Boston College Environmental Affairs Law Review

Volume 3 | Issue 4 Article 6

1-1-1974

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Cortis Cooper

# CASE STUDY OF A HYDROELECTRIC DAM: THE DICKEY-LINCOLN SCHOOL PROJECT

*By Cortis Cooper**

## I. INTRODUCTION

For years, man has searched for the perfect energy source; a device which would be inexpensive to build, easy to maintain, and utilize a costless fuel to create large amounts of useable pollution-free energy. As the symptoms of an energy crisis, whether real or manufactured, have become more painfully obvious, this search for the ideal energy source has intensified. In the past, hydroelectric dams were considered by many to be man's closest approximation to that perfect source. However, as his experience with hydro-power has grown, man has found that the truism "there is no such thing as a free lunch" also applies to hydroelectricity. Trade-offs must be made. Dickey-Lincoln is a prime example of a dam, designed primarily to generate electricity, where many paradoxical exchanges would have to be made. It is hoped that this article will serve to illustrate some fundamental problems inherent in hydroelectric projects per se, problems common to such projects wherever they are located.

The important insights gained from discussion of Dickey-Lincoln go beyond clarification of these trade-offs. From a close look at the project, one can learn how the government has made economic evaluation of large-scale water resource projects for the past 20 years. Most of the major shortcomings of these evaluation standards will come to light. Continued inspection of Dickey-Lincoln will introduce one to the new federal evaluation standards for water and land-related resources—procedures which will no doubt apply for many years to come.

Lastly, Dickey-Lincoln serves (1) to remind one of the complex effects that a large scale project has on a surrounding region and (2) to point out the inadequacies of current evaluation techniques in simplifying these complexities enough to permit decision-making

to be grounded on known facts rather than unproven assumptions or tenuous hopes.

## II. Project Description

The Dickey-Lincoln School Lakes Project would consist of two hydroelectric dams to be located on the Upper Saint John River near Maine's border with Canada (Figure I). The project would be built with federal appropriations, with a part of the initial investment to be paid back by the revenues received from power generation.

The larger of the two dams, Dickey, would be located immediately above the confluence of the St. John with the Allagash River. The 10,600 ft. long, 335 ft. high, earth-fill dam is designed to hold 7.6 million acre-feet in a reservoir which would stretch 57 miles up the St. John River. To contain this 140 square mile reservoir, and prevent it from spilling over into neighboring watersheds, several dikes would be built. Included in the dam itself would be eight large turbines, each capable of 95 megawatts (MW), yielding a combined total of 760 MW.

Lincoln School Dam would be located 11 miles downstream from Dickey Dam. It would be 1,600 feet long, 85 feet high, with a useful storage capacity of 24,000 acre-feet. Though its primary purpose would be to regulate the relatively sudden discharges which would occur from Dickey Dam,[1] it too would produce electricity from two turbines, 35 MW each, for a total of 70 MW.[2]

Altogether Dickey-Lincoln would have 830 MW of electrical capacity. The current plan is to sell 105 MW as base load to Maine at a 50% capacity factor (i.e. some turbines would operate approximately 12 hrs/day). The remaining 725 MW would be sold as peaking power to New England, principally Boston, at a 10% capacity factor (i.e. all turbines would operate approximately 2.4 hrs/day).

## III. History Of The Project

The Dickey-Lincoln Project metamorphosed out of a proposal to generate electrical power from the relatively high-amplitude tidal cycles found at Passamaquoddy Bay on the Maine-Canada border. A comprehensive report into the possibilities of such a project was first compiled in 1959 by the International Joint Commission[3] with the aid of the Corps of Engineers. In this original report the Corps proposed that a hydroelectric plant also be installed in the Upper St. John watershed. This dam would serve as an auxiliary source of

power to help level out the large fluctuations in output inherent in tidal power.

In 1965, the Department of Interior reviewed the project. They found that due to increased output and improved efficiency by the power industry in New England at other generating facilities, the relative power benefits from the proposed project fell, in turn causing the combined benefit/cost (B/C) ratio[4] to fall below unity. However, when the Dickey-Lincoln Project was evaluated on its own, the B/C ratio was found to be 1.81. The Department subsequently recommended immediate construction of Dickey-Lincoln.

That same year, an omnibus bill containing authorization for Dickey-Lincoln was narrowly passed by Congress. 25 of 28 New England congressmen voted against the bill containing the Dickey-Lincoln Project.[5] In 1966 and 1967, Congress appropriated enough money for the Corps to continue pre-construction planning of Dickey-Lincoln, but not enough to begin any actual construction.[6] During the House Public Works Subcommittee hearings on public works appropriations in 1967, Dickey-Lincoln was given much debate.[7] Opposition to the Project was led primarily by the New England power companies.[8] They saw Dickey-Lincoln as the initial step towards government-owned energy generation facilities in the region. Proponents of the project included the U.S. Army Corps of Engineers, who planned and would build Dickey-Lincoln, together with a few New England politicians and Maine citizens groups,[9] who saw the project as a means of getting cheap electrical power as well as providing much needed stimulation of the Maine economy.

During the hearings many serious doubts were raised about the project. Opponents claimed that the private utilities' power prices were continually dropping, thus reducing the high electrical rates which are paid by New Englanders and in turn reducing the need for hydro-power.[10] In addition, the validity of the Corps' construction cost estimates was also questioned.[11] Largely because of the doubts expressed during these hearings, Congress denied any additional money towards the project and has, in the intervening years, continued to do so.

It would seem that after so many refusals the project would have long since been relegated to the dreams of a few stubborn engineers. But the sudden jump in oil prices and the attendant shortages have revived the Dickey-Lincoln Project. The Corps' updated figures indicate a B/C ratio of 2.6, a dramatic increase.[12] As a result of these changes some old foes such as Boston Edison, caught in the public relations turmoil created by the "energy crisis", have muted their

opposition considerably.[13] Consequently, on June 6, 1974 the House Public Works Subcommittee added $800,000 to the fiscal year 1975 budget to update preconstruction planning for Dickey-Lincoln.[14]

Despite the apparent shift of support to Dickey-Lincoln there are still many fundamental questions to be resolved. Most of these questions center around the Corps' economic analysis of the project.

## IV. Corps Of Engineers Benefit-Cost Analysis

As can be seen from Table I, the Corps has chosen to evaluate the Dickey-Lincoln Project by means of a benefit-cost ratio. This criterion is the one recommended in a report by the U.S. Congress concerning the evaluation of water resource projects.[15] The B/C ratio used by the Corps can be defined as:

$$\text{B/C ratio} = \frac{\text{annual benefits}}{\text{annual costs}}$$

where total annual costs include recurring costs such as yearly maintenance and operating costs, plus an additional payment. This additional sum represents the repayment of a portion of the initial capital investment and is entered as "Interest and Amortization" in Table I. The magnitude of this yearly payment is given by the capital recovery factor (crf) which is a function of the social discount rate and the project life. Likewise, total annual benefits would include not only benefits that recur each year (i.e. recreation, power, etc.) but also an additional portion representing "lump" benefits that might occur occasionally during the project life; e.g., flood control. Again the factor determining the magnitude of this added portion is the crf.[16]

As of 1970, the benefit-cost ratio was probably the most popular criterion for evaluating projects in the U.S.[17] The B/C ratio is popular because it provides a simple, neat, relatively easy means of project evaluation. It has, however, immense shortcomings. The B/C ratio is a single value function and as such is necessarily inadequate for evaluating multipurpose, large scale projects.[18] For example, it cannot reveal how benefits or costs are distributed (i.e. whether a prince or a pauper receives the benefits of the project.) Like other discount-dependent techniques, the B/C ratio cannot adequately deal with the future. In addition to these more general shortcomings, common to all single-valued criteria, the B/C ratio usually underrates the productivity of a project with high annual costs. Examples can easily be found where the B/C ratio of project A may be considerably higher than the ratio for B, yet the net present benefits[19] of project B may be greater than that for A. In other words,

the project which would yield the larger profits (in present dollars) may not necessarily have the higher B/C ratio.

Yet another troublesome characteristic of the B/C ratio is that, unlike the net present benefit criterion, costs cannot be considered disbenefits or vice-versa. For example, the Corps has claimed a $1-1/4 million recreational benefit will result if Dickey-Lincoln is built. Many opponents of the project argue that there will be a net loss to recreationalists if the project is completed. The question arises as to whether this alleged loss should be included on the benefit side of the analysis (i.e. as a minus benefit) or the cost side. Because the B/C ratio is a proportion and not a sum like the net present benefit criteria, it may be significantly affected according to which side of the analysis this reaction term is placed on.

The Corps of Engineers has ascertained that the B/C ratio of the Dickey-Lincoln project is 2.6; alternatively expressed, for every $1 of cost the project will yield $2.60 of benefits. A seemingly impressive investment! However, it should be clear from the above discussion that one cannot rule upon the worthiness of a project simply on the basis of the B/C ratio. A deeper evaluation of the project is almost always needed.

