REPORT OF SUBCOMMITTEE ON HIGHWAY TYPES AND ROADSIDE AREAS

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DESIGN FOR HIGHWAY RIGHT-OF-WAY

A brief review of the previous reports by this Committee shows consistent progress in the analysis of the fundamentals of the highway cross section problem. The last three (1937, 1938 and 1939) reports of the Subcommittee on Highway Types and Roadside Areas presented a general survey of highway cross section development over the United States from 1920 to about the present time./1 In the sectional layout of highways, there are three distinct zones or divisions of the entire right-of-way; (1) Graded roadbed or space for the traveled way; (2) Roadside border or traffic-insulation strip; and (3) Adjacent land or area within view of the driver.

As old roadbeds have been widened to meet the pressing needs of traffic, the roadside space or portion of the right-of-way outside the area used by traffic has usually been narrowed to such an extent that the roadside border fails to furnish adequate insulation for the protection of traffic./2 This process of narrowing roadside space to permit the widening of traffic space within the limits of existing rights-of-way has been allowed as a temporary means of providing for immediate traffic needs. Thus, the roadside border has not been definitely planned as a primary part of the highway traffic design but has often been merely whatever part of the original right-of-way which was left over. Perhaps this has resulted because roadsides were often considered of only minor importance to the traffic rather than as primary elements in a highway design, construction and maintenance program. The necessity for obtaining greater widths of right-of-way is thus emphasized in modern highway construction. The 1938 report stressed the fact that "one of the most urgent needs in view of the future program of highway modernization is the immediate adoption of a long-time policy in acquiring and

/1 Proceedings, Highway Research Board, Vol. 17, p. 255.
/2 Proceedings, Highway Research Board, Vol. 18, p. 199.

financing right-of-way on the carefully laid out system of high-volume highways."/3

The 1939 report emphasized that the "foundation of a well-balanced highway design is an adequate width of right-of-way, with roadbed, roadside, and adjacent lands all united in proper relation."/4 It recommended that the roadsides be of adequate width to provide for the satisfactory grading of cross sections, with slope ratios differentiated for various soils and depths of cut or fill. In addition, roadside width should be sufficient to accommodate necessary tree plantings and utilities such as pole lines, etc. It is necessary also, for erosion and snow drift control, that slopes be flattened and rounded as liberally as local conditions permit. In general, the width of right-of-way should be flexible so that it may be adjusted to save important trees and other growth along the highway. In addition to these fundamental highway design requirements, the primary highway right-of-way should include occasional space OFF the traveled way for selected turnout areas for safe and convenient traffic use.

The present report (1940) reviews in a preliminary way the general relationship of right-of-way to construction as a problem in modern highway design. The physical aspects are outlined with incidental reference to the financial considerations necessary for proper understanding of the right-of-way problem as a foundation for highway construction.

The all too-general city street practice of arbitrarily establishing for country roads a fixed uniform or standard width of right-of-way within which the highway designer is forced to mold his cross section is compared with the opposite more flexible policy of first designing the highway cross section requirements and then determining the various widths of right-of-way necessary to be acquired for the construction.

In rural areas an elastic informal style of highway design is evolving from the formal rigid urban type which characterized our older roads. Traffic requirements, local conditions of soil and topography and a flexible right-of-way policy are the principle factors in this evolution. The use of fixed standards is now an obsolete policy where the natural informality of the countryside and the varied needs of the open road are involved in the construction.

Formal City Streets Versus Informal Rural Roads: It was natural in the early growth of highway mileage that roadbuilding was mainly concerned with the extension into the country of the then existing city streets so that the people of one community or town could drive to another town or city. The first step was to free the people of the mud blockade of travel, particularly in the winter months.

/3 Proceedings, Highway Research Board, Vol. 18, p. 199.

/4 Proceedings, Highway Research Board, Vol. 19, p. 237.

It was natural, during this pioneering period, that the roads be built upon a more or less uniform width of narrow right-of-way comparable to the customary fixed width used for city streets. It was natural, also, as extensions were made into the country, for the methods of street construction to tend to be followed in roadbuilding. As a result, the standard regularity of construction found in city development tended to be used in highway construction in the country.

For instance, note the initial tendency in rural highway work, when a curb is needed, to use the urban type with a vertical high face instead of the rural type of curb with a low sloping face. Also, we may note the tendency for the city sidewalk type of construction to be extended into the country for pedestrian safety. When the roadside improvement program was initiated on a national scale in 1933, even tree plantings along rural roadsides tended to be located in regular rows in imitation of the formal plantings within cities.

Since rural conditions and traffic requirements are essentially different from urban conditions and traffic needs, a flexible rather than a fixed type of highway design is needed in order to fit the variable soil and topographic conditions found in the open country. Analysis of the rural highway problem indicates that the more or less standard methods of construction employed for average city street or urban highway development are not suitable for building rural roads.

