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The Benefits and Costs of the Dickey-Lincoln Project : a Preliminary Report

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A Preliminary Report

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I. Introduction

The Dickey-Lincoln School Hydro Power Project was authorized by Congress in 1965. Advanced engineering and design work was then begun by the Army Corps of Engineering in early 1966. Further detailed design work was suspended in November, 1967 because of Congress' failure to appropriate further funds for design or construction. However, it now appears likely that Congress will include funds for continued design and engineering work in its appropriations for fiscal year 1974-75.

Each year since 1967, the Corps has used indexes of construction costs and other price indexes in order to update the estimates of construction costs to reflect current cost and price conditions. The Corps has also revised and updated the estimates of hydro electric power benefits to reflect changing economic conditions. On the basis of the detailed analysis done prior to 1967 and the subsequent revisions, the Corps presently estimates that the ratio of total benefits to total costs for Dickey-Lincoln is 2.6. However, there are two major limitations to this estimate of a benefit-cost ratio. First is that the basic data and analysis underlying the benefit-cost ratio are now alomost seven years old, and the subsequent adjustments only imperfectly reflect changes in economic techniques and methods used to calculate the benefit-cost ratio are faulty in several important respects.

In this report, I will be able to deal only with problems of technique and methodology. The work reported below is also based upon the 1967 data as revised and updated by the Corps of Engineers. However, this work does apply different techniques and methods which are considered to be correct by economists and shows that the consequence of applying correct techniques and methods leads to conclusions about the economic feasibility of the Dickey-Lincoln Project which are substantially different from those of the Corps of Engineers. Specifically, when appropriate techniques are used, the "true" benefit-cost ratio is shown to lie somewhere between 0.9 and 1.2 depending upon the assumptions made about key variables. The difference between the high and low estimates of the benefit-cost ratio is small compared to the range of uncertainty and possible error stemming from the use of old and possibly outdated data.

There are three ways in which the techniques and methods used by the Corps tend to overstate the degree of economic feasibility of the Dickey-Lincoln Project. First, the techniques used to calculate the benefits due to hydro electric power generation lead to overestimates of hydropower benefits. Second, the assumptions concerning the cost of capital used in construction of the project lead to a substantial underestimate of construction costs. nd third,not all of the true costs of the project construction are counted. Specifically, the benefit-cost analysis ignores the cost of environmental change and the losses of recreation, fish, and wildlife values associated with a freeflowing undeveloped river. If the Corps' benefit-cost analysis is corrected to take into account the first two points above, the revised benefit-cost ratio is reduced to somewhere between 0.9 and 1.2. Then, if due weight is given to the environmental damages, it appears that they would tip the scale against the project construction.

It must be emphasized that the findings reported in this paper are not definitive. If funds for further design work and study are authorized by Congress, the Corps of Engineers will be able to generate new and more up-to-date data and analysis on costs and benefits. In addition, the Corps will be required by law to prepare and circulate an environmental impact statement (EIS) "which will ensure that presently unquantified environmental amenities and values may be given appropriate consideration in decision making along with economic and technical considerations (National Environmental Policy Act of 1969)." The EIS must incorporate data on economic benefits and costs as well as environmental benefits and costs, and it must identify and evaluate alternative ways of meeting the project objectives. When the Corps' studies are completed and the EIS circulated, independent analysts and other parties of interest will have substantially more information for their debate about the merits of the project. Since these data are not presently available, the primary purpose of this report is to illustrate the importance of using correct analytical techniques and procedures in evaluating benefits and costs, and to focus attention on the critical variables and components of the data.

The next section will outline the rationale for a benefit-cost analysis and the principles to be used for defining and measuring economic benefits and costs. Subsequent sections will review and critically evaluate the most recent benefit-cost analysis undertaken for the Corps of Engineers.

II. The Principles of Benefit-Cost Analysis

In the most general sense, benefit-cost analysis is simply the application of common sense -- no more, no less. It means that whenever one is confronted with a choice or a decision as to whether to undertake a course of action, he should identify and list all of the beneficial or favorable consequences that will stem from taking that action and compare these with all of the possible adverse consequences or costs of taking that action. If the beneficial consequences are perceived to outweigh the adverse consequences, the action should be undertaken. At this level of generality the only alternatives to rational weighing of benefits and costs are the use of the essentially arbitrary decision making rules (for example, always say no) or random choices (for example, coin flipping).