As noted previously, the Corps' benefit-cost analysis is based primarily upon predecessors of S.D. #97. The "Green Book", as it is popularly called, was originally issued in 1950; it and several small revisions have been the basis for the planning of water resources and related projects in the U.S. (as well as much of the world) for the last two decades. Among its many faults, this document placed the increase of the national income[20] as the only explicit objective for government projects in the water resources field. Only a half-hearted attempt was made to provide for consideration of more intangible objectives such as environmental quality and social welfare. Thus the Green Book caused planners to evaluate essentially multipurpose projects in terms of only a single objective (i.e. national income).[21] The trend towards correcting this lack of multiobjective planning as well as other inadequacies began with publication in 1962 of Senate Document 87-97[22] and culminated in late 1973 when the President approved the Water Resources Council's (WRC) latest draft of the *Principles and Standards for Planning of Water and Related Land Resources*.[23] This latter document represents the end result of over five years of work by a special task force composed of planning experts and members of interested federal agencies (i.e. the Department of Interior, EPA, etc.). This document replaces previous criteria including S.D. #97 as the standard by

which all federally financed water and related land-resource projects will be evaluated.[24] Unlike the Green Book, this document establishes as objectives the enhancement of: (1) a more broadly defined national income known as "national economic development"; (2) environmental quality; (3) regional development and (4) social welfare.[25] The document specifies that a list of all beneficial and adverse affects are to be measured in monetary terms where possible, discounted, and the net present benefits of each quantifiable objective calculated.[26] For items which are non-monetary in nature, the document requires a complete qualitative list of the projects' effects.[27] Methods and procedures for calculating many of the tangible effects of the project are included.[28] Guidelines are provided for the entire planning phase and they can be considered a complete presentation of multiobjective planning theory.[29] The steps are:

> (1) Specify the components of the four objectives which are relevant to the plan setting;
> (2) Evaluate resource capabilities and expected economic conditions without the plan;
> (3) Formulate alternative plans to achieve varying levels of contributions to the specified components of the four objectives;
> (4) Analyze the differences among the alternative plans which reflect different emphasis among the specified components of the four objectives;
> (5) Review and reconsider if necessary the specified components of the four objectives for the plan setting and formulate if necessary additional alternative plans and
> (6) Select a recommended plan based on an evaluation of trade-offs among the alternative plans.[30]

It is safe to say that the new criteria will go a long way toward providing a much more complete, undistorted view of all the issues involved in a proposed project. The new document avoids most of the inadequacies associated with the B/C ratio and single-objective analysis. As will be noted, it also establishes a much more realistic discount rate. It remains to be seen whether or not the somewhat "construction-prone" federal agencies will faithfully adhere to the much more rigid code. Certainly the advantages of doing so are not costless, since now the planning process will become even more complex and difficult, thus requiring additional funds which could have instead been applied to the creation of more tangible products.

The Corps, having recently received the funding necessary to update its Dickey-Lincoln analysis, must, according to the WRC, use

the new criteria if they result in a "substantially reformulated analysis."[31] It would seem that application of the new standards would indeed result in a substantial change in the analysis, if for no other reason than that the new standards' discount rate is more than double the one currently used. This larger discount rate must necessarily have a profound effect on the Corps' current analysis (June 1974). Despite the fact that the Corps' analysis format is subject to change, a careful examination of the *current* analysis is still called for, in order to shed light on most of the important issues of Dickey-Lincoln.

## A. Costs

A glance at the Corps' B/C analysis (Table I) shows that one entry, "Interest and Amortization", would constitute 73% of the total annual costs incurred by the project. This high percentage is a rather obvious result of the capital-intensive nature of the project. Its magnitude makes it a critically important factor in the final B/C analysis. This quantity (Interest and Amortization) in turn is dependent on the initial construction costs of the dam, the project life, and the social discount rate. Because of their importance in the final outcome of the B/C ratio and because of their inherently controversial nature, we shall examine each of these in detail.

1. *Social Discount Rate.* The social discount rate is the discount rate to be used on public projects. There are few topics in federal project evaluation which evoke so much controversy. This follows from the sensitivity of the B/C calculation to changes in the discount rate applied. To illustrate this point, Fox and Hefindahl[32] evaluated projects authorized for construction by the Corps in 1962 with discount rates of 4, 6 and 8%. They found that at such rates, 9, 64, and 80%, respectively, of these projects would be uneconomical. Changes in the discount rate have a similar effect on the B/C ratio of Dickey-Lincoln (Figure II).

The need to discount future benefits (or costs) is based on the fact that a dollar in hand today is worth more than a dollar in hand ten years hence. How much less that future dollar is worth depends on how far in the future it will be received. The farther into the future, the less the dollar is presently worth. Or as Howe[33] puts it:

Present value of future benefits $= d_0v_0 + d_1v_1 + d_2v_2 + \ldots d_nv_n$ where $v_n$ is a benefit falling in year n. The weights $d_n$ are assumed to decrease into the future in a geometric fashion akin to compound interest. Thus:

$$d_n = \frac{1}{(1 + r^n)}$$

where r is the rate at which future revenues are discounted or more precisely the "discount rate".

In the past years, two dominant schools of thought have emerged concerning evaluation of the discount rate. The first takes into account the fact that people, as indicated above, show a willingness to pay a premium (interest) in order to expedite the immediate acquisition of goods. This frequently exhibited preference for satisfaction today over satisfaction tomorrow is referred to as a positive time preference.[34] The rate of interest at which the individual is undecided as to whether to save or spend is called his time rate of preference and should be equivalent to the individual's discount rate. As might be expected, people as a group also exhibit a positive time preference. Society's time rate of preference is equivalent to the social discount rate, since this time rate reflects society's feelings about providing for the future as opposed to current consumption. Advocates of the time rate of preference method of determining the social discount rate tend to go further. They argue that provision for the future is a socially good deed. They also maintain that because private decisions concerning consumption and investment neglect nonquantifiable benefits of providing for future generations, the level of private investment is too low. To compensate for this supposed tendency to under-save, advocates of this theory argue that society should increase its public investment by adopting a social discount rate which is below private sector rates.[35] There are many problems with this attitude. First, we are currently devoting nearly 30% of GNP towards investment for the future.[36] The next generation will probably have a higher standard of living.[37] Should we save even a larger percentage towards the future, when poverty, malnutrition, etc., are so prevalent today? Second, the use of a social discount rate below that in private sectors may be wasteful since it implies that resources will be transferred from higher return alternatives in the private sector to lower return investments in the public sector.[38] Third, the social time rate of preference is virtually impossible to measure quantitatively.

The second dominant method of evaluating the discount rate uses the opportunity cost concept. Proponents of this method cite two economic principles as the basis for their position. The first principle is that no investment is worth undertaking unless it is at least as productive as any comparable investment commonly available. Second, the rate at which any potential investment should be discounted is the rate of return which the best alternative will yield. This follows necessarily from the proposition that if the available

capital is used in the best investment, the benefits of the next best alternative must be forgone. The opportunity cost to the investor of not having additional money and hence the time value of money to him, is the rate of return on the next-best alternative. The time value of money should equal the discount rate.[39] Using the first principle, advocates of the opportunity cost method argue that the government, in its role as society's investor, should not undertake any public investment which produces less value than that to be expected from an alternative use of the same investment capital. From this it follows that the minimum social rate of return of a project should at least equal to a comparable investment in paying off the public debt (i.e., the long-term bond rate). For projects begun in the 1970's this minimum risk free rate should be about 4%.[40] Advocates, however, say that the government can do better than this long-term bond rate. As evidence, they cite the fact that the government derives its money from the private sector where rates of return are typically higher than this bond rate. It follows, then, that this private sector rate would be the smallest rate which a public project should yield, since presumably the capital needed for the public project could instead remain in the private sector, earning the private rate of return. Applying the second principle mentioned above, supporters of the opportunity cost theory maintain that because this private rate of return is the best alternative investment for society, it *is* the social discount rate. To find the private rate, one must trace the origin of the capital used on a public project to its specific source in the private sector. Because of the complexity of the economy, the problem of measuring this social opportunity cost is difficult and experts have taken many different approaches, each with its own simplifying assumptions, in an effort to resolve it. The reader who is interested in this subject is referred to a discussion by Haveman of the different approaches taken for measuring the social opportunity cost.[41] Suffice it to say here that various attempts by different experts at measuring the social discount rate using this opportunity cost method have yielded values of 5,[42] 7-1/4,[43] 8-10,[44] and 10.4%.[45] Some of the discrepancies in these values stem from the fact that each analysis was made at a different time and thus does not include effects of inflation. Moreover, differing assumptions made by the various analysts also contributed to the lack of agreement on the proper discount rate.

There has been little mention of risk thus far. Obviously, the riskier a venture the higher return rates it requires to attract investment. In the past, planners have typically ignored adding a risk

premium when evaluating a federal project. This procedure has been called into question by many, including de Neufville and Stafford.[46] They argue that on many federal projects there is a very real risk that a project will fail to live up to expectations. Benefits may not reach expected levels, and higher costs may be incurred than were planned for. Thus they conclude that risky projects should be required to show a higher rate of return, a risk premium, in order to make their expected return equal to the return on a risk-free investment. Eckstein[47] has determined that this risk premium should be about 0.5 to 1%, depending upon the amount of capital to be invested.

