

DEPARTMENT OF ENERGY
IDAHO OPERATIONS OFFICE

**FEASIBILITY OF
DETERMINATION OF LOW-HEAD HYDROELECTRIC
POWER DEVELOPMENT AT EXISTING SITES**

COOPERATIVE AGREEMENT
NO. EW-78-F-07-1787

MASTER

BRIGHTON DAM HYDROELECTRIC DEVELOPMENT

FEASIBILITY REPORT

APRIL 1979

SUBMITTED BY:

WASHINGTON SUBURBAN SANITARY COMMISSION
(GOVERNMENT AGENCY: LOCAL)

ADDRESS:

WASHINGTON SUBURBAN SANITARY COMMISSION
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BRIGHTON DAM - TRIADELPHIA RESERVOIR
WASHINGTON SUBURBAN SANITARY COMMISSION
BRIGHTON, MARYLAND

DEPARTMENT OF ENERGY
WASHINGTON SUBURBAN SANITARY COMMISSION

BRIGHTON DAM HYDROELECTRIC REDEVELOPMENT

FEASIBILITY STUDY

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SECTION 1
INTRODUCTION

1 - INTRODUCTION

The Brighton Dam Hydroelectric Redevelopment Feasibility Study has been undertaken by Acres American Incorporated (Acres) under the terms of a contract with Washington Suburban Sanitary Commission (WSSC) dated December 6, 1978. It is a candidate project under the Department of Energy (DOE) PRDA Program No. PRDA-ET-78-D-07-1706, "Feasibility of Determination of Low Head Hydroelectric Power Development at Existing Sites." The study has been jointly funded by the DOE and WSSC under Cooperative Agreement No. EW-78-F-07-1787, entered into December 13, 1978. The objective of the study was to investigate the feasibility of redeveloping the defunct hydroelectric facility at the Brighton Dam and to prepare a Feasibility Report on the findings.

The Brighton Dam is on the Patuxent River about 15 miles upstream of Laurel in Maryland. It impounds the waters of the Triadelphia Reservoir which covers an area of 800 acres. The drainage area is 78.4 square miles. The average flow over a twelve-month period is 87 cubic feet per second, and the gross head between the normal maximum reservoir level and the tailwater level is 61 feet. The old generating plant, decommissioned in 1969, consisted of two turbines and generators and had a total output of 150 kW.

This report presents the conceptual design for the installation of a 500 kW generating plant in the existing powerhouse which is built into the dam structure. This represents a 233 percent increase in the original installed capacity. Section 2 of the Report forms a summary of the investigations and findings of the study. Section 3 contains a description of the existing facilities and basic data and assumptions used in the study. Section 4 deals with the alternatives considered in developing conceptual designs for the project and selecting the recommended scheme. Section 5 presents further details of the selected design, together with cost estimates and financial and power marketing studies. The schedule for engineering, licensing and construction of the project, together with the cash flow estimate, is included in Section 6. Sections 7 and 8 deal with environmental and safety assessments. Background data and other related information are included as appendices to the report.

The WSSC Project Manager for the study was Mr. Alan L. Will. The Principal Investigator for Acres was Mr. Charles A. Debelius, assisted by Mr. Hubert F. Allman. The assistance of Baltimore Gas & Electric Company and various state and environmental agencies who have provided information and guidance during the study is gratefully acknowledged.

SECTION 2
SUMMARY



2 - SUMMARY

The redevelopment of the hydroelectric facility at Brighton Dam has been found to be both technically and financially feasible, the benefit to cost ratio being 1.53:1 compared with an equivalent coal-based generation source. Environmental impacts have been assessed as relatively slight, but some problems, due to poor water quality at the bottom of the reservoir are anticipated and solutions for these would have to be worked out. The benefit to cost ratio could thus be marginally decreased, but the relative costs of one alternative scheme compared to another would not be affected. There is no apparent impediment to proceeding with the work.

The selected development would have a single hydroelectric generating unit of 500 kW rated capacity. The gross generation from the project would be 2,840,000 kWh in a year with average rainfall. It is estimated that the total project cost would be \$734,000 (at third quarter 1978 price levels), with no allowance for funds during construction (AFDC). Based on 6.25 percent cost of money, the project would provide power at a levelized cost over the plant lifetime of approximately 23.3 mills per kWh with no AFDC or 24.6 mills/kWh with AFDC.

At present, WSSC electrical power demands at Brighton Dam amount to 147,000 kWh per year which is met by Baltimore Gas & Electric Company (BG&E). This represents only 5 percent of the potential generation at the site and BG&E have agreed in principal to purchase the surplus power.

2.1 - Description of Recommended Facility

The selected scheme would have a 4 feet diameter penstock with a butterfly shut-off valve connecting one half of the existing intake tower to the turbine. The turbine would be of the vertical shaft, axial flow, propeller type placed centrally in the existing powerhouse. It would be rated at 500 kW under a net head of 50 feet and a discharge of 130 cfs. The draft tube would be of the standard elbow type installed in the existing tailrace tunnel under the powerhouse after some additional excavation of concrete and rock. Some modification of the tunnel would also be necessary to remove the severe constriction where it emerges into the tailrace channel.

The 500 kW, 480 V generator would be mounted vertically on top of the turbine casing.

The powerhouse has a history of flooding and funds have been included in the project costs to carry out essential modifications to prevent a recurrence.

The switchboard could be installed on the floor of the powerhouse or on the mezzanine floor.

A power transformer, located in one of the downstream bays of the dam, would step-up the station output to 13.2 kV for connection to the existing BG&E Company distribution line which terminates on the site.

Plates 1 and 2 show the location of the project and the layout of the existing turbine inlet and outlet structures. Plates 3, 4, 5 and 6 show the station layouts for the four alternative schemes which were studied in depth. The selected scheme is shown at Plate 3. Plate 7 is an electrical single line diagram for the selected single unit scheme incorporating an induction generator. All plates are contained in Appendix A.

2.2 - Alternatives Considered

Recognizing that the most economically rewarding scheme was likely to be that with a minimum of civil work within the existing powerhouse structure, a number of possible alternative turbine-generator arrangements were identified. These involved the utilization of the two existing penstocks to greater or lesser degrees.

The arrangements of the plant which were studied came under two main headings:

Alternative A: With two identical units each utilizing flows in the range 50 to 70 cfs.

Alternative B: With one larger unit utilizing a flow in the range 90 to 130 cfs with, or without, a small unit to handle regulatory minimum flow of 7.5 cfs.

The existing penstocks were designed to give "straight-through" flows of 125 cfs to each of the discharge regulating valves and 20 cfs via a branch connection to the original 75 kW turbines. With this magnitude of flow, the headlosses in the pipes were not significant, but with the proposed higher output units, the head losses would be a considerable proportion of the total head available, thus seriously reducing the potential output from project. Hence, the alternative approaches of modifying the existing penstocks, or of installing a new one, were considered. For each of the alternatives, it was evident that modification of the tailace tunnel outlet would be necessary to remove the constriction.

Full consideration has been given to the number and types of units. Alternatives evaluated comprised one- and two-unit installations, utilizing Francis turbines with horizontal shafts, single-regulated Kaplan and fixed-blade propeller turbines in both horizontal and vertical configurations.

The cooperation of major U.S. and European manufacturers of small hydraulic turbines was sought for the study.

The alternative which included a very small unit to generate solely from the regulatory minimum flow of 7.5 cfs was rejected when this proved uneconomic, due to very low capacity factor and high cost per kW of the unit.

2.3 - Plant Size Selection

The plant capacity and unit sizes were selected following an analysis of the existing facility condition and layout, the hydraulic characteristics of the intake tower, penstocks, tailrace tunnel and tailrace channel, variation of available flow, comparative power values, the preferred load requirements of BG&E, and the established WSSC rules for the operation of the reservoir for water storage and flood control.

The selected 500 kW installation is considered to provide optimum usage of the available hydroelectric potential at the site. Initial plant size optimization and comparison of alternatives was based on preliminary power values published by the Federal Energy Regulatory Commission (FERC) for an alternative coal-fired generating unit source in the Pennsylvania-New Jersey-Maryland Interconnection (PJM) system. The selection of plant size and configuration will not be significantly influenced by any likely differences in power values from these published levels.

Project cost evaluations for one- and two-unit alternatives are summarized in Table 1. The total costs of the alternatives range from \$734,000 to \$880,000 in total project cost. On the basis of the costs provided by manufacturers for this study, the single 500 kW vertical shaft propeller turbine with an asynchronous generator appears to be the most cost effective alternative with the nearest contender costing 9 percent more with no improvement in performance.

2.4 - Economic Evaluation

Construction costs are based on unit costs applicable to the type of work involved on conditions similar to those prevailing in the Brighton Dam area and on pricing levels effective in the third quarter of 1978.

A single comparison of the project cost of energy to that from an alternative coal-fired source, is presented in Table 2. The cost of money for the hydroelectric plant was determined on the basis that WSSC, being a public utility, is able to obtain capital funds at 6 to 6.25 percent interest. BG&E is dependent on private financing, therefore, the equivalent cost of money for the coal-fired alternative was taken as 10 percent. Furthermore, WSSC is self insured and pays no taxes on Brighton Dam. Thus, the annual costs of the total fixed charges for the WSSC hydroelectric and the BG&E coal-fired thermal

power alternative, are 9 percent and 19.56 percent of capital cost, respectively.

The FERC power values, referred to in 2.3, suggest a capacity value of \$136/kW and an energy value of \$11.6/MWh which, for the selected Brighton Dam scheme, results in a total power value of 35.5 mills/kWh. Thus, the hydroelectric energy cost level estimated at 23.3 mills/kWh provides a benefit to cost ratio of 1.53 on 1978 costs without any provision for escalation of fuel costs in future years. Therefore, the project is economically feasible and may be expected to become an increasingly beneficial investment in years to come.

2.5 - Construction Cost Estimates and Schedules

(a) General

Detailed construction cost and schedule data were developed for the recommended hydropower redevelopment under consideration for the Brighton Dam Project. The data is presented to a degree of detail such that further detailed economic evaluations as well as financial and schedule planning may proceed with an acceptable level of confidence.

(b) Cost Estimates

Summary cost estimates, for four alternative project design concepts considered, are presented in Table 1. Detailed cost estimates were prepared for the 500 kW vertical shaft propeller unit, the 420 kW horizontal shaft tube unit and the two arrangements of twin 243 kW or 240 kW Francis units installed on the existing penstocks, with or without modification, respectively.

Cost estimates for each alternative were based on similar plant facilities, type of generator, electrical auxiliaries and controls, and modifications to tailrace. Estimated construction costs were based on current (third quarter 1978) cost levels applicable to the type of work involved and the local conditions at Brighton Dam. Additionally, unit costs for the major civil construction activities were estimated to allow for the environmentally sensitive location of the project and the resulting construction restrictions pertaining to dust, preservation of water quality and for limitations due to the flood control requirements at the existing structures.

(c) Schedules

The project schedule, Plate 8, shows the two principal phases of engineering and construction for the recommended scheme. The engineering schedule has essentially been based on concurrent licensing and engineering design and equipment procurement activities to provide the shortest construction lead time. Consecutive

licensing and engineering activities would lengthen the schedule by at least 12 months.

The FERC licensing phase of the schedule includes a 3 month preparation period in parallel with initial engineering design activities. These activities include finalizing the project arrangement and the preparation of turbine-generator procurement documents. The earliest scheduled date for receipt of the FERC License being in month twelve. Shortly after this date, the civil construction contract document is to be ready for issue to prospective bidders. If schedule delays are to be avoided, the latest date for receipt of the license is the end of the fifteenth month.

The total scheduled period from authorization to completion of the project is 32 months.

(d) Project Cash Flow

The project cash flow, shown on Table 9, is based on present day estimated costs with no allowance for future escalation. AFDC has been estimated, assuming a 6.25 percent annual cost of money and end of period payments, at an amount of \$42,300 or 5.75 percent of the estimated capital cost (\$734,000). The total project cost, including AFDC, is thus \$776,300.

2.6 - Preliminary Environmental and Safety Assessments

(a) Existing Conditions

The proposed hydroelectric redevelopment at Brighton Dam lies within WSSC owned structures and lands. The redevelopment would be integrated with the existing Triadelphia Reservoir which is currently being operated for water-storage and flood control purposes. The existing reservoir and adjacent areas are scenically attractive, provide significant wildlife habitats and are used for recreational activities on a relatively small scale during the summer months only.

(b) Preliminary Environmental Assessment

The proposed redevelopment of hydroelectric potential would have negligible impact on the present terrestrial and aquatic systems both during construction and operation of the facilities, provided adequate precautions are taken. This applies particularly to the initial start-up of the plant. If this occurs at a time of low flows, the release of poor quality water from the bottom of the reservoir could be harmful.

To assist in the selection of the most favorable alternative, preliminary environmental and safety assessments have been conducted. These assessments identified the major impacts anticipated from construction and operation of the proposed hydroelectric facility.

Detailed environmental/safety assessments would be required as part of the licensing process. The current study on the other hand, has been brief and preliminary, and has been adapted to the level of feasibility assessment appropriate at this time. The study consisted of a preliminary review of pertinent environmental reports, a site reconnaissance and contacts with individuals from state and federal agencies having expertise on the terrestrial and aquatic ecosystems found within the project area.

A summary of the environmental impact assessment is presented on Table 10.

(c) Preliminary Safety Assessment

Construction of the proposed hydroelectric facility will have a potential impact on the safety of the public as well as construction workers in the immediate vicinity of the power plant. Appropriate precautions would be necessary to minimize these risks. Design and operating procedures would have to be formulated to ensure that no significant increase in risks to public safety arise during operation of the reactivated hydroelectric installation.

2.7 Marketing Studies

WSSC is a water utility and, apart from standby diesel generators, has no operational electricity generating plant of its own. At the present rate of demand only 5 percent of the potential hydroelectric output at Brighton Dam could be used at that location. The present supply of electricity to WSSC at Brighton Dam is provided by BG&E who operate and maintain the 13.2 kV line to the facilities there. It therefore follows that the power surplus to WSSC's needs should be sold to BG&E. The only alternative to this would be for WSSC to construct their own power distribution lines to their other water pumping and sewage treatment plants. This is not considered feasible for cost and operational reasons.

Preliminary discussions with BG&E have resulted in agreement in principle. As Brighton Dam hydroelectric redevelopment could be used primarily for peaking generation, reasonably high energy values may be expected to apply. Furthermore, consideration of more rapid escalation in energy costs from fuel-dependent sources in the future indicated that hydroelectric peaking generation will be more economic on a present worth basis, over a 30 year period. WSSC could, therefore, derive significant economic benefit from a hydroelectric power plant of the particular capacity envisaged.

2.8 - Recommendation

Based on the findings of this report, it is recommended that a FERC license application be filed for the Brighton Dam redevelopment project at an early date.

TABLE 1

BRIGHTON DAM HYDROELECTRIC REDEVELOPMENTCOMPARATIVE PROJECT COSTS AND BENEFIT:COST RATIOS FOR ALTERNATIVE SCHEMES

<u>Account Item</u>	<u>A1</u> 2-240 kW Francis existing penstocks	<u>A2</u> 2-243 kW Francis modified penstocks	<u>B1a</u> 1-500 kW Vert. propeller	<u>B1b</u> 1-420 kW horiz. tube
331 Structure & Improvements	\$ 26,920	\$ 36,000	\$ 43,000	\$ 44,000
332 Reservoirs, Dams & Waterways	6,600	24,730	11,700	9,100
333 Turbines & Generators	327,000	327,000	292,300	414,100
334 Accessory Electrical	50,000	50,000	40,000	0
335 Misc. Power Plant Equipment	2,000	2,000	2,000	2,000
353 Substation Electrical	<u>15,000</u>	<u>15,000</u>	<u>2,000</u>	<u>0</u>
Subtotal	427,520	454,730	391,000	469,200
Contingencies (25%)	106,980	113,770	98,000	117,300
Engineering & Administration	<u>267,500</u>	<u>284,500</u>	<u>245,000</u>	<u>293,500</u>
TOTAL PROJECT COST	<u>802,000</u>	<u>853,000</u>	<u>734,000</u>	<u>880,000</u>
Expected Annual Generation Value (See Table 2)	97,520	98,750	101,000	84,100
Expected Annual Cost of Project	72,180	76,770	66,060	79,200
Benefit/Cost Ratio	1.35	1.29	<u>1.53</u>	1.06

SECTION 3
PROJECT DATA

3 - PROJECT DATA

Brighton Dam, built in 1943, is located on the Patuxent River approximately 15 miles upstream from Laurel, Maryland. The development comprises an Ambursen dam with a spillway using 13 Tainter crest gates and a powerhouse built between two buttresses on the right bank. It was built primarily for the storage of water and the powerhouse and hydro-generating plant were purely for use at the site for heating, lighting, operation of spillway gates, etc., there being no other supplies to the site at that time. Hence, the plant was designed to meet anticipated site demands and not to develop the full hydro potential.

Two penstocks of 30 inch diameter, embedded in the powerhouse floor, provide conduits from the intake tower to the two discharge regulators and the two water turbines. The turbines were each rated at 100 hp when utilizing a net head of 50 feet and a flow of 20 cfs. The synchronous generators were each rated at 75 kVA. The hydroelectric facilities were taken out of service in 1969 due to problems with the turbine regulating gear and excessive maintenance costs. Additionally, an electrical supply had, by that time, been laid onto the site by the local utility (BG&E).

The two discharge regulators are still in service and are used for controlling normal discharges from the reservoir. They are of the conical, cylindrically balanced type, each capable of discharging up to 125 cfs.

Photographs of the dam, powerhouse and generating units are included at the end of this section of the report.

The site potential and limitations, for determination of a suitable conceptual project design, were evaluated through collection of available data and drawings of the existing facilities and through a site examination. It was found that there was sufficient available data to substantiate, within a reasonable degree of accuracy, the technical feasibility, cost, and expected productivity of the proposed project. Further optimization of plant size and more accurate estimation of expected generation would be possible with further data collection, including downstream riverbed sectional data and impoundment volumes, and subsequent hydraulic analysis. More rigorous definition of capacity and energy values would be necessary for further analyses to be effective in optimizing the plant design.

3.1 - Site Conditions

The feasibility study included a site examination and evaluation report which is Appendix B of this report.

The site examination was held on November 28, 1978 for investigation of the existing structure and site conditions. The reservoir level had been drawn down to 349.5 feet msl so that the spillway gates could be painted. This permitted an examination of the upper gates of the intake

tower which appeared to be in sound condition. It was reported by the plant operating staff that the existing powerhouse has been inundated on numerous occasions during periods of high flow. The most serious of which was during Hurricane Agnes in 1972 when water level inside and outside the powerhouse reached 324 feet msl. Access to the power plant is limited. The doorway, which is 6'10" high by 4'3" wide, leads only to the mezzanine floor which has a limited load carrying capacity. There is no crane in the powerhouse but there are lifting loops in the roof beams which can be used for lifting equipment.

A summary of site information is tabulated on Table 3.

3.2 - Streamflow

Streamflow data was obtained from the U.S. Geological Survey WATSTORE system. The stream gage nearest Brighton Dam is gage number 01591000 on the Patuxent River upstream from the reservoir. There are 34 years of record available for this gage. The drainage area at the gage is 34.8 square miles. The drainage area at Brighton Dam is 78.4 square miles. All data was adjusted to represent flow at the dam using a factor equal to the ratio of the respective drainage areas. The annual flow duration curve is shown in Figure 1. Flow duration data for each month was used to establish the average monthly flows available for generation. The minimum release from the reservoir is 7.5 cubic feet per second. The mean monthly flows, evaporation and net monthly flows, are shown in Table 4.

3.3 - Reservoir Levels and Pondage

When the reservoir level is 365 feet msl, the impoundment behind Brighton Dam extends approximately 5 miles upstream. The reservoir storage at this level is approximately 28,000,000 cubic feet per foot of depth. The reservoir storage curve is shown in Figure 2.

The operation of the reservoir was originally solely predicated upon its use for water supply. However, after two large floods in 1971 and Hurricane Agnes in 1972, WSSC began operating the reservoir with flood control in mind. This policy change has the net result of maintaining the reservoir three feet below the top of flashboards, or at elevation 363.4 feet msl.

A report prepared for WSSC in 1972 examined the effects on flood protection of various reservoir operating policies. One of the policies examined was maintaining Triadelphia Reservoir at el. 363.4 feet msl. The results of this study show that the 363.4 feet msl water surface elevation could provide protection against floods not exceeding a 20 year frequency, and that for larger floods, the reservoir would

provide no more flood protection than if the reservoir were maintained at the top of flashboards or at el. 366.4 feet msl.

Therefore, it is felt that the current reservoir operating policy provides significant flood protection for the higher frequency floods.

3.4 - Hydraulic Design Data

The following hydraulic data were established for the conceptual design of the facilities:

Headwater Level (feet msl)	maximum - 366.4
	normal - 363.4
	minimum - 349.0
Tailwater Level (feet msl)	maximum - 324.0
	normal - 305.7
	minimum - 304.6
Normal Gross Head	57.7 ft
Normal Net Head Range	52 - 56 ft
Average River Flow	82 cfs
Design Flow Range	90 - 130 cfs

3.5 - Head Losses

A head loss analysis was performed for various penstock schemes. Losses would occur through the gates in the intake tower, at the entrance to the penstock, in skin friction in the penstock, and in any bends or valves in the penstocks.

3.6 - Tailwater

A tailwater rating curve was developed using the gage immediately downstream of the deflection wall. It was assumed that the datum of the gage is elevation 304 feet msl. The rating curve for this gage is shown in Figure 3.

3.7 - Potential Annual Energy Production and Plant Capacity

Based on an average annual flow of 84.5 cfs (after allowance for evaporation), 56 feet of net head, and an overall system efficiency of 85 percent, the potential total annual generation is approximately 3,000,000 kWh.

The generation potential of the project site was also calculated on a monthly basis subject to the following conditions:

- (1) Minimum generation time of 8 hours daily (see Section 5.1, page 5-4)
- (2) Pondage of 28,000,000 ft³/ft
- (3) Penstock head losses by $h_L = \frac{0.33 L v^{1.9}}{1,000 D^{1.1}}$

where L is the equivalent length in feet of a straight penstock
 v is penstock velocity in feet per second
 D is penstock diameter in feet

- (4) Intake head loss on one foot
- (5) Reservoir level of 363.4 feet msl except during periods of low flow when the reservoir is drawn down to meet the minimum generation hours (See 1 above)
- (6) Tailwater level based on Figure 3
- (7) Minimum release of 7.5 cfs.
- (8) All gates fully open in intake tower

An analysis was performed to determine the optimum flow for various penstock schemes. It was assumed that all excess monthly flow would be stored and the reservoir levels adjusted to be able to hold the excess flow with the maximum level at 366.4 feet msl. Six different penstock schemes were analyzed at four different flow rates. These schemes included three using existing penstocks or some modification of the existing penstock, and three using single penstocks of various sizes. Generation was computed on a monthly basis. The results of this analysis indicated that the maximum annual generation will occur at generation flows in the range of 120-125 cfs.

The power and generation figures for each scheme analyzed were estimated on the basis of the current reservoir operating policy of maintaining the water surface elevation three feet below the top of flashboards atop the spillway gates. It would be possible to increase the power and generation at Brighton Dam by allowing the reservoir level to increase to the point of providing adequate storage for flows in excess of generation flows. Assuming the power plant is operated at approximately the optimum flow (125 cfs), excess flow would only occur during the month of March, based on the mean monthly flows. The increase in reservoir level would provide a subsequent increase in net head and thus a proportionate increase in power and generation.

All power and generation figures were computed for mean monthly flows. Variation can be expected from year to year. During wet years, the generation should increase, but not in direct proportion to the increased flow (some flow will undoubtedly be spilled due to insufficient storage). During dry years, the generation would decrease due to lower flows.

TABLE 3

BRIGHTON DAM HYDROELECTRIC REDEVELOPMENT SITE DESCRIPTION

<u>Location</u> - - - - -	-On the Patuxent River approximately 15 miles upstream of Laurel, Maryland.
<u>Route From Washington D.C.</u> - - - - -	-North on I-95 to MD #198, West on #198, crossing U.S., #29, to MD #650 at Spencerville, North on MD #650 through Ashton and Brinklow to Brighton Dam Road. Right 1 mile to site on Md #216
<u>Date of Original Commissioning</u> - - - - -	-October 4, 1943
<u>Triadelphia Lake</u> - - - - -	-Storage: 21,000 acre-feet Length: 5 miles Water Surface: 800 acres Watershed: 50,000 acres
<u>Brighton Dam</u> - - - - -	-Length: 995 feet Height: 80 feet Spillway length: 260 feet with 13 - 15 ft x 18 ft Tainter crest gates
<u>Discharge Capacities</u> - - - - -	-2 Silt Valves: 250 cfs 2 Needle Valves: 260 cfs 3 Silt Valves: 405 cfs 13 Tainter Gates: 64,000 cfs 64,915 cfs
<u>Record Discharge</u> - - - - -	-17,800 cfs on June 22, 1972.
<u>Elevations (feet msl)</u> - - - - -	-Top of Tainter Gate Flashboards: 366.4 Top of Spillway Crest: 350.0 Top of Embankment Paving Slab: 375.0 Intake High-Level Gate Sill: 350.0 Intake Mid-Level Gate Sill: 323.0 Intake Low-Level Gate Sill: 309.8 Normal Max. Reservoir Level: 363.4 Average Tailwater Level: 305.5

TABLE 4BRIGHTON DAM HYDROELECTRIC REDEVELOPMENT
HYDROLOGIC DATA

<u>Month</u>	<u>Mean Monthly Flow</u> (cfs)	<u>Evaporation</u> (ft)	<u>Net Flow</u> (cfs)
January	103	.1	102
February	119	.1	118
March	132	.2	130
April	123	.3	120
May	105	.3	102
June	80	.4	76
July	65	.4	61
August	55	.4	51
September	45	.4	41
October	45	.2	43
November	58	.1	57
December	87	.1	86

TABLE 5

BRIGHTON DAM HYDROELECTRIC REDEVELOPMENT
EXPECTED MONTHLY GENERATION

<u>Month</u>	<u>Generation</u> (kWh)	<u>Generation Time</u> (hrs/day)	<u>Capacity Factor</u> (%)
January	300,000	18.5	77
February	351,000	21.7	90
March	387,000	24	100
April	358,000	22	92
May	300,000	18.5	77
June	217,000	13.4	56
July	170,000	10.5	44
August	138,000	8.5	35
September	130,000	8.0	33
October	128,000	8.0	33
November	127,000	8.0	33
December	234,000	14.6	60
TOTAL	2,840,000		

SECTION 4

ASSESSMENT OF ALTERNATIVE SCHEMES

4 - ASSESSMENT OF ALTERNATIVES

4.1 - General Considerations

The power output of a hydroelectric plant is a function of the available head, streamflow and pond storage and the operating characteristics of the turbine/generator equipment. In order to evaluate the optimum installation for site development, a series of analyses were made, adjusting these output parameters until an optimum selection of facilities was reached. The analysis was dependent upon definition of the stream flow and pondage availability, basic site oriented hydraulic design data, existing site conditions and power values and operating criteria which determine the appropriate capacity and energy benefits of the project. These have been set out in Section 2 of this report.

The following factors were taken into consideration in establishing the alternative types of installation which should be studied:

- (a) The cost per kW of generating plant is approximately in inverse proportion to the size. This favors selection of the largest possible single unit for the project.
- (b) Two identical units could probably be purchased for less than two times the cost of one such unit. This would give greater flexibility of operation and could conceivably fit into the existing penstock facilities.
- (c) It is a condition of the WSSC Water Appropriation and Use Permit that they shall maintain a minimum flow of not less than 7.5 cfs at all times immediately downstream of Brighton Dam (Triadelphia Reservoir). This requirement led to the consideration of a small generating unit to handle this discharge.
- (d) WSSC draws water for local water supply from the Rocky Gorge Reservoir, some 15 miles downstream of Brighton Dam. Rocky Gorge is a sizeable reservoir which is only partly dependent on Triadelphia for its supplies. Hence, the discharge from Brighton Dam can be varied over a considerable time period without noticeable effect on the lower reservoir. This fact, coupled with that of the considerable storage available in Triadelphia, removes the necessity for the installation of generating units with wide ranges of discharge. Discharges less than the rated flows can be accommodated by operating the plant for a shorter period of the day.
- (e) A further effect of the available storage capacity is that there need be no spillage of stored energy in the event the generating plant is out of service for short periods of maintenance or repair.

- (f) The facilities at Brighton Dam are connected to BG&E's electrical grid which is large enough to absorb variations in generation or demand at Brighton Dam. Hence, BG&E would experience no problem if the generating unit or units were shut down at any time. Furthermore, the hoists for operating the dam spillway gates have both electric and gasoline motors and are thus unaffected by loss of electrical supply.

4.1.1 - General Construction Considerations

Some modifications have been proposed for all schemes.

The powerhouse has inadequate access utilizing existing facilities for removal of old equipment and installation of the new. The proposed scheme would involve constructing an earthfill cofferdam in the tailrace channel downstream of the downstream wall of the powerhouse. The cofferdam would be made into a ramp for access from the downstream edge of the existing parking lot. The downstream wall from the mezzanine floor elevation down to the existing floor elevation would be removed between the dam buttresses for access to the powerhouse during construction. It would be replaced upon completion. When rebuilding the wall, the lower windows would be bricked up to prevent entry of water during conditions of extreme high tailwater level.

The hydraulic efficiency of the existing tailrace tunnel outlet was studied to determine if any modification would be required to handle the design flows. The existing tailrace tunnel would create a back pressure at 130 cfs and effectively increase the tailwater level to approximately 307.5 feet msl. It follows that tailrace tunnel outlet should be modified so that the head in the tunnel is approximately equal to the tailwater level. The proposed modification, similar in all schemes, is shown on the plates depicting the various alternatives. The modification would enable the dynamic energy recovery to be sufficient and uninterrupted from the turbine exit to the tailrace channel beyond the modification.

With the above factors in mind, the alternatives described in Section 4.2 were selected for study.

4.2 - Description of Alternative Schemes

4.2.1 - Identifying Alternatives

A number of turbine-generator arrangements have been identified involving the utilization of the existing penstocks to greater or lesser degrees.

The turbine arrangements considered came under two main headings:

Alternative A: Two identical units each utilizing flows in the range 50 to 70 cfs.

Alternative B: One larger unit utilizing a flow in the range of 90 to 130 cfs, with or without a small unit to handle the regulatory minimum flow of 7.5 cfs.

Within Alternative A there were two further divisions:

- A1 - Using the existing penstocks and valves with no modification.
- A2 - Using the existing penstocks up to but excluding the isolating valve and modifying the penstocks to incorporate a wye branch thereby reducing the hydraulic losses to the entrance of the turbine.

Alternative A-3, which was based on installation of new penstocks and leaving the old ones solely for the use of the discharge regulators, has been eliminated due to the expected high cost and little benefit offered by this approach.

Correspondingly, Alternative B was subdivided further:

- B1 - Using one large unit.
- B2 - Using one large unit with a smaller unit to handle the regulatory minimum flow of 7.5 cfs.

Based on the preceding considerations, five schemes were selected for further consideration in Sections 4.3 and 4.4:

- A1 - Two horizontal Francis units with spiral cases, supplied by The James Leffel Co., bolted onto the existing penstocks and draft tubes as shown on Plate 5.
- A2 - The same units as A1 bolted onto a modified penstock arrangement as shown on Plate 6.
- B1a - One vertical propeller unit from KMW installed as shown on Plate 3.
- B1b - One horizontal Tube unit from Allis-Chalmers installed as shown on Plate 4.

B2 - One large unit, either KMW or Allis-Chalmers, with a small unit from James Leffel to handle the 7.5 cfs regulatory minimum flow.

4.2.2 - Equipment Comparisons, Two Unit Installations

Referring to Table 7, data concerning the units considered for Alternatives A1 and A2 (2 unit installation) were submitted by James Leffel, Gilbert Gilkes & Gordon, and Escher Wyss.

Escher Wyss was not considered competitive because their price was more than double the others. Thus, their equipment was not evaluated further for application under Alternatives A1 and A2.

The Gilbert Gilkes & Gordon offer could be competitive but import duty and delivery costs made it less attractive. It was not evaluated any further, partly due to lack of data.

A very late response was received from Madden Paper and Paper Board Service on behalf of Tampella, Finland, offering two 225 kW units. The price was competitive, but the configuration of their units would not permit installation within the existing powerhouse facilities.

The James Leffel Co., in addition to offering the lowest equipment costs for Alternatives A1 and A2, have the advantage of experience in manufacturing replacement parts for the existing Rodney Hunt Turbines. Based on their knowledge of the existing powerhouse, Leffel claimed that their 2 unit scheme could be virtually a bolted-on arrangement. For these reasons, Leffel equipment was considered in more detail for both Alternative A1 and A2 in Sections 4.3 and 4.4.

