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Feasibility Study For

Low-Head Hydropower

On the Mill River, Northampton, Massachusetts

Conducted by the Northampton Planning Department for the U.S. Department of Energy under Cooperative Agreement No. EW-78-F-07-1789

Prepared By Curran Associates, Inc., Northampton, Massachusetts
With Montreal Engineering Company, Ltd., Montreal, Quebec

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Feasibility Study For
LOW-HEAD HYDROPOWER
On The
MILL RIVER, NORTHAMPTON, MASSACHUSETTS

Conducted by the Planning Department of the City of Northampton for the
U.S. DEPARTMENT OF ENERGY

(Cooperative Agreement No. EW-78-F-07-1978)¹⁷⁸⁹

Submitted To:

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Advanced Technology Branch
Energy & Technology Division - ID
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January, 1979

**CURRAN ASSOCIATES, INC.
ENGINEERS AND PLANNERS**

Northampton, Massachusetts
Palo Alto, California
Lima, Peru

30 April 1979

Planning Department
City of Northampton
Municipal Office Building
Northampton, Massachusetts 01060

Attn: Ms. Nancy Stack

Re: Feasibility Study for Low-Head Hydropower, Final Report

Dear Ms. Stack:

We are pleased to submit our final report entitled, "Feasibility Study for Low-Head Hydropower" in accordance with the terms of the Agreement dated 21 August 1978 between the City of Northampton and Curran Associates, Inc., and Cooperative Agreement No. EW-78-F-07-1789 between the U.S. Department of Energy and the City of Northampton.

A Summary of Findings responds in order to each of the items in Article I.B of our Agreement, with references to sections of the report containing more detailed discussion.

We thank you for your cooperation and valuable assistance throughout the study. We also thank the owners of the dams, the Massachusetts Electric Company, and the Department of Energy for their time spent in visiting the sites and discussing the projects with us. Finally, we wish to acknowledge the contributions of the staffs of both Curran Associates, Inc. and Montreal Engineering Company, Ltd. who worked together on preparation of the feasibility assessment report.

We have enjoyed working with you on this interesting and challenging project, and would welcome the opportunity to be of further assistance to the City.

Sincerely yours,

Robert G. Curran
Project Director

RGC/JRF/dm

ABSTRACT

Five existing dams along a 6.5-mile reach of the Mill River in the City of Northampton, Massachusetts were studied to assess the feasibility of developing the sites for low-head hydroelectric power generation.

Each of the dams was inspected to evaluate existing conditions and necessary work required to rehabilitate the structures. Analyses of hydrology and power potential were carried out and a packaged tube turbine-generator unit was found to be suitable for installation at all sites. Project layouts were developed making maximum use of existing structures and natural and man-made features. Capital and operation and maintenance costs were estimated based on the project layouts and the selected turbine-generator units. Financial analyses were performed using a set of baseline assumptions. Sensitivity tests of alternative assumptions were also prepared, along with analyses of assistance program alternatives. Finally, the legal, environmental, and socio-institutional considerations affecting development of the hydro projects were identified and reviewed.

Hydro developments on the Mill River were found to be technically feasible, presenting no extraordinary engineering, environmental, or legal problems. However, none of these projects, either individually or jointly, would be financially feasible without substantial assistance in the form of capital grants.

SUMMARY OF FINDINGS

The summary of findings resulting from the present feasibility assessment of potential hydro projects on the Mill River is presented below in the same order indicated in Article I, Section B, "Responsibility of the Engineers", of the Agreement of 21 August 1978 between the City of Northampton and Curran Associates, Inc. A copy of this portion of the Agreement is reproduced in Appendix C of this report.

1. Configurations and Capacities.

The proposed layouts of the hydropower facilities are described in Section 4.1 and the selection of unit sizes is given in Section 3.0. As shown in Plate 4-1, each powerhouse would be constructed adjacent to the existing dam and would contain one horizontal-shaft turbine-generator unit. The Cookes Intermediate project would involve diversion of water from the pond formed by the Button Shop dams through a penstock to a powerhouse below Cookes Dam, thereby combining the heads available at both projects.

The capital costs of the power facilities are derived in Section 4.2.1. The estimated costs are in mid-1978 dollars and include all facilities required to tie the plants into the existing distribution system. They also include allowances for engineering and Owner's administration but exclude interest during construction.

The installed capacities and estimated capital costs corresponding to the four plants selected for study throughout this report are as follows:

<u>Project</u>	<u>Installed Capacity</u>	<u>Estimated Capital Cost</u>
	kw	mid-1978 \$
Chartpak	235	880,000
Cookes Intermediate	265	1,160,000
Pro Brush	200	800,000
Smith College	<u>120</u>	<u>770,000</u>
	Total 820	3,610,000

2. Peak Power and Energy.

The estimates of power available from the hydro projects are derived in Section 3.4 and the assumed potentials for saleable peak power production are given in Section 5.2. The table below summarizes the power potentials at the four selected projects:

<u>Projects</u>	<u>Assumed Saleable Peak Power Production</u>	<u>Average Total Annual Energy Production</u> (Equivalent	
	kw	MWh/a	Barrels of Oil/a)
Chartpak	204	850	(1,420)
Cookes Intermediate	0*	1,140	(1,900)
Pro Brush	171	845	(1,410)
Smith College	106	<u>570</u>	<u>(950)</u>
		3,405	(5,680)

*The local utility indicated that it would purchase any energy available from the hydro plants but would not give credit for capacity. Since power from the Cookes Intermediate project could not be used to directly serve a well defined load, the "assumed saleable peak power production" was considered to be zero.

3. Impacts on Water Resources.

Principal uses of the Mill River in Northampton, described in Section 7.3.1, are water supply and disposal of wastewater discharges. Pro Brush withdraws small quantities of water from its pond although most of the cooling water is obtained from wells. Thus, more water is returned to the river than is withdrawn. River water is also used for irrigation of a golf course downstream from Cookes dam. None of these uses of the water resource would

be measurably altered or affected by installation and operation of hydro-power facilities. Besides Pro Brush, the only other impoundment in current use is Paradise Pond formed by the Smith College dam. This pond provides for summer and winter recreation as well as aesthetic enhancement of the campus. Major concerns expressed by Smith College officials are the need to minimize water level fluctuations in the pond, the need to maintain a small amount of flow passing over the dam for aesthetic reasons, and the need to make hydroelectric structures compatible with the existing visual character of the area. All of these needs could be met by the proposed project although only with some loss of energy generation due to intentional spillage.

4. Marketing Potential.

The marketing potential of power produced from the Mill River hydro plants is addressed in Section 5.1.

Part of the output of the Chartpak project would be used by the Chartpak company and the local utility, Massachusetts Electric Company, would buy the residual at the prevailing fuel displacement rate which is currently 2.2¢/kWh.

Massachusetts Electric Company would purchase all of the output from the Cookes Intermediate Project at the prevailing fuel displacement rate.

All of the output from both the Pro Brush and Smith College projects would be used by the current dam owners.

5. Regulatory Requirements.

Regulatory requirements applicable to hydro development of the existing Mill River dams, outlined in Section 7.2, are both formal and informal.

Upon decision to proceed with any of the projects, frequent and close coordination with all agencies involved would be important in expediting project approvals. Essential requirements would include:

- Short-form license from Federal Energy Regulatory Commission;
- Section 10 and Section 404 permits from U.S. Army Corps of Engineers;
- Waterways permit and wetlands permit from Massachusetts Department of Environmental Quality Engineering (the latter after approval by Northampton Conservation Commission);
- Consultation with and review by U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, Massachusetts Division of Fisheries & Wildlife and others.

6. Capital Investments.

Capital investments per installed kilowatt for each of the four projects are summarized in Section 6.1, while Section 6.2 describes the calculation of total costs per kilowatt-hour and return on investment. Results are given in the tables of Section 6.2 and Appendix B and are summarized as follows:

<u>Project</u>	<u>Capital Investment (\$/kW)</u>	<u>Present Value Cost for Hydro Energy* (¢/kWh)</u>	<u>Present Value Cost for Purchased Energy** (¢/kWh)</u>
Chartpak	3,400	2.89	2.32
Cookes Intermediate	4,110	2.64	----
Pro Brush	3,600	2.72	1.96
Smith College	3,750	4.03	1.93
All projects together	4,020	2.59	----

*Based on total costs over 50-year life cycle

**Based on costs to user for purchasing electricity in amounts equal to hydro project production over 50-year life cycle, allowing for utility rate inflation 4% greater than general inflation.

The return on investment assuming concurrent development of the four projects was calculated to be 4.1 percent per annum based on a project payout period of 50 years.

7. Operation and Maintenance Costs.

The anticipated operation and maintenance costs for the projects are derived in Section 4.2.2. If the four plants were operated and maintained as a single system the estimated cost would be \$55,000/annum. The corresponding figure for the operation and maintenance of a single plant would be in the order of \$20,000/annum.

8. Project Life.

On the basis of a site inspection of the dams on the Mill River, as described in Appendix A, it was concluded that the remaining life of the existing structures is unlimited. The economic life of all the hydro projects was assumed to be 50 years which is a figure often used for this purpose.

9. Environmental and Socio-institutional Impacts.

Environmental impacts of hydro developments on the Mill River would be associated with construction as well as operation of the projects as discussed in Section 7.3. Excavation and other land-disturbing activities necessary for powerhouse, tailrace, and penstock construction would generate some sediment which might be washed into the river. Because much of the required excavation would be in rock, sediment quantities would likely be small. Construction phase impacts would be minimized by scheduling work in and near the river to avoid the season of greatest recreational fishing pressure and by requiring sediment and other pollution control measures to be taken as necessary during construction.

Operational impacts relate basically to modification of natural river flows. While ponding water at Chartpak, flows in the river could be reduced to

near zero, except for seepage and local inflows, frequently for periods of a few hours and infrequently for up to 18 hours. During the summer, reduction of already low flows during part of the day could adversely affect trout and other stream biota, although augmentation of flows during the generation period could be beneficial for the stream fishery. These issues would need to be addressed further by the agencies responsible, should the projects proceed. Water flows between Button Shop south dam and Cookes dam would be substantially reduced if the Cookes Intermediate project were developed. Increased sedimentation, stagnation, and encroachment of marsh and terrestrial vegetation would be possible in the Cookes pond area due to the decreased flows.

None of the proposed Mill River projects is expected to have major social or institutional consequences locally (Section 7.4). However, the projects would contribute to the national policy of lessening dependence on foreign oil, even if only in a small way, and would set a precedent for cogeneration projects in the Massachusetts Electric Company service area.

Alternative institutional arrangements for implementing the projects would include: Individual development and operation of each project by the present owner; individual development by owners and operation by the City; development and operation of all projects by the City; or development of all projects by the City and operation by a single private contractor. Advantages of having all projects developed by the City and operated together may include: (1) potentially better ability of the City to obtain funding assistance; (2) operation and maintenance cost savings; and (3) ability to develop the full power potential by ensuring construction of the Chartpak project and associated storage capacity.

Section 1 of the Mill Acts (Massachusetts General Laws, Chapter 253) states that, "A person may erect and maintain a water mill and a dam to raise water for working it, upon and across any stream not navigable." The Acts and subsequent case law, discussed in Section 7.1 of this report, have interpreted the rights of use very broadly and provide a firm legal foundation to enable the owners to use the Mill River for hydroelectric purposes.

10. Safety.

In Section 2.0 it was concluded that the addition of a hydropower facility at any of the dams under study would not affect the safety of the existing structures.

As stated in Section 7.2 a possible safety hazard would be introduced in the course of operating the plants in periods of low flows when generation would not be continuous. At the start of generation the water level downstream of each dam would rise causing a potential problem to individuals who might have strayed into the riverbed. The magnitude of this rise should not be more than a foot or two.

11. Engineering Acceptability.

Section 4.1 concludes, on the basis of a visual inspection of the sites and the subsequent engineering work which was carried out, that the construction of a hydropower facility at each site considered is technically feasible.

12. Availability of Suitable Equipment.

The type of turbine-generator unit considered at all potential sites on the Mill River is discussed in Section 3.3. On the basis of the availability of flow and head it was concluded that the smallest-size standardized tube turbine-generator unit now available commercially from the

Allis-Chalmers company would be a suitable machine for installation at all sites under study. This type and size of unit was used to obtain equipment costs and to size the civil works at each site. On the basis of manufacturers' quotations for small generating units obtained for other studies, the cost of the Allis-Chalmers equipment is considered representative of that for alternative units. Comparison with hydro-generating equipment available from other manufacturers would be necessary at the design stage to ensure final selection of the most suitable unit.

13. Schedule.

A preliminary schedule for the design and construction of power facilities for the Chartpak, Cookes Intermediate, Pro Brush and Smith College projects is discussed in Section 4.4. The schedule is illustrated in Plate 4-3. It shows nine months of detailed design, advertisement for bids, and bid preparation and analysis prior to the award of contracts. Civil construction, and equipment fabrication, delivery, installation and testing would take a further fourteen months. This gives a total elapsed time, from the decision to proceed until all four plants are commissioned, of 23 months.

Conclusions.

Development of the existing Mill River dams for hydroelectric power production is considered technically feasible and would present no unmanageable engineering, legal, or environmental problems. However, none of these projects, either individually or jointly, would be financially feasible without substantial assistance in the form of capital grants.

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1.0 INTRODUCTION

This report describes the work carried out on the feasibility assessment of possible hydropower sites on the section of the Mill River which lies within the City of Northampton, Massachusetts.

Financial assistance for the accomplishment of the feasibility assessment was provided by the United States Department of Energy under Cooperative Agreement No. EW-78-F-07-1789 with the City of Northampton. The City also participated financially by providing services of its employees.

The assessment was carried out in accordance with the Agreement dated 21 August 1978 between the City of Northampton and Curran Associates, Inc. (CAI). An excerpt of the Agreement is contained in Appendix C of this report.

Part of the work involved in performing the assessment was subcontracted to Montreal Engineering Company, Limited (MECo). MECo provided assistance to CAI on portions of the responsibilities described in Article I, Section B of the Agreement between the City and CAI, specifically items: 1, 2, 6, 7, 8, 11, 12 and 13.

This report describes the condition of the existing structures which provide the head for potential hydropower developments on the Mill River. It gives estimates of power potential at each site considered. The layouts of the hydropower facilities together with estimates of their capital costs are included as are estimates of operation and maintenance costs. The marketability and

value of the hydro power are discussed, and an economic feasibility and benefit-cost analysis are described. Finally, the environmental, legal and socio-institutional aspects of the projects are reviewed.

A glossary of technical terms and abbreviations is included as Appendix D to assist the lay reader.

2.0 EXISTING DEVELOPMENTS

The attached Plate 2-1 shows the location, project area and river profile for the existing developments considered in this report.

The five sites under study were visited and inspected several times in the fall of 1978 to assess the general condition of the dams and to consider the most convenient method of installing hydro power facilities. The results of the inspection and the conclusions regarding the general condition of the dams, including photographs, are attached as Appendix A. The configuration of the hydroelectric facilities which would be installed at each dam is described in Section 4.1.

In general, all the dams are overflow structures of stone masonry construction and appear to be founded on sound durable rock. Only one structure would require any appreciable rehabilitation and all appear to have many years of remaining life. There are no generating facilities currently existing at any of these sites. It appears that little pondage remains at some of the dams due to reservoir silting.

Based on the observed condition and configuration of all dams it can be concluded that the addition of hydropower facilities would not affect the safety of the existing structures.

Table 2-1 gives a summary of the physical characteristics and the general condition of the dams.

Table 2-1: Summary of Existing Structures

Dam	Type	Crest Length (ft)	Maximum Height ft	General Condition	Necessary Remedial Action	Remaining Life
Chartpak	Masonry	150	28	Very Good	Replacement of top two masonry courses with concrete	Unlimited
Button Shop East	Masonry	80	10	Excellent	None	Unlimited
Button Shop South	Masonry	80	10	Excellent	None	Unlimited
Cookes Left	Masonry	80	20	Excellent	None	Unlimited
Cookes Right	Masonry	30	8	Excellent	None	Unlimited
Pro Brush	Masonry	120	15	Excellent	None	Unlimited
Smith College	Masonry	120	15	Excellent	None	Unlimited

Plate 2-1: Dam Locations and River Profile

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The quantities of water withdrawn from the Mill River, as described in Section 7.3.1, are very small in relation to the total volume of flow in the river and were disregarded in the estimation of the projects' power potential.

3.2 Available Heads

The gross head available at each site was measured during field surveys carried out in October and November 1978. River flow was very low at the time of the surveys and the measured head at each site was adjusted downwards to provide an estimate of the average gross head that would be available for power production.

Net heads were computed by reducing the corresponding gross heads by 2 percent to allow for general hydraulic losses in trashracks, intakes, tailrace, etc. An additional head loss, computed from the estimated flow and penstock size, was allowed for the long penstocks of the combined developments (see Section 4.3).

3.3 Type and Size of Units

In order to take advantage of standardized designs, resulting in reduced manufacturing costs and shorter delivery times, it was decided to select a packaged turbine-generator unit for all sites studied during the present feasibility assessment. Consideration was given to the use of the standardized Tube turbine units manufactured by Allis Chalmers. This manufacturer offers ten standardized packages with outputs ranging from 50 to 5000 kW designed specifically to develop heads up to 50 ft which are available at existing dams. The turbines are horizontal-axis, propeller-type units which provide the highest possible operating speed and maximum capacity for a given size. The powerhouse structure can therefore be substantially reduced in plan area and height. Also, the need for deep foundations is minimized, thus reducing excavation and other civil construction costs.