The Corps has used a discount rate of 3¼%, based on S.D.#97. As Baumol has pointed out there are two major shortcomings with this document's determination of the social discount rate. First, the document attempts to establish a long-term government interest rate, but fails, because: (1) it averages the indicated or coupon rate on government bonds which, in 1970 for example, was half the effective rate to the buyer, and (2) it calculates the interest rate on the bonds as if they were all long-term in nature even though they become short-term bonds as their date of redemption approaches. Hence the result is to perpetuate a low discount rate.[48]

The social discount rate which will apply to all Federally supported water resource projects in the future is given by the WRC's new standards and procedures.[49] This rate is based upon ". . . the estimated average cost of Federal borrowing as determined by the Secretary of the Treasury taking into consideration the average yield during the twelve months preceding his determination on interest-bearing marketable securities of the U.S. with remaining periods to maturity comparable to a 50 year period of investment."[50] A more specific description of the formulation procedure is not included in the document, thus making the whole process of rate determination a bit mysterious. However, two points can be made. First, because the bonds are to have "remaining periods to maturity comparable to a 50 year period of investment," this procedure corrects one of the major shortcomings of the Green Book's determination of the discount rate. Second, like the Green Book, the new WRC procedure bases its discount rate on the long term bond rate. Advocates of the social opportunity cost position maintain that this is the minimum possible rate, for reasons previously discussed. Nevertheless, the 6⅞% rate set for this year (1974) is considerably higher than the rate used previously and is much closer to the rate advocated by supporters of the social opportunity cost theory.

Because this new rate is over twice the rate used in the current analysis of Dickey-Lincoln, there is reason for concern that the Corps will retain the old procedure in its updating of its evaluation of the project. To evaluate the project at the new discount rate would mean an immediate drop in the current B/C ratio from 2.62 to about 1.4—a drastic and unfavorable result from the Corps' view. If the Corps does indeed continue to discount at 3¼% it should be clear by now that this rate is artificially low and the Corps has in effect decided to subsidize future generations. This sort of philanthropy may be a noble gesture; indeed, one's opinion about endowments to future generations may very well determine which social discount rate one prefers.

2. *Project Life.* This is the second factor upon which the enormously important "Interest and Amortization" quantity depends. As one can see from Figure II, change in the project life is a covariable with the discount rate in determining the B/C ratio. For example, if the rate is high (about 5% or greater), then a halving of the project life from 100 years to 50 years results in a lowering of the B/C ratio by only a few tenths. But by using a lower discount rate and assuming a 100 year project life, the B/C ratio will be more than 0.7 greater than would result from equivalent analysis using a 50 year life. Thus by using the questionably long 100 year project life and a low discount rate, the Corps has maximized the B/C ratio.

But the Corps feels its postulated project life is realistic. While siltation is a potential problem in most hydroelectric projects,[51] siltation does not appear especially likely to occur at Dickey-Lincoln, since hydroelectric dams downstream from the proposed site have experienced no such problem.[52] As for the machinery within the dam, it would be large and understressed. With normal maintenance and replacement of such machinery, dams previously constructed by the Corps and the Bureau of Land Reclamation have continued to function for many decades.

There is, however, another problem involved. In its analysis the Corps tacitly assumes that the discount rate, costs and benefits are not functions of time. If the past is any indication of future trends, this is indeed an unrealistic assumption. For example, the value of an isolated area to recreationalists will no doubt skyrocket, as population in urbanized areas increases. In addition, power benefits may at first out-distance rising costs, as the energy crisis becomes more acute. Yet in 75 years fusion power may be harnessed resulting in relatively costless electricity. Inflation may fluctuate by a factor of 2 or 3 or more. All of this of course is speculation, but this is exactly

the point. By choosing a project life of 100 years the Corps is dealing with the uncertain future. This uncertainty is a hazard inherent in any major project analysis, but by choosing shorter time periods extrapolations of current trends become more valid and project evaluation becomes correspondingly less speculative. Thus the economic method of present value discounting is completely inadequate when dealing with time spans as large as 100 years. If used, it may have misleading results.

3. *Construction Costs of Dam.* This is the last of the three factors upon which "Interest and Amortization" depends. This factor, like the other two, is a nightmare for the quantitative mind. Current estimates of project costs vary up to 300%. State Senator Hathaway (pro) estimates $273 million; Boston Edison (against), $1 billion; and the Corps of Engineers, $356 million.[53]

The Corps' current estimate is based upon its original study completed in the mid-60's. Since then the Corps has continued to update these original figures. However, the lack of sufficient funding to support thorough re-study has compelled the Corps to accomplish this updating by the most expedient means available. The procedure in essence consists of multiplying the original cost estimate by a "fudge factor." The factor is intended to make allowance for price changes which have occurred since the initial analysis. The final result is admittedly "quick but dirty."

Naturally the updated costs are unlikely, except by accident, to be more accurate then the original estimates. In judging the accuracy of these original estimates the House Appropriations Subcommittee in 1968 consulted a number of experts including a private engineering consulting firm, the New England Electric Coordinating Council (NECC) and the Tennessee Valley Authority (TVA). Each had different opinions on the question, reflecting the intrinsic difficulty of cost estimation.

The consulting firm of Charles T. Main, Inc. was hired by the NECC to evaluate the Corps' original estimate. The firm is a well-established, Boston-based company which has had experience in water-resource projects. The Main firm estimated the cost of Dickey-Lincoln to be $7½ million more than the Corps' 1964 estimate of $210,500,000. Approximately half of this difference could be traced to a discrepancy in prices assumed by each for earth and rock fill. The Corps based its estimate on experience from past projects.

The NECC raised several questions. First, they doubted the assumption made by the Corps of a six month working season. The NECC claimed that the season would actually be much shorter,

thereby requiring the use of much more overtime in order to finish the project on schedule. The Corps' estimate was supported by Canadian experience with similar projects in the area. Second, the NECC doubted that the average labor wage would be as low as $4,500/year, the figure upon which the Corps' estimates were based.

Somewhat more optimistic testimony was entered by the TVA. It concluded that the Corps' estimates did indeed include all the major items of cost and that the final estimate seemed reasonable. The TVA did note, however, that the Corps' cost projections were based on 1966 prices. Since the project would not be completed for 6½ years, during which prices could be expected to rise, the TVA suggested that the Corps adjust those original costs upward at 4% per year in order to compensate. Doing so would add about $50,000,000 to the Corps' construction costs.[54]

In short, there are three major questions concerning the Corps' construction cost estimates. The first is the accuracy of the Corps' updating procedure. Because of the relatively recent revival of Dickey-Lincoln there has unfortunately been as yet no published independent studies concerning the validity of the Corps' updated figures. One can however form a tentative judgment concerning these figures. In 1966 the Corps' estimated costs were $230 million as compared to the 1974 costs of $356 million. This corresponds to an approximate 6% overall annual inflation rate, which would seem reasonable for that period of time.

The second major question is that of wages. Intuitively, $4,500/year does seem at best conservative. Conceivably, this low *average* wage estimate could be justified. Thus far we have tacitly assumed that the true cost to society of each resource consumed by the project is adequately accounted for by its market price. This assumption has been reasonably correct to this point. However, in the case of wages this supposition is no longer valid. The St. John region suffers badly from unemployment and underemployment. It has been estimated by the Corps[55] that 550 people from these two categories would be employed during the construction of the project. The question arises as to what is the true social cost of employing these under-used national resources. As Kenneth Arrow has pointed out,[56] putting the idle worker or machine to work really costs society nothing, even though there is a wage or other price to be paid. In fact the project may even save society some money in the form of welfare payments and unemployment compensation, money for which society receives little substantial return. The government, as guardian of the nation's welfare, should reckon only with true social

costs. Hence, there is a benefit accruing to the national income objective by employing these resources. It is only a matter of bookkeeping[57] as to where this quantity is included in the Corps' B/C analysis. It can be subtracted from total labor costs, thus making the *average* wage appear too low, or the value can be included as a benefit. But since the Corps has included these wages as a redevelopment benefit, it cannot subtract them from total construction costs. Therefore we can conclude that the average wage of $4,500/year used by the Corps is probably too low and has led, at least in part, to the discrepancy between the Main and Corps' construction cost estimates.

The third major question concerning the Corps' projected construction costs centers on the "present cost" estimates of the Corps. There should be very little doubt that the construction costs should include inflationary increases that will occur during the project's construction. The Corps has implicitly recognized this fact every time it has updated its estimates. The TVA suggested that the costs be adjusted 4% per year but the Corps has recognized that construction costs have risen an average of 6%/year (i.e. 1974-$356 million versus 1966-$230 million.)

A current, disinterested, professional estimate is badly needed. Of the $800,000 recently appropriated by Congress towards Dickey-Lincoln, none was set aside for such a study. Back in 1966, the Main estimate was financed by the utilities, then the major opponents of the project. As noted previously, the utilities have largely backed off from their opposition and their replacements on the negative side of the controversy, the conservationists, do not have the money to finance the new professional estimate needed. Though the Main estimate was not, in fact, completely independent (since it was financed by opponents), it did shed much needed light on the technical aspects of the project's analysis. Dickey-Lincoln is, in effect, on trial. It is extremely difficult to arrive at a reasonable verdict, when an important part of the testimony (i.e. construction cost estimates) can be neither substantiated nor refuted, but must instead be accepted or rejected largely on faith.