4.2.3 - Equipment Comparisons, Single Unit Installations

For Alternatives B1 and B2 (single unit), information was received from Allis-Chalmers, Escher Wyss, Gilbert Gilkes & Gordon, James Leffel, KMW, and Stapenhorst as shown on Table 6.

The Escher Wyss price was again much higher than the others and no further consideration was given their equipment.

The remaining equipment alternatives were fairly competitive.

The Ossberger unit from Stapenhorst was set aside because of its performance characteristics. The Ossberger turbine has a flat efficiency curve all the way down to 30 percent gate, but, in turn, has a low peak efficiency of about 84 percent. As noted in paragraph 4.1 (d) above, a unit with a wide range of flows is of no advantage in this project due to storage availability.

The Allis-Chalmers 440 kW Tube unit package was eventually excluded--partly because it too had incompatible operating characteristics. The desired 130 cfs flow, was much less than the unit's optimum flow, hence it would have been operating well below its maximum efficiency. This together with problems due to high runner setting and the fact that the tailrace tunnel would have to be widened considerably, made this alternative less attractive.

The information received from Gilbert Gilkes & Gordon consisted only of telexed data giving a generator rating and price. Although their price was within the range of those other units selected for further study, the information they had supplied was inadequate to make necessary evaluation and comparisons. The project schedule did not permit time for further correspondence with overseas manufacturers. No serious problems arose in excluding their offer as it was not the lowest by any means, and problems in accommodating the unit within the confines of the powerhouse and tailrace tunnel channel could be foreseen. For these reasons, the single horizontal Francis scheme offered by Gilbert Gilkes & Gordon was not considered further.

The single unit proposed by The James Leffel Co. was eliminated because of the inordinately large physical dimensions of its penstock and pressure casing and because of size limitations of the existing tailrace tunnel. Its penstock could not have been accommodated in one half of the intake tower and, therefore, would have necessitated the use of a wye shaped extension connecting to both halves of the intake tower. Problems fitting the draft tube of this unit into the confines of the tailrace tunnel channel could also be foreseen.

The KMW vertical propeller unit and the Allis-Chalmers 420 kW tube unit are competitive and offer viable alternative equipment types which are considered in more detail in Sections 4.3.3 and 4.4.5a for alternatives B1 and B2.

For Alternative B2, responses were received from The James Leffel Co. and Gilbert Gilkes & Gordon regarding the small unit to handle the compensation flow of 7.5 cfs. Based on cost and the fact that being available in the U.S. may save in scheduling time, The James Leffel unit was considered the best choice and is evaluated further along with the KMW unit in Section 4.4.5c.

4.3 - Technical Evaluation of Alternatives

The alternatives selected for further consideration as discussed previously in Section 4.2 are evaluated in this section for their respective technical suitability.

4.3.1 - Expected Annual Generation

Technical evaluation of alternative schemes necessarily involved an examination of the potential for producing power and energy.

The objective of the power and energy calculation was to determine the available power potential by attempting to simulate as closely as possible the actual operation of a given installation at the site. In detailed optimization studies for each selected plant size, this operation simulation could have been done to any extent of detail for representative periods of river flow. The detail to which operation simulations were undertaken was generally based on the impact of the proposed project on system reliability and on incremental power values determined for the project. Under normal conditions, certain rules of operation were established, such as:

- (i) Reservoir operating rules for maximum and minimum water levels, and minimum streamflow releases.
- (ii) Maximum and minimum periods of plant operation, weekdays and weekends.
- (iii) Preferred gate settings and minimum operating flows for unit operation.

It is generally not economically practicable to undertake simulations in great detail as a part of a feasibility study such as this. A simpler approach was therefore adopted which reasonably closely approximated a more detailed simulation and allowed rapid consideration of numerous alternative selections of rated head and flow and numbers and types of unit. The approach used in the current study was based on flow records (as provided from the USGS WATSTORE programs). The turbine "rated" output was assumed to be that at the "rated" net head and maximum flow. Each type of turbine has its own efficiency characteristic which was used in the generation calculation.

The possible annual energy production for the five alternative schemes were calculated to be as follows:

<u>Alternative</u>	<u>Configuration</u>	<u>Energy (kWh)</u>
A1	2 units on existing penstocks without modification	2,685,000
A2	2 units on modified penstocks	2,719,000
B1a	1 KMW Unit	2,841,000
B1b	1 A-C Tube Unit	2,549,000
B2	As B1a with smaller unit	2,951,000

Because they employ two units, Schemes A1 and A2 would have the advantage of being able to operate longer at low flows than a large single unit. Also, due to the total generation flow of 125 cfs, relatively little water would be wasted during periods of high flow. The same can be said of Alternative B1a, whose generation flow would be 130 cfs. Alternative B1b, utilizing only 104 cfs, would waste a significant amount of water, especially during the wetter winter and spring months when the mean monthly flows reach as high as 130 cfs. This wasted water represents wasted power and energy. Scheme B2 would take advantage of even the minimum release for generation.

4.3.2 - Two Unit Alternatives A1 and A2

For an installation of this relatively small size, selection of a single unit seemed to offer certain economy. Even so, two units which could be bolted to existing penstocks were worthy of consideration since a reduction in civil works costs could offset the higher equipment costs. Hence, equipment manufactured by The James Leffel Co. was selected for further technical evaluation under Alternatives A1 and A2.

The first alternative, A1, considered the bolted-on application of Leffel type "Z" horizontal Francis turbines to the existing penstocks at the turbine shut-off gate valve as shown on Plate 5. This scheme would benefit from the simplicity of utilizing all the existing pipeworks and keeping civil work to a minimum. The main drawback to this scheme would be the loss of energy due to the high head loss in the existing pipeworks whose T branches and bends were originally designed to accommodate lesser flows.

Alternative A2 would utilize the same turbines but they would be installed on modified penstocks as shown on Plate 6. This modification could lead to some difficulties. Firstly, when removing the existing cast iron pipe sections, great care would have to be taken to avoid damaging the remaining portions of the pipe and secondly, when installing the new steel pipes there could be problems when they are bolted onto the existing cast iron penstocks.

On the other hand, the modification would provide 1.3 feet of additional head, thus increasing the annual energy production of the plant. An economic evaluation in Section 4.4.5b addresses the costs and benefits for these options.

4.3.3 - Single Unit Alternative - B1a, B1b

Installing a single unit would require either one side of the intake tower be used or that a scheme be devised for connecting the two chambers. The possibility of removing some portion of the dividing wall was studied to determine if the reduced head loss warranted the civil works costs.

For a single unit installation, a single penstock connected to one intake chamber with no further modification was selected. This arrangement would necessitate penetration of the upstream wall of the powerhouse. The structural adequacy of this approach was evaluated. The addition of a 2.5 feet thick wall against the upstream wall of the powerhouse, with new reinforcing steel which would be tied in to the existing reinforcing steel, was considered adequate.

The existing powerhouse floor over the tailrace tunnel would have to be removed to permit proper runner settings; the extent of removal would vary from one scheme to another. No structural problems were anticipated but the floor being 6 feet thick, the estimated civil costs for removal were significant.

Operation of one of the existing penstocks would be eliminated with either single unit installation. During periods of equipment outage, the regulatory minimum flow would be passed by the single remaining discharge regulator. With the two-unit installation, both discharge regulators would remain operational.

The additional civil work and the forced decommissioning of one of the discharge regulators tended to favor the two unit schemes.

The three schemes considered for a single unit installation were explained in Section 4.2. The addition of the smaller unit in Alternative B2 would simply add the cost of the unit to the cost of the alternative since no appreciable additional civil works effort would be required.

The standard horizontal tube turbine package (Alternative B1b) from Allis Chalmers offered virtually all the necessary equipment needed to complete the installation. There would be some advantage to such an arrangement because interface problems would then be resolved by the manufacturer.

The main drawbacks with this scheme would be twofold: First, due to the increase in net head resulting from the more efficient "straight in" penstock arrangement and the fact that 50 feet of head pushes against the upper limit for these "low head" hydro-turbines, a low runner setting would be necessary. This low runner setting adds considerably to the amount of civil work. Second, due to flow restrictions, the unit would have a lower power rating. This is reflected in the annual generation figure for Alternative B1b (See Section 4.3.1).

The standard KMW SV9 (Alternative Bla) would also have the advantage of being a standard turbine generator package similar to that from Allis-Chalmers. KMW manufacture two configurations of axial-flow turbines, one horizontal and one vertical. The vertical type are better suited for higher "low head" applications, due to the lower elevation of the runner, as shown on Plate 3. This turbine generator package would also require a lesser amount of civil work. Yet, larger inlet and runner diameters would enable it to handle higher flow rates efficiently, thus improving expected annual generation.

From a technical standpoint, Alternative Bla was the most attractive. The expected annual generation was greater than for any other alternative and the civil works less than for any other single unit scheme.

4.4 - Financial Assessment of Alternatives

4.4.1 - Cost Estimating Methodology

The development of preliminary costs for the Brighton Dam Hydroelectric Redevelopment involved detailed cost analysis of the key parameters of ultimate cost--the turbine-generator equipment and project civil works. The turbine-generator would have to be responsive to the operating needs of the owner, and provide predictable and reliable performance throughout the plant life (i.e., 40 years). This is the single item which, when bid for procurement, could have a major impact on the project civil works and ultimate project cost. The civil works must reflect the requirements of the generating equipment, operating needs, and local site conditions to optimize the structure design. Since these two items total between 84 and 99 percent of the project sub-total cost, the principal effort in estimating applicable quantities, unit costs, and equipment cost had to be applied to them. The remainder of the project items were less site specific and could be estimated more readily from manufacturers' price data and published data on installation labor productivity.

4.4.2 - Equipment Cost Estimating

Contacts were made with the following major U.S. and European manufacturers of small hydraulic turbines for preliminary estimating costs and data:

- Allis-Chalmers
- Barber Hydraulic Turbine, Ltd.
- Bofors-Nohab
- Brown-Boveri Corp.

- Drees & Co. GmbH
- Escher Wyss
- Gilbert Gilkes & Gordon, Ltd.
- James Leffel & Co.
- KMW Sweden
- Neyrpic
- F.W.E. Stapenhorst Inc.
- Tampella A.B.

Responses were received from Allis-Chalmers, Escher Wyss, Gilbert Gilkes & Gordon, James Leffel, KMW, Stapenhorst and Tampella. The information is summarized on Tables 6 and 7. Brown-Boveri Corp. did not respond, although available promotional literature suggested that they manufacture units in the desired size range. Only the selected schemes are discussed herein.

4.4.3 - Construction Cost Estimating

The actual costs of the civil works of a hydroelectric project or other similar construction depend on such factors as:

- (1) The availability of experienced contractors;
- (2) The amount of similar work regionally and locally;
- (3) Local labor force and labor relations;
- (4) Contract document and construction drawing accuracy;
- (5) Site restrictions and construction techniques used;
- (6) Weather and site conditions during construction.

A job cost can be heavily affected by any one of these factors or the cumulative effect of all since they ultimately determine the productivity of the contractor.

Engineering estimates were developed by breaking down into distinct units the items making up the project which would have a significant impact of project cost, taking off quantities from conceptual project drawings and assigning unit costs appropriate to the difficulty of work involved. The summation of all items provided the construction subtotal cost. A contingency was added to account for minor items not included in the estimate and to allow for reasonable cost variation outside of that projected in the unit costs. At the conceptual design stage of project development, 25 percent of the project subtotal was considered an appropriate contingency for this project.

The itemized breakdown by type of work is presented in Appendix D and is consistent with the FERC system of accounts. (FERC Form 6, "Actual Legitimate Original Cost"). Minor items are included in the major categories of work where they do not provide a significant impact on overall cost.

Unit costs were based on the cost of materials and labor (including delivery, installation, overheads and profit) required to complete construction of the item of work. Particular reference data used to establish appropriate unit costs included various manufacturers' data; U.S. Department of Labor, labor statistics; R.S. Means Co., Inc., 1979 Building Construction Cost Data; McGraw Hill Information Systems Co., Dodge Guide For Estimating Public Works Construction Costs; and Engineering News Record (1978-Third Quarterly Cost Roundup). These data, together with knowledge of the site and the proposed project facilities, formed the basis upon which individual work activities were assessed.

Engineering and Administrative costs accounted for all costs associated with project management, including acquiring permits and licenses, engineering detailed design, procurement, site construction management and commissioning the station. For this type of project the Engineering and Administration costs would be approximately 50 percent of the project construction cost.

4.4.4 - Description of FERC Accounts

Account 331.00 Structures and Improvements

Description: The modifications to the powerhouse including the removal and replacement of any concrete are included in this account (Alternative A1 excluded). Also, included is the removal and replacement of the cofferdam and downstream wall which applies to all schemes.

Account 332.00 Reservoirs, Dam and Waterways

Description: This account includes any penstocks (excluding Alternative A1). Also included, is the modification to the tail-race channel to accommodate the increased turbine discharges.

Account 333.00 Waterwheels, Turbines and Generators

Description: The turbines, governors and associated piping, the generators and exciters (where applicable) are included in this account. Alternative B1a also includes a 480 V/ 13.2 kV power

transformer in this account. For Alternative B1b, all the control, metering, and relay devices, the generator switchgear, and the 480 V/ 13.2 kV transformer including installation, are included in this account.

Account 334.00 Accessory Electrical Equipment

Description: This account includes procurement and installation of all the control metering and relay devices, and the bus voltage switchgear (excluding Alternative B1b). Also included are all the conduits, conductors, and miscellaneous hardware, along with their respective installations.

Account 335.00 Miscellaneous Power Plant Equipment

Description: This account includes a power plant drainage system including a sump pump and pipework.

Account 353.00 Station Equipment

Description: For Alternatives A1 and A2, this account includes procurement and installation costs of the 480 V/13.2 kV power transformer, including grounding, take-off equipment, mounting pad preparation, and protective fencing.

4.4.5 - Evaluation of Schemes

4.4.5a - Single Unit Schemes

The offer from Allis-Chalmers included virtually all the necessary major equipment: turbine, inlet valve, speed increaser, generator, turbine and inlet valve hydraulic control system, all electrical switchgear and protective relaying and the output transformer. Also included in their submittal was a price for the installation of the various equipment on site, and a delivery cost as shown on Table 6.

KMW submitted a package price similar to that of Allis-Chalmers. Their offer included: turbine, inlet valve, generator and transformer. The price of the unit would be subject to overseas transportation and import duty costs which have been included in the cost estimate shown on Table 6. An installation cost of 25 percent of the cost of the unit after import duty has been estimated. All the electrical equipment such as protective relaying and conductors were estimated separately. Added engineering costs were anticipated with this arrangement due to equipment interfacing compared to the Allis-Chalmers proposal.

4.4.5b - Two Unit Schemes

The James Leffel Co. supplied data and costs for a two-unit bolted-on arrangement. Their proposal included only the turbine and governor. Generator cost estimates were obtained from KATO Engineering and have been included with the turbine costs on Table 7. The equipment interfacing between turbines and existing, or modified, penstocks and between Leffel turbines and KATO generators would result in higher engineering costs than the other schemes. Although a straight percentage was used for the engineering costs at this point, more attention would have to be placed in this area during the final design stages.

Referring to Table 1, based on third quarter 1978 costs, Alternative A2 showed an annual generation revenue of \$1,230 more than Alternative A1, whilst its annual cost was \$4,590 greater. This results in a benefit to cost ratio of 0.27 for the modification of the penstocks to reduce the existing energy losses. Based on this analysis, the modified penstock versus existing penstock scheme was not considered economically feasible.

4.4.5c - Generating Unit for Minimum Flow

The application of a small generating unit to handle the regulatory minimum flow of 7.5 cfs was eliminated from consideration as a result of the following analysis:

The analysis was based on the additional annual generation which would be obtained from the small generating unit if it was used in conjunction with the single 500 kW unit and utilized the 7.5 cfs regulatory flow at all times when the larger unit was shut down due to there being insufficient water.

The small unit proposed by The James Leffel Company was rated at 25 kW for the 7.5 cfs flow. The total installed cost of the unit was estimated to be \$51,615 which was equivalent to an annual cost of \$4,645. The calculated additional annual generation which would be produced by the unit was 110,000 kWh and, based on an energy value of \$11.60/MWh with no allowance for the additional 25 kW capacity, this would yield an annual revenue of \$1,276.

This analysis yields a benefit/cost ratio of 0.27. Thus further consideration of a small unit to extract the energy from the regulatory minimum flow was discontinued.

4.5 - Recommended Scheme

Reference to Table 1 - Comparative Project Costs, shows that the single unit schemes have comparable civil work costs, which are not appreciably greater than those for the two unit schemes. This is partly due to the common requirements for modification of the tailrace and the removal and replacement of the powerhouse downstream wall for access, whose cost is significant compared to the other civil costs.

Alternative B1a, having the lowest equipment costs of all the schemes, offers the apparent least total cost in spite of relatively substantial civil costs.

Benefit to cost ratios computed for all the schemes are shown on Table 1. Because the expected annual generation, (explained in Section 4.3.1) is the greatest for Alternative B1a after exclusion of the compensation unit and because it also has the least total project cost, the benefit to cost ratio is the highest of all the schemes.

Based on the analysis discussed previously, and today's value of energy and money, the KMW single unit (Alternative B1a) is the most attractive installation. Because it is the most cost effective, it is selected as the recommended scheme.

TABLE 6
BRIGHTON DAM HYDROELECTRIC REDEVELOPMENT
TURBINE-GENERATOR MANUFACTURER DATA

Single Unit Installation 500 kW

Manufacturer	James Leffel	Gilbert Gilkes	Escher Wyss	KMW	Allis- Chalmers	Allis- Chalmers	Stapenhorst
Type of Unit	Horizontal Francis w/ pressure case	Horizontal Francis w/ spiral case	Horizontal Francis w/ spiral case	Vertical Propeller	Horizontal Tube	Horizontal Tube	Cross-Flow Ossberger
Item							
Best Efficiency(%)	90.2	NA	NA	89	90	87.5	NA
Full Gate Efficiency (%)	84.1	NA	NA	89	90	87.5	NA
Speed (rpm)	360	NA	450	612	900 ¹	900 ¹	NA
Runner dia. (inch)	NA	NA	NA	35.4	29.5	39.4	NA
Runner Setting(ft)	NA	NA	NA	E1.304.5	E1.311.00	E1.314.50	NA
Generator Rating(kw)	500	440	485	500	420 ²	440	500
Turbine Supply (\$)	150,000	260,000	422,000	150,000	311,600 ³	336,300 ³	298,000 (270,000) ⁴
Generator Supply(\$)	54,800 ⁵	incl/turbine	33,800 ⁶	60,000 incl/trans.	--	--	incl/tur.
Import Duty(7.5%)(\$)	0	19,500	31,700	15,800	0	0	0
Delivery (\$)	2,500	14,800	30,000	10,000	2,500	2,500	2,500
Installation(\$)	<u>70,000</u>	<u>70,000</u>	<u>100,000</u>	<u>56,500</u>	<u>100,000³</u>	<u>100,000³</u>	<u>74,500</u>
TOTAL	<u>\$277,300</u>	<u>\$364,300</u>	<u>\$617,500</u>	<u>\$292,300</u>	<u>\$414,100</u>	<u>\$438,800</u>	<u>\$375,000</u> <u>\$347,000⁴</u>

(1) Generator speed with increaser, turbine speed not available

(2) Rated at 57.5 ft. head

(3) Complete with valves and all electrical equipment, including generator, switchgear, controls and transformer

(4) With induction generator

(5) Ideal Electric

(6) Internal Estimate

TABLE 7
BRIGHTON DAM HYDROELECTRIC REDEVELOPMENT
TURBINE-GENERATOR MANUFACTURER DATA

	2 Unit Installations 500 kW Total			Single Unit for Compensation Flow	
Manufacturer	James Leffel	Gilbert, Gilkes & Gordon	Escher Wyss	James Leffel	Gilbert, Gilkes & Gordon
Type of Unit	Horizontal Francis w/ spiral case	Horizontal Francis w/ spiral case	Horizontal Francis	Horizontal Francis	Horizontal Francis
Item					
Best Efficiency (%)	90.0	NA	NA	NA	NA
Full Gate Efficiency (%)	82.7	NA	NA	NA	NA
Speed (rpm)	720	NA	514	900	NA
Rated Output of Generator (kW)	240 ³	220	260	25	27
Turbine Supply (\$)	113,000	143,000	331,500	36,500	50,000
Generator Supply (\$)	15,323 ¹	incl. with turbine	18,600 ²	3,615 ¹	incl. with turbine
Import Duty (7.5%) (\$)	0	10,725	25,000	0	3,750
Delivery (\$)	3,000	10,000	10,000	1,500	3,000
Installation (\$)	32,100	38,400	50,000	10,000	13,450
TOTAL (1 Unit) (\$)	163,423	202,125	435,100	\$ 51,615	\$ 70,200
TOTAL (2 Units)	<u>\$326,846</u>	<u>\$404,250</u>	<u>\$870,200</u>		

(1) KATO Engineering

(2) Internal Estimate

(3) 240 on existing penstocks, 243 on modified penstocks..

SECTION 5

CONCEPTUAL STUDY OF RECOMMENDED SCHEME

5 - CONCEPTUAL STUDY OF RECOMMENDED SCHEME

5.1 - General Considerations

The recommended scheme has been selected on the merits of its clear advantage in the benefit:cost ratio, its simplicity of design, the long-standing reputation and expertise of the manufacturer in the hydroelectric field, the good overall efficiency of the total installation including penstock, turbine, draft tube and tailrace, and the ease with which the whole unit would fit into the existing powerhouse.

The scheme would comprise a single, vertical shaft, axial flow, propeller turbine with an asynchronous generator mounted directly on top. The turbine and standard elbow type draft tube would be installed on the centerline of the existing powerhouse. The 4 feet diameter penstock, with a butterfly shut off valve, would connect the turbine inlet to one half of the existing intake tower. The turbine-generator would be a standard KMW Type SV9 unit having a turbine runner diameter of 900 mm (35.4 inches). The whole unit, including the speed increaser, if required, would be pre-assembled at the manufacturer's works. Site installation time would thus be kept to a minimum.

The installation of this unit would involve removing one of the existing discharge regulators from service, leaving the other available for use at all times to discharge the compensation flow (7.5 cfs) or any amount up to its maximum discharge (125 cfs).

The layout of the scheme is shown on Plate 3. The civil works would involve closing off both halves of the intake tower, building a cofferdam in the tailrace channel, and dewatering the tower, penstocks and tailrace tunnel. Plate 3 also shows the areas where concrete and rock would have to be removed. In addition, it is anticipated that it would be necessary to make a temporary opening in the downstream wall of the powerhouse for adequate access to remove the old plant and install the new, and the project costs include a sum of money for this. When this wall is rebuilt, the lower windows would be permanently sealed off, as these have, on at least one occasion, been submerged during a period of extreme high tailwater.

It would be necessary to modify the outlet of the tailrace tunnel to remove the bottleneck. Although not shown on the drawing, it was felt that some provision should be made for a simple draft tube bulkhead (stoplogs) to be inserted over this outlet for use when the turbine casing is open for maintenance.

The level of the turbine setting was dictated by the hydraulic factors which determined the necessary runner submergence. This in turn has determined the extent of the concrete and rock excavation required. These have been kept to a minimum.

The thickening and reinforcing of the upstream wall of the powerhouse would replace the strength lost by insertion of the larger penstock at a higher level than the original. The intake would be set at an angle to bring the turbine over the existing draft tube tunnel, thereby minimizing the excavation. The vertical configuration of the turbine lends itself to the non-alignment of intake and draft tube.

A further advantage in the vertical arrangement of the generating unit is that alignment of turbine and generator would be carried out in the factory, thus reducing the setting out on site.

For brief details of the design and operation of the turbine-generator reference should be made to the manufacturer's brochure in Appendix E.

With respect to the generator, while common utility practice is to use synchronous machines for power generation, there are a few instances where it may be economically advantageous to consider the use of an induction, or asynchronous machine. Advantages of an induction generator over a synchronous machine are as follows:

- (a) Lower initial cost of machine (due mainly to squirrel-cage rotor construction);
- (b) No excitation equipment needed (excitation derived from the connected power system in the form of lagging VARs);
- (c) No neutral grounding equipment needed (machine connected either delta or ungrounded wye);
- (d) Simpler relaying system required (no neutral fault, loss-of-field, or some of the other relays commonly found on synchronous machines);
- (e) Less equipment damage potential in the event of a close-in fault (due to inability to self-excite);
- (f) May be run at a range of speeds above synchronous (this enables some optimization of turbine capabilities with varying hydraulic head conditions).

Depending upon operations requirements, some of the "advantages" of the induction machines may turn into disadvantages for the user. For example, the elimination of the excitation equipment means that machine terminal voltage is not controllable, except by varying the voltage of the incoming line. The fact that the machine requires an external source of VARs means that it would be unable to generate power unless connected to an external system containing synchronous generators. The external system is also needed to establish the frequency of the generator power output.

However, the conceptual design of the electrical system has been based upon the use of the less costly induction-type generator. Preferences of the operating agency (WSSC), as well as the utility (BG&E) which would be expected to purchase the power generated at Brighton Dam, must be considered during the final system design.

The preliminary design for the plant electrical equipment is shown on the single-line diagram (see Plate 7). This drawing illustrates the system configuration of the recommended one-unit plant. Copies of the drawing have been sent to BG&E for comment but the study schedule did not allow time for feedback.

The unit would be equipped with an individual power circuit breaker (52G) and protective relay system. A second 480 V power circuit breaker would be provided to supply power to the station and dam auxiliary equipment. This arrangement would permit operation of the auxiliaries with the generator out of service. No circuit breakers would be used in the 13.2 kV incoming lines; disconnection from the system would be by means of a manually operated fused disconnect switch.

Protective relays would be provided to detect and trip the circuit breaker in the event of overcurrent, current imbalance, differential current flows in the bus run to the circuit breaker, overvoltage and machine overtemperature. Differential current flows in the power transformer would also trip the unit breaker. Metering would be provided as shown on Plate 7, with revenue metering performed on the 13.2 kV side of the power transformer.

The power transformer would be of the oil-filled type, of a class resulting in the greatest economy (quite likely FA, but possibly OA or FOA). A minimum of protective equipment would be specified for the transformer, possibly only some type of overtemperature device. Lightning arrestors would be provided on the high-voltage side of the transformer.

Interconnection between the generator and the circuit breaker cubicle and the power transformer would be by means of a metal-clad aluminum-conductor busway. Other electrical connections (metering, control, relaying, etc.) would be by means of insulated copper conductors in rigid galvanized steel conduit.

The Brighton Dam powerhouse has a past history of flooding conditions, with water reaching considerable depths within the turbine gallery on some occasions. Proposed civil works modifications would provide some floodproofing. Even so, electrical equipment should be placed on the mezzanine floor level when at all possible. The only equipment which must be installed in the turbine gallery is the generator itself (for obvious reasons). With the application of the KMW SV9 unit, the generator would be mounted vertically on top of the turbine, hence, lessening the risk of its immersion.

The power transformer could be conveniently located under the downstream face of the dam, between two dam buttresses to the southwest of the powerhouse. This would provide three fire-walls around the transformer, leaving the front opening to be protected by a security fence. The concrete beam running from buttress to buttress across the dam would be a convenient place to locate takeoff equipment and the 13.2 kV disconnect switches.

5.2 - Basic Operating Characteristics of Recommended Scheme

For the purposes of studying the feasibility of the redevelopment of the hydroelectric generating facility at Brighton Dam, it was assumed that the flood control requirement for the reservoir would be maintained.

The operation of the power plant with respect to available flow and daily hours of operation can be determined from the flow at the USGS Unity gage. After correcting flow for drainage area differences and evaporation, the time of operation can be determined from the equation:

$$T = \frac{(Q_{avg} - Q_m) \times 24}{Q_{gen} - Q_m}$$

where T = time of operation in hours per day

Q_{avg} = available flow (cfs)

Q_m = maintenance flow (7.5 cfs)

Q_{gen} = generation flow (cfs)

For $Q_{gen} = 130$ and $Q_m = 7.5$ this reduces to

$$T = .196 (Q_{avg} - 7.5)$$

When operating the reservoir according to this equation, daily head variation will result from drawdown during generation hours (if Q_{avg} is less than Q_{gen}). However, each day the reservoir level will rise to its original level during the non-generation hours. If a minimum generation time criteria is to be met and the drawdown is available, the following equation can be used to compute drawdown:

$$D = \frac{(T \times Q_{gen} + (24-T) Q_m - 24 Q_{avg}) \times 3600}{S}$$

where D = daily drawdown in feet

T = minimum generation time in hrs.

S = storage in ft³/ft

For T = 8, $Q_{gen} = 130$, $Q_m = 7.5$ and S = 28,000,000 this reduces to:

$$D = .00013 (1160 - 24 Q_{avg})$$

It should be noted that drawing down the level of the reservoir would decrease the net head and hence power and generation.

The operation of the power plant would not conflict with the current operating policy of the reservoir. The expected generation was based on

maintaining a reservoir three feet below the top of the flashboards and discharging 7.5 cfs during non-generation hours. However, the conflict with flood control requirements cannot be ignored. Maintaining a lower reservoir level for flood protection means the maximum power and energy at the site cannot be developed.

5.3 - Potential Annual Energy Production

The expected monthly generation and daily hours of operation are shown on Table 5. These figures are based on maintaining the reservoir level at 363.4 feet msl. The capacity could be increased from 534 kW to 562 kW if the reservoir level were maintained at 366.4 feet msl. Theoretically, it would be possible to maintain this reservoir level and not require any storage, based on a generation flow of 130 cubic feet per second and the maximum monthly net flow from Table 4 of 130 cfs. However, in practice, the flow will exceed 130 cfs and, if the reservoir were maintained at 366.4 feet msl, there will be no provision for storage and the excess flow would be wasted. For this reason the annual generation would not increase in direct proportion to the increase in net head.

5.4 - Evaluation of Annual Costs

The project cost tabulation for the alternatives developed is presented on Table 1 (See Section 2).

The annual costs include the following charges:

Interest on Capital-----	6.25%
Depreciation (based on 40 yr. plant life)-----	0.45%
Insurance (WSSC Self-Insured - no charge to project)-----	0.00%
General and Administration-----	1.20%
Operation and Maintenance-----	1.10%
TOTAL FINAL CHARGES-----	9.00%

General and Administration: 1.2% of the project cost of \$734,000 would provide approximately \$8,808. This is expected to adequately cover all administrative and legal costs associated with the operation of the power generating plant, particularly since WSSC already have special departments dealing with matters relating to public relations, recreational facilities, reporting to federal authorities, etc..

Operation and Maintenance: 1.1 percent of the project cost would provide approximately \$8,000 per year for the operation and maintenance of the generating plant. Again, WSSC already have maintenance crews for their water treatment, sewage and other plants including electrical and mechanical equipment, similar in many respects to hydroelectric generating plant--the additional facilities at Brighton Dam would be maintained by the same crews.

With respect to the operation of the plant, Brighton Dam is manned for 24 hours/day for water control; therefore, little additional cost is to be expected for the same operator to control the generating plant.

5.5 - Capital Investment and Anticipated Plant Life

The selected scheme would involve a capital investment of \$734,000. This total sum includes \$391,000 for the hardware and civil works, plus a contingency which is a higher percentage than would normally be provided because it takes into consideration that the prices quoted were mainly budget prices and not firm bids, and because even a minor problem on a small project could consume a large percentage of the cost. A sum of \$245,000 (50 percent of the material and construction costs plus contingency) has been allowed for the engineering and administration costs. This, again, is a higher than normal percentage due to the size of the project. It includes funds for licensing application, preparation of contracts, bidding, contract award, engineering detailed designs for civil, mechanical and electrical works and project management.

The plant would be expected to have a useful life of 40 years as is normal for a hydroelectric plant.

To protect the investment, it would be essential that the powerhouse be made secure against inundation.

For a description of the project schedule and the cash flow related thereto, refer to Section 6.

5.6 - Financial Evaluation and Marketing of Power

Power produced from the proposed hydro would logically be fed into the BG&E electrical system, which services the locale. BG&E's generating facilities are primarily nuclear, providing about 60 percent of its capacity, with coal- and oil-fired steam units providing the bulk of the remaining capacity plus a small amount of gas turbine generating capacity. Future expansions planned include two oil-fired steam units to provide intermediate load service and an additional coal-fired steam plant.

The proposed hydroelectric generating unit would have a 500 kW capacity and generate approximately 2,840,000 kWh per year with an overall capacity factor of 65 percent and a minimum capacity factor of approximately 33 percent during the months of August through October (see Table 5).

