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MASTER

FEASIBILITY STUDY
CANTON HYDROELECTRIC PROJECT
FINAL REPORT — VOLUME 1

Prepared for the
Town of Canton, Connecticut
June 1979
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and the Town of Canton

DEVELOPMENT AND RESOURCES CORPORATION
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CANTON HYDROELECTRIC PROJECT
FEASIBILITY STUDY

FINAL REPORT

VOLUME I

JUNE 1979

SUMMARY AND CONCLUSIONS

The Canton Hydroelectric Project study was undertaken to determine the feasibility of redeveloping hydroelectric power generation facilities at the Upper and Lower Dams on the Farmington River at Collinsville, Connecticut.

The integrity of the existing dams and power plants was investigated and found to be generally adequate. The intake channels, powerhouses and tailraces will require refurbishing but no major repairs. The Lower Dam will require some repair to correct surface deterioration conditions. New flashboard installations are contemplated for both the dams. Some of the project alternatives require expansion of the existing powerhouses.

Energy production operational studies were performed on 25 generating unit alternatives for the two sites. Detailed cost estimates were prepared for seven Upper and five Lower site alternatives, and a detailed economic analysis of ten project alternatives was performed. Included were seven alternatives for developing both sites and three alternatives for developing the Upper site only. Installed project capacities ranged from 530 to 2730 kilowatts with energy production in the first year of service ranging between 3.33 and 10.33 million kilowatt hours. A detailed discussion and results of the capacity and production studies are contained in Section IV of this report.

The project analysis included consideration of future increased flow diversions from the Farmington River by the Metropolitan District of Hartford. These diversions will result in reductions of project energy production of around 15 percent at the end of the 40-year project life.

To accommodate the State of Connecticut's Farmington River Atlantic Salmon Program, fish facilities consisting of fishways for upstream migrants and a louver screen and bypass system for downstream migrants were provided. The fish facilities costs allocatable to the power project are approximately $316,000 for the Upper site and $361,000 for the Lower site and represent between 16 and 36 percent of the total project construction costs.

Three power marketing options were analyzed:

1. Direct sale of all power to Northeast Utilities (NU).
2. Distribution of project power to seven Town of Canton facilities, with surplus sold to NU and backup provided by NU.
3. Distribution of project power to the Town facilities, with a diesel-generating unit backup and sale of the surplus to NU.

The economic analysis included an assessment of the project feasibility sensitivity with respect to the initial and future escalation of the value of energy.

Based on a 1981 to 1983 construction period with a 40-year project life and an interest rate of seven percent, project bonds of between 1.0 and 4.9 million dollars will be required. With 1979 energy values of 2.2 cents for Option 1 and 2.0 cents for Options 2 and 3, a cost inflation rate of six percent, and an energy value escalation rate of eight percent the project benefit-cost ratios were found to range from 1.4 to 1.9. The benefit-cost ratios for Options 1 and 3 are approximately equal while Option 2 was found to be less feasible. It should be noted that Option 3 will require higher initial funding and will be susceptiblo to the negative effect of fuel price escalation when compared with Option 1. Based on uniform bond amortization and inflation rates, all alternatives and options were found to have a negative cash flow during the early years of operation. The results of the project economic analysis are discussed in Section V and summarized on Tables V-20 through V-23 and on Figure V-5 in this report.

The conclusions of this study are:

1. The project is economically feasible on a 40-year life cycle basis.
2. Short-term financing, bond payment adjustments, or other special financial arrangements will be needed to provide for the negative cash flow during the early years of operation.
3. The Town of Canton should further pursue the power marketing and financing aspects of the project.

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I. INTRODUCTION

PURPOSE

This report has been prepared to evaluate the economic, engineering, and environmental feasibility of redeveloping hydroelectric power on the Farmington River at the Upper and Lower site. The report appraises the condition of the existing facilities, presents the redevelopment alternatives, analyzes the power and energy potential of the site, develops streams of project costs and revenues, addresses the legal and institutional aspects and develops an implementation plan for the project.

AUTHORITY

The engineering services were authorized under a grant by the Department of Energy (DOE) to the Town of Canton, Connecticut, and subsequent agreement between Development and Resources Corporation (D&R) and the Town of Canton.

SCOPE AND PARTICIPATION

The specific scope of engineering services is outlined between D&R and the Town of Canton. In general, the services comprise appraisals and comparative evaluations to determine the best plan for redeveloping the hydroelectric potential at the project sites including preparation of the project report. The Town of Canton Conservation Commission participated in data gathering, provided local coordination, prepared the social and environmental assessment portion of this study, and reviewed the entire report.

OTHER PERTINENT STUDIES AND DOCUMENTS

Various pertinent studies and other documents used in the preparation of this study are included as Appendices or listed in the Bibliography.

ACKNOWLEDGEMENTS

Staff members from the following organizations were very helpful in furnishing information necessary for the completion of this feasibility study: State of Connecticut Department of Environmental Protection; Northeast Utilities; Hartford Electric Light Company; Metropolitan District of Hartford; State of Connecticut Public Utilities Control Authority; State of Connecticut Power Facilities Evaluation Council; Farmington River Watershed Association; U.S. Army Corps of Engineers, Waltham, Massachusetts Office; Hydrologic Engineering Center of the U.S. Army Corps of Engineers, Davis, California; U.S. Geologic Survey, Water Resources Division, Hartford Office; U.S. Department of Housing and Urban Development, Federal Insurance Administration, Boston, Massachusetts; Allis-Chalmers; James Leffel & Company; F.W.E. Stapenhorst Company; Beloit Power Systems; General Electric Company; Armco Steel Company; Philadelphia Gear Corporation; Westinghouse Corporation; Generators Unlimited; Andron-Nickles Company; and Foundation Sciences, Inc. In addition, the assistance of Milo C. Bell, Fisheries Consultant, and Mr. Guy F. Whitney, former Collins Company Chief Engineer, was of great value.

II. SITE CHARACTERISTICS AND EXISTING FACILITIES

LOCATION AND DESCRIPTION

The Canton Hydroelectric Project involves the redevelopment of two dam sites on the Farmington River, which is the fourth largest tributary to the Connecticut River. The sites are located approximately 40 stream miles upriver of the confluence with the Connecticut River. Hartford is less than 20 miles to the southeast. A site location map is shown in Figure II-1.

The Upper Dam is in the Collinsville section of the Town of Canton. Adjacent to the dam site are the buildings which once housed the Collins Company, the developer of both sites. The Lower Dam is located 1.2 miles downstream between Burlington and Avon. The powerhouse is in the latter town. The details of the location of the dams are shown on Figure II-2. A profile of the river is shown on Figure II-3.

The Town of Canton is at present working towards obtaining a "historical district" designation for the Upper Dam area. It is already listed in the National Register of Historical Sites.

HISTORY AND PRESENT USAGE

The Farmington River in the Collinsville area has been a source of power since the early 1700's. During colonial times a timber dam was erected at the Upper site on the river to supply power to a saw and grist mill.

The Collins Company was organized on the Farmington River in the very early 1800's and began using the power of the river to run the factory which produced high grade axes, machetes, and other related tools. The company replaced the original timber dam with the present stone structure in 1837. The materials to build the dam were obtained from the community of Collinsville. In 1849, it was determined that the water supply was not adequate, and two additional feet were added to the dam to increase the water storage area. The water power was used to operate water wheels which, in turn, drove the factory's machinery.

In the early 1900's, the Collins Company installed 12 turbines and generators to supply the company with electrical power. Nine small generators were located within the plant and were able to supply 1500 kw to the factory at all times. Three larger generators were installed on the river and were used as much as possible, usage being governed by the volume of water coming down the river. A flow of 500 cfs was needed to run the three generating units. The company produced as much power as possible at all times.

The Lower Dam and its generating station were completed in July 1914, and contained two generators which supplied 500 kw each. The present powerhouse at the Upper Dam was completed in the late 1920's and was the preferred source of power. It had an installed capacity of 400 kw supplied by a single unit.

The power facility in the factory consisted of nine small Holyoke turbines and various types of generators. The powerhouse at the Lower site was equipped with two sets of Allis-Chalmers turbines and generators. The single unit at the upstream powerhouse consisted of a Leffel turbine and Westinghouse generator.

The smaller generators could supply power even with low flows, but the larger units were preferred at times of higher flows. The bulk of the power generated at the sites was consumed by the Collins Company. Excess energy was sold to the Hartford Electric Light Company (HELCO). In fact, during the flood of 1955, Collins' generating stations were the sole source of power for the Hartford Hospital and the radio stations of central Connecticut.

Available records indicate that a total effective installed capacity of 2000 kw generated an average of over seven million kwh annually in the early 1950's. By the early 1960's, these had been reduced to 1600 kw and six million kwh. All the electrical power generation facilities operated with originally installed equipment until the closing of the Collins Company in 1965, with the exception of a few small generators replaced after the 1955 flood.

Upon the closing of the Collins Company, the dams and powerhouses were acquired by HELCO. In 1966, the utility abandoned the sites and either removed, destroyed, or left in a bad state of repair all power equipment. HELCO passed the ownership of the dams and power facilities to the Connecticut Department of Environmental Protection (DEP) at no cost. The Commissioner of DEP has supplied the Conservation Committee with a letter granting the Town of Canton the right to develop the sites for hydropower, contingent upon a DEP review of study results.

The control of the water in the Farmington River was historically under the direction of the Farmington River Water Power Company. This company came into existence soon after the Civil War. The company received the water rights to the river by a grant from the State of Massachusetts. This gave the Farmington River Power Company the right of eminent domain to the flow of the Farmington River and all its tributaries within Massachusetts.

The Collins Company was a major stockholder in this power company, and the two companies shared officers and manpower. Other original stockholders in the power company were the Greenwoods Company of New Hartford and the Stanley Works of New Britain. The Collins Company purchased the Greenwoods' interest when that company went out of business in the early 1900's. The Stanley Works is now the sole stockholder of the Farmington River Power Company and continues to operate the Rainbow facility downstream of Canton.

The Metropolitan District Commission (MDC) presently has the rights to regulate the flow upstream of the site, subject to certain constraints. One of these is maintenance of specific flow requirements for the Rainbow operation.

For many years the water storage area formed by the Collins Company's dams has provided recreational facilities for area residents. Canoe clubs, crew clubs, skaters, water skiers, and fishermen are but a few of the groups that have taken advantage of the reservoirs over many years.

FARMINGTON RIVER BASIN

The drainage area above the Upper Dam is 354 square miles. An average flow duration curve for the Farmington River is shown on Figure II-V. The Farmington River is regulated by many upstream reservoirs. These include the multi-purpose Colebrook and Otis Reservoirs of the Corps of Engineers and the Barkhampsted and Compensating Reservoirs which were developed by the Metropolitan District Commission for water supply purposes. There are other reservoirs within the Farmington River Basin above the project, as shown on Figure II-1 and in Appendix A.

The Metropolitan District currently has plans for future diversion of additional flows from the West Branch of the Farmington River as is discussed in detail in Section IV of this report.

GEOLOGIC CONDITIONS

Records indicate that the existing structures are founded on competent rock. The area is located in Seismic Zone I (minor damage) in accordance with the Uniform Building Code. A detailed reconnaissance engineering geologic investigation is included as Appendix B to this report.

WATER QUALITY

The water quality in the Farmington River is excellent and will not be a significant consideration in the design, construction or operation of the project. Water quality sampling data for the river at Collinsville are contained in Appendix C.

FLOOD HAZARD ASSESSMENT

Facilities Safety

The Upper power plant floor is at approximately elevation 292.5 and there is a concrete parapet to approximately elevation 296. The parapet will protect the plant from inundation against a 50-year (two percent chance of occurrence) storm of 30,000 cubic feet per second. See Figure II-10, Flow Frequency Relationship.

The Lower power plant and gate house floors are at approximately elevation 276.7 and the 100-year flood level is at approximately elevation 275.

Flood flow in excess of the 100-year return frequency will result in inundation of the power plant equipment but should not cause any significant structural damage to the powerhouses or Lower Dam gate house.

The Upper and Lower Dams have been analyzed for safety under flood flow conditions as discussed in diversion dams-stability review paragraphs of this report.

Project Operations

The operations of the project will not increase the flood hazard to adjacent lands and properties. Flashboard heights of three and five feet, respectively, will be used at the Upper and Lower Dams. The flashboard supports are designed to fail at about two to three feet of overflow, resulting in a maximum water level at around elevation 292 at the Upper Dam and 273 at the Lower Dam. These waters are approximately equivalent to that of a 2.5-year or 40 percent chance of occurrence flood flow level.

Dam Failure

Failure of the diversion dams will result in a short period of increased flood wave height downstream of the dams. There are no structures or other facilities downstream of the Lower Dam that would be affected by the increased water level. Several homes are located along the west bank of the river approximately 0.5 of a mile downstream of the Upper Dam with floor levels at around elevation 280. These structures will be subject to some flooding from a return frequency storm of around 60 years. Should dam failure occur during a 50-year storm or greater, the homes would be subject to some inundation. The storage behind the Upper Dam is less than 200 acre-feet. An assumed 25-foot-wide, sudden breach of the dam would result in a short term peak flow discharge of around 5,000 cubic feet per second, or the equivalent of about a one-year frequency storm.

DIVERSION DAMS

Description and Condition

The Upper Dam is approximately 18 feet high at maximum and 350 feet long. This gravity overflow structure is composed of stone masonry with a vertical face on the downstream side. Steel pipes spaced at four feet have been installed at the crest of this structure to accommodate use of wooden flashboards up to 3.0 feet high. Visual inspection indicates that water passes through and between the wooden flashboards and these units would therefore need to be replaced for power generation. The dam itself, however, appears to be in good operating condition as no passage of water was noted through the structure and there have been no apparent lateral or vertical structure displacements. Plan drawings of the Collinsville Upper Dam facility also indicate that the masonry structure is located directly in front of the original timber dam that was apparently left in place. No drawings or cross-sections of this older structure were available at the time of this study, and it could not be visually inspected because of the river flows. The type and present condition of this timber structure therefore, could not be assessed.

The Lower Dam is a gravity overflow concrete structure approximately 20 feet high at maximum with a crest length of 350 feet. During field reconnaissance, significant amounts of ravelling at the crest of this structure were indicated by the sharp jets and leakage of water passing over the crest. It should be further noted that the degree of deterioration at the crest is not known and that close examination of these areas would be recommended to determine the extent, if any, of leakage through the diversion structure. Progressive ravelling of the concrete caused by the passage of water through the structure could compromise the dam's structural integrity. No apparent vertical or horizontal structural displacements were noted during field inspections.

Dam Foundations

Visual inspection of the dam foundations at either the Upper or Lower sites could not be made because of flowing water. However, no lateral movement or settlement of the structures was noted during field reconnaissance trips. Field inspection further indicates that there are many rock outcroppings between the Upper and Lower Dams. Based upon the geological report on the area and visual observations, these rock formations are generally composed of schists and gneiss that are very hard and durable. Reference is made to the geology report included in Appendix B for a more complete description of the general regional and site geology.

An available detail drawing of the Lower Dam indicates that this structure has been "keyed" into bedrock. These keys should prevent lateral displacement of the structure by the internal resistance of the key itself and the additional volume of foundation material that must be moved before the structure can slide. Furthermore, as judged by the strength of the surrounding rock formations, the structural capability of the foundation is considered to be competent and capable of withstanding the dam loadings and hydraulic flows to which it is subject.

The foundation for the Upper Dam has been capable of sustaining the past dam and hydraulic loadings up to the present time. This is evidenced by the fact that no settlement or lateral movement of the dam could be noted during field reconnaissance trips. A general surface geology report further indicates that there are many rock foundations in the vicinity of the Upper Dam. Based on the Upper Dam's past experience, coupled with the surface geology, a strong possibility exists that the Upper Dam is founded on firm, hard bedrock which is capable of sustaining the required hydraulic and structural loads.

Stability Review

In order to assess the structural integrity of both diversion structures, each dam's structural loading conditions and stability were analyzed. Calculations were based on the available section drawings and, for the purposes of calculation, each structure was considered to be homogeneous in nature. Table II-1 displays both the loading conditions and the design criteria utilized for determining each of the dam's factors of safety with regard to stability.

The loading cases displayed in these tables represent the maximum loads that each dam would be subject to under normal, seismic, and flood conditions. In order to assess earthquake loading conditions, seismic events of two different intensities have been used as a basis for review. Thus, Case II has been defined as a probable earthquake intensity while Case III defines the maximum credible seismic event. In order to account for vertical earthquake accelerations, both the weight of water above the structure and the dam itself were modified by an acceleration factor equivalent to 50 percent of the horizontal seismic loads applied. Case IV represents the peak river discharges based on the 50-year flood condition.

In all load cases silt is assumed to be in place and is taken into consideration in determining the resultant loads to apply. This assumption derives from the probability that over the years significant amounts of silt and sand have accumulated against the upstream faces of the dams. Since it is not known how impervious the silt or foundation may be, full hydrostatic heads are used as a measure of the uplift forces. Thus, a straight line variation from headwater to tailwater is used in evaluating the magnitude of uplift forces. It should be noted, however, that if the silt material deposited on the upstream face of the dams is clay-like, it could be relatively impervious. This event would therefore change the flow path of water beneath the structures, creating a differential in uplift pressure across the dam which would be something less than fully hydrostatic. Since the actual differential in pressures is not known, both maximum and minimum possible uplift loads were utilized in the analysis of each diversion structure. Based on the above loading conditions, factors of safety against overturning, uplift, and actual sliding factors, using stresses of each dam's base elevation, were calculated. The results of these findings are displayed in Table II-2.

A problem could exist with regard to stability since calculations indicate that the dams' overturning factors of safety are below normally expected values. In view of these low safety factors, it is apparent that some type of anchorage most probably exists at the toe of these structures. This conclusion is also substantiated by the fact that both structures have withstood over 142 years and 65 years of flows, respectively, ranging to a maximum of at least 61,000 cubic feet per second (which occurred in the year 1955). This flow is approximately equivalent to a 250-year return frequency or a 0.4 percent chance of recurrence.

It is also possible that the bedrock upon which these structures are located may tend to drain, thereby reducing the hydrostatic pressure and resulting uplift forces underneath the structures. It is recommended that the magnitude of pressures at the toe and heel of each structure undergo field testing to determine the magnitude of actual uplift forces. Further review and structural analysis of each structure should then be carried out on the basis of observed uplift pressures and actual anchorage conditions.

It is also necessary that a more detailed inspection be made of both Collinsville dams when the river flows can be diverted through the adjacent intake channels and/or sluice gates to assure that there is no water flowing over the crest of the dams. Such an inspection is required to verify that the downstream face of each structure is structurally intact and also to verify that there has been no undercutting at the downstream face at the interface with the bedrock. Signs of seepage should be looked for along with signs of deterioration of the cement mortar.

These activities would be included in the final site investigation and design stages of project implementation.

POWER PLANT INTAKES AND TAILRACES

Upper Power Plant

The intake to the Upper Power Plant consists of an uncontrolled opening in the diversion dam and an excavated channel with a reinforced concrete wall on the river side leading to the powerhouse. A retaining wall is provided on the land side of the plant entrance.

Timber slide gates with manually operated geared lifts were provided for plant intake and wasteway gates. These gates and the hoist shall be replaced.

The tailrace has a non-reinforced concrete training wall on the river side and a retaining wall on the land side.

All concrete appears to be in relatively good condition with no apparent significant cracking or displacements. There is a moderate amount of surface cracking and spalling which appear to be readily repairable.

The existing steel bar trashracks are intact and are considered restorable by removal, cleaning, and replacement of bent and severely corroded bars and recoating.

The tailrace channel is filled with debris and sediment and will require dredging.

The existing facilities are shown on Figures II-5 through 9, and Plates II-1 and II-2.

Lower Power Plant

The intake channel gate house consists of a reinforced and non-reinforced concrete substructure and a non-reinforced brick wall superstructure with a steel truss roof structure. The structure is in good condition except for substructure concrete spalling which can be repaired. The existing timber gates will be replaced; however, the belt-driven, motor-operated hoists are in good condition and will be refurbished. The entry and some of the windows are damaged and will be replaced, as will the wooden roofing. The brick superstructure is in good condition and no significant restoration work will be needed. The brick walls are 12 inches in thickness and about 12 feet in height. The wall will meet all current structural design criteria of the Uniform Building Code.

The intake channel has concrete walls partially along both sides of the channel that will require some surface repair. No significant cracking or displacements were noted.

The power plant trashracks are in moderately good condition and can be refurbished. The intake gate hoists have been removed and new gates and hoists will be needed.

The tailrace channel is partially filled with sediment and debris and will require cleaning.

GENERATION EQUIPMENT

At the Upper Power Plant, the original Leffel turbine with a Type 2 wheel, rated at 400 kva at 164 rpm, is in place. However, the power shaft is bent and the unit is known to be in poor condition.

The turbine pit has been sealed with concrete. The unit is not considered salvable.

The original turbines at the Lower Power Plant were Allis-Chalmers Francis runners rated at 425 kw at 90 rpm. One of the units is in place, but is in poor condition and is not considered salvable.

All other equipment including generators, switchgear and transformers, have been removed from the plants and discarded.

POWERHOUSES

Description and Existing Condition

Since "as-built" drawings of the existing power plants were not available, examination of both the Upper and Lower powerhouse structures was limited to visual inspection and measurements were taken during field reconnaissance. No visual signs were noted that any significant lateral or vertical movement at either structure had taken place in the past.

Upper Powerhouse

The Upper Powerhouse is approximately 23 feet, 6 inches wide by 31 feet long. This structure consists of a concrete substructure with a brick masonry superstructure and pitched steel truss roof supports.

Walls -- The structure walls are 12 inches thick, consisting of unreinforced brick masonry extending approximately 25 feet above grade. Door and window openings, rectangular in size, are provided between 16-inch pilasters. Beams supported on the brick pilasters have been provided on inside opposite walls to accommodate use of a travelling crane. The brick walls appear to be in good condition as no signs of cracking or deterioration were noted during field reconnaissance.

Roof -- Tile roofing is supported through use of steel trusses and purling. The present condition of the roof is such that replacement of many roof tiles will be necessary to provide a watertight installation.

Substructure -- The substructure consists of reinforced concrete walls that are approximately 16 inches thick. These concrete walls generally extend below the ground surface except on the river side where they are exposed to the soffit level. No significant spalling or deterioration of the concrete superstructure was noted during field inspections.

Lower Powerhouse

The Lower Powerhouse is approximately 39 feet wide by 51 feet, 6 inches long. It consists of a timber roof with unreinforced brick walls and an unreinforced concrete substructure.

Walls -- The walls are 16 inches thick extending a maximum height of 35 feet, 6 inches. Beams supported on brick pilasters are provided on inside opposite walls to accommodate use of a travelling crane. Some of the lower windows and door openings have been boarded or bricked up for safety precautions. These windows and doors will therefore need to be replaced; however, the brick superstructure itself appears to be in good condition.

Roof -- Timber roof support beams are used to support a flat timber planking. Replacement of some wood planks and additional sealing will be necessary to provide a watertight installation.

Substructure -- The concrete substructure appears to be in good repair as no deterioration or cracking of the concrete was noted.

STRUCTURAL REVIEW

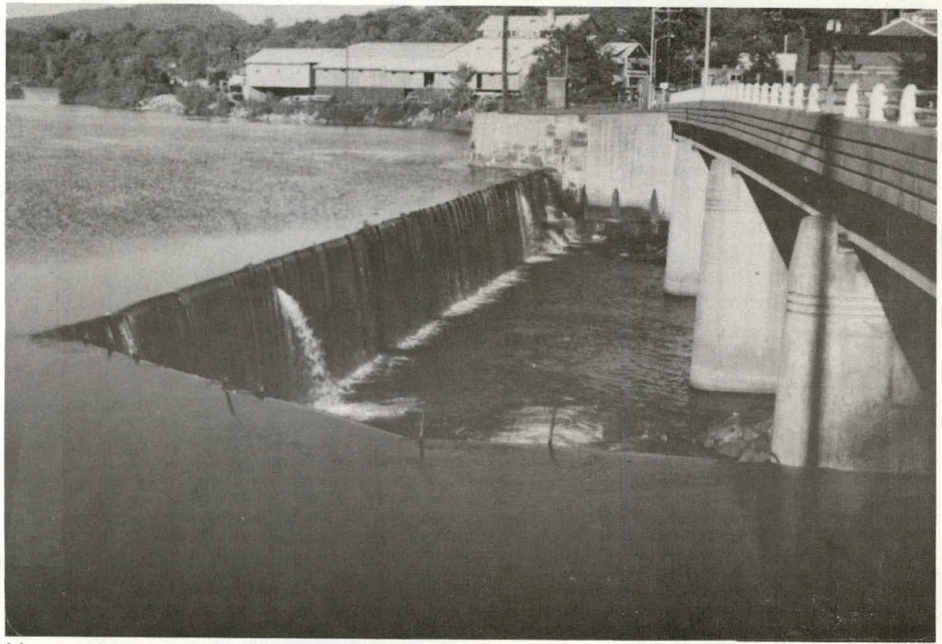
Stability of the existing powerhouses was limited to analysis of the structural loading conditions and review of the superstructure masonry walls since "as-built" drawings and details were not available. Because both of these structures were built in the early 1900's, it is assumed that no reinforcing steel exists in either the masonry walls or footings. Masonry stresses, wind loads, and seismic loads as determined from the "Uniform Building Code (UBC)" were used as a basis for review. All allowable stresses in the brick masonry walls were increased by one-third to account for short-term, transitory loads such as those imposed by winds and earthquakes. The design criteria and results are as follows:

Wind Loads -- As determined from Figure 4 of the UBC, both powerhouse structures are located in a basic wind zone of 25 pounds per square foot. Accordingly, to meet UBC requirements, the brick masonry walls should be designed for a minimum of 20 pounds per square foot to 25 pounds per square foot depending upon the structure heights. Using a maximum tension of 24 pounds per square inch in the unreinforced masonry walls, calculations indicate that the existing walls of both structures are good for at least 11 pounds per square foot lateral wind load.