4. *Annual Costs—Dam.* The largest entry (90% of the annual costs for dams is, as noted before, the "Interest and Amortization" quantity. Hence any criticism of the Corps' figures for maintenance, major replacements and loss of land taxes is of much less significance unless it can be shown that these figures are considerably in error. Opponents argue that the "loss of land taxes" figures are indeed quite wrong. The Corps currently includes taxes lost from

lands which will be covered by the reservoir. Those against the project say the taxes lost figure should also include the federal and state taxes which would be paid by an equivalent private plant. The logic behind this argument will become more evident when we discuss how the government evaluates power benefits from Dickey-Lincoln. Suffice it to say that if this argument succeeded it would result in the addition of approximately $2 million to the loss of taxes column.[58]

## B. Benefits

1. *Power.* A glance at the Corps' benefit analysis will show that one item, power, constitutes about 95% of the total benefits claimed for the project. Therefore the amount and price of that power is crucial to the outcome of the B/C ratio.

The Corps' power analysis is divided into three categories. Under the first, "Marketed in Maine," is an entry which amounts to $5.411 million. This quantity is the estimated charge to Maine customers of devoting 105 MW of *capacity* to them. This charge is incurred by the customers whether or not they are actually using any power. Under this fixed charge lies another quantity, the charge to the consumers for the number of hours during which that capacity is actually generating energy. In the case of Maine, 105 MW of capacity would generate electricity for about 12 hrs/day. For Boston, 625 MW of capacity would generate power for about 2 1/2 hrs/day. Included in both entries is a number less than unity which represents the transmission losses. The total cost of Maine's energy would be $0.022/kilowatt-hour (KWH). For Boston the cost would be $0.049/KWH, reflecting the more costly nature of peaking power.

The last entry in the Corps' power benefit analysis is labeled "Downstream." This is energy that would result from increased output from Canadian hydroelectric plants downstream from Dickey-Lincoln. This increased output would be due to the regulatory effect Dickey-Lincoln would have on the flow of the St. John. The 350 megawatt-hours (MWH) figure represents half of the increased output. The other half would go to Canada.

The power prices used in the Corps' benefit analysis were derived by the Federal Power Commission (FPC) and are based on the "alternative cost" approach. This evaluation procedure is founded on the idea that market prices indicate what people are willing to pay for goods or services, and this willingness to pay can be taken as the measure of benefits or social value which are gained by construction of the project. Some benefits such as recreation, flood

protection etc., do not have clearly defined market prices. However, in the case of power, which obviously does have a market price, the alternative cost concept has been widely used to evaluate power benefits created by hydro-projects in terms of the prices charged by a thermal power plant.[59] The idea is that if the hydro-plant were not built, then the consumer would end up paying no less than the prices charged by the least-cost alternative thermal plant. The concept can be abused. For instance, as Howe points out, it would obviously be wrong to evaluate alternative means of connecting the Columbia River to the Colorado River, by including as water benefits for one scheme the price of delivering water by another alternative.[60] Upon evaluation, one scheme's net benefits would be higher than all others and it would be the best alternative. However, the implicit assumption that either a project or an alternative will indeed be built has resulted in a favorable analysis for the plan, when in fact the plan may not be economical from the overall view of the nation. In the case of power benefits, this implicit assumption is generally valid. If the hydroelectric plant is not built, it is safe to say that utilities will build thermal plants to take the hydro-plant's place. However, if the nation's power demand is not rising, this "will be built anyway" assumption may not be true and application of the least-cost alternative concept would no longer be valid.

There are other possible abuses of the alternative-cost concept. The FPC, in evaluating the alternatives for Dickey-Lincoln, has committed most of these abuses, as we shall see.

For electricity marketed in Boston the FPC determined that a gas turbine constructed by the private utilities and located in Boston would provide the least-cost alternative peaking power equivalent to Dickey-Lincoln. The alternative's prices would be $16.50/KW and $0.03/KWH, the prices used in the Corps' analysis for power marketed in Boston. For electricity marketed in Maine the Commission determined that the least-cost alternative would be a private fossil fuel steam plant located in Maine which would provide base power similar to that expected from Dickey-Lincoln.

There are at least three reasons why the FPC's alternatives do not represent the true least-cost alternatives. First, Dickey-Lincoln would not produce many KWH compared to more modern facilities (only about one quarter of the yearly total of Edison's new Mystic River plant.)[61] Hence the least-cost alternatives will necessarily be small in order to be equivalent and thus will not be able to take advantage of the increasing economies of scale experienced by larger, more efficient plants.

A second problem is that the FPC does not add to its least-cost price a surcharge to represent the social costs characteristic of the alternative, namely additional air and thermal pollution and the use of a nonrenewable resource. To quantify these types of social costs is concededly difficult and controversial, but the FPC simply avoided the difficulty by not including this surcharge. The analyst should not forget however that these social costs do exist and if quantifiable, would result in an increase in the primary project's benefits relative to those of the alternative.[62]

The third major stumbling block stems from the way the FPC used the alternative cost technique. If the method is to work, it is essential that resources that would be needed for each of the alternatives be measured with the same set of prices. Since the discount rate is simply the price paid for the use of capital, it too must be uniform in comparing the alternatives. Uniformity of treatment must also extend to taxes, which are included in costs. If the costs of the public project include a reduced discount rate and smaller taxes than the alternative, then the net benefits of the project are overestimated.[63]

In addition to these two terms, the least-cost alternative should, in order to be equivalent, have approximately the same life-span as the project under consideration. Otherwise, one is trying to compare quite different benefit and cost streams.[64] For example, the least-cost alternative to a 50-year life project might be two consecutive 25-year life thermal plants. It is quite doubtful that the FPC has taken such possibilities into account. To project the prices charged by the least-cost thermal alternative system to a 100-year life hydro-project would be nearly impossible. Uncertainties of the future, such as possible development of relatively costless fusion power, would render any attempt too speculative to be meaningful.

The FPC evaluated the private alternative (of approximately 25-year life) using a discount rate of 8 3/4% and included all state and federal taxes.[65] The Corps on the other hand evaluated Dickey-Lincoln using a 3 1/4% rate, a 100-year life, and excluded all taxes except those lost from the lands to be covered by the reservoir—an obvious attempt to stack the deck in favor of the federal project. Obvious, because use of these three terms (i.e. 100-year life, 3 1/4% discount rate and essentially no taxes) in the evaluation of any capital-intensive project would favor a federal project instead of a private alternative paying standard private sector rates.

To make a proper comparison would have required the FPC to evaluate the alternative private schemes (of 100-year life) with a

discount rate of 3 1/4% and no state and federal taxes.

Because of the relatively small flow of the St. John, Dickey-Lincoln would produce only 1 billion KWH/year.[66] Most of that power would be transmitted to Boston for approximately 2 1/2 hours per day to be used to serve the peak needs of that city. This amount of electricity would amount to about 10% of the total New England peak period demand.[67] Boston Edison claims its past records show that there is actually no well defined peak in Boston's consumption. Instead, use climbs to a "plateau" during the day and remains there for about eight hours and then drops off.[68]

There are of course consumers other than Boston. These customers, consisting mostly of New England municipal electric utilities, have expressed a willingness to buy 600 MW of peaking power from the project.[69]

The billion KWH/year that would be produced by Dickey-Lincoln would in 1980 amount to about 1% of New England's total electrical demand.[70] This may seem like a ridiculously small amount but the reader is reminded that the manner of its production and distribution will make it fully 10% of *peak* demand in the region. Percentages are only ratios and as such can hide important facts. Even the large new Mystic River thermal plant, for instance, will supply only 4% of New England's total demand. One must instead look at the margin, thinking of the many thousands of homes these small percentages could help heat or cool.

The power from Dickey-Lincoln would be marketed by the Department of Interior. The prices actually charged customers would not be those listed on the Corps' benefit analysis. Instead the prices are set such that those annual costs attributed to power (about 95%) would be repaid annually from the power revenues.[71] The annual costs as calculated by the Interior Department are based on a 5 7/8% discount rate and a 50-year repayment period.[72] All transmission, maintenance and construction costs are included. Non-power benefits such as redevelopment and flood control are not required by the Department to be paid back by power revenues.[73] Currently the Department of Interior expects to charge $0.025/KWH as compared to the so-called least-cost alternative charge of $0.0344.[74] It is doubtful that these prices would represent much of a savings to New Englanders, since they would apply only to about 1% of the region's total power, the annual bill for which is about $1.6 billion.[75] Residents of small towns might save proportionately more, however, if their municipal power companies buy a considerable percentage of their power from the project.

2. *Prevention of Flood Damages.* This is one of the many benefits for which a market price does not exist. It is however reasonable to assume that inhabitants of a potentially floodable area would be willing to pay at least the value of expected average flood losses in order to prevent the flood. Again, this willingness to pay is taken as the measure of benefits which is gained by construction of the project.