Power values, established on a regional basis by FERC (June 23, 1978) for the National Hydropower Study, provided the principal comparison of the value of Brighton's output. Based upon the alternative generating sources tabulated for the Pennsylvania-New Jersey-Maryland Interconnection (PJM) power pool, of which BG&E is a member, the Brighton hydropower facility was compared to a coal-fired alternative with a \$136/kW.yr capacity value and \$11.6/MWh energy value which gave the following:

Capacity	500 kW x \$136/kW.yr	= \$ 68,000
Energy	2,840 MWh x \$11.6/MWh	= \$ 33,000
Total Value		<u>\$101,000/yr</u> or 35.5 mills/kWh

Alternatively, in discussing BG&E's interest in purchasing power from WSSC (BG&E letter to WSSC, March 6, 1979 - refer to Appendix E), the purchase power arrangement would involve alternative present day fuel and capacity costs with peak and off-peak metering. The capacity value presently at \$0.04/kW/day should be applicable since at least 8 hours of peak operation could be delivered with the proposed hydro during the BG&E peak. It was understood that the capacity value would only be applicable to six days per week (not Sunday). The energy value would be 90 percent of the "running rate" (average purchase interchange rate) with a 33 percent incentive for peak production (7am to 11 pm) and a 33 percent reduction for off-peak production (11 pm to 7 am). The present "running rate" is approximately 25 mills/kWh and fluctuates with the fuel market on a monthly basis. The capacity value is also changeable, except on an annual basis, which over a period of years would reflect the increased fixed cost of generating facilities.

The present day average power value of Brighton hydropower based on a possible purchase power contract value comes to 30 mills/kWh (refer to Table 8) compared with the 35.5 mills value from FERC data (refer to Table 2). Additionally, the impact of increased power costs to BG&E which would result in increased value of Brighton power, are presented for 5 percent and 7 percent escalation rates on Table 8. It was found that the levelized power value for a 30 years projection would be 51.5 and 65.9 mills/kWh, respectively, for such escalation rates. This indicates that the 35.5 mills value is a relatively conservative value to utilize for economic analysis of Brighton hydropower.

TABLE 8

BRIGHTON DAM HYDROELECTRIC REDEVELOPMENT
PURCHASE POWER VALUE

Capacity Value

at \$40/MW/day for 6 day week
 = \$12.48/kW/year

(Calculated Annually)

Energy Value

at 90% of Average Monthly Rate
 w/ 4/3 x value for 7 am - 11 pm
 and 2/3 x value for 11 pm - 7 am

Present Rate = 25 mills/kWh
 (Calculated monthly)

Brighton Dam Production

Capacity - 500 kW

Capacity Value = 500 x \$12.48
 = \$6,240/year

Generation: 2,840,000 kWh

Energy Value:

Peak = \$25 x 0.9 x 4/3 x 2,442 MWh
 = \$73,260

Off Peak = \$25 x 0.9 x 2/3 x 398 MWh
 = \$5,970

Total = \$79,230/year

Total Power Value = \$85,470/yr or 30 mills/kWh

Impact of Variable Power Value on Level Life Cycle Value

Assume: Cost of Money at 6.25% (i)

Increase of power cost at (a) 5% (e₁)
 (b) 7% (e₂)

Consider 30 year period (n)

Calculation:

$$\text{level factor (r)} = \frac{i}{1 - (1+i)^{-n}} \cdot \frac{1}{1+i} \cdot \frac{1 - X^n}{1 - X}$$

$$\text{where: } X = \frac{1 + e}{1 + i}$$

$$r_a = (i \text{ 6.25\%, } e \text{ 5\%, } n \text{ 30}) = 1.78$$

$$r_b = (i \text{ 6.25\%, } e \text{ 7\%, } n \text{ 30}) = 2.34$$

Results: Level Power Value Considering 5% Escalation = 30 (1.78) = 53.4
 mills/kWh

Level Power Value Considering 7% Escalation = 30 (2.34) = 70.2
 mills/kWh

SECTION 6
SCHEDULE FOR ENGINEERING
AND CONSTRUCTION

6 - SCHEDULE FOR ENGINEERING AND CONSTRUCTION

The project is expected to require 32 months from authorization to commissioning. The project schedule for licensing, engineering, procurement and construction is presented on Plate 8. The schedule shows the principal activities during each project phase. It considers a smooth transition of activities with no extraordinary delays. No significant float time has been included between various activities that are in series, although actual activity durations are, for the most part, liberal.

The early project phases would depend upon parallel activities including FERC licensing, detailed engineering design, and procurement of the turbine-generator equipment and penstock. Timing of the equipment contract award allows 4 months for completion of detailed design activities and 15 months for equipment delivery. Detailed design would ultimately provide for a general construction contract document which is scheduled for preparation at the same time the license is expected to be received. It has been anticipated that the license application would be processed promptly because of the small project size and use of an existing dam, impoundment and powerhouse structures.

The construction activity would be awarded in one general construction contract at month 22. The contract would encompass all civil and structural construction work, together with the installation of the penstock and all electrical and mechanical equipment excluding the turbinegenerator equipment. It is proposed that the procurement contracts for turbine-generator and all equipment included in the package cost would include installation service.

6.1 - Project Cash Flow

An estimate of the cash flow required for the financing of the project is shown on Table 9. This covers the entire life of the project from its authorization to its completion and has been based on present day costs with no allowance for future escalation. The payments have been assumed to be payable in quarterly installments. An allowance has been made for funds to be made available during construction.(AFDC). This has been estimated, assuming a 6.25 percent annual cost of money and end of period payments, at an amount of \$42,300 or 5.75 percent of the estimated capital cost (\$734,000). The total project cost, including AFDC, is thus \$776,300.

TABLE 9

BRIGHTON DAM HYDROELECTRIC REDEVELOPMENT
PROJECT CASH FLOW

Year	Period*	Payments	Cumulative Payments	AFDC**	Cumulative AFDC
	(\$)	(\$)	(\$)	(\$)	(\$)
1	1	37,750	37,750	0	0
	2	50,750	88,500	600	600
	3	12,750	101,250	1,400	2,000
	4	77,750	179,000	1,600	3,600
2	5	60,750	239,750	2,900	6,500
	6	66,750	306,500	3,800	10,300
	7	62,750	369,250	4,900	15,200
	8	89,350	458,600	6,000	21,200
3	9	117,170	575,770	7,500	28,700
	10	103,750	679,520	9,400	38,100
	11***	54,480	734,000	4,200	42,300

*Periods are in quarters, i.e. 3 months

**Allowance for Funds During Construction (AFDC) at 6.25 percent annual interest, end of period payments accumulating through in-service date.

***Commercial service date - 2nd week of month 31 in period 11 (i.e. 6/11/84)

SECTION 7
ENVIRONMENTAL AND
REGULATORY CONSIDERATIONS

7 - ENVIRONMENTAL AND REGULATORY CONSIDERATIONS

7.1 - Background

The Triadelphia Reservoir and the downstream Rocky Gorge Reservoir (also known as the T. Howard Duckett Reservoir) provide water supply and storage facilities for an average yearly supply rate of up to 55,000,000 gallons per day (84.6 cfs) to the WSSC system. Brighton Dam was originally constructed in 1943 for this primary purpose with secondary benefits from power generation, flood protection and recreation.

The dam was constructed following approval of the engineering plans by the Maryland Water Resources Commission. Water use is also authorized by the Water Resources Commission (now Administration) under permit 38-SAP-001, effective February 1, 1978. The permit requires a minimum release from Brighton Dam of 7.5 cfs to the Patuxent River.

During the period from 1943 until 1969, the 150 kW hydroelectric facility, constructed with the dam, was operated until it was determined uneconomical to maintain by WSSC. Since that period, the primary method of discharging water downstream has been through the two thirty inch regulating valves. Each valve can discharge up to about 125 cfs to the downstream channel.

Raw river water for supply to the WSSC system is provided by storage in the Triadelphia and Duckett Reservoirs and natural river flow in the Patuxent River. The combined reservoir storage is approximately ten billion gallons (30,000 acre-feet). The treatment facilities and raw water intake are near the Duckett Reservoir dam fifteen miles downstream of Brighton Dam. In order to keep raw water pumping energy requirements to a minimum, the general rule during low flow periods is to keep levels higher at Duckett Reservoir by drawing storage from Triadelphia Reservoir. Presently, the releases from Triadelphia are altered as required by WSSC water diversion and rainfall conditions.

Flood control storage at the Triadelphia Reservoir has been established by WSSC since 1972 to include the three feet below top of the gates. According to the 1972 Engineering Report for WSSC by Gannett Fleming Cordry and Carpenter Inc., with the existing flood control allocation, downstream flood protection at Laurel is provided for a flood recurrence interval of 20 years or less.

Outdoor public recreation benefits at Triadelphia are considerable due to its large freshwater impoundment area and its location in the heart of the Baltimore-Washington metropolitan area, which has a population of over 5,000,000 residents. At Triadelphia, four boat launching facilities service the 800 acre impoundment. A successful warm water fishery is managed in each reservoir by WSSC and, between the reservoirs, the river is managed by the state as a trout fishery. Three public

picnic areas and a hunting area are also provided on the WSSC property adjoining the reservoir. Comparable facilities are found at the Duckett Reservoir in addition to bridle paths. During 1978 an estimated 159,000 people utilized the recreational facilities at the two reservoirs. The recreational programs at these reservoirs are strictly controlled by WSSC under established regulations. Particular restrictions on swimming and bank erosion control are established specifically for maintenance of water supply quality.

7.2 - Project Impacts

As proposed, the operation of the hydroelectric facility could have a significant environmental impact if the intake water is taken from the lower gate level. This is an impact which could be mitigated and additionally would be reversible. Other aspects of establishing the project are not expected to have any significant adverse impacts, except for the temporary effects of construction, based on the following facts:

- (a) The facilities would be located completely within the existing powerhouse structure, except for the station power transformer.
- (b) The operation will not affect the normal range and pattern of reservoir levels nor location of the intake facility.
- (c) The operation would be within the normal range of discharge quantity and will involve the same approximate discharge daily in volume as would presently be allocated. However, the pattern of discharge would be more regimented to daily periods of operation between the hours of 7 am and 11 pm.
- (d) There would be no foreign substances discharged into the river and appropriate facilities would be designed to prevent accidental spill of toxic or dangerous substance into the river.

The issue of drawing water from the lower gate of the intake tower is considered as the major potential impact of the facility. Presently, except under extraordinary conditions, water is drawn for discharge at the mid-height and upper intake gates during warmer months. The lake apparently becomes stratified and, under occasion of drawing from the lower level, a very poor quality water is discharged which is detrimental to the downstream fishing and aesthetically undesirable.

The basic hydroelectric redevelopment plan presumes the intake of water from the lower intake gate to minimize head losses and resultant loss of

generation. The alternatives available would be:

- (a) Operate continuously with the lower gate open to deplete the stagnant hypolimnion (lower level) or keep it from getting fully established during the summer season,
- (b) Utilize only the middle and upper gates for operating, thus reducing the generation by approximately 7 percent, or
- (c) Modify the gate openings at an intermediate level by providing an additional gate 3'-6" x 5'-0" to replace the low level gate and to maintain similiarly small head losses.

The first alternative would be expected to have a significant impact in affecting the upstream and downstream aquatic environment. If appropriate authorities, including state and federal fisheries personnel, agreed to consider this alternative, the station could initially be operated under this regime with monitoring and contingent stop action. The contingency would be to revert to operational alternative "b" which would mitigate the impact of hydro operation. Under this course of action the gate modification could be undertaken at a later date in coordination with a reservoir drawdown for dam inspection or some other mutually beneficial reason. Should alternative "a" be considered unacceptable prior to project authorization, then the intake gate modification should be planned as a part of the hydro construction activity.

Considering the above, there would be no impact of the project operation on land and water use of the Brighton Dam and impoundment area if alternative mitigating measures are taken. Similiarly, there would be no impact on terrestrial biota or on aquatic biota upstream in the impoundment. There would, however, be some effect on water resources, and possibly the aquatic environment downstream of the powerhouse, due to altering the method of discharge from an atmospheric free discharge to a laminar flow discharge through the turbine. Under the present regulator valve discharge, considerable thermodynamic transfers occur in evaporation, evaporative cooling and dissipation of energy associated with the valve flow release. This obviously results in evaporation losses, cooling of the water and super saturation with oxygen and other gases. The overall impact of the proposed project operation on the downstream water environment has not been monitored or analytically studied. However, based upon the unpolluted quality of the river water, it is not anticipated that any significant adverse impact or irreversible short term effect would be associated with the operation of the proposed hydro facility.

Construction activities over the nine month construction period would provide an obvious environmental impact. The construction area would be within the confines of the present Brighton operating area but would require relocation of the dam operators and public permits office for

safety reasons in order to isolate the construction, operation and recreational activities. Traffic control measures must also be taken on the same basis, although heavy construction traffic would not occur due to the small project size. Some air quality impact would be expected from fugitive dust and some water turbidity and erosion would occur from cofferdam placement and removal. All of the above adverse construction impacts could be either mitigated or controlled to minimize their impact through good construction practices involving appropriate safety procedures and housekeeping practices. These items and specific cofferdam placement restrictions should be included in the construction contract specification.

The attached Table 10 summarizes the above environmental effects associated with the proposed Brighton Dam Hydroelectric Redevelopment.

7.3 - Regulatory Considerations

The proposed project would require authorization by the Federal Energy Regulatory Commission (FERC) in the form of a minor license for a hydroelectric project and several construction permits from the federal, state and county level. These requirements and the address of the respective agency is shown on Table 11.

The agencies involved have been contacted to determine the application requirements involved and not to discuss details of the proposed project activities. Prior to proceeding with the licensing, all of the agencies listed should be contacted in addition to the following agencies who would review and comment on various previously discussed aspects of the project as a part of the licensing and permit process:

- (a) U.S. Department of Interior, Bureau of Outdoor Recreation
- (b) U.S. Department of Interior, Bureau of Sport, Fishery and Wildlife
- (c) State of Maryland, Department of Natural Resources, Fisheries - Administration.

Categorically, the permits cover two basic construction activities, building and disturbance of the streambed. The first is a building permit required by Montgomery County. No further local entities are believed to be involved in permit jurisdiction. The disturbance permit involves placement and removal of fill (cofferdam) and excavation in the tailrace channel. These permits are duplicative on the state and federal level involving separate application forms and data content to be submitted to the Water Resources Administration (Watershed Division) and to the U.S. Army, Corps of Engineers.

In addition, a state project authorization from the Wetlands Division of Resources Administration is a prerequisite to any federal license or permit issuance. This is called a "Water Quality Certification" which involves a statement by the Water Resources Administration that the proposed project activities are not reasonably expected to cause contravention of stream standards.

TABLE 10BRIGHTON DAM HYDROELECTRIC REDEVELOPMENT
SUMMARY OF ENVIRONMENTAL EFFECTS

<u>Factor Considered</u>	<u>Description of Effect</u>
Land Use	No additional land will be used or affected by reestablishing hydro generating facilities at the powerhouse. Short term disruption to the recreational facilities near the facility will occur during construction.
Water Resources	There will be no changes to the range of reservoir levels or downstream discharges. None of the existing water uses will be affected by the proposed hydro facilities. Discharge patterns may be more pronounced during low flow periods since discharges will be made primarily between 7 am and 11 pm to take advantage of peak period power values. A minor variation in water temperature and dissolved oxygen may occur at the discharge due to the laminar flow pattern of the turbine discharge compared to the energy dissipating (regulating valve) discharge. Depending upon the alternative chosen, water quality parameters may be altered due to low level reservoir discharges (Alt.A). The overall impact would require a complex evaluation to establish clearly the effects of Alt. A.
Air Quality	Only affected during construction by vehicle transportation at the site and excavation in the draft tube exit.
Terrestrial Biology	No habitat will be disturbed except approximately 50 feet of river bank adjoining the powerhouse and parking lot to be used during construction for cofferdam access.
Aquatic Biology	Impacts are expected to the fishery and other aquatic biota if low level reservoir releases (Alt. A) are made during summer months. For other operating alternatives no impacts are expected, since no variation to reservoir operations, maintenance of minimum flow or discharge range occurs.
Socio-Economics	No significant benefit will occur to the locale except for short term construction jobs. No additional permanent job positions are associated with operating and maintaining the facility.
Historic Sites	No impacts,
Energy Conservation	The project will produce 2,840,000 kWh per year by water power, saving the equivalent of 4,500 barrels of oil per year.

TABLE 11BRIGHTON DAM HYDROELECTRIC REDEVELOPMENT
REGULATORY LICENSE AND PERMITS

<u>Governmental Level</u>	<u>Jurisdictional Agency</u>	<u>Description</u>
Federal	FERC 825 N. Capitol St. Washington, D.C. 20426 202-655-4000	Minor Project License under Section 4.60 of the Regulations under the Federal Power Act
	U.S. Army, Corps of Engineers P. O. Box 1715 Baltimore, MD 21203 301-962-3670	Permit for Dredge and Fill in placing and removing material in the river channel. (Eng. Form 4345 is used)
	Water Resources Administration Department of Natural Resources Tawes State Office Building Annapolis, MD 21401 301-269-3871	
State	a. Wetlands Division b. Watershed Division	Water Quality Certification Waterways Construction Permit for structure alterations and stream disturbance.
Local	Environmental Protection Department Montgomery County 6110 Executive Building Rockville, MD 20852	Building Permit

SECTION 8
SAFETY ASSESSMENT



8 - SAFETY ASSESSMENT

The construction and operation of the project could cause potentially unsafe conditions to exist, requiring specific attention for the removal of the conditions, guarding against exposure to them or appropriately warning of their nature. This assessment identifies the principal measures which should be implemented to prevent unsafe conditions or to protect against them.

Appropriate considerations during design of the project facilities would include: (1) development of design criteria consistent with identified potential safety problems and applicable codes, and (2) specific attention to safety considerations during review of drawings and design documents.

During construction of the project, all occupational safety requirements under existing federal, state, and local regulations must be complied with. Each contractor should be required to provide an accident prevention plan with his work proposals. This plan would cover general public safety measures such as site security and traffic control, as well as construction safety methods and facilities.

Operation of the facility would have some potential impact on occupational safety and public safety considerations. Occupational safety would relate to the operation and maintenance of the facility. Unsafe conditions may exist when working on the dam, on machinery or on electrical facilities. For the most part, unsafe conditions should be minimal for normal operating activities due to appropriate design of the facilities. However, unsafe conditions cannot be completely prevented for unusual activities in operating and maintaining the station. Safe work practices and regular safety training must be integral parts of the operations routine.

8.1 - Project Design Safety Issues

Potentially unsafe conditions should be identified before detailed design efforts commence to make safety issues an integral part of the design effort. Additionally, applicable federal, state, local and industrial codes and standards must be complied with to insure a safe facility from the aspects of structural adequacy and personnel safety features.

Particularly important safety issues specific to the project which must be addressed during design are:

- (i) Stability of the project structures under applicable loadings, including hydraulic, seismic, ice and wind loads as well as other dead and live loads.
- (ii) Design flood conditions and interrelationship of the project facilities, the existing flood channel and existing flood control works.
- (iii) Specific construction procedures and restrictions necessary, based on design requirements (e.g. demolition and blasting criteria, care and handling of river flows, cofferdams and excavation restrictions.)
- (iv) Security and protection of dangerous project facilities for which fences, barriers, warning alarms, or other devices are necessary.
- (v) Appropriate clearances, guards, apparatus, special tools, and safety systems to provide personnel with a safe structure in which to perform operating and maintenance functions.
- (vi) Procedures and means by which dewatering and inspection of facilities and removal of major equipment components for servicing can be undertaken later in the plant life.

The recommended method for incorporating safety considerations into the design program involves the careful preparation of a Design Criteria Manual in the early stage of the detail design activity. The manual, covering each engineering discipline and project facility, would define basic design requirements based on the site data and the preliminary engineering plan. The design requirements would incorporate applicable criteria from (or reference to) pertinent design, building and safety codes (including standards and regulations).

Assurance of the effectiveness of the manual in the completed design drawing or document will be determined by the normal design practices of engineering supervision during the work and checking for compliance with the design criteria (including appropriateness and accuracy of design) prior to issue. Before construction documents are released for bidding, a thorough final review by a safety engineer should be accomplished. All engineering personnel should be educated before and during the job on engineering safety and design requirements.

8.2 - Construction Safety Issues

The principal regulatory safety requirement during construction is compliance with standards of the Occupational Safety and Health

Act (OSHA) which places the responsibility for safety on the construction contractor's site supervisor and requires rectifying action where unsafe conditions exist or unsafe actions occur. The site safety standards include requirements for reporting accidents, periodic site inspections and weekly safety training.

Site activities must also comply with all other federal, state and local regulations which are applicable to health and safety or any special conditions on licenses or permits for construction of the project.

It is recommended that each construction contractor be required to submit an "Accident Prevention Plan" as a part of his proposal which will define his project safety policy, procedures and facilities, to comply with OSHA and other safety and health regulations.

Inspectors representing the owner should be trained in the detection and correction of safety deficiencies and they should check the contractor's compliance with his own accident prevention plan.

8.3 - Operation Safety Issues

Operation and maintenance of the project will have potential impact on occupational and public safety issues. Occupational safety is principally regulated under OSHA and implemented by the plant owner. Public safety related matters involving dam safety and operations will be regulated under specific conditions of the FERC license.

An operating manual providing procedures for start-up, shutdown, cleaning, isolating, tagging, teardown and other aspects of operation and maintenance of the plant facilities and equipment should provide a key source for identifying and neutralizing potentially dangerous conditions or actions. This would supplement the basic supervisor/worker instructional safety program required under OSHA and the specific safety requirements instituted by WSSC.

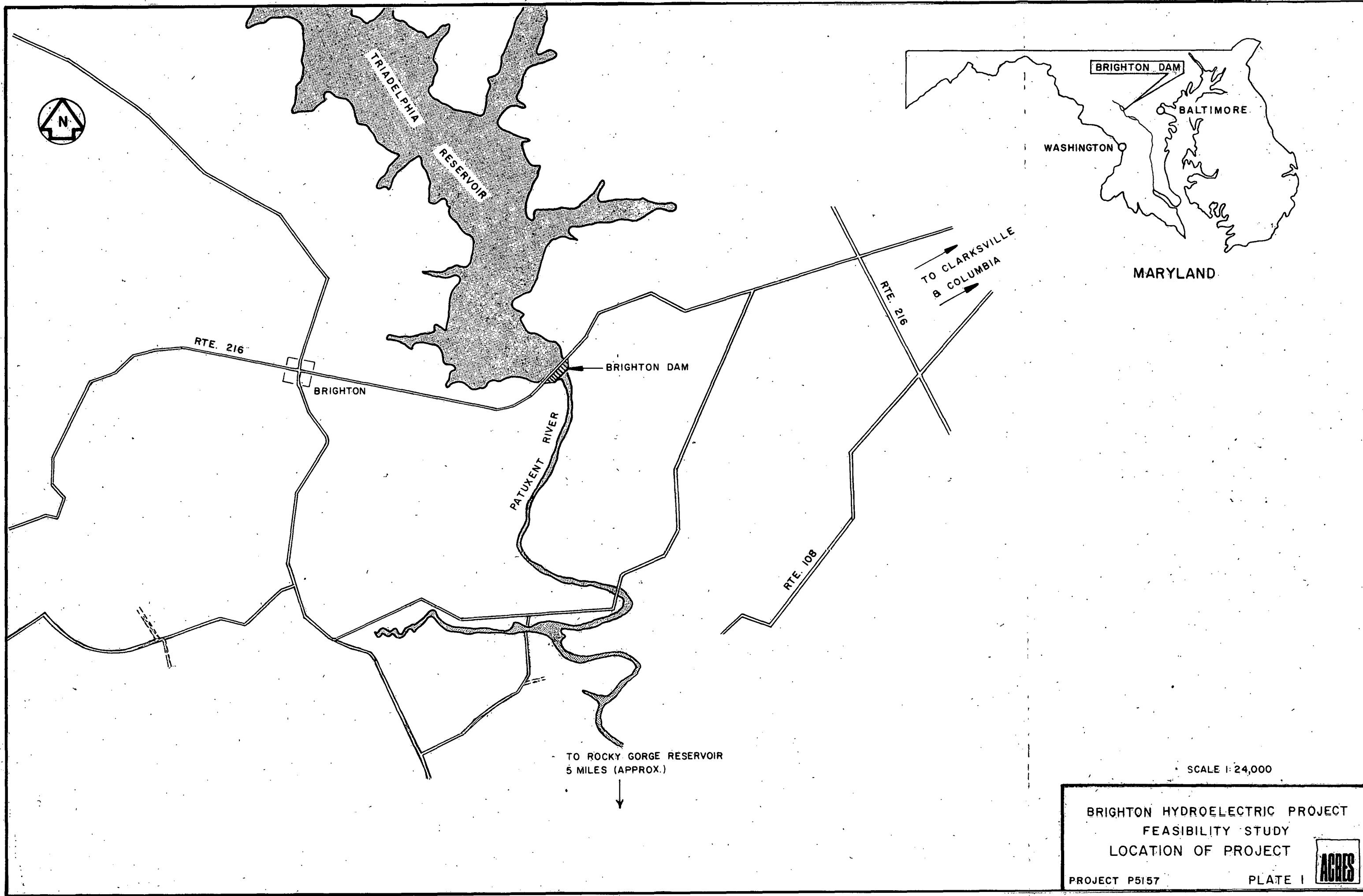
Public safety considerations include: (1) proper security of the powerhouse and switchyard from access by the public, and (2) proper warning devices and procedures for normal or abnormal operating flow conditions.

Security of the switchyard and powerhouse by barricade, fencing and warning signs should be in accordance with applicable American National Standards Institute (ANSI) codes. These facilities would be a part of the design responsibilities discussed in Section 8.1.

An emergency action plan should be developed for the project to quickly provide the operator, the WSSC supervisor and local regional emergency forces with procedures to follow in case of major structural failure, fires or accident. The plan must include a procedure in case of a dam failure to comply with normal conditions contained in FERC licenses. All such plans should be updated on a regular basis and periodic training sessions should be conducted to ensure operating personnel are aware of their emergency tasks.

APPENDIX A
PLATES





BRIGHTON HYDROELECTRIC PROJECT
FEASIBILITY STUDY
LOCATION OF PROJECT

PROJECT P5157

PLATE 1



SCALE 1:24,000

TO ROCKY GORGE RESERVOIR
5 MILES (APPROX.)

