. Consideration has also been given to special commuter rates and to the amount of revenues which would be lost if government vehicles were allowed to use the bridges without charge. The basic toll schedules follow:

Vehicle Type	*Basic 10c Pass. Toll*	*Basic 15c Pass. Toll*
Pass. Cars, pickups, panels	.10	.15
Commuters (50-ticket book)	.08	.10
Medium trucks (2-axle, 6-tires)	.15	.20
Heavy trucks (3 or more axles)	.25	.35
Buses	.25	.35

Four possible combinations of Potomac River bridges have been examined for revenue bond feasibility. Scheme I is composed of two new crossings (the Outer Bridges) at Cabin John and Jones Point. Scheme II is a Potomac River Toll Bridge System composed of the four existing bridges and four or five new structures. Schme III, the Central Crossings, envisions the same Potomac River Bridge System as Scheme II, but bridges at Cabin John and Jones Point would be financed from sources other than revenue bonds and would be operated without tolls. Scheme IV would consist of the same Central Crossings as Scheme III, but would permit the Memorial Bridge to remain a free structure.

Scheme I — A toll bridge plan which includes only the Outer Bridges (Cabin John and Jones Point) cannot be financed by revenue bonds on the basis of data derived from this study. Income would not be sufficient to amortize a required $36,500,000 bond issue.

Revenue bonds might finance a $17,500,000 bridge structure only at Jones Point with a toll schedule based on a 25c passenger car rate. The project would not become feasible until 1960 or later, and extensive approach roads would have to be provided without cost to the project.

Scheme II — Construction of an eight-bridge Potomac River Toll Bridge System is estimated to cost $155,000,000 and might be financed by a basic 10c toll schedule if bond interest were kept below 3½ percent. At 3½ percent, level debt service during the 40-year life of revenue bonds might not be quite sufficient to meet the standards set by investors. A basic 15c toll schedule would provide sufficient revenues for a feasible project.

Scheme III — A Potomac River Toll Bridge System composed of only the Central Crossings (omitting the Outer Bridges at Cabin John and Jones Point) could earn sufficient revenues from a basic 10c toll schedule to make revenue bond financing of the required $117,500,000 investment appear feasible.

Scheme IV — Bridges and approach roads included in the Central Crossing Plan could be financed from tolls on all Central Crossings except the Memorial Bridge. A 10c basic toll schedule would provide sufficient income to finance $109,500,000 of 40-year revenue bonds if interest rates were kept below 3½ percent. At 3½ percent or greater, anticipated revenues during the life of 40-year revenue bonds might not be considered adequate to meet the standards set by investors. A basic 15c toll schedule would provide sufficient revenues for a feasible project.