In the last 46 years of record the St. John has caused ten major floods in the area immediately below the dam site. Three of these have occurred in the last four years.[76] The worst, in 1974, caused $3 million worth of damage, mostly to the town of Fort Kent and the surrounding farm lands. The average yearly cost of these floods (not updated to include 1974) is $60,000, the value included in the Corps' B/C analysis. Unfortunately, this is strictly a monetary value placed on physical property losses and as such does not reflect the non-quantifiable factors such as the human suffering that results from a flood. In addition, the Corps' quantity does not include the added productivity of the flood plain that would result from the removal of the threat of flooding.

Because the Corps does not include these factors, it is probably safe to say that its figure of $60,000 is too low. But here again, it is nearly impossible to estimate the actual values. Fortunately for the overall analysis of this particular project this problem is not crucial. Even if this prevention benefit were twice as large, it would still be insignificant when compared with the total annual benefits.

Those proponents of Dickey-Lincoln who favor the project solely on the grounds of its flood control benefits are treading on thin ice. There are many single-purpose alternatives to the project which would cost only a fraction of Dickey-Lincoln and yet yield much of the same flood control benefits. These alternatives include flood-plain managing, flood control dikes, watershed replanting, etc. In fact, the Corps has plans for a $2 million dike to protect the town of Fort Kent. Even though the dike is not intended to protect the surrounding farm lands,[77] it would result in the reduction of most of the flood damage in the area at a cost less than 2% of the bill for Dickey-Lincoln.

3. *Recreation.* In the original Corps analysis of 1964, recreation benefits expected to result from the project were listed as zero. During the last updating, the Corps re-evaluated this factor and concluded that because of Dickey-Lincoln there would be an overall increase in the number of user-hours in the St. John watershed.[78] If this increase could be multiplied by a realistic figure representing

recreationalists' willingness to pay, one would arrive at a value for recreational benefits from the project. Of course, determination of these two quantities (i.e. increase in user-hours and willingness to pay) is difficult, but the Corps has apparently made a stab at it, since it has produced a figure of $1.5 million for this benefit category. Regrettably, the Corps has not yet made available the figures upon which the estimate is based.

Ecology groups including the Sierra Club and the Appalachian Mountain Club argue that this quantity should be negative, reflecting the losses in recreational opportunities that the project would bring. They back up their claims by citing such losses as:

(a) Loss of brook trout fishing. Today the St. John along with the adjoining Allagash are rated as two of the 100 best trout fishing streams in the country.[79] The brook trout currently inhabiting the St. John would be replaced by lake trout and other varities of lake-type fish.

(b) Loss of a wilderness wildlife habitat. Today the area abounds with deer, moose, and other wild animals. Its subjection to relatively light hunting has permitted the St. John watershed to serve as a storage area from which other more heavily hunted areas are replenished. Deer appear to be the species which would be hardest hit by the project. Currently there are 17,600 acres of deer yards (winter browsing grounds) that would be flooded by the reservoir. The flooding represents a potential loss to the area of 2200 deer.[80] Good conservation management could prevent most of this potential loss from becoming actual. Effects on other area wildlife are less foreseeable, though it is reasonable to hypothesize that wildlife numbers would decrease simply because 140 square miles would be covered by the reservoir.

(c) Loss of a canoeable stream. The St. John and the Allagash are considered by many to be two of the best canoeing streams in the U.S.[81] The anatomy of the Allagash watershed would not be directly affected by Dickey-Lincoln. However, canoeing enthusiasts who had previously used the St. John could be expected to switch to the Allagash, thereby increasing its use. Many wilderness enthusiasts already consider the Allagash too crowded.

In 1966 it was estimated that about 4700 recreationalists used the upper St. John.[82] It is unclear what effect Dickey-Lincoln would have on total recreational use of the area, but the nature of the area would obviously be changed from the current wilderness stream-type to a lake-type environment. If the lake were created somewhere in the arid southwest, near a large population center, use could be

expected to jump. However, Maine is blessed with many beautiful, large lakes which would tend to compete with the project lakes. But in the northeast, the St. John and the Allagash are the last two remaining wilderness streams. Thus because of its nearly unique characteristics, the wild, free-flowing St. John has a higher marginal utility to canoeists, hunters and brook fishermen than to lake-boatmen, swimmers, etc., who have other resources at their disposal. Consequently, it will take a greater number of the latter group, paying a lower market price, to equal the total benefit derived from a smaller number of the first group, willing to pay a higher price (reflecting the river's higher marginal utility to them in its present form). The new WRC standards have recognized this fact by establishing two classes of outdoor recreation, each with its own simulated market price. The "general" class, including boating, swimming, picnicking, and most warm water fishing, is to be valued at between $0.75 to $2.25 per user-day. The "specialized" class, including hunting, fishing etc. is to be valued between $3.00 and $9.00 per user-day.[83] The Corps must be certain to take into account these different market prices when evaluating the recreational benefits of Dickey-Lincoln.

4. *Redevelopment.* The area redevelopment benefit represents the effect of added employment that would result from the project. The Dickey-Lincoln project would be located in Aroostook County, where the mean income of 40% of the population was $3,000/year in 1966.[84] In calculating the redevelopment benefits, the Corps included wages of the estimated 35 area people who would be continually employed during the life of the project. This quantity is then added to the wages (averaged over 100 years) of the estimated 550 unemployed and underemployed local area people who would be hired during the construction period.[85] Thus the Corps' figure does not take into account the well known multiplier effect. When the project is completed there may be net added employment, both primary—e.g., technicians, engineers, etc. working for the project, and secondary—e.g., doctors, barbers, gas station owners, etc. who will be needed to provide goods and services both for the people employed directly by the project and for those attracted to the project for other reasons, such as boaters, swimmers, etc. The local economy must consequently expand to adjust to the needs of the new employer. An example can illustrate the magnitude of this multiplier effect: before construction of the Glenn Canyon hydroelectric dam on the Colorado River, the average population density of the area for a 100 mile radius was less than one person per square

mile.[86] In 1970, 6 years after the dam's completion, there existed a modern town of 1500 people (Page, Arizona),[87] with an average wage of $10,000[88] per year. All of the jobs are a direct result of the dam, which has added more than $4,500,000 to the local economy (450 wage earners X $10,000).[89] Granted, regional differences between the two areas require one to use caution in analogizing between the Glenn Canyon project and Dickey-Lincoln. For one thing, each year over a half million[90] lake-hungry visitors come to Lake Powell, primarily from the surrounding arid region, and thus supply many of the 450-plus jobs in Page. It is doubtful that the reservoir created by Dickey-Lincoln would attract nearly as many people, since the surrounding region abounds with lakes. Therefore, the Maine project might not create as many secondary redevelopment benefits as the Arizona project. Nevertheless it is possible that Dickey-Lincoln may have much more far-reaching effects on the local economy than envisaged by the Corps. The net value of these effects depends greatly on one's definition of benefits.

Certainly not all changes in the local economy brought about by the project would be positive. Currently the timber industry harvests $600,000 worth of lumber each year from the 75,000 acres of cutable forest land which would be covered by the reservoir.[91] Some opponents of the project claim that when the multiplier effect is taken into account, this harvestable land adds $200 per acre to the local economy of the St. John region.[92] If this is true, the building of Dickey-Lincoln would represent a whopping $15 million ($200/acre times 75,000 acres) loss to the region's economy, overwhelming any of the benefits accruing to the local area from the project. Proponents of the project counter by noting that 90% of the timber harvested from the area is being sold to nearby Canada and that most of it is being cut by Canadian labor.[93] The fact remains nevertheless that money is being pumped into the area from the lumbering industry. This revenue can be expected to increase as lumber prices continue to climb. Supporters of the project also argue however that the lumber companies have over-cut the St. John watershed, worsening the flooding problem and so depleting the number of mature trees that it will be another 40 years before a harvestable stand can be regrown.[94] Though most of the calculations involved in the discussion of lumber industry benefits are highly debatable, one fact should be clear: if the 75,000 acres of forests are not flooded by the project, they would supply a substantial amount of renewable lumber sometime in the future and thus would contribute a considerable benefit to the local economy.

There is another potential danger to the local economy posed by the project. The dams would create a "boom and bust" effect on the locale. Construction employment is expected to increase steadily until the eighth and final year when it would be drastically cut. This abrupt cutback could be expected to be somewhat painful to the economy in the short run at least.

Thus the two-sided nature of Dickey-Lincoln is apparent in strictly local economic terms as well. If the project is built, the region will experience immediate, rather large benefits (the construction boom) which would drop suddenly to a level of benefits which might be less than those the area would experience if the project were not built at all.

## V. Environmental Impact

Conservationists have been vehemently opposed to the project. Some of the reasons for their antipathy have been included in the "Recreation" discussion, *supra*. But there would be other impacts on the immediate area, including:

(a) a 40-foot fluctuating water level periodically exposing 30,000 acres of so-called "bath tub ring;"

(b) installation of 150 miles of transmission lines through Maine;

(c) strip-mining of aggregate for the dams from the site area;

(d) building of 5 dikes, some located in remote parts of the area.