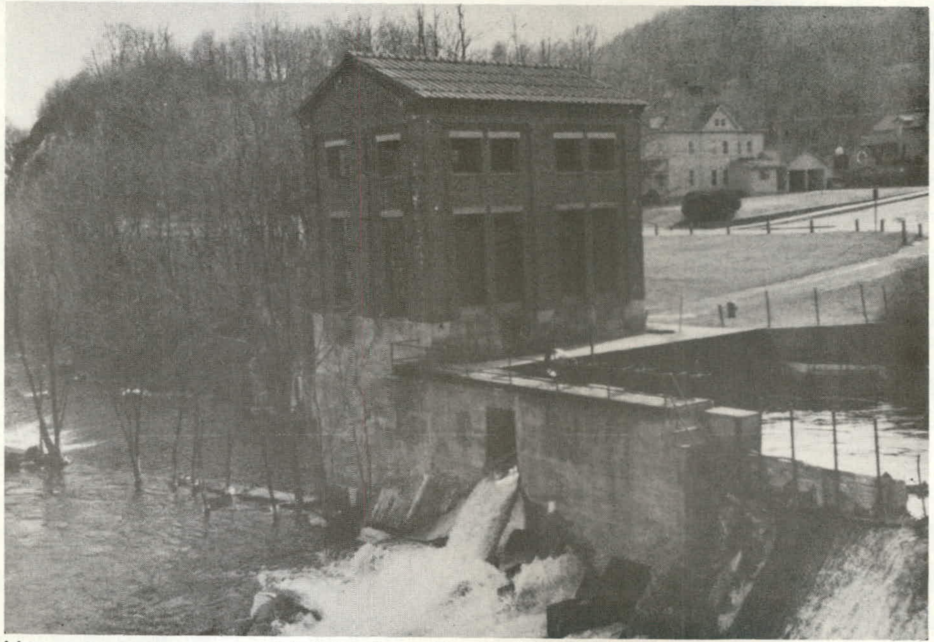
Seismic Loads -- Figure 1 of the UBC indicates that the powerhouse structures are located in Seismic Risk Zone 1. Therefore, the superstructure should be designed for a minimum lateral seismic load equivalent to five percent of the vertical dead weight. Analysis of the existing walls indicates that a lateral load capacity of 9.1 percent and 6.9 percent for the Upper and Lower Powerhouses, respectively, has been provided.

Review of the above indicates that the existing walls meet the UBC code for earthquake requirements while for wind the designs may be deficient. It should be emphasized, however, that the above analysis is based upon no special inspection of the brick walls during construction. Therefore, depending upon the actual grout and masonry strengths, the maximum allowable wind loading could go as high as 22 pounds per square foot. Furthermore, some shielding of the building structures from high wind velocities could be expected due to their proximity to mountains and other natural or man-made structures. It is believed that a somewhat reduced wind loading may therefore be applicable for the design of the Lower Powerhouse due to its location adjacent to trees and mountains.

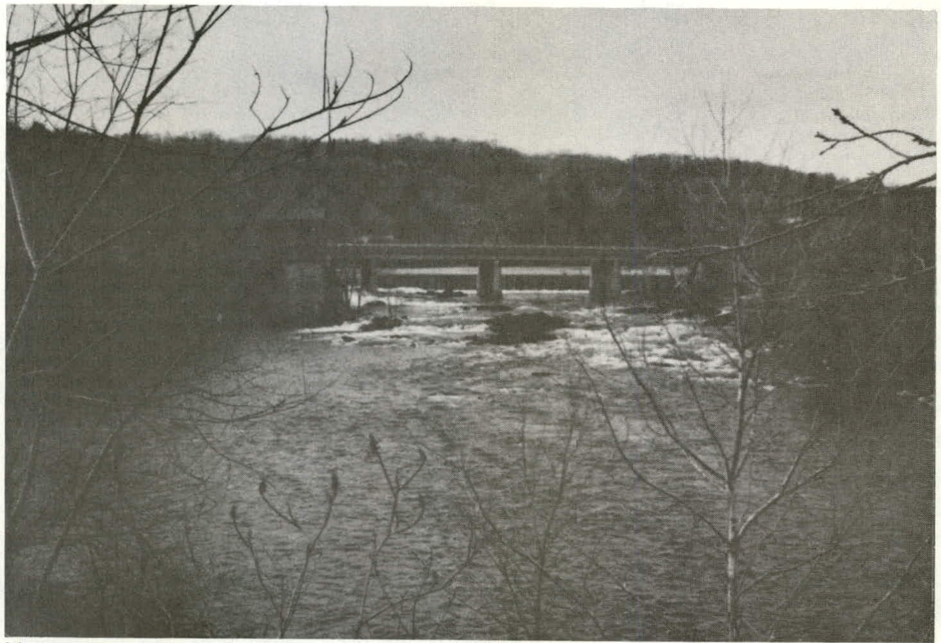
Since the redevelopment plans for the power plants are based on unmanned operations with only periodic visits by operation and maintenance personnel, it is concluded that the existing powerhouses are structurally adequate for their intended uses.



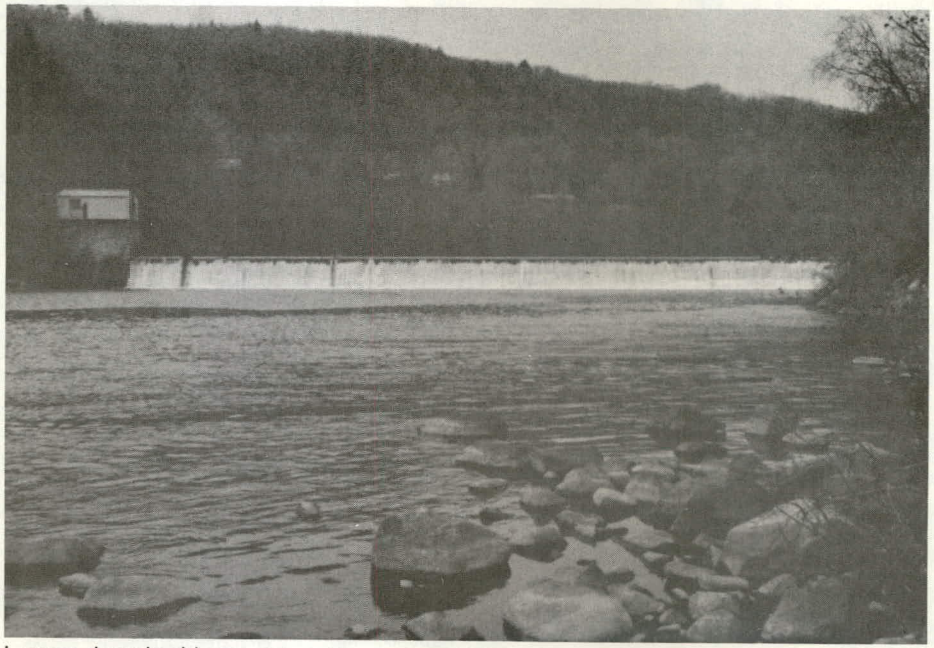
Upper dam and Route 179 Bridge looking west to east from right abutment. Intake to powerhouse in foreground.



Upper powerhouse and intake from Route 179 Bridge looking southwest.

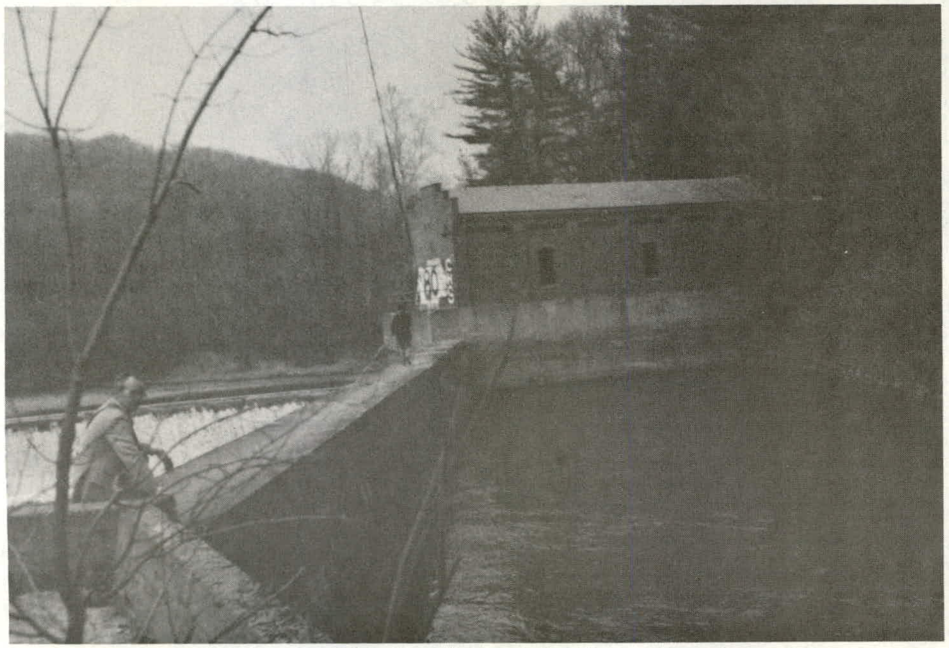


Upper powerhouse, dam, and Route 179 Bridge, looking upstream.



Lower dam looking upstream.

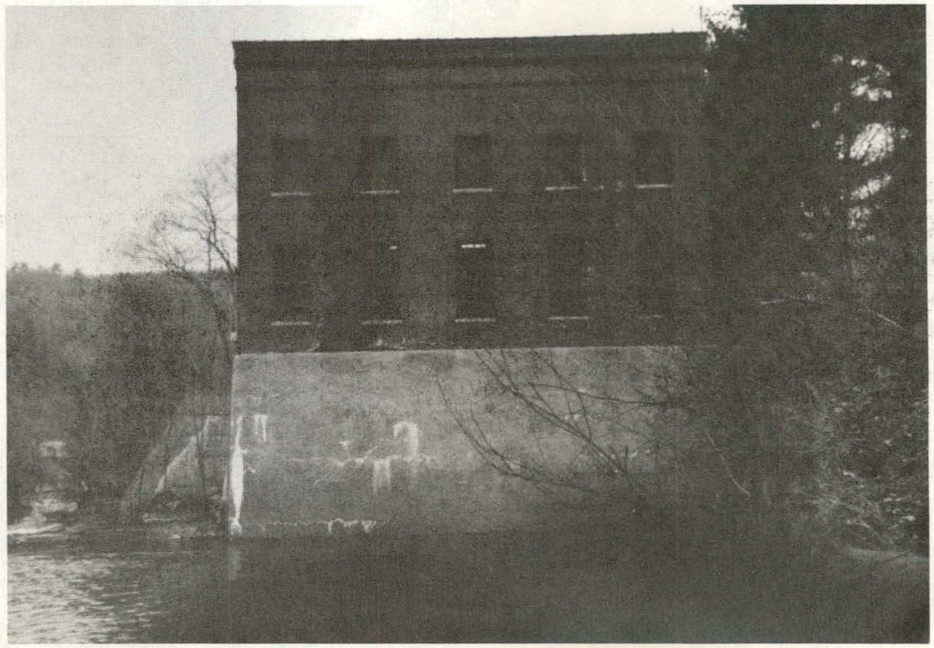
PLATE II-1



Lower dam, gatehouse, and intake channel, looking upstream

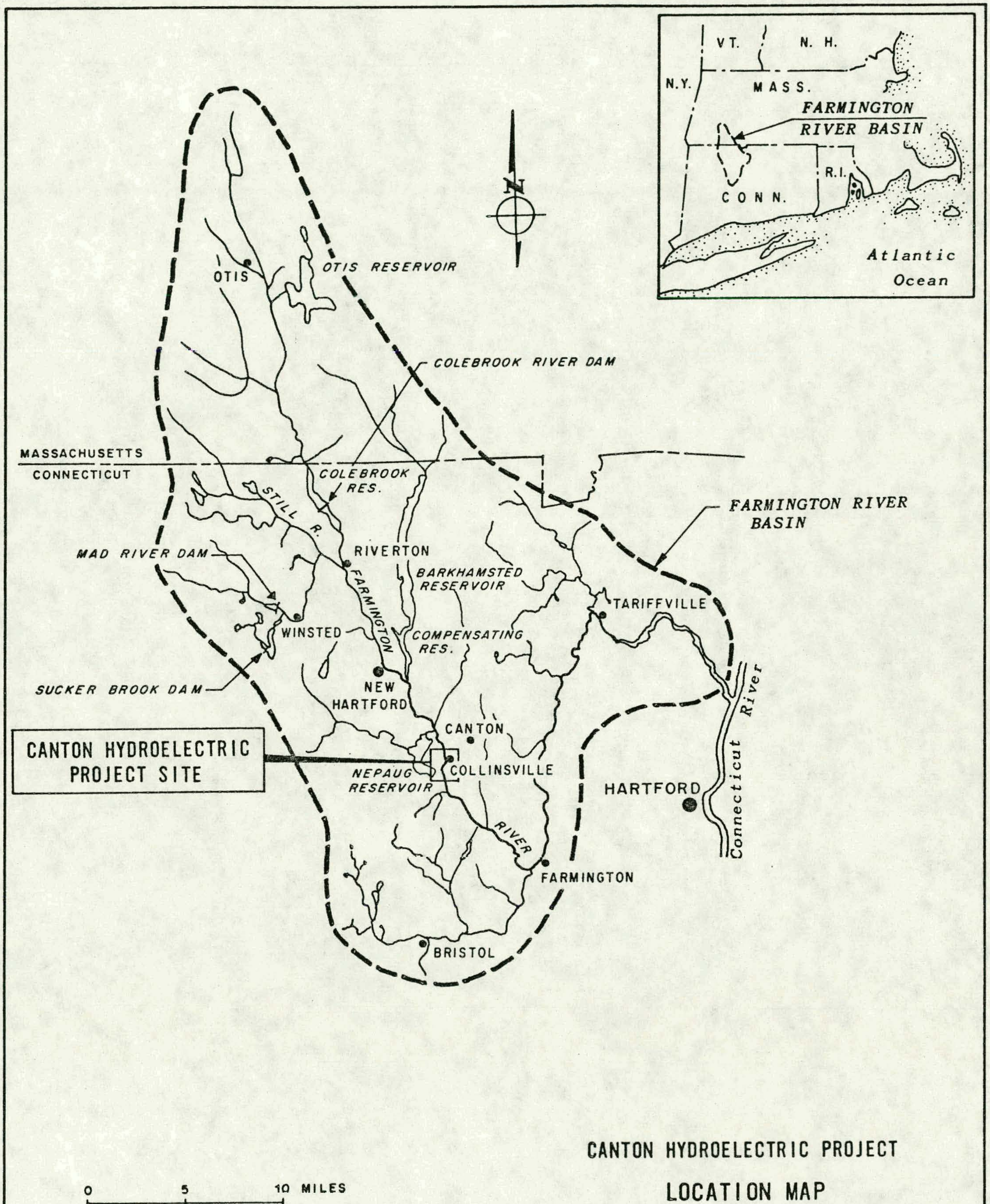
Lower powerhouse and intake channel, looking downstream

Lower powerhouse looking downstream



Lower powerhouse looking upstream

PLATE II-2



CANTON HYDROELECTRIC PROJECT

LOCATION MAP

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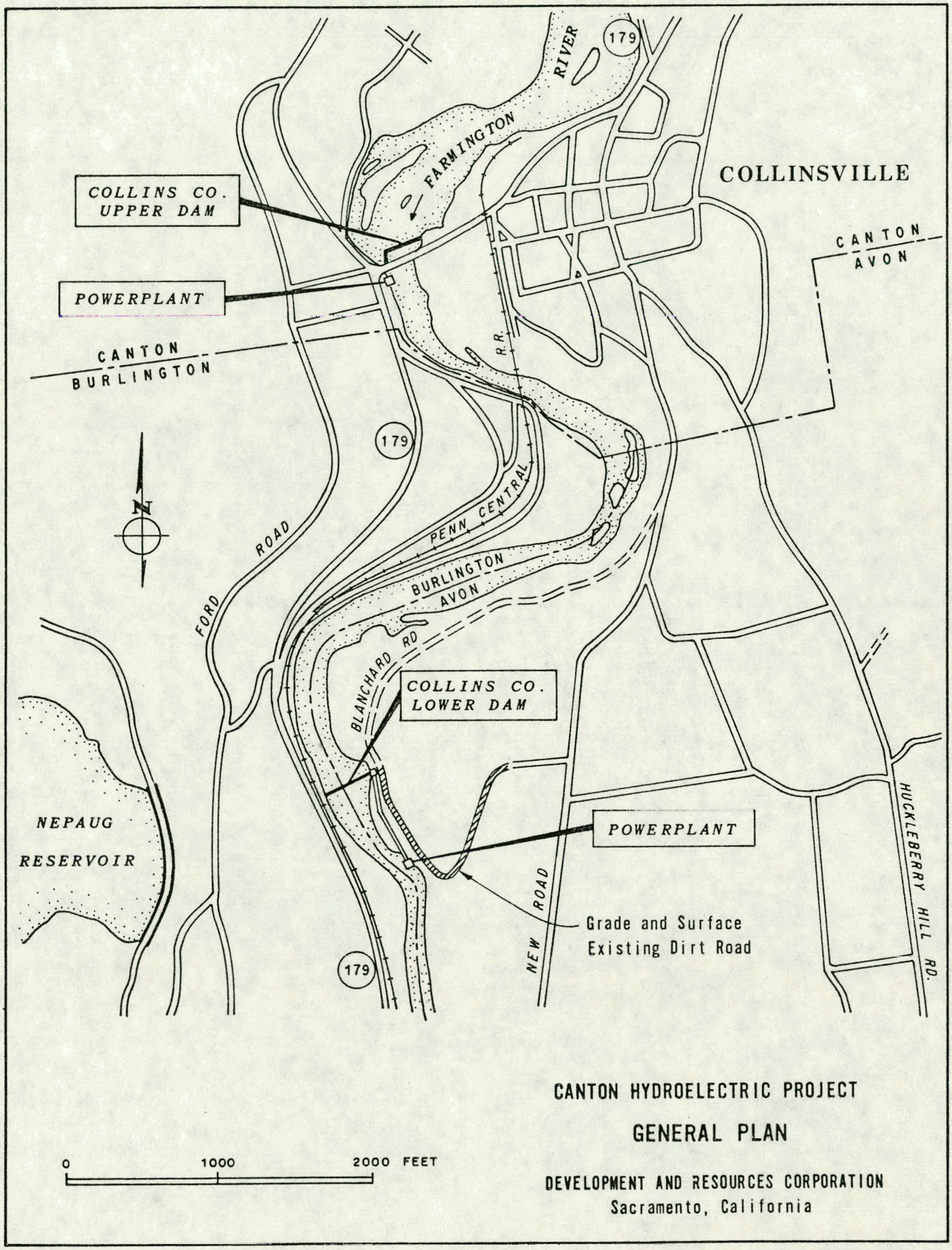
Figure II-1



CANTON HYDROELECTRIC PROJECT

GENERAL PLAN

DEVELOPMENT AND RESOURCES CORPORATION
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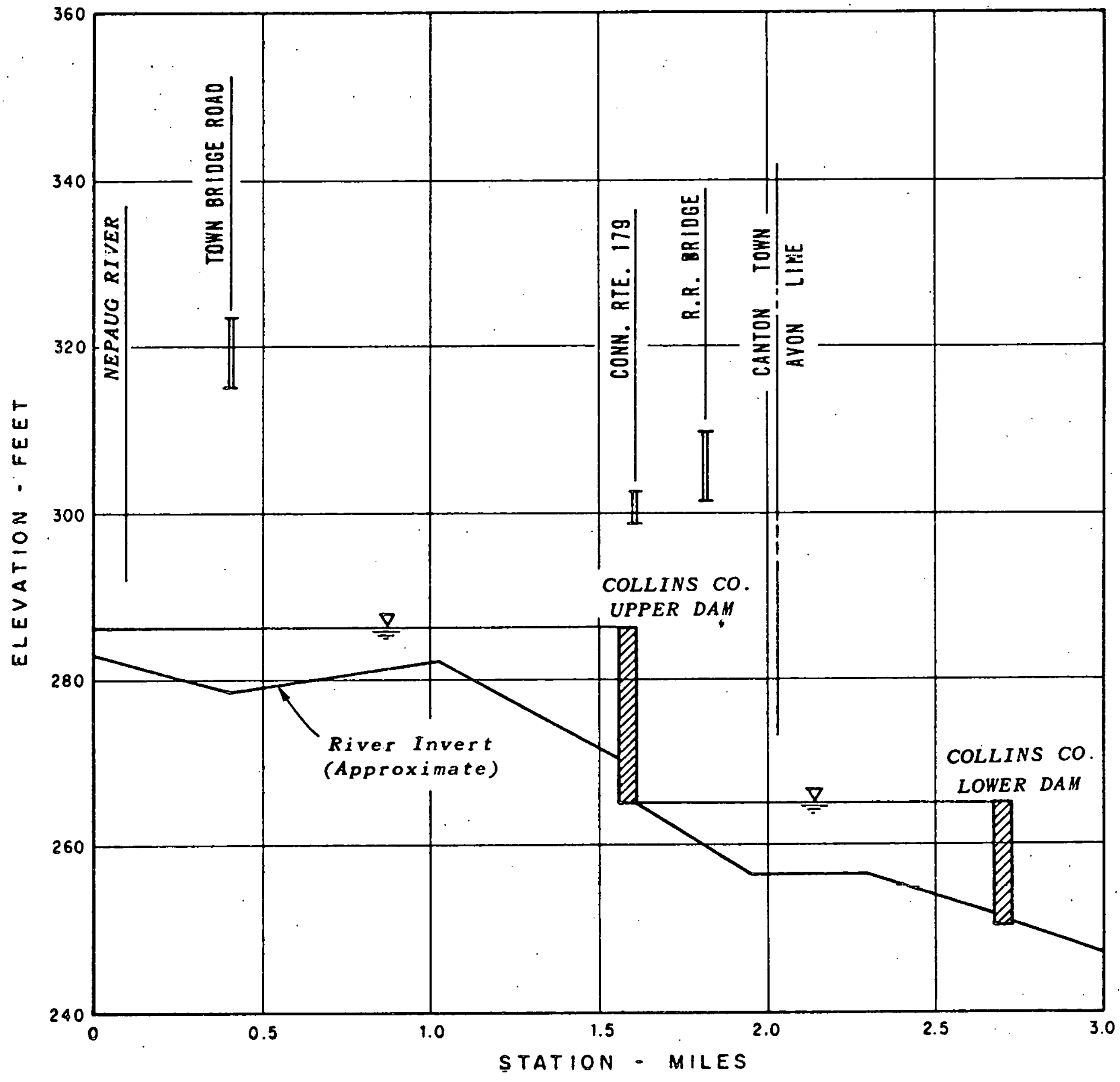
Figure II-2