Benefit-cost analysis might best be seen as a scale or balance where the benefits are piled on one tray, the costs are piled on the other and the purpose is to see which way the scales tip. However, this analogy points to one of the limitations to applying the rationale of benefit-cost analysis. The objective application of benefit-cost analysis to decision making requires that all of the benefits and the costs be expressed and measured in some common units, for example, weight in the case of the scales.

One of the major stated purposes of water resources development projects is to increase the overall efficiency of the economic system in the use of resources such as labor, capital, and land in the production of goods and services. The appropriate scale or yardstick to apply to projects undertaken in the name of economic efficiency is dollar values. The measure of the favorable effects of such a project would be the dollar value of the goods and services produced by the project where values are determined by or measured by the willingness to pay of individuals to receive these outputs. In many instances, the outputs of projects are not sold in markets, so that dollar value or willingness to pay is not regularly observed or recorded. For example, an individual would be willing to pay something to use the road between his home and his workplace even though no tollbooth has been set up to exploit that willingness to pay. In these cases willingness to pay and value must be estimated or inferred on the basis of other information. Part of the art of benefit-cost analysis is the development of these techniques for estimating values.

On the cost side, the appropriate measure is the value of other goods and services which must be foregone or given up in order to free the resources for utilization in this project. This is the notion of <u>opportunity costs.</u> For example, if a certain project requires a year of work by a laborer, the cost is what that laborer would have produced elsewhere if he had not been utilized in this project. That is the opportunity cost of labor. In a market economy, the prices of resources such as labor, capital, and land are usually accurate measures of their opportunity cost. But for some resource inputs, market values are not available; hence opportunity costs must be estimated or inferred on the basis of other information. For example, if a hydroelectric project requires the damming of a free flowing river, one of the things that is lost or foregone in undertaking the project is the value of the recreational, fish, wildlife, and other environmental services provided by the river in its natural state. While these values are not readily measurable in dollar terms, their loss is surely a cost which must be weighed against whatever benefits the project is supposed to bring.

Benefit-cost analysis can be a truly reliable guide to making decisions on resource allocation only if all of the benefits and costs are identified, measured, and placed in dollar units so they can be weighed on the economist's scale. Clearly this is a counsel of perfection. These conditions can never be met totally. No benefit-cost analysis can adequately identify and measure all of the relevant variables. This does not mean that benefit-cost analysis should be scrapped as a guide to decision making. But also it does not mean that benefit-cost analysis should proceed by counting only those things for which dollar price tags are available and ignoring those favorable and adverse effects which cannot be readily expressed in dollar terms.

There is a middle ground which makes maximum use of the available information. This is first to provide an accounting of all the benefits and costs which can be expressed in dollar terms, and second, to accompany this with a description of and quantification of the other favorable and adverse effects which are expected to stem from the project.[1] This listing permits persons involved in the decision making process to identify and assess the non-economic consequences of economic decisions.

While an adequate listing of the non-economic eonsequences of undertaking the Dickey-Lincoln project is not yet possible, the National Environmental Policy Act is meant to ensure that this information is compiled and made available to persons involved in the decision making process.

III. The Corps' of Engineers Benefit-Cost Analysis

On the basis of the earlier design and engineering studies updated for changes in construction costs and prices over the last seven years, the Corps of Engineers estimates that the dam and associat d power facilities will cost $384,800,000 including interest during construction. In addition, transmission facilities are expected to cost $129,100,000. Half of the investment in transmission facilities is attributed by the Corps to the Dickey-Lincoln project, i.e., the Dickey-Lincoln share is $64,550,000. The total construction cost for the facilities in current dollars is estimated to be:

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1. This is essentially what is called for by the Water Resources Council in "Principles and Standards for Planning Water and Related Land Resources." This is also consistent with the requirements of the National Environmental Policy Act.