On the basis of the streamflows and heads available it was concluded that the smallest size of standardized turbine available from Allis-Chalmers, which has a throat diameter of 750 mm (about 30 inches), would be a suitable machine for installation at all sites under study. Plate 3-1 shows the typical characteristics of this unit. In addition to the turbine and generator, the package includes an inlet valve, draft tube liner, speed increaser, static exciter-voltage regulator, and protection and control equipment. Because of the large variation in streamflows occurring in the Mill River and the limited amount of pondage available, it was assumed that turbines with adjustable runner blades would be used to permit generation with acceptable efficiency over a wide range of discharges. The Allis-Chalmers packaged unit was selected here in order to obtain equipment costs and to size the civil works at each site. On the basis of manufacturers' quotations for small generating units obtained for other studies, the cost of the Allis-Chalmers equipment is considered representative of that for alternative units. Comparison with hydro-generating equipment available from other manufacturers would be necessary at the design stage to ensure final selection of the most suitable unit.

3.4 Power Available

The capacity available at each site was calculated from the discharge capacity of the selected unit and the net head available, assuming an over-all efficiency of 0.864. This was composed of a best gate turbine efficiency of 0.90, generator efficiency of 0.97 and a transformer efficiency of 0.99.

The energy potential at each site was estimated from the volume of runoff of the flow duration curve below the corresponding unit discharge capacity horizon, and the available net head, using an over-all efficiency of 0.787. The lower efficiency used to estimate energy was based on an annual average turbine efficiency of 0.82 to allow for operation at less than best gate discharge due

PERCENT OF FULL LOAD
 RELATIVE TURBINE EFFICIENCY VERSUS PERCENT OF FULL LOAD
 ADJUSTABLE BLADE - FIXED GATE PACKAGED UNIT

NET HEAD IN FEET
 UNIT DISCHARGE VERSUS NET HEAD IN FEET
 750 mm STANDARD TUBE UNIT

NOTE:

BASED UPON FIGURES 2 & 7, RESPECTIVELY,
 OF THE ALLIS-CHALMERS BROCHURE ENTITLED
 "STANDARIZED-HYDROELECTRIC GENERATING UNITS".

to low river flows, lower heads due to high flows, unit down time, and other factors. The other component efficiencies were assumed to remain the same.

The computation of the amounts of energy available was based upon the use of limited pondage, primarily supplied by the rehabilitation of Chartpak, which would be required to allow some hours of generation from low average daily flows. Any restriction on pondage availability, its use, or a requirement for minimum hourly releases during days of extremely low river flow, would have the effect of reducing the energy that was estimated to be available.

A preliminary estimate was made of the average monthly distribution of energy generation at the hydro plants on the basis of the variation in streamflow in each month and the turbine efficiency at different discharges. Table 3-2 gives the results of this estimate.

Table 3-2: Estimated Average Monthly
Distribution of Energy Generation

<u>Month</u>	<u>Average Monthly Generation</u> (Percent of Annual Generation)
January	8.4
February	8.2
March	15.6
April	19.1
May	13.9
June	7.4
July	3.1
August	2.5
September	2.7
October	3.3
November	7.2
December	8.6
	100.0

4.0 LAYOUTS AND COST ESTIMATES

4.1 Project Layouts

The layouts for all developments were prepared so that maximum use could be made of the existing structures, and natural and man-made features.

Each intake would be an integral part of the upstream slope of the dam. It would be of concrete and would include a trashrack and bulkhead gate. The area upstream would be dredged to provide a clear approach channel and reduce the rate of silting of the intake. It is likely that occasional dredging of the approach channels would be necessary and an allowance for this was made in the operation and maintenance costs discussed in Section 4.2.2.

The layout of each powerhouse was based on that required to house the packaged tube turbine-generator selected in Section 3.3. It would comprise a single operating room containing the valve and turbine controls, the generator and electrical equipment. Equipment would be installed and maintained by means of a mobile crane with access through a detachable roof hatch. The operating floor level would be determined by the level of the draft tube, the roof of the draft tube being at the level of the operating floor. The powerhouse sketches shown in Plate 4-1 illustrate the type of arrangement applicable to the Smith College site. All other powerhouse layouts would be similar.

The generator output would be cable-connected at 600 V to the generator breaker and then to the generator transformer where the voltage would be stepped up to 13.8 kV. The connection to the 13.8 kV distribution system would be by means of a short distribution line, circuit breakers, protection and utility metering as specified by Massachusetts Electric Company. A station service supply would be

NOTE:

UPSTREAM OF LINE XX DETAILS WILL VARY TO SUIT GEOMETRY OF EXISTING DAM OR PROPOSED LOCATION. ARRANGEMENT SHOWN IS APPLICABLE TO WORKS AT SMITH COLLEGE DAM. POWERPLANT LAYOUT IS APPLICABLE TO ALL DEVELOPMENTS.

Plate 4-1: Typical Powerplant Layout

tapped to the load side of the generator breaker to supply plant services and start-up power for the unit auxiliaries. The units would be equipped with protection and control which would be included in the basic turbine-generator package.

During operation automatic shutdown and start-up of the units would be controlled by headpond level sensors.

On the basis of a visual inspection of the sites and the subsequent engineering work which was carried out it can be concluded that the construction of a hydro-power facility at each site considered is technically feasible.

4.1.1 Chartpak. The dam would be restored by placement of concrete to raise the crest level of the central spillway section to that of the auxiliary spillway adjoining the left bank. The concrete would be faced with masonry on the downstream face in order to retain a uniform appearance. The powerhouse would be built in the open area below the spillway adjacent to the left bank. The tailrace would be cut from the powerhouse area back into the river through the rock ridge that currently exists.

4.1.2 Button Shop. The powerhouse would be located on the left bank immediately below the eastern dam because the available head could be developed there with less tailrace excavation than would be the case at the southern dam.

The intake would be set in the area of the original penstock intake and a new penstock would be routed close to the old penstock line. The tailrace would discharge directly into the river channel.

4.1.3 Cookes. The powerhouse would be sited below the main dam on the left bank. Due to the proximity of the dam to the road bridge, it would not be possible to site the powerhouse as close to the dam as would be desirable and hence a short penstock would be required.

4.1.4 Pro Brush. The intake and powerhouse would be located close to the left bank. A tailrace channel would be cut in solid rock for a distance of about 400 feet downstream to increase the available head.

4.1.5 Smith College. The powerhouse would be sited below the existing gate structure on the left bank and would utilize the existing gate and pipe through the dam. Little excavation would be necessary since the existing stilling area could accommodate the powerhouse. The existing wooden flashboards would be replaced by a concrete cap on the dam crest. This would not cause instability in the structure.

4.1.6 Combined Developments. The proximity of the upper three projects presents an opportunity to combine their development. This would result in reduced powerhouse and generating equipment costs but the saving would be offset by the cost of, and the increased head losses occurring in, the longer conduit systems.

Three alternative methods of developing the total head between the Chartpak headpond and the tailwater below Cookes dam were considered. Alternative I assumed three separate power plants at Chartpak, Button Shop and Cookes (Cokes Low). Alternative II comprised separate development at Chartpak, together with combining the heads of Button Shop and Cookes (Cokes Intermediate). Alternative III would have only one power facility and would concentrate the head of all three sites in the powerhouse at Cookes (Cokes High).

The development as three separate projects would include the project layouts as described in Sections 4.1.1, 4.1.2, and 4.1.3. For the Cookes Intermediate development a penstock would be buried alongside the road from the Button Shop intake to a powerhouse located downstream of Cookes Dam, using sewer-laying techniques. For the Cookes High development, water would be diverted from the river at Chartpak. The penstock would be encased in concrete for the first 350 feet to prevent ice damage and the remainder of the penstock would be buried alongside the existing road running between the Chartpak and Cookes Dams.

Layout drawings of the Intermediate and High developments, showing the penstock alignments, are shown in Plate 4-2.

4.2 Cost Estimates

4.2.1 Capital Costs. The unit prices used to develop construction costs in the present study were based on direct costs prevailing in the Northampton area in mid-1978. Unit prices were obtained by increasing the direct costs by 20 percent to allow for contractors' overhead and profit.

The factory prices of the packaged turbine-generator units were obtained from the manufacturer and an allowance of \$100,000 was added for delivery, installation and commissioning of each unit.

The cost of plant mechanical and electrical equipment was based on experience with similar work of this nature. The electrical equipment cost includes the metering, protection and distribution line necessary to tie the plants into the nearest point on the existing 13.8 kV electricity distribution system in the City, as specified by the Massachusetts Electric Company.

Plate 4-2: General Arrangement of Combined Development Alternatives

Each capital cost estimate includes an allowance for engineering and Owner's administration.

A summary of capital costs in mid-1978 dollars, excluding interest during construction, is given in Table 4-1.

4.2.2 Operation and Maintenance Costs. All four hydro plants which might be developed are located in a 6.5 mile stretch of the Mill River within the City of Northampton. It is envisaged that they would be operated and maintained as a single system and that these tasks would be undertaken by the City's Public Works Department in conjunction with their other work. Thus, the cost of operating and maintaining the plants was estimated as an incremental cost. Annual costs, excluding capital repayment, were divided into four categories: operation, routine maintenance, interim replacement and insurance; and each of these is discussed below.

The plants would be designed to shut down automatically in case of any major trouble so that a visit, say, every second day on average would normally be sufficient to check on plant operation. During the visit the mechanic would carry out such duties as adjustment of turbine gates to suit streamflow conditions, check oil and air pressures and bearing lubrication, perform minor repairs and keep plant records. It is estimated that each round trip visit would take about five hours. For the purposes of estimating it was assumed that a total of 1000 manhours per year would be required for operation of the plants. An annual payroll cost of \$30,000 for 2000 hours, or \$15/hour, was used giving a cost of time for plant operation of \$15,000 per year. A vehicle would also be required part-time and an allowance of \$2000 per year was made to give a total estimated annual cost of plant operation of \$17,000.

Table 4-1: Summary of Capital Cost Estimates (\$ x 10³)

	Chartpak	Button Shop	Cookes Low ⁽¹⁾	Cookes Int. ⁽¹⁾	Cookes High ⁽¹⁾	Pro Brush	Smith College
<u>CIVIL</u>							
Dam Work	48	5	5	5	48	5	12
Intake	42	16	32	16	42	19	19
Powerhouse	43	40	40	40	40	43	36
Tailrace Excavation	3	2	2	2	2	13	--
Penstock	--	30	--	180	579	--	--
SUB-TOTAL	136	93	79	243	711	80	67
Contingency 25%	34	23	20	61	178	20	17
TOTAL CIVIL	170	116	99	304	889	100	84
<u>EQUIPMENT</u>							
Intake Gate and Trashrack	20	20	20	20	20	20	20
Penstock Pipe	3	18	3	108	336	3	3
Turbine-Generator	350	340	350	350	375	350	340
Electrical Equipment	165	160	163	163	163	165	167
SUB-TOTAL	538	538	536	641	894	538	530
Contingency 10%	54	54	54	64	89	54	53
TOTAL EQUIPMENT	592	592	590	705	983	592	583
CONSTRUCTION COST	762	708	689	1009	1872	692	667
Engineering and Owner's Administration	118	112	111	151	288	108	103
CAPITAL COST	880	820	800	1160	2160	800	770

Notes: (1) See Section 4.3.

(2) Costs are in mid-1978 dollars and represent all facilities required to tie the plants into the existing 13.8 kV distribution system in the City. They include allowances for engineering and Owner's administration but exclude interest during construction.

Routine maintenance of the plants would be required. This would include such things as cleaning trashracks, replacing minor parts of the equipment, and keeping the plant and grounds clean and tidy. It was assumed that this would require a further 1000 manhours at an average rate of \$10 per hour giving a cost of time of \$10,000 per year. A vehicle would also be necessary to carry out this work and, as before, an allowance of \$2000 per year was made. In addition, an annual sum of \$6000 was allowed for parts and materials. It was also assumed that a dragline would be required for several days each year to remove silt from the intakes and headponds, and an allowance of \$3000 was made to cover this cost. This results in a total annual estimated cost for routine maintenance of \$21,000.

Interim replacement would include non-routine maintenance of civil works, such as repair of concrete, as well as replacement of electrical and mechanical equipment. It was estimated that, on average, about \$12,000 per year would be required to cover this work.

It was assumed that insurance would be carried on the four plants to cover loss by fire and third party risks. It can be expected that the annual premium for such insurance coverage would be in the order of \$5000.

The total estimate of the annual costs for the four plants, excluding capital repayment, is \$55,000. This represents about 1.5% of the estimated total capital cost of \$3.61 million.

Because of economies of scale which might be expected to occur with the conjunctive operation and maintenance of all four plants, the corresponding annual cost for an individual plant would likely be a greater percentage of its capital cost and might be in the order of \$20,000 per project.

4.3 Combined Development Alternatives

For the development of the upper three projects the three alternatives were compared on the basis of index energy cost using the corresponding capital costs developed in Section 4.2.1 and the average annual energy estimates given in Section 3.0. Table 4-2 shows the comparison and indicates that Alternative II, which combines the head at Button Shop and Cookes, together with the separate development of Chartpak, is the most economic method of developing the head in this reach of river. Consequently, Alternatives I and III were not considered further in the present study.

Table 4-2: Comparison of Alternative Developments for
Chartpak, Button Shop, and Cookes Projects

	Alternative		
	I	II	III
<u>Capital Cost (\$ x 10³)</u>			
Chartpak	880	880	--
Button Shop	820	--	--
Cookes	<u>800</u>	<u>1160</u>	<u>2160</u>
TOTAL	2500	2040	2160
<u>Average Energy (MWh/a)</u>			
Chartpak	850	850	--
Button Shop	315	--	--
Cookes	<u>680</u>	<u>1140</u>	<u>2080</u>
TOTAL	1845	1990	2080
<u>INDEX ENERGY COST</u> <u>(\$/Av. Ann. MWh)</u>			
	1355	1025	1040

4.4 Project Schedule

Plate 4-3 shows a preliminary schedule for the design and construction of the power facilities. It was assumed that all developments would be under construction

simultaneously. Work would begin on the civil construction of all sites at about the same time. The commissioning of units would begin with Smith College, which has the least construction work, to allow more time for the additional work at Cookes and Chartpak.

As shown in Plate 4-3 a minimum of nine months would be required prior to award of contracts for detailed design, advertisement for bids, and preparation and analysis of bids. The contract for the turbine-generator units would be placed early in the year with delivery of the first turbine runner between six and eight months later. Electrical equipment would be scheduled for delivery about September. The civil contract should be awarded in the spring, at about the same time as the major equipment contract, with construction proceeding during the summer. All civil work, including penstock installation, would be completed by the end of the year. The powerhouses would be enclosed by early fall in order to allow unit installation to proceed through the late fall and winter unhindered by the weather. Units would be commissioned at the various sites at about one-month intervals.

If a decision were made to implement any of the projects, application for a Federal Energy Regulatory Commission (FERC) short-form license should be made as soon as possible after the decision to proceed. Also, coordination should be begun with the federal and state agencies involved in environmental reviews and other aspects to minimize delays on approvals for the project. By actively involving relevant agencies early in the licensing process, it is likely that agreements can be arrived at expeditiously. Barring delays, the licensing could proceed concurrently with the design and be completed prior to the scheduled construction start shown on Plate 4-3.

Plate 4-3: Preliminary Schedule of Developments

5.0 MARKETING POTENTIAL AND VALUE OF POWER

5.1 Value of Power

During the course of the present study meetings were held with representatives of Massachusetts Electric Company (MEC), which is the electric utility serving the City of Northampton, to discuss the possibility of MEC purchasing the power from the proposed hydro developments and to discover what price MEC would be willing to pay for the power. Officials of the utility indicated that MEC policy is to cooperate in, what they term, "cogeneration projects" and that they would be willing to buy energy available directly from the Mill River projects at the prevailing fuel displacement rate (currently 22 mills/kWh). The utility would give no credit for capacity associated with power purchased directly from the hydro projects.

The dams and water rights at Chartpak, Pro Brush and Smith College are owned by industrial and educational establishments which purchase electricity from MEC according to the appropriate rate schedules. If power from the corresponding hydro plants were used to reduce purchases by the owners from MEC then the value of power from these plants would be substantially in excess of the fuel displacement rate. MEC indicated that since the amount of power from the Mill River plants would be small, use of the output to reduce purchases would not result in the application of a different rate schedule to these three customers.

Power from the Cookes Intermediate project could not be used to directly serve a well defined electrical load and, hence, power from this plant was assumed to be sold directly to MEC at the fuel displacement rate.

A computer program was developed to assist in the calculation of the value of the average power output from the Chartpak, Pro Brush and Smith College plants. The program replicates the computation of monthly billings according to the utility's rate structures applied to each of the three individual owners. The program was first run using actual monthly peak demand and energy usage from the most recent year of record, from data supplied by the owners. This established a baseline annual cost of purchased power for each owner. The program was then rerun with the peak and average energy potential of each project subtracted from the appropriate monthly baseline totals to simulate an average billing year with the project in operation.

For the purposes of this second run it was assumed that the hydro plants could supply reliable peaking capacity to the owners during the high and medium flow months of the year. The amount of reliable peaking capacity at each of the three plants was estimated by reducing the corresponding value of installed capacity to reflect the likelihood of having to produce peak power at less than optimal conditions. The average monthly energy outputs at each plant were calculated from the appropriate average annual value using the monthly distribution given in Section 3.4.

The results of the computer simulation of monthly utility billings for Chartpak, Pro Brush and Smith College, with and without the hydro plants in operation, are given in Exhibits 5-1, 5-2, and 5-3, respectively.

In the cases of Pro Brush and Smith College all of the power produced by the corresponding hydro plants could be consumed by the owners to reduce purchases from MEC. Therefore, for each of these two projects the value of power was

taken as the difference between utility charges for the historical case and the case with the hydro plant in operation.