CANTON HYDROELECTRIC PROJECT

FARMINGTON RIVER PROFILE

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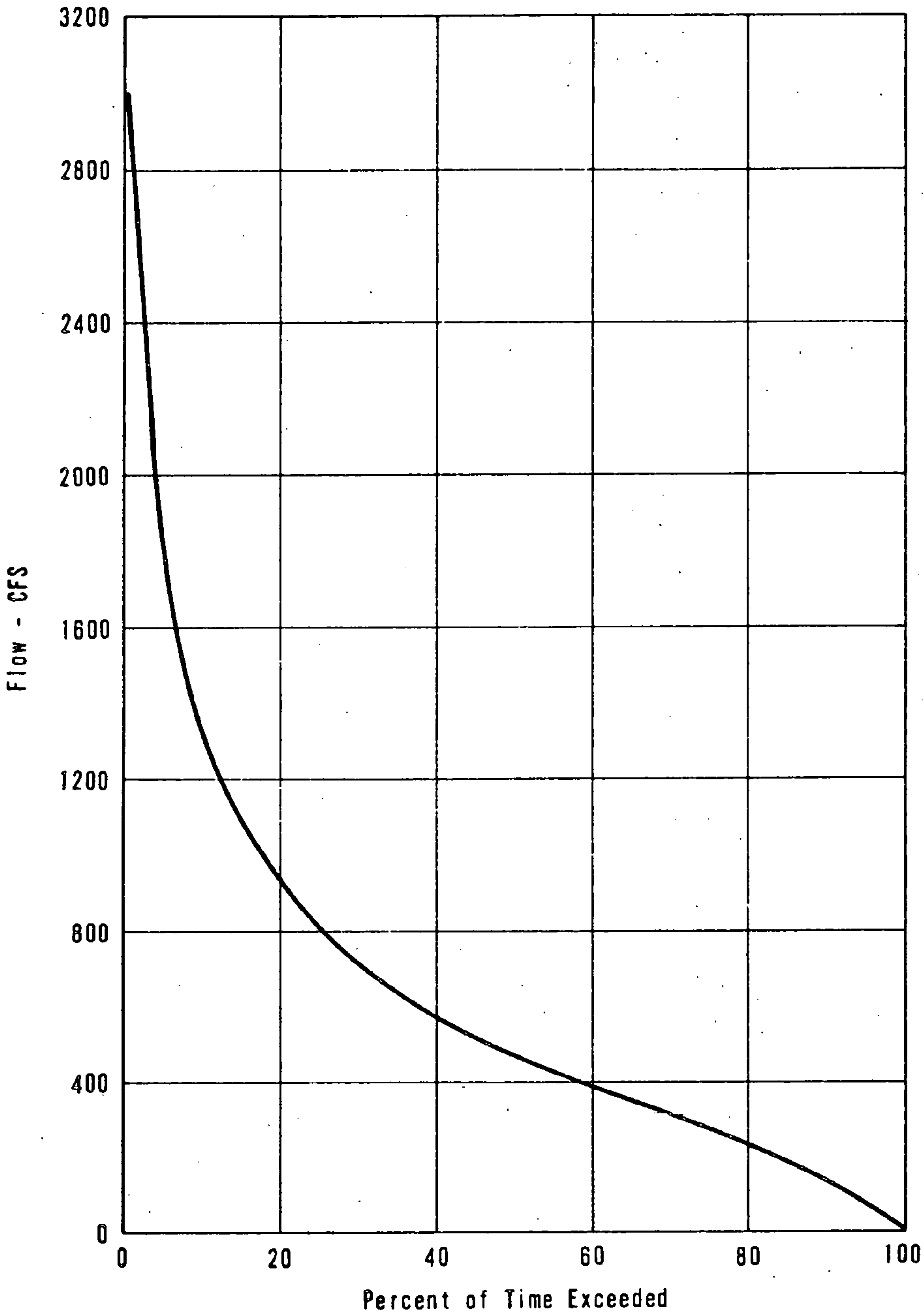
Figure II-3



Source: U.S. Geological Survey, Daily Flow Records

CANTON HYDROELECTRIC PROJECT

ANNUAL - FLOW DURATION 1964-1976
FARMINTON RIVER AT COLLINSVILLE

DEVELOPMENT AND RESOURCES CORPORATION
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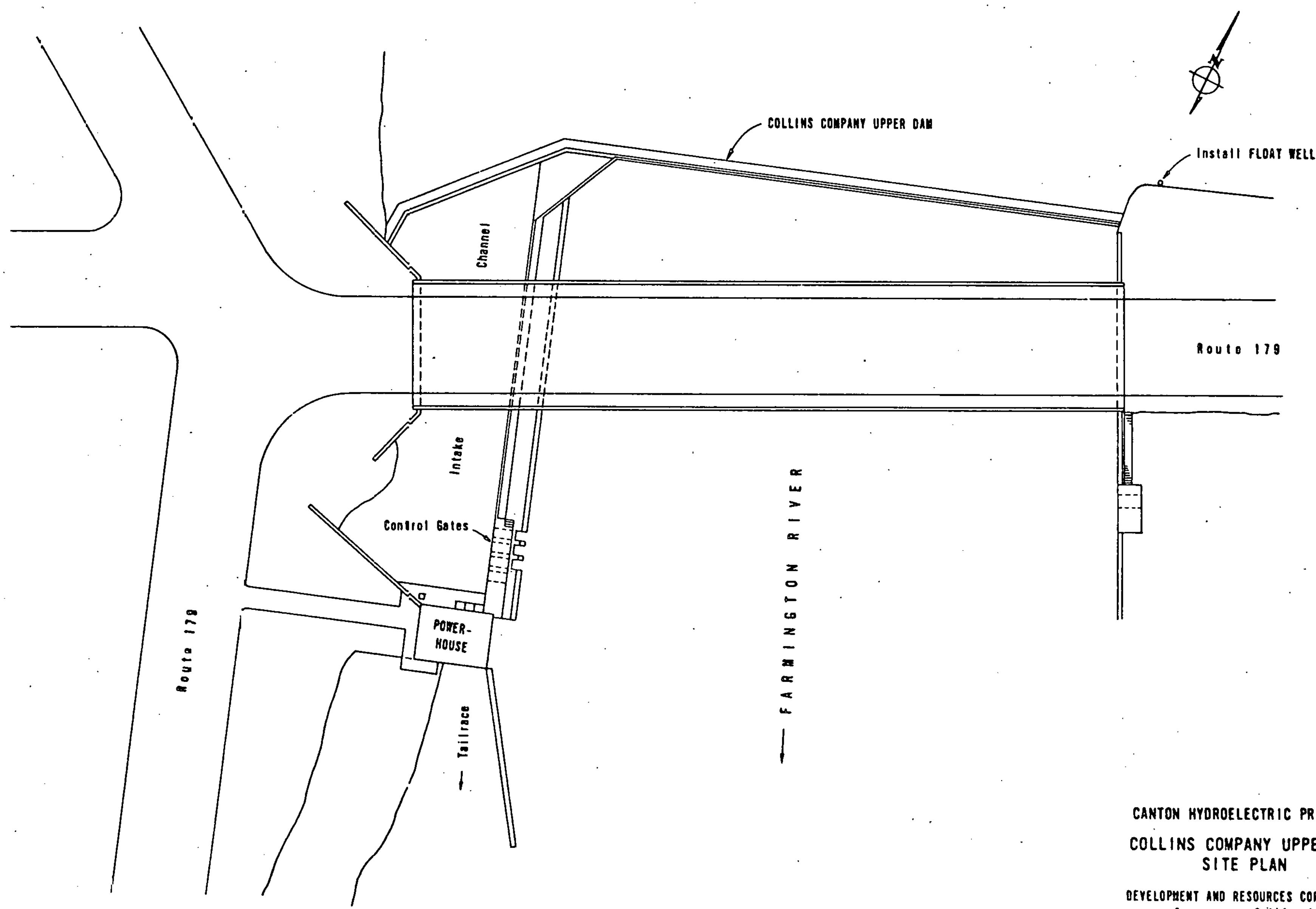
Figure II-4



CANTON HYDROELECTRIC PROJECT

COLLINS COMPANY UPPER DAM
SITE PLAN

DEVELOPMENT AND RESOURCES CORPORATION
Sacramento, California

Figure II-5

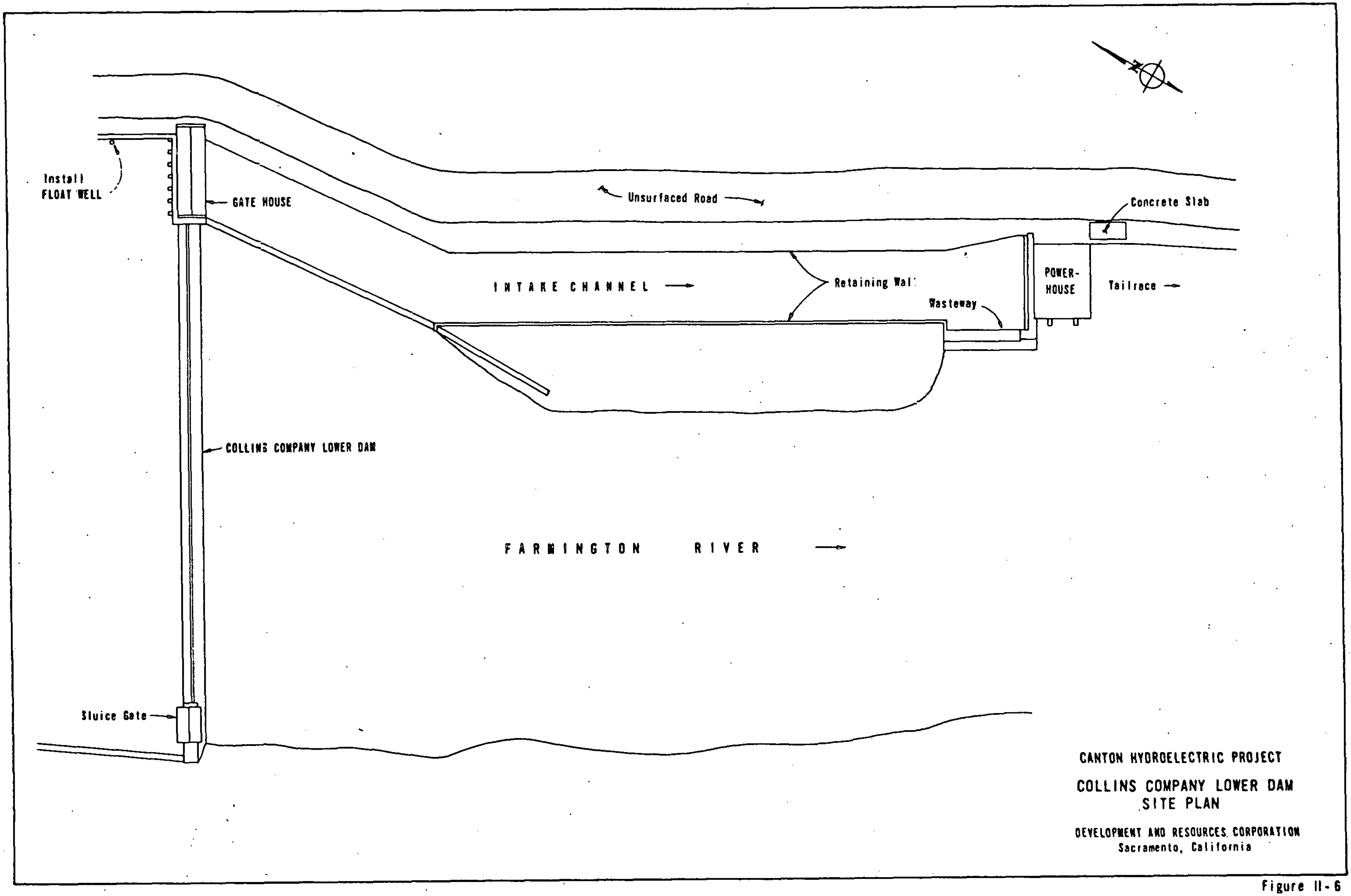
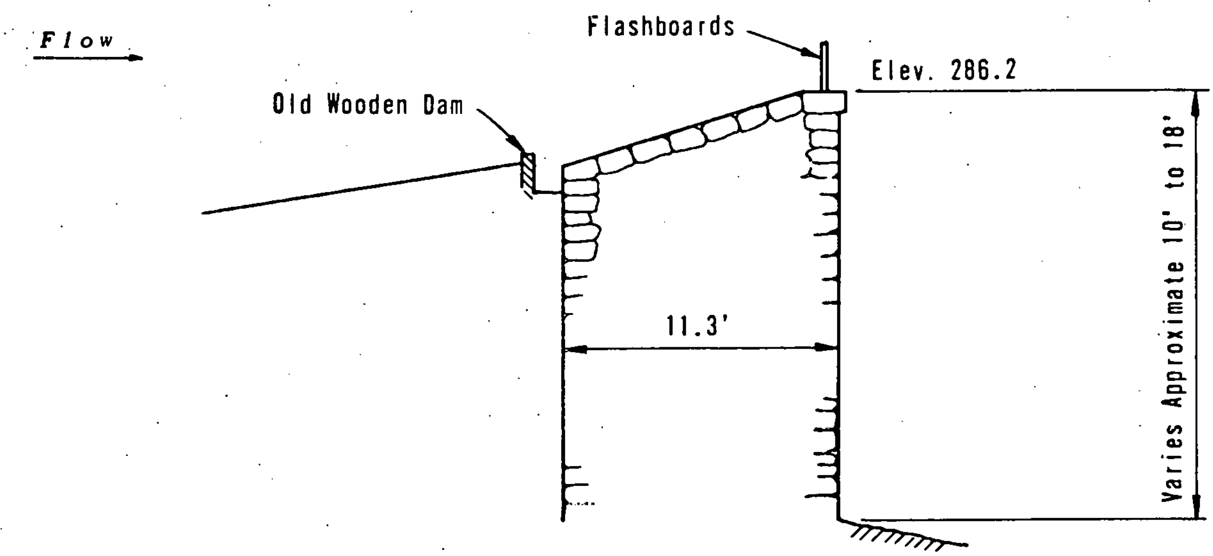
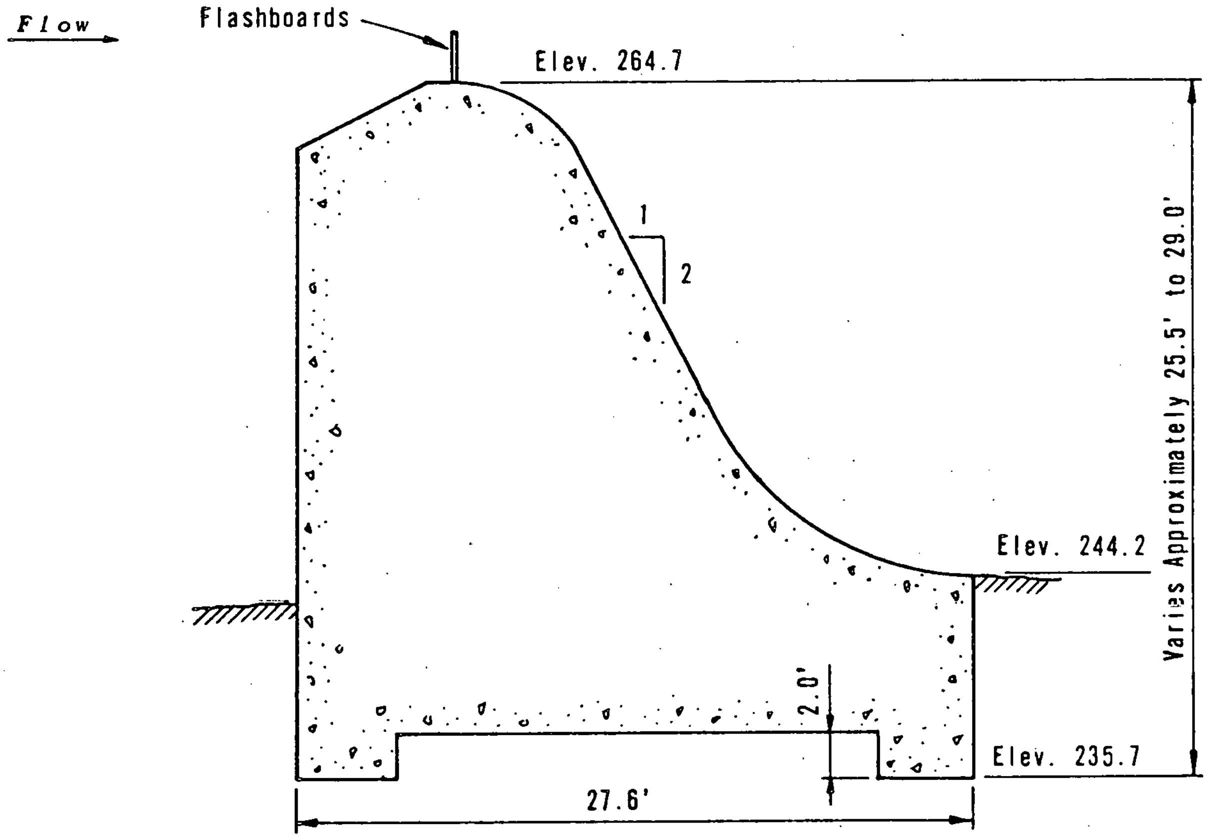

Install
FLOAT WELL
GATE HOUSE
Unsurfaced Road
Concrete Slab
INTAKE CHANNEL
Retaining Wall
Wasteway
POWER-
HOUSE
Tailrace
COLLINS COMPANY LOWER DAM
FARMINGTON RIVER
Sluice Gate
CANTON HYDROELECTRIC PROJECT
COLLINS COMPANY LOWER DAM
SITE PLAN
DEVELOPMENT AND RESOURCES CORPORATION
Sacramento, California

Figure II-6



UPPER DAM SECTION



LOWER DAM SECTION

CANTON HYDROELECTRIC PROJECT

TYPICAL DAM SECTIONS

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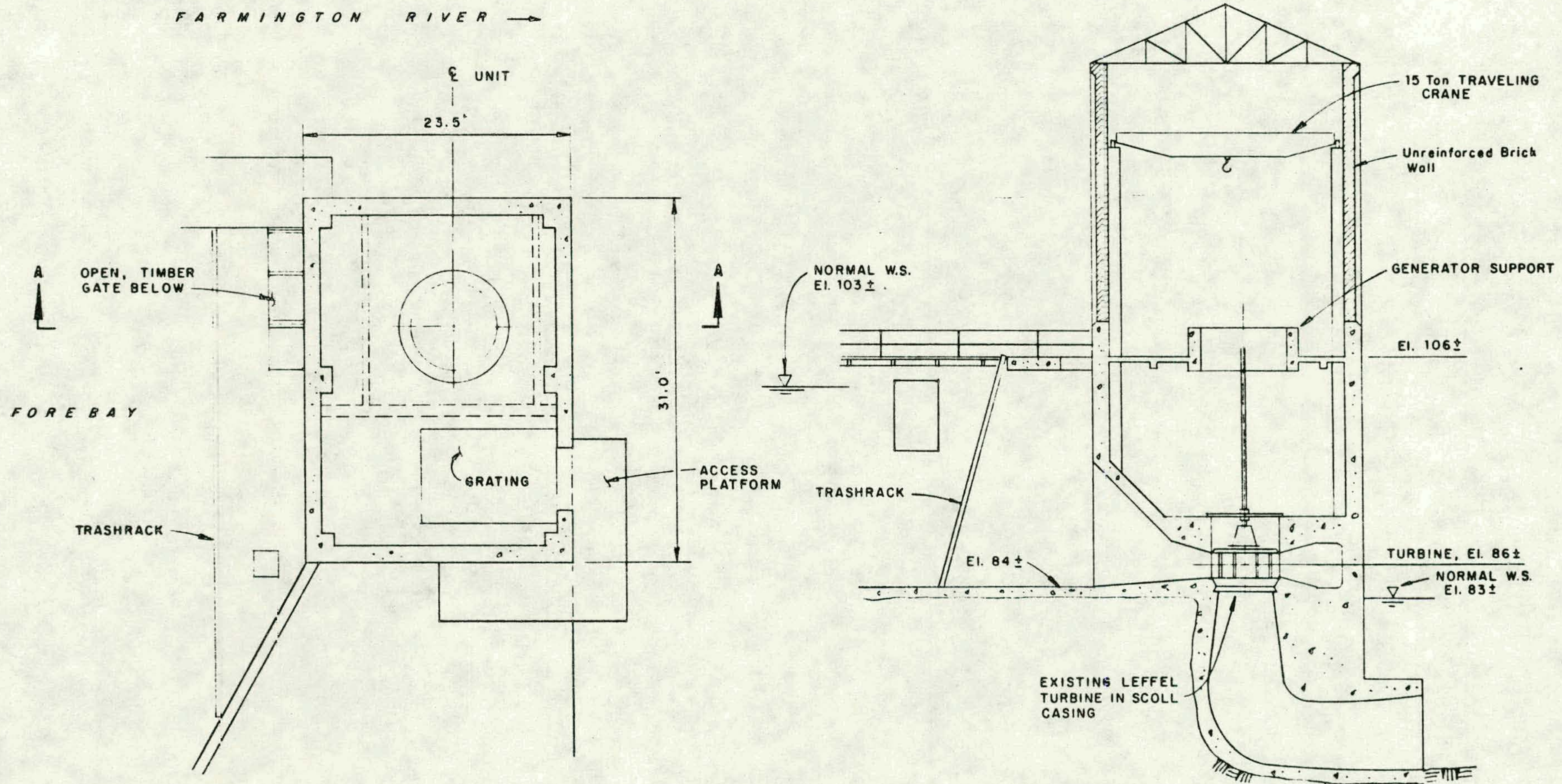
Figure II-7



PLAN

SECTION A-A

CANTON HYDROELECTRIC PROJECT

EXISTING UPPER POWERPLANT

DEVELOPMENT AND RESOURCES CORPORATION
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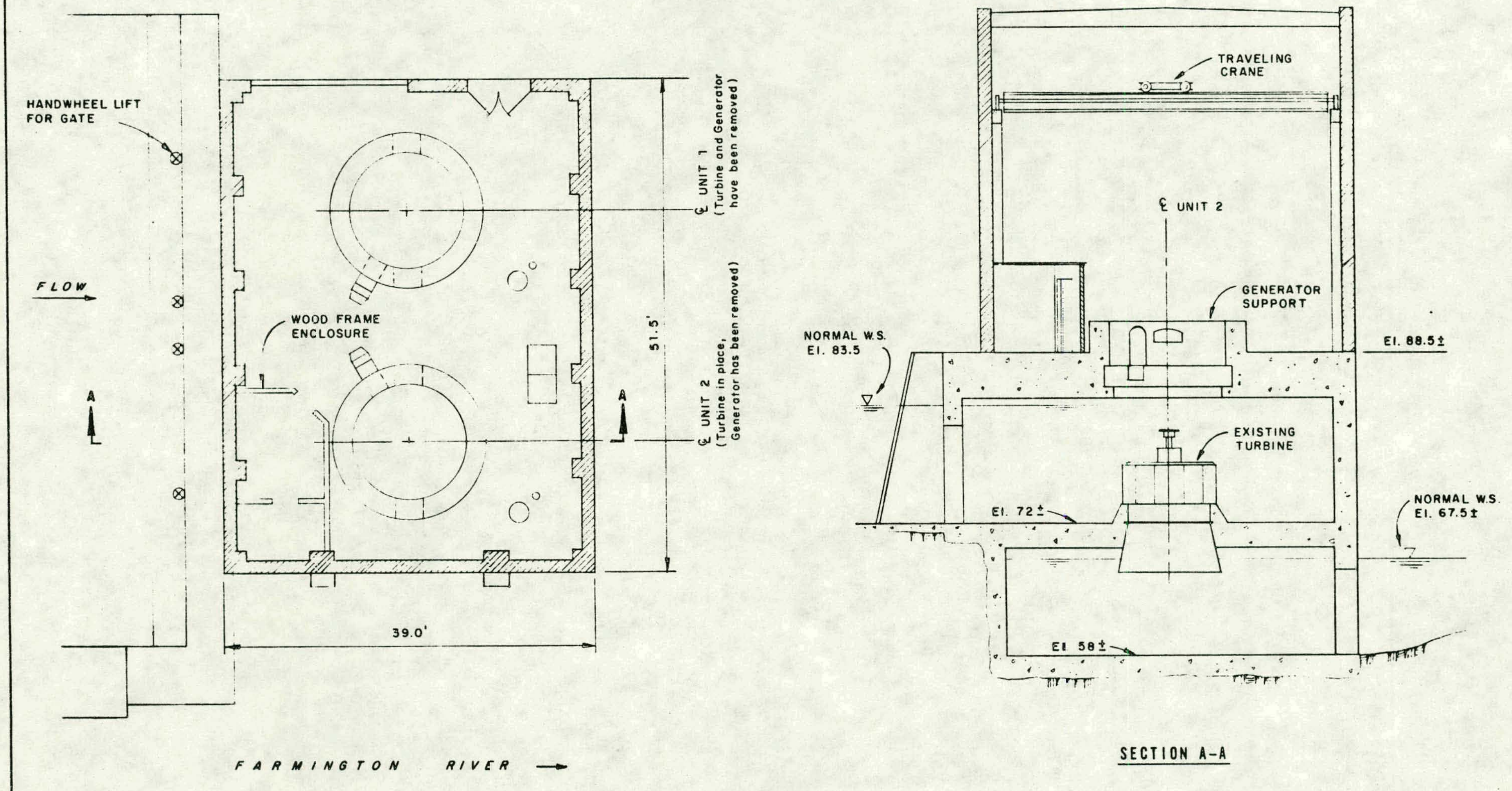
Figure II-8



