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L. Douglas James

University of Kentucky

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The Economic Analysis of Recreational Reservoirs

BY L. DOUGLAS JAMES

Editor's Note: With the increase of expenditures of revenue by state and federal agencies for public facilities, e.g., highways, recreational areas, and the like, it has become evident that the project planner must be able to justify his request for revenue, i.e., the benefit must exceed the cost. The following article is an example of one type of study that may be made to justify a large expenditure for a recreational reservoir. It will be of value both to the project planner who must justify his proposal and to those who would attack a proposed project, by familiarizing the latter with the type of analysis they will have to rebut.

Editor's Introduction

In response to a statement by Senator Clinton P. Anderson of New Mexico, on the Senate Floor, a Senate Resolution was passed authorizing the publication, as a Senate document, of an agreement of the Secretaries of the Army, Agriculture, Health, Education and Welfare, and Interior relating to the formulation and evaluation of policies and standards in the development of water-resources projects. First approved by President Kennedy, the document is presently being applied by the above-mentioned departments. This agreement governs all formulation, evaluation, and review of water and related land resources plans insofar as they are consistent with existing law or other applicable regulations.

The basic objective in the formulation of these plans is to provide the best use, or combination of uses, of water and related land resources to meet short and long-term needs and in-

* Assistant Professor
Department of Civil Engineering
University of Kentucky
Lexington, Kentucky

sure economic development and growth. Standards for formulating the plan, whether for one over-all project or for each specific purpose of a comprehensive project, are expressed in the provisions of the agreement:

All plans shall be formulated with due regard to all pertinent benefits and costs, both tangible and intangible. Benefits and costs shall be expressed in comparable economic terms to the fullest extent possible . . . . (a) tangible benefits exceed project economic costs. (b) each separable unit or purpose provides benefits at least equal to its costs.4

Thus several significant resource uses and purposes compete in the development of a water-resources project.5 The water-resources planner is not only required to demonstrate the economic feasibility of the entire project, but of each separable unit within the project. This article attempts to outline a method for demonstrating the required economic feasibility of one of the several competing uses of water— that of outdoor recreation.

In order to justify inclusion of a recreational unit within a proposed project, the benefit expected to result from the unit must be demonstrated to exceed the cost of including the unit. This is significant to the lawyer in several ways. Whether a recreational use justifies necessary expenditures, as to which of two beneficial uses of water is to prevail in light of the social factors involved, and the safeguarding of the interests of all people in society,6 are areas where an understanding of the cost-benefit analysis and its underlying principles will be useful to the lawyer as an advocate in modern society. This is especially significant in view of the recent growth in independent federal policy, and its divergence from state standards in the field of outdoor recreation.

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4 Id. at 7-8.
5 Among these competing uses are domestic, municipal, agricultural, and industrial uses of water; water quality control; navigation; hydro-electric power; flood protection control or prevention; land and beach stabilization; drainage; watershed protection and management; forest and mineral production; grazing and cropland improvement; outdoor recreation, as well as sport and commercial fish and wildlife protection and enhancement; and preservation of unique areas of natural beauty, historic and scientific interest.
6 An analogous situation can be seen in the selection of highway routes where a failure to evaluate degrees of private injury on each of several proposed routes may be classified as arbitrary action by the courts. See Tippy, Review of Route Selections for the Federal Aid Highway Systems, 27 Mont. L. Rev. 131 (1966).
I. INTRODUCTION

Recreation is rapidly becoming one of the primary purposes of reservoir construction. Thus, the water-resources planner must give increased attention to the recreational features of proposed projects. He must not only decide upon the feasibility of including recreational features within a particular project, but he must make numerous decisions on their extent and nature. For example, he must decide whether the reservoir surface area should be 100, 1000, or 10,000 acres, whether the shoreline facilities should accommodate 100, 1000, or 10,000 visitors per day, and whether provision should be made for daytime picnickers at the expense of nighttime campers.

If recreational planning is to progress in an orderly fashion, objective criteria must be used to answer these questions. While economic analysis is limited by theoretical as well as practical data-gathering problems, it provides the soundest basis available for objective project evaluation. Many fail to appreciate that the techniques which have gained wide acceptance for proving economic feasibility—that benefits exceed the costs—can be used to even greater advantage to determine the optimum magnitude of project development and to answer the countless design questions inherent in detailed planning.