Some of these environmental consequences would be clearly irretrievable losses which would be traded off for the benefits to be derived from the project. Other effects, such as loss of wildlife, could be reduced through sound planning. Some of these problems will hopefully be put into sharper focus when the Corps submits an Environmental Impact Statement.

There are, of course, also positive environmental effects to be expected from the project. Dickey-Lincoln will produce safe, nonpolluting energy from a renewable source. Neither of the two current power alternatives (nuclear or fossil fuel)[95] can claim these extremely attractive features. This is the root of the dilemma which faces environmentalists if the premise is accepted that New England's power consumption must, or at least will, increase. They have chosen to try to save a wilderness area at the possible cost to the environment of having to cope with the additional types and amounts of pollution which would be produced by additional nuclear or fossil fuel plants.

## VI. Proposed Changes in the Corps' Analysis

After careful consideration of the Corps' Economic Analysis of Dickey-Lincoln, the writer proposes the following changes (see Table II):

(a) the discount rate be changed from 3 3/4% to 8 3/4%, the rate used by the FPC with respect to the private alternative (thus placing the alternative on an equal footing with the project for comparison purposes), and because this value falls within the bounds of feasible discount rates suggested by economists;

(b) the project life be changed to 50 years in order to make discounting techniques more valid, although at the higher social discount rate of 8 3/4% this change is less important;

(c) an item be added to the initial construction costs in order to include inflation which can be expected to occur during the construction period;

(d) an annual cost of $2 million/year be added to represent insurance and taxes paid by the least-cost alternative—again, to make comparison more valid;

(e) recreation benefits be carried at zero until the Corps is able to show that use of the area by general category recreationalists would increase enough to more than offset the losses to present users in the special category.

Redevelopment benefits should remain unchanged, but not without noting that this quantity might well decrease if, upon further study, it should be shown that the region has indeed not been overcut and will continue to produce the amount of lumber currently being harvested, thus making up for the loss of $600,000 annually in timber revenues currently collected. On the other hand, if the Corps can show that the net value of recreational use of the area will substantially increase, thereby creating more secondary employment opportunities, this redevelopment quantity should be increased accordingly.

All other calculations by the Corps remain unchanged, although some of them, especially the initial construction costs, are questionable for reasons already discussed.

If the suggested changes are incorporated into the analysis, the B/C ratio falls slightly below unity. In the strictest economic sense the project is not economically justifiable. However, one should note that the economic consequences of almost all the opponents' major criticisms were included in the evaluation (the exceptions being construction costs and redevelopment), tilting the analysis somewhat in their favor. In spite of this recalculation, the B/C ratio

remains very close to unity, indicating that minor changes in a few key factors could make the project quite viable, at least as compared to other federal projects that have been built in the past.

One must keep in mind that the above analysis is necessarily somewhat inaccurate. An updated Corps analysis, faithfully following the WRC standards, would be much more desirable. The author's analysis is rather an attempt to rectify what seem to be the more obvious shortcomings of the Corps' current evaluation and to get a more quantitative appreciation for the effect that changes suggested by opponents would have on the B/C ratio.

## VII. Conclusions

The status of Dickey-Lincoln is changing rapidly, due in part to the varying Middle East situation and the energy crisis. Despite this state of flux there are some basic problems concerning the project that remain unchanged. These include:

(a) the uncertain yet highly influential natures of the social discount rate and the project life;

(b) the uncertainty of construction cost estimates;

(c) the inadequacy of discounting techniques in long term project evaluation;

(d) the FPC's mis-application of the alternative-cost method of evaluation;

(e) the inability to quantify some benefits and costs associated with the project, especially redevelopment, recreation and environmental costs and benefits;

(f) the recreational trade-off: swapping whitewater canoeing, backpacking, stream fishing, etc., for more commonly accessible forms of recreation such as lake boating and fishing, swimming and picknicking;

(g) the uncertain impact of the project on overall area redevelopment;

(h) the environmental trade-off: a relatively small amount of pollution-free, renewable, safe power versus the relatively "dirty" nuclear or fossil fuel alternative.

It is very unsatisfying to work through an analysis and evaluation such as the above and at the end not have a definite "yes" or "no" answer to the problem that was posed. Yet this is the predicament of an analyst of the Dickey-Lincoln Project. The project appears to be neither the boon to New England claimed by its proponents nor the ecological disaster claimed by its opponents. It is instead a seemingly even trade-off. Only with additional information, not

available at this time, can a rational judgment be made about the project. The additional information should include a truly updated and reworked Corps analysis, not the fudged one currently available; at least one professional, independent analysis; an Environmental Impact Statement; a much closer look at the "Redevelopment" impact of the project; clarification of the basis for the Corps' projected "Recreation" benefits. Also required are quantitative evaluations of such alternatives as

(a) federally financed installation of insulation into private buildings;

(b) peak power pricing;

(c) zero power growth;

(d) different methods of stimulating the depressed economy of northern Maine; and

(e) the possible installation of flood-control dams above the Dickey area.

Some of this information will be disclosed when the Corps finishes its re-analysis of the project. It should be noted that if the new WRC criteria were conscientiously applied in the analysis of Dickey-Lincoln most of these questions would be answered. Regardless of how the information is obtained, it will cost money. It would be funds well spent, since without this additional knowledge a rational answer to the ultimate question posed by Dickey-Lincoln is not possible. That final conundrum remains: whether a small but signifcant amount of cheap, pollutionless, renewable, inheritable power is worth the investment of hundreds of millions of dollars of scarce capital and the destruction of an ecosubsystem dependent upon one of the few remaining wilderness streams.

## TABLE I

### U.S. ARMY CORP OF ENGINEERS

### ECONOMIC ANALYSIS—ANNUAL COSTS AND BENEFITS

(based on 3¼% interest rate and 100-year life)

| | |
|---|---|
| **TOTAL INVESTMENT—DAMS** | |
| Construction Costs of Dams | $356,000,000 |
| Interest During Construction | 28,800,000 |
| Total Investment | $384,800,000 |
| Capital Recovery factor 100 yr. life | .03388 |
| **ANNUAL COSTS—DAMS** | |
| Interest and Amortization | $ 13,037,000 |
| Operation and Maintenance | 1,500,000 |
| Major Replacements | 248,000 |
| Loss of Land Taxes | 98,000 |
| Sub-Total Dams | $ 14,883,000 |
| **TOTAL INVESTMENT—POWER LINES** | |
| Construction Costs of Transmission Line | $123,100,000 |
| Interest During Construction | 6,000,000 |
| Total Investment | $129,100,000 |
| **ANNUAL COSTS—POWER LINES** | |
| Interest and Amortization | $ 4,374,000 |
| Operation and Maintenance | 950,000 |
| Major Replacements | 394,000 |
| Sub-Total Trans. Lines | $ 5,718,000 |
| **TOTAL ANNUAL COSTS** | |
| Dickey-Lincoln School Lakes Dams | $ 14,883,000 |
| Transmission Lines (50%) | 2,859,000 |
| ANNUAL COSTS | $ 17,742,000 |
| ANNUAL BENEFITS (See next page) | $ 46,492,000 |
| B/C RATIO | 2.62/1 |