Today, we observe an interesting change; that instead of city streets being extended into the country, the primary rural State highways are now being extended into the centers of cities to provide necessary traffic relief in urban areas. The recent reversal in the direction and process of development - that is, from the country into the city instead of the extension of the city into the country - marks a turning point in the concept of highway design and construction in the United States.

In the adaptation of construction to meet each problem as it arises, we are witnessing the beginning of what may be called a more scientific period of highway planning and design, with a more flexible and natural pattern of development displacing the earlier fixed standards of construction. For example, note the techniques of subgrade stabilization used as a means of equalizing various degrees of soil support under road surfaces. Note the increasing use of spiral easements and long directional curvature in new alignments instead of the long tangents with short circular curves. Note the revolution that is taking place in grading methods wherein cut and fill slopes are flattened and rounded to meet various topographic conditions instead of backslopes being graded to a uniform ratio regardless of the height of the cut (or fill) or local variation in soil condition. Note the general placement of trees in natural groups instead of the former practice of placing them in regular rows.

The policy of fitting each construction to the particular field requirements of city or country is in many ways dependent upon the use of an equally flexible policy in the acquisition of right-of-way for highway improvement. Right-of-way limitations often handicap the carrying out of such a planning policy.

The initial disadvantage in design practice of trying to place a flexible type of highway cross section upon an inflexible "standardized" right-of-way of fixed width instead of an adequately designed right-of-way of varying width is self evident. The need for a more flexible and broader policy for the design and acquisition of right-of-way for primary rural highways is accordingly emphasized in this report. The right-of-way is the most permanent part of any highway investment; therefore it should be designed to meet various requirements the same as any other element of the highway construction.

Adequate widths of right-of-way based on a flexible policy as outlined in this report, are fundamental to an economic modernization program on a nation-wide scale. The attached chart showing percentages of traffic on roads in the United States indicates how potentially effective the early adoption and general use of a more flexible right-of-way design might be as an applied policy in connection with modern highway construction and reconstruction of old road mileages. From this summary chart, it is indicated that less than one half of all rural roads in the United States are surfaced, and that nearly 90 per cent of the rural roads are outside of the State and Federal-aid systems. The primary rural highways and trans-city connections, however, carry about 57 per cent of the total average travel per vehicle. Thus, with only about 10 per cent of rural road mileage now included in the State systems, there is unlimited opportunity for the sound use of a flexible design policy in connection with right-of-way problems for rural roads.

The relative approximate percentages of capital investment in right-of-way and construction for the rural and the urban types of construction are illustrated in the charts accompanying this report. The studies covering the "Status of Improvements on the State Highway and Federal-aid Systems" as compiled from the Annual Reports of the American Association of State Highway Officials indicate that approximately 4 per cent of the total annual capital investment on extensive rural highway construction was expended for the acquisition of highway right-of-way and approximately 96 per cent was expended each year for the construction of roads and bridges. For intensive urban developments, however, as on the Westchester County, New York, parkway system, expenditures for the acquisition of lands and the construction improvement were about equal in amount, or approximately 50 per cent each of the total capital investment in the entire parkway system. The comparatively high land costs for this specialized system of urban parkways is thus shown to be about ten times the relatively low expenditures for rights-of-way on the typical rural State highway systems./5

/5 See attached 'Chart Showing Relative Approximate Percentages of Capital Investment in Right-of-Way and Construction'.

Other rural and urban types of special highway examples were studied for comparison. The chart shows that comparative figures for rural types vary from about 7.5 per cent to about 15 per cent for cost of right-of-way. It is indicated in these studies that from 8 to 12 per cent, or about two to three times the 4 per cent average expenditure for right-of-way on the State systems might be assumed to be a reasonable proportion of the total capital investment by the States for insurance that adequate right-of-way facilities would be provided for normal primary rural highway improvements.

Three graphic charts are included in this report to show the approximate number of acres required per mile of highway at various widths of right-of-way and at various costs per acre. A careful analysis of these graphs will show that, for the majority of rural highway mileage, flexibility in design through the widening of right-of-way to meet various roadside conditions may be carried out at a relatively small percentage of the cost of the entire highway construction.

For example, let us assume that a primary two-lane road with an existing 75-ft. right-of-way is to be reconstructed on a 125-ft. right-of-way at an average cost of $25,000 per mile. The 50-ft. increase in width of right-of-way would represent six additional acres per mile, which at an assumed average cost of $100 per acre would require $600 for the widened right-of-way, or about 2-1/2 per cent of the construction expenditure. In round figures, then, if we assume that the initial 75-ft. right-of-way represented about 5 per cent of the original construction cost and add about 2-1/2 per cent for the 50-ft. reconstruction widening, we arrive at a total of about 7-1/2 per cent for the whole expenditure for right-of-way (125 ft.) purposes. This assumed percentage may be rightly considered as an insurance premium for a sound highway investment policy.

Summary: Experience in highway development has proven that conditions and traffic requirements of the country are essentially different from those of the city. Consequently two general types of highway have developed, the urban or formal (artificial) type, and the rural or informal (natural) type. The initial pioneering practice of superimposing the city type of construction upon the country is now giving way to the more flexible application of highway design principles to fit the different needs of the open road.