Economic analysis approaches the optimization of project size through the use of marginal curves. A measure of project size or the degree of project development—the number of recreation visitors facilities at a reservoir are designed to accommodate for example—is selected. Project costs and benefits are calculated as a function of project size as expressed by this measure. The results are plotted as total value curves. The slopes of each of the two curves equal the marginal costs and the marginal benefits respectively, and may be plotted as functions of project size. The optimum design, as determined from the marginal value curves, is the point where marginal cost equals marginal benefit or, as determined from the total value curves, where the maximum departure between the total cost and the total benefit occurs. Application of this approach requires review of the nature of outdoor recreation.

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7 See Figure 1, Appendix A.
8 See Figure 2, Appendix A.
II. THE NATURE OF OUTDOOR RECREATION

Recreation provides physical, mental, and emotional relaxation to those seeking personal enjoyment through leisure time activities. This may be contrasted with activities undertaken to earn an income and such routine activities of life as eating and sleeping. The water-resources planner is interested in outdoor recreation activities associated with the presence or proximity of water, particularly reservoirs. Many leisure time activities require direct use of the water, e.g., boating, ice skating, swimming, and fishing. For picnicking, camping, and hiking the water by its proximity merely serves to enhance the value of the activity to the participant.

Lakes, rivers, and streams have always fascinated man providing him with relaxation and enjoyment in outdoor activities centered around water. However, a number of factors have recently combined to intensify participation in water-based recreation. Increased incomes and decreased working hours have allowed people to spend more money and time on leisure activities. Modern transportation facilities have made it possible to seek recreation at more distant sites; expanding urbanization has forced those who could otherwise enjoy the open space of the farm to seek outdoor recreation away from home. Every forecast indicates that the demand for recreation will continue to expand much faster than the total population. From 1953 to 1963, attendance at Corps of Engineers Reservoirs increased an average of 13.6 percent per year with the increase in 1963 being 16 percent. During this period, the annual rate of population growth was 1.7 percent.

Recreational development in a water-resources project is accomplished by constructing a dam and reservoir which provides a body of water. Peripheral facilities along the shoreline are designed to provide the desired recreational areas designated for picnicking, boating, swimming, camping, and fishing. Thus, by providing the water and peripheral facilities, the water-resources planner is seeking to satisfy the need for outdoor recreation.

III. DEVELOPING THE MARGINAL COST CURVE

The first step in developing a marginal cost curve for recrea-

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tional development is the selection of an appropriate measure of project size. The most widely accepted unit for measuring the quantity of recreation provided is the user-day. A user-day—alternately called the visitor-day—is one day's use of the site by one person. However, a person may engage in a number of different activities while spending a day at the site. An activity-day is one day during which an individual engages in a particular activity—boating, swimming, or hiking—at a particular site. An activity-day implies participation in the activity sometime during the day. Since many visitors will engage in more than one activity in a day, the total number of user-days spent at a recreational reservoir is smaller than the total number of activity-days.10

In estimating the number of visitors which can be accommodated at a site, it is necessary to designate specific areas for specific activities. The principal activities are boating, swimming, fishing, camping, picnicking, and hiking. During the planning stage, the gross area suitable for recreational use is outlined on topographic maps; this total area is then subdivided among the activities to be provided at the site. A number of guidelines for determining the suitability of an area for an activity have been provided by various groups and analysts.11 The facilities for indirect activities should be installed in areas of moderate slopes, having a good view, and within easy walking distance of the lake. Limits are arbitrary, but most recreation areas should be within one-half mile of the lake on slopes less than 20 per cent and separated from through highways and other nonrecreational land. The swimming areas are normally concentrated in a few spots along the shoreline with ready access, sandy beaches, and some shallow water. Boating will cover most of the reservoir surface except swimming areas, limited areas near the dam and spillway, and where restricted to provide better fishing. Once the space dedicated to each activity is outlined on a map, the acreage by activity is readily tabulated.

10 These factors can be put into equation form. See Equation 1, Appendix B.
The activity capacity is the maximum number of activity-days the area dedicated to a specific activity can accommodate without excessive crowding. Such capacity is determined by dividing the space dedicated to the specific activity by the capacity coefficient appropriate for the activity. The capacity coefficient is the space required to provide for one activity-day of use. Because the recreational area will not be used to full capacity every day of the year, the annual number of activity-days which will be spent in a given activity must be determined as a fraction of activity capacity.

The number of people engaged in a recreational activity will vary from day to day during the year. The intensity coefficient may be estimated from two utilization factors. Reservoir visitation is normally higher on Sunday than on any other day of the week. The weekly utilization factor \( f_w \) is the average intensity of use over the week divided by the average intensity of Sunday use. Reservoir visitation is normally higher in July than in any other month. The seasonal utilization factor \( f_s \) is the average intensity of Sunday use over the year divided by the activity capacity. Use will normally equal or exceed that indicated by the capacity coefficients during the summer and decline sharply during the winter months. Seasonal utilization will vary among activities with picnicking or hiking extending further into the colder months than swimming. Thus, seasonal utilization, \( f_s \), must be determined individually by activity. The weekly and seasonal utilization factors may be estimated from weekly and seasonal utilization curves. The total number of activity-days which a recreational reservoir can provide may be estimated by adding the activity-days for the individual activities.