Investment in dams and generating equipment	$384,800,000
Transmission facilities	64,550,000
Total investment	$449,350,000

In most presentations of benefit-cost data, both the benefits and the costs are expressed in terms of annual flows or dollars per year. This requires that the total investment incurred at the beginning of the project. The annual equivalent of investment costs can be interpreted as the amount required in equal annual installments to recoup the initial investment plus interest over the life of the project. The Corps assumes that the Dickey-Lincoln dam will have a useful life of 100 years. They assume that interest would be charged at the rate of 3 1/4% per year. The annual costs used below are based upon these assumptions. The annual benefits and costs as calculated by the Corps of Engineers are as follows:

ANNUAL BENEFITS	PER YEAR
The value of electric power	$44,365,000
Flood control damages avoided	60,000
Recreation benefits	1,250,000
Redevelopment benefits	817,000
Total annual benefits	$46,492,000
ANNUAL COSTS	
Annual equivalent of investment costs plus operation, maintenance and replacement 100 years at 3 1/4%	$17,742,000
BENEFIT TO COST RATIO	2.6

IV. Review and Critique

There are three major criticisms to be made of the Corps' benefit-cost analysis. The first concerns the technique for estimating hydro-electric power benefits. The second is the assumption concerning the cost of capital or the interest rate used to calculate annual project costs. And the third concerns the omission of the costs of environmental changes.

If it can be shown that the electrical energy to be produced by Dickey-Linooln would be produced by some other source if Dickey-Lincoln were not built, then the cost of producing electricial energy from the alternative can be used as a measure of benefits of Dickey-Lincoln power. This is because if Dickey-Lincoln were built, it would not be necessary to use labor, capital, and other resources in constructing and operating the alternative. That savings in resources as measured by the cost of the alternative is the benefit of using Dickey-Linooln to generate the electrical energy.

The proper application of the "cost of alternative" technique for estimating benefits requires both the identification of an appropriate alternative, and the correct measurement of the cost of that alternative. The Corps of Engineers has assumed that in the absense of Dickey-Lincoln, a combination of oilfired steam base load equipment in Maine and gas turbine equipment in Boston would be the most likely alternative to meet existing and projected changes in the demand for electric energy.

The Corps can be criticized for not considering a wider range of alternatives both for providing increments to supply and for altering the patterns of demand. For example, a full investigation of the economic feasibility of Dickey-Lincoln as a source of peaking power for New England would require an investigation of the effect of peak load pricing on the load curve and the growth in electricity demand. If peak load users were charged something approaching the marginal costs they impose on the system, it is possible that changes in the time pattern of electricity demand would make additional investments in peaking capacity such as Dickey-Lincoln unnecessary. Also some less conventional supply alternatives should be investigated, including the recent suggestion that sustained yield management of the forestry area proposed to be flooded by Dickey-Lincoln could produce enough wood fuel to support an equivalent sized steam generating facility at competitive cost. It is beyond the scope of this paper to analyze these alternatives. It should be noted, however, the Corps is required by law to investigate and evaluate the full range of alternatives as part of its environmental impact statement.

The proper measurement of the cost of the alternative requires an understanding of the distinction between real costs and financial costs. Real costs are the opportunity costs of the labor, capital, and other resources actually used in the construction and operation of the alternative. Financial costs are those money payments that are recorded on the books of the constructing and operating agency. The real costs of a particular facility are independent of who constructs and operates that facility. But financial costs of a given facility can vary depending upon the identity of the operating agency. For example, if a privately owned utility company builds a generating facility, it must pay substantial amounts in realy property taxes to the local taxing authority. An identical facility owned and operated by a public agency will be tax exempt. The realy cost of the two facilities would be the same, but the financial costs are different. It is the real costs of the alternative facility which are relevant as a measure of the benefits of a hydro-electric development such as Dickey-Lincoln.