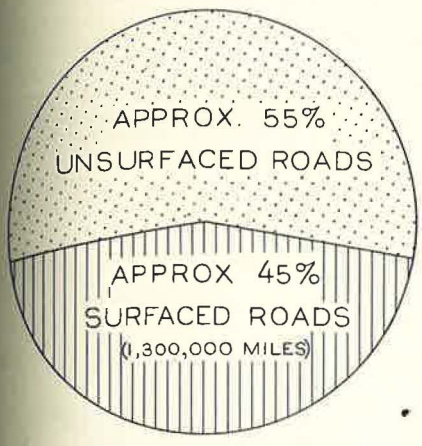
The need for a more flexible and broader administrative policy for the design and acquisition of right-of-way is emphasized in the report because the right-of-way is the most permanent part of any highway investment. The studies covering the 5-year period from 1935 to 1940 indicate that less than 5 per cent of the total annual capital investment on the State highway systems was expended for rights-of-way. It is indicated in these studies that it should be generally possible in rural areas to obtain adequate right-of-way at a relatively small increase in proportion to total construction cost.

Flexibility in the widths of highway right-of-way is essential in order to have the road construction fit the various roadside soil and topographic conditions. It is indicated that the wider adoption and more general use of such a flexible policy in order to have rights-of-way fit particular design requirements should be possible for the majority of highway mileage. The practice of using fixed standards in rural highway construction is now obsolete. Therefore, highway rights-of-way should be acquired to meet varying conditions the same as any other element of the highway construction programs.

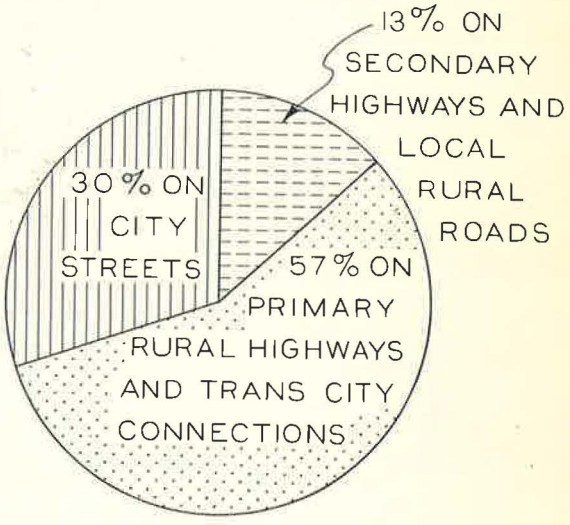
Conclusion: Mutual understanding of the whole highway design cross section requirements by the right-of-way engineer, the location and design engineer, the bridge and construction engineer, the maintenance engineer, and the landscape engineer, should be helpful in developing effective cooperation for the correlated design of the modern wide highway for various traffic needs.

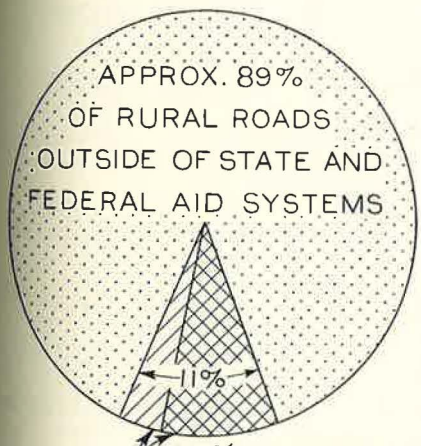
CHART SHOWING PERCENTAGES OF TRAFFIC ON ROADS IN THE UNITED STATES

ALL RURAL ROADS
(3,000,000 MILES)



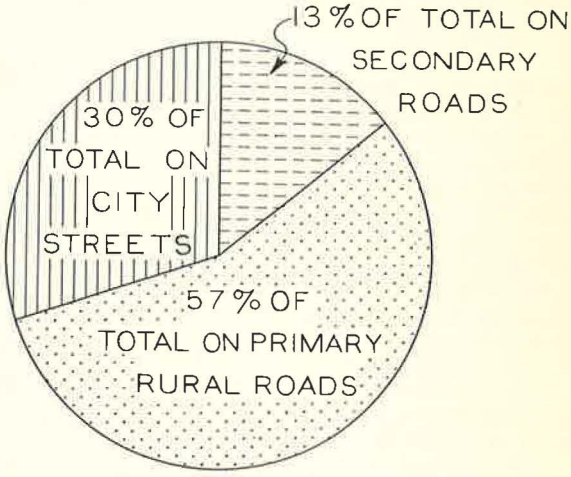
TOTAL TRAVEL





11% APPROX. OF PRIMARY RURAL ROADS IN SYSTEM OF WHICH 72% APPROX. ARE ON THE FEDERAL AID SYSTEM

AVERAGE TRAVEL PER VEHICLE



ON:

1 - PRIMARY RURAL HIGHWAYS AND TRANSCITY CONNECTIONS	5,000 MILES
2 - SECONDARY HIGHWAYS AND LOCAL RURAL ROADS	1,190 MILES
3 - CITY STREETS	2,680 MILES
TOTAL	8,870 MILES

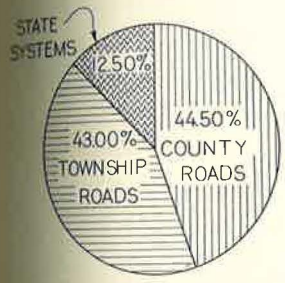
P.R.A. Nov. 1940

STATUS OF IMPROVEMENTS ON THE STATE HIGHWAY SYSTEMS
(INCLUDING THE FEDERAL AID SYSTEM)

COMPILED FROM ANNUAL REPORTS OF A.A.S.H.O.

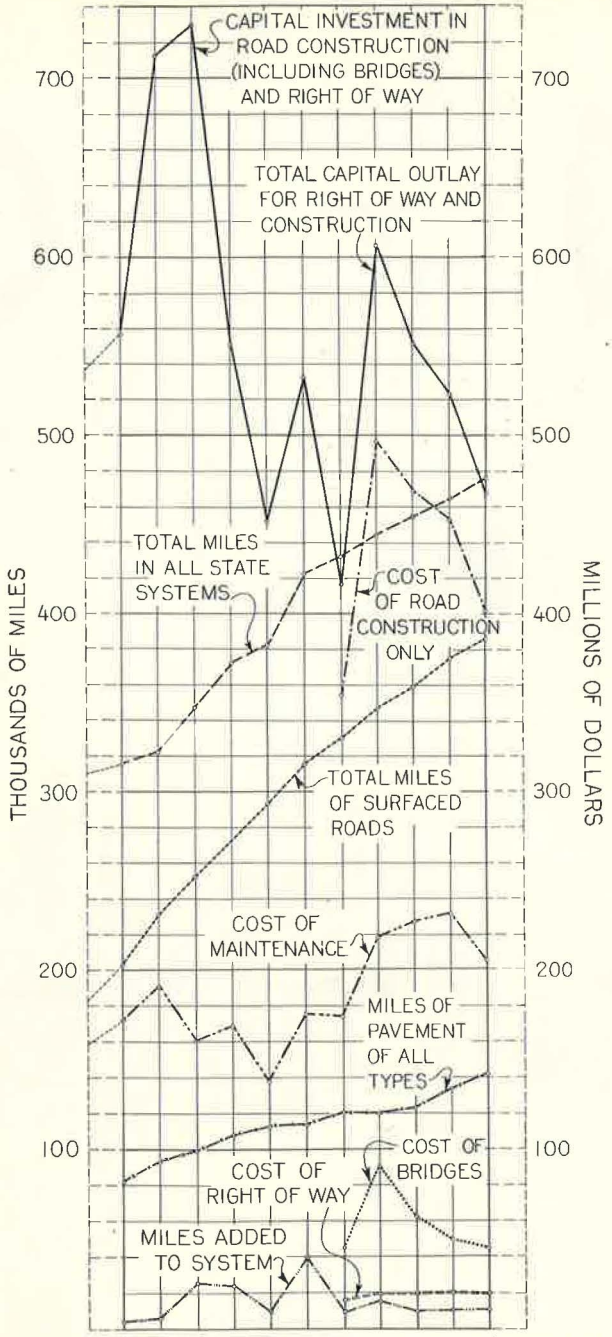
"IN 1917-1918 THERE WERE A LITTLE OVER 6 MILLION MOTOR VEHICLES IN COUNTRY: NOW (AFTER 10 YEARS) WE ARE TRYING TO FURNISH A RUNNING BED FOR OVER 24,000,000." . . . "THEN A LITTLE OVER 40,000 MILES OF STATE HIGHWAYS IN ANY KIND OF SURFACING. WHILE TODAY (1928) THERE ARE OVER 352,000 MILES SURFACED." *

*FROM 1928 ANNUAL REPORT OF AMERICAN ASSOCIATION STATE HIGHWAY OFFICIALS.)



382,688 MILES ON STATE SYSTEMS (12½%±) (OF ALL STATES)
1,353,515 MILES COUNTY ROADS (44½%± OF ALL ROADS)
1,332,716 MILES TOWNSHIP ROADS (43%± OF ALL ROADS)
3,068,919 MILES RURAL HIGHWAYS IN THE UNITED STATES *

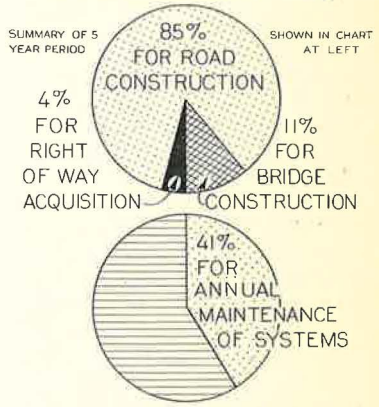
*ACCORDING TO 1935 ANNUAL REPORT OF AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS.)