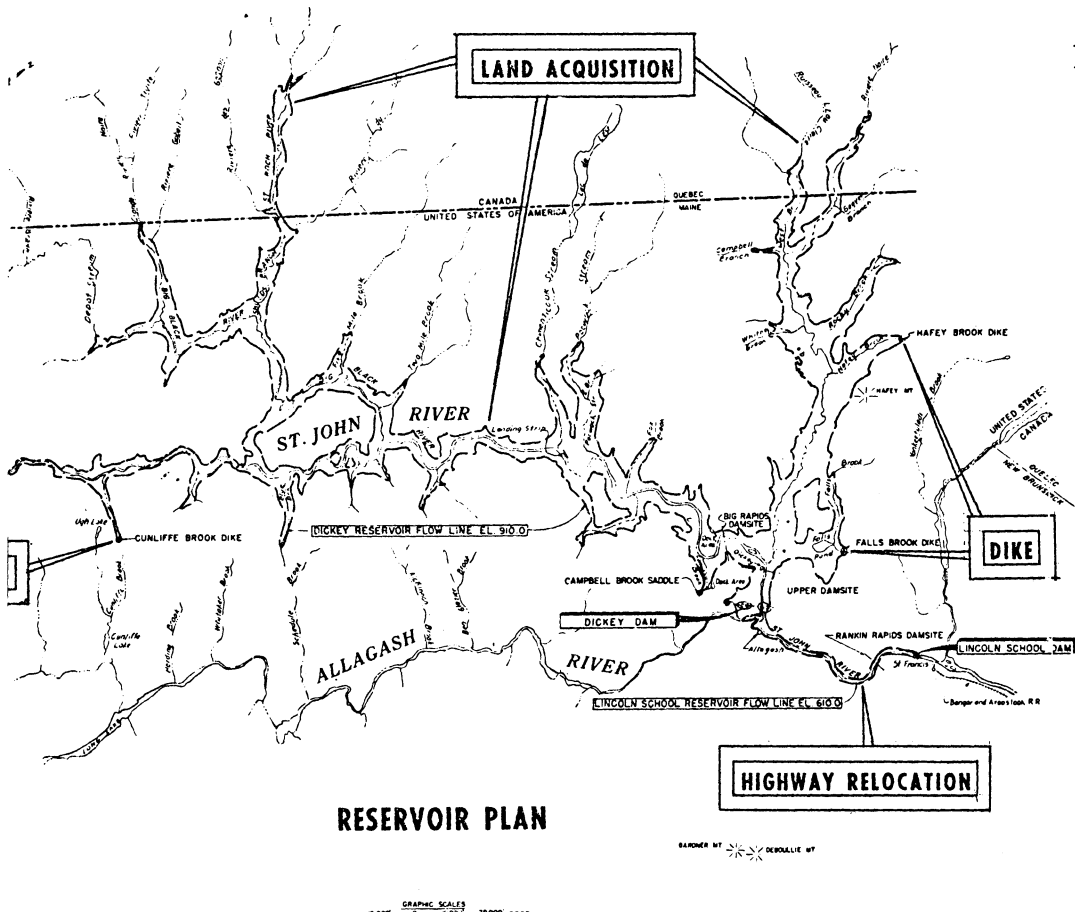
## DICKEY-LINCOLN SCHOOL LAKES

| | |
|---|---|
| ANNUAL BENEFITS | |
| Marketed in Maine | |
| 105,000 kw x 0.95 x $54.25 | $ 5,411,000 |
| 372,000,000 kwh x 0.95 x $.010 | 3,534,000 |
| Marketed in Boston | |
| 725,000 kw x 0.905 x $16.50 | $ 10,826,000 |
| 782,000,000 kwh x 0.929 x $.030 | 21,794,000 |
| Downstream | |
| 350,000,000 kwh x $.008 | 2,800,000 |
| Sub-Total Power | $ 44,365,000 |
| PREVENTION OF FLOOD DAMAGES | 60,000,000 |
| RECREATION | 1,250,000 |
| REDEVELOPMENT | 817,000 |
| TOTAL ANNUAL BENEFITS | $ 46,492,000 |

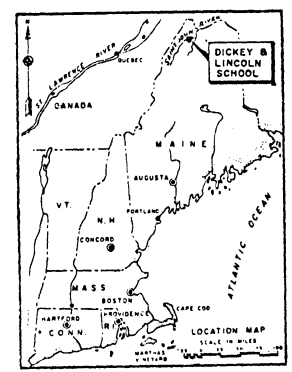
TABLE II
REVISED ECONOMIC ANALYSIS

| | |
|---|---|
| **TOTAL INVESTMENT—DAMS** | |
| Construction Costs of Dams | $356,000,000 |
| >Inflation During Constr. Period (6½%) | 52,000,000 |
| >Interest During Construction | 44,000,000 |
| Total Investment—Dams | 452,000,000 |
| >Capital Recovery Factor (50 yr. life & 8 3/4%) | 0.08884 |
| **ANNUAL COSTS—DAMS** | |
| >Interest and Amortization | $ 40,156,000 |
| Operation & Maintenance | 1,500,000 |
| Major Replacements | 248,000 |
| >Loss of Land Taxes | 2,098,000 |
| | 44,002,000 |
| **TOTAL INVESTMENT—POWER LINES** | |
| Construction Costs | $123,100,000 |
| >Interest During Construction | 16,250,000 |
| Total Investment—Lines | 139,350,000 |
| **ANNUAL COST—POWER LINES** | |
| >Interest & Amortization | $ 12,380,000 |
| Operation and Maintenance | 950,000 |
| Major Replacements | 394,000 |
| Sub-Total Lines | 13,724,000 |
| **TOTAL ANNUAL COSTS** | |
| >Dickey-Lincoln School Lakes Dams | $ 44,002,000 |
| >Transmission (50%) | 6,862,000 |
| ANNUAL COSTS | 50,864,000 |
| **ANNUAL BENEFITS** | |
| Power | $ 44,365,000 |
| Prevention of Flood Damages | 60,000 |
| >Recreation | 0 |
| Redevelopment | 817,000 |
| ANNUAL BENEFITS | $ 45,242,000 |
| B/C RATIO | 0.89 |

FIGURE I

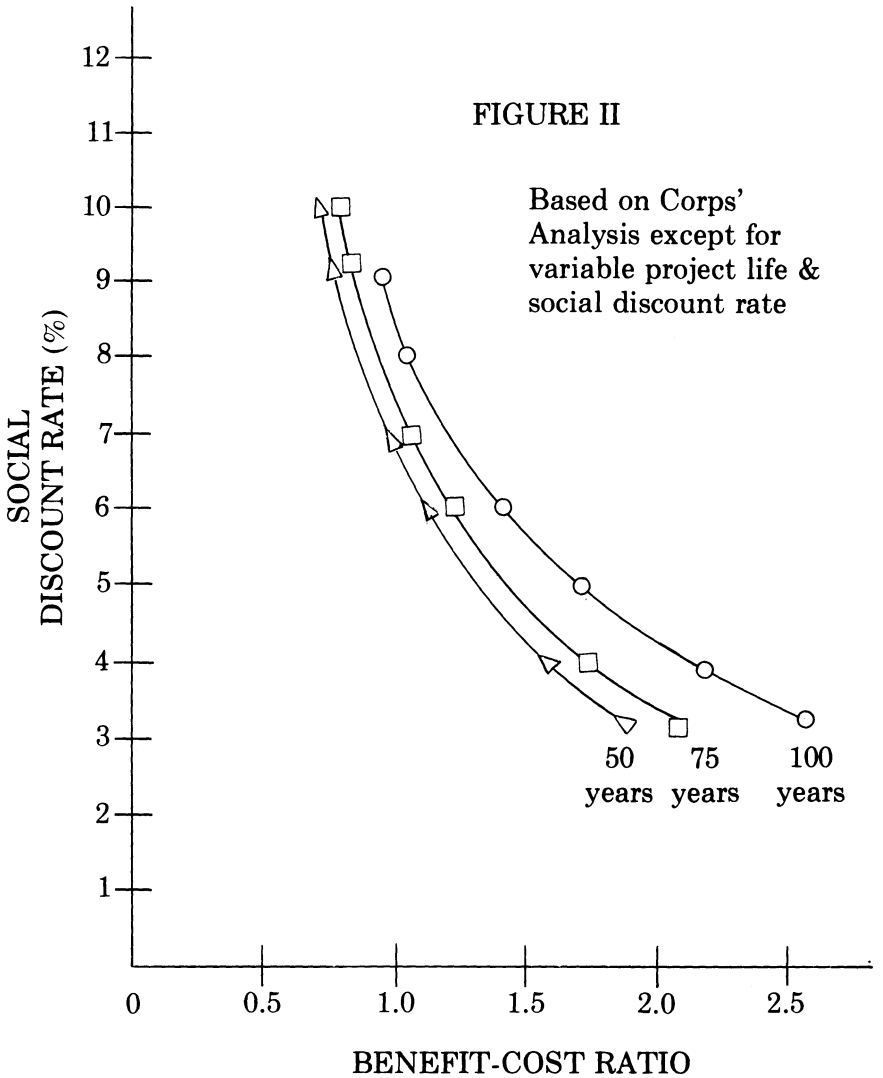



RESERVOIR PLAN



DICKEY-LINCOLN DAM

FIGURE II



FOOTNOTES

*Student at Massachusetts Institute of Technology, Civil Engineering Program.

[1]These discharges would occur from the upper dam for about 2½ hours per day, and would result from use of the Dickey Dam as a source of peaking power.

[2]Specifications from U.S. Army Corps of Engineers, New England Division, Waltham, Mass. Hereinafter cited as Corps Specifications.

[3]The International Joint Commission is a joint Canadian-American committee originally established in 1909 to settle questions concering use of the waters of the St. John River.

[4]Benefit/cost (B/C) ratio equals either present value of benefits and costs or annual benefits, where "present value," "annual benefits" and "annual costs" will be defined later. Suffice it to say at this point that if the B/C ratio falls below 1.0, benefits from the project are worth less than the costs involved, and the project is uneconomical.

[5]Manning, R., *A Study of the Dickey-Lincoln Hydroelectric Project*, unpublished report to the Sierra Club, at 47 (1971). Hereinafter cited as Manning.

[6]The 1966 appropriation contained in PL 89-298 exemplifies this procedure of keeping controversial projects on the back burner.

[7]*Hearings on Public Works Appropriations for 1968 Before the Subcomm. on Public Works of the House Comm. on Appropriations*, 90th Cong. 1st Sess. 380-441. Hereinafter cited as *Hearings*.

[8]Manning, *supra* n. 5, at 45.

[9]*Id.*

[10]*Id.* at 45-46.

[11]*Id.*

[12]Corps Specifications, *supra* n. 2. *See also* Table I.

[13]Kindleberger, R.S., "Dickey-Lincoln: Dam Ogre or Power Gem?" BOSTON GLOBE, May 9, 1974, at 2. Hereinafter cited as Kindleberger.

[14]*Id.*

[15]*Policies, Standards and Procedures in the Formulation, Evaluation and Review of Plans for Use and Development of Water and Related Land Resources*, Senate Doc. No. 97, 87th Cong. 2nd Sess. (1962).