At certain times of the year the Chartpak project would produce more electrical power than the company could use. It was assumed that the unusable, or residual, portion of the plant output would be sold directly to MEC at the fuel displacement rate.

5.2 Calculation of Direct Project Benefits

The value of power from each hydro plant in this Section is based on the rates and prices applicable in 1978. In the economic analysis described in Part 6 an inflation factor was applied to give estimates of value in subsequent years.

5.2.1 Chartpak. As discussed in Section 5.1, revenue from the Chartpak project would derive from two sources. Firstly, that portion of the plant output which could be used by the Chartpak company was valued at the saving to the company in purchases from the utility. Secondly, the residual portion of plant output would be sold to the utility at the fuel displacement rate.

Using the computer simulations shown in Exhibit 5-1, the total value of power produced by the Chartpak hydro plant was calculated as follows:

Capacity available to meet peak demand	204 kW
Average annual hydro energy output	850,000 kWh
Portion used by Chartpak company	691,000 kWh
Residual portion sold to utility	159,000 kWh
Historical annual utility billing	\$ 53,827
Simulated billing with average annual hydro output	<u>23,102</u>
Average annual revenue equivalent	\$ 30,725
Average annual residual energy	159,000 kWh
Sale price to utility	<u>2.2¢/kWh</u>
Average annual direct revenue	\$ 3,498
Total average annual direct benefits	<u>\$ 34,223</u>

5.2.2 Cookes Intermediate. All output from the Cookes Intermediate project was assumed to be sold directly to the utility at the fuel displacement rate and the corresponding annual revenue was calculated as follows:

Average annual hydro energy output	1,140,000 kWh
Sale price to utility	<u>2.2¢/kWh</u>
Total average annual direct benefits	<u>\$ 25,080</u>

5.2.3 Pro Brush. All plant output from this project would be used by the Pro Brush company to reduce purchases from the utility. The value of hydro power produced was estimated as follows, using the calculations shown in Exhibit 5-2:

Capacity available to peak demand	171 kW
Average annual hydro energy output	845,000 kWh
Historical annual utility billing	\$727,560
Simulated billing with average annual hydro output	<u>692,857</u>
Total average annual direct benefits	<u>\$ 31,703</u>

5.2.4 Smith College. Again, all hydro plant output would be used by Smith College to reduce purchases from the utility. Exhibit 5-3 was used to calculate the value of the hydro power from this project as follows:

Capacity available to meet peak demand	106 kW
Average annual hydro energy output	570,000 kWh
Historical annual utility billing	\$579,957
Simulated billing with average annual hydro output	<u>558,906</u>
Total average annual direct benefits	<u>\$ 21,051</u>

COMPUTATION OF ANNUAL REVENUE EQUIVALENT FOR CHARTPAK PROJECT

PROJECT PAK		DEMAND/ENERGY ANALYSIS FOR LOW-HEAD HYDRO, MILL RIVER, NORTHAMPTON, MASS.											HISTORIC CASE
SCHEDULE 022	RATE	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT	OCT.	NOV.	DEC.
A. DEMAND CHARGE													
TOTAL DEMAND (KW)		267.	267.	271.	256.	273.	342.	348.	378.	324.	302.	264.	275.
CHARGE(\$)													
FIRST 5	\$21.20	21	21	21	21	21	21	21	21	21	21	21	21
NEXT 5	\$2.36	11	11	11	11	11	11	11	11	11	11	11	11
NEXT 15	\$2.01	30	30	30	30	30	30	30	30	30	30	30	30
NEXT 75	\$1.87	140	140	140	140	140	140	140	140	140	140	140	140
XCS OF 100	\$1.73	288	288	295	269	299	418	429	480	387	349	283	302
SUBTOTAL(\$)		490	490	497	471	501	620	631	682	589	551	485	504
B. ENERGY CHARGE													
USAGE (1000 KWH)		89.	87.	83.	85.	84.	108.	121.	128.	107.	100.	73.	86.
FUEL ADJUSTMENT(\$)	\$.01800	1602	1566	1494	1530	1548	1944	2178	2304	1925	1800	1314	1548
CHARGE(\$)													
FIRST 500	\$.03859	19	19	19	19	19	19	19	19	19	19	19	19
NEXT 500	\$.03100	15	15	15	15	15	15	15	15	15	15	15	15
NEXT 4,000	\$.02822	112	112	112	112	112	112	112	112	112	112	112	112
NEXT 5,000	\$.02563	128	128	128	128	128	128	128	128	128	128	128	128
NEXT 40,000	\$.02470	988	988	988	988	988	988	988	988	988	988	988	988
NEXT 50,000	\$.02289	77	77	96	27	105	421	448	585	338	238	64	114
XCS OF 100,000	\$.02134	0	0	0	0	0	0	0	0	0	0	0	0
XCS OF 200 HU/KW	\$.02033	542	542	550	520	555	695	707	768	658	613	410	559
XCS OF 300 HU/KW	\$.01926	171	132	32	157	78	104	319	281	188	181	0	67
XCS OF 400 HU/KW	\$.01624	0	0	0	0	0	0	0	0	0	0	0	0
SUBTOTAL(\$)		3654	3579	3434	3496	3548	4426	4914	5200	4371	4094	3050	3550
=====													
C. TOTAL(\$)		4144	4069	3931	3967	4049	5046	5545	5882	4960	4645	3535	4054
=====													
TOTAL CHARGES FOR YEAR (\$)=													53827

EXHIBIT 5-1

COMPUTATION OF ANNUAL REVENUE EQUIVALENT FOR CHARTPAK PROJECT (CONT.)

PROJECT-CHARTPAK		DEMAND/ENERGY ANALYSIS FOR LOW-HEAD HYDRO, MILL RIVER, NORTHAMPTON, MASS.											HYDRO	CASE
SCHEDULE G22	RATE	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT	OCT.	NOV.	DEC.	
A. DEMAND CHARGE														
TOTAL DEMAND (KW)		63.	63.	67.	52.	69.	138.	348.	378.	324.	302.	60.	71.	
CHARGE (\$)														
FIRST 5	\$21.20	21	21	21	21	21	21	21	21	21	21	21	21	
NEXT 5	\$2.36	11	11	11	11	11	11	11	11	11	11	11	11	
NEXT 15	\$2.01	30	30	30	30	30	30	30	30	30	30	30	30	
NEXT 75	\$1.87	71	71	78	50	82	140	140	140	140	140	65	86	
XCS OF 100	\$1.73	0	0	0	0	0	65	429	480	387	349	0	0	
SUBTOTAL (\$)		133	133	140	112	144	267	631	682	589	551	127	148	
B. ENERGY CHARGE														
USAGE (1000 KWH)		18.	17.	0 *	0 *	0 *	45.	95.	107.	84.	72.	12.	13.	
FUEL ADJUSTMENT (\$)	\$.01800	324	306	0	0	0	810	1710	1925	1512	1296	216	234	
CHARGE (\$)														
FIRST 500	\$.03859	19	19	0	0	0	19	19	19	19	19	19	19	
NEXT 500	\$.03100	15	15	0	0	0	15	15	15	15	15	15	15	
NEXT 4,000	\$.02822	112	112	0	0	0	112	112	112	112	112	112	112	
NEXT 5,000	\$.02563	128	128	0	0	0	128	128	128	128	128	128	128	
NEXT 40,000	\$.02470	64	64	0	0	0	434	988	988	988	988	49	74	
NEXT 50,000	\$.02289	123	100	0	0	0	398	448	585	338	238	0	0	
XCS OF 100,000	\$.02134	0	0	0	0	0	0	0	0	0	0	0	0	
XCS OF 200 HL/KW	\$.02033	0	0	0	0	0	0	516	638	390	235	0	0	
XCS OF 300 HL/KW	\$.01926	0	0	0	0	0	0	0	0	0	0	0	0	
XCS OF 400 HL/KW	\$.01624	0	0	0	0	0	0	0	0	0	0	0	0	
SUBTOTAL (\$)		785	744	0	0	0	1916	3936	4410	3502	3031	539	582	
C. TOTAL (\$)														
		918	877	140	112	144	2183	4567	5092	4091	3582	666	730	
TOTAL CHARGES FOR YEAR (\$)=												23102		
EXCESS ENERGY PROVIDED BY HYDRO (KWH/YR)= 159000.00														

* Usage is regligible (less than 1000 kwh)

EXHIBIT 5-2

COMPUTATION OF ANNUAL REVENUE EQUIVALENT FOR PRO BRUSH PROJECT

PROJECT-PROBRUSH		DEMAND/ENERGY ANALYSIS FOR LOW-HEAD HYDRO, MILL RIVER, NORTHAMPTON, MASS.										HISTORIC CASE	
SCHEDULE H	RATE	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT	OCT.	NOV.	DEC.
A. DEMAND CHARGE													
TOTAL DEMAND (KW)		2700.	3150.	3300.	3000.	3000.	3300.	3300.	3300.	3500.	2800.	3250.	3250.
CHARGE(\$)													
FIRST 500	\$830.00	830	830	830	830	830	830	830	830	830	830	830	830
XCS OF 500	\$1.57	3454	4160	4396	3925	3925	4396	4396	4396	4710	3611	4317	4317
SUBTOTAL(\$)		4284	4990	5226	4755	4755	5226	5226	5226	5540	4441	5147	5147
E. ENERGY CHARGE													
USAGE (1000 KWH)		1520.	1545.	1305.	1815.	1135.	1610.	1605.	1525.	1775.	1515.	1605.	1475.
FUEL ADJUSTMENT(\$)	\$0.01800	27360	27809	23490	32670	20429	28980	28889	27450	31950	27270	28889	26550
CHARGE(\$)													
FIRST 50,000	\$0.02648	1324	1324	1324	1324	1324	1324	1324	1324	1324	1324	1324	1324
NEXT 50,000	\$0.02350	1175	1175	1175	1175	1175	1175	1175	1175	1175	1175	1175	1175
XCS OF 100,000	\$0.02043	8989	10827	11440	10215	10215	11440	11440	11440	12258	9397	11236	11236
XCS OF 200 HU/KW	\$0.01927	5202	6070	6359	5781	5781	6359	6359	6359	6744	5395	6262	6262
XCS OF 300 HU/KW	\$0.01464	3952	4611	4611	4392	3440	4831	4831	4831	5124	4099	4758	4758
XCS OF 400 HU/KW	\$0.01362	3677	3881	0	4086	0	3949	3881	2792	4767	3813	4154	2383
XCS OF 500 HU/KW	\$0.01310	2227	0	0	4126	0	0	0	0	327	1506	0	0
SUBTOTAL(\$)		53906	55697	48399	63769	42364	58058	57899	55371	63669	53979	57798	53688
C. TOTAL(\$)													
		58190	60687	53625	68524	47119	63284	63125	60597	69209	58420	62945	58835
TOTAL CHARGES FOR YEAR (\$)=												724560	

COMPUTATION OF ANNUAL REVENUE EQUIVALENT FOR PRO BRUSH PROJECT (CONT.)

PROJECT-FROBUSH		DEMAND/ENERGY ANALYSIS FOR LOW-HEAD HYDRO, MILL RIVER, NORTHAMPTON, MASS.										HYDRO	CASE
SCHEDULE H	RATE	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
A. DEMAND CHARGE													
TOTAL DEMAND (KW)		2529.	2979.	3129.	2829.	2829.	3129.	3300.	3300.	3500.	2800.	3079.	3079.
CHARGE(\$)													
FIRST 500	\$830.00	830	830	830	830	830	830	830	830	830	830	830	830
XCS OF 500	\$1.57	3185	3892	4127	3656	3656	4127	4396	4396	4710	3611	4049	4049
SUBTOTAL(\$)		4015	4722	4957	4486	4486	4957	5226	5226	5540	4441	4879	4879
B. ENERGY CHARGE													
USAGE (1000 KWH)		1449.	1476.	1173.	1654.	1018.	1547.	1579.	1504.	1752.	1487.	1544.	1402.
FUEL ADJUSTMENT(\$)	\$0.01800	26082	26568	21114	29772	18324	27846	28422	27071	31536	26766	27792	25236
CHARGE(\$)													
FIRST 50,000	\$0.02648	1324	1324	1324	1324	1324	1324	1324	1324	1324	1324	1324	1324
NEXT 50,000	\$0.02350	1175	1175	1175	1175	1175	1175	1175	1175	1175	1175	1175	1175
XCS OF 100,000	\$0.02043	8290	10129	10742	9516	9516	10742	11440	11440	12258	9397	10537	10537
XCS OF 200 HU/KW	\$0.01927	4873	5740	6029	5451	5451	6029	6359	6359	6744	5395	5933	5933
XCS OF 300 HU/KW	\$0.01464	3792	4361	3430	4141	2478	4580	4831	4831	5124	4099	4507	4507
XCS OF 400 HU/KW	\$0.01362	3444	3873	0	3853	0	4023	3527	2506	4767	3813	4193	2320
XCS OF 500 HU/KW	\$0.01310	2416	0	0	3137	0	0	0	0	26	1139	58	0
SUBTOTAL(\$)		51306	53170	43814	58369	38268	55719	57078	54706	62954	53108	55519	51032
C. TOTAL(\$)													
		55321	57892	48771	62855	42754	60676	62304	59932	68474	57549	60398	55911
TOTAL CHARGES FOR YEAR (\$)=												692857	
EXCESS ENERGY PROVIDED BY HYDRO (KWH/YR)=													
0													

COMPUTATION OF ANNUAL REVENUE EQUIVALENT FOR SMITH PROJECT

PROJECT-SMITH		DEMAND/ENERGY ANALYSIS FOR LOW-HEAD HYDRO, MILL RIVER, NORTHAMPTON, MASS.											HISTORIC CASE	
SCHEDULE H	RATE	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT	OCT.	NOV.	DEC.	
A. DEMAND CHARGE														
TOTAL DEMAND (KW)		2520.	2556.	2700.	2484.	2772.	2520.	2808.	2664.	2520.	2736.	2808.	2808.	
CHARGE(\$)														
FIRST 500	\$830.00	830	830	830	830	830	830	830	830	830	830	830	830	
XCS OF 500	\$1.57	3171	3227	3454	3114	3567	3171	3623	3397	3171	3510	3623	3623	
SUBTOTAL(\$)		4001	4057	4284	3944	4397	4001	4453	4227	4001	4340	4453	4453	
B. ENERGY CHARGE														
USAGE (1000 KWH)		1135.	1192.	1408.	1138.	1181.	1008.	1166.	1102.	1332.	1368.	1253.	1246.	
FUEL ADJUSTMENT(\$)	\$.01800	20345	21456	25344	20484	21258	18144	20988	19836	23976	24624	22554	22428	
CHARGE(\$)														
FIRST 50,000	\$.02648	1324	1324	1324	1324	1324	1324	1324	1324	1324	1324	1324	1324	
NEXT 50,000	\$.02350	1175	1175	1175	1175	1175	1175	1175	1175	1175	1175	1175	1175	
XCS OF 100,000	\$.02043	8253	8400	8989	8106	9283	8253	9430	8842	8253	9136	9430	9430	
XCS OF 200 HU/KW	\$.01927	4856	4925	5202	4786	5341	4856	5411	5133	4856	5272	5411	5411	
XCS OF 300 HU/KW	\$.01464	3689	3741	3952	3636	4058	3689	4110	3900	3689	4005	4110	4110	
XCS OF 400 HU/KW	\$.01362	1661	2309	3677	1966	983	0	582	495	3432	3726	1767	1672	
XCS OF 500 HU/KW	\$.01310	0	0	759	0	0	0	0	0	943	0	0	0	
SUBTOTAL(\$)		41295	43330	50422	41477	43422	37441	43020	40705	47648	49262	45771	45550	
=====														
C. TOTAL(\$)		45299	47387	54706	45421	47819	41442	47473	44932	51649	53602	50224	50003	
												TOTAL CHARGES FOR YEAR (\$)=		579957

COMPUTATION OF ANNUAL REVENUE EQUIVALENT FOR SMITH PROJECT (CONT.)

PROJECT-SMITH		DEMAND/ENERGY ANALYSIS FOR LOW-HEAD HYDRO, MILL RIVER, NORTHAMPTON, MASS.										HYDRO	CASE
SCHEDULE H	RATE	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT	OCT.	NOV.	DEC.
A. DEMAND CHARGE													
TOTAL DEMAND (KW)		2414.	2450.	2594.	2378.	2666.	2414.	2808.	2664.	2520.	2736.	2702.	2702.
CHARGE(\$)													
FIRST 500	\$830.00	830	830	830	830	830	830	830	830	830	830	830	830
XCS OF 500	\$1.57	3054	3061	3287	2948	3400	3004	3623	3397	3171	3510	3457	3457
SUBTOTAL(\$)		3834	3891	4117	3778	4230	3834	4453	4227	4001	4340	4287	4287
B. ENERGY CHARGE													
USAGE (1000 KWH)		1082.	1145.	1319.	1029.	1102.	966.	1148.	1088.	1317.	1349.	1212.	1197.
FUEL ADJUSTMENT(\$)	\$.01800	19476	20610	23741	18522	19836	17388	20664	19584	23706	24281	21815	21546
CHARGE(\$)													
FIRST 50,000	\$.02648	1324	1324	1324	1324	1324	1324	1324	1324	1324	1324	1324	1324
NEXT 50,000	\$.02350	1175	1175	1175	1175	1175	1175	1175	1175	1175	1175	1175	1175
XCS OF 100,000	\$.02043	7820	7967	8554	7673	8850	7820	9430	8842	8253	9136	8997	8997
XCS OF 200 HU/KW	\$.01927	4651	4721	4998	4582	5137	4651	5411	5133	4856	5272	5206	5206
XCS OF 300 HU/KW	\$.01464	3534	3586	3797	3481	3903	3534	4110	3900	3689	4005	3955	3955
XCS OF 400 HU/KW	\$.01362	1885	2247	3533	1059	484	5	337	305	3432	3467	1786	1582
XCS OF 500 HU/KW	\$.01310	0	0	288	0	0	0	0	0	746	0	0	0
SUBTOTAL(\$)		39565	41630	47412	37816	40709	35897	42451	40263	47181	48660	44258	43785
C. TOTAL (\$)													
		43399	45521	51529	41594	44939	39731	46904	44490	51182	53000	48545	48072
TOTAL CHARGES FOR YEAR (\$)=												558906	
EXCESS ENERGY PROVIDED BY HYDRO (KWH/YR)=													
0													

6.0 ECONOMIC FEASIBILITY AND BENEFIT-COST ANALYSIS

6.1 Summary of Capital Costs and Power Outputs

The following table summarizes the results of the estimates of capital costs and power potentials. As discussed in Section 4.3, it was assumed that the heads at Button Shop and Cookes would be combined.