TO CLARKSVILLE
& COLUMBIA

RTE. 216

RTE. 108

BRIGHTON DAM

BRIGHTON

RTE. 216

PATUXENT RIVER

TRIADELPHIA
RESERVOIR

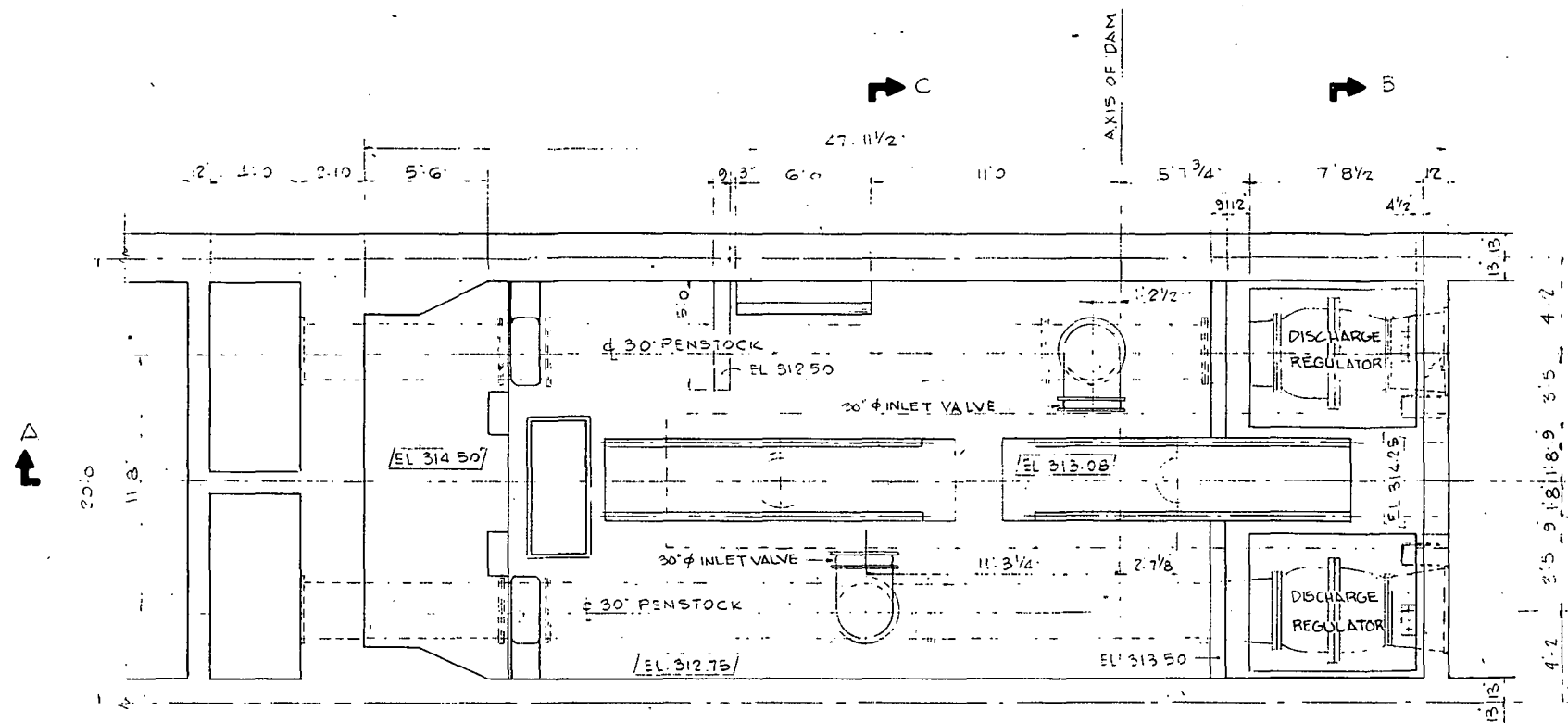
BRIGHTON DAM

BALTIMORE

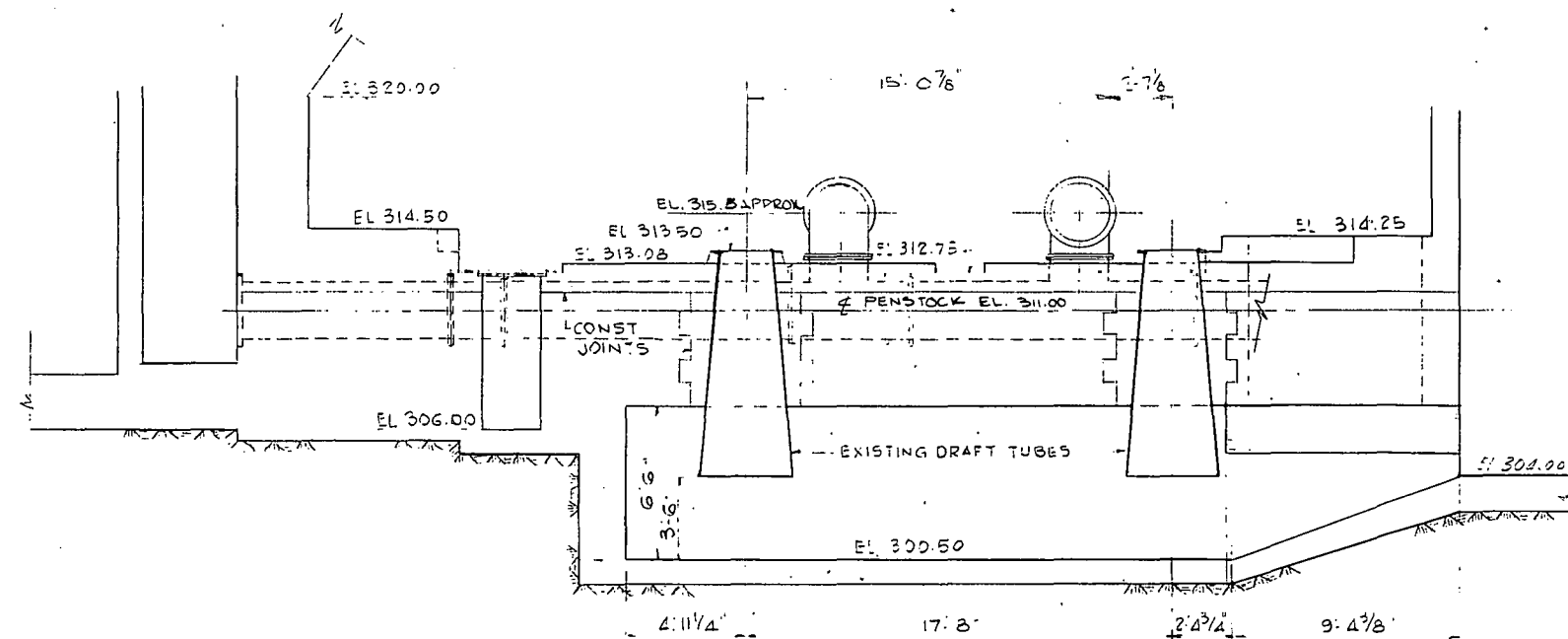
WASHINGTON

MARYLAND

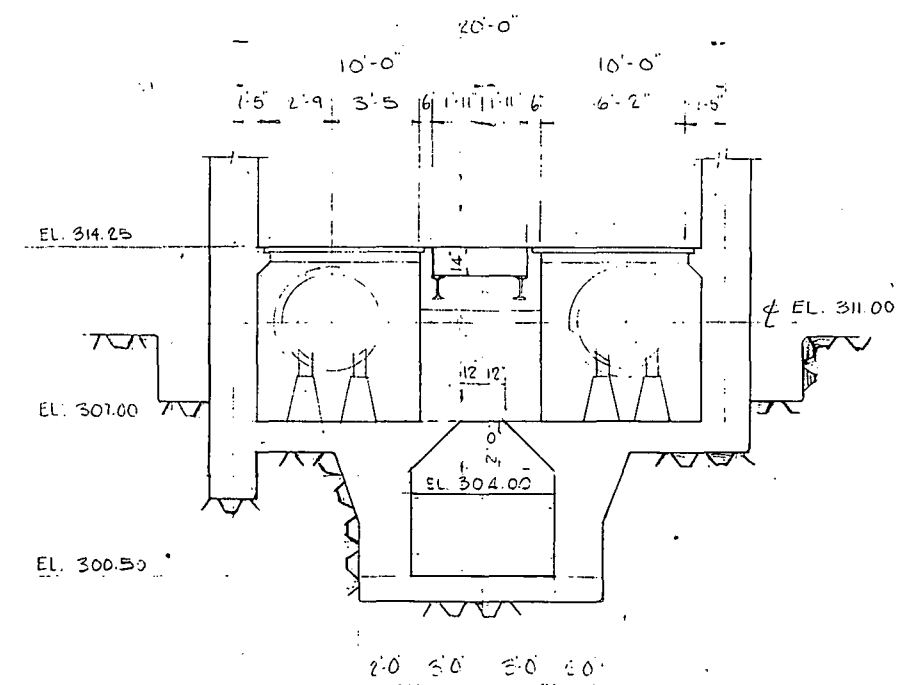




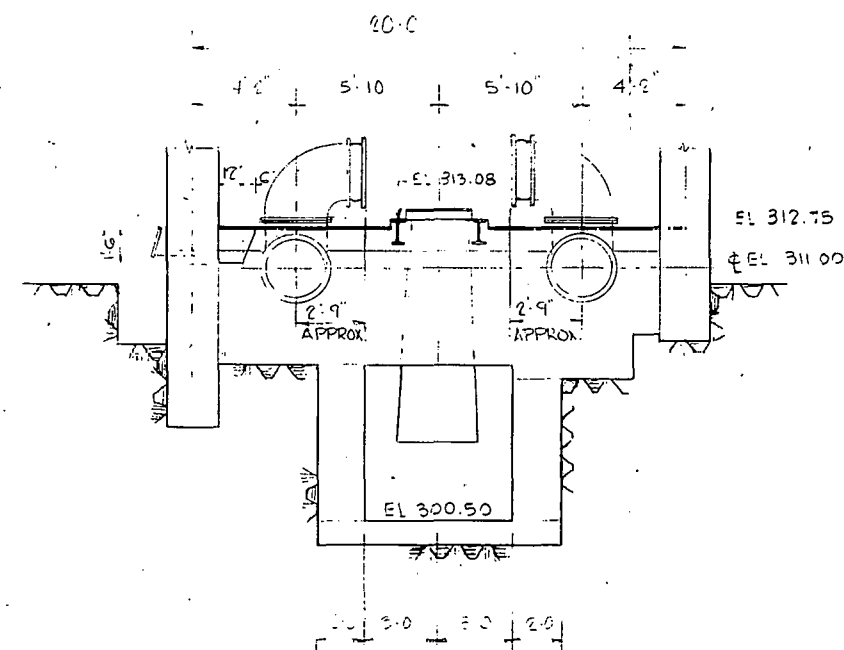
SECTIONAL PLAN



SECTION A-A



SECTION P-P



SECTION Q-Q

SCALE 0 4 8 FEET

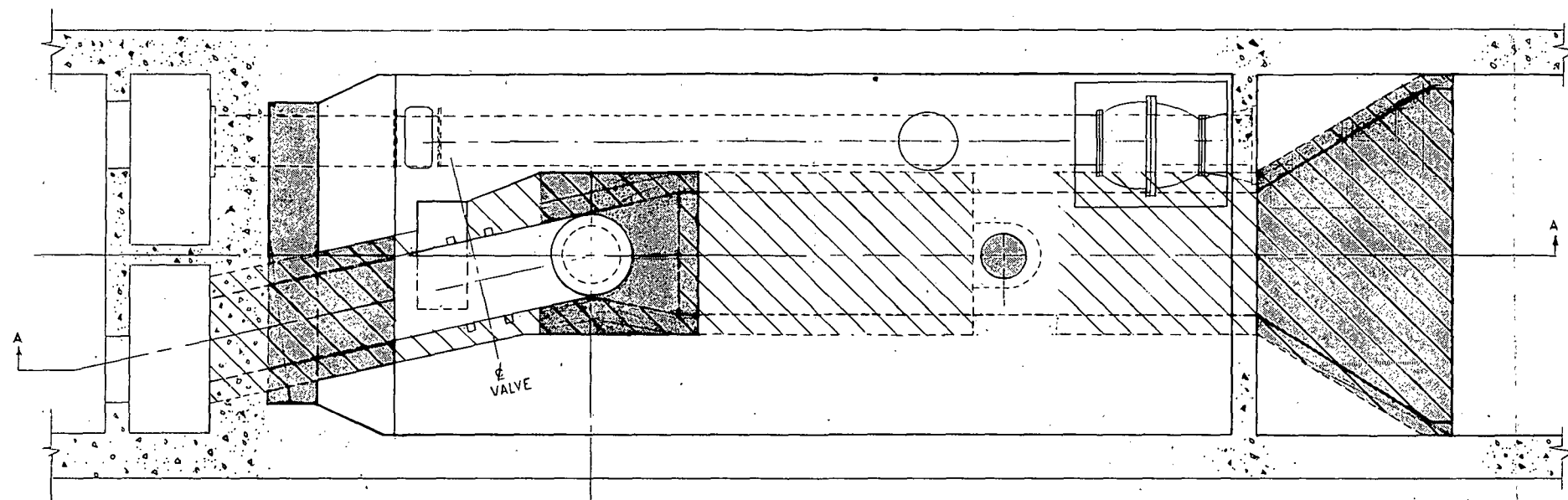
BRIGHTON DAM HYDROELECTRIC REDEVELOPMENT
FEASIBILITY STUDY

EXISTING TURBINE INLET & OUTLET STRUCTURES

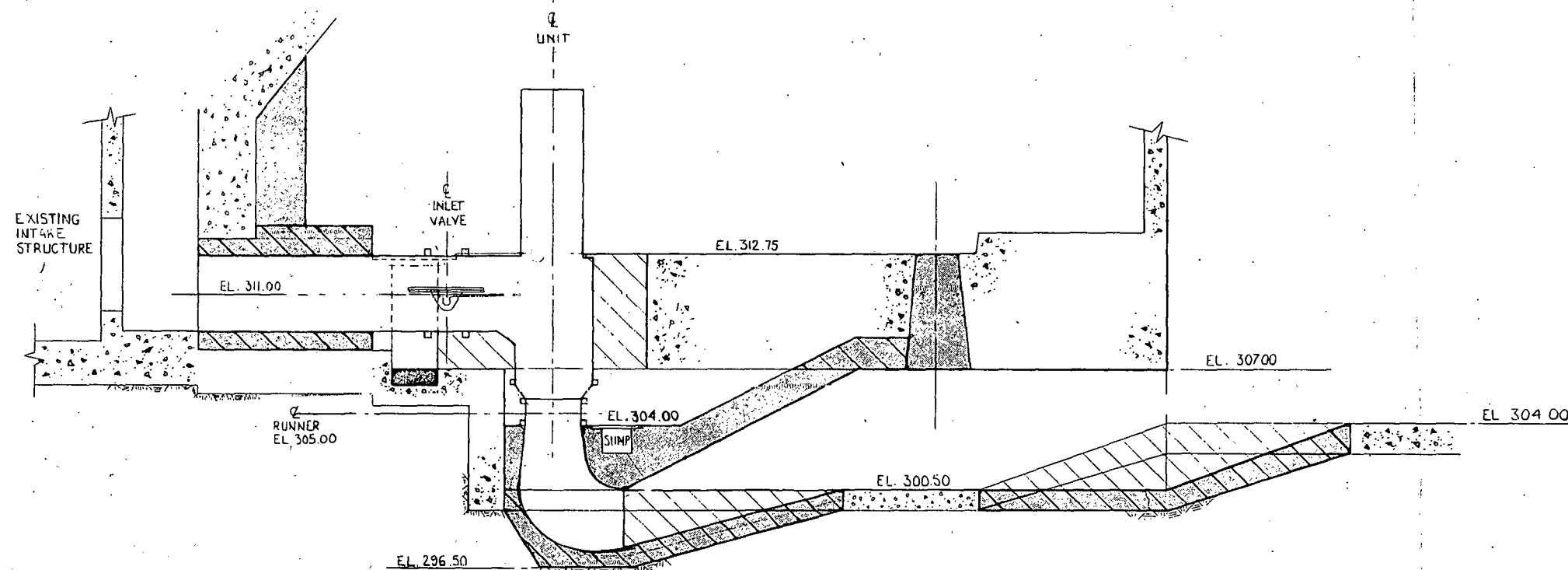
DWG. NO. SK 5157-B-001
PROJECT P5157.00

PLATE 2

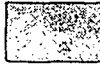
ACRES



PLAN VIEW



SECTION A-A

-  REMOVE CONCRETE OR ROCK
-  NEW CONCRETE
-  EXISTING CONCRETE

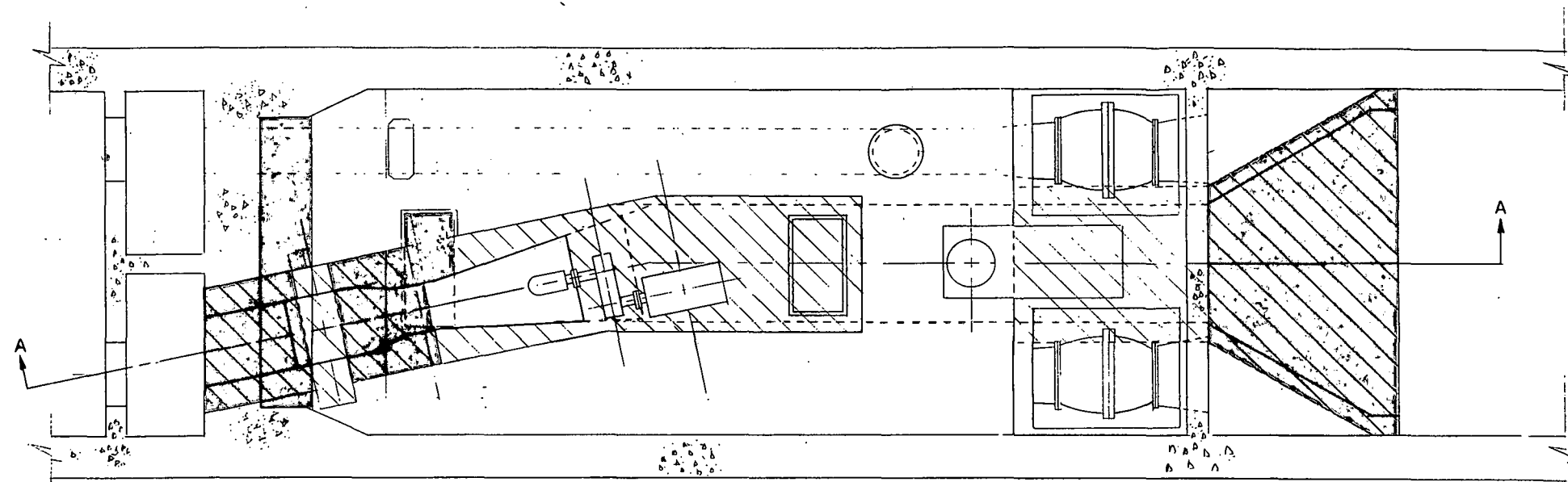
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BRIGHTON DAM HYDROELECTRIC REDEVELOPMENT
FEASIBILITY STUDY

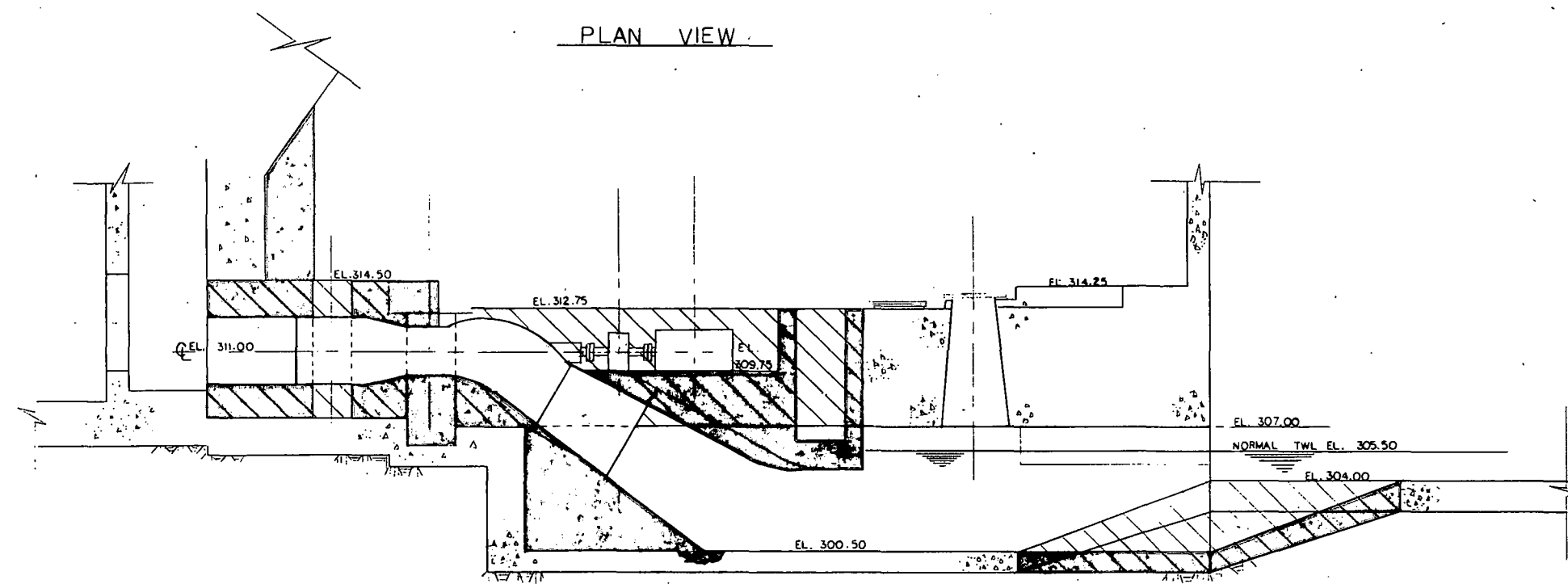
ONE-500KW STANDARD VERTICAL TUBE
KMW. SV-9.

DWG. NO. SK 5157 B 007 PLATE 3
PROJECT P5157.00

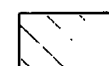
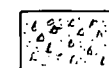




PLAN VIEW



SECTION A-A

-  REMOVED CONCRETE OR ROCK
-  NEW CONCRETE
-  EXISTING CONCRETE

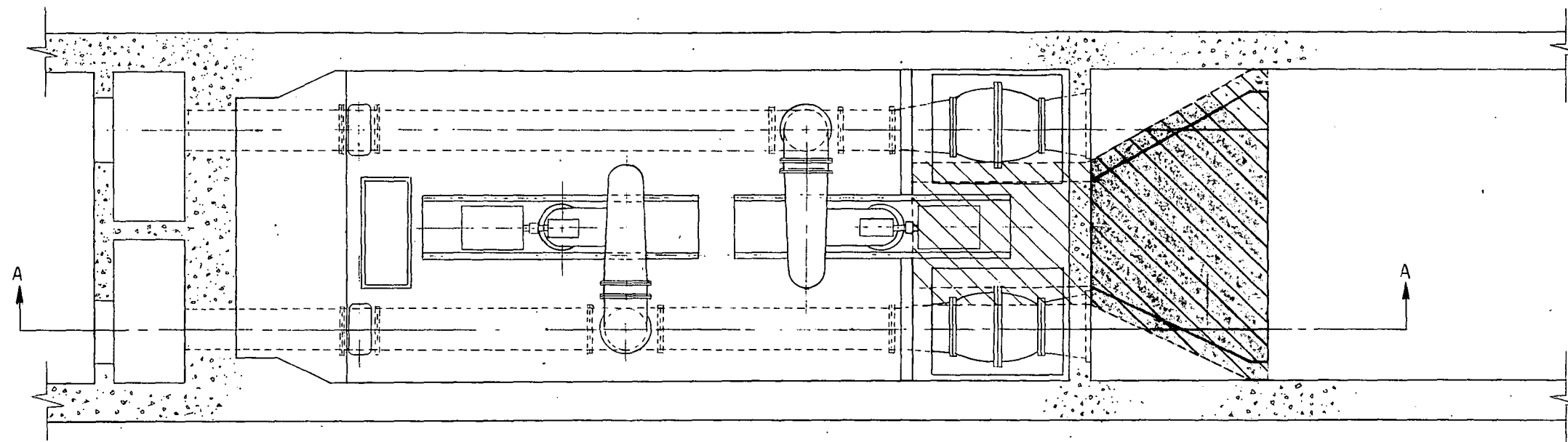
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BRIGHTON DAM HYDROELECTRIC REDEVELOPMENT
FEASIBILITY STUDY
ONE-420KW STANDARD TUBE UNIT

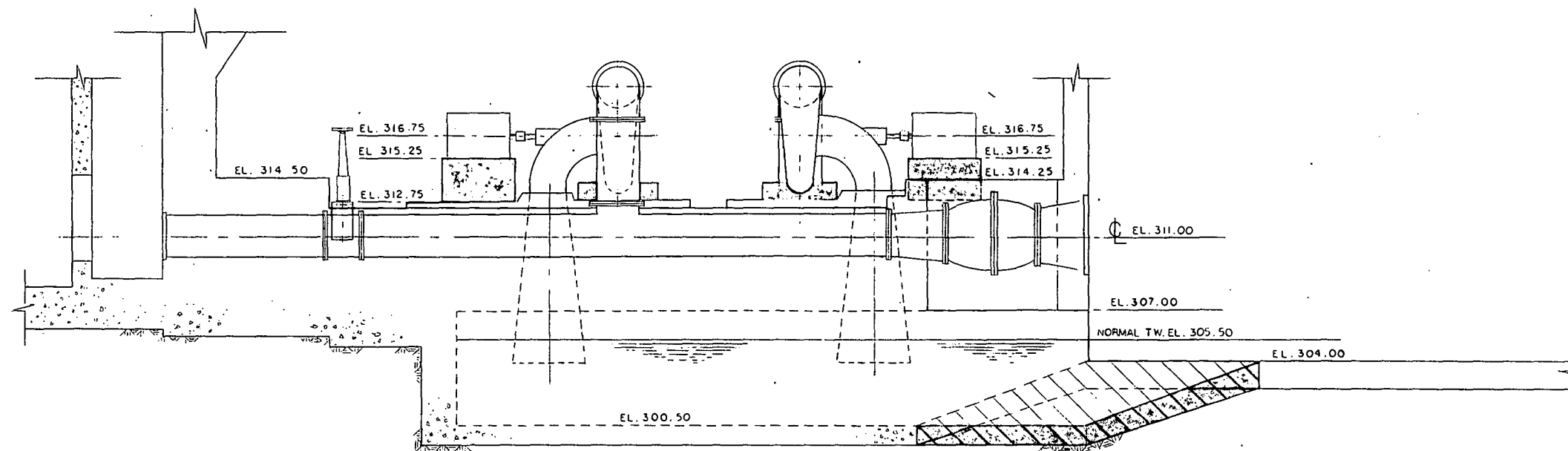
DWG. NO. SK 5157 B005
PROJECT P5157.00

PLATE 4

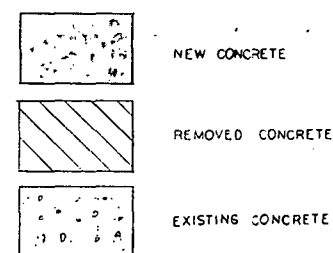




PLAN VIEW



SECTION A-A



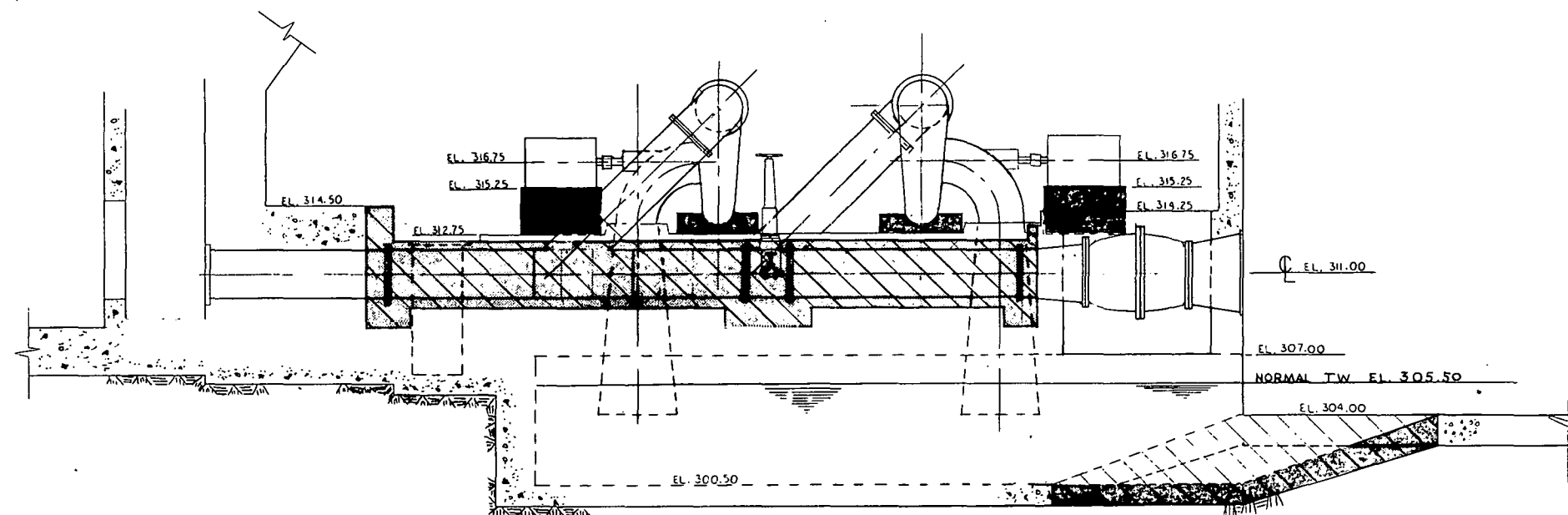
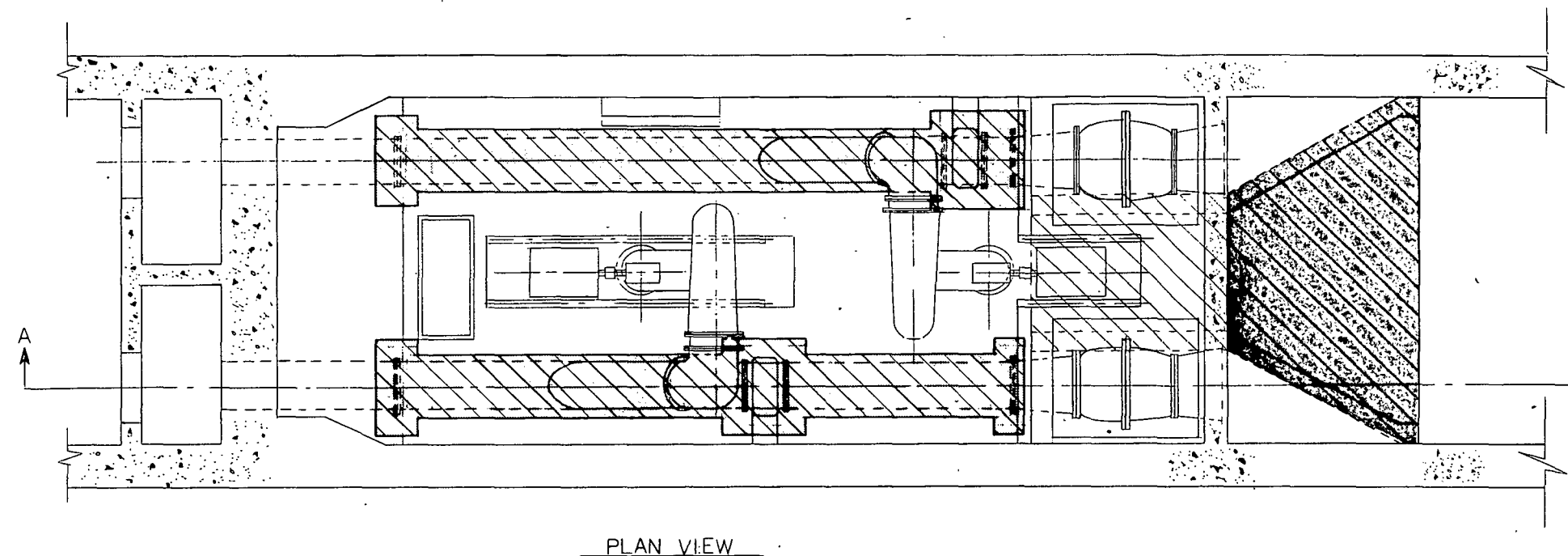
SCALE 0 4 8 FEET

BRIGHTON DAM HYDROELECTRIC REDEVELOPMENT
FEASIBILITY STUDY
TWO-240KW STANDARD HORIZONTAL FRANCIS UNITS
ON EXISTING PENSTOCKS

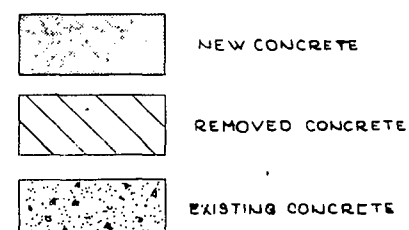
DWG. NO. SK 5157B007
PROJECT P5157.00

PLATE 5

AGRES



SECTION AA



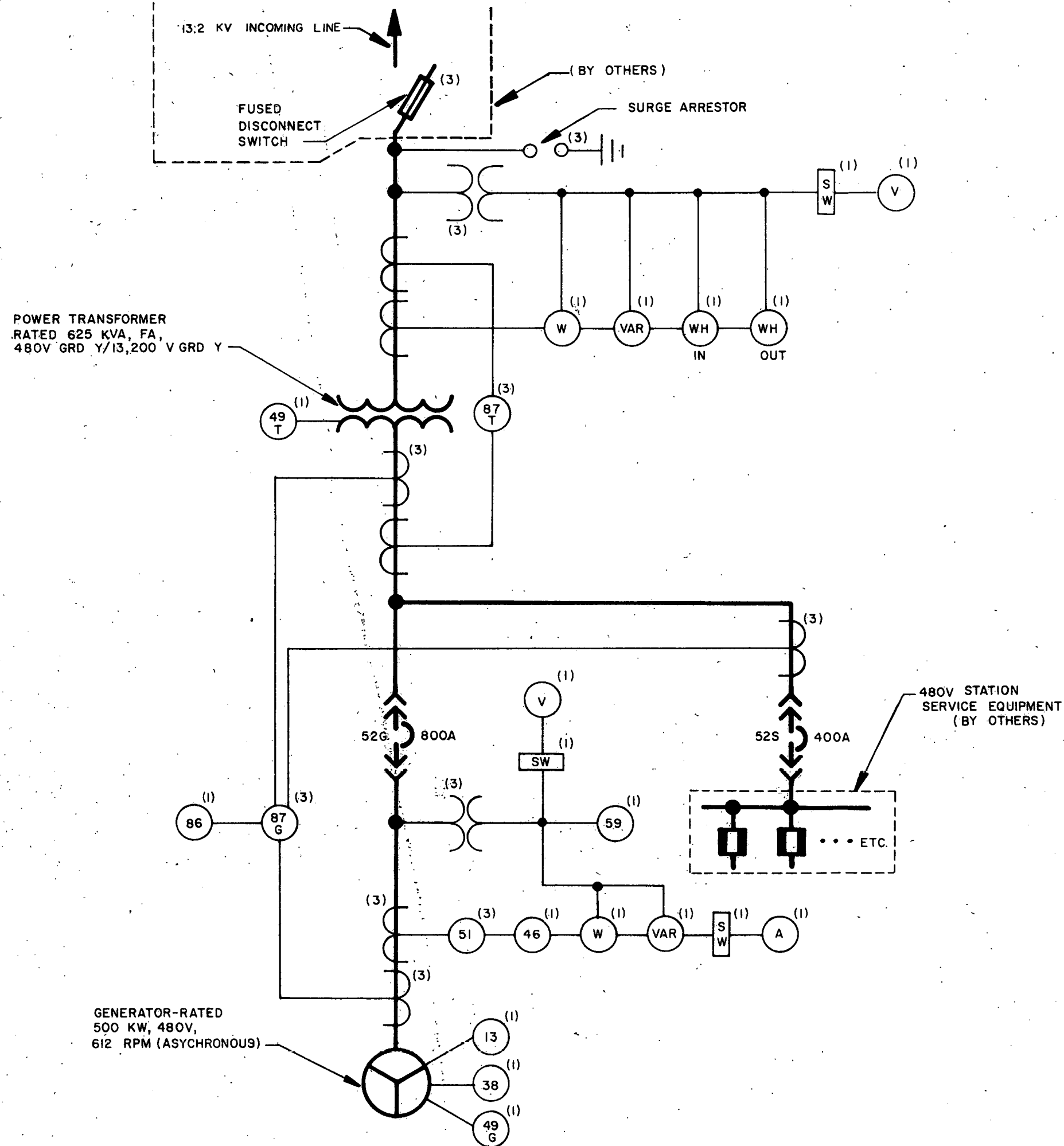
SCALE 0 4 8 FEET

BRIGHTON DAM HYDROELECTRIC REDEVELOPMENT
FEASIBILITY STUDY
TWO-243KW STANDARD HORIZONTAL FRANCIS UNITS
ON MODIFIED PENSTOCKS

DWG. NO SK 5157 B 002
PROJECT P 5157.00

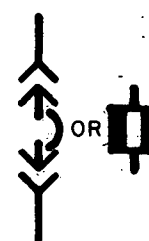
PLATE 6



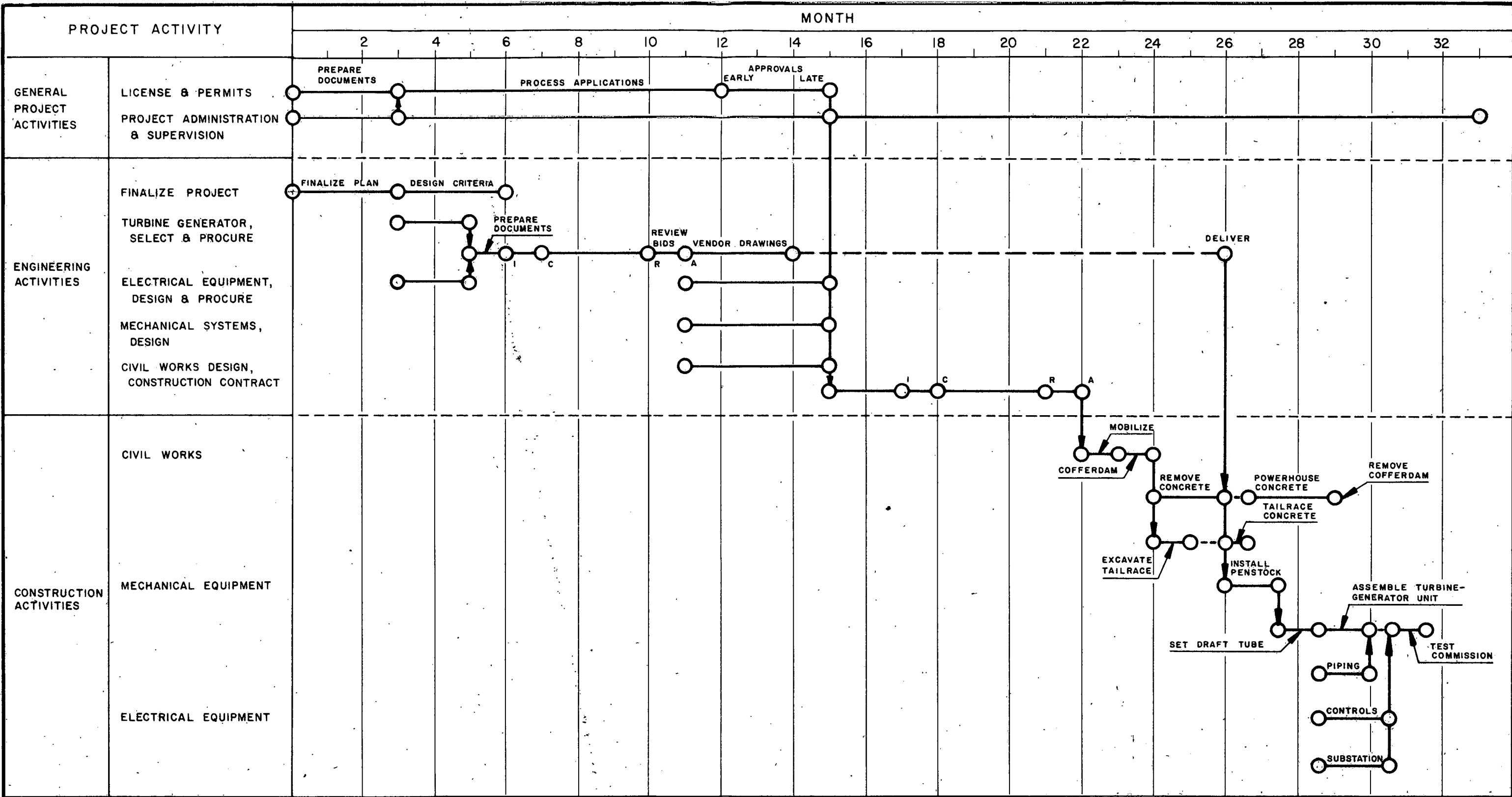


NOTES:

- (13) SYNCHRONOUS SPEED SWITCH-SET TO OPERATE AT 95-100 % SYNCHRONOUS SPEED TO ENABLE 52G TO BE CLOSED
- (38) BEARING OVERTEMPERATURE RELAY-TRIPS 86
- (46) PHASE CURRENT IMBALANCE RELAY-TRIPS 86
- (49 G) OVERTEMPERATURE RELAYS-TRIP 86
- (49 T) TIME OVERCURRENT RELAY-TRIPS 86
- (51) OVERVOLTAGE RELAY-TRIPS 86
- (59) HAND RESET LOCKOUT RELAY-TRIPS AND BLOCKS CLOSING OF 52G
- (86) GENERATOR / BUS DIFFERENTIAL CURRENT-RELAY-TRIP 86
- (87 G) TRANSFORMER DIFFERENTIAL CURRENT RELAY-TRIPS 86
- (87 T) AMMETER
- (A) VOLTMETER
- (V) VARMETER
- (VAR) WATTMETER
- (W) WATTHOUR METER
- (WH) PHASE SELECTOR SWITCH
- (S W) POWER CIRCUIT BREAKER



OR POWER CIRCUIT BREAKER



LEGEND:

- I ISSUE TO OWNER
- C CALL BIDS
- R RECEIVE BIDS
- A AWARD CONTRACT



APPENDIX B
SITE EXAMINATION AND
EVALUATION REPORT

WASHINGTON SUBURBAN SANITARY COMMISSION
BRIGHTON DAM HYDROELECTRIC REDEVELOPMENT
SITE VISITATION REPORT

SECTION 1 - AGENDA

SECTION 2 - SUMMARY

SECTION 3 - DETAILS OF EXISTING PLANT

- 3.1 - Intake Tower
- 3.2 - Penstocks
- 3.3 - Discharge Regulating Valves
- 3.4 - Powerhouse Drainage
- 3.5 - Turbine Inlet Valves
- 3.6 - Turbines
- 3.7 - Governors
- 3.8 - Governor Hydraulic Power Packs
- 3.9 - Generators
- 3.10 - Exciters
- 3.11 - Generator Control Panels and Switchboard
- 3.12 - Station Supplies Transfer Switches
- 3.13 - Baltimore Gas & Electric Supply
- 3.14 - Powerhouse Access

SECTION 4 - CONDITION AND LIMITATIONS OF EXISTING PLANT

- 4.1 - Intake
- 4.2 - Penstocks
- 4.3 - Discharge Regulators
- 4.4 - Powerhouse Drainage
- 4.5 - Turbine Inlet Valves
- 4.6 - Turbines
- 4.7 - Governors
- 4.8 - Hydraulic Power Packs
- 4.9 - Generators
- 4.10 - Exciters
- 4.11 - Generator Control Panels and Switchboard
- 4.12 - Station Supplies Transfer Switches
- 4.13 - Baltimore Gas & Electric Supply
- 4.14 - Powerhouse Access and Lifting Facilities
- 4.15 - Reservoir Operation

SECTION 5 - LIMITATIONS ON REDEVELOPMENT OF THE SITE

- 5.1 - Space Availability
- 5.2 - Lifting and Moving Facilities
- 5.3 - River Flow
- 5.4 - Capacity of Existing Penstocks
- 5.5 - Powerhouse Security From Flooding
- 5.6 - Transmission Line

WASHINGTON SUBURBAN SANITARY COMMISSION
 BRIGHTON DAM HYDROELECTRIC REDEVELOPMENT
SITE VISITATION REPORT

Date of Visit: November 28, 1978

Attendees: Alan L. Will-----WSSC
 Paul Hancock-----WSSC
 Hugh F. Allman-----AAI
 Peter G. Phillips-----AAI
 Richard L. Powell-----AAI
 Joseph Sangermano-----AAI

1 - AGENDA

Familiarize project team with existing structures, equipment, plant layout and transmission line.

Visually assess general condition.

Meet with operating and maintenance staff to augment the above information and ascertain standard procedures and criteria.

Collect details of existing plant.

2 - SUMMARY

Discussions with the site superintendent revealed that the powerhouse had been flooded on a number of occasions, the worst of which was in June 1972 during Tropical Storm Agnes. The generating plant had not been operated since then and it was evident from the superficial examination that it should not be returned to service without extensive overhaul and testing.

The Superintendent also reported that serious defects in the turbine regulating gear had caused the units to run away on occasions. The units were eventually stopped by closure of the turbine inlet valves. No internal examination of the turbines, generators, governors, etc., was made during the visit.

The station layout is generally as shown on the drawings received from WSSC. Lifting facilities are minimal. The mezzanine floor has been divided off from the remainder of the powerhouse by a wood/glass partition. The only access for entry or removal of equipment is via the mezzanine floor.

The reservoir level was considerably lower than normal, having been drawn down to 349.5 feet to permit repainting of the spillway gates. This also made it possible to inspect the two upper sluices in the intake tower. The bottom two sluices are normally kept closed to prevent drawing off poor quality water from the bottom of the reservoir.

3 - DETAILS OF EXISTING PLANT

3.1 - Intake Tower

Trash Racks - 18 ft. 6 in. wide extending from elevation 309.25 to elevation 365.00 leading into common chamber for both units.

Manufacturer: Continental Bridge Company, Chicago, Illinois.

Sluice Gates

Manufacturer: Chapman Valve Manufacturing Co., Indian Orchard, Mass.

Two gates at each of three elevations leading to separate chambers for each unit.

2 gates 24 in. x 36 in. having sills at el. 350.00

2 gates 24 in. x 36 in. having sills at el. 323.00

2 gates 42 in. x 60 in. having sills at el. 309.83

All gates are operated by hand gear mounted on the top deck of the intake tower at el. 373.00.

3.2 - Penstocks

One 30 in. diameter cast iron pipe line for each unit with 30 in. OS&Y flanged end gate valves with 4 in. by-pass valves.

Valves supplied by Rensselaer Valve Company, Troy, New York.

3.3 - Discharge Regulating Valves

Manufacturer: Baldwin Southmark Division, Baldwin Loco. Works, Eddystone, Pennsylvania.

Two 36 in. inlet diameter and 24 in. outlet diameter type E.

Larner-Johnson free discharge regulators, arranged for hand control.

The two valves will discharge 260 cfs total when full open with reservoir at el. 365.

3.4 - Powerhouse Drainage

Sump Pump: One type CL-3 vertical centrifugal pump 50 gpm against 20 feet total dynamic head, driven by 1 hp motor, 440 V, 3 ph, 60 Hz, 1200 rpm, direct connected. Control is by automatic float switch.

3.5 - Turbine Inlet Valves

Supplier: Rensselaer Valve Company, Troy, New York.

Type: 30 in. OS&Y flanged end gate valves with level gears and hand wheel (no by-pass)

3.6 - Turbines

Manufacturer: Rodney Hunt Machine Company, Orange, Massachusetts.

Model: W2276

Type: Horizontal shaft. 900 rpm, rotation counterclockwise from coupling end

100 hp under 50 feet net head with 80 percent gate opening.

3.7 - Governors

Manufacturer: Woodward.

Type: LR; 3,000 ft. lb.; size 5 1/2 x 9

Serial Nos. 23735 and 23736

3.8 - Governor Hydraulic Power Packs

Manufacturer: Woodward

Rotary Pump size 21

Serial Nos. 23735 and 23736

3.9 - Generators

Manufacturer: Electric Machinery Company, Minneapolis, Minnesota

Type: Synchronous, open machine, end plate bearings

Serial No. 8235 (Instruction Book No. 67)

Size: AC-8; 240-480 V; 180-90 A; 75 kVA; 3 phase; 60 Hz; 0.8 pf; 60 kW; 900 rpm; max. overspeed 25 percent; Temp. Rise - Arm. 50°C (Therm.); Field 60°C (Res.)

Excitation: d.c. 125 V; 12 A

3.10 - Exciters

Manufacturer: Electric Machinery Co., Minneapolis, Minnesota

Type: Direct connected shunt wound d.c. generator with field rheostat (no pilot exciter); 2 kW; 125 V; 16 A; 900 rpm; 2 prs. of poles.

3.11 - Generator Control Panels and Switchboard

Manufacturer: Electric Machinery Co., Minneapolis, Minnesota. Located on Mezzanine floor (e), 326.00).

Generator Control Panels each consists of:

- 2 ammeters, 1 kW meter
- 1 Field Rheostat
- 1 Generator Speed/Load Controller
- 1 Generator Contactor Control Switch (trip/auto)
- 1 Generator Contactor - electrically controlled
- 1 AVR-pulsing type
- 1 Exciter Field Switch-knife type with shorting contact
- 1 Field Discharge Resistor
- 1 Set of Main Generator Fuses
- 1 Small auxiliary relay - purpose unknown
- 1 Transformer 240/115 V, 500 VA, single phase
- 1 Automatic Synchronizer

Switchboard containing:

Circuit Breakers controlling supplies to gate heaters, etc.

Synchronizing Swing Panel originally contained:

Synchroscope, switch, frequency meter

3.12 - Station Supplies Transfer Switches

At some time since the completion of the project, two, 'three position' switchboxes have been mounted on the downstream wall of the powerhouse.

The position of the switch selects the source of power, i.e. Turbine/off/Baltimore Gas & Electric.

One switch box is for the lighting circuits and the other for heating.

3.13 - Baltimore Gas & Electric Supply

The incoming supply to the powerhouse is stepped down by a pole-mounted bank of single phase transformers (Y-Y) to 480 volts, 4-wire, 3-phase and carried overhead to the powerhouse wall.

3.14 - Powerhouse Access

The doorway to the powerhouse is at el. 326.00 and is 4 ft. 3 in. wide by 6 ft. 10 in. high at the center. The opening has a semicircular arch at the top.

This leads onto the mezzanine floor which according to the Final Construction Report-Supplement (page 52) has a somewhat limited load carrying capacity.

4 - CONDITION AND LIMITATIONS OF EXISTING PLANT

4.1 - Intake

The upper section of the trash racks, in common with the spillway gates, has been repainted. The Site Superintendent reported that the procedure was: first, sand blast to bare metal; follow by three identical coats of paint. Internal inspection of the intake tower down to the water level (el. 349) showed the trash racks to be intact. The central gap between the left and right sections of the racks was approximately twice the size of the spacing of the bars of the racks.

The two sluice gates at el. 350 appeared to be in sound condition.

It was reported that one of the gates at el. 323 could not be operated. Attempts were being made to arrange an inspection by divers.

The largest gates at el. 309.83 were in the closed position and had been maintained in that position for a long time. This was to avoid passing poor quality water from the bottom of the reservoir.

For best efficiency of the generating plant it would be necessary to open the bottom gates since these are considerably larger than the higher gates and would therefore incur less hydraulic loss.

4.2 - Penstocks

Internal inspection of the penstocks was not possible as the discharge regulators were in operation. Such inspection should be made during redevelopment of the plant. Access would be via the intake tower after closure of all the sluices and dewatering.

The penstock valves appear to be well maintained and were reported to be in good working order.

4.3 - Discharge Regulators

These are well maintained and in good working order.

4.4 - Powerhouse Drainage

From the discussions with the Site Superintendent, it was evident serious problems had occurred and were likely to reoccur. The powerhouse had been flooded on a number of occasions--the most serious of which was as a result of Tropical Storm Agnes in 1972. Apparently it was not possible to state where the water came in as it appeared to be entering via many places.

The Final Report on Brighton Dam (see page 16, section k) records that "From study of the topography below the dam, it was computed, approximately that under extreme flood conditions the back water will not rise above el. 319 or 320, and the powerhouse has been designed and water-proofed against this remote condition". Hence, the door to the interior of the spillway is at el. 320 and the lower windows in the downstream wall of the powerhouse are at el. 321. On the occasion of the most serious flooding, water entered via all these openings until the level inside reached approximate el. 324, equal to that in the tailrace.

Inspection of the station drain sump was made from the station floor without removal of the grating. It appeared to contain some deposits but these of themselves would not have affected the working of the flap-valves.

The windows at el. 321 had been replaced by steel plate, but it was understood that no sealant had been applied around the frames.

The condition of the flap-valves in the drains to the spillway interior were not examined on this occasion.

4.5 - Turbine Inlet Valves

These valves appeared in good condition externally but would have to be overhauled if being retained for the development.

4.6 - Turbines

No reports on the condition of the turbines or other components of the generating plant were available. However, the Site Superintendent gave a verbal report to the effect that it was problems with the regulation of the units and their inadequacy to meet the on-site power demands that led to discontinuation of their use prior to 1972 flooding. The defects in the regulating gear had allowed the units to go to runaway speed on occasions. This condition gave cause for serious concern as the generators are limited to a safe overspeed of not more than 25 percent.

No problems due to trash entering the turbine 'shutters' (wicket gates) were reported but eels had proved troublesome and unpleasant to remove.

Internal examination of the turbines was not considered necessary at this time.

4.7 - Governors

These appear in good order externally, but it is possible internal damage has been caused due to entry of water.

4.8 - Hydraulic Power Packs

These could also have been damaged due to entry of water.

4.9 - Generators

The generators are enclosed with grease-lubricated bearings mounted in the end-plates. The slip rings were not visible.

The turbine generators have flywheels and hand/foot operated brake pads.

Governor speed control is effected by a P.M.G. which was belt-driven from the mainshaft.

The generator main connection and exciter field connection are routed via embedded ducts from the machines to the control panels. The only inspection/pull boxes are located on the downstream wall of the powerhouse, below the panels. Other conduits passing through these boxes carry control cabling. Electrical connections between the governor and pump are also via embedded conduit.

4.10 - Exciters

The d.c. exciters, mounted on the ends of the generators are of the open type and shunt-connected fields. The commutators and brushgear show corrosion consistent with standing idle in a hostile environment. There is no evidence of excessive wear. No electrical tests were made.

4.11 - Generator Control Panels and Switchboard

These are mounted on the mezzanine floor and therefore escaped damage during the power station flooding.

The automatic synchronizing device appears to be a voltage measuring relay, which can be operated by the application of voltage from different phases of the generators.

The units have never been run in parallel to the Baltimore Gas & Electric system, only with each other to meet load demands at Brighton Dam. Apart from the eventual inability to meet the demand, the electrical system gave trouble-free operation.

4.12 - Station Supplies Transfer Switches

These contactors are of relatively new construction and are in good condition. They are designed to prevent interconnection of the generators with the incoming line.

4.13 - Baltimore Gas & Electric Supply

The voltage and load carrying capacity of the incoming line has yet to be established.

4.14 - Powerhouse Access and Lifting Facilities

From the Final Report it is evident that in the interests of economy little provision was made for the lifting or moving of plant in or out of the powerhouse. There are three lifting loops cast into each beam of the powerhouse roof giving coverage of the entire floor area. The safe working load for each lifting point is not indicated. After removal of the internal wall to the mezzanine floor there should be no problem in removing existing equipment, or installing new, provided it is dismantled into manageable parts.

The Elgin filter and intermediate tank, shown on the station arrangement drawing No. 45 as being close to the upstream wall, have been removed completely, thus increasing the space available for rearrangement of plant if required.

4.15 - Reservoir Operation

In order to provide some flood protection it is WSSC current practice to maintain the reservoir level at approximately 3 ft below the top of the spillway gate flashboards.

5 - LIMITATIONS ON REDEVELOPMENT OF THE SITE

5.1 - Space Availability

There is sufficient space in the station to permit the installation of larger units.

5.2 - Lifting and Moving Facilities

Careful consideration must be given to the manner in which any future plant will be transported into and within the powerhouse. There will be no problem in removing the existing plant.

5.3 - River Flow

The minimum flow maintenance requirement of the Water Appropriation and Use Permit may necessitate the use of one small generating unit to cope efficiently with small flows over extended periods.

The tailrace pond is small and the storage there is insufficient to maintain flow in the river after discharge from the dam ceases.

5.4 - Capacity of Existing Penstocks

The existing penstocks could pass larger flows without undue head loss but the arrangement whereby the connection to the turbines are via 'T' pieces results in considerable losses.

The possibility of making a new opening into the intake tower is one which will require careful consideration.

5.5 - Powerhouse Security From Flooding

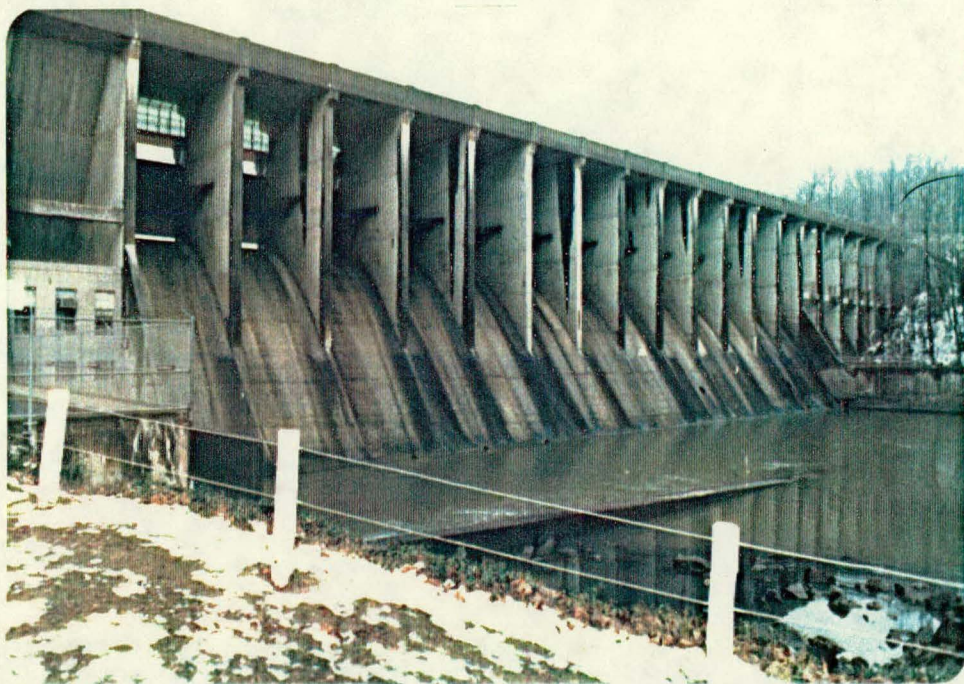
Any redevelopment scheme must include:

- a) proposals to prevent major leakage into the station,
- b) upgrading of drainage pump(s),
- c) structural checks on downstream and dividing walls of station to ensure adequate strength to withstand higher than originally anticipated tailwater levels.

5.6 - Transmission Line

It is probable that the existing Baltimore Gas & Electric line will be adequate to handle the generation from this station, but this requires confirmation.

APPENDIX C
PHOTOGRAPHS



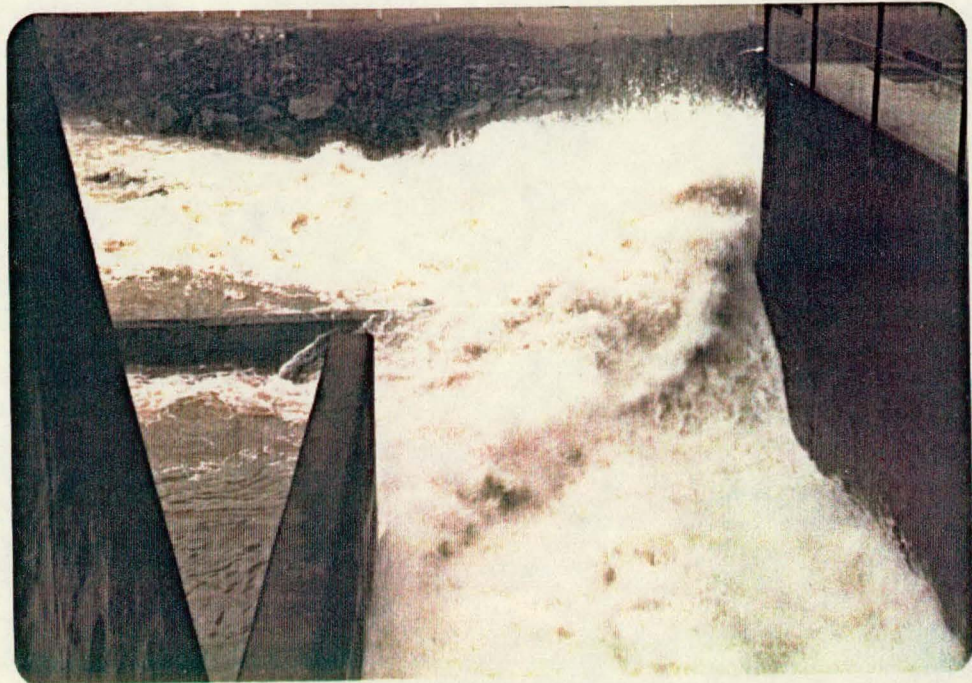
Downstream Side of Spillway
Powerhouse in left hand corner



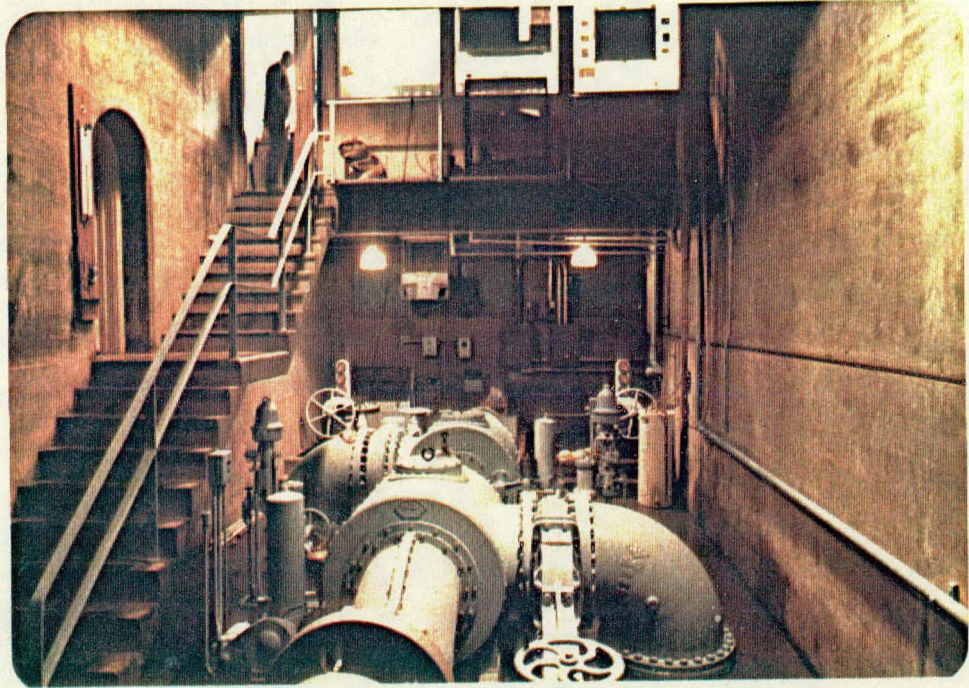
Intake Tower and Controls for Gates



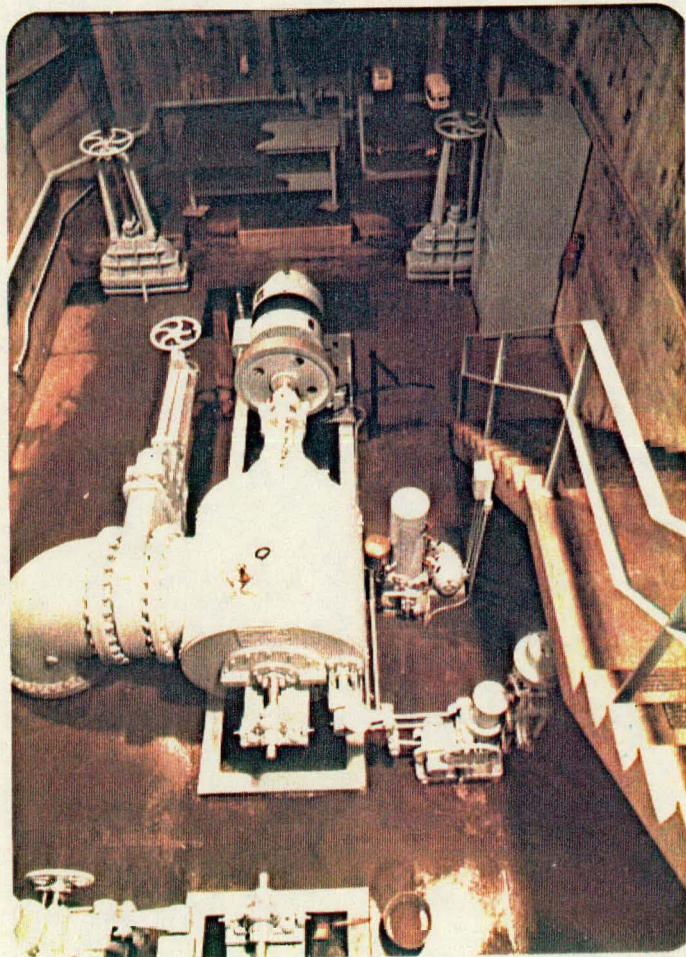
Downstream View of
Powerhouse and Spillway



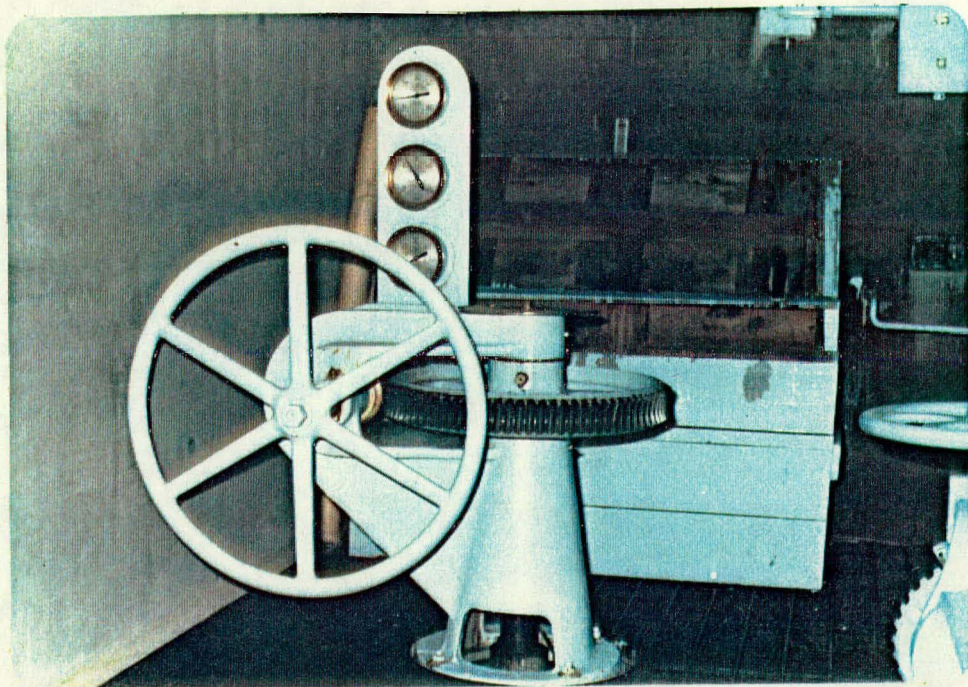
Tailrace Channel
Discharge Regulators Full Open



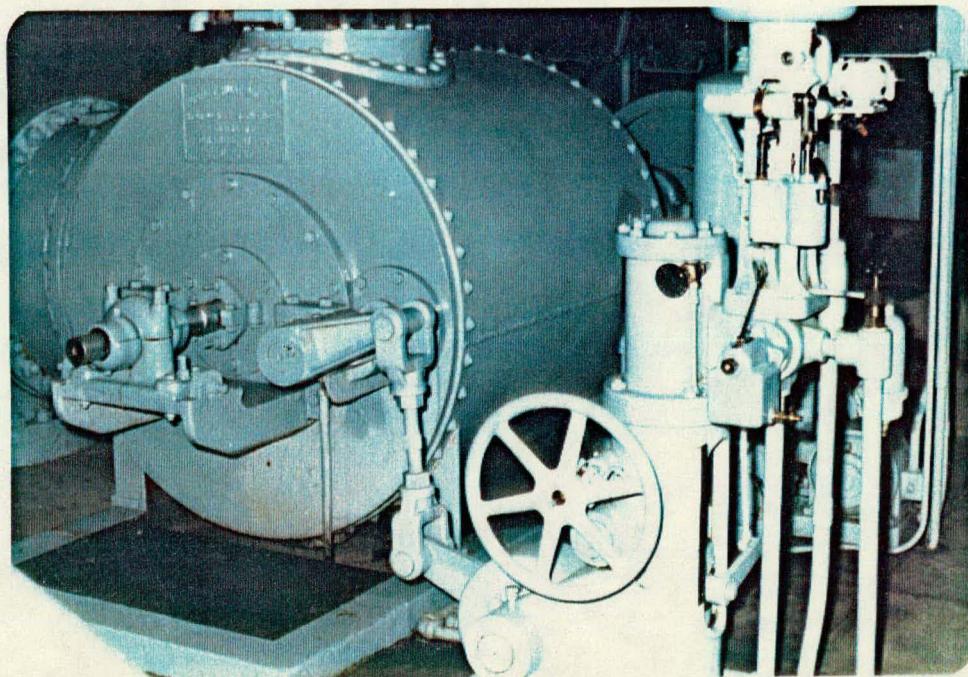
General View of
Powerhouse Looking Downstream