Based on these concepts, the marginal cost curve may be developed through the following six steps.

1. For each of a series of reservoir sizes covering the range within which the optimum size may potentially lie, the area to be dedicated to each activity is designated.

2. The number of activity-days which can be accommodated

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12 See Table 1, Appendix A.
13 These factors can be put into equation form. See Equation 2, Appendix B.
14 See Figure 3, Appendix A.
15 See Figure 4, Appendix A.
16 See Equation 3 and Equation 4, Appendix B.
by the designated areas is estimated by applying the appropriate capacity coefficients to each one.

3. The annual user-days that each reservoir size will accommodate is computed by use of an equation after appropriate values have been selected for the various utilization factors.\(^{17}\)

4. The cost of providing a reservoir of each designated size and of including the associated peripheral facilities is estimated. The cost is the sum of the installation, operation, and maintenance expenses expressed as a discounted average annual value over the life of the project.

5. The total annual cost of each reservoir size is then plotted against the annual user-days which it can accommodate to get the total cost curve.\(^{18}\)

6. The marginal costs for accommodating specific user volumes equal the slope of the cost curve and are plotted against the annual user-days which can be accommodated to get the marginal cost curve.\(^{19}\)

IV. DEVELOPING THE MARGINAL BENEFIT CURVE

An early method to estimate recreation benefits used the total benefit as the cost of developing an alternative recreational site. Due primarily to the arbitrary nature of the alternative cost approach, the evaluation of recreation benefit from changes in the value of land surrounding a new facility has been proposed on the theory that increased land values represent a capitalization of willingness to pay for improved access to the facility.\(^{20}\) However, neither of these methods provides the marginal benefit curve, commonly called the demand curve, necessary for project optimization. The demand curve is a plot of the number of people willing to pay a specific price to use a site as a function of that price. Questionnaires asking a representative cross-section of recreational users how much they would pay for the use of a site, is not practical since most users really do not know. The demand curve might be developed from data relating the number of visitors to admission fees; however, such data is limited. Since all visitors in-

\(^{17}\) See Equation 4, Appendix B.
\(^{18}\) See Figure 1, Appendix A.
\(^{19}\) See Figure 2, Appendix A.
cur cost in arriving at the site, the most satisfactory method for developing a demand curve is to relate the number of visitors to travel cost, a function of travel distance.

Logically, the number of visits to a recreational site by the people of a community should increase with community population and decrease with the distance between the community and the site. The relationship between visitation and distance may be used to develop a marginal benefit curve through the following steps:

1. The reservoir is viewed as being at the center of a target with the surrounding area divided into distance zones. For example, the first zone might be the area within 20 miles of the reservoir, the second zone between 20 and 40 miles, and subsequent zones between 40 and 60, 60 and 100, 100 and 200, 200 and 300, and 300 and 500 miles. Visitation from distances greater than 500 miles might be neglected. The cutoff distance of 500 miles is arbitrary but larger distances should be used for reservoirs located in remote areas and smaller distances for those in heavily populated areas.

2. After each zone has been laid out on a map by compass, zone population is determined from census data. As an approximation, the entire population of each county may be figured as being within the zone containing its largest city.

3. The propensity to engage in water-based outdoor recreation, K, must be selected for the population of each zone based on the age, income, and urban fraction of the population; the quality of the roads to the site; and the degree of competition from other reservoirs. Socio-economic characteristics of the population will govern K within the closer zones, but the more distant zones will contain a larger population within which socio-economic diversity will balance out to an average value.

4. Using the relationship between visitation and distance, and taking the airline distance from the home of the visitor to the site in miles, D, as the distance from the reservoir to the center of population of the zone, an estimate of the number of people who will visit the reservoir from each zone can be made. Total visitation is the sum of the zone visitations.

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21 The typical regression analysis of collected data on these variables results in an equation. See Equation 5, Appendix B.
5. After adding an arbitrarily selected distance (say 20 miles) to the value of D for each zone, the number of visitors who would still travel from the zone to the reservoir even if they had to go the additional distance can be calculated.

6. The procedure can be repeated for a series of distances added (say 20, 40, 60, 100, 200, 300, and 500 miles) to get the number of visitors as a function of the distance added.