Table 6-1: Summary of Capital Costs and Power Potentials:

Development	Installed Capacity	Average Energy	Capacity Factor	Capital Cost	Index Costs	
					Capacity	Energy
	kW	MWh/a		\$ x 10 ³	\$/kW	\$/Av. Ann. MWh
Chartpak	235	850	0.41	880	3740	1040
Cookes Int.	265	1140	0.49	1160	4380	1020
Pro Brush	200	845	0.48	800	4000	950
Smith College	<u>120</u>	<u>570</u>	<u>0.54</u>	<u>770</u>	<u>6420</u>	<u>1350</u>
All Projects	820	3405	0.47	3610	4400	1060

Note: Costs are in mid-1978 dollars and represent all facilities required to tie plants into the existing 13.8 kV distribution system in the City. They include allowances for engineering and Owner's administration but exclude interest during construction.

The anticipated useful life of the projects as used in the benefit-cost analyses was taken to be 50 years. This is based upon a 50-year life for all equipment and new civil works, allowing for interim replacements in the operating costs. On the basis of the field inspections, described in Appendix A, it is anticipated that the remaining life of the existing structures is in excess of 50 years.

6.2 Feasibility and Benefit-Cost Methodology

Economic feasibility of each of the four Mill River projects was assessed

in terms of annual cash flow projections and present-value investment analysis. A program was developed to allow for testing of the sensitivity of project feasibility to changes in cost variables. Cost variables were manipulated to represent the effects of alternative potential federal or state programs to assist in the development of low-head hydroelectric facilities. Criteria provided for evaluating project feasibility included overall benefit-cost ratio, cost per kilowatt-hour, investment benefit-cost ratio, internal rate of return on investment, and first year of positive cash flow, as well as the annual cash flow projections.

Sample financial analyses for the combined projects, as well as for each individually, are presented in Exhibits 6-1 through 6-5. The projections are carried through a 50-year investment life cycle, preceded by two years of engineering and construction. Cash flow is shown annually by column for the first 10 years, and by 5-year intervals thereafter. Present value of cash flow categories is indicated in the column on the far right.

Elements of the financial analysis include the following:

- A. Operating and Maintenance Costs. O&M costs, as determined in Section 6.4, reflect significant economies of scale. While annual O&M costs for the combined projects is projected to be \$55,000, the annual cost for each project individually is estimated to be \$20,000. Inflation is included according to a rate specified as an input variable.
- B. Value of Power. The phrase "value of power" is used as a label signifying the value to the user of the plants' electrical output, evaluated at the cost of purchased energy. The inflation rate applied to this cost is

specified as an input variable.

- C. Sales Revenue. All electricity generated by the Cookes Intermediate project, and residual electricity from the Chartpak project, would be sold to Mass. Electric Co. at the "fuel displacement" rate of 22 mills/kWh. The inflation rate is specified as input.
- D. Net Operating Revenues. Total cash flow income (e.g., benefits) less O&M costs equals net project operating revenues. This value is the cash flow available on an annual basis to repay the total capital invested in the project, plus provide for a return on invested capital. Part of this return on invested capital accrues to lenders as debt interest payments, and part accrues to the owner(s) as return on equity after payment of income taxes.
- E. Return on Investment. This figure indicates the annual return on invested capital as the ratio of annual net operating revenues to total initial investment. It is a measure of the attractiveness of an investment relative to alternative uses of capital (on an annual basis).
- F. Interest. It is assumed for purposes of analysis that the major portion of capital cost is financed through a corporate or municipal sinking fund bond issue. Annual interest payments on the face value of the bonds, over a twenty year term typical of municipal financing, are shown in the examples. The interest rate is a specified input variable.
- G. Sinking Fund. A sinking fund with level annual payments is established to provide for repayment of bond issue principal at the end of the financing term. Interest earned on the sinking fund is a specified input variable.

H. Cash Flow Before Tax. Net income less debt retirement (interest and sinking fund payments) equals cash flow balance. This is, in effect, the "profit" from the project, although the true profit for a corporate entity would deviate from this value somewhat depending on the details of accounting practice with regard to depreciation and other factors.

I. Cash Flow After Tax. For the Pro Brush and Chartpak projects, gross cash flow income is assumed to be subject to the prevailing corporate income tax rate (46%). "Profit" is reduced accordingly.

J. Equity. Equity is the capital supplied by the owner, as distinct from the capital supplied through financing (e.g., bonds). Categories of potential equity investment include:

--Engineering and Administration. These are the "development costs" incurred during the pre-operational phase of the project. They include primarily engineering fees and the time spent by the owner's administrative and technical staff, and are shown in years D1 and D2.

--Construction Interest. Interest must be paid on the loan used to finance progress payments to the construction contractors. If the owner pays this interest, it is shown in year D2.

--Dam Value. The existing dam and the land under it is contributed to the project by the owner. If this structure is deemed to have any current value, or if any potential value is foregone by virtue of its use in the project, then such value (less the present worth of ultimate salvage value) is part of the owner's equity investment.

--Other. This category is included to account for any miscellaneous or contingency expenses to the owner. An example would be fees paid to the bond underwriters. Also included in this row would be any funds supplied directly by the owner toward the cost of civil works or generating equipment.

- K. Annual Return on Equity. Annual return on equity is the ratio of annual after-tax cash flow balance to owner's initial equity in the project. It is a measure of the attractiveness of a project from the owner's point of view (on an annual basis).
- L. Investment Benefit-Cost Ratio. This ratio consists of the present value of total net operating revenues divided by the present value of total invested capital, using the current Water Resources Council's standard discount rate of 6-5/8 percent. Present value analysis is useful in that it allows future benefits to be rationally related to present costs, and further allows for comparison of alternatives which have different investment patterns. However, a value greater than one does not necessarily imply that a project is desirable. The ratio is more appropriately viewed as a composite of all of the annual returns on investment, and can only be evaluated in comparison to other options for the use of capital. On the other hand, a project with a ratio less than one is not a likely candidate for investment, unless public policy considerations dictate such a decision.
- M. Return on Investment (Internal Rate). The internal rate of return on an investment is a measure of the economic "profitability" of an investment. The rate is computed as the discount rate which yields a present value of all benefits equal to the present value of all costs. This rate is then evaluated by comparison to the standard federal discount rate (6 5/8%).
- N. Overall Benefit-Cost Ratio. This measure is similar to the investment benefit-cost ratio, except that net operating income is broken down in the computations: O&M costs are calculated in the denominator with costs, and benefits are strictly revenues or their equivalent. This method is more

typically used in evaluating public sector projects, and corresponds to the meaning of the term "benefit-cost ratio" in general usage.

- O. Cost per Kilowatt-Hour. Present value of total costs (capital plus O&M) divided by total electrical output over the fifty year life cycle of the plant gives an average overall cost of electrical generation per kilowatt-hour over the life of the plant. This present value cost should be used only for comparison among the individual projects and cannot be compared directly with the prevailing current price of electrical energy.

6.3 Sensitivity Testing

The design of the program used to perform the economic analysis described above allowed for a wide range of simulations to model the economic effects of a variety of project conditions and potential assistance programs. The possibilities demonstrated in these tests include the following:

- A. Inflation. Separate input values are specified for inflation rates relative to O&M costs, value of power plant output to user, and sales price of power to the utility. Consistent with the basis of the federal discount rate, the analysis is in constant or "real" dollars. Hence the inflation rates specified are differentials over and above the prevailing general or "monetary" inflation rate.
- B. Financing Arrangements. The effects of extended financing terms, and of higher and lower bond and sinking fund interest rates, were tested by changing input variables appropriately.
- C. Equity/Debt Ratio. A test where 25% of construction cost is supplied by the owner (thereby reducing the amount to be financed) demonstrated the sensitivity of project feasibility to a maximum plausible equity contribution.

Conversely, a simulation was run involving only token equity participation by the owner.

- D. Annual O&M Costs. Tests were run with O&M costs substantially lower than projected to simulate the possible savings to the owners from use of existing technical staff and equipment for project operation.
- E. Development Grants. Engineering/administration and construction interest costs were removed from the financial analysis to simulate grants for project pre-operational planning and development.
- F. Loan Guarantees. The market interest rate for long term debt was reduced by 2% to simulate the effect of a loan guarantee program.
- G. Tax Advantages. Income taxes were reduced from 46% to 25% to simulate the effects of such programs as accelerated depreciation or an investment tax credit.
- H. Construction Grants. Input specifications allow for removal of any desired portion of construction cost from the financial analysis to simulate the effect of a construction grant program. Tests were run with 25% and 50% construction grants.

6.4 Results

The results of economic analysis for "baseline" projections (i.e., with the "most probable" values for input variables) are those shown in Exhibit 6-1 for all projects jointly and in Exhibits B-1 through B-4 (Appendix B) for individual projects. Neither the four projects combined, nor any projects individually,

EXHIBIT 6-1

FINANCIAL ANALYSIS FOR ALL PROJECTS JOINTLY

PROJECT-COMBIN01
FINANCIAL ANALYSIS OF LOW-HEAD HYDRO, MILL RIVER, NORTHAMPTON, MASS.

LISTING OF INPUT DATA

ENGR/ADMIN COSTS, YEAR D1 (K\$)=	200.00
ENGR/ADMIN COSTS, YEAR D2 (K\$)=	280.00
SOURCE OF ENGR/ADMIN COSTS=	OWNER
CONSTR. INTEREST COST, YEAR D2 (K\$)=	110.00
SOURCE OF CONSTR. INTEREST COSTS=	OWNER
OPERATION + MAINTENANCE COST (K\$/YR)=	55.00
VALUE OF EXISTING DAM (K\$)=	350.00
VALUE OF MISC. EQUITY, YEAR D1 (K\$)=	20.00
VALUE OF MISC. EQUITY, YEAR D2 (K\$)=	20.00
POWER AVAILABLE FROM HYDRO (KWH/YR)=	3405000.
VALUE OF PLANT OUTPUT (AS OF YR D1)(K\$/YR)=	83.48
EXCESS ENERGY FROM HYDRO (KWH/YR)=	1299000.00
SALE PRICE FOR EXCESS ENERGY (C/KWH)=	2.20
TOTAL CONSTR. COST (W/O ENGR/ADMIN)(K\$)=	3130.00
CONSTR. COST TO BE FINANCED (K\$)=	3130.00
CONSTR. COST FROM GRANT (K\$)=	0
CONSTR. COST FROM OWNER (K\$)=	0
YEARS FOR CONSTR. FINANCING=	20
DEBT INTEREST RATE (%/YR)=	8.00
SINKING FUND INTEREST RATE (%/YR)=	9.00
CORPORATE TAX RATE (%)=	26.00
ANNUAL INFLATION RATE, O + M (%/YR)=	2.00
ANNUAL INFLATION RATE, ENERGY SAVED (%/YR)=	4.00
ANNUAL INFLATION RATE, ELEC. SALES (%/YR)=	4.00

CALCULATED DATA

AMOUNT BORROWED, YEAR D1 (K\$)=	0
AMOUNT BORROWED, YEAR D2 (K\$)=	0
TOTAL BORROWED, YEAR 1 TO 50 (K\$)=	3130.00
CUM. TOTAL INVESTMENT, YEAR D1 (K\$)=	570.00
CUM. TOTAL INVESTMENT, YEAR D2 (K\$)=	980.00
CUM. TOTAL INVESTMENT, YEAR 1 TO 50 (K\$)=	4110.00

1.

PROJECT-COMBINO1		FINANCIAL ANALYSIS OF LOW-HEAD HYDRO, MILL RIVER, NORTHAMPTON, MASS.																			
YEAR	D1	D2	1	2	3	4	5	6	7	8	9	10	15	20	25	30	35	40	45	50	PV(K\$)
OPER. +MAINT. COSTS(K\$/YR)																					
	0	0	55.	56.	57.	58.	60.	61.	62.	63.	64.	66.	73.	80.	88.	98.	108.	119.	131.	145.	940.
BENEFITS(K\$/YR)																					
VAL. POWER	0	0	90.	94.	98.	102.	106.	110.	114.	119.	124.	129.	156.	190.	231.	282.	343.	417.	507.	617.	2176.
SALES REV.	0	0	31.	32.	33.	35.	36.	38.	39.	41.	42.	44.	54.	65.	79.	96.	117.	143.	174.	211.	745.
TOTAL	0	0	121.	126.	131.	136.	142.	147.	153.	159.	166.	173.	210.	255.	311.	378.	460.	560.	681.	828.	2921.
NET OPERATING REVENUES(K\$/YR)																					
	0	0	66.	70.	74.	78.	82.	87.	91.	96.	101.	107.	137.	175.	222.	280.	352.	440.	549.	683.	1981.
RETURN ON INVESTMENT(%/YR)																					
	0	0	2.	2.	2.	2.	2.	2.	2.	2.	2.	3.	3.	4.	5.	7.	9.	11.	13.	17.	
DEBT RETIREMENT(K\$)																					
INTEREST	0	0	250.	250.	250.	250.	250.	250.	250.	250.	250.	250.	250.	250.	0	0	0	0	0	0	2414.
SINKG. FUND	0	0	61.	61.	61.	61.	61.	61.	61.	61.	61.	61.	61.	61.	0	0	0	0	0	0	590.
TOTAL	0	0	312.	312.	312.	312.	312.	312.	312.	312.	312.	312.	312.	312.	0	0	0	0	0	0	3003.
CASH FLOW(K\$)																					
BEFORE TAX	0	0	-245.	-242.	-238.	-234.	-229.	-225.	-220.	-215.	-210.	-205.	-174.	-136.	222.	280.	352.	440.	549.	683.	-1022.
AFTER TAX	0	0	-245.	-242.	-238.	-234.	-229.	-225.	-220.	-215.	-210.	-205.	-174.	-136.	164.	207.	261.	326.	406.	505.	-1281.
EQUITY(K\$)																					
ENGR/ADMIN	200.	280.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONST. INT.	0	110.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DAM VALUE	350.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
"OTHER"	20.	20.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	570.	410.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RETURN ON EQUITY(%)																					

Table 6-2 Sensitivity Tests for All Projects Jointly

Sensitivity Tests	Input Baseline Value	Input Test Value	Overall Benefit- Cost Ratio	Cost/kWh (¢)	Investment Benefit- Cost Ratio	1st Yr. of Positive Cash Flow
BASELINE PROJECTION	All	--	.66	2.59	.57	After Debt Retirement
1. Inflation (O&M)	2%	1% 3%	.68 .64	2.51 2.69	.61 .52	" "
2. Inflation (Value of Output)	4%	2% 6%	.51 .94	2.59 2.59	.37 .92	" "
3. Inflation (Elec- tricity sales)	4%	2% 6%	.61 .76	2.59 2.59	.50 .69	" "
4. Financing Term	20 Yr.	30 Yr 40 Yr	.66 .66	2.59 2.59	.57 .57	" "
5. Debt Interest	10%	6% 8%	.66 .66	2.59 2.59	.57 .57	" "
6. Sinking Fund Interest	9%	7% 11%	.66 .66	2.59 2.59	.57 .57	" "
7. Equity/Debt Ratio	.24	.01 .43	.71 .66	2.42 2.59	.62 .57	" "
8. Annual O&M Cost	\$20K	\$ 5K \$12.5K	.75 .70	2.29 2.44	.72 .64	" "

show a benefit-cost ratio greater than .73 or an internal rate of return on investment greater than the specified discount rate. The two most favorable projects from an economic standpoint are Chartpak and Pro Brush, but neither of these would be attractive as corporate investments without substantial public subsidies.

6.4.1 Sensitivity Analysis. Summary results of the sensitivity analyses are shown in Table 6-2 and Tables B-1 through B-4 in Appendix B. These tables show the effects on five criteria for investment feasibility from alterations in projected values of eight input variables. Baseline results for the five criteria are shown in each table as a benchmark for comparison.

The findings indicate that the investment criteria are quite sensitive to the projected rate of inflation in utility rates (as reflected in the value of plant output to the user) relative to general inflation. Inflation in electrical rates in the range of 6% greater than general inflation is a threshold for attractive (but not competitive) project economics. However, as shown in Table 6-3, electric rate increases have not approached this level since the year immediately following the oil embargo.

Table 6-3: Comparison of Electric Rates and General Inflation

Year	Avg. Annual Bill per kWh Small Comm./Indust. Users*		Consumer Price Index		Difference
	Rate	Chng. From Prior Year	Index	Chng. From Prior Year	
1973	2.30¢		133.1		
1974	2.85¢	23.9%	147.7	11.0%	12.9%
1975	3.23¢	13.3%	161.2	9.1%	4.2%
1976	3.45¢	6.8%	170.5	5.8%	1.0%
1977	3.86¢	10.6%	181.5	6.5%	4.1%

*Data from Electrical World, McGraw-Hill, Inc., New York.