NOTE: A NEW FEDERAL POLICY WAS ADOPTED BY THE CONGRESS AND BECAME LAW JUNE 16, 1936 WHICH PROVIDES FEDERAL FUNDS FOR ROADS OFF THE FEDERAL AID SYSTEM. SEC. 7 "PROVIDED, THAT THE SUMS HEREIN AUTHORIZED SHALL BE APPLIED TO SECONDARY OR FEEDER ROADS, RURAL FREE DELIVERY MAIL ROADS, AND PUBLIC SCHOOL BUS ROUTES." *

*(FROM 1936 ANNUAL REPORT AMERICAN ASSOCIATION STATE HIGHWAY OFFICIALS)

AVERAGE CAPITAL OUTLAY FOR RIGHT OF WAY, BRIDGE AND ROAD CONSTRUCTION 1936 TO 1940.



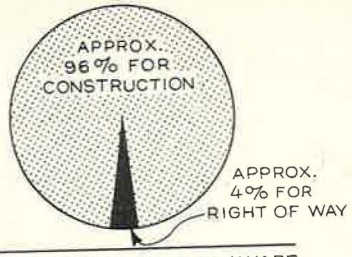
NOTE: "MANY MILES OF ROAD ON THE STATE SYSTEMS ARE SURFACED OR EVEN PAVED BUT THEY ARE IN NEED OF REBUILDING, RELOCATION OR WIDENING TO MEET THE PRESENT NEEDS OF THE TRAVELING PUBLIC NOT ONLY FOR COMFORT, BUT FOR SAFETY AS WELL" . . . "IN VIEW OF THE FACT THAT BUT A SMALL PART OF THIS WORK CAN BE UNDERTAKEN IN ANY ONE YEAR, THE SERIOUSNESS OF THE SITUATION SHOULD MAKE THOSE RESPONSIBLE FOR THE UP KEEP AND IMPROVEMENT OF HIGH WAYS A MATTER OF MORE THAN ORDINARY CONCERN." *

* (FROM PAGE 3, 1938 ANNUAL REPORT OF A.A.S.H.O.)

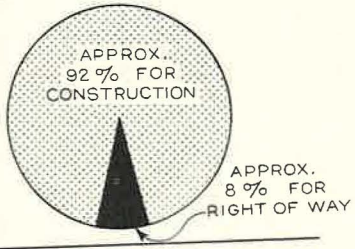
P.R.A. Nov. 1940

CHART SHOWING RELATIVE APPROXIMATE PERCENTAGES OF CAPITAL INVESTMENT IN RIGHT OF WAY AND CONSTRUCTION

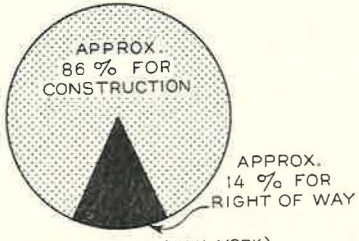
STATE HIGHWAY SYSTEMS
AVERAGE FOR THE 5-YEAR PERIOD 1936-1940
(GENERAL RURAL HIGHWAY CONSTRUCTION)



DUPONT HIGHWAY–DELAWARE
(RURAL SOUTH 36 MILES ONLY)
(GRADES NOT SEPARATED)

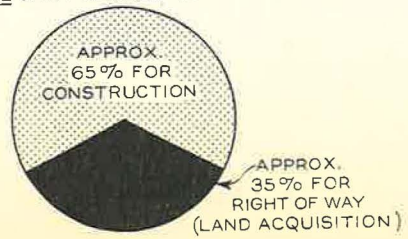


NEW BRONX PARKWAY EXTENSION
(RURAL)



(1933 REPORT OF THE (NEW YORK) WESTCHESTER CO. PARK COMMISSION)

MERRITT PARKWAY—CONNECTICUT
RURAL-WITH GRADES SEPARATED

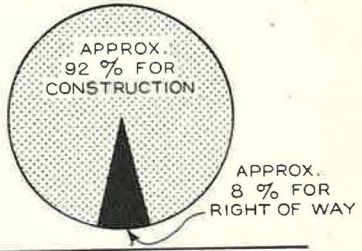


MOUNT VERNON MEMORIAL HIGHWAY
VIRGINIA
(RURAL)

WESTCHESTER COUNTY PARK SYSTEM-NEW YORK
TOTAL FOR 11-YEARS 1922–1933*
(SPECIAL URBAN PARKWAY DEVELOPMENT)

* INCLUDES ACQUISITION OF RIGHT OF WAY ON WHICH CONSTRUCTION HAS NOT BEEN COMPLETED

PENNSYLVANIA TURNPIKE
(RURAL 160 MILES ALL GRADES SEPARATED)