7. Since most visitors to recreational reservoirs travel by automobile, the cost per mile can be taken as the sum of the variable cost of vehicle operation—excluding fixed costs of vehicle ownership which are not incremental to any given trip—the value of time spent in travel, and the cost of food, lodging, and other miscellaneous expenses in excess of the cost of living at home.2

8. The final step is to multiply each travel distance added in step six by the cost per mile as determined in step seven and plot the product against the number of visitor-days associated with each incremental distance in step six. The area under the resulting curve indicates the total recreational benefit.23

V. Optimum Installed Capacity

The optimum installed capacity provides for the annual number of recreation visitors for which marginal benefits equal marginal costs or the supply and demand curves cross. The optimum reservoir size is obtained from the relationship between reservoir size and activity capacity as determined in the third step of developing the marginal cost curve. Finally, the optimum area to be dedicated to each activity is estimated from the optimum annual number of recreation visitors and the activities provided by the optimum reservoir size.24

VI. Incorporating Growth in Recreation Demand

To provide for an anticipated increase in recreation demand with time, the procedure for developing the marginal benefit curve should be modified as follows.

1. Select the distance zones as before.
2. Estimate the existing population in each zone and then the

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22 The cost can be expressed in equation form. See Equation 6, Appendix B.
23 The computational procedure is illustrated in Example I, Appendix C.
24 See Figure 5, Appendix A.
projected population at specific dates in the future. For example, one might tabulate for a given zone existing population, population 25 years hence, and population 50 years hence.

3. Estimate the existing value and projected values of the propensity, \( K \), of the population within each zone to engage in water-based outdoor recreation at the same dates for which the population, \( P \), was projected. \( K \) is best projected from trends in the factors influencing recreation demand. Increased income, youth, and leisure are expected to multiply the propensity to use outdoor recreation facilities in future years. A possible offsetting factor is the deterioration in the quality of the recreation experience as a result of greater crowding and competition among sites.

4. Calculate the product of \( K \) and \( P \) for the first zone at each date for which a projection was made.

5. Assume an expansion curve of this product between projection dates and use the appropriate interest rate for project analysis to compute a discounted average annual product over the life of the project.

6. Compute in the same manner a discounted average annual \( KP \) product over the life of the project for each of the other distance zones.

7. Use the discounted average product in the equation giving the total annual number of visitor-days spent at the site, and continue through the balance of the procedure for calculating the marginal benefit curve as outlined originally, starting with step four.

VII. Value of A Visitor-Day

A common practice in recreation analysis has been to divide the total recreation benefit by the number of visitors to obtain a unit value per visitor-day. Additional insight can be gained by examining the above method of estimating recreational benefits to determine what value per visitor-day is implied. While total benefit divided by total visitation gives an average value per visitor-day, the value to a particular visitor is directly proportional to the distance from his home to the recreational site.

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25 See Equation 5, Appendix B.
26 See Equations 7-11, Appendix B.
By evaluating recreational benefits by a fixed assigned unit value per visitor-day regardless of travel distance to the reservoir, one would conclude that a day-use recreation site located within a metropolitan area has much larger benefits than a very high quality but more remote site. However, the value per visitor-day increases with travel distance. The total benefit or the product of the value per visitor-day and the number of visitor-days will be much lower for a reservoir near a metropolitan area where the average visitor lives close to the facility than for a more remote reservoir accommodating an equal number of visitors.

VIII. LIMITATIONS

The main drawbacks in the method outlined above for the evaluation of recreational benefits and the determination of optimum reservoir size are that the method is no help in determining the optimum activity composite—how total recreational space should be divided among activities—or the optimum capacity coefficients—the space required to accommodate a single user engaged in an activity. The rules of economic optimization indicate the optimum activity composite to be that which maximizes the total net benefit of the project or the sum of the areas between the activity marginal benefit curves and their respective marginal cost curves. Sufficient data is not available to estimate independent marginal benefit curves for each activity; but, more important, the demand for one activity depends on the availability of other activities. More campers will be attracted by improved swimming and boating facilities. The psychic inter-relationship among demand curves violates the requirement for economic optimization of independent demand. Thus, the recreational activity composite cannot be selected on the basis of economic efficiency. Theoretically, it would be possible to select an activity composite to maximize the user-days provided by a given expenditure for recreational development or enjoyed within a given recreation area. However, this would not be optimum development because it would lead to overdevelopment of lower valued, at the expense of higher valued,

27 See Equation 11, Appendix B.
activities. Picnicking and swimming would gain at the expense of camping and boating.

In practice, the division of available space among activities must be based on the judgment of the planner, who is guided by the physical features of the site, the climate, and the existing pattern of recreational use of similar reservoirs. He must also consider the functional appeal of the reservoir, which depends on its location with respect to population centers. Close proximity will favor day use with emphasis on lower valued activities while greater distances favor vacation use and more overnight facilities.