The Corps assumed that the alternative to Dickey-Lincoln would be privately owned. In calculating the cost of this alternative, the Corps included substantial amounts of federal and local taxes -- financial costs but not real resource costs. The Corps also included the cost of insurance in its measure of cost of alternatives. This is legitimate in that insurance representa a cost of bearing the risk of possible accidental loss or damage. However, no comparable charge for insurance was included in the cost estimates for Dickey-Lincoln. Since the alternatives must be evaluated on a comparable basis, either the insurance cost must be deducted from the cost of alternatives or an additional charge for insurance should be added to the cost of Dickey-Lincoln. The latter procedure is used below in a subsequent section where revised benefit-cost figures are presented.

The cost of alternatives and therefore the estimates of hydro-electric power benefits are quite sensitive to the assumptions made about the cost of fuel oil used in the alternative. The estimates used by the Corps in their most recent evaluation were made in January 1974 in the midst of great uncertainty about the future course of fuel oil prices. It is essential that the benefits estimates be revised to take into account the most recent data on fuel prices. And it would be desirable to present alternative estimates of hydroelectiric benefits based on different assumptions about future oil prices.

The interest rate or discount rate used to convert investment costs to annual equivalent costs may be the most important single variable in deteriming the benefit-cost ratio for very long-lived investments such as hydroelectric dams. The interest rate represents the opportunity cost to society of the capital used to build a project which yields its benefits over a long period of time. The best measure of the cost of capital to society is the rate of return or interest that the capital could earn if placed in some alternative investment.

Most economists agree that the best measure of this opportunity cost is the rate of return on investment in the private sector of the economy. Although there is some disagreement as to the precise figure most economists would agree that this rate of return and the discount rate which should be used in benefit-cost analysis lie somewhere between 8% or 10%.

Federal policy governing the choice of a discount rate for use in benefit-cost analysis has been a major source of political controversey. A high discount rate used in project analysis leads to high estimates of project costs and low benefit-cost ratios. The choice of low discount rates has the opposite effect. Federal policy established in 1962 based the discount rate on the coupon interest rate of outstanding long term U.S. Treasury securities (Senate Document 97). Because of a technicality of federal law , the only long term government securities outstanding during the 60's were iseued during the late 1940's and earlier. Because of the unusual money market conditions of the time, all of these securities carried unusually low coupon rates. As a consequence the discount rate used in evaluating projects during the 60's, including Dickey-Lincoln, reflected the unusual money market conditons of twenty years before and bore no relationship to current money market conditons or opportunity costs of capital.

This situation would have been substantially corrected if the Proposed Principles and Standards for Planning Water and Related Land Resources ratified by President Nixon in September, 1973, the Water Resources Council retreated to the position that "the government's investment decisions are related to the cost of federal borrowing," and established the discount rate for the evaluation of new projects at 6 7/8% (Water Resources Council, 1973, PP. 34784, 24822).

Even this retreat was not enough for Congress. The Water Resources Development Act of 1974 further lowers the discount rate to be used in evaluating projects which have not yet been authorized by Congress. The Act also includes the so called "grandfather clause" which requires that all subsequent evaluations of projects which have once been authorized by Congress be analyzed using the discount rate in force at the time of Congressional authorization. Since Dickey-Lincoln was authorized in 1965 under the old policy, the discount rate to be used for current evaluation and analysis must still be the outdated and quite unrealistic 3 1/4%.

As will be shown below, if the discount rate of 6 7/8% recommended by the Water Resources Council is used, and other appropriate adjustments are made, Dickey-Lincoln is only marginally justifiable on narrow economic grounds. Higher discount rates push the benefit-cost ratio below one. And if a 10% discount rate reflecting the true opportunity cost of capital is used, the project would be clearly unjustifiable on economic grounds alone.[2]

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2. Since one of the real costs of construction is interest during construction, use of a higher discount rate would also mean a higher total investment. The results reported below do not include this adjustment.

The third major criticism of the Corps' benefit-cost ratio is its failure to reflect all of the opportunity costs of constructing the dam and in particular the opportunity cost of diverting a free flowing river and its associated wildlands and forests to hydrological stoarage purposes. As was argued above, it is essential that even those costs which cannot be valued in monetary terms must be identified and quantified where possible so that decision makers can be aware of them and weigh and assess them in relation to the measured economic benefits in their dollar dimension. The Corps of Engineers will be compelled to provide information of this kind as part of their project evaluation when they draw up an environmental impact statement for Dickey-Lincoln.