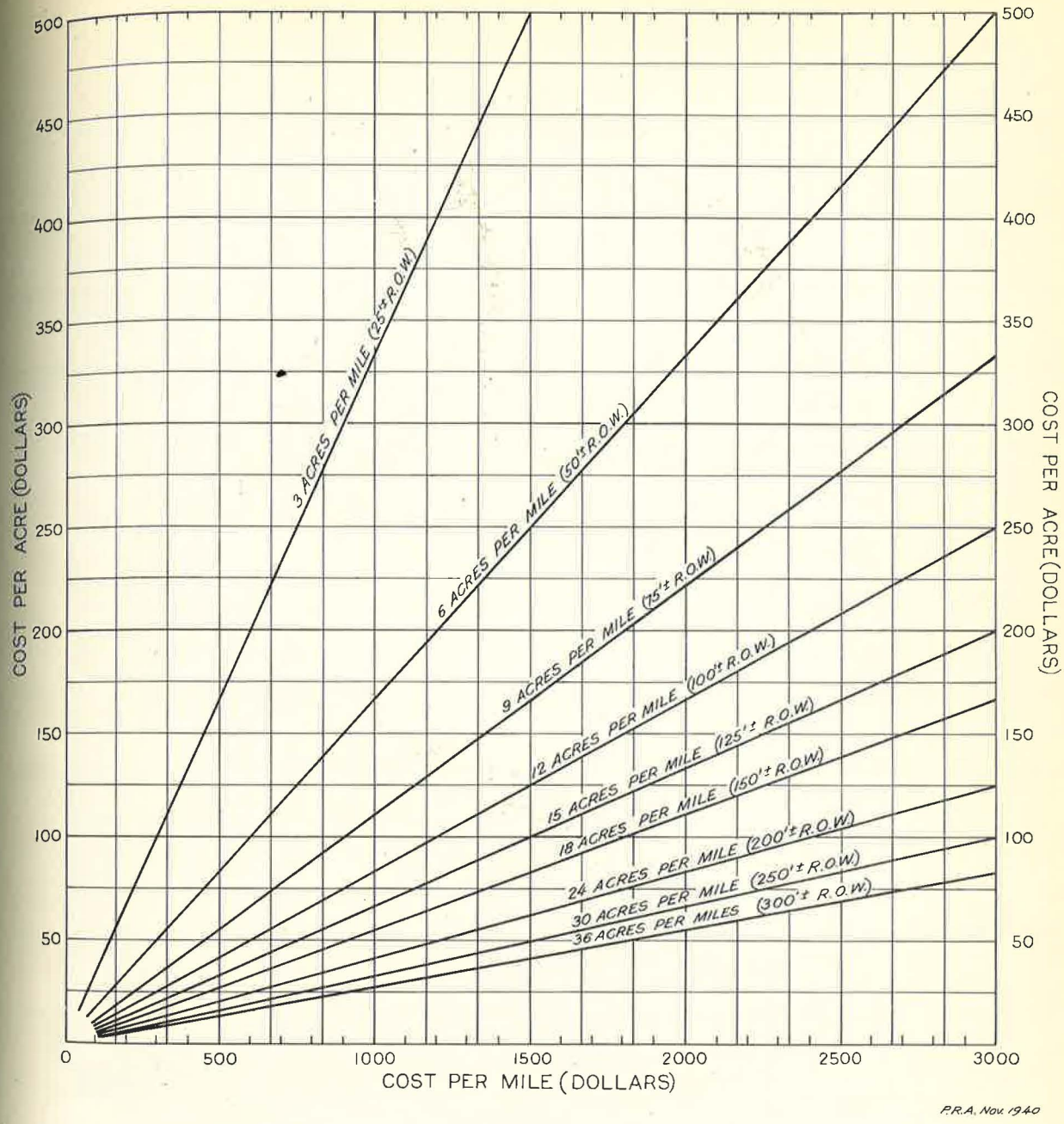


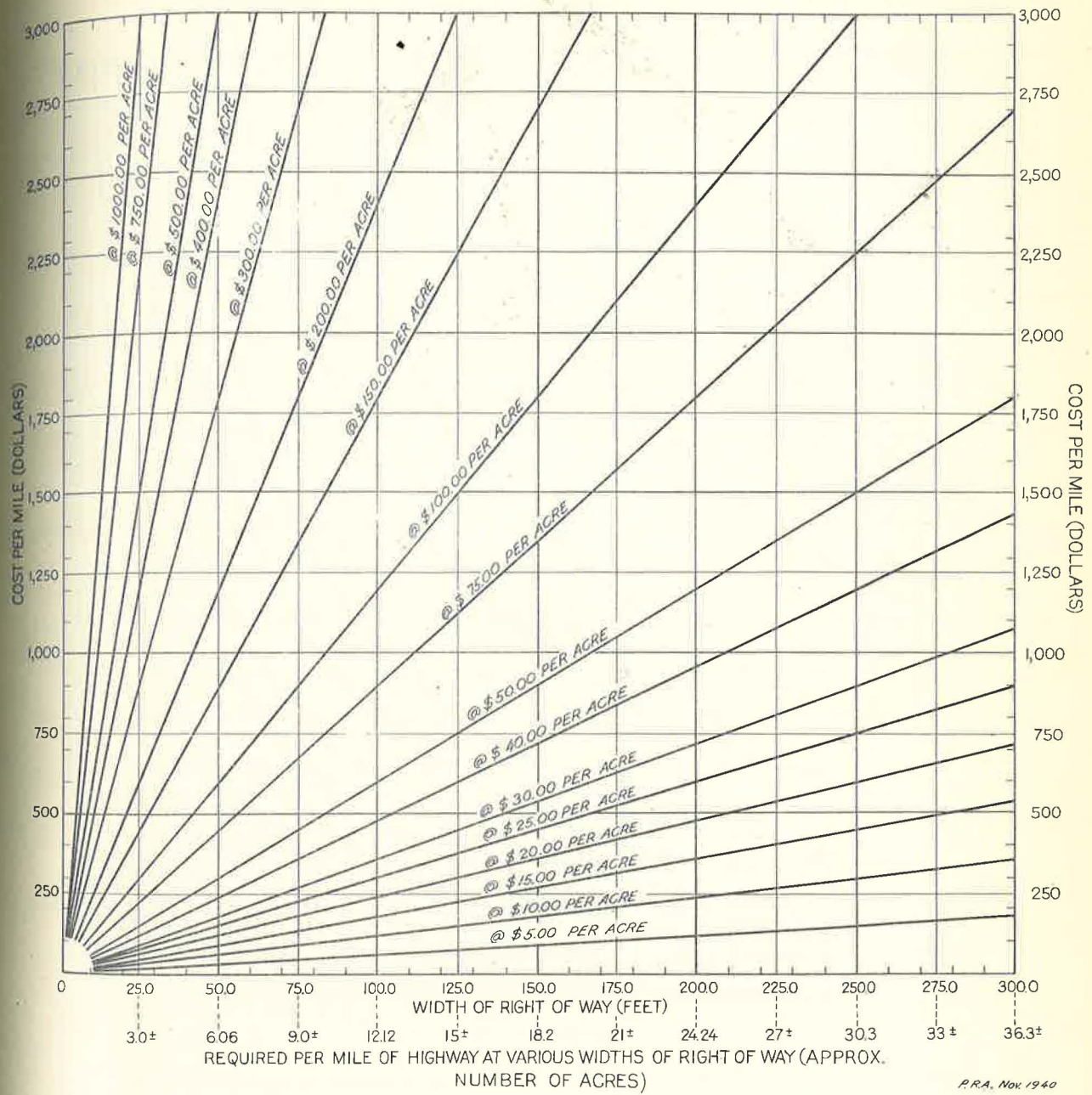
OLD BRONX PARKWAY* (URBAN)