The attractiveness of a recreational activity to an individual depends on the number of others who wish to engage in it simultaneously. This dependence also violates the independent demand requirement of economic efficiency and means that capacity coefficients must also be selected by the judgment of the planner. The desirability of a site generally increases with use by others until users begin to feel crowded. The crowding is usually psychological rather than physical. The optimum intensity is probably somewhere on the crowded side of the use at which a site provides maximum attractiveness to the user. It is about equal the intensity where significant numbers of people leave to seek other recreation.

IX. Conclusion

While further research is still required to quantify some of the relationships which have been conceptually presented, marginal cost and benefit curves provide a framework for picking the optimum degree of recreational development at a proposed site. The procedure has only recently been applied to outdoor recreation but has been used for a much longer time in planning for flood control, irrigation, hydroelectric power, and other major water-resources project purposes.
Appendix A

Fig. 1. Typical Total Values Curves.

Fig. 2. Typical Marginal Value Curves.
Fig. 3. Weekly Utilization Curve.

Fig. 4. Seasonal Utilization Curve.
Fig. 5. Optimum annual volume of use as found from intersection of marginal cost and marginal benefit curves with BCDE equal to total project cost, ACDE equal to gross project benefits, ABE equal to net project benefits, and CD is the optimum annual volume of use.

### TABLE 1. Typical Capacity Coefficients

<table>
<thead>
<tr>
<th>Activity</th>
<th>Space</th>
</tr>
</thead>
<tbody>
<tr>
<td>Picnicking</td>
<td>0.025 Ac.</td>
</tr>
<tr>
<td>Camping</td>
<td>0.0625 Ac.</td>
</tr>
<tr>
<td>Boating</td>
<td>0.5 Ac.</td>
</tr>
<tr>
<td>Swimming</td>
<td>0.00025 Ac.</td>
</tr>
<tr>
<td>Trail</td>
<td>0.05 Mi.</td>
</tr>
</tbody>
</table>

**Appendix B**

**Equation 1:**

\[ U = f_a A_t \]

where \( U \) is the total annual number of user-days, \( A_t \) is the annual number of activity-days, and \( f_a \) is the factor relating the two. The factor \( f_a \) can never exceed one since \( U \) is always less than or equal to \( A_t \).
Equation 2:

\[ A_i = 365 \; k_i \; R_i \]

where \( R_i \) is the activity capacity in users, \( i.e. \), the space devoted to the activity divided by the appropriate capacity coefficient, \( k_i \) is the intensity coefficient which represents the average daily fraction of the capacity of the area used during the year, and the 365 converts to an annual basis.

Equation 3:

\[ A_t = \sum_{i=1}^{r} A_i = 365 f_w \sum_{i=1}^{r} (f_{si} R_i) \]

where \( A_t \) is the total activity-days spent in all activities at the site during the year, \( r \) is the number of activities provided at a given site, \( A_i \) is the total activity-days spent in activity \( i \) at the site during the year, \( f_w \) is the weekly utilization factor, \( f_{si} \) is the seasonal utilization factor for activity \( i \), and \( R_i \) is the maximum number of users per day the space dedicated to activity \( i \) can accommodate without excessive crowding.

Equation 4:

Combining equation 1 with equation 3 gives the user-days provided by the activity composite available at a site:

\[ U = 365 \; f_a \; f_w \sum_{i=1}^{r} (f_{si} \; R_i) \]

where \( U \) is the total annual number of visitor-days spent at the site, \( f_a \) is the ratio of user-days to activity-days, and the remaining terms are as defined for Equation 3.

When planning a new recreation reservoir, the factors \( f_a \), \( f_w \), and \( f_s \) should be estimated from data collected at regional recreational reservoirs. Utilization curves plotted from counts of those engaged in the various activities at various times may be used to estimate \( f_w \) and \( f_s \). Data on \( U \) and \( A_t \) must be collected to estimate \( f_a \). One can normally expect \( f_a \) to range between 0.3 and 0.5. A value of 0.44 was determined for Dewey Reservoir in Kentucky.
Equation 5:

\[ U = \frac{KP}{D^n} \]

where \( U \) is the total annual number of visitor-days spent at the site, \( P \) is the population \( D \) miles from the site, and \( K \) and \( n \) are constants determined by regression analysis.