Financing arrangements have no effect on the project feasibility criteria. This is to be expected, since interest rates and bond terms affect neither capital invested nor net operating income, and thus are not relevant to the projects as economic propositions. Rather, these variables have an impact on annual cash flow, as defined herein, and thus pertain to the attractiveness of the projects as potential investment vehicles for particular municipal or corporate entities.

The feasibility criteria are sensitive in a modest degree to variation in annual O&M costs, but not to such an extent as to alter the overall evaluation of the projects' economic potential.

6.4.2 Program Alternatives. Summary results of the analyses of five possible programs of public assistance for low-head hydroelectric projects are shown in Table 6-4 and Appendix B Tables B-5 through B-8.

The analyses indicate that major capital grants in excess of 25 percent of construction costs would be required to make any of the projects yield a benefit-cost ratio of one or more from the standpoint of the municipal or corporate owner; hence the projects would become feasible from their point of view. It should be emphasized, however, that grant programs do not change the real economics of a project. Capital investment is not reduced, but the accounting for part of its cost is merely shifted from the project to an exogenous agency. Therefore, the true economic analyses for the assistance program alternatives remain the initial baseline results.

Table 6-4 Analysis of Assistance Program Alternatives for All Projects Jointly

Program Alternatives	Effect	Overall Benefit- Cost Ratio	Cost/kWh (¢)	Investment Benefit- Cost Ratio	1st Yr. of Positive Cash Flow
BASELINE PROJECTION		.66	2.59	.57	After Debt Retirement
1. <u>Development Grant:</u> <u>Grant for Eng./Admin.</u> <u>+ Construct. Interest</u> <u>Costs</u>	Equity investment reduced by \$590K	.75	2.27	.67	"
2. <u>Development Grant</u> <u>+ Loan Guarantee</u>	Not Applicable				
3. <u>Development Grant</u> <u>+ Loan Guarantee</u> <u>+ Accelerated</u> <u>Depreciation +</u> <u>Investment Tax</u> <u>Credit</u>	Not Applicable				
4. <u>Development Grant</u> <u>+ Grant for 25%</u> <u>of Construction</u> <u>Cost</u>	Equity investment reduced by \$590K; debt reduced by \$782K	.90	1.90	.86	"
5. <u>Development Grant</u> <u>+ Grant for 50%</u> <u>of Construction</u> <u>Cost</u>	Equity investment reduced by \$590K; debt reduced by \$1565K	1.13	1.52	1.20	"

7.0 LEGAL, ENVIRONMENTAL, AND SOCIO-INSTITUTIONAL OVERVIEW

The following sections address the water rights, regulatory, environmental, and socio-institutional questions surrounding development of hydro facilities at existing dams on the Mill River. From this initial overview, there do not appear to be any major problems that would serverely constrain or prevent project development. Should operating licenses be sought for any of the projects, the questions discussed in this chapter would need to be formally addressed as part of the license application process.

7.1 Water Rights

Riparian owners have the authority to appropriate the use of flowing water in non-navigable streams under the provisions of the Mill Acts (Mass. General Laws, Chapter 253). Section 1 states that, "A person may...erect and maintain a water mill and a dam to raise water for working it, upon and across any stream not navigable." *The term "water mill" is not restricted, and includes a mill operated by water to generate electricity. (Duncan v. New England Power Co., 113 N.E. 781).

This right of use has been very broadly construed by Massachusetts courts. The rule established by the courts is that,

...every proprietor of land through which a watercourse runs has a right to the use of the impelling force of the current, or what is more familiarly called the head and fall of the current, for mill purposes, so far as they exist on his own land, if there be any such head and fall within his own limits. (Gould v. Boston Duck Co., 79 Mass. 442)

*The term "streams not navigable" for purposes of the Mill Acts was meant to prohibit interference of dams with waterborne commerce. It is thus construed much more narrowly than "navigable waters" in the context of Section 404 and other Federal permits (see Section 7.2) which presently cover the great majority of waters of the United States, even including tributaries of traditionally navigable streams all the way to their headwaters.

7-1

This right to make use of "head and fall" within the owner's boundaries is pre-emptive, so long as that use is "reasonable," and the owner is therefore not liable for damages such use may impose on other downstream users:

... (The owner has) a right to use the water in a reasonable and lawful manner to work and operate his mill, whatever might be the effect of such use in reference to any easement to which proprietors of land situated at any point below it might otherwise be entitled. Each proprietor of land through which a natural watercourse flows has a right as owner of such land, and as inseparably connected with and incident to it, to the natural flow of the stream for any hydraulic purpose to which he may think fit to apply it; and it is a necessary consequence from this principle that such proprietor cannot be held responsible for any injurious consequences which result to others, if the water is used in a reasonable manner, and the quantity used is limited by, and does not exceed, what is reasonably and necessarily required for the operation and propulsion of works of such character and magnitude as are adapted and appropriate to the size and capacity of the stream and the quantity of water usually flowing therein. (City of Springfield v. Harris, 86 Mass. 494)

The courts have explicitly recognized that the right to the "natural flow" is secondary to the right to use the "head and fall," so that flow modification is taken for granted:

By the rule that all proprietors of land through which a watercourse passes have an equal right to the use of the power of the stream for mill purposes, it is not to be understood that each or any one has a right to the natural flow of the stream in the manner in which it ran originally, or as it would run if no mill were erected on it, or to be worked by it; in its mere natural flow, it affords no power. Dams must be made to raise it, and canals and sluices to conduct, apply and discharge it. The right to erect these works, and to change the natural mode of the flow of the current, is incident to the right of applying it to the working of mills, and this right therefore is common to every riparian proprietor... The mere erection of a dam, and the use of the water in driving wheels, must necessarily derange its steady and constant natural flow, and substitute a different manner, as to the time and mode of holding it up and letting it down. So far as such mode is reasonably incidental to the use of the stream for mill purposes, it is the right of the proprietor, and constitutes, in part, the mill privilege which the law gives him. (Gould v. Boston Duck Co.)

The Mill Acts further provide that a mill owner, in appropriating reasonable use, may flood upstream land--subject, however, to compensation in damages to upstream owners.

These statutory rights, and the case law interpreting them, provide a firm legal foundation to enable the owners to use the Mill River dams for hydroelectric purposes.

7.2 Regulatory Requirements

Federal, state and possibly local governments would become involved in various regulatory aspects of the Mill River hydro developments. The regulatory involvement would begin with a license application to the Federal Energy Regulatory Commission. The projects would meet the criteria set forth in recently promulgated rules for short-form hydroelectric licensing (published in Federal Register, September 11, 1978). The short-form license process is designed to eliminate obstacles to the development of small capacity water power projects. An application would contain a detailed description of the project as well as three major attachments: Exhibit K, a detailed map of the project lands and boundaries, Exhibit L, engineering drawings of project structures and equipment, and an environmental report.

During preparation of the application and environmental report, various resource agencies, including the Fish and Wildlife Service, Environmental Protection Agency, and Corps of Engineers in the Federal government; Massachusetts Department of Environmental Quality Engineering, Division of Fisheries & Wildlife, and Department of Environmental Management; the Northampton Conservation Commission, and others, would have to be consulted and their comments obtained. In addition to such consultation, permits would be required from several

of these agencies. Two permits would be required from the Corps of Engineers: (1) under Section 10 of the Rivers and Harbors Act of 1899 and (2) under Section 404 of the Federal Water Pollution Control Act Amendments of 1972 (discharge of dredged or fill material to navigable waters).

The Department of Environmental Quality Engineering (DEQE) would have the authority to issue a waterways permit for the projects, and DEQE's Division of Water Pollution Control would issue a water quality certificate. An Environmental Notification Form (ENF) would have to be filed with the Secretary of Environmental Affairs within 10 days after filing the first application for a state permit. The Secretary would then determine the need for an environmental report (EIR) on the project. Finally, the projects would require wetlands permits issued by the Department of Environmental Quality Engineering after approval by the Northampton Conservation Commission.

Should a decision to proceed with any of the projects be made, frequent and close coordination with all of the agencies would be important to expedite the regulatory reviews and issuance of permits and licenses. Such consultation would help to resolve potential problems and conflicts before formal actions are taken. Procedures and requirements at the state level for dealing with small hydro facilities may become more standardized in the future, especially if increasing numbers of projects are developed.

7.3 Environmental Impacts

The installation of hydroelectric generating facilities at existing dams on the Mill River would in general have considerably less environmental impact than would be the case if entire new projects were to be constructed. Since all projects would be constructed and operated in a similar manner, effects

on the environment would be comparable for each of the dams, except where differences would arise due to locational and other site-specific factors. The following discussion conforms to the Federal Energy Regulatory Commission's format for environmental reports in conjunction with short-form hydroelectric license applications. This discussion is intended only as an overview of environmental concerns and impacts that would likely be associated with the hydro developments. Should license applications be submitted for the projects, more detailed environmental assessments would need to be prepared.

7.3.1 Environmental Setting. The Mill River watershed drains about 59 square miles in the City of Northampton and several towns to the west and north. Historically, the Mill River was utilized extensively to provide water, direct water power, and hydroelectricity for numerous mills and factories. From about 1850 to 1930 most of the dams on the river fell into disuse and were gradually abandoned. Presently, use of the river for water supply is very limited. The City of Northampton has a small water supply reservoir on Roberts Meadow Brook, a tributary which flows into the Mill River a short distance downstream from the Chartpak dam. Also, Pro Brush withdraws about 3,800,000 cu. ft. annually from its impoundment, and a greater volume from its well supplies. The Northampton Country Club also uses water during the summer months for golf course irrigation.

Water quality in the Mill River is generally good, although it is affected by some point and nonpoint sources of pollution. The river is presently designated Class B by the Massachusetts Department of Environmental Quality Engineering, Division of Water Pollution Control. The Town of Williamsburg, just upstream and bordering on the City of Northampton, will shortly begin construction of a sanitary sewerage system to serve the populated center of town and eliminate the discharge of untreated wastes to the river. Sewage from the

town will be conveyed to Northampton's sewage treatment plant on the Connecticut River via the City's sewage system. Outlying homes will continue to rely on individual septic tank systems.

Two industries presently have permits to discharge wastes to the Mill River. Pro Brush has ten separate discharges with a combined flow averaging 1.17 MGD. The discharges are non-contact cooling water only; the remainder of the plant's wastes are discharged to the City sewer system. The Mill River discharges are subject to permit limitations regarding flow, temperature, and pH and have negligible effect on water quality.

Northampton Manufacturing Corporation is the other source of discharges to the Mill River. The company has two discharges, 100,000 gpd of cooling water and 4,500 gpd of plating wastes. The plating wastes contain minute amounts of chromium, copper, zinc, and several other metals. Daily discharges are very small in relation to streamflow in the river.

Runoff from agricultural and urban land in the watershed undoubtedly has some influence on stream quality, particularly with respect to suspended solids, nutrients, and coliform bacteria. A comprehensive water quality survey of the river has not been undertaken to determine the possible magnitude of such effects. However, the Massachusetts Division of Water Pollution Control confirms that water quality is generally acceptable and adequate for fish life. Completion of sewer construction in the Town of Williamsburg will remove an important source of pollution and result in improvement in water quality.

The Mill River and its tributaries are regularly stocked with trout to support recreational fishing. According to the Fisheries Manager of the

Massachusetts Division of Fisheries & Wildlife, Connecticut Valley District, about 1,500 fish are stocked annually (springtime) in the Northampton section of the Mill River, as far downstream as Look Memorial Park (just below Cooke's Dam). Stocked species have been brook trout and rainbow trout in roughly a 1:2 ratio. Preferable stocking for the reach would be mostly brook trout with a small number of brown trout, but availability of fish from the hatcheries generally controls the mix. In the past, trout were stocked further downstream in the Pro Brush area and may be again if water quality is improved. Fall stocking from late September through mid-October is carried out if fish are available and flow and temperature conditions are suitable, although this has not been done for the last several years.

Discussions with the Chief of Fisheries of the Division of Fisheries & Wildlife confirmed that there are no plans, present or future, for anadromous fish restoration work in the Mill River watershed.

Considerable recreational use is made of the Mill River, both formally and informally. In addition to sport fishing, other activities include swimming, canoeing, sailing, ice skating, and aesthetic enjoyment.

Both the Pro Brush and Chartpak dams are reportedly popular for swimming, particularly for diving or jumping from the spillways into the deep holes at the bases of the dams. The companies indicate that such activity is difficult to control.

The Mill River flows through Look Memorial Park and enhances the attractiveness of that area. A variety of ducks and geese reside at Willow Lake, fed by the river, and picnic grounds are located in streamside areas. The river forms

the western boundary of the park and is an important element in its scenic beauty.

Paradise Pond is a fifteen-acre impoundment formed by the Smith College dam. The pond is a central point of recreational activity as well as an aesthetic highlight of the college campus. Many of the campus buildings overlook the pond, and the athletic fields are located on the opposite side across the river. Smith College has boat and bath houses on the pond for its physical education and recreation programs; in the winter the pond is kept clear of snow and flooded to maintain good ice for skating.

Downstream from Smith College, the river flows through the Arcadia Wildlife Sanctuary to the Oxbow, an old meander of the Connecticut River. The Sanctuary, which is owned and operated by the Massachusetts Audubon Society, contains 561 acres of marsh, woodland, and fields in the area of the Oxbow and the mouth of the Mill River. The Oxbow itself is a popular fishing spot for warm water fish and is heavily used for boating, providing access to the Connecticut River. Many people enjoy bird watching, nature study, hiking, and other outdoor activities in the sanctuary area.

The Mill River has a fairly steep gradient from its headwaters downstream to the Smith College dam; the flood plain is very limited in extent over much of the river's reach, confined by the narrow valley and steep banks. Upstream of the dams, somewhat larger areas are subject to flooding, most noticeably above the Pro Brush dam. Flooding limits for the Mill River under various flow conditions have been mapped as part of a Flood Insurance Study prepared by the U.S. Department of Housing and Urban Development.

7.3.2 Environmental Impacts. Impacts that could be expected from hydro development on the Mill River may be categorized generally as construction phase impacts and operational phase impacts.

Construction Phase: Actual construction work would be undertaken simultaneously at all sites as discussed in Section 4.4. Civil work would begin in the spring and continue through the summer and into the fall of the year.

The major potential sources of impacts during construction are excavation, earth-moving, and other land-disturbing activities which could result in sediment pollution in the river. At all dam sites some rock excavation is required, but this would not generate large quantities of sediment. However, excavation and dredging of the intake areas upstream of the dams would undoubtedly cause temporary increases in turbidity. Presently, there is virtually no sediment in unimpounded segments of the Mill River, indicating that the gradient and flow are sufficient to flush out any fine material that might accumulate.

For the Cookes Intermediate project, the penstock from the Button Shop pond to Cookes dam would necessitate trench excavation along a flat, level route for the most part. Its location would minimize the potential for pollution during construction, except at the stream crossing point and in the vicinity of Cookes dam, where some sediment might be introduced to the river unless precautions are taken. The development of additional head at Pro Brush dam would require excavation of a 400-foot long tailrace channel in solid rock below the dam. This work would involve operation of heavy equipment near and in the stream bed and some sediment pollution would unavoidably result.

Pollution during the construction period would be controlled by including in

the specifications for the project measures designed to minimize erosion and sedimentation. Essentially these requirements would deal with the scheduling of various activities and installation of sediment basins or other structures.

The project schedule described in Section 4.4 is governed mainly by the time involved in the ordering, fabrication, and delivery of the generating units and associated equipment. Since the civil works construction required for the projects is relatively minor, there would be a fair degree of flexibility in the timing of construction activities to minimize impacts on water quality. During the months of April, May, and June, the season of heaviest fishing pressure, excavation and other work directly in the stream bed would be minimized at Chartpak and Cookes dams to avoid adverse impacts on trout fishing in the stocked segment of the river. Aspects of the work having little or no impact on water quality, such as the penstock for the Cookes Intermediate project and miscellaneous dam work, could be undertaken during the spring when entry to the stream is either difficult due to high water or undesirable due to recreational usage. Major excavation work in the stream bed, for example, construction of the Pro Brush tailrace, would be done in the late summer or early fall when river flow would be low, sediment pollution more easily controlled, and interference with recreational fishing minimized.

The U.S. Fish and Wildlife Service and the Massachusetts Division of Fisheries & Wildlife have tentatively indicated their desire that construction work directly in and affecting the stream be avoided during the months of April through August, although these dates could be modified in response to detailed project proposals in the event that decisions were made to proceed with design and construction. The agencies' primary concern is minimization of activities and associated disturbances during the best fishing months of April, May, and June.

In addition to scheduling of construction to minimize impacts, measures would be taken to reduce introduction of sediments to the river from work areas. Temporary check dams and sediment basins would be constructed as necessary to allow settling out of suspended solids from site drainage water. Accumulated sediments would be removed at the completion of work. All construction activities would be carried out so as to conform with applicable water quality standards and any special conditions that might be imposed.

Other construction-related impacts would be temporary and of lesser concern. Noise and dust would be associated with the construction, but impacts would not be significant due to the small scale and short duration of activities.