CANTON HYDROELECTRIC PROJECT

EXISTING LOWER POWERPLANT

DEVELOPMENT AND RESOURCES CORPORATION
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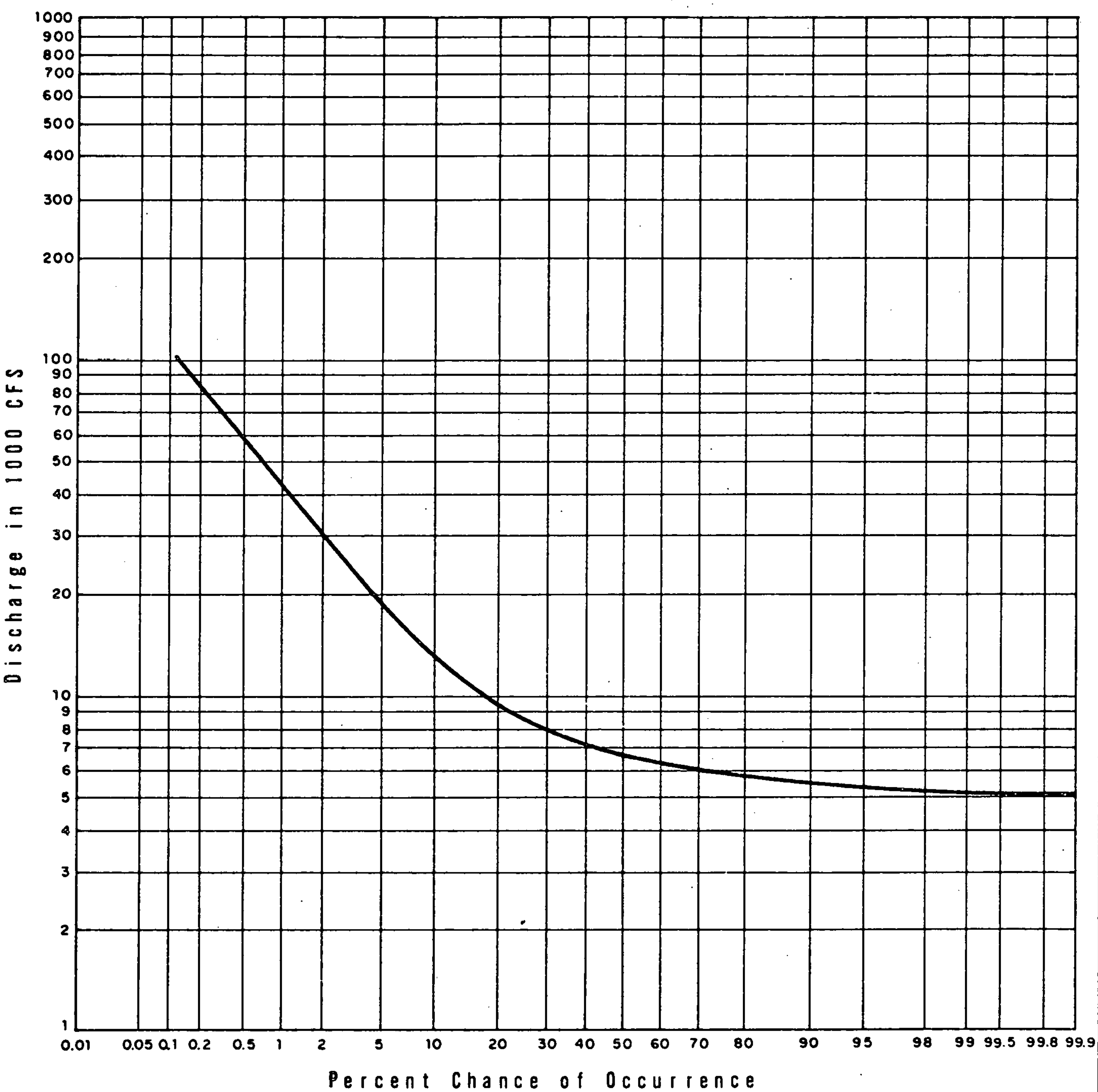
Figure II-9



SOURCES: FLOOD PLAIN INFORMATION, West Br. and Farmington River - Canton, New Hartford and Barkhamsted, Conn. - The Dept of the Army, New England Div., Corps of Engineers, Waltham, Mass. May 1977

CONNECTICUT RIVER BASIN, Master Manual of Reservoir Regulation, Appendix J, Farmington River Watershed Colebrook R. Dam and Res., Mad R. and Res., Sucker Br. Dam and Res., Conn. and Mass. - Dept. of the Army, New England Div., Corps of Engineers, Waltham, Mass., June 1970

CANTON HYDROELECTRIC PROJECT

PEAK DISCHARGE FREQUENCY CURVES
FARMINGTON RIVER AT COLLINSVILLE

DEVELOPMENT AND RESOURCES CORPORATION
Sacramento, California

Figure II-10

TABLE II-1

COLLINSVILLE DAMS

Design and Loading Criteria for Stability and Stress Analysis

Item	Design Loading Case			
	I	II	III	IV
Flashboards	Yes	Yes	Yes	No
Water Surface Elevation				
Upper	U/S=289.2 D/S=266.8	U/S=289.2 D/S=266.8	U/S=289.2 D/S=266.8	U/S=294.7 D/S=286.7
Lower	U/S=269.7 D/S=253.7	U/S=269.7 D/S=253.7	U/S=269.7 D/S=253.7	U/S=275.2 D/S=269.7
Reservoir Silting at Dam				
Upper	282.5=assumed existing level	282.5=assumed existing level	282.5=assumed existing level	282.5=assumed existing level
Lower	264.7=assumed existing level	264.7=assumed existing level	264.7=assumed existing level	264.7=assumed existing level
Uplift Pressure	100 percent	100 percent	100 percent	100 percent
Seismic				
Horizontal	0	0.075	0.20	0
Vertical	0	0.0375	0.10	0.
Stability				
Sliding Factor	0.7	0.7	0.7	0.7
Water Pressure	62.4 pcf	62.4 pcf	62.4 pcf	62.4 pcf
Saturated Soil Pressure	86 pcf	86 pcf	86 pcf	86 pcf

TABLE II-2

COLLINSVILLE UPPER AND LOWER DAMS
STABILITY AND STRESS ANALYSIS SUMMARY

Item	Case Number I	II	III	IV
LOWER DAM				
Stress (elevation 235.7)				
Heel (psi) 1/	+24.8	+30.6	+40.2	+14.2
Toe (psi) 1/	- 5.9	-13.2	-25.3	+ 7.4
Stability				
Uplift factor of safety	1.91	1.84	1.72	1.72
Overturning factor of safety with full uplift	1.21	1.06	.87	1.37
Overturning factor of safety without uplift	2.84	2.22	1.58	3.37
Sliding factor 2/	0	0	0	0
UPPER DAM				
Stress (elevation 267.83)				
Heel (psi) 1/	+62.9	+69.9	+84.7	+44.5
Toe (psi) 1/	-34.3	-42.7	-60.0	-25.6
Stability				
Uplift factor of safety	3.95	3.80	3.60	1.91
Overturning factor of safety with full uplift	.91	.76	.62	.93
Overturning factor of safety without uplift	1.32	1.04	.79	1.43
Sliding factor	.80	.99	1.36	.80
Actual sliding factor without uplift	.59	.73	.97	.38

1/ All stresses and safety factors with full hydrostatic uplift forces unless noted otherwise.

2/ Lower Dam deyed into bedrock which is assumed capable of resisting applied horizontal loads.

III. REDEVELOPMENT ALTERNATIVES

A full range of potential redevelopment alternatives for the Canton Hydroelectric Project were assessed. Detailed operational and energy production studies were performed for thirteen Upper and twelve Lower power plant alternatives of various equipment types and arrangements. Preliminary cost and benefit estimates were developed for these alternatives and the most technically and economically viable alternatives were selected for detailed cost studies. Detailed estimates were prepared for seven Upper Power Plant alternatives and for five Lower Power Plant alternatives.

Detailed economic analyses were performed for 10 project alternatives selected on the basis of cost and technical considerations.

Descriptive and comparative data and basic criteria for each alternative are included in the section, while energy production estimates, and cost and economic analyses are presented in Sections IV and V.

BASIC DATA AND TECHNICAL CONSIDERATIONS

Various data and basic technical considerations provided the framework for selection and evaluation of the different redevelopment alternatives. Following is a brief summary of the various basic components.

Hydrologic Data

United States Geological Survey flow records were used for the Farmington River gage, located just upstream of the project site. The flow records from 1965 to 1977 were adopted for the project energy production estimate. This period was determined to be representative of long-term average conditions.

The flood discharge frequency relationships included in the Flood Plain Information Reports for the Farmington River at Canton and Avon, and the Corps' reservior operations manual for Colebrook River, Mad River and Sucker Brook Dams and Reservoirs were used in determining potential flood flows. Flood flow assessments were correlated with the information shown on Flood Profile Drawings and Flood Hazard Maps of the U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Insurance Study, as well as the Corps' Flood Plain Information reports.

Geotechnical Data

A reconnaissance engineering geologic investigation is included as Appendix B to this report.

Maps, Drawings, and Field Investigations

U. S. Geological Survey topographic maps, Northeast Utility transmission and distribution system maps, partial "as-built" drawings of the existing dams, flood plain information and flood insurance maps were used. Additional site data were obtained during site investigations.

Manufacturer Data

Cost, performance data, and descriptive information for different types of equipment were obtained by means of special submittals from various manufacturers. The manufacturers and the type of information obtained included the following:

Manufacturer	Subject of Data
Allis-Chalmers	Turbines, governors, speed increasers, generators, and controls
James Leffel Company	Turbines and governors
F.W. Stapenhorst (Ossberger)	Turbines, generators, governors, speed increasers, and controls

Additional data were obtained from various manufacturers' catalogs and technical information including those of General Electric, Westinghouse, Onan Power System, Beloit Power Systems, Philadelphia Gear Corporation, Armco Steel Corporation, and Pacific Pump Company.

PROJECT GENERATION FACILITIES

The following describes the primary components which make up the project facilities that need to be considered in reactivating hydroelectric generation at the Upper and Lower Dams and Power Plants.

Cofferdamming and Dewatering

Timber bulkhead cofferdamming is anticipated upstream of the Upper Power Plant. The bulkheads can be placed across the uncontrolled inlet through the existing dam. An earth embankment cofferdam constructed from local borrow sources will be used downstream of the Upper Power Plant and both upstream and downstream of the Lower Power Plant.

Forebays and Inlet

The existing trashracks will be removed, cleaned, and inspected and repaired as needed. Damaged sections should be replaced and the rack shall be recoated for corrosion protection and reinstalled.

The headgate and wasteway gate should be removed and replaced. Steel bulkhead type gates with manual hoists will be used for the alternatives with wicket-gated, fixed blade propeller turbines. Roller gates with motor operating lifts will be used for the adjustable blade propeller tube turbines. Conventional slide gates with manual pedestal lifts will be used with the cross flow turbines. Structural steel stoplogs should be provided for installation upstream of the gate for closure for gate inspection and maintenance.

The entire forebay should be dewatered and thoroughly inspected for any structural deterioration or damage. Structural repair and patching should be performed as necessary.

Gate House

The Lower Dam gate house will be cleaned, repaired, and remodeled as needed. The headgate will replaced and the existing belt-driven hoist will be refurbished.

Powerhouses - Rehabilitation

The powerhouses should be completely cleaned and refurbished. The water supply facilities should be replaced and doors, broken windows, and roof tiles replaced; metal work should be cleaned and repainted as necessary. It is anticipated that the existing cranes will be rehabilitated. Provisions have been included for nominal ventilation facilities. The installation of sump pumps will be required for the Ossberger alternatives.

Structural rehabilitation would include relatively minor repairs of spalling and surface cracking of concrete.

Powerhouse Expansions and Modifications

Installation of the Ossberger turbines will necessitate removal of the existing generator floors and modification of the turbine floor levels as shown in Figures IV-6 and III-11. A single Ossberger unit installation at the Upper Plant will require some expansion of the turbine room to provide adequate space for the generating units. The building superstructure will not be modified.

Installation of two units at the Upper Power Plant will require expansion of the powerhouse as is shown on Figures III-1 and III-2. The new substructure construction will be conventional reinforced concrete construction, while the superstructure walls will be reinforced brick designed so that expansion will be identical in appearance to the existing building. A tile-covered, steel-truss-supported roof, similar to the existing one, will be provided.

At the Upper Power Plant the existing spiral case and elbow type draft tube would be used with slight modification for the installation of one of the Leffel propeller turbines while the second unit would be in an open flume setting.

The Allis-Chalmers units would require the construction of elbow type draft tubes for all units. This will necessitate base slab removal and some rock excavation beneath the existing Lower Powerhouse. This work will require temporary shoring and will need to be performed with great care.

Structural steel-supported, grating-type maintenance platforms would be provided where shown on the drawings for use in equipment and bulkhead removal and installation.

Diversion Dams

Wooden plank flashboards with steel pipe supports will be installed on both dams. Flashboard height will be three feet on the Upper and five feet on the Lower Dam as was used historically.

The ravelled crest of the Lower Dam will be repaired by removal of the deteriorated concrete and replacement by shotcreting or guniting. This work would be performed during periods of low river flows when the upstream water level can be lowered by diversion through the power plant and the existing right bank sluice gates.

Tailrace

The tailrace channel at both plants will be cleaned of debris and sediment and reshaped as necessary. The tailrace training wall at the Upper Plant will be inspected and repaired as needed.

Access and Parking

The asphalt paved parking area at the Upper Plant will be enlarged and repaved.

At the Lower site the Blanchard Road access will be graded and gravel surfaced to the gate house and dam as shown on Figure II-2.

Turbines, Governors, and Speed Increasers

As indicated in Table III-1, the generating unit alternatives were developed from three basic turbine types based on data received from three manufacturers. All of the turbine types are technically adequate for use in the project. There will be varying degrees of modification required for the interior of the plant as well as differences between the turbine types. The cost, performance and other technical data received from the manufacturers is preliminary in nature and a definite determination of the most appropriate equipment type and manufacturer should not be made from this information. Firm bid prices, guaranteed performance data and delivery times, and complete dimensional data and weights for use in determining civil works requirements are needed before a final equipment selection can be made. Each of the turbine types and the more significant factors relative to their installation for this project are described in the following paragraphs. Efficiencies of the various turbines are shown in Table III-2.

Fixed Blade Vertical Propeller Units -- Alternatives, Upper 1, 2, 3 and Lower 1 and 2. The James Leffel & Company provided data on the fixed blade propeller units with wicket gates and UG type Woodward governors.

At the Upper Plant one of the units would be installed in the existing semi-spiral case and elbow draft tube. A second unit would have a conical draft tube and would be in an open flume setting as would both of the units at the Lower Plant. These would require less significant structural modifications than the other turbines investigated.

As shown in Table III-2, these units are characterized by efficient operation but with a more restricted operating range than the other alternatives. Without speed increasers these units require relatively low speed and costly generators.

The manufacturer indicates that these units can be delivered in about nine months.

Cross Flow Unit -- Alternatives, Upper 4 and 5, and Lower 3. The F. W. Stapenhorst Company provided data for cross flow turbine generating sets as manufactured by Ossberger of West Germany. These units are of a radial, modified impulse-type turbine with cylindrical runners. The flow to the units is controlled by adjustable guide vanes that can be closed, thereby providing the function of upstream valves or gates. The units are provided with draft tubes for full head recovery.

The generating sets include a flywheel to aid in control of speed during load changes. The turbines are low speed and double reduction speed increasers are therefore provided to permit the use of high speed standard generators.

To prevent water column separation and loss of head the manufacturer recommends a maximum draft head of 13 feet. To meet this requirement it will be necessary to remove the generator floor and install the generating set on the modified turbine floors. However, the manufacturer also indicates that they may be able to accommodate the existing draft head, but that additional design studies and possibly testing would be necessary before this can be guaranteed.

The turbine efficiency will be slightly lower than for other types at full load; however, due to the guide vane system and the runner characteristics, the performance curves are quite "flat", and the units will operate over a wider range of flow. The efficiencies will vary from around 83 to 85 percent at full load to around 80 percent at one-sixth load. Woodward governors would be provided for control of the inlet guide vanes.

The manufacturer indicates that around 14 months will be required for delivery and that about 65 percent of equipment and materials will be of North American origin.

Adjustable Blade Vertical Tube Units -- Alternatives, Upper 6 and 7, and Lower 4 and 5. Allis-Chalmers provided data on complete generator units including the turbine, a right-angle bevel-spiral gear speed increaser, generator, blade positioner (governor), controls and accessories.

These turbines would be installed in open flume inlets with roller type headgate for startup and close control. Elbow-type draft tubes are required, resulting in the need for more significant structural modifications than for the other turbine alternatives.

The units have good operating efficiencies over a wide range of flow although speed increasers result in about three percent additional losses. The speed increaser provides for the use of standard low cost horizontal generators.

Generators

The generator types vary according to the turbine manufacturer and powerhouse site. Specific ratings for the generators considered under each alternative are given in Table III-1. A brief summary of the type of generators considered with respect to turbine manufacturer is as follows:

Allis-Chalmers: The generator is part of the Allis-Chalmers standardized package and is a horizontally mounted, two-bearing, synchronous, high speed machine rated 4160 VAC, 3Ø, 60 Hz.

Ossberger: The generator is part of the Ossberger turbine-generator package and is a horizontally mounted, two-bearing, synchronous, high speed machine rated 480 VAC, 3Ø, 60 Hz.

Leffel: The generator is a synchronous, slow speed machine rated 480 VAC, 3Ø, 60 Hz.

Excitation Equipment

The excitation for the Ossberger and Allis-Chalmers alternatives is supplied by full wave rectified, brushless exciters and the equipment is mounted on the generator by the manufacturer. The excitation for the Leffel alternative is supplied by a separate static exciter and is mounted together with the control and voltage regulation in a metal-clad cabinet. Voltage regulation for all alternatives is automatic and is solid state.

Switchgear and Control

The type and rating of the power circuit breakers depend upon the voltage of the generator and are as follows:

Allis-Chalmers:	5 kv metal-clad switchgear
Ossberger:	480v low voltage switchgear
Leffel:	480v low voltage switchgear

The measurement, indication, metering, protection and control equipment will be consistent with the type of switchgear and will be standard switchboard quality. Control equipment will provide for automatic operation of the plant and will utilize reservoir water level as the controlling parameter. Devices will provide interface between operator and equipment. Points for remoting alarms would be furnished. Protective devices will protect equipment from unnecessary damage due to malfunctions and failures.

The 5 kv switchgear would be located outdoors in a weather-proof enclosure. The 480v switchgear would be located indoors. In both cases the control, protection and metering equipment would be located indoors.

Station Service

Station service would be provided from the utility distribution system. A 50 kva, 4800/480-120v, 3Ø distribution transformer with service entrance and panelboard would provide station power for auxiliaries, lighting and maintenance.

Utility Connection

A power transformer for connection to HELCO distribution system and for plant isolation was considered. The power transformer is sized according to plant capacity for each alternative. For the purpose of this study, outdoor oil-filled, pad-mounted-type transformers with fuse protection are used. Shielded copper cable with XLPE insulation and PVC jacket is used for 4160v and 23 kv applications. Type THW 600v stranded copper cable is used for 480v applications.

Grounding

The plant ground system is based on use of buried 4/0 copper cable, in accordance with IEEE Standard No. 80.

Lighting

Plant lighting is based on utilizing Hi bay fixtures with 400 watt metal Halide lamps and 4-foot fluorescent fixtures for safety lighting. The assumed maintained lighting level employs 50-foot candles indoors and five-foot candles outdoors.

Ventilation Duct and Fan

Exhaust fans and ducting are included to provide a nominal ventilation of the power plants of around 10 air changes per hour.

Sump Pump

With the Ossberger units a float-switch controlled sump pump would be provided in the generator floor. The pump will have a minimum capacity of about 1 gpm for each 300 square feet of submerged wall area.

Service Pump

A service pump will provide for a general water supply and speed increaser cooling water. This pump would also be used for dewatering of the turbine pits and draft tubes.

Ice Prevention System

Ice formation on the fish screen louvers and trashrack shall be prevented by means of a bubbler system.

The bubbler system would consist of an air compressor with pipe outlets at 10-foot spacings just below the bottom of and upstream of the fish screen louvers. The system shall provide two cfm of air at 30 psi pressure to each nozzle.

Optional Town Distribution Line

The optional distribution line would be a 4160v underground system using direct burial 5 kv shielded and jacketed XLPE insulated copper cable. The sizes used are 4 AWG for service taps and 2/0 AWG for the main distribution feeder. The cable would be run in conduit where it passes under streets. Concrete access vaults are provided at service tie-in points.

Optional Distribution Transformers

Distribution transformers to be used with the optional distribution line are sized according to the existing services and would be the pad-mounted, oil-filled type.

Optional Diesel Engine Generating Sets

For Backup two 500 kw/480v/3Ø diesel-driven generating sets were used. The generating sets would be furnished with automatic sequential on-line connection and automatic load shedding capability. The generating sets would be housed in a prefabricated steel building.

FISH FACILITIES

Preliminary layouts of the proposed fish facilities in connection with the development of the Canton Hydroelectric Project are shown on Figure III-15 and III-16. The design of the facilities are predicated on providing the functional requirements outlined in the report, "Farmington River Atlantic

Salmon Program and Passage Requirements at the Collinsville Dams," as prepared by the State of Connecticut, Department of Environmental Protection, and included in Appendix D. The facilities herein described are intended to provide a functionally equivalent and possibly more economical solution to the fish passage requirements in connection with the proposed hydroelectric project. The design is based on the preliminary report prepared by Mr. Milo C. Bell and included in Appendix D to this report.

Fishways

The proposed fishway would be of the pool and overflow weir type with dimensions of five feet by five feet with eight foot pool lengths and one-foot drop between pools. The fishways would have single weir notches and would operate with a flow of around five cubic feet per second. Flow inlets would be provided at two levels so the fishway will be operable when the flashboards are either installed or removed. Attraction water will be supplied to the lowest fishway pool at amounts equal to at least three percent of the counter attraction or power plant flow. The attraction flow will be pumped, with a gated backup gravity feed that will automatically open if the pump fails to operate, and will enter the fishway through a diffuser. A secondary side entrance to the fishway will be provided for periods when water is being spilled through the wasteway gates. The fishway entrance will be of the V-trap type. The fishway will be of reinforced concrete construction.

The fishway would enter the power plant intake channels. The maximum flow velocity in the channel would be around four feet per second at a flow of 3,000 cubic feet per second and less than two feet per second under normal operating conditions. The intake channel entrance opening in the Upper Dam and gate openings in the Lower Dam gate house would be enlarged to reduce the maximum flow velocities to less than six feet per second. In addition, two of the six gate bays at the Lower Dam gate house would be "roughened" by means of wooden slats to provide an added fish attraction.

Spill and Barrier Facilities

To assure that upstream migrants will be attracted to the fishways, all river flow up to 3,000 cubic feet per second will either be passed through the power plant or will be spilled through the wasteway gates adjacent to the plant and there will be no spill over the dams. The gates will be motor operated with a standby power source and will be actuated by a water level sensing device located in an upstream stilling well. The gates will be opened automatically when the river flow exceeds the power plant capacity and when there is a plant failure. Rock or concrete barriers and/or excavated channels will be provided to direct the flow toward the fishway entrances.

At the Lower Dam and Power Plant, a low concrete or rock and gabion fish barrier will be constructed across the river at a uniform elevation to prevent fish movement that may occur as a result of small flows that result from flashboard leakage.

A review of the 1965-77 river flow records shows that flows in excess of 3,000 cubic feet per second have occurred only 10 times during the upstream migration periods of April 1 to June 30 and September 15 to November 15 for the 12-year period.

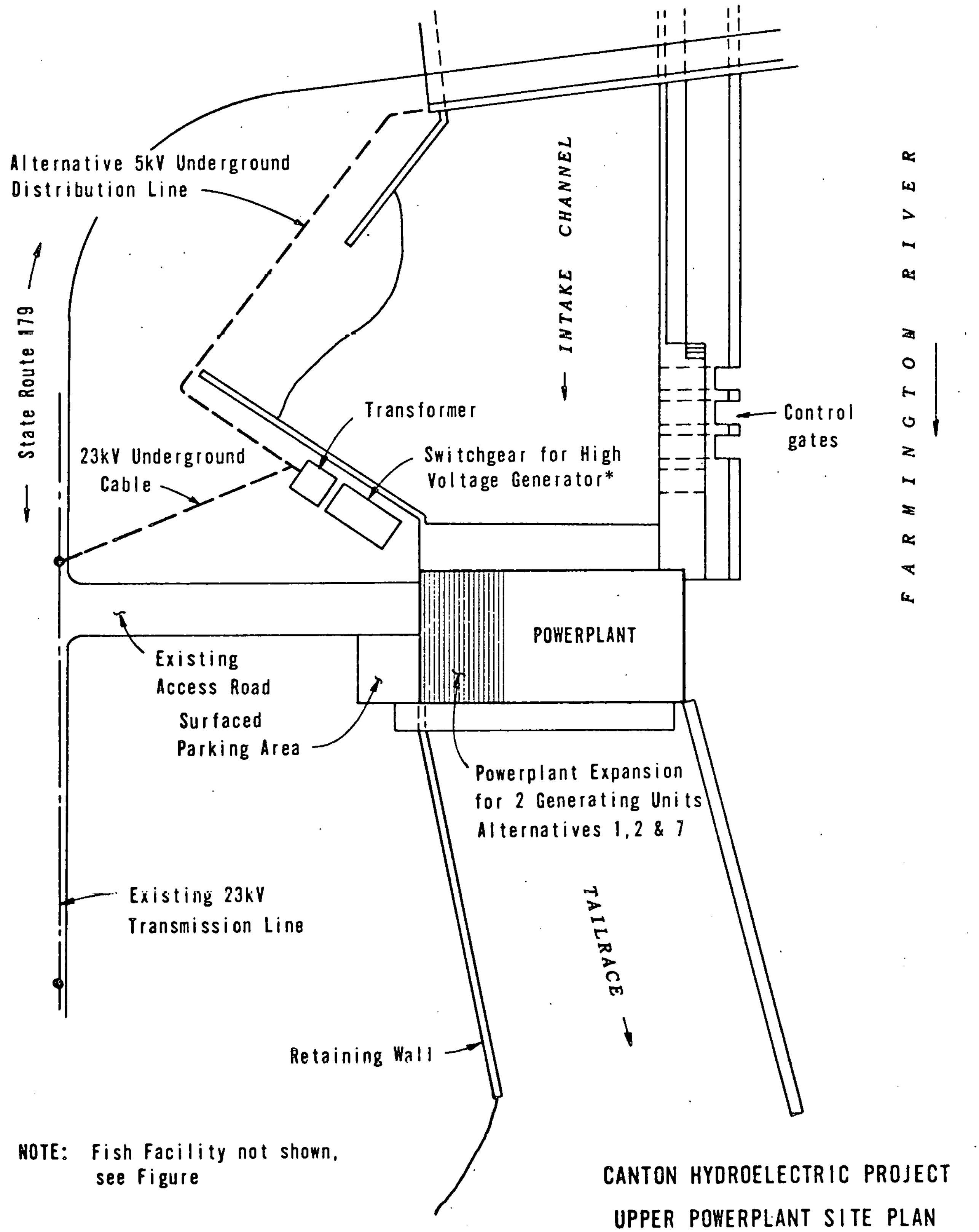
Downstream Migrant Facilities

A conventional vertical louver screen will be provided to prevent downstream migrants from entering the turbines. A bypass inlet will be located at the apex of the screen and the bypass conduit will discharge into the fishway. The screen angle is set at approximately 15 degrees to limit the velocities through the louver to less than 0.5 foot per second under normal power operating conditions and 1.5 feet per second under the 3,000 cubic feet per second flow condition. The last five feet of the louver screen and the bypass inlet will be constructed to allow for field adjustment of screen and louver angles so that an optimum configuration can be established based on actual operating experience. The louver spacing will be approximately one inch and flow straightening vanes will be provided at about 6-inch spacings.