[16]An alternative definition of the B/C ratio is

$$\frac{\text{present value of benefits}}{\text{present value of costs}}$$

This method simply discounts all future benefits and costs back to one time period, the present. This "present value" ratio is numerically equivalent to the "annual" ratio provided that both are evaluated with the same discount rate and project life.

[17]de Neufville, R. and J.H. Stafford, SYSTEMS ANALYSIS FOR ENGINEERS AND MANAGERS, at 163, 174 (New York: McGraw-Hill, 1971). Hereinafter cited as de Neufville.

[18]*Id.*

[19]Net present benefits equals present value of benefits minus present value of costs.

[20]National income is defined as the total money value of the flow of final products of a nation. *See* Samuelson, P., ECONOMICS, 8th ed. at 170 (New York: McGraw-Hill, 1970).

[21]Major, D.C., *Multiobjective Water Resources Planning*, review draft of *Water Resources Monograph 4* for the American Geophysical Union, Washington, D.C., at 6-9 (1973). Hereinafter cited as Major.

[22]*See* n. 15 *supra.*

[23]U.S. Water Resources Council, *Principles and Standards for Planning of Water and Related Land Resources,* FEDERAL REGISTER, Vol. 38, No. 174, Sept. 10, 1973. Hereinafter cited as WRC.

[24]WRC, *supra* n. 23, as cited by Manning, *supra* n. 5, at 22.

[25]Manning, *supra* n. 5, summary pp. 5-6.

[26]*Id.* at 111-138.

[27]*Id.*

[28]*Id.* at 37-84.

[29]Major, *supra* n. 21, at 11.

[30]WRC, *supra* n. 23, summary p. 7.

[31]*Id.* at 25.

[32]Fox, J.K. and O.C. Herfindahl, *Attainment of Efficiency in Satisfying Demands for Water Resources,* AMERICAN ECONOMIC REVIEW, Vol. 54 No. 3, at 168 (May 1974) as cited by de Neufville, *supra* n. 17, at 173.

[33]Howe, C.H., *Benefit/Cost Analysis for Water System Planning, Water Resources Monograph No. 2* of the American Geophysical Union, at 64-65 (Baltimore: Publication Press, 1971). Hereinafter cited as Howe.

[34]*Id.* at 63.

[35]Haveman, R.H., *The Opportunity Cost of Displaced Private Spending and the Social Discount Rate,* WATER RESOURCES RESEARCH, Vol. 5 No. 5, 948 (Oct. 1969). Hereinafter cited as Haveman.

[36]Tullock, G., *The Social Rate of Discount and the Optimal Rate*

*of Discount: Comment,* QUARTERLY JOURNAL OF ECONOMICS, May 1964, 331-336.

[37]Readers of THE LIMITS OF GROWTH (Meadows, D.H., D.L. Meadows and W.W. Behrems; New York: Universe Books, 1972) may seriously question this statement.

[38]Haveman, *supra* n. 35, 948 *et seq.*

[39]de Neufville, *supra* n. 17, at 153, 160.

[40]Hirshleifer, J. and D.L. Shapiro, *The Treatment of Risk and Uncertainty,* THE ANALYSIS AND EVALUATION OF PUBLIC EXPENDITURE: THE PPB SYSTEM, 489-504, as cited in de Neufville, *supra* n. 17, at 168.

[41]Haveman, *supra* n. 35, at 949-951.

[42]Eckstein, O., WATER RESOURCES DEVELOPMENT, at 99 (Cambridge, Mass.: Harvard University Press, 1958). Hereinafter cited as Eckstein.

[43]Haveman, *supra* n. 35, at 955.

[44]Baumol, W.J., *On the Appropriate Discount Rate for the Evaluation of Public Projects*, published in Hinrichs, H.H. and G.M. Taylor (eds.), PROGRAM BUDGETING AND BENEFIT-COST ANALYSIS, 202-212 (Pacific Palisades, Cal.: Goodyear Publishing Co., 1969). Cited by de Neufville, *supra* n. 17, at 170, 172.

[45]Stockfisch, J.A., *Measuring the Opportunity Cost of Government Investment*, at 490 (Institute for Defense Analysis, 1969), as cited by WRC, *Proposed Principles and Standards for Planning Water and Related Land Resources,* FEDERAL REGISTER Vol. 36 No. 245 at 24167 (December 21, 1971).

[46]de Neufville, *supra* n. 17, at 171.

[47]Eckstein, *supra* n. 42, at 87.

[48]Baumol, *supra* n. 44.

[49]WRC, *supra* n. 23.

[50]WRC, *supra* n. 23, summary p. 9.

[51]Dams in Europe which were expected to produce power for many tens of years have in fact been filled in prematurely by the rivers which feed them. Siltation is also occurring in the lakes behind several dams in the western United States, especially those in the Colorado River watershed.

[52]Hathaway, W., "Dickey-Lincoln Dam: Boon for New England Or Ecological Disaster?", BOSTON GLOBE, April 7, 1974, at A-1.

[53]Correspondence with Dr. J. MacKenzie, President of the Union of Concerned Scientists, Massachusetts Institute of Technology, Cambridge, Mass., May 1974.

[54]*Hearings, supra* n. 7, as cited by Manning, *supra* n. 5, at 52-60.

[55]*Id.* at 64.

[56]Arrow, K.J., *Criteria for Social Investment,* WATER RESOURCES RESEARCH, Vol. 1 No. 1, at 8 (1965).

[57]While this statement may not be strictly true for all methods of calculating the B/C ratio, it is valid for the net-present-benefit method; *see* n. 19 *supra*.

[58]Correspondence with Mr. Frank Lee, Environmental Affairs Division, Boston Edison, Boston Mass., April 1974.

[59]Howe, *supra* n. 33, at 56.

[60]*Id.*

[61]Swatek, "Dickey-Lincoln Dam: Boon for New England Or Ecological Disaster?" BOSTON GLOBE, April 7, 1974, at A-1. Hereinafter cited as Swatek.

[62]The new WRC criteria do require that these social costs be included at least qualitatively under the environmental and social welfare objectives.

[63]Eckstein, *supra* n. 42, at 241.

[64]Howe, *supra* n. 33, at 57.

[65]Correspondence with Mr. Richard Reardon, Special Assistant to the Chief of Engineering Division, U.S. Army Corps of Engineers, New England Division, Waltham, Mass., May 1974. Hereinafter cited as Reardon Correspondence.

[66]Swatek, *supra* n. 61.

[67]Reardon Correspondence, *supra* n. 65.

[68]Correspondence with Mr. Frank Lee, Environmental Affairs Division, Boston Edison, Boston, Mass., April 1974.

[69]*Hearings*, supra n. 7, as cited by Manning, *supra* n. 5, at 79.

[70]Swatek, *supra* n. 61.

[71]*Hearings, supra* n. 7, as cited by Manning, *supra* n. 5, at 73.

[72]Corps Specifications, *supra* n. 2.

[73]*Hearings, supra* n. 7, as cited by Manning, *supra* n. 5, at 73.

[74]Corps Specifications, *supra* n. 2.

[75]Swatek, *supra* n. 61.

[76]Corps Specifications, *supra* n. 2.

[77]Kindleberger, *supra* n. 13.

[78]Reardon Correspondence, *supra* n. 65.

[79]Wynn, D., *One Hundred Best Trout Streams,* OUTDOOR LIFE, May 1959, as cited by Manning, *supra* n. 5, at 79.

[80]Hengsbach, J.L., *A Recreational Study of the Upper Saint John River Watershed*, University of Maine *Bulletin* No. 682, at 47 (February 1970). Hereinafter cited as Hengsbach.

[81]It should be noted, however, that the generally low water level in the St. John makes even canoeing impossible except for a few weeks each year.

[82]Hengsbach, *supra* n. 80, at 29.

[83]WRC, *supra* n. 23, at 52.

[84]Ploch, L.A. and N.L. LeRay, *Social and Economic Consequences of the Dickey-Lincoln School Hydroelectric Power Development on the Upper St. John Valley, Maine—Phase I, Construction* (March 1968), as cited by Manning, *supra* n. 5, at 65.

[85]*Hearings, supra* n. 7, as cited by Manning, *supra* n. 5, at 64.

[86]HAMMOND WORLD ATLAS, at 189 (New York: Hammond, Inc. 1969).

[87]Department of Commerce, United States Census Bureau, CHARACTERISTICS OF THE GENERAL POPULATION, Vol. 1 Part 4 (Arizona), at 59 (1970). Hereinafter cited as Census.

[88]Corresponence with Page-Lake Powell Chamber of Commerce, Page, Arizona; April, 1974.

[89]Census, *supra* n. 87.

[90]Statement from Arizona Office of Economic Planning and Development, Community Development Section, 3003 N. Central Ave., Phoenix, Arizona.

[91]Hengsbach, *supra* n. 80.

[92]Statement of C.H. Goodall, Executive Director, Maine Natural Resources Council.

[93]Kindleberger, *supra* n. 13.

[94]*Id.*

[95]So-called pump-back systems are not considered a true alternative, since they must be charged by nuclear or fossil-fuel plants.