In addition to the three major criticisms raised above, there are several points to be made concerning the other components of beneifts estimated by the Corps. The Corps estimates $60,000 per year in flood control benefits. These benefits are measured by the expected value of flood damages avoided by the construction of the dam. This is an appropriate measure of flood control benefits provided that the dam structure is the least costly method for preventing the economic damage to the flood threatened areas. However, if alternative flood damage prevention measures can provide equivalent protection at a cost of less than $60,000 per year, then the cost of the alternative is the appropriate measure of flood control benefits. As part of its project analysis and environmental impact statement, the Corps will have to consider alternative means of providing the flood protection to Fort Kent and neighboring areas.

The second largest class of benefits identified and measured by the Corps is recreation opportunities on the lake. The Corps estimates an average use of approximately 833,300 recreation-days over the life of the project. They assume a value per recreation-day of $1.50 yielding total recreation benefits of $1,250,000 per year (Corps of Engineers Letter dated April 26, 1974).

It is difficult to know what to make of this estimate. There are analytical techniques for predicting future recreation use at potential sites. But it is unclear whether the Corps used any of these techniques in arriving at their projected figure for use. In the absence of any documentation for their estimate, it is difficult to take it at face value. Given the distance of the site from major population centers, the low population of the immediate area, the relatively low quality of the recreation experience to be provided, and the availability of many superior quality locations for flatwater recreation within the state, it seems likely that the 833,300 recreation-days per year is a substantial overestimate of recreation use.[3]

Also the unit value assigned by the Corps requires further examination. There are analytical techniques for estimating a willingness to pay per user day on the part of individual recreationists. However, these techniques are difficult and time consuming to apply to individual sites. As a substitute the Water Resources Council "Principles and Standards" authorized project analysts to assign a unit value to general recreation experiences of between $0.75 -- 2.25 (Water Resources Council, 1973, p. 24804). The choice of value within that range is to be made on the basis of the quality of the site which would include distance and accessibility) and availability of substitute or alternative recreation sites. In the case of the Dickey-Lincoln lake, these considerations would appear to argue for a unit value toward the lower end of the range.

Finally the Corps counts as redevelopment benefits a portion of the wages to be paid for constructing the project and during early years of operation, arguing that some of these wages will go to workers presently unemployed or underemployed within the project area. The logic of the argument is acceptable. The opportunity cost of utilizing a presently unemployed worker in the construction of the dam is zero. This fact can be reflected either by a downward adjustment of estimated construction costs, or by assigning an offsetting benefit of wages to unemployed workers. However, the estimates of the numbers of unemployed and underemployed workers available for the project were based on labor market surveys done seven or eight years ago. The corps will have to make a new survey to determine the present labor market conditions in this area. Furthermore the logic of the argument also compels us to look for possible offsetting

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3. Since isolated numbers are difficult to interpret without some frame of reference for comparison, the following figures are provided to put the Corps' estimate in perspective. The visitor-days at Acadia Nat'l Park in 1970 totalled 2,300,000; while visitor-days along the Allagash Waterway for the same year were only 37,000.

adverse employment effects in the region. For example, if flooding of forest land causes a reduction in employment in the wood products industries, there may be offsetting unemployment effects which should be counted against the redevelopment benefits. If some workers in the wood products industries experience prolonged periods of unemployment, i.e., if they are unable to move quickly into alternative employment, then the net effect of the project on unemployment in the region would be smaller than estimated by the Corps. And accordingly redevelopment benefits would be reduced.

V. Revising the Cost-Benefit Ratio

In this section some of the major adjustments to the Corps of Engineers figures that are discussed above are made and the results summarized. The critical variable in the benefit-cost analysis is the discount rate used as an estimate of capital cost. In this section I will present the revised benefit-cost ratios under two alternative assumptions: the first being a dsicount rate of 6 7/8% as recommended in the "Proposed Principles and Standards" of the Water Resources Council; and the second being a discount rate of 8 3/4% which the Federal Power Commission estimates as the cost of capital to the private utility industry. The 8 3/4% discount rate is used here primarily because of the ready availability of data of the cost of alternative electricity supplies based on this discount rate.