A structural steel beam and grating maintenance platform on concrete piers will be provided immediately downstream of the louvers.

PROJECT ALTERNATIVES

Detailed cost and economic studies were performed on 10 project alternatives as shown on Table V-19. Included are seven combinations of Upper and Lower Power Plant alternatives and three alternatives of Upper Plant redevelopment only.



NOTE: Fish Facility not shown, see Figure

* Switchgear for Low Voltage Generator Alternative is Located in Powerplant

CANTON HYDROELECTRIC PROJECT

UPPER POWERPLANT SITE PLAN

ALTERNATIVES 1,2,3,6 & 7

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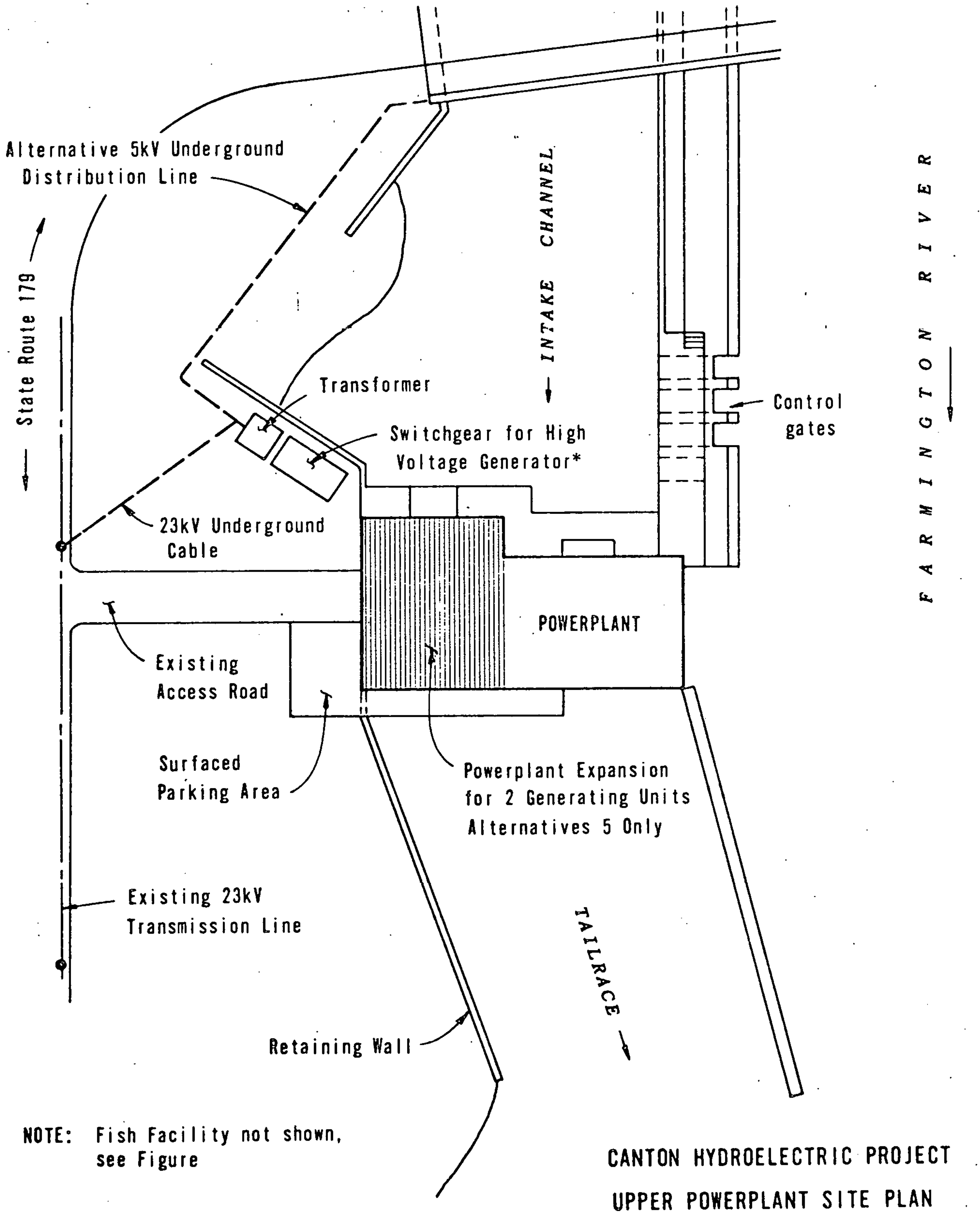
Figure III-1



NOTE: Fish Facility not shown, see Figure

* Switchgear for Low Voltage Generator Alternative is Located in Powerplant.

CANTON HYDROELECTRIC PROJECT

UPPER POWERPLANT SITE PLAN

ALTERNATIVES 4 AND 5

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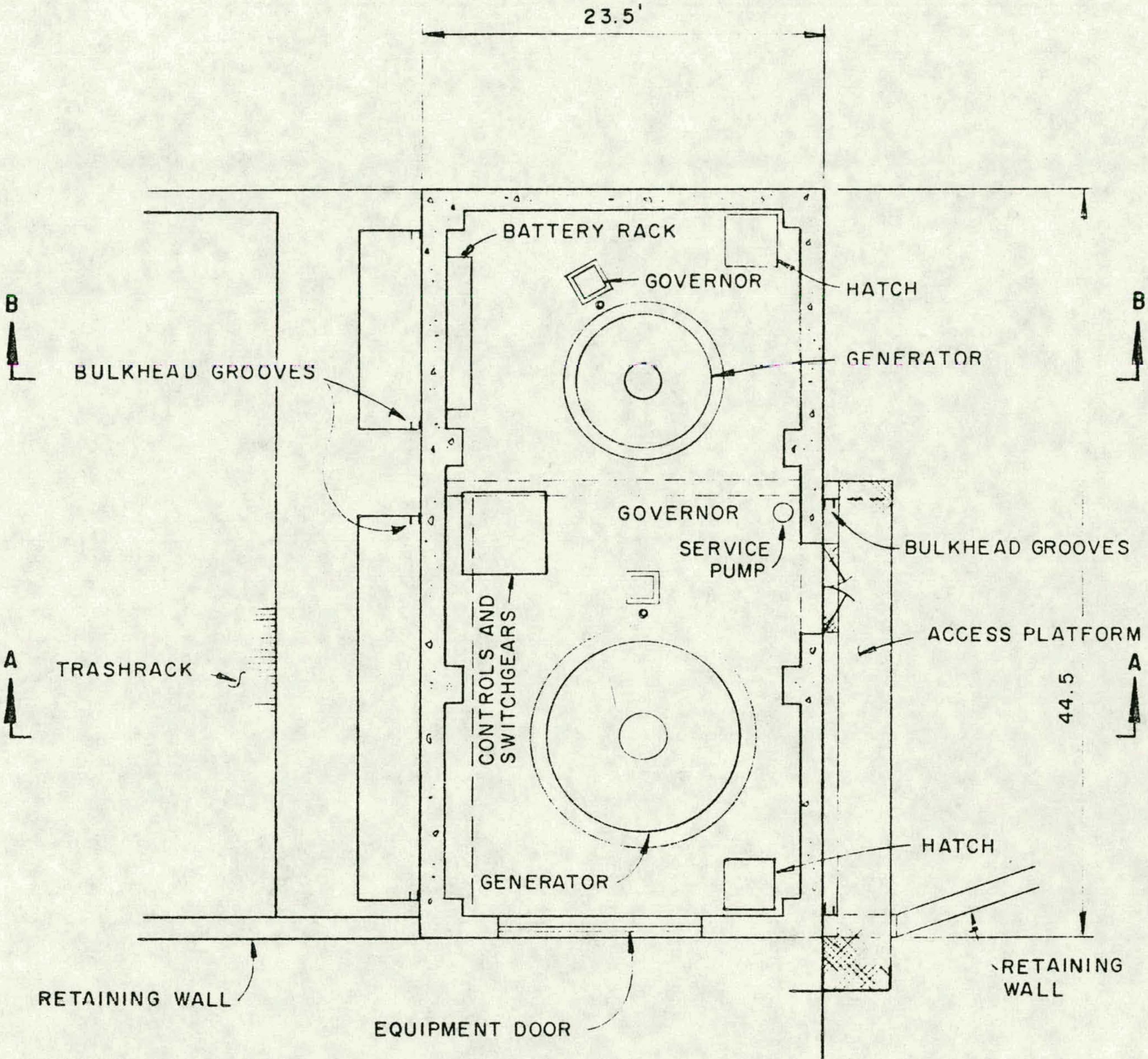
Figure III-2



PLAN

Note: Alternative 1 shown, Alternative 2 two small units and Alternative 3 (single unit) similar.

CANTON HYDROELECTRIC PROJECT
UPPER POWERPLANT
ALTERNATIVES 1,2, AND 3

DEVELOPMENT AND RESOURCES CORPORATION
Sacramento, California

Figure III-3

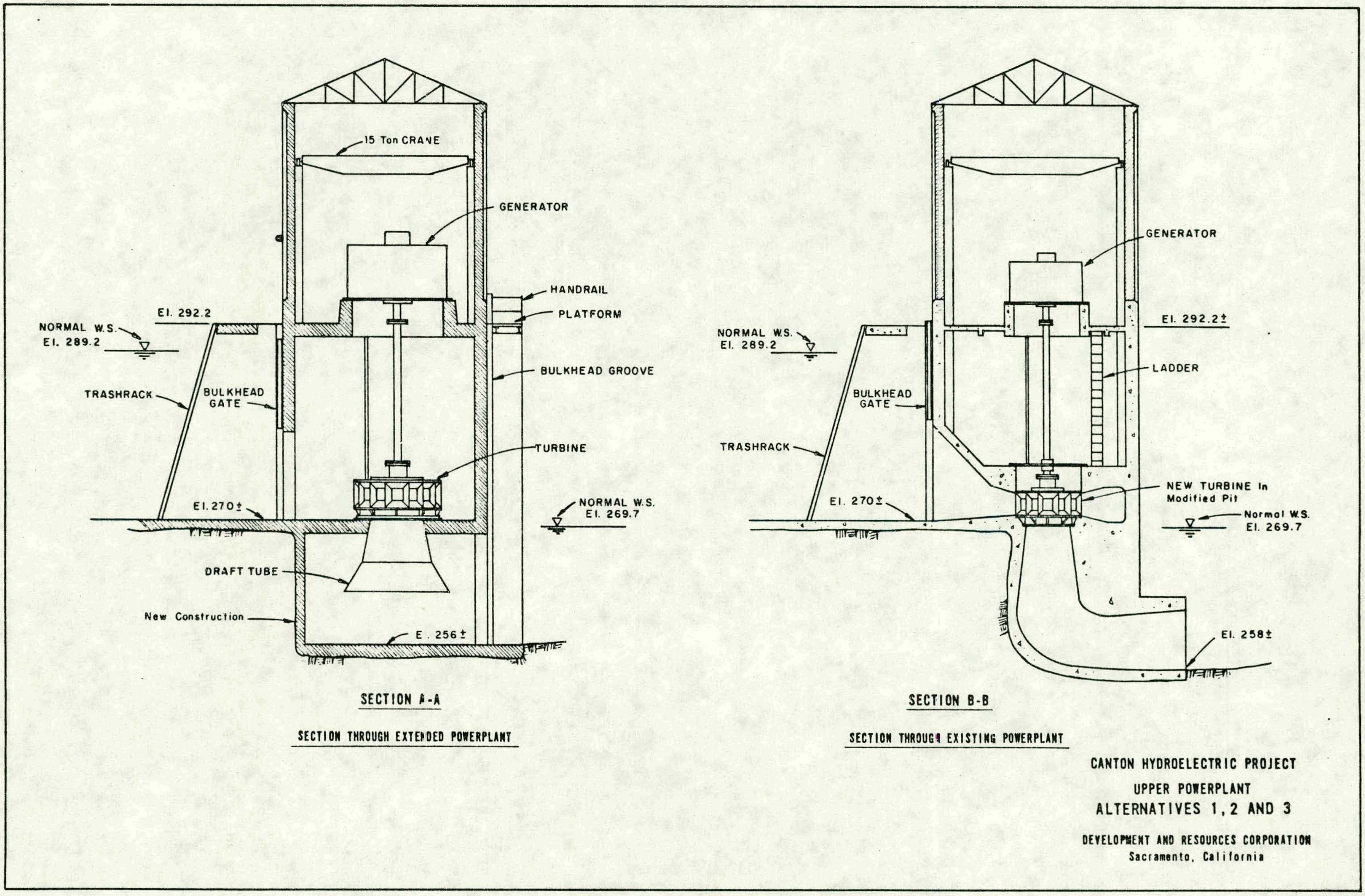
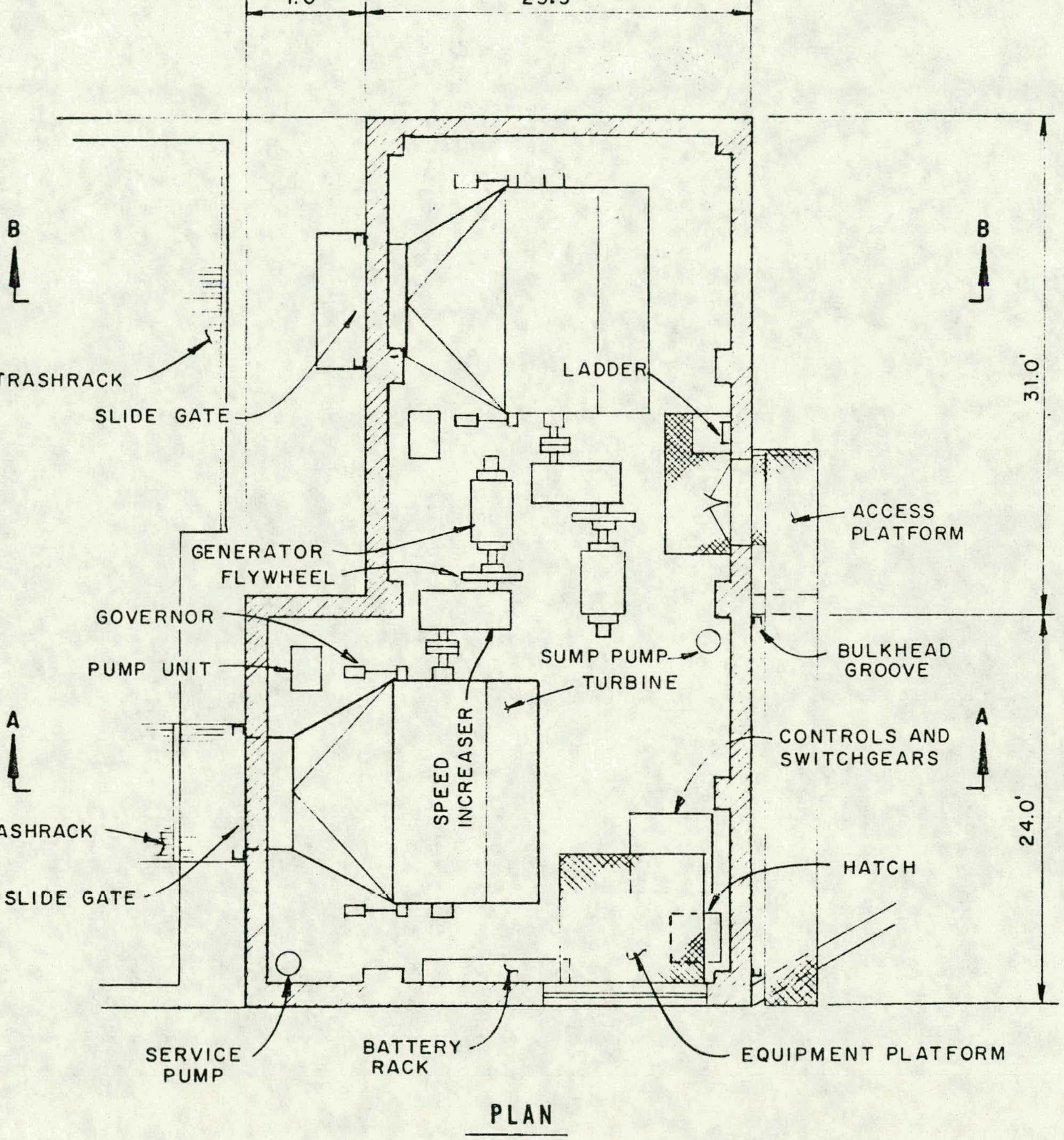

15 Ton CRANE
GENERATOR
HANDRAIL
PLATFORM
El. 292.2
NORMAL W.S.
El. 289.2
BULKHEAD GROOVE
TRASHRACK
BULKHEAD
GATE
TURBINE
El. 270±
NORMAL W.S.
El. 269.7
DRAFT TUBE
New Construction
E. 256±
SECTION A-A
SECTION THROUGH EXTENDED POWERPLANT
GENERATOR
El. 292.2±
NORMAL W.S.
El. 289.2
LADDER
BULKHEAD
GATE
TRASHRACK
NEW TURBINE In
Modified Pit
El. 270±
Normal W.S.
El. 269.7
El. 258±
SECTION B-B
SECTION THROUGH EXISTING POWERPLANT
CANTON HYDROELECTRIC PROJECT
UPPER POWERPLANT
ALTERNATIVES 1, 2 AND 3
DEVELOPMENT AND RESOURCES CORPORATION
Sacramento, California

Figure III-4



Note: Alternative 5 shown, Alternative 4 (single unit) similar.

CANTON HYDROELECTRIC PROJECT

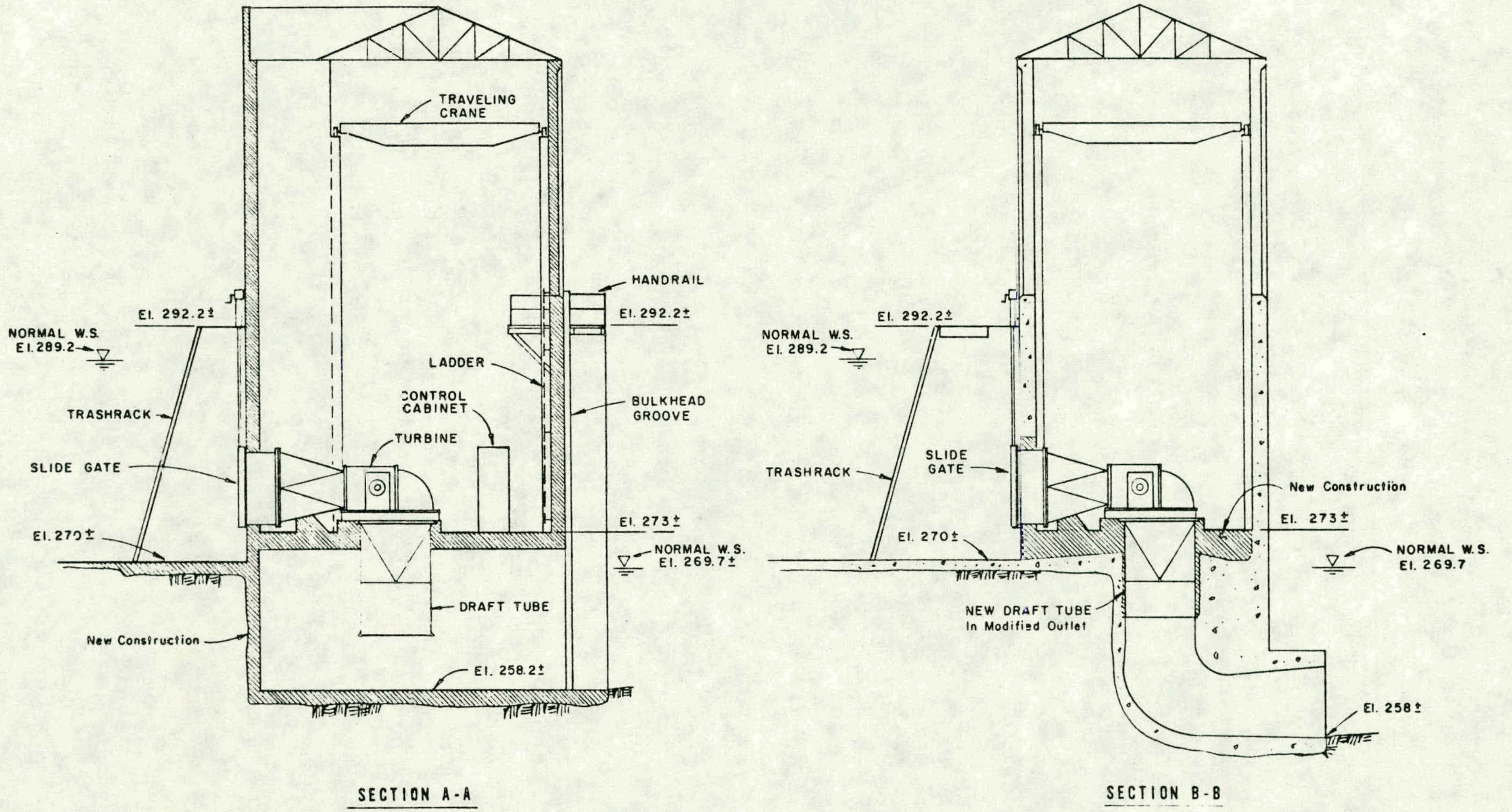
UPPER POWERPLANT

ALTERNATIVES 4 AND 5

DEVELOPMENT AND RESOURCES CORPORATION

Sacramento, California

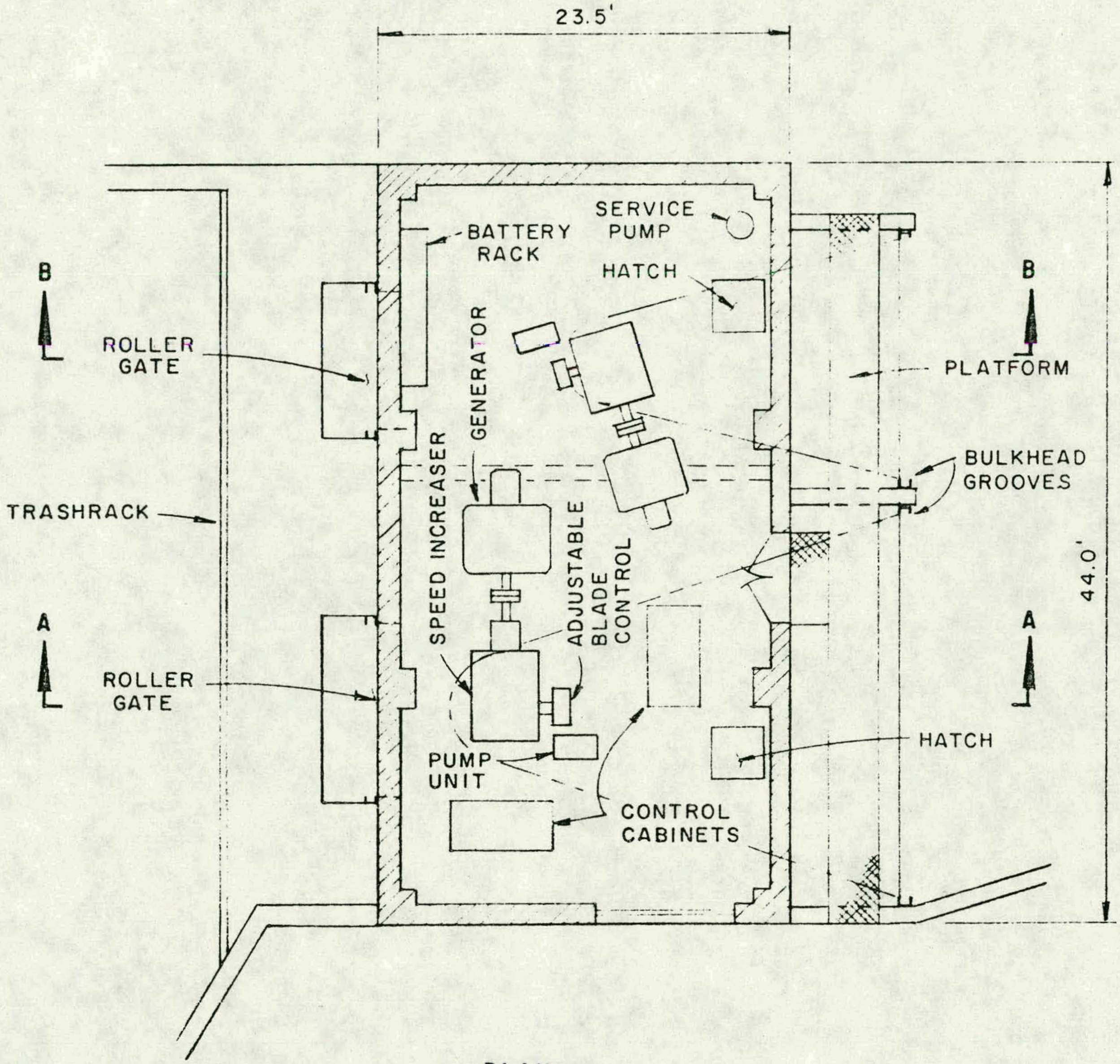
Figure III-5



CANTON HYDROELECTRIC PROJECT
UPPER POWERPLANT
ALTERNATIVE 4 AND 5

DEVELOPMENT AND RESOURCES CORPORATION
Sacramento, California

Figure III-6



PLAN

Note: Alternative 6 shown, Alternative 7 (single unit) similar.