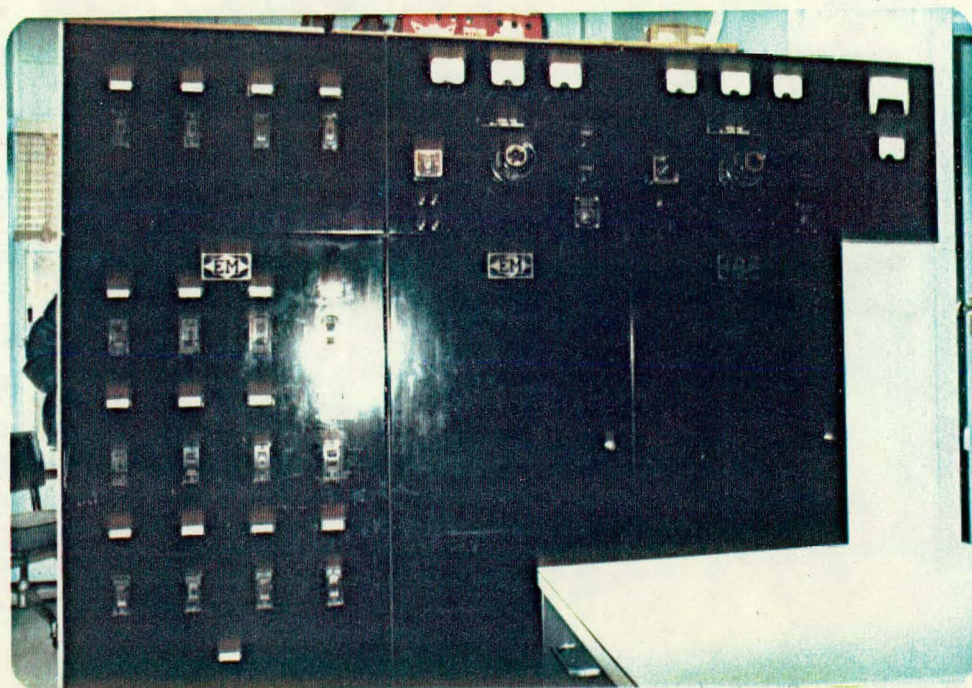
Overhead View
of Upstream Unit



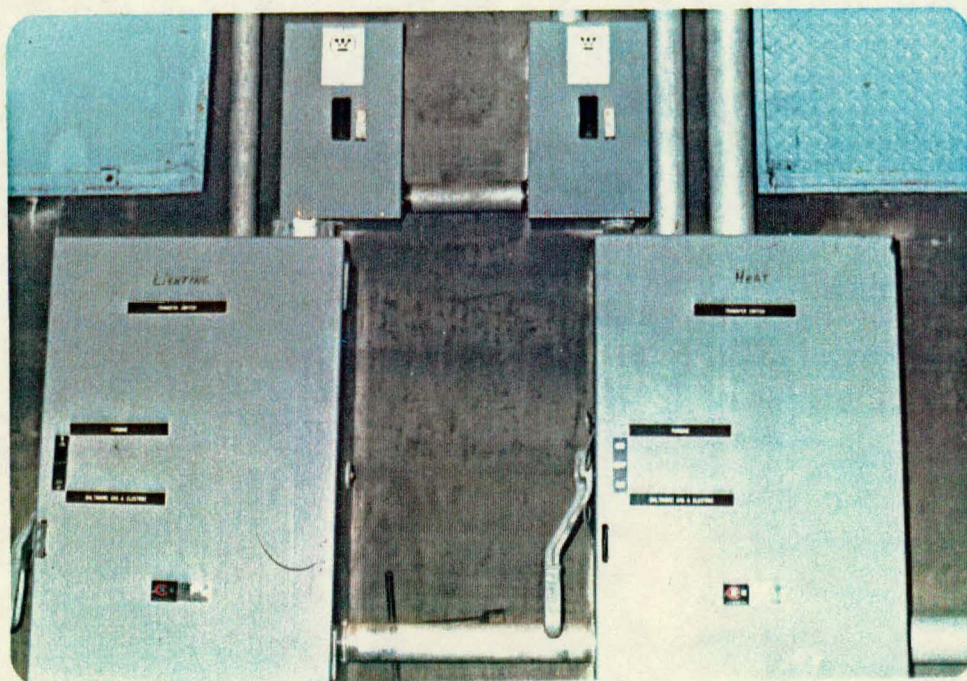
Handgear for Discharge Regulator



Existing Turbine and Governor



Turbine/Generator Control Panels



Transfer Switches for Station Supplies

APPENDIX D
DETAIL COST ESTIMATES



ESTIMATE SUMMARY

Alternative A1 - Two 240 kW horizontal Francis
turbines on existing penstocks

CLIENT Washington Suburban Sanitary Commission TYPE OF ESTIMATE Preliminary

PROJECT Brighton Dam APPROVED BY CAD

JOB NUMBER P5157.00

FILE NUMBER .30

SHEET 1 OF 4

BY JCS DATE 2/79

CHKD RLP DATE 3/79

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
331.00	Structures & Improvements				26,920		
332.00	Reservoirs, Dams & Waterways				6,600		
333.00	Waterwheels, Turbines & Generators				327,000		
334.00	Accessory Electrical Equipment				50,000		
335.00	Miscellaneous Power Plant Equipment				2,000		
353.00	Station Equipment				15,000		
	Construction Total				427,520		
	Contingencies (25% - approx.)				106,980		
	Engineering & Administration				267,500		
	TOTAL PROJECT COSTS				802,000		



ESTIMATE SUMMARY

Alternative A1 - Two 240 kW horizontal Francis
turbines on existing penstocks

CLIENT Washington Suburban Sanitary Commission TYPE OF ESTIMATE Preliminary
PROJECT Brighton Dam APPROVED BY CAD

JOB NUMBER P5157.00
FILE NUMBER .30
SHEET 2 OF 4
BY JCS DATE 2/79
CHKD RLP DATE 3/79

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
331.	Power Plant Structures & Improvements						
.1	Power House						
.11	Cofferdam and pumping						
.111	Structure	700	c.y.	6.50	4,600		
.113	Removal	700	c.y.	2.50	1,800		
.16	Remove existing Equipment		L.S.		10,000		
.17	Downstream Wall Removal & Replace for access						
.171	Remove	12	c.y.	160.00	1,920		
.172	Replace						
.1721	Concrete	12	c.y.	100.00	1,200		
.1722	Forms	650	s.f.	10.00	6,500		
.1723	Reinforcing Steel	1,200	lb.	0.75	900		
	Total Power Plant Structures and Improvements					26,920	
332.	Reservoirs, Dams & Waterways						
.9	Tailrace						
.91	Excavation & Demolition	20	c.y.	125.00	2,500		
.92	Concrete	15	c.y.	100.00	1,500		
.93	Forms	157	s.f.	10.00	1,600		
.94	Reinforcing Steel	1,500	lb.	0.75	1,000		
	Total Reservoirs, Dams and Waterways					6,600	



ESTIMATE SUMMARY

Alternative A1 - Two 240 kW horizontal Francis
turbines on existing penstocks

CLIENT Washington Suburban Sanitary Commission TYPE OF ESTIMATE Preliminary
PROJECT Brighton Dam APPROVED BY CAD

JOB NUMBER P5157.00
FILE NUMBER .30
SHEET 3 OF 4
BY JCS DATE 2/79
CHKD RLP DATE 3/79

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
333.	Waterwheels, Turbines and Generators						
.1	Turbines, Governors, Pumps and Piping						
.11	Turbines and Governors	2	L.S.		226,000		
.2	Generators, Exciters and Appurtenances						
.21	Generators and direct-connected exciters	2	L.S.		30,650		
.4	Delivery				6,000		
.5	Installation				64,200		
	Total Waterwheels, Turbines and Generators				327,000		
334.	Accessory Electric Equipment						
.1	Connections, Supports and Structures						
.12	Conductors and insulators		L.S.		19,000		
.2	Switchgear and Control Equipment						
.23	Circuit Breakers		L.S.		17,000		
.25	Switchboards and appurtenances		L.S.		14,000		
	Total Accessory Electric Equipment					50,000	



ESTIMATE SUMMARY

Alternative A1 - Two 240 kW horizontal Francis
turbines on existing penstocks

CLIENT Washington Suburban Sanitary Commission TYPE OF ESTIMATE _____

PROJECT Brighton Dam APPROVED BY CAD

JOB NUMBER P5157.00
FILE NUMBER .30
SHEET 4 OF 4
BY JCS DATE 2/79
CHKD RLP DATE 3/79

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
335.	Miscellaneous Power Plant Equipment						
.1	Auxiliary Equipment						
.11	Unwatering and low level drainage system	1	L.S.		2,000		
	Total Miscellaneous Power Plant Equipment				2,000		
353.	Substation Equipment						
.21	Transformer Supply				13,000		
.211	Install	1	L.S.		2,000		
	Total Substation Equipment				15,000		



ESTIMATE SUMMARY

Alternative A2 - Two 243 kW horizontal Francis
turbines on modified penstocks
CLIENT Washington Suburban Sanitary Commission TYPE OF ESTIMATE Preliminary
PROJECT Brighton Dam APPROVED BY CAD

JOB NUMBER P5157.00
FILE NUMBER .30
SHEET 1 OF 4
BY JCS DATE 2/79
CHKD RLP DATE 3/79

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
331.00	Structures & Improvements				36,000		
332.00	Reservoirs, Dams & Waterways				24,730		
333.00	Waterwheels, Turbines & Generators				327,000		
334.00	Accessory Electrical Equipment				50,000		
335.00	Miscellaneous Power Plant Equipment				2,000		
353.00	Station Equipment				15,000		
	Construction Total				454,730		
	Contingencies (25%)				113,770		
	Engineering & Administration				284,500		
	TOTAL PROJECT COSTS				853,000		



ESTIMATE SUMMARY

Alternative A2 - Two 243 kW horizontal Francis
turbines on modified penstocks

CLIENT Washington Suburban Sanitary Commission

TYPE OF ESTIMATE Preliminary

PROJECT Brighton Dam

APPROVED BY CAD

JOB NUMBER P5157.00

FILE NUMBER .30

SHEET 12 OF 4

BY JCS DATE 2/79

CHKD RIP DATE 3/79

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
331.	Power Plant Structures & Improvements						
.1	Power House						
.11	Cofferdam and pumping						
.111	Structure	700	c.y.	6.50	4,600		
.113	Removal	700	c.y.	2.50	1,800		
.12	Excavation						
.123	Demolition	24	c.y.	150.00	3,600		
.15	Substructure						
.151	Concrete	27	c.y.	100.00	2,700		
.1511	Forms	107	s.f.	10.00	1,070		
.1512	Reinforcing Steel	2,160	lb.	0.75	1,700		
.16	Remove existing Equipment		L.S.		10,000		
.17	Downstream Wall Removal & Replace for access						
.171	Remove	12	c.y.	160.00	1,920		
.172	Replace						
.1721	Concrete	12	c.y.	100.00	1,200		
.1722	Forms	650	s.f.	10.00	6,500		
.1723	Reinforcing Steel	1,200	lb.	0.75	900		
	Total Power Plant Structures and Improvements					36,000	



ESTIMATE SUMMARY

Alternative A2 - Two 243 kW horizontal Francis
turbines on modified penstocks

CLIENT Washington Suburban Sanitary Commission TYPE OF ESTIMATE Preliminary
PROJECT Brighton Dam APPROVED BY CAD

JOB NUMBER P5157.00
FILE NUMBER .30
SHEET 3 OF 4
BY JCS DATE 2/79
CHKD RLP DATE 3/79

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
332.	Reservoirs, Dams & Waterways						
.8	Penstocks						
.82	Y-Branch	2	each	2,000	4,000		
.83	Pipe	60	l.f.	92.00	5,500		
.84	Flanges	10	each	863.00	8,630		
.9	Tailrace						
.91	Excavation & Demolition	20	c.y.	125.00	2,500		
.92	Concrete	15	c.y.	100.00	1,500		
.93	Forms	157	s.f.	10.00	1,600		
.94	Reinforcing Steel	1,500	lb.	0.75	1,000		
	Total Reservoirs, Dams and Waterways					24,730	
333.	Waterwheels, Turbines and Generators						
.1	Turbines, Governors, Pumps and Piping						
.11	Turbines and governors	2	L.S.		226,000		
.2	Generators, Exciters and Appurtenances						
.21	Generators and direct-connected exciters	2	L.S.		30,650		
.4	Delivery				6,000		
.5	Installation				64,200		
	Total Waterwheels, Turbines and Generators					327,000	

D-7



ESTIMATE SUMMARY

Alternative A2 -- Two 243 kW horizontal Francis
Turbines on modified penstocks

CLIENT Washington Suburban Sanitary Commission TYPE OF ESTIMATE Preliminary

PROJECT Brighton Dam APPROVED BY CAD

JOB NUMBER P5157.00
FILE NUMBER .30
SHEET 4 OF 4
BY JCS DATE 2/79
CHKD RIP DATE 3/79

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
334.	Accessory Electric Equipment						
.1	Connections, Supports and Structures						
.12	Conductors and insulators		L.S.		19,000		
.2	Switchgear and Control Equipment						
.23	Circuit Breakers		L.S.		17,000		
.25	Switchboards & Appurtenances		L.S.		14,000		
	Total Accessory Electric Equipment					50,000	
335.	Miscellaneous Power Plant Equipment						
.1	Auxiliary Equipment						
.11	Unwatering and low level drainage system	1	L.S.		2,000		
	Total Miscellaneous Power Plant Equipment					2,000	
353.	Substation Equipment						
.21	Transformer Supply	1			13,000		
.211	Install		L.S.		2,000		
	Total Substation Equipment					15,000	



ESTIMATE SUMMARY

Alternative B1a - One 500 kW vertical propeller
Turbines

CLIENT Washington Suburban Sanitary Commission TYPE OF ESTIMATE Preliminary

PROJECT Brighton Dam APPROVED BY CAD

JOB NUMBER P5157,00
FILE NUMBER ,30
SHEET 1 OF 4
BY JCS DATE 2/79
CHKD RLP DATE 3/79

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
331.00	Structures & Improvements				43,000		
332.00	Reservoirs, Dams & Waterways				11,700		
333.00	Waterwheels, Turbines, and Generators				292,300		
334.00	Accessory Electrical Equipment				40,000		
335.00	Miscellaneous Power Plant Equipment				2,000		
353.00	Station Equipment				2,000		
	Construction Total				391,000		
	Contingencies, (25%)				98,000		
	Engineering & Administration				245,000		
	TOTAL PROJECT COSTS				734,000		



ESTIMATE SUMMARY

Alternative Bla - One 500 kW vertical propeller
Turbines

CLIENT Washington Suburban Sanitary Commission

TYPE OF ESTIMATE Preliminary

PROJECT Brighton Dam

APPROVED BY CAD

JOB NUMBER P5157.00

FILE NUMBER .30

SHEET 2 OF 4

BY JCS DATE 2/79

CHKD RLP DATE 3/79

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
331.	Power Plant Structures & Improvements						
.1	Power House						
.11	Cofferdam and pumping						
.111	Structure	700	c.y.	6.50	4,600		
.113	Removal	700	c.y.	2.50	1,800		
.12	Excavation						
.123	Solid rock & concrete demolition	46	c.y.	150.00	6,900		
.15	Substructure						
.151	Concrete	32	c.y.	100.00	3,200		
.1511	Forms	400	s.f.	10.00	4,000		
.1512	Reinforcing steel	2,600	lb.	0.75	1,950		
.16	Remove existing Equipment		L.S.		10,000		
.17	Downstream Wall Removal & Replace for access						
.171	Remove	12	c.y.	160.00	1,920		
.172	Replace						
.1721	Concrete	12	c.y.	100.00	1,200		
.1722	Forms	650	s.f.	10.00	6,500		
.1723	Reinforcing Steel	1,200	lb.	0.75	900		
	Total Power Plant Structures and Improvements					43,000	



ESTIMATE SUMMARY Alternative Bla - One 500 kW vertical propeller
Turbine
CLIENT Washington Suburban Sanitary Commission TYPE OF ESTIMATE Preliminary
PROJECT Brighton Dam APPROVED BY CAD

JOB NUMBER P5157.00
FILE NUMBER .30
SHEET 3 OF 4
BY JCS DATE 2/79
CHKD RLP DATE 3/79

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
332.	Reservoirs, Dams & Waterways						
.8	Penstocks						
.83	Pipe 4' diameter, 10.5 ft		L.S.		5,100		
.9	Tailrace						
.91	Excavation & Demolition	20	c.y.	125.00	2,500		
.92	Concrete	15	c.y.	100.00	1,500		
.93	Reinforcing Steel	1,500	lb.	0.75	1,000		
.94	Forms	157	s.f.	10.00	1,600		
	Total Reservoirs, Dams and Waterways					11,700	
333.	Waterwheels, Turbines and Generators						
.1	Turbines, Governors, Pumps, and Piping						
.11	Turbines and governors	1	L.S.		150,000		
.2	Generators, Exciters and Appurtenances						
.21	Generators and direct-connected exciters	1	L.S.		60,000		
.4	Import Duty				15,800		
.5	Delivery				10,000		
.6	Installation				56,500		
	Total Waterwheels, Turbines, and Generators					292,300	



ESTIMATE SUMMARY Alternative Bla - One 500 kW vertical propeller
Turbine
CLIENT Washington Suburban Sanitary Commission TYPE OF ESTIMATE Preliminary
PROJECT Brighton Dam APPROVED BY CAD

JOB NUMBER P5157.00
FILE NUMBER .30
SHEET 4 OF 4
BY JCS DATE 2/79
CHKD RLP DATE 3/79

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
334.	Accessory Electric Equipment						
.12	Conductors and insulators		L.S.		13,000		
.23	Circuit Breakers		L.S.		15,000		
.25	Switchboards and appurtenances		L.S.		12,000		
	Total Accessory Electric Equipment					40,000	
335.	Miscellaneous Power Plant Equipment						
.11	Unwatering and low level drainage system		L.S.		2,000		
	Total Miscellaneous Power Plant Equipment					2,000	
353.	Substation Equipment						
.21	Transformer Supply						
.211	Install		L.S.		2,000		Included in Acct. 333
	Total Substation Equipment					2,000	



ESTIMATE SUMMARY

Alternative Blb - One 420 kW Tube Turbine

CLIENT Washington Suburban Sanitary Commission

TYPE OF ESTIMATE Preliminary

PROJECT Brighton Dam

APPROVED BY CAD

JOB NUMBER P5157.00

FILE NUMBER .30

SHEET 1 OF 4

BY JCS DATE 2/79

CHKD RLP DATE 3/79

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
331.00	Structures & Improvements				44,000		
332.00	Reservoirs, Dams & Waterways				9,100		
333.00	Waterwheels, Turbines & Generators				414,100		
334.00	Accessory Electrical Equipment				0		
335.00	Miscellaneous Power Plant Equipment				2,000		
353.00	Station Equipment				40,0200		
	Construction Total				469,200		
	Contingencies (25%)				117,300		
	Engineering & Administration				293,500		
	TOTAL PROJECT COSTS				880,000		



ESTIMATE SUMMARY

Alternative B1b - One 420 kW Tube Turbine

CLIENT Washington Suburban Sanitary Commission

TYPE OF ESTIMATE Preliminary

PROJECT Brighton Dam

APPROVED BY CAD

JOB NUMBER P5157.00

FILE NUMBER .30

SHEET 12 OF 4

BY JCS DATE 2/79

CHKD RLP DATE 3/79

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
331.	Power Structures & Improvements						
.1	Power House						
.11	Cofferdam and pumping						
.111	Structure	700	c.y.	6.50	4,500		
.113	Removal	700	c.y.	2.50	1,800		
.12	Excavation						
.123	Solid rock & concrete demolition	45	c.y.	150.00	6,750		
.15	Substructure						
.151	Concrete	40	c.y.	100.00	4,000		
.1511	Forms	402	s.f.	10.00	4,020		
.1512	Reinforcing steel	3,200	lb.	0.75	2,400		
.16	Remove existing equipment		L.S.		10,000		
.17	Downstream wall removal						
.171	Remove	12	c.y.	160.00	1,920		
.172	Replace						
.1721	Concrete	12	c.y.	100.00	1,200		
.1722	Forms	650	s.f.	10.00	6,500		
.1723	Reinforcing Steel	1,200	lb.	0.75	900		
	Total Power Plant Structures and Improvements					44,000	



ESTIMATE SUMMARY

Alternative Blb - One 420 kW Tube Turbine

CLIENT Washington Suburban Sanitary Commission TYPE OF ESTIMATE Preliminary

PROJECT Brighton Dam APPROVED BY CAD

JOB NUMBER P5157.00
FILE NUMBER .30
SHEET 3 OF 4
BY JCS DATE 2/79
CHKD RLP DATE 3/79

No.	DESCRIPTION	QUANTITY	UNIT	COST / UNIT	AMOUNT	TOTALS	REMARKS
332.	Reservoirs, Dams & Waterways						
.8	Penstocks						
.83	Pipe 42" diam. 1/2" plate	1	L.S.		2,500		
.9	Tailrace						
.91	Excavation & Demolition	20	c.y.	150.00	2,500		
.92	Concrete	15	c.y.	100.00	1,500		
.93	Forms	157	s.f.	10.00	1,600		
.94	Reinforcing Steel	1,500	lb.	0.75	1,000		
	Total Reservoirs, Dams & Waterways					9,100	
333.	Waterwheels, Turbines & Generators						
.1	Turbines, Governors, Pumps and Piping		H.P.				
.101	Supply and delivery	1	L.S.		314,000		
.102	Install				100,000		
.21	Generators & direct-connected exciters						
.211	Generator - Supply & Delivery						Included in 333.101
.212	Install						Included in 333.102
	Total Waterwheels, Turbines and Generators					414,000	



ESTIMATE SUMMARY

Alternative Blb - One 420 kW Tube Turbine

CLIENT Washington Suburban Sanitary Commission TYPE OF ESTIMATE Preliminary
PROJECT Brighton Dam APPROVED BY CAD

JOB NUMBER P5157.00
FILE NUMBER .30
SHEET 4 OF 4
BY JCS DATE 2/79
CHKD RLP DATE 3/79

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
334.	Accessory Electric Equipment						
.12	Conductors and insulators		L.S.		0		Included in 333.00
.23	Circuit breakers		L.S.		0		Included in 333.00
.25	Switchboards and appurtenances		L.S.		0		Included in 333.00
335.	Miscellaneous Power Plant Equipment						
.1	Auxiliary Equipment						
.11	Unwatering & low level drainage system		L.S.		2,000		
	Total Miscellaneous Power Plant Equipment					2,000	
353.	Substation Equipment						
.21	Transformer Supply		L.S.		0		Included in 333.00
.211	Install		L.S.		0		Included in 333.00
	Total Substation Equipment					0	

APPENDIX E
MANUFACTURERS' DATA

APPENDIX E

EQUIPMENT DESIGN AND MANUFACTURER DATA

Several manufacturers of hydroelectric power equipment and associated large specialty equipment were approached early in the feasibility study preparation to provide technical data and equipment cost estimates in support of the alternative conceptual designs. Due to other commitments some manufacturers did not respond and the short duration of the study hindered full development and analysis of manufacturers' data.

We would like to acknowledge the following equipment manufacturers for their input of preliminary data and equipment costs to this report.

1. Turbines-Generators:

The following manufacturers were contacted and correspondence received is included in this appendix.

- | | |
|----------------------------------|----------------------------|
| - Allis-Chalmers | - James Leffel & Co. |
| - Barber Hydraulic Turbine, Ltd. | - KMW Sweden |
| - Sulzer Bros. Inc. | - Neyrpic |
| - Bofors-Nohab | - Drees & Co. GmbH |
| - Brown-Boveri Corp. | - F.W.E. Staphenhorst Inc. |
| - Gilbert Gilkes & Gordon, Ltd. | - Tampella A.B. |

Responses were received from:

- | | |
|---------------------------|----------------------------|
| - Allis-Chalmers | - Sulzer Bros. Inc. |
| - Gilbert Gilkes & Gordon | - F.W.E. Staphenhorst Inc. |
| - James Leffel & Co. | - Tampella A.B. |
| - KMW Sweden | |

2. Electrical Equipment:

The following manufacturers were contacted and information was received.

- | | |
|--------------------|--------------------|
| - General Electric | - KATO Engineering |
| - Ideal Electric | |

Correspondence received is contained in this appendix.

TELEPHONE: SWEDEN (46) - 550 152 00
TELEX: 66050 KMWKSN S



ACRES AMERICAN INC.

INFORMATION SHEETS
FOR
HYDRAULIC TURBINES AND GENERATORS

SUBMITTED BY KMW Sweden, AB Karlstads Mekaniska Werkstad,

Kristinehamn Works, S-681 01 Kristinehamn, Sweden

PROJECT Brighton Dam Hydroelectric Redevelopment DATE 1/26/79

LOCATION Brighton, Maryland

OWNER Washington Suburban Sanitary Commission

1. PLANT DATA

Rated Plant Output	<u>500</u>	<u>kw</u>
Plant Design Flow	<u>130</u>	<u>cfs</u>
Rated Net Head	<u>50</u>	<u>ft</u>
Range of Net Head - maximum	<u>57</u>	<u>ft</u>
- minimum	<u>36</u>	<u>ft</u>

Water Levels

Headwater - maximum	El. <u>366.5</u>
- normal	El. <u>365</u>
- minimum	El. <u>350</u>
Tailwater - maximum	El. <u>320</u>
- normal	El. <u>306</u>
- minimum	El. <u>304</u>

Generator - phases/frequency 3/60 Hz

- flywheel effect Normal

Other Information _____

E-4

2.1 Technical Data

Number of Units.....	1	
Type <u>Standard miniturbine</u>	SV9	
Rated Power at Full Gate.....	500	hp kW
Turbine Efficiency - full gate.....	88.5	89 % See
- best gate.....	89.5	89 % <i>Talex</i> 79/03/08
Asynchronous Speed.....	612	rpm
Runner Diameter.....	35.4	in.
Submergence of Centerline of Runner below min. TWL.....	1	ft

2.2 Prices (Budget price)

	Shut-off valve	FOB Swedish port
Turbines and Governors	- Supply & Delivery (<u>1</u> units) ..	\$ <u>150.000</u>
	- Installation (units)	\$

Fixed runner blades and guide vanes.

3.1 Technical Data

Number of Units..... 1

Type Asynchronous

Rated Power..... ~ 500 kW

Power Factor.....

Synchronous Speed..... 612 rpm

Recommended Voltage..... KV

Dimensions

- Outside Diameter of Air Housing..... in.

- Overall Height (Vertical Units) See pamphlet in.

- Overall Length (Horizontal Units)..... in.

Heaviest Lift..... lb

3.2 Prices (Budget price)

with Transformer etc. FOB Swedish port
Generator ~~and Exciters~~ - Supply & Delivery (1 Units) \$ 60.000

- Installation (Units) \$

P5157.00

COPY OF TELEX RECEIVED IN BUFFALO OFFICE MARCH 8, 1979 at 7:55 a.m.

VIA WUI

0747 03/08

ACRES BUFF

66050z KMWKSN S

2004

79/03/08

HBJ/198/KF4

ATTN: H.F. Allman

MINITURBINE SV9

WITH REFERENCE TO YOUR TELEX OF MAR 06, 1979

WE WOULD LIKE TO ANSWER AS FOLLOWS:

1. ESTIMATED PRESENT COST OF SHIPMENT OF TURBINE , GENERATOR
ETC TO US EAST COAST PORT US DOLLARS 4.000.
2. DUE TO A MISTAKE IN OUR INTERNAL COMMUNICATIONS EFFICIENCIES
FOR FULL GATE AND BEST GATE WAS STATED IN INFORMATION SHEET.
WITH FIXED RUNNER BLADES AND GUIDE VANES WE INSTEAD GIVE 89 per cent
AS TURBINE EFFICIENCY.
3. GENERATOR WEIGHT ABOUT 3500 KG.
4. TURBINE HEAVIEST LIFT ABOUT 4000 KG.
5. DRAFT TUBE OUTLET DIMENSIONS:
WIDTH 2330 MM, HEIGHT 985MM.
DISTANCE FROM UNIT VERTICAL CENTRELINE TO DRAFT TUBE OUTLET
ABOUT 4000MM.
6. DIMENSIONS L2 1820 MM.
7. DIMENSION FROM UPSTREAM FACE OF INLET VALVE TO UNIT CENTRELINE
ABOUT 2000MM.
8. VOLTAGE FOR GENERATOR 480V IS OK.

REGARDS

H BJUREK/KMW

/OSL

66050Z KMWKSN S*

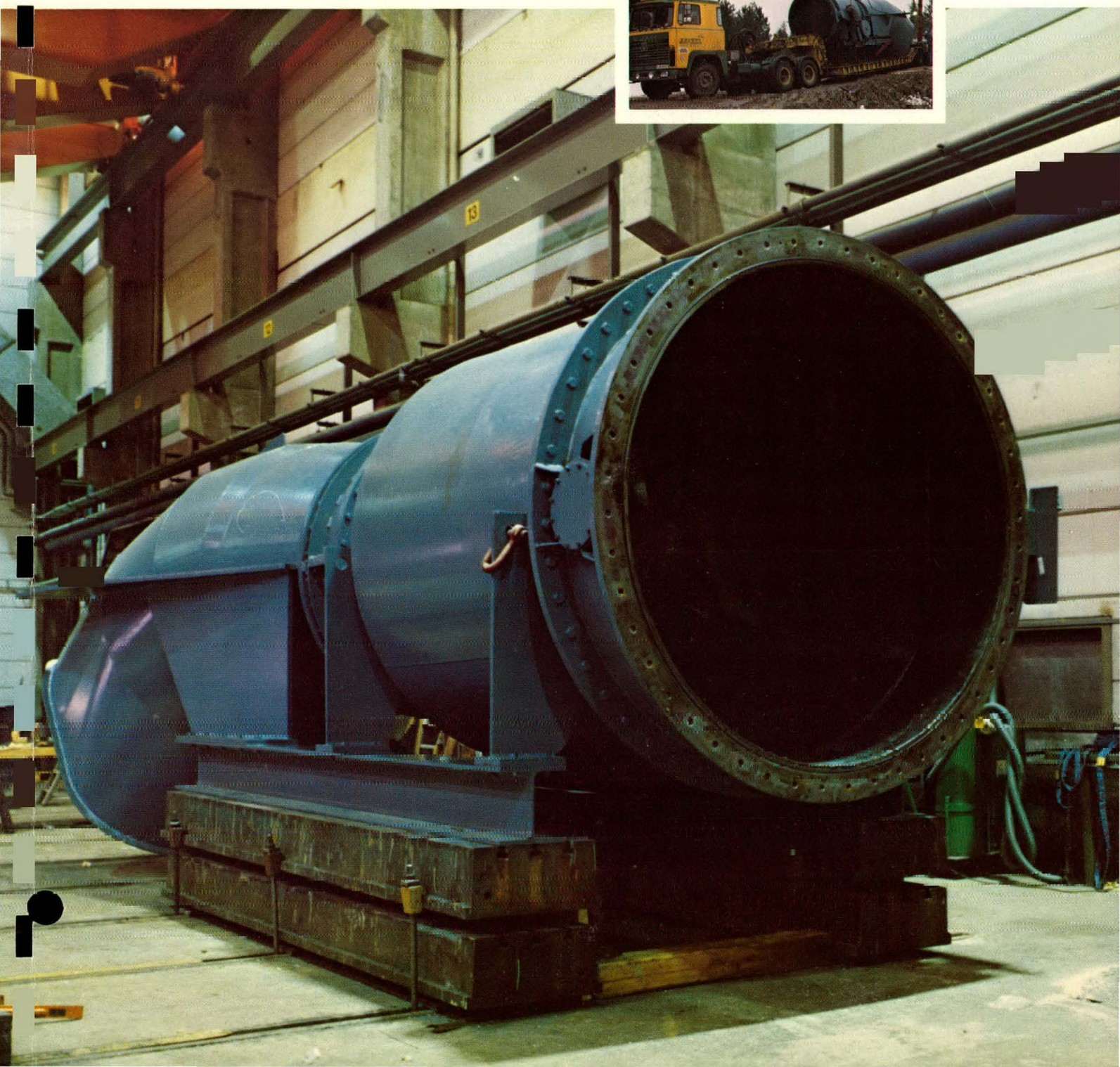
ACRES BUFF

FOR INTL TELEX DIAL 101 - CABLEGRAMS 6481

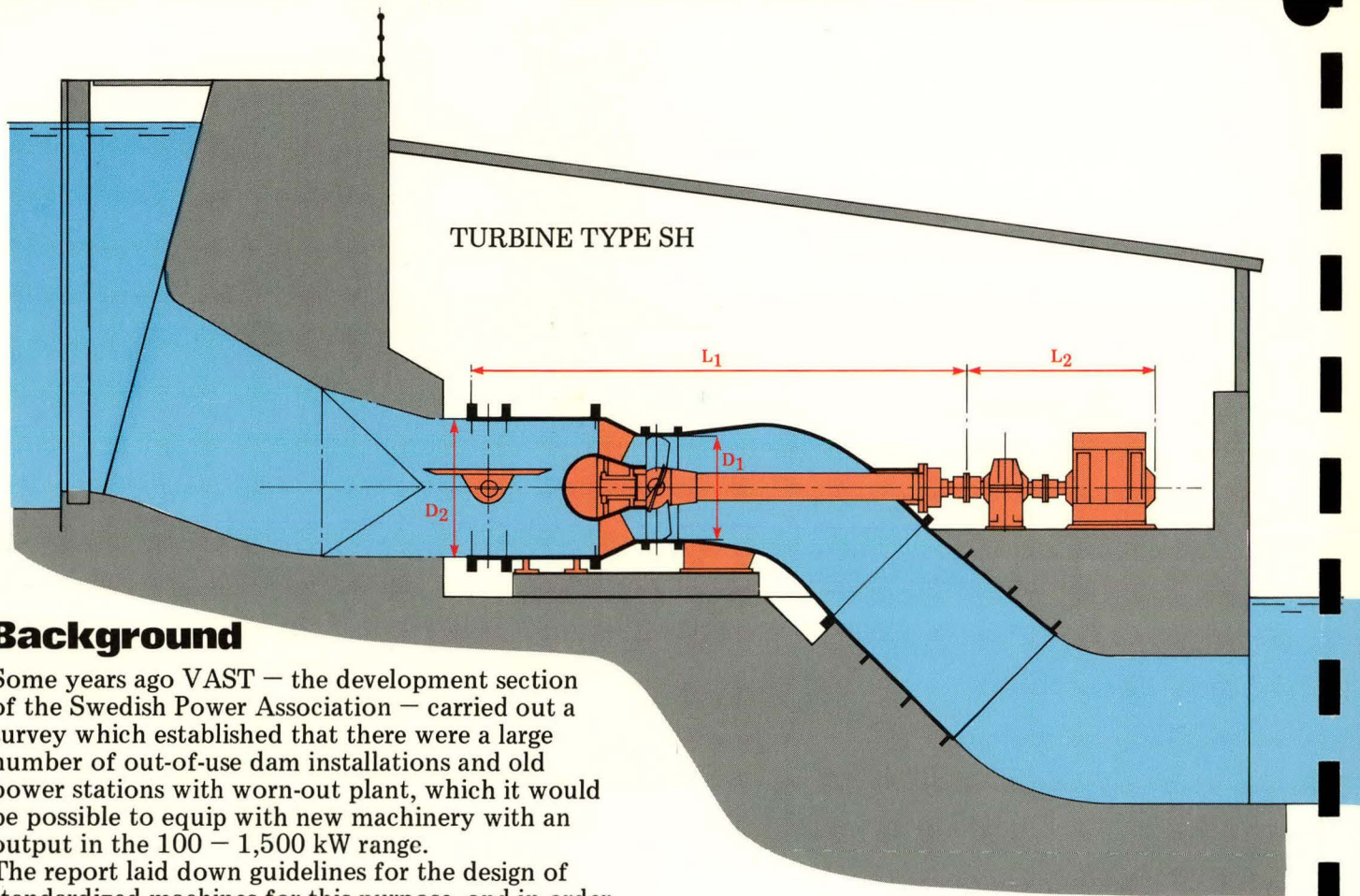
Original copy of telex will be forwarded in the mail.