Mean values of 100,000 for \( K \) and 3 for \( n \) have been estimated from studies on Missouri reservoirs [see Ullman, A Measure of Water Recreation Benefits: The Meramec Basin Example, Water Resources Management for the Needs of an Expanding Society 15 (1964)]. He found \( K \) to vary between 10,000 and 1,000,000 depending on reservoir and population characteristics. Expressed in logarithmic form, \( K \) has been found to be 8000 and \( n \) to be 2.39 for the Kerr Reservoir along the Virginia-North Carolina border [See Knetsch, Economics of Including Recreation as a Purpose of Eastern Water Projects, 46 Journal of Farm Economics 1148 (1964)]. The value of \( n \) Ullman found for \( n \) is higher than that found for more unique recreation areas, but the low \( n \) for unique sites probably stems from the fact that many of those visiting a unique site from more distant communities are touring a group of vacation attractions. The \( U \) in equation 5 represents the number who would visit the site with the reservoir less the number who would visit it anyway.

For the purpose of applying equation 5 in the absence of better data, \( n \) may be taken as 3 and \( K \) may be taken as 100,000 for average circumstances but varied between the limits of 10,000 and 1,000,000 depending on the natural endowment, development, and competitive position of the site and the socio-economic position of the population. A fully developed, unique site monopolizing the outdoor recreational opportunity of a young and wealthy group of suburbanites would result in a maximum value of \( K \). Opposite social and economic conditions would produce a minimum value. Such recreational activities as picnicking, camping, and hiking would take place at many sites without reservoir construction. In evaluating \( K \), only the net increase in recreational activity induced by the reservoir should be considered in reservoir justification.

Equation 6:

\[ C = 2.42 \left[ (1+a) \frac{m}{t/v} \right] / bp \]

where \( C \) equals the cost in dollars per mile incurred to enjoy one
visitor-day at the site, 2.42 is the product of 2.0 which accounts for round trips and 1.21 which was taken as an average value for road distance divided by airline distance, \( b \) is the average number of days a visitor remains at the site, \( p \) is the average number of visitors traveling in a vehicle, \( M \) is the variable vehicle operating cost in dollars per mile, \( t \) is the value of a vehicle-hour of travel time in dollars, \( \nu \) is the mean travel velocity in miles per hour, and \( a \) is the expense for food, lodging, and other miscellaneous items during travel above that which would normally be spent at home as a fraction of vehicle operating cost and will normally increase with travel distance because a greater travel distance will require more stops for food and lodging.

A wealth of data has been collected by highway planners for use in evaluating the terms in equation 6 [See A.A.S.H.O., COMMITTEE ON PLANNING AND DESIGN POLICIES, ROAD USER BENEFIT ANALYSES FOR HIGHWAY IMPROVEMENTS (1962); WINCH, THE ECONOMICS OF HIGHWAY PLANNING (1963). Ullman (supra, Equation 5, Appendix B) determined the values of 2.0 for \( b \) and 3.5 for \( p \) from data collected at Meramac State Park, Missouri. The University of Kentucky Bureau of Business Research [1962] found average values of 2.27 for \( b \) and 2.55 for \( p \) for Kentucky state parks. The national average of the marginal travel cost has been estimated to be 0.053 dollars per mile. See Smith, FUTURE HIGHWAYS AND URBAN GROWTH (1961). The value placed on travel time is an estimate of the willingness-to-pay to reach a destination faster. The importance of including travel time in the calculation is demonstrated by the fact that the time required for the trip rather than vehicle operating cost is often the primary factor determining whether or not a family will visit a given site. A reasonable value for \( t \) is $1.50. The value for \( a \) will range from zero for those living close to the site to over 1.0 for those coming long distances. Vehicle operating cost is as low as 25 percent of total travel cost on long trips, but total travel cost includes expenses which are not incremental to the trip because they would be incurred were the vacationers to remain home.

**Equation 7:**

The average value of the recreation reservoir to visitors coming a specified distance may be estimated from equation 5 using a value for \( n \) of 3. Since the number of visitors per capita who are willing to travel \( Z \) miles or further is

\[
Q = K Z^{-3} = K / Z^3
\]
the number of visitors per capita who are willing to travel exactly $Z$ miles may be found from the absolute value of the differential of this quantity or

**Equation 8:**

$$Q' = 3KZ^{-4} = \frac{3K}{Z^4}$$

Market analysts commonly call $Q$ the market penetration index. The net benefit the site provides to a particular visitor equals the travel cost he is willing to incur less that which he actually has to pay. The savings to an individual willing to travel $Z$ miles but only living $D$ miles from the site may be expressed as

**Equation 9:**

$$S = C(Z-D)$$

The various individuals who live $D$ miles from the site will have varying distances which they would be willing to travel, and equation 8 indicates the number willing to travel each distance. The total net benefits or savings to individuals living $D$ miles from the site may be found by combining Equations 8 and 9 and summing to get