Operational Phase. Operationally, a system of hydroelectric dams on the Mill River would have no direct impacts on water quality. The major environmental consideration is modification of natural flow and its effects on uses of the river. At high discharges, above the discharge capacities of the units (about 125 cfs at the upper three projects and 110 cfs at Smith College), essentially the projects could be operated continuously and would have no effect on the natural flow of the river with excess water being spilled over the dams. On the average this situation would occur about 60 days per year at Chartpak, increasing to 100 days per year at Smith College due to the larger drainage area and lower discharge capacity of that unit. These high river flows are to be expected predominantly in the spring months, although they may occasionally occur at any time of the year. Project operation would cause no environmental impacts in these circumstances.

At river flows less than turbine capacities, the projects would generally not be operated all the time. The limited pondage available, primarily at Chartpak,

would be used to regulate flows for power production at times when most useful to the users and at the best possible efficiency. Generally, this mode of operation would involve: (1) restricting river flows to a minimum at Chartpak for filling the pond to maximum operating level; and (2) generating for a six-hour period at a rate equal to inflow plus augmentation from pondage. Operation of the downstream three projects would be largely dependent on the releases from Chartpak although minor re-regulation of flows could occur.

The pondage assumed to be available at Chartpak would be sufficient to augment natural flows by about 15 cfs over a six-hour period. During much of the year this pondage could be replenished by storing inflows for a few hours. On occasional days of very low flow it might be necessary to hold back water at Chartpak for longer periods to permit pond refilling.

At the start of the generation period, downstream water levels would rise, creating a possible safety hazard to individuals who might have strayed into the river bed. However, discharge capacities of the turbines would limit the possible rise in water levels to no more than a foot or two.

River regulation for hydroelectric power production would not be likely to have any significant effects on water quality. During the day when wastewater discharges would largely occur, the hydro projects would be in operation and river flows would be augmented from pondage, providing higher than natural discharges for dilution and transport of wastes. Upon completion of a sewerage system in Williamsburg there will be virtually no untreated sewage entering the river and the minor discharges from Pro Brush and Northampton Manufacturing Corporation are of no special concern with regard to hydro operation.

Whenever river flows are less than the unit discharge capacities, hydro operation will cause fluctuations in flow over the course of a day, from near zero while ponding to anywhere from 20 to 125 cfs during the six hour generation period, as previously described. Because flows in this range would be confined to the river channel and because the river bed is predominantly rock and gravel, the potential for stream bed and bank erosion due to hydro operation is very low and problems of this nature are unlikely.

In the case of the Cookes Intermediate project, hydro operations would have effects different from those at other dams. Essentially, the diversion of water via penstock from the Button Shops pond to a powerhouse below Cookes dam would cause a reduction in flow to near zero in the river segment between the projects. During power generation periods at river flows less than 125 cfs, little or no water would be spilled at the Button Shop dams, except for incidental leakage. However, at a progress meeting on 13 December 1978, it was learned that the City is considering replacement of both bridges across the river bend near the eastern Button Shop dam (see Plate 4-2) with dikes for the roadway. Under this plan the river meander would be eliminated.

If both the dike and hydro projects were implemented, the possible environmental effects of diversion for hydro operation would be of less concern. The Cookes pond stretches upstream to within a few hundred feet of the Button Shop South dam, so that only a short segment would be dewatered. High flows in excess of that used for power generation would continue to pass over the south dam and then over Cookes dam. Effects of a decrease in flow between the dams would possibly include a greater degree of siltation due to reduced flushing, more stagnant conditions during low flows, and encroachment of marsh and terrestrial vegetation. Since the Cookes pond is presently quite shallow and silted in,

the possible changes in types of vegetation would be the principal environmental concern. Such changes would not necessarily be detrimental but would represent a shift in the ecological character of the pond. Any excess water not used for power production would, however, be spilled over the Button Shop south dam and help to reduce stagnation and vegetation encroachment in Cookes pond.

Recreational fishing could be affected by alteration of flows in the Mill River, although during the best fishing months of April - June effects on flow would not be very great most of the time. During the month of April, natural river flows would be altered very little or not at all, as water would be spilled a large portion of the time. In May and June, spillage would be less and water would sometimes be held back at night, normally for only a few hours, to refill the ponds. On many days during these months, the natural or slightly higher than natural river flow would be maintained for all but the few nighttime hours when water would be ponded. Flows would seldom be restricted for an extended period, such as on weekends, simply because insufficient pondage is available. Fluctuations at the start or end of a generating cycle could be inconvenient for fishermen and perhaps a safety hazard, although river stages would not be greatly affected in the range of generating discharges.

Trout fishing in the Mill River is maintained by stocking on a "put and take" basis, with little natural reproduction or carryover of stocked fish through the summer or to the following year. During the summer, reduction of already low river flows during part of the day for pond filling could create additional stress on the stream fishery. However, augmentation of flow during the day and ponding at night could possibly reduce the daytime rise of water temperature due to greater water depth and velocity accompanying increased flows. High water temperature is one reason, among others, that few if any trout survive from

season to season. The issue of flow regulation effects on the stream fishery would need to be addressed further by the agencies responsible should license applications be submitted for one or more of the projects.

No adverse impacts downstream in the Arcadia Wildlife Sanctuary would be likely to occur as a result of hydro operations. Water levels in the Oxbow and lower reaches of the Mill River in the sanctuary are affected by a downstream hydro-electric dam on the main stem Connecticut River. Cyclic fluctuations in water levels which occur due to that dam's operation are considerably greater than would be occasioned by operation of the Mill River projects.

Concern for aesthetics in the Paradise Pond area could affect the way in which the Smith College dam is operated for power production. Specifically, Smith College officials have indicated that pondage operations which prevent water from spilling over the dam might be unacceptable to the college. The "water-falls" appearance is understandably an important attribute of the area's scenery; allowances for intentionally spilling some small amount of water over the dam at certain times (just during daylight hours, for instance) would reduce the annual energy production and corresponding revenues by perhaps several percent. The actual magnitude of the effect would have to be evaluated in a detailed operational study based on criteria for dam overflows specified by Smith College.

7.3.3 Summary. The principal environmental impacts during the construction phase would be temporary increases in suspended solids in the Mill River below construction areas, possible short-term disruption of recreational fishing, and general disturbance due to excavation, equipment movement, and other operations. None of these potential problems is very great due to the small scale of required construction work. Techniques to minimize erosion from disturbed areas and

minimize sediment loads to the stream would be required in construction specifications for the projects, in accordance with established water quality standards and other applicable requirements.

Operational phase impacts would be associated mainly with modifications of natural river flow during certain times of the year. The small amount of pondage available at each site precludes the possibility of ponding water and impeding natural river flow for more than ten continuous hours except during extreme low-flow periods. Specific operating conditions with respect to minimum flow releases, the stream fishery, and water quality would need to be determined through discussion and negotiation with the responsible Federal and State agencies.

7.4 Socio-Institutional Factors

None of the proposed Mill River projects is expected to have major social or institutional consequences. No impact on the economic or demographic circumstances of Northampton is anticipated, other than the transitory stimulus of construction activity and the multiplier effects of O&M expenditures. Both of these benefits would be minor in relation to Northampton's overall economy, and thus the social implications would be negligible.

On the other hand, any or all of the projects would make a contribution to the implementation of public policy at the national level. Each would contribute--however marginally--to lessening U.S. dependence on foreign oil, and each would substitute use of a renewable resource in place of a depleting one. Further, the process of project development and operation would reinforce the necessary bonds of cooperation between the public and private sectors in the area of resource management. In addition, the projects would set a laudable precedent

for implementation of cogeneration projects within the service area of Massachusetts Electric Company.

There are several alternative institutional arrangements which could be employed in implementing the Mill River hydroelectric projects. These include:

- (1) Individual development and operation of any of the projects by the respective owners;
- (2) Individual development by the owners and coordinated operation of all projects by the City;
- (3) Development and operation of all projects by the City; and
- (4) Development by the City and coordinated operation of all projects by a City-hired private contractor.

Unified development of the four projects by the City would have a number of advantages, among them economies of scale in construction costs and limiting the duration of construction activities and associated disruption. Coordinated operation would also result in some operation and maintenance cost savings as well as enable the system to be regulated for most efficient use of the water and head available at the four projects. For these reasons development of all projects by the City with coordinated operation by either the City or a private contractor would be preferable to individual development and operation. In addition, the City as a public entity might have greater opportunity and ability to obtain funding assistance for the projects.

APPENDIX A

DAM INSPECTION REPORT

APPENDIX A - DAM INSPECTION REPORT

A.0 Introduction

Inspection of the series of five dams on the Mill River within the confines of the City of Northampton, Massachusetts was carried out on 5 October 1978. The objective of the examination was to assess the general condition of the dams in conjunction with carrying out a feasibility assessment of providing electric power generating facilities at each, or a combination of several, of these dams.

The flow in the river at the time of the inspection was low, estimated to be of the order of 5 to 10 cfs. This made it possible to carry out a reasonably complete examination of each of the dams. The results of the examination are discussed in the following paragraphs.

Photographs of the individual dams accompany the corresponding subsections.

A.1 General Observations

Built in the late 1800's, all the dams appeared to be of a similar design and construction, varying mainly in their configuration. Basically, all are over-flow structures, of stone masonry construction and appear to be founded on sound, durable rock formations. From all indications, each dam was built with an inclined face on the upstream side and a vertical face on the downstream side. Three of the dams are provided with outlets embedded within the masonry. All the dams are less than 200 feet in length and none exceeds a height of 30 feet from the lowest foundation levels.

Over the years, some of the dams have been infilled with sediments to the point where they no longer provide any significant storage. The three upstream dams in this series appear to be serving no useful purpose at this time. However, the two lowest dams are still being utilized. One of these, provided with an intake in the left abutment, serves as a source of cooling water for a small factory complex nearby and the other is being utilized for recreational purposes. To serve these functions, the impoundments behind both of these dams have required periodic flushing and dredging to remove the accumulation of sediments and other debris.

On the basis of the observed condition and configuration of each dam it can be concluded that the addition of a hydropower facility would not increase the safety hazard of the structure.

A.2 Condition of the Dams

A.2.1 Chartpak. This is the farthest upstream of the complex of dams in question. It is the highest of the dams and appears to be the one that has suffered the most from deterioration. It has a crest length of about 150 feet and its maximum height approaches 28 feet. A steel pipe about 4 feet in diameter has been embedded in the masonry next to the right abutment about 5 feet below the crest. This pipe outlet was open at the time of the inspection but only a small portion of the river flow was passing through it, with the majority flowing over the damaged spillway.

The main spillway section occupies the central portion of the dam. Based on available sketches, this overflow section is 94 feet long with the original sill level about 4 feet below the crest of an adjoining auxiliary spillway located against the left abutment. At some stage in the past, the sill of the main spillway was either reinforced or lined with wood. This woodwork has

long since rotted away and only remnants remain embedded along the upstream edge of the spillway opening. Most of the stone blocks in the top two courses of the masonry forming the spillway sill have been loosened and many have been pushed over the crest by floods and ice pressures. Some of these fallen blocks can be seen broken and scattered across the riverbed downstream of the dam.

Apart from the deterioration of the spillway masonry and the cracking and spalling of the concrete which caps the stonework on the crests of the abutment sections, the dam appears to be in remarkably good condition. It showed no signs of instability or any noticeable deterioration of the stone blocks themselves. Similarly there was no evidence of any undercutting or erosion of the underlying rock foundation. In all, the structure gave the impression of having been well built and of being well preserved.

Although there appeared to be leakage through the mortar joints at depth below the spillway section, this may not necessarily be the case. Rather it is strongly suspected that most of the leakage is occurring through joints at the surface where these joints have deteriorated as a result of frost action. The leakage is inconsequential as far as the integrity of the over-all structure is concerned but may be of importance in view of the limited minimum flow available for power production. With limited remedial work, notably the repair of the spillway section, the useful life of the dam could be prolonged indefinitely and, if necessary, grouting could reduce the leakage.

General observations indicate that bedrock occurs within 2 to 3 feet of the ground surface on both abutments of this dam. Access to this structure is somewhat limited. However, it can be reached by a well established trail on the left bank of the river. This trail extends to a paved road where it appears to pass through the yard of a residence.

Photograph A-1: Chartpak Dam

Photograph A-2: Button Shop South Dam

A.2.2 Button Shop. This dam consists of two separate sections, each on a separate branch of the river where it has divided to form an island. The dams themselves are situated at the head of this island and are each about 80 feet long and 10 feet high. Of the two component dams, the eastern one, immediately above a road bridge, is the more readily accessible, at least from its left bank. Both dams are overflow sections and are completely contained in rock which extends to within 1 to 2 feet of the ground surface. The rock appears to be badly shattered but otherwise remains in place with no noticeable evidence of serious weathering or spalling to an extent that would affect the integrity of the dams.

The masonry of both sections was found to be sound and stable. Seepage through the masonry could not be assessed because of the flow over the dams, but from all indications any such seepage is not likely to be any more serious than that observed at the Chartpak dam, described earlier. In general, the masonry of these structures has deteriorated very little over the decades, and, as near as could be determined, remains virtually as originally built some 100 years ago. Certainly, there is no evidence to suggest or suspect that they will not last equally as long or longer.

A.2.3 Cookes. This dam also comprises two sections which are separated by a short stretch of high ground. They are located just upstream of a road bridge, on the same road as that which adjoins the Button Shop dams just described. However, unlike either the Chartpak or the Button Shop dams, these two are arched in the upstream direction. The left branch or the main section, is about 80 feet long and about 20 feet high, while the right section is only about 30 feet long and from 6 to 8 feet high. Both sections are founded and contained in rock which outcrops on both banks. Although extensively fractured and jointed, this rock gave the impression of being tight and

Photograph A-3: Button Shop East Dam

Photograph A-4: Cookes Dam

showed no distress that would affect the stability and general integrity of the overlying dams.

The masonry, as in the case of the Button Shop dams, was found to be sound and durable with no indications of distress or widespread deterioration. There is no question that these dams were well built and can be expected to continue to perform satisfactorily for an indefinite period. The fact that they have suffered no ill effects, especially from freeze-thaw action, is probably due to their being continuously submerged under sheets of flowing water.

A.2.4 Pro Brush. This approximately 120-foot long, 15-foot high dam currently serves to provide a limited quantity of cooling water to the Pro Brush industrial complex. This dam is equipped with about a 2-foot diameter opening at the base of the dam near mid-length. This outlet, controlled with a butterfly valve, is used periodically to flush out the sediment accumulation from the reservoir.

Like the dams described in the previous sections of this report, this structure is founded on, and abuts into, sound, competent rock which appears to be tight in spite of extensive fracturing and jointing.

In a like manner, the masonry of this dam appears to have endured the test of time, showing no obvious defects or deterioration either due to wear or freeze-thaw action. It has been well constructed and should continue to be trouble-free for many decades. As in the previous cases, seepage was not readily apparent because of flow over the dam but seepage either through or under the structure is not likely to be of any consequence.

A.2.5 Smith College. Located within the grounds of Smith College, this last

Photograph A-5: Pro Brush Dam

Photograph A-6: Smith College Dam

dam in question is contained in the flood plain of the Mill River. The natural left bank at the damsite reaches heights well over 50 feet whereas the right bank which confines the reservoir on that side is a man-made dike. The approximately 120-foot long, 15-foot high dam would seem, and was reported to be, founded on rock. Its left bank may also contain bedrock although the channel immediately downstream on that side is protected by a concrete retaining wall which deflects the outlet discharges into the main river channel. The right bank, as indicated above, is a man-made embankment and therefore is not expected to contain bedrock, except possibly close to the foundation level. Immediately downstream of the dam this bank of the river channel is protected with riprap.

The outlet through the left end of the dam is equipped with a screw-stemmed sliding gate and water discharges through a circular pipe about 30 to 36 inches in diameter. The outlet was opened during the inspection visit to permit examination of the dam.

This dam is somewhat different from those previously described. The masonry is composed of smaller rock blocks and has a concrete toe as well as a cap. In order to provide water depth for college boating and other recreational activities the water level has been raised by the installation of about 18 inches of flashboards which are anchored to steel rods embedded in the masonry.

In general this dam exhibited the same good construction as the upper four dams. The masonry appeared to be sound and tight with no readily detectable evidence of any distress or instability. The only portion of the overall structure in need of appreciable maintenance was found to be the concrete retaining wall of the left river bank below the dam. This wall exhibited numerous cracks and spalls. However, these defects have not advanced to the point of

severely endangering the integrity of the wall. On the other hand early repairs would save more costly ones later.

As noted earlier, the masonry of this dam is sound and is expected to remain in this condition indefinitely.

APPENDIX B

FINANCIAL ANALYSIS, SENSITIVITY TEST,
AND ASSISTANCE PROGRAM ALTERNATIVES ANALYSIS
FOR INDIVIDUAL PROJECTS

EXHIBIT B-1
FINANCIAL ANALYSIS OF CHARTPAK PROJECT

PROJECT-CHT.PK01
FINANCIAL ANALYSIS OF LOW-HEAD HYDRO, MILL RIVER, NORTHAMPTON, MASS.