CANTON HYDROELECTRIC PROJECT

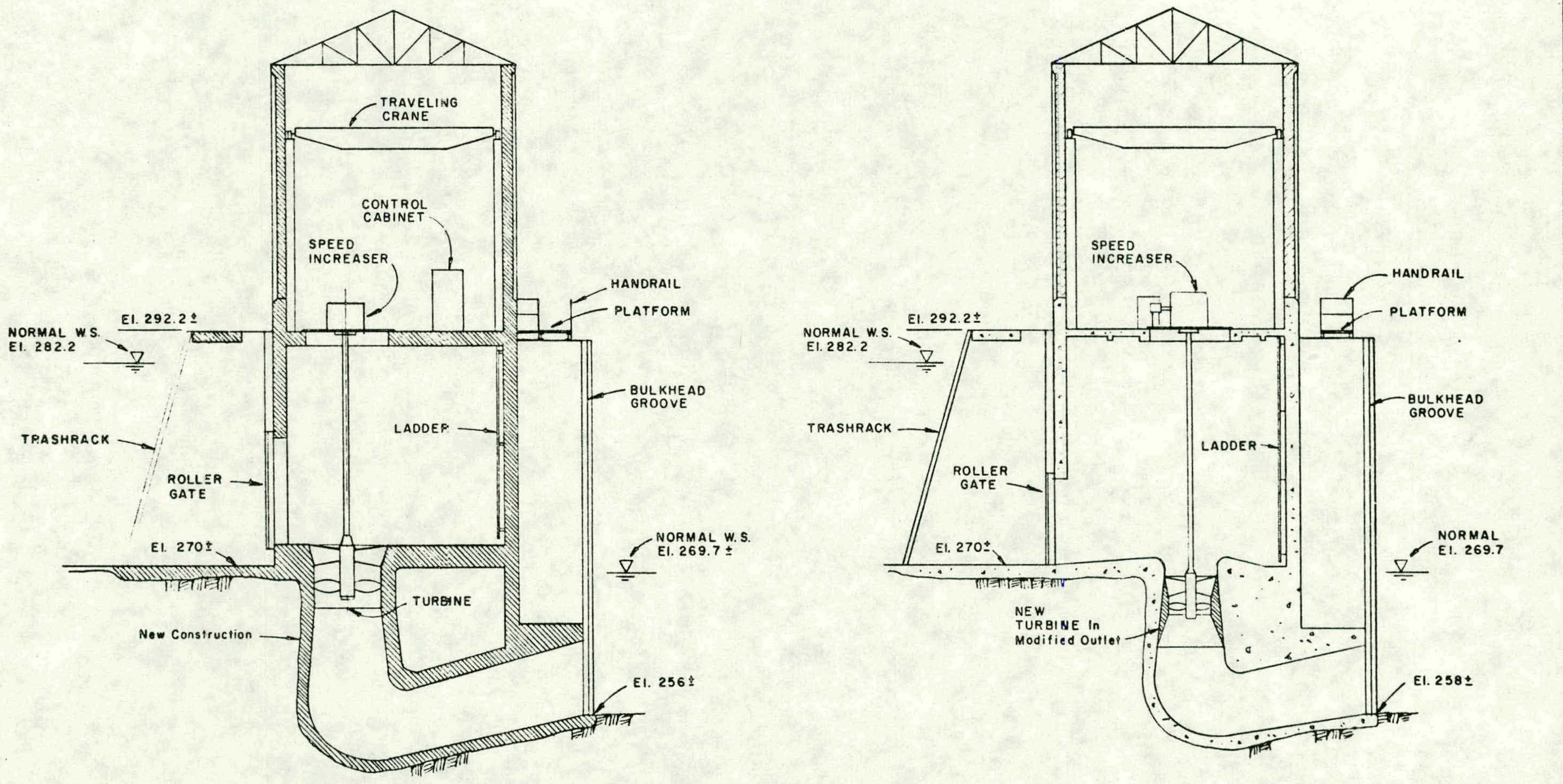
UPPER POWERPLANT

ALTERNATIVES 6 AND 7

DEVELOPMENT AND RESOURCES CORPORATION

Sacramento, California

Figure III-7



SECTION A-A

SECTION B-B

CANTON HYDROELECTRIC PROJECT

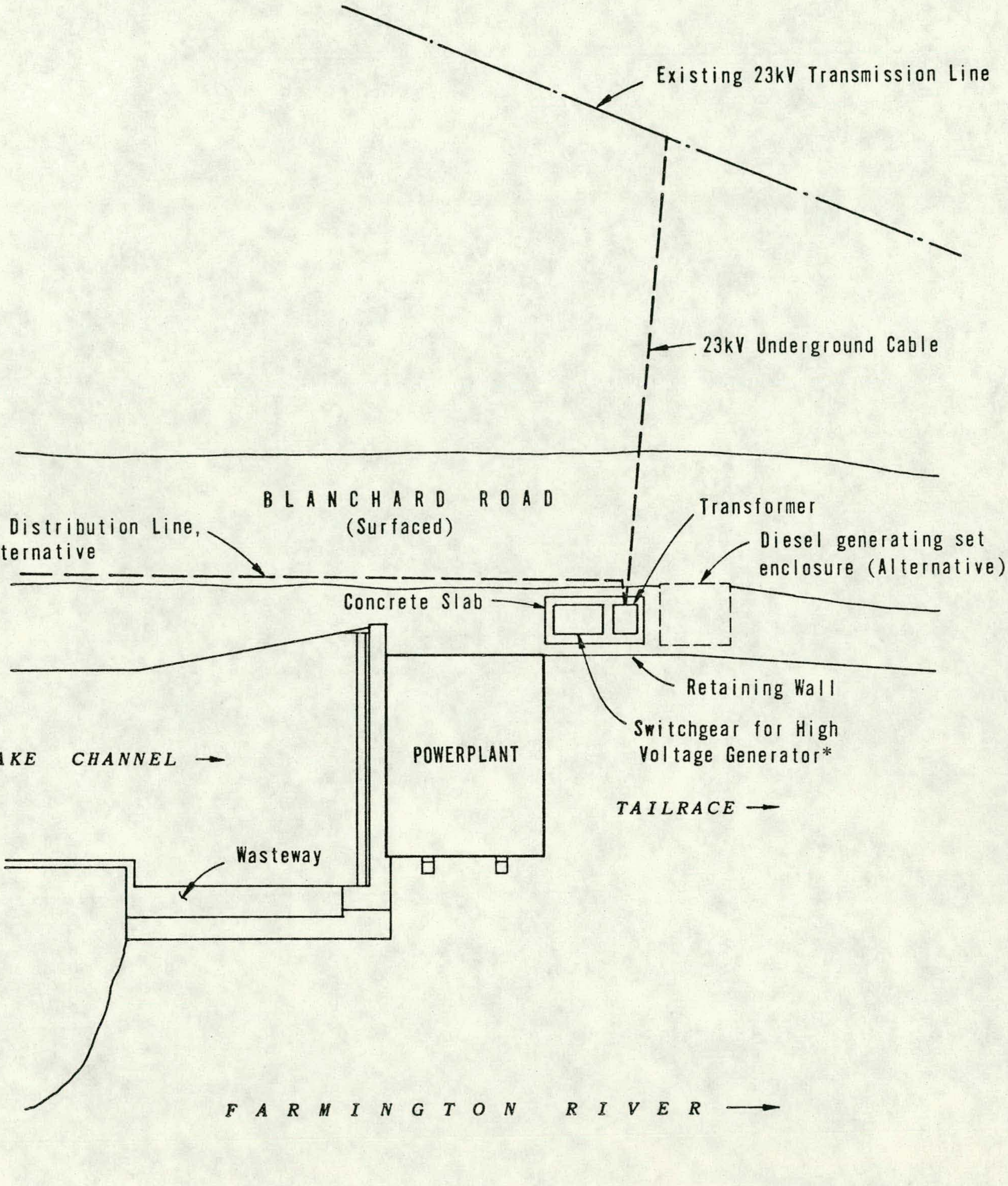
UPPER POWERPLANT

ALTERNATIVES 6 AND 7

DEVELOPMENT AND RESOURCES CORPORATION

Sacramento, California

Figure III-8



NOTE: Fish Facility not shown, see Figure

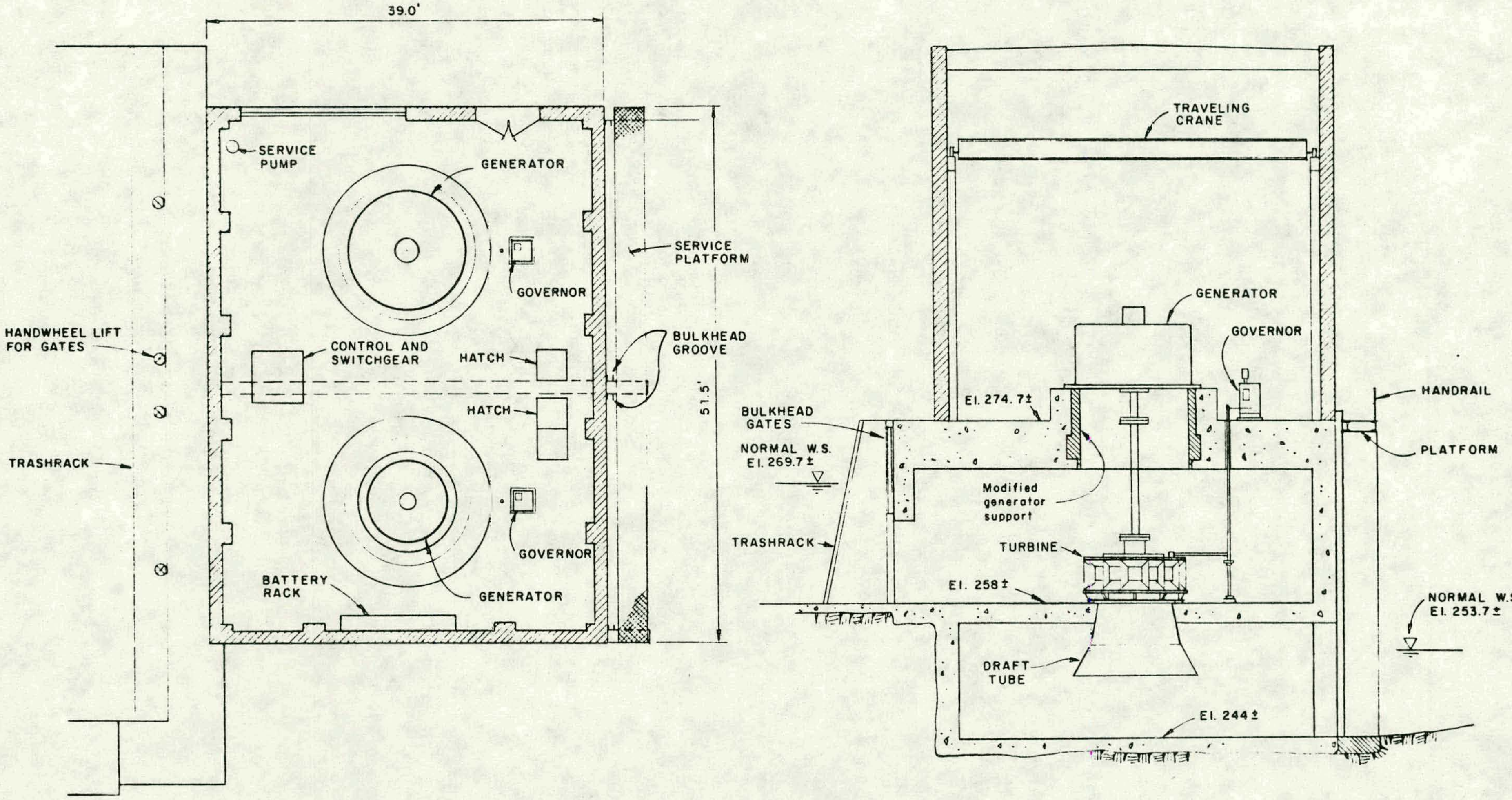
* Switchgear for Low Voltage Generator Alternative is Located in Powerplant