KMW Miniturbines

E-7



KMW mini turbine



Background

Some years ago VAST — the development section of the Swedish Power Association — carried out a survey which established that there were a large number of out-of-use dam installations and old power stations with worn-out plant, which it would be possible to equip with new machinery with an output in the 100 – 1,500 kW range.

The report laid down guidelines for the design of standardized machines for this purpose, and in order to lay the foundations in practice for this work, VAST assisted in the development of six prototype installations.

Three of these installations were provided with KMW turbines and the other three had turbines of another make.

For the sake of maximum simplicity and thus of minimizing machine costs these prototype machines were built with fixed runner and guide vanes.

This will also be the normal form of the standard turbines, series production of which is now envisaged.

Main dimensions

All measurements in millimetres.

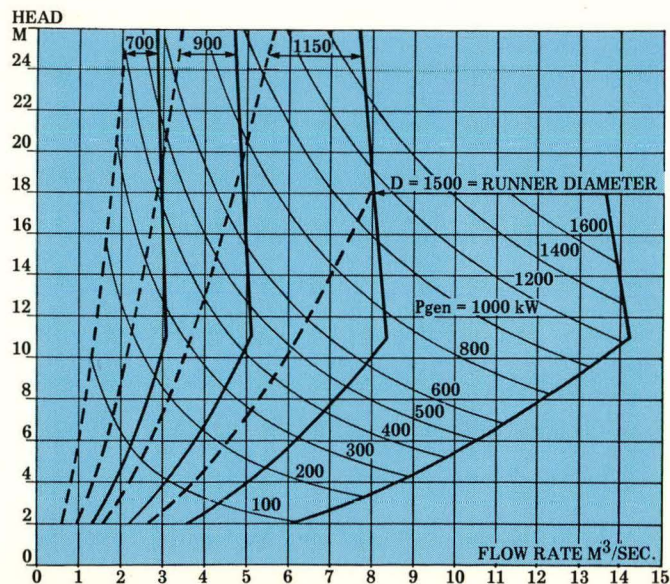
	D ₁	D ₂	L ₁	L ₂ max	min	L ₃	L ₄
SH 7	700	950	3700	2540	1260		
SH 9	900	1200	4700	2720	1610		
SH 11	1150	1550	6000	3120	1760		
SH 15	1500	2000	7700	3120	2250		
SV 7	700	950	4500	2920	1430	1480	1790
SV 9	900	1200	5700	3280	1770	1900	2300
SV 11	1150	1550	7300	3930	2220	2430	2940
SV 15	1500	2000	9600	3930	2420	3170	3840

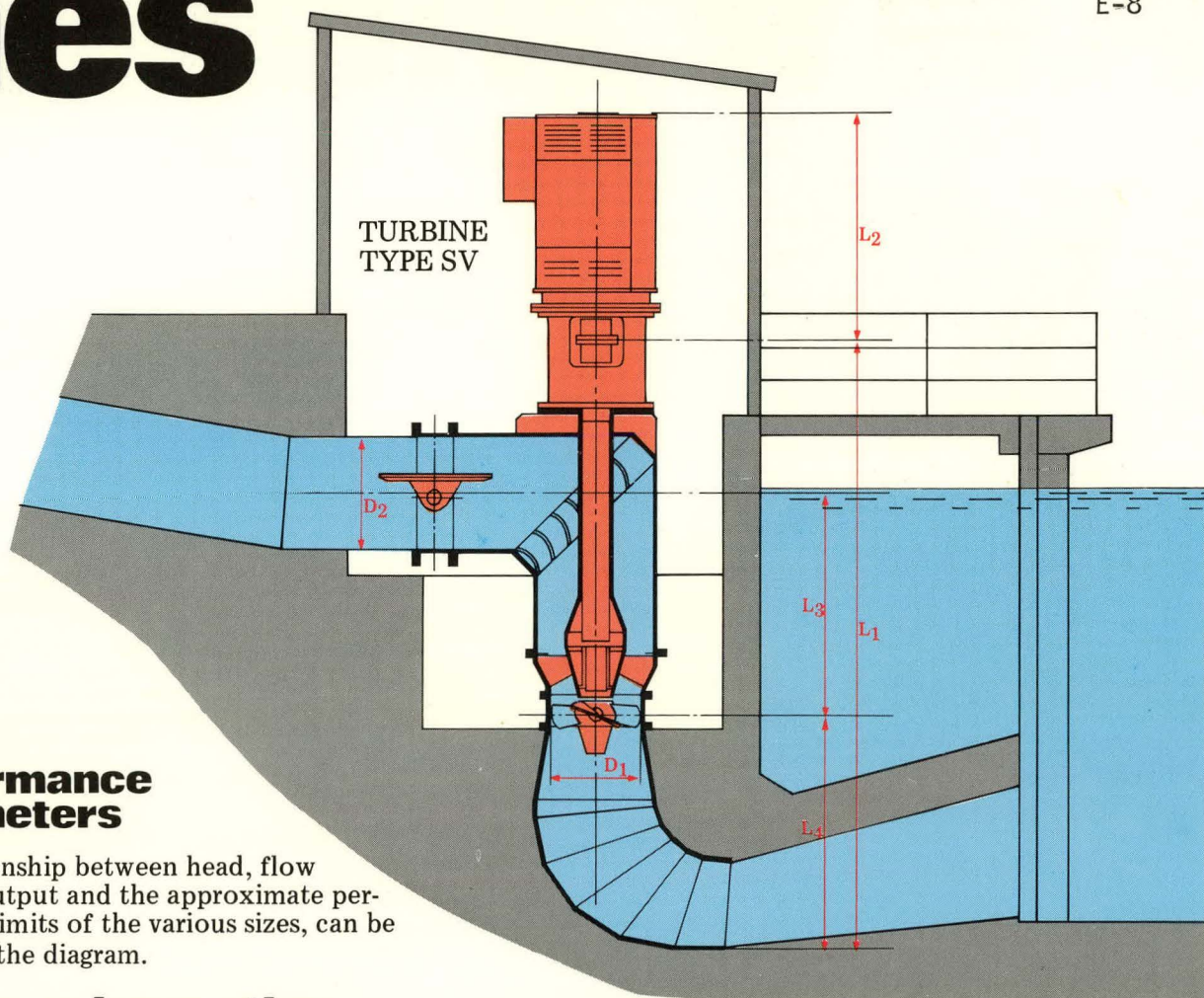
D₁ = runner diameter. The measurement L₂ varies according to the output of the generator and to whether or not gearing is included. Subject to alteration without prior notice.

Turbines of other shaft alignments than those shown, and of other designs and dimensions, are in the course of development.

Dimensions and types

KMW is now offering standard turbines with runner diameters from 0.7 m (27 1/2") to 1.5 m (59") in both a horizontal and a vertical version (types SH and SV respectively). Please see the illustrations and the table.





Performance parameters

The relationship between head, flow rate and output and the approximate performance limits of the various sizes, can be seen from the diagram.

Design and operation

The main components of the mini-turbine unit are the turbine and shut-off valve, the generator and, where required, the gearing.

The availability of either horizontal or vertical versions means that it is to a large extent possible to use existing buildings from older power stations. Standardized design reduces the cost of the turbine, as foundry patterns and production tools can be used for a large number of units.

Matching the runner and guide vane angles to the particular flow rate gives a high efficiency even though the turbine is not "tailor made" for the installation.

The runner vanes are made from stainless steel or nickel-aluminium bronze castings and the runner chamber is of stainless steel.

The shaft bearing nearest to the runner is a water-lubricated rubber bearing and at the opposite end is an oil-lubricated combined thrust and radial bearing, designed to take up the axial load of the turbine.

The combined thrust and radial bearing can in certain cases be built into the gearing, where this is required for the installation concerned.

The gearing, where included, and the oil-lubricated bearings are dimensioned for a minimum service life of 100,000 hours of operation.

The turbines are pre-assembled at the works as far as transport and handling considerations will allow. Assembly time at the site of installations is thus

reduced to a minimum.

The shut-off valve has a replaceable rubber seal, which seals against a seat in the form of a stainless steel ring in the valve body. The valve is opened with the aid of a hydraulic servomotor and closed by means of a closing weight mounted on the valve crank. Where desirable the shut-off valve may be replaced by an automatically controlled sluice gate at the inlet.

The generator is of the asynchronous type and is connected to the existing mains supply via a transformer. The electric grid needs to be powerful enough to permit instantaneous switching on or disconnection of the full power of the unit.

The unit is started by slowly opening the shut-off valve, regulating the speed during the switching-on stage, while the mains supply controls the speed when the unit is running.

The equipment is thus simplified by the fact that no speed regulator is required.

The unit is switched on and off intermittently with the aid of the shut-off valve, which is controlled by level-sensing switches at the inlet.

Operation is therefore fully automatic.

Where the discharge does not permit intermittent operation at full output the runner of the turbine can at an additional price be provided with governor control of the runner blades. In this way the output can be varied continuously between full load and approximately half load.



View of our modern and well-equipped turbine laboratory at Kristinehamn

Project enquiries

To assist us in dealing with your project the following information should if possible be provided at the time of making enquiry:

1. Name and location of the power station and the watercourse
2. Normal head and any variations in the water levels
3. Expected discharge after development
4. Length and diameter of existing or planned penstock
5. Whether partial-load operation is required
6. Lowest level of tail water surface when in operation
7. If the existing power station building is to be used, drawing or sketch of this, giving details of levels and measurements.

History

Water turbines constitute a product line with an old tradition at KMW. The first turbines were built at the Karlstad Works back in the 1870's. When the works at Kristinehamn was incorporated in the company in 1897 turbine manufacture was transferred there. Over the years since that time large numbers of turbines of every conceivable type have been produced at Kristinehamn. Including turbines built under licence from KMW in various countries, there are some 3,700 units with a total capacity of around 35 million kilowatts installed in power stations all over the world.

KMW

T 178-E

★ A MEMBER OF THE AXEL JOHNSON GROUP

AB KARLSTADS MEKANISKA WERKSTAD · KRISTINEHAMN WORKS
FACK · S-681 01 KRISTINEHAMN · SWEDEN · PHONE 0550/152 00 · TELEX 660 50

RECEIVED FEB 9 1979

February 7, 1979

ATTENTION: Mr. Hugh F. Allman

SUBJECT: Brighton Dam
Allis-Chalmers Inquiry No. 6-33349

Gentlemen:

In response to your letter of January 26, 1979, we are pleased to enclose technical information and preliminary prices. We have completed your Information Sheets for the two alternatives as you had requested.

These estimates include the turbine, intake butterfly valve, flexible coupling, 900 RPM synchronous generator, blade positioner and hydraulic power unit as described in our enclosed bulletin. Also included in the estimates are the indoor synchronous generator protection and control panel, outdoor cubicle for metering equipment, high voltage switch and fuse including utility interface, and the power transformer.

We have also enclosed performance curves for the two alternatives. We hope this information is helpful to you. Should you have any questions, please do not hesitate to contact us.

Very truly yours,

Very truly yours,
R C Taylor

R. C. Taylor
Application Technician

RCT/cb

cc: Mr. J. H. Fischer ✓

[illegible]

SUBMITTED BY Allis-Chalmers, Hydro-Turbine Division

P. O. Box 712, York, PA 17405

PROJECT Brighton Dam Hydroelectric Redevelopment DATE 1/26/79

LOCATION Brighton, Maryland.

OWNER Washington Suburban Sanitary Commission

1. PLANT DATA

Rated Plant Output..... 420 kW

Plant Design Flow..... 104 cfs

Rated Net Head 56.2 ft

Range of Net Head - maximum 59.2 ft

- minimum 42.8 ft

Water Levels

Headwater - maximum	E1.	366.5
---------------------	----------	-------

- normalEl. 365

- minimumEl. 350

Tailwater - maximumEl. 320

- normalE1. 306

- minimumEl. 304

Generator - phases/frequency3/60 Hz

- flywheel effectNormal

Other Information

2. TURBINES

2.1 Technical Data

Number of Units.....	One (1)	
Type	750mm standardized TUBE turbine w/adjustable 5-blade	
Rated Power at Full Gate.....		hp
Turbine Efficiency - full gate.....	90	%
- best gate.....	--	%
Synchronous Speed.....		rpm
Runner Diameter.....	750mm (29.53 in.)	in.
Submergence of Centerline of Runner below min. TWL.....	2.13m (7 ft)	ft

2.2 Prices

Turbines and Governors - Supply & Delivery (1 units)..\$311,600
 - Installation (1 units).....\$100,000 (approx.)
 - Delivery (1 units).....\$ 2,500

3. GENERATOR

3.1 Technical Data

Number of Units.....	One (1)	
Type - induction, full overspeed capability		
Rated Power.....	425	kW
Power Factor.....		
Synchronous Speed.....	900	rpm
Recommended Voltage.....	480 (as requested)	KV
Dimensions		
- Outside Diameter of Air Housing.....	NA	in.
- Overall Height (Vertical Units).....		in.
- Overall Length (Horizontal Units).....	NA	in.
Heaviest Lift.....	NA	lb

3.2 Prices

Generators and Exciters - Supply & Delivery (1 Units).\$ NA
- Installation (1 Units).....\$ NA

Generator price is included in turbine package.

SUBMITTED BY Allis-Chalmers, Hydro-Turbine Division

P.O. Box 712, York, PA 17405

PROJECT Brighton Dam Hydroelectric Redevelopment DATE 1/26/79

LOCATION Brighton, Maryland

OWNER Washington Suburban Sanitary Commission

Rated Plant Output.....	440	kW
Plant Design Flow.....	120	cfs
Rated Net Head	50	ft
Range of Net Head - maximum	57	ft
- minimum	36	ft

Levels		
Headwater	- maximum	E1. 366.5
	- normal	E1. 365
	- minimum	E1. 350
Tailwater	- maximum	E1. 320
	- normal	E1. 306
	- minimum	E1. 304

Generator - phases/frequency3/60 Hz

- flywheel effectNormal

Other Information

Turbines and Governors - Supply (1 units).. \$354,000
- Installation (1 units).....\$100,000 (approx.)

3. GENERATOR

3.1 Technical Data

Number of Units..... one (1)

Type - synchronous, full overspeed capability

Rated Power..... 450 kW

Power Factor..... .9

Synchronous Speed..... 900 rpm

Recommended Voltage..... .480 KV
(as requested)

Dimensions

- Outside Diameter of Air Housing..... NA in.

- Overall Height (Vertical Units)..... NA in.

- Overall Length (Horizontal Units)..... NA in.

Heaviest Lift..... NA lb

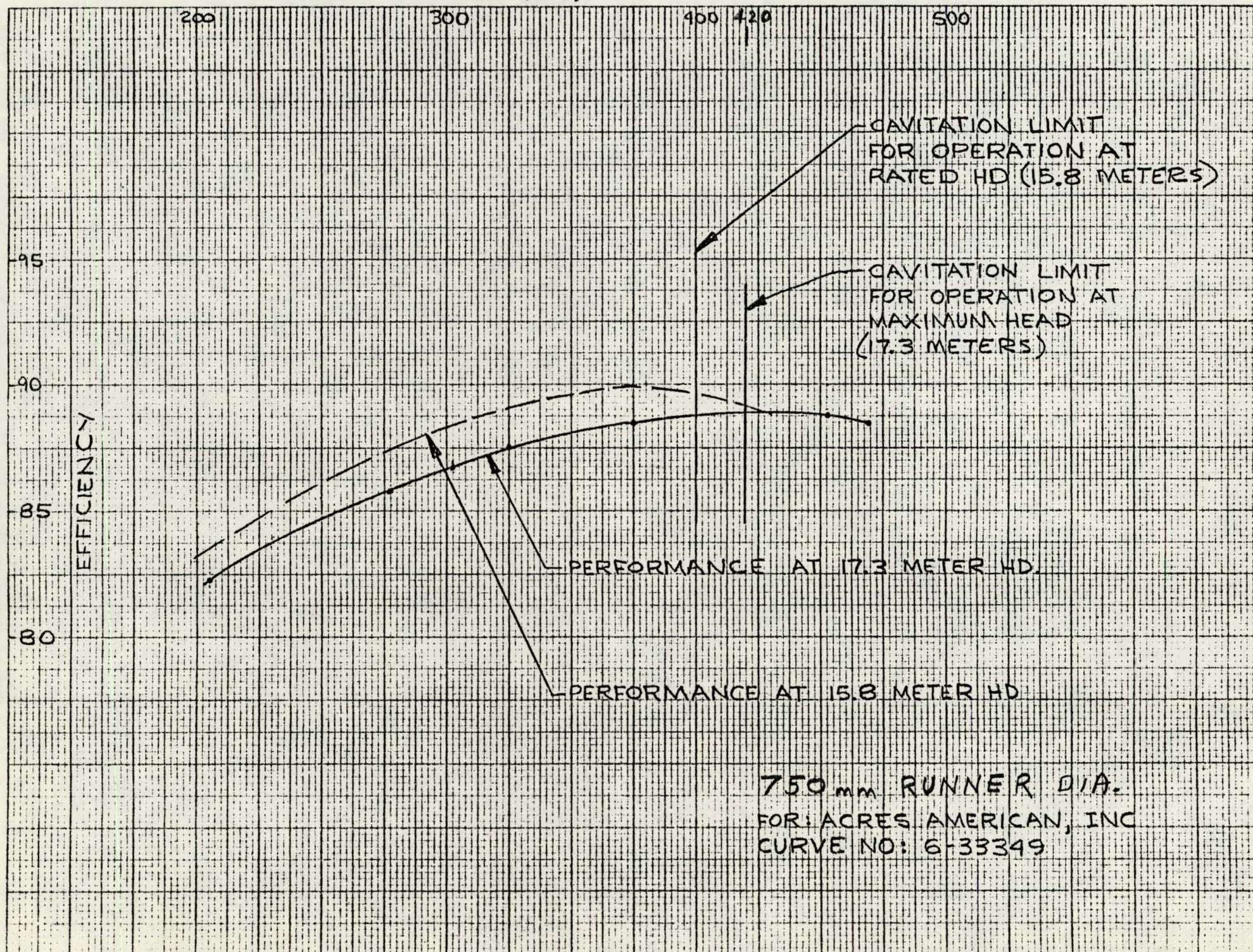
3.2 Prices

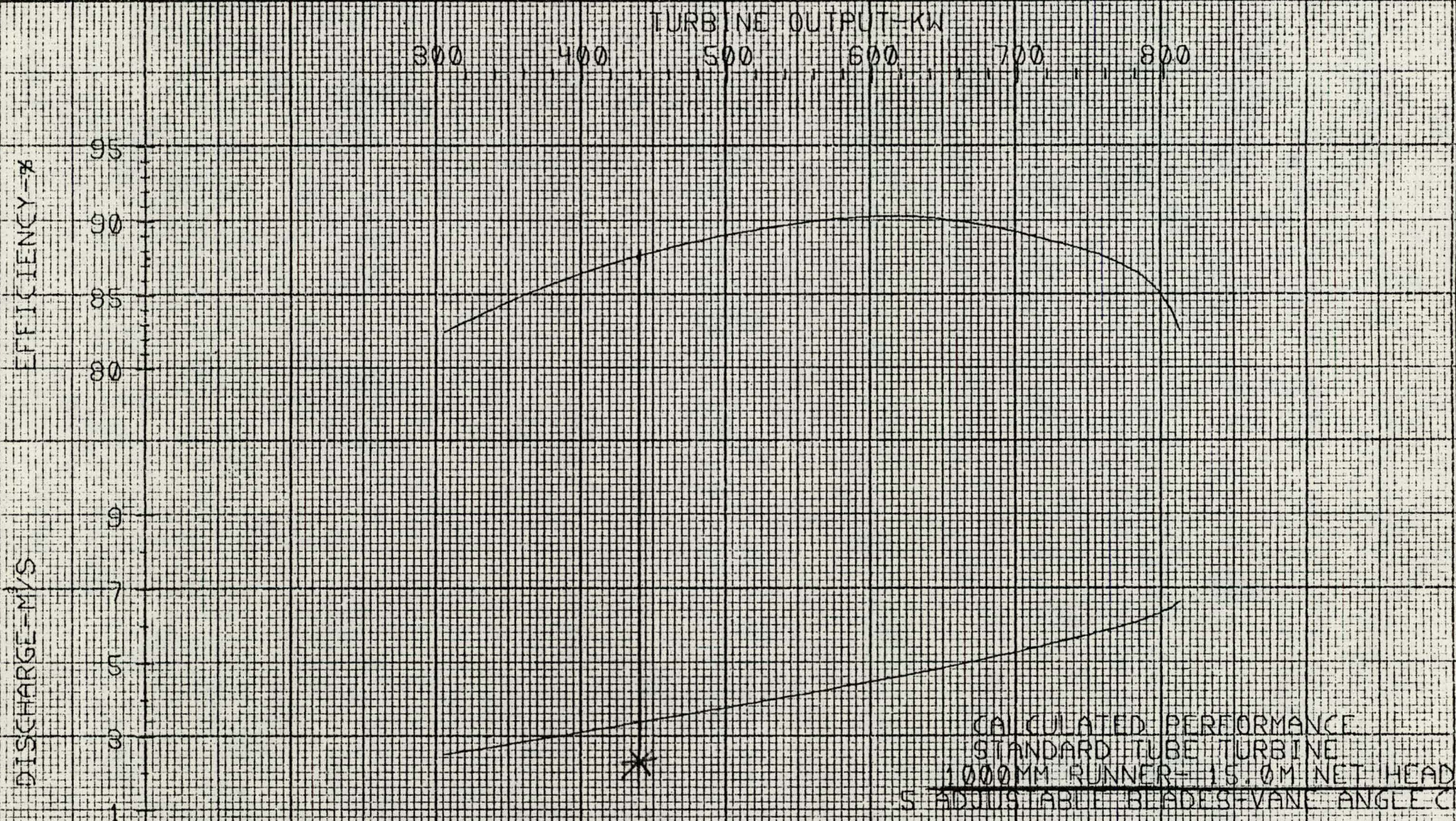
Generators and Exciters - Supply & Delivery (1 Units). \$ NA

- Installation (1 Units)..... \$ NA

Generator and exciter prices are included in turbine package.

TURBINE OUTPUT (KW)





*OUTPUT LIMIT - WITH UNIT
 CENTERLINE SETTING AT 3.96
 METERS TO MINIMUM TAILWATER

FOR: ACRES AMERICAN, INC

BY: ALLIS-CHALMERS CORPORATION
 HYDRO-TURBINE DIVISION

CURVE NO: 6-33349

RECEIVED FEB 5 1979

— OUR 116th ANNIVERSARY YEAR —

THE JAMES LEFFEL & CO.

MANUFACTURERS OF

HYDRAULIC TURBINES**SCOTCH BOILERS-STOKERS****SPRINGFIELD, OHIO, U.S.A.****45501**

J G W
CABLE ADDRESS
"LEFFEL SPRINGFIELD OHIO"

TELEPHONE 323-6431
J AREA CODE 513

ALL CONTRACTS AND AGREEMENTS ARE CONTINGENT UPON STRIKES, ACCIDENTS OR OTHER CAUSES BEYOND OUR CONTROL, AND SUBJECT TO APPROVAL AT THE HOME OFFICE AT SPRINGFIELD, OHIO.
ALL QUOTATIONS F.O.B. FACTORY, SPRINGFIELD, OHIO, UNLESS OTHERWISE STATED, AND ARE FOR PROMPT ACCEPTANCE ONLY.
ALL RIGHTS RESERVED TO CORRECT ERRORS ON QUOTATIONS OR ANY OTHER MATTER HEREIN.

February 2, 1979

* AIR MAIL *

ACRES AMERICAN INCORPORATED
Consulting Engineers
Suite 329, The Clark Building
Columbia, Maryland 21044

Attention: Mr. Hugh F. Allman
Senior Mechanical Engineer

Subject: Leffel W79-221
BRIGHTON DAM HYDROELECTRIC
REDEVELOPMENT FEASIBILITY STUDY
Your: #P5157.18

Dear Mr. Allman:

Referring further to the letter you sent to us on January 26 and please also refer to Mr. Groff's letter of January 30, we note that you are engaged by the Washington Suburban Sanitary Commissions to investigate the feasibility of redeveloping the powerhouse at their BRIGHTON DAM and that the feasibility report will be submitted to the US Department of Energy under their PRDA program.

We note the comments you have made further in reference to the Hydraulic conditions you have available at this BRIGHTON DAM development and referring to page 2 of your letter, you want us to figure on turbine looking at two basic alternatives.

We will refer to each of these alternates as Proposition #1 and Proposition #2 and we plan on giving you the necessary engineering information and quote you on turbine equipment which you have requested under these two propositions.

With your letter we also received drawing #SK5157 B-001, Project P5157.00 which was made up by Acres and we have made a careful study of what can be done in reference to turbine equipment that could be installed in this present powerhouse.

PROPOSITION #1

Referring to you letter page 2, you are interested in two identical units rating at approximately 270 KW with the turbines connected to the existing penstock or some slight modifications if this would be required.

ACRES AMERICAN INCORPORATED

-2-

W79-221

We note that you have a net effective head available of 50' and you refer to a flow of 130 CFS. You want two units - each driving a 270 KW generator which requires a turbine to have an output of 405 HP. Based on the hydraulic conditions you have available of 50' net effective head and 130 CFS, a turbine operating under these hydraulic conditions would have an output of approximately 627 HP.

If you want two turbines, each would have a rating of 313.5 HP based on the hydraulic conditions you refer to.

We have made a careful study of the drawing that you sent to us and using the present draft tube that is now in place and also using a spiral casing with an inlet diameter of 30" this rather restricts us to the power obtained from turbines under these diameters as indicated on your drawing.

We can furnish a horizontal spiral case turbine unit with an inlet diameter of 30" which could be connected to the 30" diameter elbow which is shown on your drawing.

We note that you have a 30" inlet valve and the spiral casing could be connected to this 30" diameter inlet valve. However, we are hoping that that valve is a gate valve and not a butterfly valve since a butterfly valve would more or less restrict the area somewhat due to the area taken up by the butterfly valve disk. However, we are neglecting and not considering the butterfly valve you have shown on the drawing.

We can furnish a Leffel type "Z" horizontal spiral case turbine unit. The inlet to the spiral casing being 30" in diameter.

The performance of this turbine would be as follows when operating at a speed of 720 RPM under a net effective head of 50'.

% Load	720 RPM	50' Net Head	
	Horsepower	Exp. Efficiency	Exp. CFS
1.00	340	82.7	72.5 ✓
95	323	90.0	86.4 63.3
90	306	89.2	60.5
80	272	85.4	56.2
70	238	81.0	51.8
60	204	77.0	46.7
50	170	72.8	41.2

Please note that the maximum horsepower, as indicated, would only be 340 HP or a total of 680 HP for two units in operation. We could furnish you with somewhat larger turbine but the inlet diameter of 30" of the spiral casing restrict the horsepower rating also the diameter of the top of the draft tube would kind of restrict the output.

ACRES AMERICAN INCORPORATED

-3-

W79-221

We could install a larger unit but this would mean larger draft tube diameter at the top of the draft tube and also a larger penstock. However, since you say that you want approximate output, we have taken for granted that this will be satisfactory. As stated, this unit can be fitted into the pipeline and the draft tube you have available.

The maximum runaway speed will be 1200 RPM.

The hydraulic thrust setup by the turbine runner will be 6420 pounds. This would be taken on the turbine bearing and no end thrust would be communicated to the generator bearings since this is the horizontal spiral case turbine unit.

The governor effort to operate the turbine gates would be 1920 FT LB.

As stated above, the spiral casing would be 30" in diameter.

We are, herewith, enclosing Photograph L-556 showing a similar design of turbine. Also, Photograph L-797 is enclosed.

The unit would be furnished with semi-steel spiral casing, outside type gate mechanism, runner made of cast steel, gates made of cast steel, semi-steel discharge elbow. We plan on using the present draft tube.

The unit would also be furnished with shafting and self-oiled lubricated bearing - water cooled.

For this turbine, as referred to above, approximate price:

Price - - - - -	\$98,000.00 f.o.b. factory
	Springfield, Ohio - for 1
Gross shipping weight - - -	30,000 pounds - for 1

If a governor would be required for this turbine, we can furnish a Woodward type UG governor, price approximately:

Price - - - - -	\$15,000.00 f.o.b. factory
	Springfield, Ohio - for 1
Gross shipping weight - - -	1200 pounds - for 1

We are also enclosing Sheet 1089E, please refer to installation #5.

Please bear in mind that the price quoted above does not include the vertical conical plate steel draft tube.

ACRES AMERICAN INCORPORATED

-4-

W79-221

PROPOSITION #2

Referring to Proposition #2, in your letter you state that you would like a turbine driving a generator which would have an output of 500 KW plus a small unit which would drive a 35 KW generator since the minimum flow which has to be discharged continuously the discharge would be 7-1/2 CFS.

Referring to the large capacity turbine and based on the flow conditions and the head, which you refer to as 50' net head and 130 CFS, a turbine operating under these conditions would have an output of 627 HP.

You state that you had to rearrange the piping valves and draft tube and alter major changes of the powerhouse to install one large capacity turbine unit.

You refer to the turbine driving a 500 KW generator which means that the turbine would have a rating of 750 HP.

Since you are making major changes to the powerhouse, we are considering installing a Leffel style 24 turbine instead of a spiral casing which will reduce the cost of the turbine and we refer you to sheet 1089E, please refer to installation 15.

The intake to the pressure case could be made as shown on installation 15 and the piping available could be connected to the pressure case.

We are also enclosing Photograph L-619 showing a similar setup and design of unit.

The performance of this larger capacity turbine unit will be as follows when operating at a speed of 360 RPM under a net effective head of 50'.

% Load	360 RPM	50' net head	
	Horsepower	Exp. Efficiency	Exp. CFS
1.00	750	84.1	157
95	712	89.6	142
90	675	90.2	132
80	600	88.1	120
70	525	86.0	107.7
60	450	83.5	95.4
50	375	81.0	81.7

The maximum runaway speed would be 607 RPM.

ACRES AMERICAN INCORPORATED

-5-

W79-221

The hydraulic thrust setup by the turbine runner will be 8160 pounds.

The turbine would be furnished with its own radial and thrust bearing and the thrust bearing would take care of this hydraulic thrust and no end thrust would be communicated to the generator bearings.

The governor effort to operate the turbine gates would be 4,240 FT LB.

The steel pressure case will be 9' in diameter and the inlet approximately 6' 6" in diameter. Perhaps the two pipes coming into the powerhouse could be connected by means of an Y branch and connect rightdirect to the pressure case.

This unit would be furnished with submerged type of gate mechanism - the operating mechanism inside the case would be connected by means of levers and links to a gate shaft which would extend outside the pressure case for connection to governing equipment.

The turbine would be furnished with a quarter turn elbow made of semi steel and a new vertical conical plate steel draft tube of ample length for proper submergence into the tail water. Complete shafting will be furnished as well as self-oil lubricated radial and thrust bearing. The shafting will be furnished with a forged flange for direct connection to a generator forged flange coupling.

For this complete turbine unit, price approximately:

Price - - - - - \$135,000.00 f.o.b. factory
Springfield, Ohio
Gross shipping weight - - 50,000 pounds (approximate)

If a governor would be required, we can furnish a Woodward UG governor, price approximately:

Price - - - - - \$15,000.00 f.o.b. factory
Springfield, Ohio
Gross shipping weight - - 1200 pounds

We believe that the above will meet with your requirements under Proposition #2

Referring now to the small turbine, that you refer to in your letter, that you have to pass a minimum compensation flow of 7-1/2 CFS which must be discharged continuously at all times. We note that you refer to a small turbine driving a 35 KW generator.