LISTING OF INPUT DATA

ENGR/ADMIN COSTS, YEAR D1 (K\$)=	60.00
ENGR/ADMIN COSTS, YEAR D2 (K\$)=	70.00
SOURCE OF ENGR/ADMIN COSTS=	OWNER
CONSTR. INTEREST COST, YEAR D2 (K\$)=	27.00
SOURCE OF CONSTR. INTEREST COSTS=	OWNER
OPERATION + MAINTENANCE COST (K\$/YR)=	20.00
VALUE OF EXISTING DAM (K\$)=	75.00
VALUE OF MISC. EQUITY, YEAR D1 (K\$)=	10.00
VALUE OF MISC. EQUITY, YEAR D2 (K\$)=	10.00
POWER AVAILABLE FROM HYDRO (KWH/YR)=	850000. -
VALUE OF PLANT OUTPUT (AS OF YR D1)(K\$/YR)=	30.72 -
EXCESS ENERGY FROM HYDRO (KWH/YR)=	159000.00
SALE PRICE FOR EXCESS ENERGY (C/KWH)=	2.20
TOTAL CONSTR. COST (W/O ENGR/ADMIN)(K\$)=	800.00 -
CONSTR. COST TO BE FINANCED (K\$)=	800.00 -
CONSTR. COST FROM GRANT (K\$)=	0
CONSTR. COST FROM OWNER (K\$)=	0
YEARS FOR CONSTR. FINANCING=	20
DEBT INTEREST RATE (%/YR)=	10.00
SINKING FUND INTEREST RATE (%/YR)=	9.00
CORPORATE TAX RATE (%)=	46.00
ANNUAL INFLATION RATE, O + M (%/YR)=	2.00
ANNUAL INFLATION RATE, ENERGY SAVED (%/YR)=	4.00
ANNUAL INFLATION RATE, ELEC. SALES (%/YR)=	4.00

CALCULATED DATA

AMOUNT BORROWED, YEAR D1 (K\$)=	0
AMOUNT BORROWED, YEAR D2 (K\$)=	0
TOTAL BORROWED, YEAR 1 TO 50 (K\$)=	800.00
CUM. TOTAL INVESTMENT, YEAR D1 (K\$)=	145.00
CUM. TOTAL INVESTMENT, YEAR D2 (K\$)=	252.00
CUM. TOTAL INVESTMENT, YEAR 1 TO 50 (K\$)=	1052.00

FINANCIAL ANALYSIS OF CHARTPAK PROJECT (CONTD.)

FINANCIAL ANALYSIS OF LOW-HEAD HYDRO, MILL RIVER, NORTHAMPTON, MASS.

YEAR	D1	D2	1	2	3	4	5	6	7	8	9	10	15	20	25	30	35	40	45	50	FV(K\$)
OPER. +MAINT. COSTS(K\$/YR)																					
	0	0	20.	20.	21.	21.	22.	22.	23.	23.	23.	24.	26.	29.	32.	36.	39.	43.	48.	53.	342.
BENEFITS(K\$/YR)																					
VAL.OUTPUT	0	0	33.	35.	36.	37.	39.	40.	42.	44.	45.	47.	58.	70.	85.	104.	126.	153.	187.	227.	801.
SALES REV.	0	0	4.	4.	4.	4.	4.	5.	5.	5.	5.	5.	7.	8.	10.	12.	14.	17.	21.	26.	91.
TOTAL	0	0	37.	38.	40.	42.	43.	45.	47.	49.	51.	53.	64.	78.	95.	115.	140.	171.	208.	253.	892.
NET OPERATING REVENUES(K\$/YR)																					
	0	0	17.	18.	19.	20.	22.	23.	24.	26.	27.	29.	38.	49.	63.	80.	101.	128.	160.	200.	550.
RETURN ON INVESTMENT(Z/YR)																					
	0	0	2.	2.	2.	2.	2.	2.	2.	2.	3.	3.	4.	5.	6.	8.	10.	12.	15.	19.	
DEBT RETIREMENT(K\$)																					
INTEREST	0	0	80.	80.	80.	80.	80.	80.	80.	80.	80.	80.	80.	80.	0	0	0	0	0	0	771.
SINKG.FUND	0	0	16.	16.	16.	16.	16.	16.	16.	16.	16.	16.	16.	16.	0	0	0	0	0	0	151.
TOTAL	0	0	96.	96.	96.	96.	96.	96.	96.	96.	96.	96.	96.	96.	0	0	0	0	0	0	922.
CASH FLOW(K\$)																					
BEFORE TAX	0	0	-79.	-78.	-76.	-75.	-74.	-73.	-71.	-70.	-68.	-67.	-58.	-47.	63.	80.	101.	129.	160.	200.	-371.
AFTER TAX	0	0	-79.	-78.	-76.	-75.	-74.	-73.	-71.	-70.	-68.	-67.	-58.	-47.	34.	43.	55.	69.	86.	108.	-503.
EQUITY(K\$)																					
ENGR/ADMIN	60.	70.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
CONST.INT.	0	27.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
DAM VALUE	75.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
OTHER	10.	10.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
TOTAL	145.	107.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
RETURN ON EQUITY(Z)																					
	0	0	-31.	-31.	-30.	-30.	-29.	-29.	-28.	-28.	-27.	-27.	-23.	-19.	13.	17.	22.	27.	34.	43.	
INVESTMENT BENEFIT-COST RATIO=.62																					
OVERALL RATE OF RETURN ON INVESTMENT (Z)= -38.16																					
OVERALL BENEFIT COST RATIO=.73																					
COST PER KILOWATT-HOUR (CENTS/KWH)= 2.8918																					

EXHIBIT B-2
FINANCIAL ANALYSIS OF COOKES INTERMEDIATE PROJECT

PROJECT-COOKES01
FINANCIAL ANALYSIS OF LOW-HEAD HYDRO, MILL RIVER, NORTHAMPTON, MASS.

L I S T I N G O F I N P U T D A T A

ENGR/ADMIN COSTS, YEAR D1 (K\$)=	71.00
ENGR/ADMIN COSTS, YEAR D2 (K\$)=	90.00
SOURCE OF ENGR/ADMIN COSTS=	OWNER
CONSTR. INTEREST COST, YEAR D2 (K\$)=	37.00
SOURCE OF CONSTR. INTEREST COSTS=	OWNER
OPERATION + MAINTENANCE COST (K\$/YR)=	20.00

VALUE OF EXISTING DAM (K\$)=	100.00
VALUE OF MISC. EQUITY, YEAR D1 (K\$)=	10.00
VALUE OF MISC. EQUITY, YEAR D2 (K\$)=	10.00

POWER AVAILABLE FROM HYDRO (KWH/YR)=	1140000.
VALUE OF PLANT OUTPUT (AS OF YR D1) (K\$/YR)=	0
EXCESS ENERGY FROM HYDRO (KWH/YR)=	1140000.00
SALE PRICE FOR EXCESS ENERGY (C/KWH)=	2.20

TOTAL CONSTR. COST (W/O ENGR/ADMIN) (K\$)=	1059.00
CONSTR. COST TO BE FINANCED (K\$)=	1059.00
CONSTR. COST FROM GRANT (K\$)=	0
CONSTR. COST FROM OWNER (K\$)=	0
YEARS FOR CONSTR. FINANCING=	20

DEBT INTEREST RATE (%/YR)=	8.00
SINKING FUND INTEREST RATE (%/YR)=	9.00
CORPORATE TAX RATE (%)=	0

ANNUAL INFLATION RATE, O + M (%/YR)=	2.00
ANNUAL INFLATION RATE, ENERGY SAVED (%/YR)=	1.00
ANNUAL INFLATION RATE, ELEC. SALES (%/YR)=	4.00

C A L C U L A T E D D A T A

AMOUNT BORROWED, YEAR D1 (K\$)=	0
AMOUNT BORROWED, YEAR D2 (K\$)=	0
TOTAL BORROWED, YEAR 1 TO 50 (K\$)=	1059.00

CUM. TOTAL INVESTMENT, YEAR D1 (K\$)=	181.00
CUM. TOTAL INVESTMENT, YEAR D2 (K\$)=	318.00
CUM. TOTAL INVESTMENT, YEAR 1 TO 50 (K\$)=	1377.00

FINANCIAL ANALYSIS OF LOW-HEAD HYDRO, MILL RIVER, NORTHAMPTON, MASS.

YEAR	D1	D2	1	2	3	4	5	6	7	8	9	10	15	20	25	30	35	40	45	50	PV(K\$)
OPER. +MAINT. COSTS(K\$/YR)																					
	0	0	20.	20.	21.	21.	22.	22.	23.	23.	23.	24.	26.	29.	32.	36.	39.	43.	48.	53.	342.
BENEFITS(K\$/YR)																					
VAL.OUTPUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SALES REV.	0	0	27.	28.	29.	31.	32.	33.	34.	36.	37.	39.	47.	57.	70.	85.	103.	125.	152.	185.	654.
TOTAL	0	0	27.	28.	29.	31.	32.	33.	34.	36.	37.	39.	47.	57.	70.	85.	103.	125.	152.	185.	654.
NET OPERATING REVENUES(K\$/YR)																					
	0	0	7.	8.	9.	9.	10.	11.	12.	13.	14.	15.	21.	28.	37.	49.	64.	82.	105.	133.	312.
RETURN ON INVESTMENT(%/YR)																					
	0	0	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	2.	3.	4.	5.	6.	8.	10.	
DEBT RETIREMENT(K\$)																					
INTEREST	0	0	85.	85.	85.	85.	85.	85.	85.	85.	85.	85.	85.	85.	0	0	0	0	0	0	817.
SINKB.FUND	0	0	21.	21.	21.	21.	21.	21.	21.	21.	21.	21.	21.	21.	0	0	0	0	0	0	200.
TOTAL	0	0	105.	105.	105.	105.	105.	105.	105.	105.	105.	105.	105.	105.	0	0	0	0	0	0	1016.
CASH FLOW(K\$)																					
BEFORE TAX	0	0	-98.	-98.	-97.	-96.	-95.	-94.	-94.	-93.	-92.	-91.	-85.	-77.	37.	49.	64.	82.	105.	133.	-704.
AFTER TAX	0	0	-98.	-98.	-97.	-96.	-95.	-94.	-94.	-93.	-92.	-91.	-85.	-77.	37.	49.	64.	82.	105.	133.	-704.
EQUITY(K\$)																					
ENGR/ADMIN	71.	90.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
CONST.INT.	0	37.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
DAM VALUE	100.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
OTHER	10.	10.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
TOTAL	181.	137.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
RETURN ON EQUITY(%)																					
	0	0	-31.	-31.	-30.	-30.	-30.	-30.	-29.	-29.	-29.	-29.	-27.	-24.	12.	15.	20.	26.	33.	42.	
INVESTMENT BENEFIT-COST RATIO= .27																					
OVERALL RATE OF RETURN ON INVESTMENT (%)= -73.18																					
OVERALL BENEFIT COST RATIO= .44																					
COST PER KILOWATT-HOUR (CENTS/KWH)= 2.6365																					

EXHIBIT B-3
FINANCIAL ANALYSIS OF PRO BRUSH PROJECT

PROJECT-PRO.BR01
FINANCIAL ANALYSIS OF LOW-HEAD HYDRO, MILL RIVER, NORTHAMPTON, MASS.

LISTING OF INPUT DATA

ENGR/ADMIN COSTS, YEAR D1 (K\$)=	50.00
ENGR/ADMIN COSTS, YEAR D2 (K\$)=	63.00
SOURCE OF ENGR/ADMIN COSTS=	OWNER
CONSTR. INTEREST COST, YEAR D2 (K\$)=	24.00
SOURCE OF CONSTR. INTEREST COSTS=	OWNER
OPERATION + MAINTENANCE COST (K\$/YR)=	20.00

VALUE OF EXISTING DAM (K\$)=	75.00
VALUE OF MISC. EQUITY, YEAR D1 (K\$)=	10.00
VALUE OF MISC. EQUITY, YEAR D2 (K\$)=	10.00

POWER AVAILABLE FROM HYDRO (KWH/YR)=	845000.
VALUE OF PLANT OUTPUT (AS OF YR D1)(K\$/YR)=	31.70
EXCESS ENERGY FROM HYDRO (KWH/YR)=	0
SALE PRICE FOR EXCESS ENERGY (C/KWH)=	2.20

TOTAL CONSTR. COST (W/O ENGR/ADMIN)(K\$)=	727.00
CONSTR. COST TO BE FINANCED (K\$)=	727.00
CONSTR. COST FROM GRANT (K\$)=	0
CONSTR. COST FROM OWNER (K\$)=	0
YEARS FOR CONSTR. FINANCING=	20

DEBT INTEREST RATE (%/YR)=	10.00
SINKING FUND INTEREST RATE (%/YR)=	9.00
CORPORATE TAX RATE (%)=	46.00

ANNUAL INFLATION RATE, D + M (%/YR)=	2.00
ANNUAL INFLATION RATE, ENERGY SAVED (%/YR)=	4.00
ANNUAL INFLATION RATE, ELEC. SALES (%/YR)=	4.00

CALCULATED DATA

AMOUNT BORROWED, YEAR D1 (K\$)=	0
AMOUNT BORROWED, YEAR D2 (K\$)=	0
TOTAL BORROWED, YEAR 1 TO 50 (K\$)=	727.00

CUM. TOTAL INVESTMENT, YEAR D1 (K\$)=	135.00
CUM. TOTAL INVESTMENT, YEAR D2 (K\$)=	233.00
CUM. TOTAL INVESTMENT, YEAR 1 TO 50 (K\$)=	959.00

EXHIBIT B-3

FINANCIAL ANALYSIS OF PRO BRUSH PROJECT (CONT.)

PROJECT-PRO.BR01			FINANCIAL ANALYSIS OF LOW-HEAD HYDRO, MILL RIVER, NORTHAMPTON, MASS.																					
YEAR	D1	D2	1	2	3	4	5	6	7	8	9	10	15	20	25	30	35	40	45	50	PV(K\$)			
OPER. +MAINT. COSTS(K\$/YR)																								
	0	0	20.	20.	21.	21.	22.	22.	23.	23.	23.	24.	26.	29.	32.	36.	39.	43.	48.	53.	342.			
BENEFITS(K\$/YR)																								
VAL.OUTPUT	0	0	34.	36.	37.	39.	40.	42.	43.	45.	47.	49.	59.	72.	88.	107.	130.	158.	193.	234.	826.			
SALES REV.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
TOTAL	0	0	34.	36.	37.	39.	40.	42.	43.	45.	47.	49.	59.	72.	88.	107.	130.	158.	193.	234.	826.			
NET OPERATING REVENUES(K\$/YR)																								
	0	0	14.	15.	16.	17.	18.	20.	21.	22.	23.	25.	33.	43.	56.	71.	91.	115.	145.	182.	485.			
RETURN ON INVESTMENT(%/YR)																								
	0	0	1.	2.	2.	2.	2.	2.	2.	2.	2.	3.	3.	4.	6.	7.	9.	12.	15.	19.				
DEBT RETIREMENT(K\$)																								
INTEREST	0	0	73.	73.	73.	73.	73.	73.	73.	73.	73.	73.	73.	73.	0	0	0	0	0	0	701.			
SINKB.FUND	0	0	14.	14.	14.	14.	14.	14.	14.	14.	14.	14.	14.	14.	0	0	0	0	0	0	137.			
TOTAL	0	0	87.	87.	87.	87.	87.	87.	87.	87.	87.	87.	87.	87.	0	0	0	0	0	0	838.			
CASH FLOW(K\$)																								
BEFORE TAX	0	0	-73.	-72.	-71.	-70.	-68.	-67.	-66.	-65.	-63.	-62.	-54.	-44.	56.	71.	91.	115.	145.	182.	-353.			
AFTER TAX	0	0	-73.	-72.	-71.	-70.	-68.	-67.	-66.	-65.	-63.	-62.	-54.	-44.	30.	39.	49.	62.	78.	98.	-471.			
EQUITY(K\$)																								
ENGR/ADMIN	50.	63.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
CONST.INT.	0	24.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
DAM VALUE	75.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
"OTHER"	10.	10.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
TOTAL	135.	97.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
RETURN ON EQUITY(%)																								
	0	0	-31.	-31.	-30.	-30.	-30.	-29.	-28.	-28.	-27.	-27.	-23.	-19.	13.	17.	21.	27.	34.	42.				
INVESTMENT BENEFIT-COST RATIO=							.60							OVERALL RATE OF RETURN ON INVESTMENT (%)=							-40.28			
OVERALL BENEFIT COST RATIO=							.72							COST PER KILOWATT-HOUR (CENTS/KWH)=							2.7233			

EXHIBIT B-4
FINANCIAL ANALYSIS OF SMITH PROJECT

PROJECT-SMITH01
FINANCIAL ANALYSIS OF LOW-HEAD HYDRO, MILL RIVER, NORTHAMPTON, MASS.

L I S T I N G O F I N P U T D A T A

ENGR/ADMIN COSTS, YEAR D1 (K\$)=	50.00
ENGR/ADMIN COSTS, YEAR D2 (K\$)=	60.00
SOURCE OF ENGR/ADMIN COSTS=	OWNER
CONSTR. INTEREST COST, YEAR D2 (K\$)=	23.00
SOURCE OF CONSTR. INTEREST COSTS=	OWNER
OPERATION + MAINTENANCE COST (K\$/YR)=	20.00
VALUE OF EXISTING DAM (K\$)=	100.00
VALUE OF MISC. EQUITY, YEAR D1 (K\$)=	10.00
VALUE OF MISC. EQUITY, YEAR D2 (K\$)=	10.00
POWER AVAILABLE FROM HYDRO (KWH/YR)=	570000.
VALUE OF PLANT OUTPUT (AS OF YR D1)(K\$/YR)=	21.05
EXCESS ENERGY FROM HYDRO (KWH/YR)=	0
SALE PRICE FOR EXCESS ENERGY (C/KWH)=	2.20
TOTAL CONSTR. COST (W/O ENGR/ADMIN)(K\$)=	700.00
CONSTR. COST TO BE FINANCED (K\$)=	700.00
CONSTR. COST FROM GRANT (K\$)=	0
CONSTR. COST FROM OWNER (K\$)=	0
YEARS FOR CONSTR. FINANCING=	20
DEBT INTEREST RATE (%/YR)=	10.00
SINKING FUND INTEREST RATE (%/YR)=	9.00
CORPORATE TAX RATE (%)=	0
ANNUAL INFLATION RATE, O + M (%/YR)=	2.00
ANNUAL INFLATION RATE, ENERGY SAVED (%/YR)=	4.00
ANNUAL INFLATION RATE, ELEC. SALES (%/YR)=	4.00

C A L C U L A T E D D A T A

AMOUNT BORROWED, YEAR D1 (K\$)=	0
AMOUNT BORROWED, YEAR D2 (K\$)=	0
TOTAL BORROWED, YEAR 1 TO 50 (K\$)=	700.00
CUM. TOTAL INVESTMENT, YEAR D1 (K\$)=	160.00
CUM. TOTAL INVESTMENT, YEAR D2 (K\$)=	253.00
CUM. TOTAL INVESTMENT, YEAR 1 TO 50 (K\$)=	953.00

EXHIBIT B-4

FINANCIAL ANALYSIS OF SMITH PROJECT (CONT.)