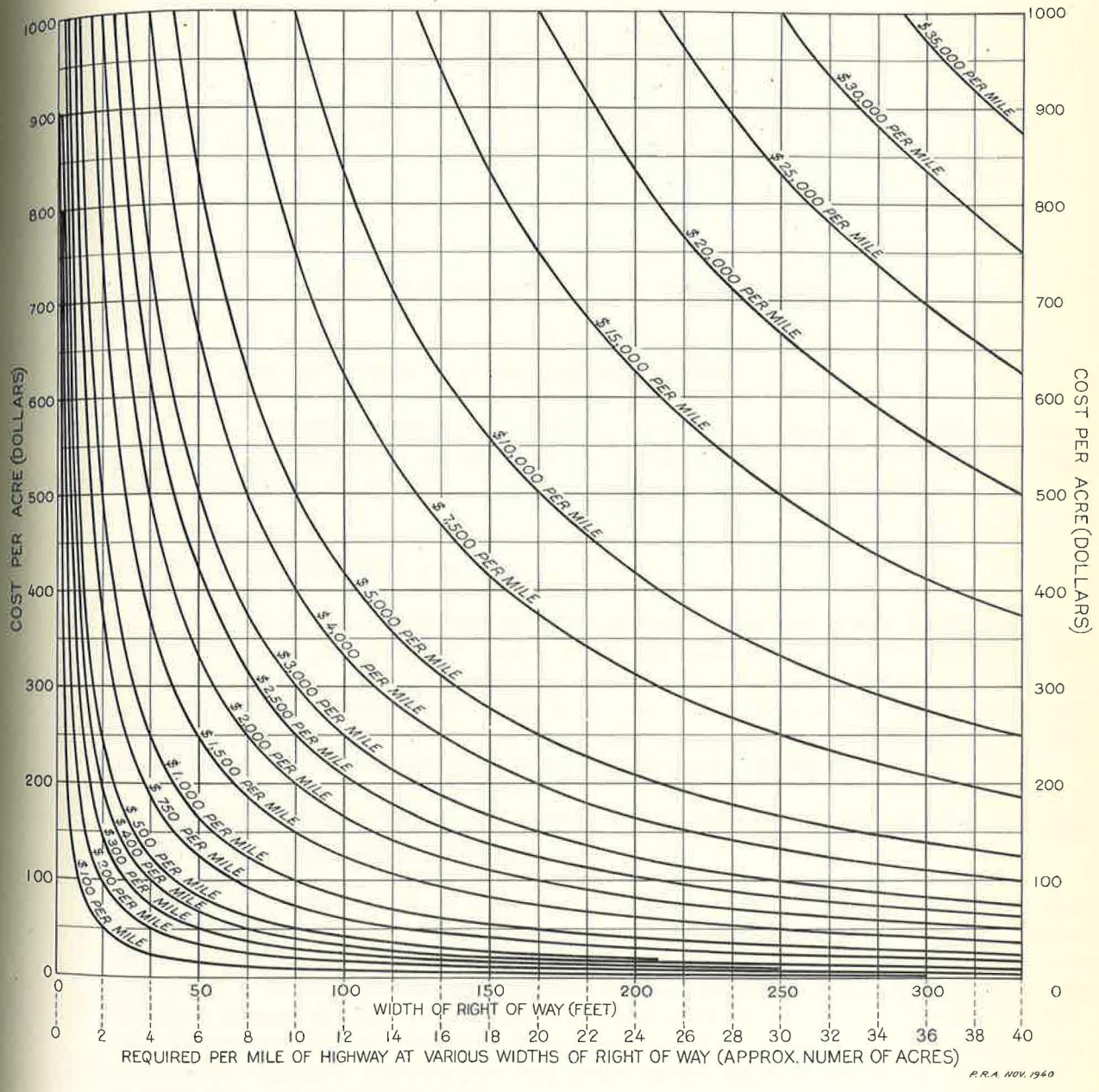
(* 1925 FINAL REPORT OF THE BRONX PARKWAY COMMISSION, WESTCHESTER COUNTY N.Y.)