**Equation 10:**

$$S_t = \sum S' = \lim_{x \to \infty} \int_0^x 3C KZ^{-4} (Z-D) \, dz = \frac{C K}{2} D^{-2}$$

Dividing by $Q$ (the number of people receiving benefit by visiting the reservoir) gives

**Equation 11:**

$$V = \frac{S_t}{Q} = \frac{CK/2D^2}{K/D^3} = \frac{CD}{2}$$

where $V$ is the mean value per visitor-day enjoyed by those living $D$ miles from the reservoir.
Appendix C

EXAMPLE I: Sample Calculation of Marginal Benefit Curve

The following data is based on Dewey Reservoir (Jenny Wiley State Park), Floyd County, Kentucky. The calculations are intended to present the method of developing a marginal benefit curve rather than portray the recreational benefits from the park in question.

1. The population within zones is estimated from 1960 census data and a map showing county boundaries within the United States to be

<table>
<thead>
<tr>
<th>Zone</th>
<th>Range</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0-20 miles</td>
<td>97,000</td>
</tr>
<tr>
<td>2</td>
<td>20-40</td>
<td>249,000</td>
</tr>
<tr>
<td>3</td>
<td>40-60</td>
<td>504,000</td>
</tr>
<tr>
<td>4</td>
<td>60-100</td>
<td>1,860,000</td>
</tr>
<tr>
<td>5</td>
<td>100-200</td>
<td>10,290,000</td>
</tr>
<tr>
<td>6</td>
<td>200-300</td>
<td>20,130,000</td>
</tr>
<tr>
<td>7</td>
<td>300-500</td>
<td>48,500,000</td>
</tr>
</tbody>
</table>

2. The values of \( K \) for the zones closer to Dewey Lake are expected to be low because the reservoir is located in an area populated mostly by low income families having a lower than average inclination to partake of water-based recreation. The values for the more distant zones are lower than the average of 100,000 because the reservoir is in an isolated area with few complementary attractions and poor access in three directions. \( K \) by zone is estimated as

<table>
<thead>
<tr>
<th>Zone</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10,000</td>
</tr>
<tr>
<td>2</td>
<td>10,000</td>
</tr>
<tr>
<td>3</td>
<td>10,000</td>
</tr>
<tr>
<td>4</td>
<td>40,000</td>
</tr>
<tr>
<td>5</td>
<td>70,000</td>
</tr>
<tr>
<td>6</td>
<td>70,000</td>
</tr>
<tr>
<td>7</td>
<td>70,000</td>
</tr>
</tbody>
</table>

3. Computations to estimate total visitor-days as a function of additional travel distance are provided in Table A below.

4. A value for \( C \), the cost in dollars per mile to enjoy one visitor-day, is estimated from equation 6 using \( b=2.27 \) days, \( p=2.55 \) visitors per vehicle, \( m=0.053 \) dollars per mile, \( t=1.50 \) dollars per hour, \( v=40 \) miles per hour, and \( a=0.50 \). The result is \( C=2.42\left(1.5 \left(0.053\right)+1.50/40\right)/(2.27)(2.55)\approx$0.0489 per mile. The cost of each travel distance is also shown on Table A.

5. The marginal benefit curve is plotted from the data on
Table A on Figure A below. The area under the curve yields an annual benefit of $2,135,000 per year. Based on an annual total of 986,000 visitor-days (Table A), this annual benefit implies an average benefit per visitor of $2.17.
### TABLE A. Computations for Deriving the Marginal Benefit Curve