PROJECT-SMITH01		FINANCIAL ANALYSIS OF LOW-HEAD HYDRO, MILL RIVER, NORTHAMPTON, MASS.																									
YEAR	D1	D2	1	2	3	4	5	6	7	8	9	10	15	20	25	30	35	40	45	50	PV(K\$)						
OPER. +MAINT. COSTS(K\$/YR.)																											
	0	0	20.	20.	21.	21.	22.	22.	23.	23.	23.	24.	26.	29.	32.	36.	39.	43.	48.	53.	342.						
BENEFITS(K\$/YR.)																											
VAL.OUTPUT	0	0	23.	24.	25.	26.	27.	28.	29.	30.	31.	32.	39.	48.	58.	71.	86.	105.	128.	156.	549.						
SALES REV.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
TOTAL	0	0	23.	24.	25.	26.	27.	28.	29.	30.	31.	32.	39.	48.	58.	71.	86.	105.	128.	156.	549.						
NET OPERATING REVENUES(K\$/YR.)																											
	0	0	3.	3.	4.	4.	5.	6.	6.	7.	8.	9.	13.	19.	26.	35.	47.	62.	80.	103.	207.						
RETURN ON INVESTMENT(Z/YR.)																											
	0	0	0.	0.	0.	0.	1.	1.	1.	1.	1.	1.	1.	2.	3.	4.	5.	6.	8.	11.							
DEBT RETIREMENT(K\$)																											
INTEREST	0	0	70.	70.	70.	70.	70.	70.	70.	70.	70.	70.	70.	70.	0	0	0	0	0	0	675.						
SINKG.FUND	0	0	14.	14.	14.	14.	14.	14.	14.	14.	14.	14.	14.	14.	0	0	0	0	0	0	132.						
TOTAL	0	0	84.	84.	84.	84.	84.	84.	84.	84.	84.	84.	84.	84.	0	0	0	0	0	0	807.						
CASH FLOW(K\$)																											
BEFORE TAX	0	0	-81.	-80.	-80.	-79.	-79.	-78.	-77.	-77.	-76.	-75.	-71.	-65.	26.	35.	47.	62.	80.	103.	-600.						
AFTER TAX	0	0	-81.	-80.	-80.	-79.	-79.	-78.	-77.	-77.	-76.	-75.	-71.	-65.	26.	35.	47.	62.	80.	103.	-600.						
EQUITY(K\$)																											
ENGR/ADMIN	50.	60.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
CONST.INT.	0	23.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
BAN VALUE	100.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
OTHER	10.	10.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
TOTAL	160.	93.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
RETURN ON EQUITY(Z)																											
	0	0	-32.	-32.	-32.	-31.	-31.	-31.	-31.	-30.	-30.	-30.	-28.	-26.	10.	14.	19.	24.	32.	41.							
INVESTMENT BENEFIT-COST RATIO=							.26							OVERALL RATE OF RETURN ON INVESTMENT (Z)=							-74.41						
OVERALL BENEFIT COST RATIO=							.48							COST PER KILOWATT-HOUR (CENTS/KWH)=							4.0290						

Table B-1 Sensitivity Tests For Chartpak Project

Sensitivity Tests	Input Baseline Value	Input Test Value	Overall Benefit- Cost Ratio	Cost/kWh (¢)	Investment Benefit- Cost Ratio	1st Yr. of Positive Cash Flow
BASELINE PROJECTION	All	--	.73	2.89	.62	After Debt Retirement
1. Inflation (O&M)	2%	1% 3%	.75 .69	2.78 3.03	.67 .55	" "
2. Inflation (Value of Output)	4%	2% 6%	.52 1.09	2.89 2.89	.33 1.12	" "
3. Inflation (Elec- tricity sales)	4%	2% 6%	.70 .77	2.89 2.89	.59 .68	" "
4. Financing Term	20 Yr.	30 Yr 40 Yr	.73 .73	2.89 2.89	.62 .62	" "
5. Debt Interest	10%	6% 8%	.73 .73	2.89 2.89	.62 .62	" "
6. Sinking Fund Interest	9%	7% 11%	.73 .73	2.89 2.89	.62 .62	" "
7. Equity/Debt Ratio	24.00%	.01% 43.00%	.76 .73	2.75 2.89	.66 .62	" "
8. Annual O&M Cost	\$20K	\$ 5K \$12.5K	.92 .81	2.29 2.59	.91 .76	" "

Table B-2 Sensitivity Tests For Cookes Intermediate Project

Sensitivity Tests	Input Baseline Value	Input Test Value	Overall Benefit- Cost Ratio	Cost/kWh (¢)	Investment Benefit- Cost Ratio	1st Yr. of Positive Cash Flow
BASELINE PROJECTION	All	--	.44	2.64	.27	After Debt Retirement
1. Inflation (O&M)	2%	1%	.45	2.55	.31	"
		3%	.42	2.74	.22	"
2. Inflation (Value of Output)	4%	2%	.44	2.64	.27	"
		6%	.44	2.64	.27	"
3. Inflation (Elec- tricity sales)	4%	2%	.30	2.64	.09	"
		6%	.68	2.64	.58	"
4. Financing Term	20 Yr.	30 Yr	.44	2.64	.27	"
		40 Yr	.44	2.64	.27	"
5. Debt Interest	10%	6%	.44	2.64	.27	"
		8%	.44	2.64	.27	"
6. Sinking Fund Interest	9%	7%	.44	2.64	.27	"
		11%	.44	2.64	.27	"
7. Equity/Debt Ratio	.23	.01	.46	2.49	.29	" "
		.45	.44	2.64	.27	"
8. Annual O&M Cost	\$20K	\$ 5K	.52	2.19	.49	"
		\$12.5K	.48	2.41	.38	"

Table B-3 Sensitivity Tests For Pro Brush Project

Sensitivity Tests	Input Baseline Value	Input Test Value	Overall Benefit- Cost Ratio	Cost/kWh (¢)	Investment Benefit- Cost Ratio	1st Yr. of Positive Cash Flow
BASELINE PROJECTION	All	--	.72	2.72	.60	After Debt Retirement
1. Inflation (O&M)	2%	1% 3%	.75 .68	2.61 2.87	.66 .52	" "
2. Inflation (Value of Output)	4%	2% 6%	.49 1.12	2.72 2.72	.27 1.17	" "
3. Inflation (Elec- tricity sales)	4%	2% 6%	.72 .72	2.72 2.72	.60 .60	" "
4. Financing Term	20 Yr.	30 Yr 40 Yr	.72 .72	2.72 2.72	.60 .60	" "
5. Debt Interest	10%	6% 8%	.72 .72	2.72 2.72	.60 .60	" "
6. Sinking Fund Interest	9%	7% 11%	.72 .72	2.72 2.72	.60 .60	" "
7. Equity/Debt Ratio	.24	.01 .48	.76 .72	2.58 2.72	.65 .60	" "
8. Annual O&M Cost	\$20K	\$ 5K \$12.5K	.92 .81	2.12 2.42	.91 .76	" "

Table B-4 Sensitivity Tests For Smith Project

Sensitivity Tests	Input Baseline Value	Input Test Value	Overall Benefit- Cost Ratio	Cost/kWh (¢)	Investment Benefit- Cost Ratio	1st Yr. of Positive Cash Flow
EASELINE PROJECTION	All	--	.48	4.03	.26	After Debt Retirement
1. Inflation (O&M)	2%	1% 3%	.50 .45	3.86 4.24	.31 .18	" "
2. Inflation (Value of Output)	4%	2% 6%	.33 .75	4.03 4.03	.04 .64	" "
3. Inflation (Elec- tricity sales)	4%	2% 6%	.48 .48	4.03 4.03	.26 .26	" "
4. Financing Term	20 Yr.	30 Yr 40 Yr	.48 .48	4.03 4.03	.26 .26	" "
5. Debt Interest	10%	6% 8%	.48 .48	4.03 4.03	.26 .26	" "
6. Sinking Fund Interest	9%	7% 11%	.48 .48	4.03 4.03	.26 .26	" "
7. Equity/Debt Ratio		.01 .47	.52 .48	3.73 4.03	.29 .26	" "
8. Annual O&M Cost	\$20K	\$ 5K \$12.5K	.63 .55	3.05 3.50	.59 .43	" "

Table B-5 Analysis of Assistance Program Alternatives for Chartpak Project

Program Alternatives	Effect	Overall Benefit- Cost Ratio	Cost/kWh (¢)	Investment Benefit- Cost Ratio	1st Yr. of Positive Cash Flow
BASELINE PROJECTION		.73	2.89	.62	After Debt Retirement
1. <u>Development Grant:</u> <u>Grant for Eng./Admin.</u> <u>+ Construct. Interest</u> <u>Costs</u>	Equity investment reduced by \$157K	.82	2.56	.74	"
2. <u>Development Grant</u> <u>+ Loan Guarantee</u>	Equity investment reduced by \$157K; debt int. rate reduced 10% to 8%	.82	2.56	.74	"
3. <u>Development Grant</u> <u>+ Loan Guarantee</u> <u>+ Accelerated</u> <u>Depreciation +</u> <u>Investment Tax</u> <u>Credit</u>	Equity investment reduced by \$157K; debt int. rate reduced 10 to 8%; effective corp. tax rate reduced 45% to 25%	.82	2.56	.74	"
4. <u>Development Grant</u> <u>+ Grant for 25%</u> <u>of Construction</u> <u>Cost</u>	Equity investment reduced by \$157K; debt reduced by \$200K	.97	2.17	.94	"
5. <u>Development Grant</u> <u>+ Grant for 50%</u> <u>of Construction</u> <u>Cost</u>	Equity investment reduced by \$157K; debt reduced by \$400K	1.18	1.78	1.32	"

Table B-6 Analysis of Assistance Program Alternatives for Cookes Intermediate Project

Program Alternatives	Effect	Overall Benefit- Cost Ratio	Cost/kWh (¢)	Investment Benefit- Cost Ratio	1st Yr. of Positive Cash Flow
BASELINE PROJECTION		.44	2.64	.27	After Debt Retirement
1. <u>Development Grant:</u> <u>Grant for Eng./Admin.</u> <u>+ Construct. Interest</u> <u>Costs</u>	Equity investment reduced by \$198K	.49	2.32	.32	"
2. <u>Development Grant</u> <u>+ Loan Guarantee</u>	Not Applicable				
3. <u>Development Grant</u> <u>+ Loan Guarantee</u> <u>+ Accelerated</u> <u>Depreciation +</u> <u>Investment Tax</u> <u>Credit</u>	Not Applicable				
4. <u>Development Grant</u> <u>+ Grant for 25%</u> <u>of Construction</u> <u>Cost</u>	Equity investment reduced by \$198K; debt reduced by \$265K	.59	1.94	.41	"
5. <u>Development Grant</u> <u>+ Grant for 50%</u> <u>of Construction</u> <u>Cost</u>	Equity investment reduced by \$198K; debt reduced by \$529.5K	.74	1.56	.57	"

Table B-7 Analysis of Assistance Program Alternatives for Pro Brush Project

Program Alternatives	Effect	Overall Benefit- Cost Ratio	Cost/kWh (¢)	Investment Benefit- Cost Ratio	1st Yr. of Positive Cash Flow
BASELINE PROJECTION		.72	2.72	.60	After Debt Retirement
1. <u>Development Grant:</u> <u>Grant for Eng./Admin.</u> <u>+ Construct. Interest</u> <u>Costs</u>	Equity investment reduced by \$137K	.80	2.43	.70	"
2. <u>Development Grant</u> <u>+ Loan Guarantee</u>	Equity Investment reduced by \$137K; debt int. rate reduced 10% to 8%	.80	2.43	.70	"
3. <u>Development Grant</u> <u>+ Loan Guarantee</u> <u>+ Accelerated</u> <u>Depreciation +</u> <u>Investment Tax</u> <u>Credit</u>	Equity investment reduced by \$137K; debt int. rate reduced 10 to 8%; effective corp. tax rate reduced 45% to 25%	.80	2.43	.70	"
4. <u>Development Grant</u> <u>+ Grant for 25%</u> <u>of Construction</u> <u>Cost</u>	Equity investment reduced by \$137K; debt reduced by \$182K	.94	2.08	.90	"
5. <u>Development Grant</u> <u>+ Grant for 50%</u> <u>of Construction</u> <u>Cost</u>	Equity investment reduced by \$137K; debt reduced by \$363.5K	1.14	1.72	1.25	"

Table B-8 Analysis of Assistance Program Alternatives for Smith Project

Program Alternatives	Effect	Overall Benefit- Cost Ratio	Cost/kWh (\$)	Investment Benefit- Cost Ratio	1st Yr. of Positive Cash Flow
BASELINE PROJECTION		.48	4.03	.26	After Debt Retirement
1. <u>Development Grant:</u> <u>Grant for Eng./Admin.</u> <u>+ Construct. Interest</u> <u>Costs</u>	Equity investment reduced by \$133K	.53	3.61	.30	"
2. <u>Development Grant</u> <u>+ Loan Guarantee</u>	Equity investment reduced by \$133K; debt int. rate reduced 10% to 8%	.55	3.53	.31	"
3. <u>Development Grant</u> <u>+ Loan Guarantee</u> <u>+ Accelerated</u> <u>Depreciation +</u> <u>Investment Tax</u> <u>Credit</u>	Not Applicable				
4. <u>Development Grant</u> <u>+ Grant for 25%</u> <u>of Construction</u> <u>Cost</u>	Equity investment reduced by \$133K; debt reduced by \$175K	.64	3.02	.40	"
5. <u>Development Grant</u> <u>+ Grant for 50%</u> <u>of Construction</u> <u>Cost</u>	Equity investment reduced by \$133K; debt reduced by \$350K	.77	2.51	.55	"

APPENDIX C

ARTICLE I, SECTION B,

"RESPONSIBILITY OF THE ENGINEERS,"

FROM AGREEMENT OF 21 AUGUST 1978 BETWEEN

CITY OF NORTHAMPTON AND CURRAN ASSOCIATES, INC.

APPENDIX C

ARTICLE I - DESCRIPTION OF RESPONSIBILITIES

B. Responsibility of the ENGINEERS - The ENGINEERS are responsible to assure that the feasibility assessment is accomplished in a manner consistent with the provisions of this Agreement. The ENGINEERS' proposal prepared for the CITY in March 1978, identified as "Feasibility Study for Low-Head Hydropower," as amended on May 19, 1978, is made a part of this Agreement by this reference; however, if there is any conflict between the content of the proposal and the content of this Agreement, the content of this Agreement governs. The tasks provided for in the proposal are to be accomplished, and are to result in, a final feasibility assessment report which will include, as a minimum, the following information:

1. Expected configuration and capacity of the hydropower facility.
2. Estimated performance characteristics of the hydroelectric power facility including the potential for peak power production and an estimate of average annual energy production.
3. Expected impact of the hydropower installation on other perceived water resource needs of the area and the current use of the reservoir.
4. Marketing potential of the power produced.
5. The necessary requirements of the Federal Energy Regulatory Commission, the U. S. Army Corps of Engineers, and other appropriate Federal, state, regional, and local agencies.
6. Capital investment per installed kilowatt, total cost per kwh, and return on investment.
7. Anticipated annual operation and maintenance costs.
8. Anticipated project life.
9. An initial assessment of the environmental impact and socio-institutional factors.
10. An initial assessment of the safety hazard, if any, introduced by the addition or rehabilitation of a power plant and other hydropower appurtenances.
11. Appropriate analyses resulting in sound judgment as to the engineering acceptability of the proposed site for hydroelectric power development.
12. Investigation of the availability of a suitable turbine(s), generator(s), and accessories required for the proposed hydroelectric power development.
13. Development plan (schedule) for putting power on-line.

APPENDIX D

GLOSSARY OF SELECTED TECHNICAL TERMS

APPENDIX D

GLOSSARY OF SELECTED TECHNICAL TERMS

Capacity factor - The ratio of the average capacity used over a certain period to the installed capacity of a generating unit. As used herein capacity factor is calculated on an average annual basis. It is a measure of the degree of utilization of a plant's maximum potential generating capability.

cfs - Cubic feet per second, a measure of the rate of water flow.

Gross head - The difference in elevation between water levels immediately above and below a dam.

Installed capacity - The rate of energy production by a hydroelectric generating unit under best operating conditions, expressed in kilowatts.

kw - Kilowatt, a unit of power equal to 1,000 watts or 1.34 horsepower.

MWh/a - Megawatt-hours per annum. One megawatt equals 1,000 kilowatts. A megawatt-hour is a unit of energy or work equivalent to the power of one megawatt operating for one hour.

Net head - The difference in water levels that can be utilized for power generation after adjusting gross head downward to account for friction and other efficiency losses.

Penstock - a conduit or pipe for conducting water from a reservoir to a powerhouse.

Tailrace - channel into which water passing through a hydroelectric turbine is discharged.