ACRES AMERICAN INCORPORATED

-6-

W79-221

With this larger capacity turbine, we can furnish a Leffel style 7 unit and we are, herewith, enclosing Photograph L-1695 showing this type of turbine.

Referring to a turbine driving a 35 KW generator, the unit would have a rating in the neighborhood of 53 HP. However, if you refer to a flow of 7-1/2 CFS and a net head of 50' a turbine operating under these hydraulic conditions would only have a rating of 35 HP.

We have this style 7 turbine unit all developed and designed and we believe that this would meet with your requirements.

This turbine, as shown on the photograph, will have a rating of 40 HP operating under a net head of 50' at a speed of 900 RPM and require a maximum quantity of water of 8.6 CFS. At 35 HP, this unit would discharge approximately 7-1/2 CFS.

The maximum runaway speed will be 1630 RPM. The governor effort to operate the turbine gates will be 226 FT.LB.

The inlet to the pressure case would be 18" in diameter.

The unit would be very similar to that shown on photograph and we are also enclosing and referring you to sheet 1089E, please refer to installation 10 or 17.

The turbine would be furnished with wicket gates, submerged type of gate mechanism - this mechanism is connected by means of levers and links to the turbine gate shaft which would extend outside the pressure case and would be connected by means of levers and links to governor equipment if this would be required.

The unit would be furnished with discharge elbow and also vertical conical plate steel draft tube.

The bearings would be of the ball or roller type design. Shafting would be furnished, however, at this time, we are not quoting on a fly wheel as shown on the photograph.

For this complete turbine unit, without generator or governing equipment, approximate price:

Price - - - - - \$24,500.00 f.o.b. factory
Springfield, Ohio

Gross shipping weight - 2900 pounds (approximate)

If a governor would be required, we could furnish a Woodward UG governor with ample capacity to operate the turbine gates.

Price - - - - - \$12,000.00 f.o.b. factory
Springfield, Ohio

Gross shipping weight - 1,000 pounds

ACRES AMERICAN INCORPORATED

-7-

W79-221

We are hoping that you can obtain prices on the generator equipment locally on all of the above equipment referred to.

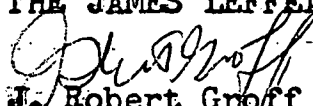
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Referring to Proposition #1 and Proposition #2, we would appreciate your examining the above information we are sending you and quoting on and if you need any further information in reference to our turbine selection, please let us know.

Appreciate hearing from you further in reference to the above.

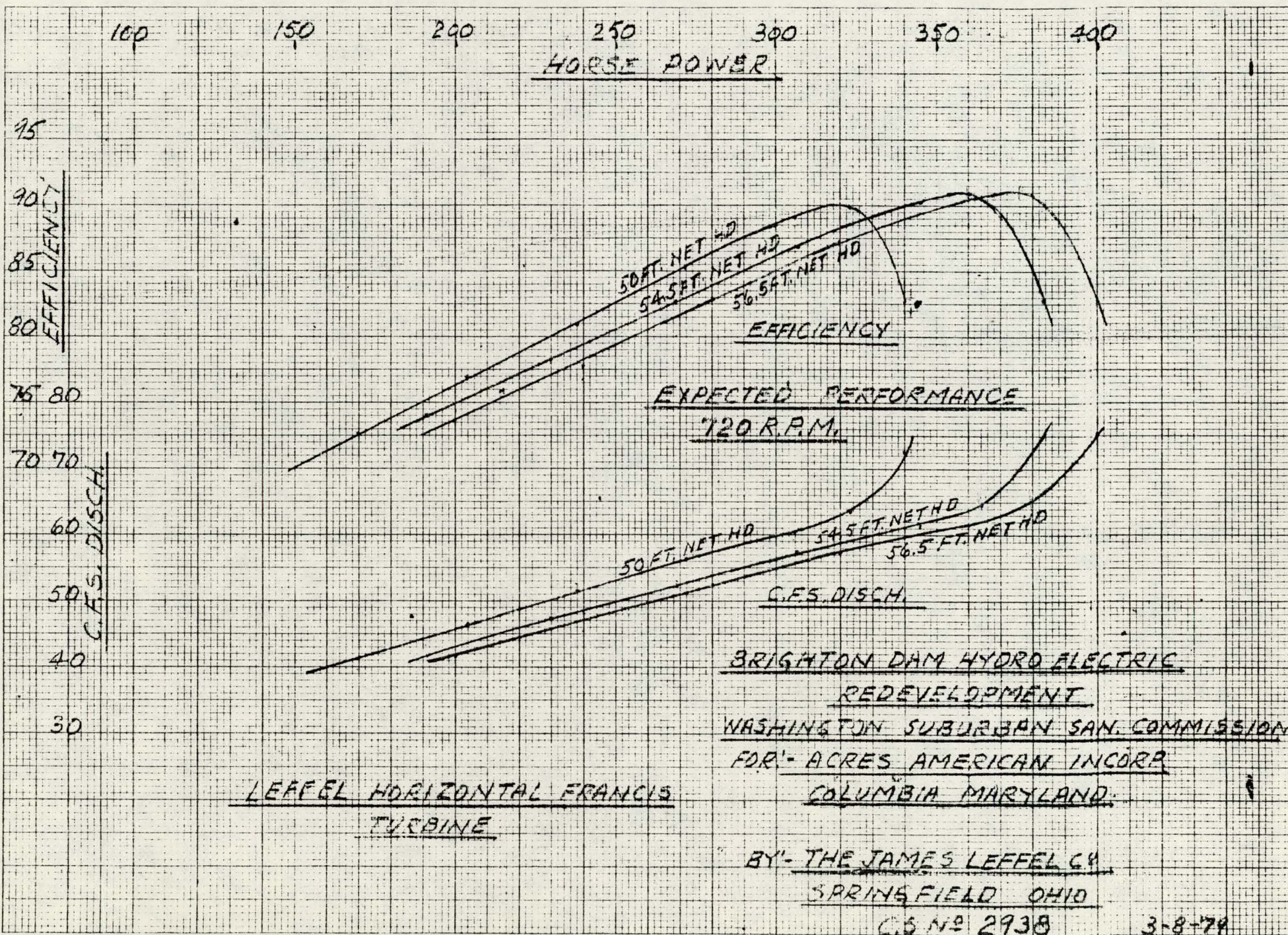
Yours truly,

THE JAMES LEFFEL & COMPANY


J. Robert Groff
President & General Manager

RS:sjs

Enclosures: Sheet 1089E
Photographs L-556, L-619, L-797, & L-1695



RECORD OF TELEPHONE CALL

E-26

JOB NO. P5157.00

FROM (Originator) Mr. F. Kanger

DATE 2/21/79

Company F.W.E. Stapenhorst

FILE NO. .18

TO J. Sangermano

Company AAI

SUBJECT Turbine-Generator Set for Brighton Dam

Budget prices for 500 kW at design head and flow of 50' & 130 c.f.s.

respectively:

Synchronous

\$298,000

Induction

270,000

Package includes:

-Turbine

-Generator

-Speed Increaser

-Governor

-Generator Control Panel

CIRCULATE TO:

	HFA
	LS
	file

western union

Telegram

BRC102(1124)(1-1192946052)PD 02/21/79 1121

RECEIVED FEB 23 1979

ICS IPMIIHA IISS

IISS FM WUI 21 1121

VMS COLUMBIA MD

UWB5999 LBD638 65125 91

UWNX HL GWBD 086

KENDAL CUMBRIA VIA WUI 86/84 21 1557

LT

ALLMAN ACRES AMERICAN INCORPORATED

SUITE 329

THE CLARKE BUILDING

COLUMBIA(MD) 210114

WSSC WATER TURBINE YOUR P5157/18 STOP ONE FRANCIS TURBINE WITH
INDUCTION GENERATOR 440 KW 130 CUSEC 50 FEET TOTAL APPROX BUDGET
130000 EST CIF 7400 STOP TWO FRANCIS TURBINES WITH GENERATORS
220 KW 65 CUSEC 50 FEET EACH TOTAL APPROX BUDGET 71500 EACH EST

SF-1201 (RS-69)

CIF 3900 EACH STOP ONE HYDEC IMPULSE TURBINE WITH GENERATOR 27
KW 7.5 CUSEC 57 FEET TOTAL APPROX BUDGET 25000 EST CIF 1500 STOP
PRICES POUNDS STERLING

WILLIAMS GILKES

COL 329-WSSC P5157/18 440 KW 130 50 130000 7400 220 KW 65 50-
71500 3900 27 KW 7.5 57 25000 1500

NNN

NNNN

992.5300

Mrs. W. Jackson

By 1921a
J. M. M. M.

FOR INTL TELEX DIAL 101 - CABLEGRAMS 6481

CORPORATION

PHONE (212) 248-4025.
(212). 248-9373

cc. Timo Salovaara
Peter von Koskull

QUOTATION

RECEIVED FEB 14 1979
E-30

KATO Engineering

SUBSIDIARY OF RELIANCE ELECTRIC

1415 FIRST AVENUE MANKATO, MINNESOTA, U.S.A. 56001

TELEPHONE: 507-625-4011

Quotation No. GAF 767

TELEX: 29-0786

TVILINI

DISTRIB

TO

FROM

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NO

Date: February 9, 1979

Attention: Joe Sangermano

Your Reference: phone call of 2-7-79

cc. Wilson Associates

We are pleased to quote you the following

ITEM	QUAN.	DESCRIPTION	PRICE NET EACH
1	1	BRUSHLESS REVOLVING FIELD GENERATOR CODE 8P2-0725 35 KW, 43.75 KVA, .8 power factor, 60 hertz, 900 RPM, 3 phase, 480 volts, wye connected, 4 wire, with direct connected brushless rotating exciter, Basler KR4F voltage regulator with +1% regulation with cross current compensation for parallel operation and transformer. The generator will be of the independent two ball bearing type with shaft extension suitable for direct drive. Temperature rise 80°C Duty cycle Continuous Insulation Class F Enclosure Open Dripproof Standard Kato Commercial Test & Documentation NOTE This unit is capable of overspeeds to 1630 RPM.	\$3,615.00 NET EACH
2	1	Same as item #1 except for the following: 75 KW, 93.75 KVA, Code 8P2-1500	\$5,225.00 NET EACH
3	1	BRUSHLESS REVOLVING FIELD GENERATOR CODE 10P5-2000 270 KW, 337.5 KVA, .8 power factor, 60 hertz, 720 RPM, 3 phase, 480 volts, wye connected, 4 wire, with direct connected brushless rotating exciter, Basler SR4 voltage regulator with +1% regulation SHIPMENT: _____ weeks after receipt of formal purchase order.	

Prices are F.O.B. Mankato with freight allowed to first destination in the continental U.S.A. not including Alaska, unless otherwise specified.

TERMS: 1% 15 days; net 30 days subject to credit approval. Quotation firm for 45 days and subject to terms on reverse side.

BY: Continued on page 2

KATO ENGINEERING COMPANY

KATO Engineering

SUBSIDIARY OF RELIANCE ELECTRIC

1415 FIRST AVENUE MANKATO, MINNESOTA, U. S. A. 56001

TELEPHONE: 507-625-4011
TELEX: 29-0786

Quotation No. GAF 767

Date: February 9, 1979

TO Acres American

Attention: _____

Page 2

Your Reference: _____

We are pleased to quote you the following

ITEM	QUAN.	DESCRIPTION	PRICE NET EACH
		Item #3 continued.... with cross current compensation for parallel operation, and transformer. The generator will be of the independent tow ball bearing type with shaft extension suitable for direct drive. Temperatuer rise 80°C Duty cycle Continuous Insulation Class F Enclosure Open Dripproof Standard Kato Commercial Test & Documentation NOTE This unit is capable of overspeeds to 1200 RPM Customer's confirming purchase order must be in our possession before order is released for shop production. Your prompt response in this matter will assist our scheduling the best delivery time possible.	
4	1	Same as item #3 except: 500 KW, 625 KVA, Code 10P6-1900 <i>Roger O. Dalluge</i> Roger O. Dalluge Contract Administrator	\$15,323.00 NET EACH \$20,419.00 NET EACH
PRICES ARE FIRM FOR 45 DAYS AND SUBJECT TO CHANGE THEREAFTER. CONSULT FACTORY FOR AN EXTENSION OF THIS DATE. Estimated delivery #1 18 weeks #2 18 weeks #3 24 weeks #4 36 weeks ARO SHIPMENT: _____ weeks after receipt of formal purchase order.			

RECEIVED FEB 16 1979

QUOTATION FROM

IDEAL ELECTRIC CO.

330 EAST FIRST STREET • MANSFIELD, OHIO 44903 U. S. A.

TELEPHONE (AREA CODE 419) 522-3611 • TELEX 98-7410

TO Acres American
Suite 329
The Clark Building
Columbia, Maryland 21044

Negotiation No. GGSH 791622 ADate February 14, 1979Your Inquiry Phone Request

Attn: Joe Sangermano

Gentlemen:

We are pleased to quote you on the following equipment and materials subject to conditions specified below.

Item #1 - 1 - IDEAL Type "SAB", 625 KVA, 500 KW, 80% P.F., 360 RPM, 3 phase, 60 hertz, 480 volts, 105° C rise by res., continuous duty above a 40° C ambient, Class "F" insulation, horizontal, open dripproof, two bracket, two bearing low speed brushless synchronous generator with damper windings.

1 - IDEAL Type "FRBA", suitable KW, 360 RPM, 105° C rise, Class "F" insulation, horizontal, brushless exciter, direct connected.

1 - Static type voltage regulator system including:

Static type voltage regulator
Voltage adjusting rheostat
Three phase sensing circuitry
Isolation power transformer

TOTAL NET PRICE EACH

Generator, exciter and voltage regulator ... \$54,800.00

Item #2 - 1 - IDEAL Type ATG Squirrel Cage Induction Generator, open dripproof, horizontal, two bearing, 105° C rise by res., cont. duty, 40° C ambient, 500 KW, 480 volts, 3 phase, 60 cycle, 360 SRPM.

To include:

1. Insulation Class F

NET PRICE EACH GENERATOR

... \$50,700.00

Terms:

F. O. B. Mansfield, Ohio

Shipment

Quotations are based on acceptance within 15 days; are subject to change without prior notice and to the approval of an executive officer of the company. Deliveries are contingent upon delays beyond our control.

Respectfully submitted,

THE IDEAL ELECTRIC & MFG. CO.

By _____

GENERAL ELECTRIC

POWER SYSTEMS

SALES OPERATIONS

GENERAL ELECTRIC COMPANY 5565 STERRETT PLACE, COLUMBIA, MD. 21044

March 6, 1979

Mr. J. Sangermano
 Acres American
 5565 Sterrett Place
 Columbia, Maryland 21044

Subject: Brighton Dam Hydroelectric
 Redevelopment Project

Dear Joe:

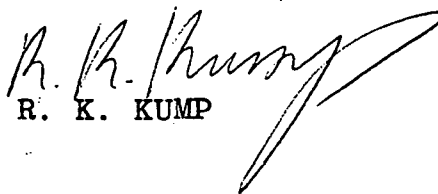
We are pleased to respond to your February 8, 1979 request with the following estimating prices for small horizontal synchronous hydro-generators.

	<u>Rated Capacity</u> (KW)	<u>Generator Rating</u> (KVA)(.8pf)	<u>Est. \$</u> (,000)
1.	35	43.75	15
2.	75	94.	17.5
3.	270	338	22.5
4.	500	625	85

These estimates include rotating SCR exciters and voltages regulators.

If we can be of further assistance, please give me a call.

Very truly yours,


 R. K. KUMP

sn

BALTIMORE GAS AND ELECTRIC COMPANY

Energy Services

RECEIVED
PROJECT MANAGEMENT

MAR 8 1979

March 6, 1979

WASHINGTON SUBURBAN
SANITARY COMMISSION

Mr. Alan L. Will
Project Management Engineer
Washington Suburban Sanitary Commission
4017 Hamilton Street
Hyattsville, Maryland 20781

Dear Mr. Will:

This is to confirm our discussion at the Brighton Dam with your consulting Engineer to discuss the possible installation of a 500 kVa water turbine generator.

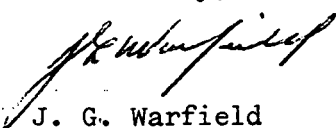
The company is interested and will work with you and your engineer for a satisfactory installation. At the present the company will offer to pay 90% of the P.J.M. (interconnection) running rate with an adjustment for peak hours.

Our electric service to the dam is 277/480 volt secondary service supplied from 3 - 100 kVa pole mounted transformers. The primary line is 4 wire 13.2 kV.

The design of this installation must be compatible with the company's system and must include the necessary "in" and "out" metering, relaying and transformers. Please have your engineer submit his preliminary design to the company for comment prior to final drawings.

Should you desire additional information, kindly contact the undersigned.

Yours truly,


J. G. Warfield
Senior Engineer

JGW/gde

cc: Mr. F. E. Brennan
Mr. C. D. Alvey

Under 17 Attached

APPENDIX F
COMPUTER MODEL PROGRAM



EVALUATION OF HYDRO POTENTIAL BASED ON AVERAGE MONTHLY FLOWS
(FLOOD CONTROL DAMS)

CALLING NAME: BAVMONQ

1 - SUMMARY

This program is designed to aid the engineer in the selection of an installed capacity for a proposed hydroelectric plant with peaking power capability. Given a design flow, required generation time, and plant and site specifications, the program will select an installed capacity based on the wettest month of the year and will produce monthly tabulations of generation flow, reservoir fluctuation, net head, duration of generation, power and energy output, revenue, and capacity factor. An optional cost analysis routine will determine if a gas turbine is necessary to meet peaking demands and will calculate installed and operating costs of both the hydro development and the gas turbine.

2 - INPUT DATA

Data is entered interactively when requested by the program. The following values are needed:

2.1 - Flow data

- (a) Average river flows for January through December (cfs)
- (b) Index of the wettest month (e.g. April = 4).

2.2 - Plant type information

- (a) With or without penstock
- (b) Penstock length (ft)
- (c) Penstock velocity (ft/sec)

2.3 - Equipment data

- (a) Number of units
- (b) Type of unit

2.4 - Revenue projections

- (a) Marketable power prices (\$/kW-month)
- (b) Marketable energy prices (mills/kWh)

2.5 - Site specifications

- (a) Pondage per foot (cu.ft/ft)
- (b) Channel invert (ft)
- (c) Rise in tailwater level per cfs of downstream flow (ft/cfs)
- (d) Initial monthly reservoir levels (ft)
- (e) Monthly maintenance flow (cfs)

2.6 - Generation requirements

- (a) Minimum generation time (hrs.)
- (b) Maximum generation flow (cfs)

2.7 - Additional input for calculation of the cost of peaking with a gas turbine

- (a) Maximum peaking power demands for January through December (kW)
- (b) Maximum peaking energy demands for January through December (kWh)
- (c) Monthly interest rate (%)
- (d) Capital cost of the hydro development excluding the power plant (\$)
- (e) Cost of the power plant (\$/kW installed capacity)
- (f) Cost of gas turbine generation (\$/kW - month)
- (g) Cost of energy production by the gas turbine (mills/kWh)

3 - RESTRICTIONS AND ASSUMPTIONS

3.1 - Flow data

Monthly flows should be entered in sequence, beginning with January, and separated by commas. This applies in all cases throughout the program when a series of numbers for twelve months is requested. The index of the wettest month is the integer referring to that month, for example, if March is the wettest month, "3" is the correct entry. A month is assumed to consist of 30.4 days.

3.2 - Plant type information

If no penstock is specified, head losses through the plant are assumed to equal one foot. If a penstock length and velocity are entered, penstock

diameter is calculated based on the input velocity and design flow. For a penstock of length l and diameter d ,

$$h_L = \frac{l}{1000} K_s \frac{v^{1.9}}{d^{1.1}}$$

where $K_s = .33$ for a steel penstock

3.3 - Equipment

It is possible to select four types of turbines for this program: Kaplan (double regulated), Kaplan (single regulated), Francis, and fixed blade propeller. There is no restriction on the number of units but they must all be of the same type. No turbine will operate below an arbitrary limit set by the program. These limits expressed as a percentage of full gate flow are as follows:

Kaplan (double regulated).....	30%
Kaplan (single regulated).....	45%
Francis.....	50%
Fixed blade propeller.....	70%

The efficiency curves for each turbine are shown on page F-6. Generator efficiency is assumed to be 95%. The units will operate according to the following restrictions:

- (a) For monthly generation times greater than eight hours, a maximum number of units will run at full gate flow and a single unit will use the remaining water. This unit will not operate, however, if its supply is below the limit shown above.
- (b) For monthly generation times less than eight hours, a maximum number of units will operate at best gate flow and a single unit will use the remaining water.

3.4 - Revenue projections

Marketable power and energy values are needed for each month. The user should note that the demand value is in dollars per kW-month.

3.5 - Site specifications

Pondage per foot represents the increase in reservoir storage in cubic feet obtained with an increase in elevation of one foot.

Channel invert (C_{inv}) and rise in tailwater elevation per cfs of downstream flow (generation flow + flow over the dam, T) should be chosen such that $C_{inv} + (T \cdot Q)$ will equal the tailwater elevation for flow Q .

Initial monthly reservoir levels should reflect any losses in addition to those incurred in the plant. The monthly maintenance flow is the minimum required downstream flow at all times during that month.

3.6 - Generation requirements

The maximum generation flow will be used to determine plant capacity. The program will attempt to maintain this flow or the corresponding 88% flow (best gate, see restriction 3.3) in each month. However, generation time will always remain above the minimum specified duration even at the expense of reduced generation flow.

3.7 - General Notes

There is no required format for any data entry. Internal commas, however, may not be used (for example, 2914.3 not 2,914.3). Any data may be entered in exponential form (for example 2.914E3; where "E" represents the base 10).

4 - METHOD OF SOLUTION

Generation times are first determined as explained in the previous section. Reservoir fluctuations are calculated next. The maximum reservoir level represents the average of initial reservoir levels of the month in question and the month immediately following. The minimum level reflects any draw-down which may occur during the day. Average level is the mean of the maximum and minimum.

Tailwater levels are calculated utilizing the channel invert and foot per cfs rise, as explained in Section 3.5. Net head is equal to the average reservoir level minus tailwater elevation and plant losses (excl. turbine).

The plant is rated according to the generation flow and net head in the wettest month. After the plant is rated, power and energy production, capacity factors and revenues are determined for each month.

In the calculation of hydro-gas turbine costs, an installed capacity for the gas turbine based on the maximum monthly demand deficit will be selected. The capital cost of the hydroelectric development per month is the interest charge on the sum of the capital cost of development excluding the power plant and the cost of the installed capacity. The monthly cost of gas turbine generation and gas turbine energy production are calculated based on the input values of capital cost and energy cost and the calculated installed gas turbine capacity and monthly energy demand deficit.

5 - PROGRAM STRUCTURE

The program is divided into input, output, and calculation sections. A subroutine is used to locate flow percentages on the turbine efficiency curves and determine the corresponding efficiencies by linear interpolation.

EVALUATION OF HYDRO POTENTIAL BASED ON AVERAGE MONTHLY FLOWS
(SITE NOT USED FOR FLOOD CONTROL)

CALLING NAME: BLOWELL

1 - SUMMARY

This program is a variation of the evaluation of hydro potential program already described (page F-1) for sites not being used for flood control. Its differences will be given here. Anything not specifically mentioned should be assumed identical to BAVMONQ.

2 - INPUT DATA

The index of the wettest month is not required.

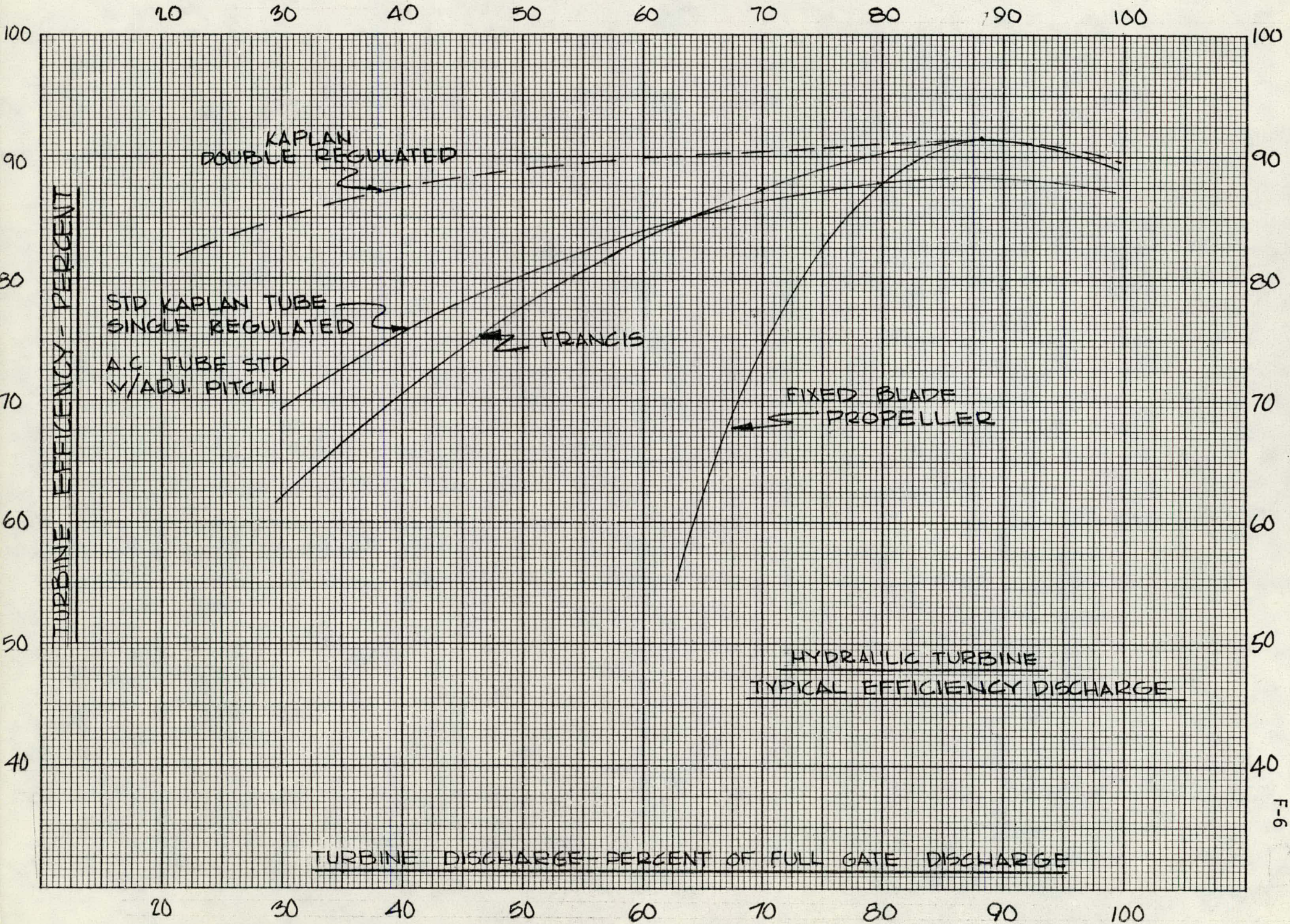
3 - RESTRICTIONS AND ASSUMPTIONS

3.1 - Equipment

Turbine efficiency curves are shown on page F-6. When river flow exceeds best gate flow, a maximum number of units will run at full gate. When river flow is less than best gate unit flow, units will operate at best gate.

4 - METHOD OF SOLUTION

Maximum monthly reservoir levels are equal to initial monthly reservoir levels. The units are rated according to the month with the largest combination full-gate flow and maximum head. Maximum head is calculated with maximum reservoir levels instead of average reservoir levels.



6 - SAMPLE RUN6.1 - Input

ENTER 12 FLOW VALUES, JAN.-DEC.
? 4600,4774,5658,5976,5668,4194,2684,2284,2322,2804,4004,4632.
PLANT TYPE? 1=WITH PENSTOCK,2=WITHOUT PENSTOCK
? 2
NUMBER OF UNITS?
? 2
TYPE OF UNIT? 1=KAPLAN,2=KAPLAN WITHOUT WICKET GATES,
3=FRANCIS,4=FIXED BLADE PROPELLER
? 4
MARKETABLE POWER PRICES, \$/KW, JAN.-DEC.?
? 5.83,5.83,5.83,5.83,5.83,5.83,5.83,5.83,5.83,5.83,5.83,5.83
MARKETABLE ENERGY PRICES, MILLS/KWH, JAN.-DEC.?
? 28,28,28,28,28,28,28,28,28,28,28,28.
RISE IN RESERVOIR VOLUME/FT RESERVOIR LEVEL?
? 29140000.
CHANNEL INVERT, RISE IN TW/CFS GEN. FLOW?
? 49, .00025
MINIMUM GENERATION TIME?
? 8.
INITIAL MONTHLY RESERVOIR LEVELS, JAN.-DEC., FT?
? 80.4,81.6,81.6,81.6,80.4,85,85,85,85,85,85,85.
MONTHLY MAINTENANCE FLOWS, JAN-DEC, CFS?
? 500,500,500,500,500,500,500,500,500,500,500,500.
MAXIMUM GENERATION FLOW, CFS?
? 6000.

6.2 - Output

NUMBER OF UNITS=2
 FULL GATE FLOW= 3000. CFS
 BEST GATE FLOW= 2640. CFS
 RATED HEAD= 33.7 FT
 FULL GATE POWER= 7158. KW
 BEST GATE POWER= 6514. KW
 MINIMUM GENERATION TIME= 8.0 HRS
 MONTH USED FOR UNIT RATING = JUNE
 FIXED BLADE PROPELLER TURBINES
 NO PENSTOCK

MONTH	AVG FLOW(CFS)	GEN FLOW(CFS)	INITIAL	RESERVOIR LEVEL (FT)			
				AVERAGE	AV MAX	AV MIN	TW(FT)
JANUARY	4600.	5280.	80.4	79.5	80.4	78.7	50.3
FEBRUARY	4774.	5280.	81.6	80.9	81.6	80.3	50.3
MARCH	5658.	6000.	81.6	81.1	81.6	80.6	50.5
APRIL	5976.	6000.	81.6	81.6	81.6	81.5	50.5
MAY	5668.	6000.	80.4	79.9	80.4	79.5	50.5
JUNE	4194.	5280.	85.0	83.8	85.0	82.5	50.3
JULY	2684.	5280.	85.0	83.2	85.0	81.5	50.3
AUGUST	2284.	5280.	85.0	83.3	85.0	81.7	50.3
SEPTEMBER	2322.	5280.	85.0	83.3	85.0	81.7	50.3
OCTOBER	2804.	5280.	85.0	83.2	85.0	81.5	50.3
NOVEMBER	4004.	5280.	85.0	83.6	85.0	82.2	50.3
DECEMBER	4632.	5280.	85.0	84.2	85.0	83.3	50.3

MONTH	GEN TIME(HR)	POWER(KW)	ENERGY(KWH)	CAPACITY FACTOR	HEAD(FT)
JANUARY	20.6	10914.	6834163.	65.39	28.2
FEBRUARY	21.5	11454.	7476163.	71.53	29.6
MARCH	22.5	12593.	8621305.	82.49	29.6
APRIL	23.9	12780.	9288786.	88.88	30.1
MAY	22.6	12088.	8291912.	79.34	28.4
JUNE	18.5	12547.	7078448.	67.73	32.4
JULY	11.0	12348.	4118638.	39.41	31.9
AUGUST	9.0	12387.	3374925.	32.29	32.0
SEPTEMBER	9.1	12382.	3445323.	32.97	32.0
OCTOBER	11.6	12344.	4343457.	41.56	31.9
NOVEMBER	17.6	12492.	6684874.	63.96	32.3
DECEMBER	20.7	12707.	8018750.	76.72	32.8

6.2 - Output Continued:

MONTH	POWER VALUE(\$/KW)	POWER REV(\$)	EN VALUE(MILLS/KWH)	ENERGY REV(\$)
JANUARY	5.83	63631.23	28.00	191356.58
FEBRUARY	5.83	66774.88	28.00	209332.57
MARCH	5.83	73416.77	28.00	241396.54
APRIL	5.83	74507.36	28.00	260086.01
MAY	5.83	70475.12	28.00	232173.54
JUNE	5.83	73149.27	28.00	198196.54
JULY	5.83	71989.61	28.00	115321.86
AUGUST	5.83	72216.78	28.00	94497.91
SEPTEMBER	5.83	72185.58	28.00	96469.06
OCTOBER	5.83	71965.10	28.00	121616.80
NOVEMBER	5.83	72827.93	28.00	187176.47
DECEMBER	5.83	74082.43	28.00	224525.00

TOTAL ENERGY= 77576745. KWH

TOTAL CAPACITY REVENUE=\$ 857222.

TOTAL ENERGY REVENUE=\$ 2172149.

TOTAL REVENUE=\$ 3029371.

PLANT CAPACITY FACTOR= 61.86 %