HUTCHINSON RIVER PARKWAY (URBAN)
WESTCHESTER COUNTY, NEW YORK

P.R.A. Nov. 1940


COST PER ACRE (DOLLARS)
500
450
400
350
300
250
200
150
100
50
0
500
1000
1500
2000
2500
3000
COST PER MILE (DOLLARS)
3 ACRES PER MILE (25'± R.O.W.)
6 ACRES PER MILE (50'± R.O.W.)
9 ACRES PER MILE (75'± R.O.W.)
12 ACRES PER MILE (100'± R.O.W.)
15 ACRES PER MILE (125'± R.O.W.)
18 ACRES PER MILE (150'± R.O.W.)
24 ACRES PER MILE (200'± R.O.W.)
30 ACRES PER MILE (250'± R.O.W.)
36 ACRES PER MILES (300'± R.O.W.)
P.R.A. Nov. 1940


@ $1000.00 PER ACRE
@ $750.00 PER ACRE
@ $500.00 PER ACRE
@ $400.00 PER ACRE
@ $300.00 PER ACRE
@ $200.00 PER ACRE
@ $150.00 PER ACRE
@ $100.00 PER ACRE
@ $75.00 PER ACRE
@ $50.00 PER ACRE
@ $40.00 PER ACRE
@ $30.00 PER ACRE
@ $25.00 PER ACRE
@ $20.00 PER ACRE
@ $15.00 PER ACRE
@ $10.00 PER ACRE
@ $5.00 PER ACRE
COST PER MILE (DOLLARS)
3,000
2,750
2,500
2,250
2,000
1,750
1,500
1,250
1,000
750
500
250
0
25.0
50.0
75.0
100.0
125.0
150.0
175.0
200.0
225.0
250.0
275.0
300.0
WIDTH OF RIGHT OF WAY (FEET)
3.0±
6.06
9.0±
12.12
15±
18.2
21±
24.24
27±
30.3
33±
36.3±
REQUIRED PER MILE OF HIGHWAY AT VARIOUS WIDTHS OF RIGHT OF WAY (APPROX. NUMBER OF ACRES)
P.R.A. Nov. 1940


$35,000 PER MILE
$30,000 PER MILE
$25,000 PER MILE
$20,000 PER MILE
$15,000 PER MILE
$10,000 PER MILE
$7,500 PER MILE
$5,000 PER MILE
$4,000 PER MILE
$3,000 PER MILE
$2,500 PER MILE
$2,000 PER MILE
$1,500 PER MILE
$1,000 PER MILE
$750 PER MILE
$500 PER MILE
$400 PER MILE
$300 PER MILE
$200 PER MILE
$100 PER MILE
COST PER ACRE (DOLLARS)
COST PER ACRE (DOLLARS)
0 100 200 300 400 500 600 700 800 900 1000
0 50 100 150 200 250 300
WIDTH OF RIGHT OF WAY (FEET)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
REQUIRED PER MILE OF HIGHWAY AT VARIOUS WIDTHS OF RIGHT OF WAY (APPROX. NUMER OF ACRES)
P.R.A. NOV. 1940