CANTON HYDROELECTRIC PROJECT

LOWER POWERPLANT SITE PLAN

DEVELOPMENT AND RESOURCES CORPORATION
Sacramento, California

Figure III-9

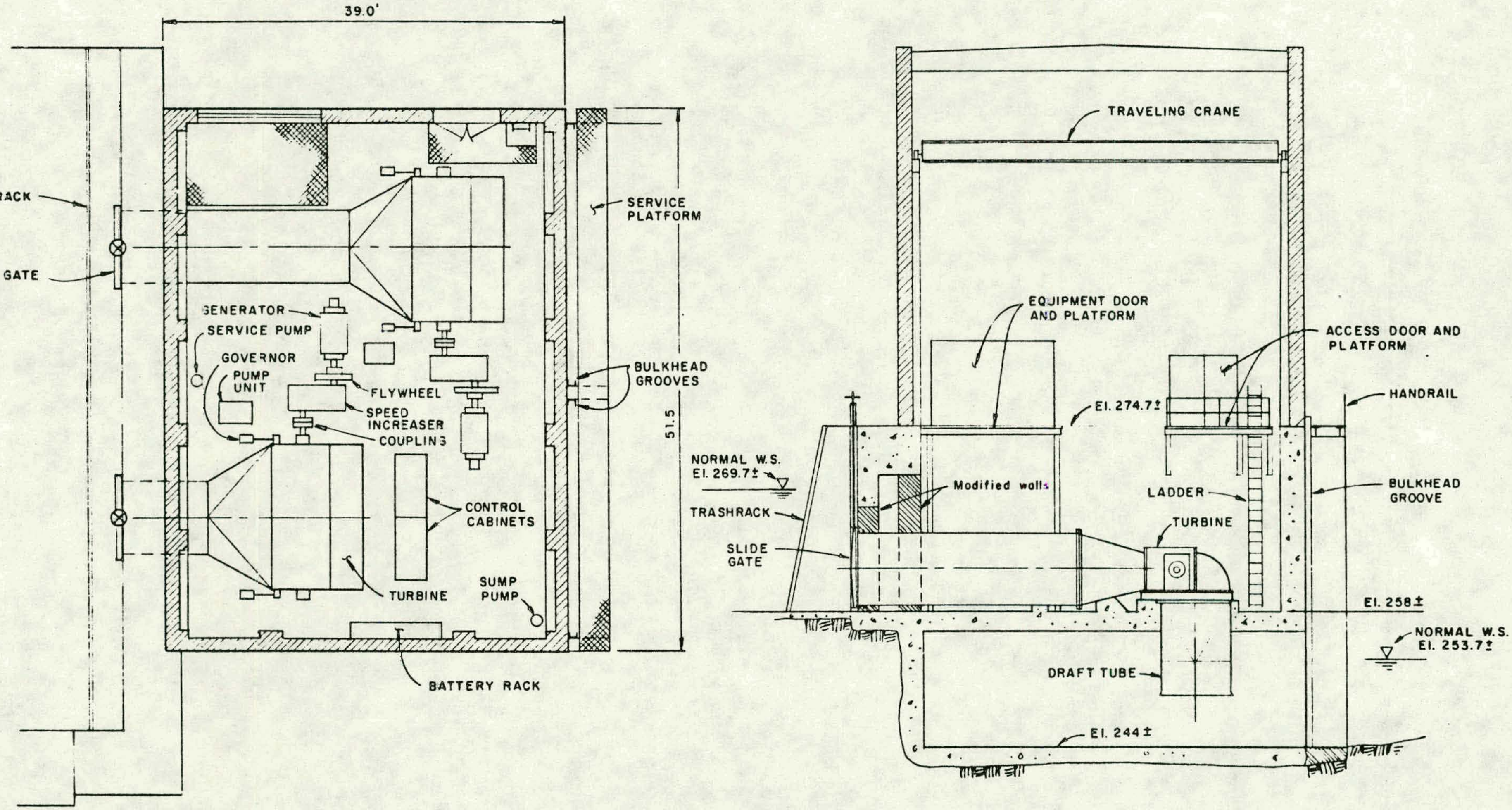


CANTON HYDROELECTRIC PROJECT

LOWER POWERPLANT
ALTERNATIVES 1 AND 2

DEVELOPMENT AND RESOURCES CORPORATION
Sacramento, California

Figure III-10

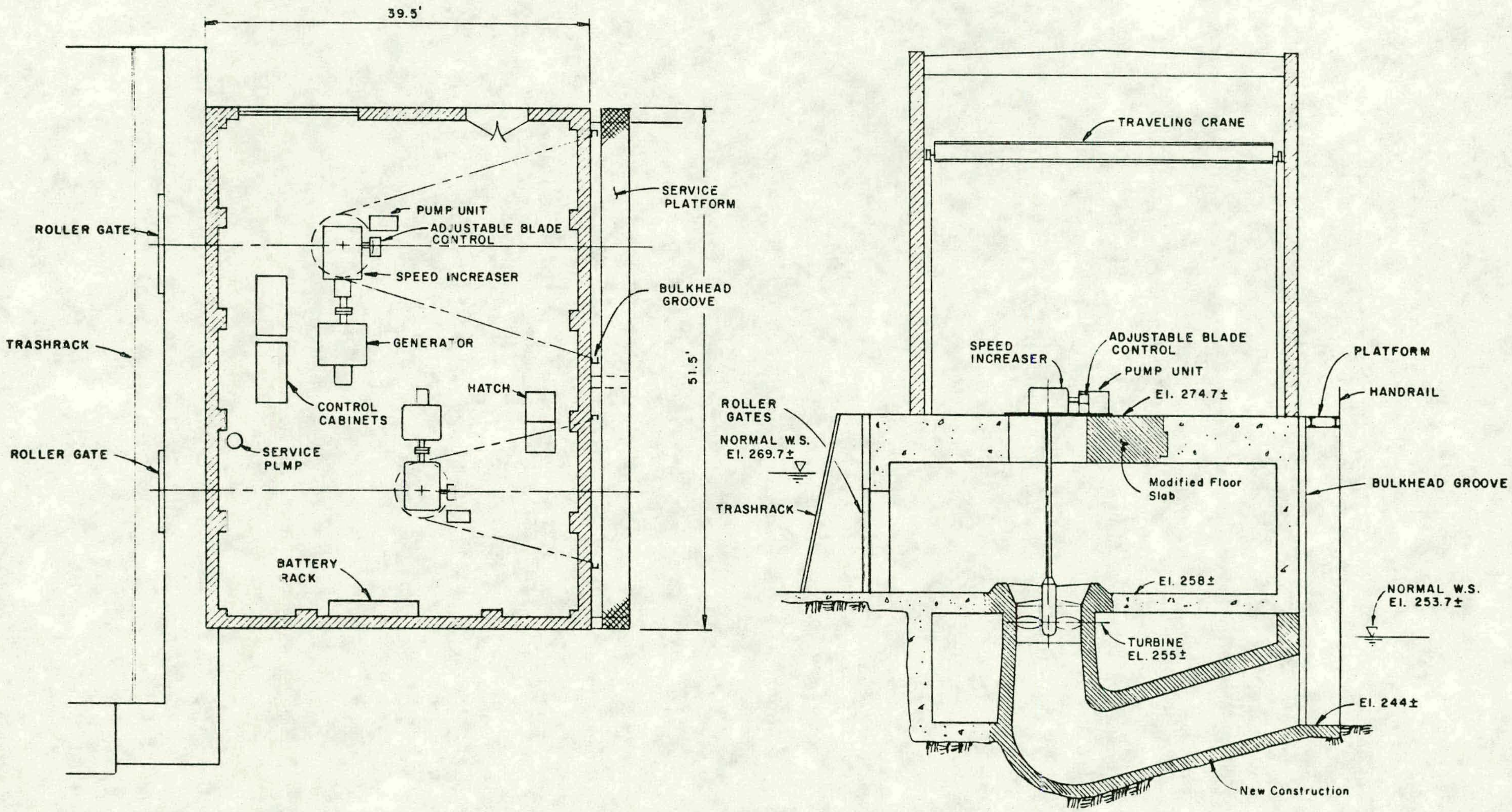


CANTON HYDROELECTRIC PROJECT

LOWER POWERPLANT
ALTERNATIVE 3

DEVELOPMENT AND RESOURCES CORPORATION
Sacramento, California

Figure III-11

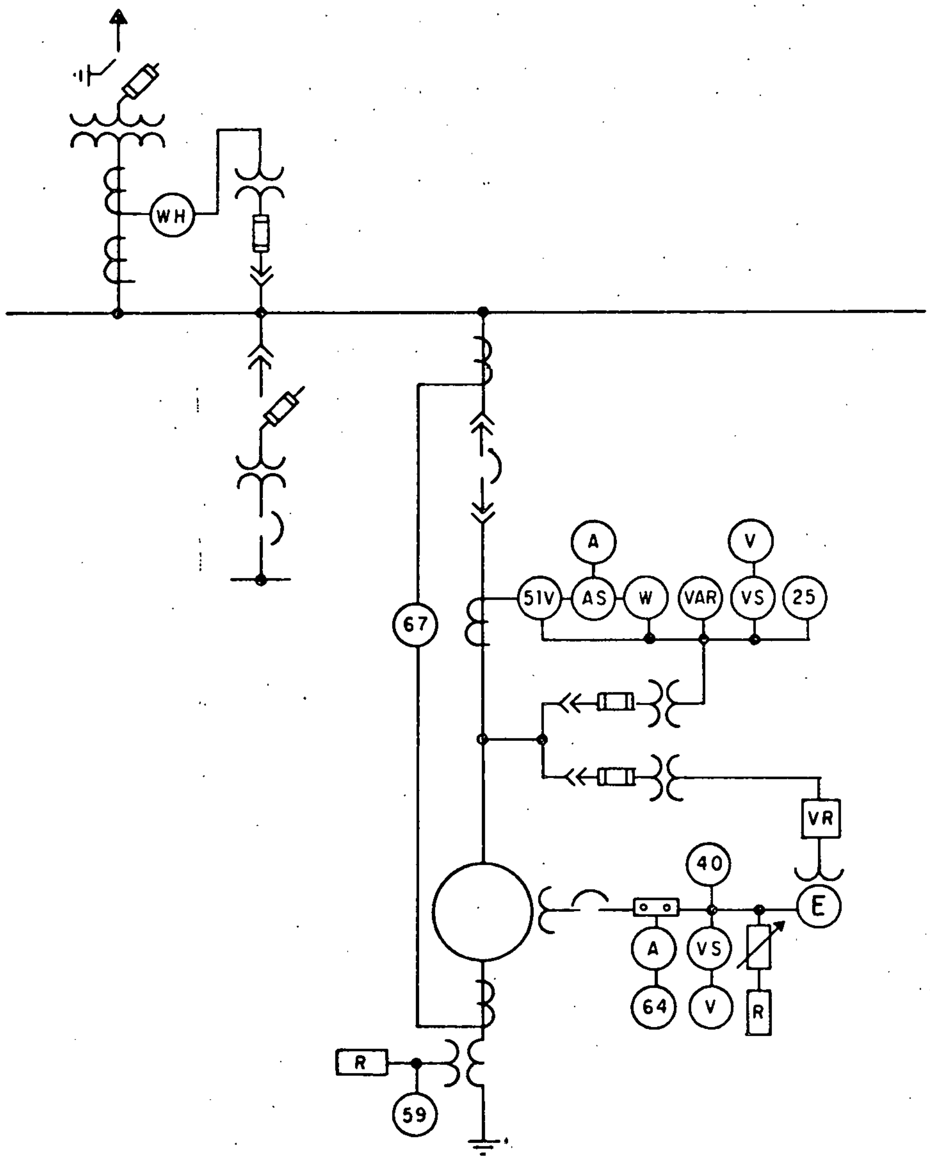


CANTON HYDROELECTRIC PROJECT

LOWER POWERPLANT
ALTERNATIVES 4 AND 5

DEVELOPMENT AND RESOURCES CORPORATION
Sacramento, California

Figure III-12



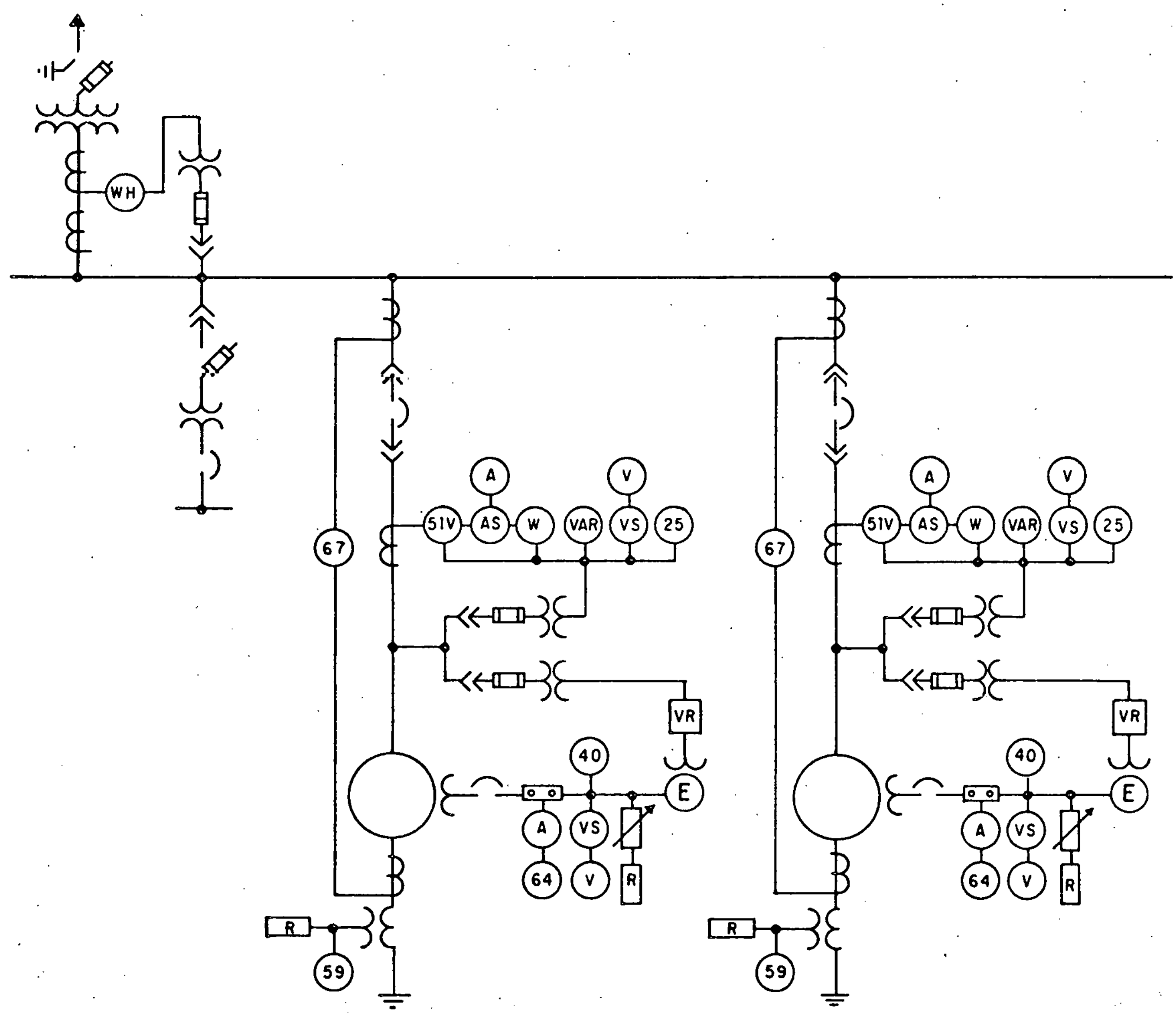
ALT. NO.	UNIT - KW
	UPPER POWERPLANT
3	1 - 530
4	1 - 452
7	1 - 347

CANTON HYDROELECTRIC PROJECT

SINGLE LINE DIAGRAM
ONE UNIT

DEVELOPMENT AND RESOURCES CORPORATION
Sacramento, California

Figure III-13



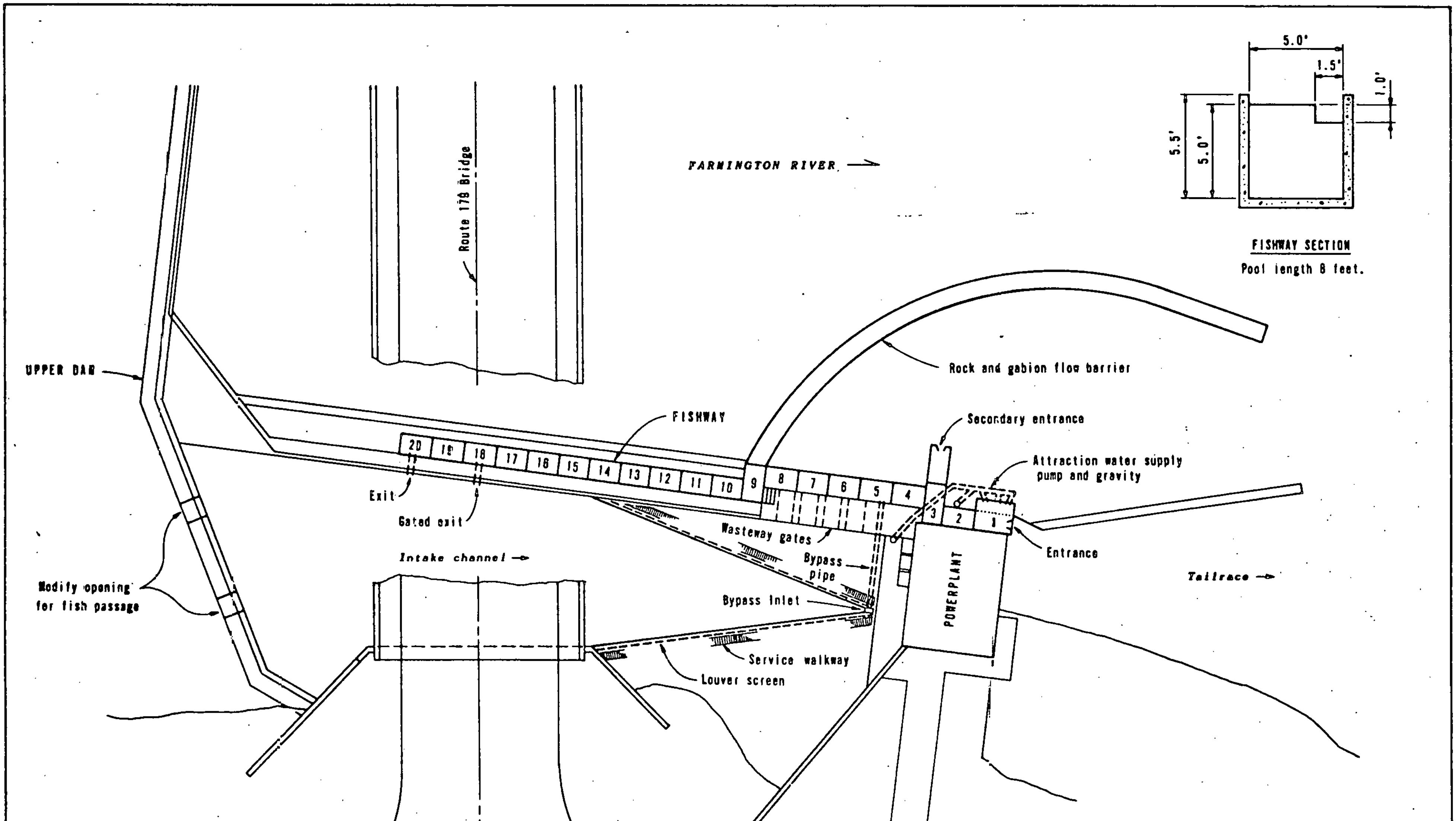
ALT. NO.	UNIT - KW
	UPPER POWERPLANT
1	1 - 530
	1 - 1040
2	2 - 530
5	2 - 452
6	1 - 347
	1 - 895
	LOWER POWERPLANT
1	1 - 380
	1 - 780
2	2 - 380
3	2 - 325
4	1 - 248
	1 - 640
5	2 - 248

CANTON HYDROELECTRIC PROJECT

SINGLE LINE DIAGRAM
TWO UNITS

DEVELOPMENT AND RESOURCES CORPORATION
Sacramento, California

Figure III-14

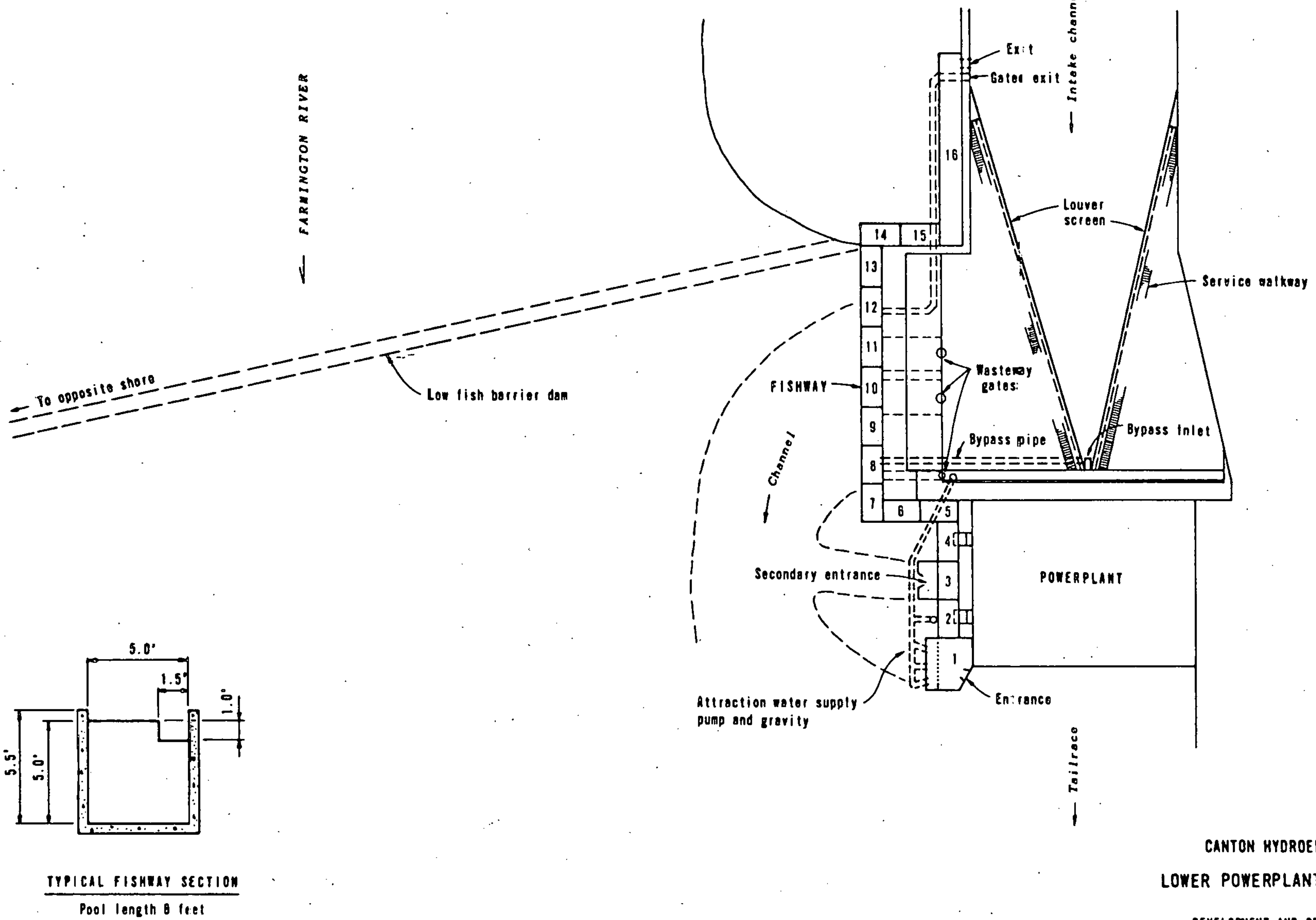


CANTON HYDROELECTRIC PROJECT

UPPER POWERPLANT FISH FACILITIES

DEVELOPMENT AND RESOURCES CORPORATION
Sacramento, California

Figure III-15



CANTON HYDROELECTRIC PROJECT

LOWER POWERPLANT FISH FACILITIES

DEVELOPMENT AND RESOURCES CORPORATION
Sacramento, California

Figure III-16

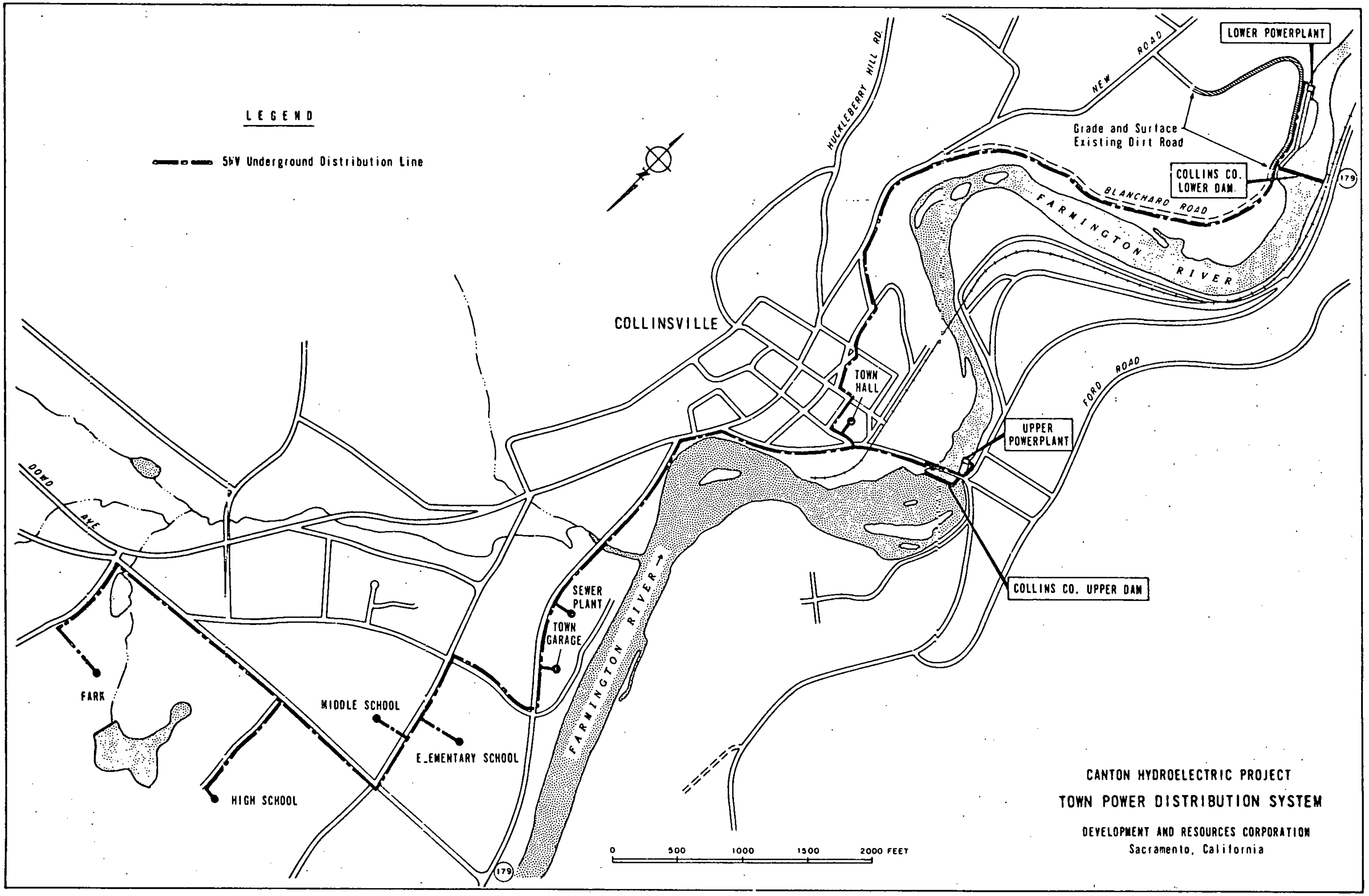


Figure III-17

TABLE III-1

GENERATING UNITS - EQUIPMENT DATA

Turbine Type	Turbine Runner Diameter	Generator Configuration	Output - KW		Speed - RPM				Generator Output Voltage	Turbine Manufacturer
					Turbine		Generator			
			Upper	Lower	Upper	Lower	Upper	Lower		
VPF	42 inches	V	530	380	225	200	225	200	480	Leffel
VPF	60 inches	V	1,040	780	156	138	154	138	480	Leffel
CF	--	H	452	325	85	76	1,200	1,200	4,160	Ossberger
VPA	1,250 mm	H	347	248	285	255	900	900	4,160	Allis-Chalmers
VPA	2,000 mm	H	895	640	200	180	900	900	4,160	Allis-Chalmers

VPF - Vertical Shaft Propeller - Fixed Blades
CF - Cross Flow - Horizontal Shaft
VPA - Vertical Shaft Propeller - Adjustable Blade - Tube Turbine
V - Vertical
H - Horizontal

TABLE III-2

TURBINE EFFICIENCIES

UNIT SIZE KW OUTPUT															
UPPER	530			1040			452			347			895		
LOWER	380			780			325			248			640		
MANUFACTURER	LEFFEL			LEFFEL			OSSBERGER			ALLIS-CHALMERS			ALLIS-CHALMERS		
	Flow-cfs		Eff %	Flow-cfs		Eff %	Flow-cfs		Eff %	Flow-cfs		Eff %	Flow-cfs		Eff %
	Upper	Lower		Upper	Lower		Upper	Lower		Upper	Lower		Upper	Lower	
PERFORMANCE	384	343	86.0	1100	778	87.0	353	318	83.0	262	234	85.0	675	604	85.0
	350	313	90.0	1045	730	91.0	300	370	83.5	241	216	87.5	621	555	88.5
	334	299	89.0	990	676	90.2	248	223	84.0	224	200	90.0	586	524	90.5
	308	275	85.8	880	623	87.0	209	188	83.0	207	185	91.0	551	493	91.5
	283	253	81.7	770	572	83.0	170	153	82.0	190	170	91.0	517	463	92.0
	258	231	76.8	660	522	78.0	111	100	81.0	172	154	90.0	482	431	92.0
	232	208	71.2	550	466	72.8	53	48	80.0	155	139	88.5	448	401	91.3
										138	123	84.5	414	370	89.8
										124	111	80.5	379	339	88.3
													344	308	86.5
													310	277	84.3
													258	231	80.5

TABLE III-3A

GENERATING UNITS - OPERATIONAL ALTERNATIVES

Alternatives Lower Plant	Number and Capacity of Units (KW)	Installed Capacity (KW)	Annual Energy Production (KWH) Yr. 1983	Yr. 2033	Turbine Manufacturer
1	1 - 380 1 - 780	1,160	4,450,000	3,840,000	Leffel
2	2 - 380	760	3,780,000	3,290,000	Leffel
3	2 - 325	650	3,600,000	3,220,000	Ossberger
4	1 - 248 1 - 640	888	4,270,000	3,780,000	Allis-Chalmers
5	2 - 248	506	3,140,000	2,840,000	Allis-Chalmers
6	2 - 780	1,560	4,070,000	--	Leffel
7	1 - 780	780	3,150,000	--	Leffel
8	1 - 380	380	2,120,000	--	Leffel
9	3 - 325	975	4,250,000	--	Ossberger
10	2 - 640	1,280	4,610,000	--	Allis-Chalmers
11	1 - 640	640	3,450,000	--	Allis-Chalmers
12	1 - 380	380	2,2020,000	--	Allis-Chalmers

TABLE III-3B

GENERATING UNITS - OPERATIONAL ALTERNATIVES

Alternatives Upper Plant	Number and Capacity of Units (KW)	Installed Capacity (KW)	Annual Energy Production (KWH) Yr. 1983	Yr. 2033	Turbine Manufacturer
1	1 - 1,040 1 - 530	1,570	5,890,000	5,060,000	Leffel
2	2 - 530	1,060	5,030,000	4,340,000	Leffel
3	1 - 530	530	3,330,000	2,910,000	Leffel
4	1 - 452	452	3,120,000	2,860,000	Ossberger
5	2 - 452	904	4,850,000	4,320,000	Ossberger
6	1 - 895 1 - 347	1,232	5,750,000	5,040,000	Allis-Chalmers
7	1 - 347	347	2,500,000	2,290,000	Allis-Chalmers
8	2 - 1,040	2,080	5,270,000	--	Leffel
9	1 - 1,040	1,040	4,089,000	--	Leffel
10	3 - 452	1,356	5,690,000	--	Ossberger
11	2 - 347	894	4,290,000	--	Allis-Chalmers
12	2 - 895	1,790	6,111,000	--	Allis-Chalmers
13	1 - 895	895	4,610,000	4,010,000	Allis-Chalmers

IV. PROJECT ENERGY PRODUCTION OPERATION STUDIES

Project energy production studies were performed by computer simulation of the operations of the plants using historical flow data and forecast flow modifications, manufacturer's equipment performance data, and the site characteristics. This section describes the data and methods used in performing these studies.

HYDROLOGIC STUDIES

Final generation studies used actual recorded daily flows at Collinsville from the water years 1966 through 1977 (October 1, 1965 to September 30, 1977). Flows have been recorded by the U.S. Geological Survey at Collinsville since November of 1962. The 1966-1977 period was selected after an assessment of the long-term flow records available from a gage located at Riverton, approximately 12 miles upstream of Collinsville. The long-term, 1937-1977 flows, were found to closely correlate with the 1966-1977 period on both a monthly and annual basis with the average annual flow determined to be within 1.5 percent, as shown in Table IV-1. It was then concluded that the 1966-1977 flow records validly represented long-term flow conditions at Collinsville.

It also should be noted that the Colebrook Reservoir, a major Corps of Engineers flood control and storage facility on the West Branch of the Farmington River, did not become operational until the 1969 water year. The operation of the reservoir has resulted in some stabilization of the flows in the Farmington River, thereby resulting in a larger percentage of flows falling within the operational range of the generation requirement.

The Corps is currently assessing the feasibility of the installation of hydroelectric facilities at Colebrook which, if implemented, could result in further flow stabilization, thus benefiting the proposed Canton project. However, it should be noted that higher than average runoff from the Farmington River basin has been experienced during the period following the construction of Colebrook, so it would not be a valid representation of the basin's long-term hydrologic characteristics.

The Metropolitan District Commission currently has plans for diverting additional flows from the West Branch by means of a tunnel between their West Branch and Barkhampsted Reservoirs. The current MDC forecast of the timing and magnitude of these diversions is shown in Table IV-2.

In order to determine the effect of the forecasted diversions, it was assumed that the project would be implemented by the Fall of 1983, and that the project life would be 40 years. The current monthly pattern of diversions and reservoir releases was determined from the USGS flow records. The increases in diversions and reductions in releases for the year 2023 were calculated based on assuming the same general pattern of operations. The results of this study are shown in Table IV-3. The added diversions and reduced releases were then used to determine the modified energy production using the 1966-1977 historical flow data as the basis for recalculating the energy production.

INITIAL STUDIES

Prior to making inquiries to manufacturers, initial generation studies were performed to establish preliminary generation unit sizes. Typical performance characteristics for the type of equipment anticipated was used in conjunction with an average annual flow duration curve for the period from water year 1966 through 1977, as shown on Figure II-4.

Typical average annual energy production, plant factors, and approximate unit costs were assessed, and preliminary unit sizes selected to serve as a basis for the manufacturer's inquiries.

INSTALLED CAPACITY

Operational studies were performed on different alternatives that are technically feasible. The selection was based on information furnished by manufacturers, and site characteristics. The range of newly installed capacities investigated varied from 325 to 2080 kilowatts. The installed capacities used in the generation studies to calculate the energy potential for each alternative investigated are shown on Table III-3A and B.

The basic data and criteria used in performing energy production and operational studies were:

- -- Daily flow records for the period of 1966-1977.
- -- Forecasted diversions by the Metropolitan District Commission for the year 2023.
- -- Diversion of flows for the fish passage facilities equal to a minimum of three percent of the power plant flows during the migration periods of April 1 to June 30, and September 15 to November 15.

-- All flows up to 3000 cfs would pass through the turbine, fish facilities, or spill gates during the fish migration periods.
-- Headwater and tailwater rating curves based on the diversion dam configuration or Farmington River hydraulic characteristics as shown on Figures IV-1 and IV-2.
-- The net head utilized is the difference between headwater and tailwater minus hydraulic losses which are a function of flow.
-- Calculated hydraulic losses consisting of inlet, fish louver screen, trashracks, penstock and exits were accounted for.