<table>
<thead>
<tr>
<th>Additional Cost</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>Total Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range (Miles)</td>
<td>0</td>
<td>20</td>
<td>40</td>
<td>60</td>
<td>100</td>
<td>200</td>
<td>300</td>
<td>48,500,000</td>
</tr>
<tr>
<td>P</td>
<td>97,000</td>
<td>249,000</td>
<td>504,000</td>
<td>1,860,000</td>
<td>10,290,000</td>
<td>20,130,000</td>
<td>48,500,000</td>
<td></td>
</tr>
<tr>
<td>Q = K / D^3</td>
<td>3.64</td>
<td>0.370</td>
<td>0.0800</td>
<td>0.0781</td>
<td>0.0207</td>
<td>0.00448</td>
<td>0.00109</td>
<td></td>
</tr>
<tr>
<td>U = QP</td>
<td>353,000</td>
<td>92,000</td>
<td>40,000</td>
<td>145,000</td>
<td>213,000</td>
<td>90,000</td>
<td>53,000</td>
<td>986,000</td>
</tr>
<tr>
<td>D</td>
<td>20</td>
<td>0.978</td>
<td>34</td>
<td>70</td>
<td>100</td>
<td>170</td>
<td>270</td>
<td>420</td>
</tr>
<tr>
<td>Q = K / D^3</td>
<td>0.254</td>
<td>0.0800</td>
<td>0.0292</td>
<td>0.0400</td>
<td>0.0142</td>
<td>0.00356</td>
<td>0.000945</td>
<td></td>
</tr>
<tr>
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<td>20,000</td>
<td>15,000</td>
<td>74,000</td>
<td>146,000</td>
<td>72,000</td>
<td>46,000</td>
<td>398,000</td>
</tr>
<tr>
<td>D</td>
<td>40</td>
<td>1.956</td>
<td>54</td>
<td>90</td>
<td>120</td>
<td>190</td>
<td>230</td>
<td>440</td>
</tr>
<tr>
<td>Q = K / D^3</td>
<td>0.0635</td>
<td>0.0292</td>
<td>0.0137</td>
<td>0.0231</td>
<td>0.0102</td>
<td>0.00287</td>
<td>0.000822</td>
<td></td>
</tr>
<tr>
<td>U = QP</td>
<td>6,200</td>
<td>7,300</td>
<td>6,900</td>
<td>43,000</td>
<td>105,000</td>
<td>57,800</td>
<td>39,900</td>
<td>266,100</td>
</tr>
<tr>
<td>D</td>
<td>60</td>
<td>2.934</td>
<td>74</td>
<td>90</td>
<td>110</td>
<td>140</td>
<td>210</td>
<td>310</td>
</tr>
<tr>
<td>Q = K / D^3</td>
<td>0.0247</td>
<td>0.0137</td>
<td>0.00751</td>
<td>0.0146</td>
<td>0.00756</td>
<td>0.00235</td>
<td>0.000719</td>
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</tr>
<tr>
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<td>3,400</td>
<td>3,800</td>
<td>27,200</td>
<td>77,800</td>
<td>47,300</td>
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<td>196,800</td>
</tr>
<tr>
<td>D</td>
<td>100</td>
<td>4.890</td>
<td>114</td>
<td>130</td>
<td>150</td>
<td>180</td>
<td>250</td>
<td>350</td>
</tr>
<tr>
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<td>0.00455</td>
<td>0.00296</td>
<td>0.00666</td>
<td>0.00448</td>
<td>0.00163</td>
<td>0.000560</td>
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</tr>
<tr>
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<td>1,500</td>
<td>12,800</td>
<td>46,100</td>
<td>32,800</td>
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<td>122,200</td>
</tr>
<tr>
<td>D</td>
<td>200</td>
<td>9.780</td>
<td>214</td>
<td>230</td>
<td>250</td>
<td>280</td>
<td>350</td>
<td>450</td>
</tr>
<tr>
<td>Q = K / D^3</td>
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<td>0.000822</td>
<td>0.000640</td>
<td>0.00182</td>
<td>0.00163</td>
<td>0.000768</td>
<td>0.000324</td>
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</tr>
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<td>200</td>
<td>320</td>
<td>3,390</td>
<td>16,770</td>
<td>15,460</td>
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<td>51,950</td>
</tr>
<tr>
<td>D</td>
<td>300</td>
<td>14.670</td>
<td>314</td>
<td>350</td>
<td>350</td>
<td>380</td>
<td>450</td>
<td>550</td>
</tr>
<tr>
<td>Q = K / D^3</td>
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<td>0.000278</td>
<td>0.000233</td>
<td>0.000729</td>
<td>0.000768</td>
<td>0.000421</td>
<td>0.000204</td>
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</tr>
<tr>
<td>U = QP</td>
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<td>70</td>
<td>120</td>
<td>1,350</td>
<td>7,800</td>
<td>8,470</td>
<td>9,890</td>
<td>27,840</td>
</tr>
<tr>
<td>D</td>
<td>500</td>
<td>24.450</td>
<td>514</td>
<td>530</td>
<td>550</td>
<td>580</td>
<td>650</td>
<td>750</td>
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<tr>
<td>Q = K / D^3</td>
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<td>0.000067</td>
<td>0.000060</td>
<td>0.000205</td>
<td>0.000255</td>
<td>0.000166</td>
<td>0.000096</td>
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</tr>
<tr>
<td>U = QP</td>
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<td>20</td>
<td>30</td>
<td>390</td>
<td>2,620</td>
<td>3,340</td>
<td>4,660</td>
<td>11,060</td>
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</table>