At a discount rate of 6 7/8% and an estimated project life of 100 years, the annual equivalent of construction costs and operating, maintenance, and replacement costs is $33,349,000. The Federal Power Commission has provided comparable estimates of the cost of alternative sources of electrical energy also based on a discount rate of 6 7/8% (Federal Power Commission Letter), January 29, 1974). These cost estimates do not include taxes or insurance for the private alternatives; so they are strictly comparable with the estimate of the cost of the hydroelectric project. The hydropower benefits based on the cost of the alternative are $37,304,000. The ratio of hydro power benefits alone to total project costs is 1.12.

We lack an empirical basis for revising the Corps' estimate of recreation, flood control and redevelopment benefits. However, it seems more likely that these are overestimates of the true value rather than underestimates. However, utilizing the Corps' estimates of these other benefits, the benefit-cost situation can be summarized as follows:

ANNUAL BENEFITS	PER YEAR
Hydro Power benefits	$37,304,000
Recreation benefits	1,250,000
Flood Control	60,000
Redevelopment	817,000
Total annual benefits	$39,431,000
ANNUAL COSTS	
Additional costs of environmental damages	(value unknown)
BENEFIT TO COST RATIO	less than 1.18

When the 8 3/4% discount rate is used, the annual equivalent of costs is equal to $42,192,000.[4] The Federal Power Commission has also estimated the costs of providing alternative power with an assumed cost of capital of 8 3/4%. The FPC's estimate included the cost of taxes. Their estimate of the cost of alternative is $43,802,000 (Federal Power Commission Letter, January 29, 1974). In order to make this figure comparable with the cost of the hydro electric development, it is necessary to deduct the financial cost of taxes from this estimate. The data to make a precise determination are not available. However, the data in Federal Power Commission Hydro Electric Power Evaluation make it possible to make an approximate adjustment.[5] The cost of alternative power, net of charges for taxes, was calculated to be $39,747,000. Adding the Corps' estimates of flood control, recreation, and redevelopment benefits yields the following summary tables:

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4. This includes $449,000 per year for insurance as recommended by the Federal Power Commission. See Federal Power Commission, 1968, p.80.

5. Table 50 shows that perhaps over a third of the capacity cost of the coal fired alternative is due to charges for federal, state and local taxes. To be conservative, it was assumed here that one quarter of the capacity charges for the gas turbine and oil fired systems were due to charges for taxes.

ANNUAL BENEFITS	PER YEAR
Hydro Electric power benefits	$39,747,000
Recreation benefits	1,250,000
Flood control	60,000
Redevelopment	817,000
Total annual benefits	$41,874,000
ANNUAL COSTS	
Additional costs of environmental damages	(value unknown)
BENEFIT TO COST RATIO	less than 0.99

To summarize, in this section we have adjusted the estimates of benefits and costs provided by the Corps to take into account the proper procedure for defining and measuring the benefits of hydro power development and to reflect more accurately the opportunity cost of capital. Under assumptions most favorable to the project, i.e., a 6 7/8% discount rate and zero environmental damages, the ratio of benefits to costs is approximately 1.2. This is clearly an upper bound estimate. The true figure would be less than this if the environmental costs of the project could be included.

Under the more realistic assumption of an 8 3/4% discount rate, the upper bound estimate of the ratio of benefits to costs is 0.99. Taking into account the environmental damages and the possible overstatement of recreation benefits simply reinforces the conclusion that the project is not economically justifiable at this discount rate. And at a 10% discount rate, the benefit-cost ratio would be substantially below 1.0.

The economic case for the Dickey-Lincoln project is hardly overwhelming. In fact even under the most favorable assumptions, the excess of benefits over costs is small compared to the possible errors in the magnitudes of all variables due to a reliance on outdated data and estimates from the 1966 and 1967 studies by the Corps. This suggests the need not only for further study, but also great caution before large committments of environmental and economic resources are made.

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