FINAL STUDIES

Final energy production studies were performed using a computer model of the plant operations. This program has been verified by comparison with simulating the historical operations of an existing plant and comparing the results. The program basically performs the following tasks:

-- Uses daily historical data and deducts any required diversions or bypass flows.
-- Calculates the headwater and tailwater from predetermined rating curves.
-- Determines the flows to each turbine from a predetermined operational plan.
-- Determines gross head, head losses and net available head.
-- Determines efficiencies from equipment performing rating curves based on manufacturers' data.
-- Calculates energy daily, monthly, annually and for the period of record.
-- Turbine efficiencies were developed from manufacturers' supplied information. Table III-2 shows the relationship of flow to efficiency that was utilized for each type of turbine unit considered.
-- Efficiencies of the speed increaser, generator, and step-up transformer were as follows:

Item	Percent Efficiency
Single Stage Parallel Shaft Speed Increaser	98
Right angle or Double Stage Speed Increaser	97
Generators over 400 KW	95
Generators under 400 KW	93
Step-Up Transformers	98

-- The maximum feasible composite power plant efficiency, based on a preset operational sequencing of units, was utilized for each energy production simulation.

-- Forced outage of three percent of the time was adopted based on United States Bureau of Reclamation experience data.

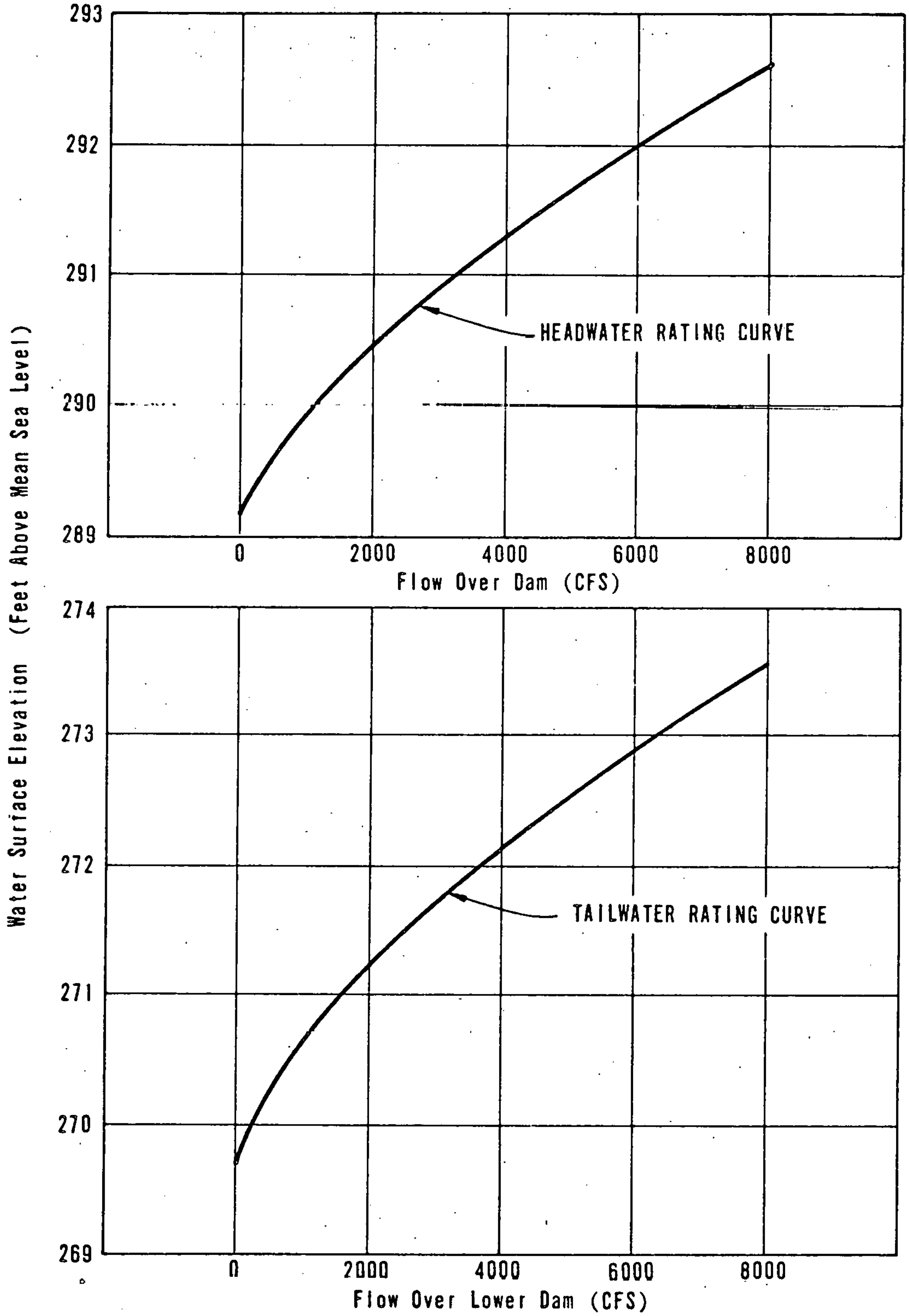
-- The plant operates as a run-of-the-river plant. No adjustments for storage were made.

RESULTS OF GENERATION STUDIES

The total project average annual energy production varies from 2.1 million kwh to over 10.3 million kwh for a total installed capacity of 2630 kw. Tables III-3, IV-4, and IV-5 summarize the energy production for the various alternatives.

These energy production results, along with cost estimates for the various alternatives investigated, will allow evaluation of the project's economic feasibility.

The Canton Hydroelectric Project would operate on a run-of-the-river basis. It may be possible to operate the plants so that some peaking power could be made available for some parts of each day. However, such an operation could result in a significant, adverse impact on the migratory fisheries and the recreational use of the river; therefore, it was not considered to be a viable alternative. Due to the wide fluctuations of flow in the Farmington River, no firm power can be developed. Therefore, all energy that will be produced at the plant is non-firm (or secondary) energy.



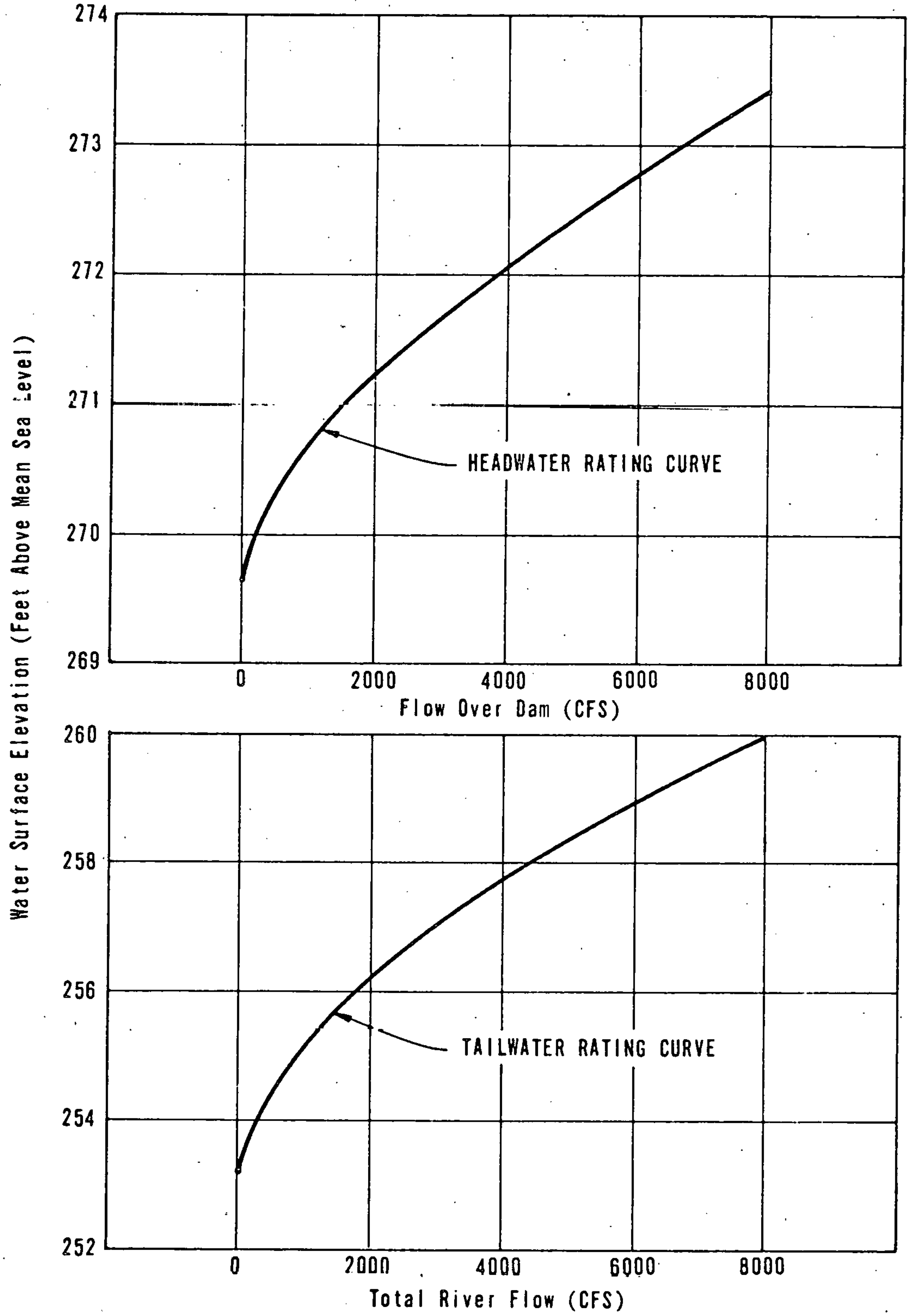
CANTON HYDROELECTRIC PROJECT

UPPER POWERPLANT

HEADWATER AND TAILWATER RATING CURVES

DEVELOPMENT AND RESOURCES CORPORATION
Sacramento, California

Figure IV-1



CANTON HYDROELECTRIC PROJECT

LOWER POWERPLANT

HEADWATER AND TAILWATER RATING CURVES

DEVELOPMENT AND RESOURCES CORPORATION
Sacramento, California

Figure IV-2

TABLE IV-1

FARMINGTON RIVER AT RIVERTON

FLOW CORRELATION MONTHLY AVERAGES

	Flow - Cubic Feet Per Second	
	1965-1977	1937-1977
October	280.2	266.3
November	391.2	407.3
December	468.2	447.1
January	340.0	392.8
February	436.0	401.4
March	530.5	638.7
April	720.0	865.7
May	515.5	508.5
June	385.6	337.7
July	375.6	239.4
August	309.4	248.0
September	314.9	238.0
Annual Average	422	416

TABLE IV-2
FARMINGTON RIVER
METROPOLITAN DISTRICT COMMISSION
PROJECTED WATER USES AND DIVERSIONS

USE	In MGD (Million Gallons per Day)					
	1980	1990	2000	2010	2020	2030
Use by towns presently served with heated water	54	65	75	84	94	103
Use by towns taking raw water and towns not presently served taking heated water	2	7	8	8	9	10
TOTAL USE	56	72	83	92	103	113
Total use in Billion Gallons/Year	20.4	26.3	30.3	33.6	37.6	41.2

Note: 1978 use was 53 mgd or 19.4 billion gallons. All water is taken from the Farmington River Valley System (West & East Branch and Nepaug Reservoirs).

Figures are based on projection given in an in-house report: Metropolitan District Commission staff report, "Report to the Manager of the State and MDC Water Policy Task Force, September 1976."

TABLE IV-3

RESERVOIR RELEASES AND DIVERSIONS
FARMINGTON RIVER AT COLLINSVILLE

	Flow - Cubic Feet Per Second		
Month	Release or Diversions 1966-1977	Decrease Releases or Increased Diversions (2023)	New Total Diversion (2023)
October	+ 55	30	+ 25
November	-107	58	-165
December	-242	131	-373
January	-127	69	-196
February	-162	88	-250
March	-333	180	-513
April	-313	170	-483
May	-103	56	-159
June	- 72	39	-111
July	+118	64	+ 54
August	+113	61	+ 52
September	+ 72	39	+ 33

TABLE IV-4
MONTHLY ENERGY PRODUCTION - INITIAL YEAR 1983
MILLIONS OF KWH

Alternative	MONTH												Total Annual
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Upper Power Plant													
1	0.32	0.41	0.57	0.44	0.46	0.76	0.82	0.70	0.42	0.34	0.31	0.32	5.89
2	0.30	0.36	0.49	0.39	0.41	0.61	0.63	0.58	0.36	0.30	0.29	0.21	5.03
3	0.22	0.26	0.32	0.27	0.27	0.35	0.35	0.35	0.28	0.21	0.23	0.19	3.30
4	0.22	0.25	0.29	0.27	0.26	0.30	0.30	0.31	0.26	0.23	0.23	0.20	3.12
5	0.31	0.36	0.46	0.39	0.40	0.54	0.56	0.53	0.36	0.32	0.31	0.31	4.85
6	0.34	0.41	0.55	0.46	0.47	0.68	0.71	0.64	0.42	0.37	0.34	0.36	5.75
7	0.17	0.20	0.23	0.23	0.21	0.24	0.23	0.24	0.21	0.20	0.18	0.16	2.50
Lower Power Plant													
1	0.25	0.31	0.43	0.34	0.37	0.54	0.57	0.51	0.32	0.27	0.25	0.29	4.45
2	0.23	0.28	0.37	0.30	0.32	0.44	0.42	0.28	0.24	0.24	0.24	0.27	3.78
3	0.24	0.27	0.35	0.29	0.30	0.39	0.38	0.38	0.27	0.25	0.25	0.23	3.60
4	0.26	0.31	0.41	0.35	0.35	0.49	0.49	0.47	0.31	0.29	0.27	0.27	4.27
5	0.21	0.24	0.30	0.27	0.26	0.32	0.31	0.31	0.25	0.23	0.22	0.22	3.14

V. PROJECT ECONOMICS

CAPITAL COSTS

All capital costs were estimated on a current, April 1979 basis. Costs were determined from preliminary designs for the various facilities based on the descriptions and criteria as detailed in Section III, Redevelopment Alternatives. Costs are based on manufacturers' quotations and catalog costs for equipment, standard construction costs, estimating guides, and actual costs of similar facilities in other projects. Where cost data from prior projects were used, the costs were escalated to a current basis by means of the U.S. Bureau of Reclamation Cost Indices for Hydroelectric Projects as reported on a quarterly and annual basis in the Engineering News Record. Detailed cost summaries for generating unit alternatives are shown on Tables V-1 through V-7.

Contingencies

A contingency factor of 20 percent was added to all estimated costs, except manufacturers' quotations. The contingency factor is intended to cover variations in costs due to various factors such as the condition of existing facilities, foundation conditions, and local and periodic variations in the availability and cost of labor, equipment and materials. No contingency was added to the manufacturers' quotations since these values normally have either been accurately determined or already include contingencies.

Engineering and Administration Costs

An engineering and administration cost of 10 percent of the estimated construction cost was used. These values are intended to represent all future engineering and administrative costs required for project implementation. Included would be costs associated with obtaining federal, state and local licenses and permits; site investigations such as geotechnical exploration, surveys and inspection of existing facilities; engineering design; construction supervision; and project management.

Civil Works

The costs of the project civil works were based on preliminary designs, estimated construction quantities, and unit prices determined from cost guides, and costs from other projects. The Dodge Guide to Public Works and Heavy Construction Costs, the Means Building Construction Cost Data, and the Building Cost File were used. Specific considerations in the cost estimate included:

1. Earth embankment cofferdam costs were based on preliminary design and Dodge Guide unit prices for excavation and embankment while timber bulkhead cofferdam costs were based on estimates of basic materials and labor required for construction, placement and removal.

2. Dewatering and cleanup costs were based on estimates of labor and equipment required. Included in this item are the costs of inspecting and cleanup of the existing facilities so restoration work can be performed.

3. Restoration cost for the existing power intake and powerhouses are based on estimates of manpower, time and materials required for complete inspection of the facilities, miscellaneous brick and concrete patching, roofing replacement, door and window replacement, metal work painting and repair, and general cleanup. Replacement costs for miscellaneous items were based on the Dodge and Means Cost Guides.

4. Control gate and bulkhead costs were based on actual bid prices from similar projects and current price quotations from the Armco Steel Corporation.

5. The cost of rock excavation required for power plant expansion or modification was based on hand tool excavation methods since blasting in the area of the existing structures could endanger their integrity.

6. The costs of concrete construction were based on the use of conventional materials with 3000-pound per square inch (psi) compressive strength concrete and 60,000-psi tensile strength reinforcing steel in accordance with American Concrete Institute and American Society for Testing and Materials (ASTM) standards.

7. The cost of structural steel for fish screen louvers, maintenance platforms, bulkheads, gates and other facilities was based on using ASTM A36 steel with designs in accordance with the American Institute for Steel Construction standards.

Turbines, Governors and Speed Increasers

Turbine and governor supply costs were quoted by the James Leffel Company, F.W. Stapenhorst Company representing Ossberger turbine, and Allis-Chalmers provided quotations which included a speed increaser, generator, and controls, as well as the turbine and governor.

Miscellaneous Mechanical Facilities

The crane restoration costs were based on manpower and materials estimates, general cleanup, servicing, worn part replacement, and installation of new operator motors for the existing overhead maintenance cranes.

The cost of miscellaneous facilities such as pumps, ventilation fans and ducts, and the ice prevention bubbler system were based on the preliminary design of these facilities, manufacturers' catalog data and the cost of similar facilities in other projects.

Generators

The cost of the generators varies with the kva rating, rpm, voltage, power factor, type (horizontal or vertical) and whether they are to take any thrust or support rotating parts. The selection of the three alternative equipment types took these characteristics into consideration. The position of the turbine determined whether the machine was horizontal or vertical. The cost of the generators, in gross figures, is directly proportional to the kva size, assuming constant power factor, and is inversely proportional to the speed. The cost data used in the comparisons were based on quotes received by the suppliers in the case of Ossberger and the Allis-Chalmers alternatives, and on quotes received in the past adjusted to 1979 prices for the Leffel alternatives.

Excitation Equipment

The cost of the excitation equipment was included as a part of the turbine generator package price for Allis-Chalmers and Ossberger. The excitation is solid state with rheostat adjustment and automatic voltage regulation. For the Leffel alternative, the excitation equipment was assumed to be 11 percent of the cost of the generators. The excitation equipment includes solid state exciters, voltage regulation, excitation adjustment rheostats, controls and protective relaying.

Switchgears and Controls

The cost of the switchgear was based on 4160 volt, 1200 ampere, 250 mva, metal-clad standard equipment for the Allis-Chalmers alternatives, and 480 volt, 3Ø, 2000 ampere, 18 mva low voltage switchgear for the Leffel and Ossberger alternatives. The prices were taken from manufacturers' catalogs adjusted by the latest multiplying factors.

The cost of the control equipment, such as indicating instruments, protective devices and control devices was included as part of the turbine-generator package price for Allis-Chalmers and partially for Ossberger. For Leffel and Ossberger, the cost of this equipment is based on standard switchboard quality devices consistent with the 480v class of switchgear proposed. Cost is included for automatic control systems except for level-sensing equipment which is included in the civil works cost.

Station Service

The cost of the station service equipment was determined from manufacturers' catalog prices for standard equipment. The cost included a 5 kv fused disconnect; 50 kva, 4800/480-120v, 3Ø transformer and a 225 amp 3Ø lighting and distribution panelboard.

Utility Connection

The cost of connecting the plant to the Hartford Electric Light Company transmission system was based on a 3Ø step-up transformer from 4160v (or 480v) to 4800v (or 23 kv) and a power-fused disconnect switch. The transformer would vary in size from 500 kva to 2000 kva for the different alternatives.

Miscellaneous Electrical Equipment

The cost for the miscellaneous electrical equipment was based on newly installed equipment according to latest prices and installation costs. Generator and transformer leads are 5 kv shielded XLPE cable with PVC jacket in the case of the Ossberger and Allis-Chalmers alternatives, and 600v THW for Leffel. Conduit is surface-mounted where possible and is rigid for power wires and EMT for lighting and outlets. Other wiring is 600v THW. Devices are of standard specification grade. Lighting for the generator room is based on 50-foot candles illumination. Grounding will be provided by a 4/0 bare copper cable ground grid.

Provisions for telephone and data channel are included in the costs. Fire detection and alarms will be provided by an ionic detection system. Dry chemical type fire extinguishers, wall mounted, are used.

Optional Town Distribution Line

The cost of the optional underground 5 kv distribution line is based on a 2/0 AWG shielded XLPE cable with a PVC jacket, and an estimated 20 percent of the line in conduit where it passes under paved streets. The cost includes five concrete access and maintenance vaults. The replacement of asphalt concrete road surfacing was estimated to be required along about 20 percent of the line length. The cost of these facilities was based on unit costs from the Means Estimating and Dodge Guides.

Optional Distribution Transformers

The cost of the optional distribution transformers for connection to the town's facilities is based on manufacturers' catalog data and the Means Guide. The transformer capacities are as listed in Section IV of this report.

Optional Diesel Engine Generating Sets

The cost of the two 500 kw diesel engine generating sets is based on data from Generator Unlimited, distributors of Onan Engine Generating Sets. The generating set enclosure cost was based on data in the Means Guide for prefabricated steel building placed on a reinforced concrete slab foundation.

ANNUAL OPERATING COSTS

General operation and maintenance of the power plant will require personnel trained in hydroelectric plant operation. The plant would not require continuous supervision and it has been assumed that full-time personnel would not be assigned to the plant.

OPERATION AND MAINTENANCE COST

Operation and maintenance costs were determined from experience cost curves included in the U. S. Bureau of Reclamation's Estimating Manual. These curves are based on the installed plant capacity and on average cost data through 1970. The costs were adjusted to a current basis by an index equal to approximately 90 percent of the construction and equipment cost indices for hydroelectric projects. These costs are intended to cover personnel, equipment, and materials needed to perform all normally scheduled operation and maintenance activities and minor repairs.

Actual operation and maintenance costs may vary significantly from the estimated values. Should the plant be integrated into the already established operation and maintenance of the Hartford Electric Light Company, substantial economies could be realized through the use of available personnel and equipment. The establishment of a new operations and maintenance entity to handle this plant could result in high initial cost required for the procurement of equipment and tools, materials and parts, and the training of personnel.

REPLACEMENT COSTS

The costs for future major repairs and the replacement of major component equipment parts were estimated from experience data included in the U.S. Bureau of Reclamation's Estimating Manual. These costs are recorded as a percentage of the original investments. The USBR data were consolidated and the following future cost percentages were used, as shown below.

Item	% Replacement in Year 20	30	40	50
Turbines and Generators	--	9	6	10
Switchgears and Transmission	--	40	--	12
Miscellaneous Electrical Equipment	11	33	23	6

Replacement costs were determined for the full 50-year period; however, only the costs required through 30 years were used in assessing the project economics. Providing for replacement for 30 years should assure successful project operations throughout its 40-year economic life.

The costs were indexed to the year of anticipated occurrence based on an escalation rate of 6 percent. An annual 30-year sinking fund account was calculated on the basis of 7 percent interest.

PLANT ADMINISTRATION

Administrative personnel will be necessary to oversee the operation of the facilities. This will include the maintenance of permanent records of the plant's revenues and expenses, handling of personnel and payroll, if appropriate, preparation of yearly submittals to the Federal Energy Regulatory Commission, and continuing conformance with local, state, and federal regulations.

LICENSES AND INSURANCE

The reactivated facility will be subject to a license charge per year as per the Federal Energy Regulatory Commission guidelines. This charge is based on the authorized installed capacity plus the annual energy output for each installation in millions of kilowatt hours.

Property insurance will be required to protect against property damages and public liability.

ENERGY MARKET EVALUATION

The following marketing options were analyzed as part of the project economic evaluation:

Option 1: The town keeps its existing services from the Hartford Electric Company (HELCO) and sells the entire output of the project to the Northeast Utilities (NU) through connection to the adjacent HELCO transmission system.

Option 2: The town constructs a local distribution line (Figure III-17) and delivers power to the seven facilities shown on Table V-12. Surplus energy would be sold to NU and the utility would provide backup/standby services for periods when the project facilities could not meet town needs.

Option 3: The town would provide a diesel backup unit in addition to the local distribution line to serve the needs of the seven facilities and would sell the surplus to NU.

Additional options are available to the town that may prove viable and are worthy of investigation during the final marketing investigation phase of the project. They include:

-- In lieu of the town constructing the independent distribution line required in Option 2, the power could possibly be wheeled from the project sites through the utilities system to the town facilities. This option can be evaluated only after the utility has evaluated the effect on their system and the added operating cost involved, upon which a wheeling charge would be based. It should be noted that the largest of the town's loads, the high school, is now served from a source north of the town, in the opposite direction from the project sites.

-- Space is available for locating an energy-intensive industry of significant size in the old Collins Company complex foundry building immediately across the river from the Upper Power Plant; the site could be served by the project facilities in lieu of the seven town facilities evaluated in Options 2 and 3.

MARKET OPTIONS 2 AND 3 ENERGY AND DEMAND EVALUATION

The town facilities monthly and annual demands and energy requirements are shown on Table V-12. Composite daily demand duration relationships were synthesized for the town facilities based on the monthly energy usage and demand factors, and are summarized on Table V-13. The monthly demand, energy requirements, and duration relationships were incorporated into the energy production model described in Section IV. The modified model then calculated the energy used by the town facilities, the surplus energy available for sale, and the backup demands and energy on a daily basis with monthly and annual summaries. The results of this study are summarized on Table V-14, and copies of the computer printouts are included in Appendix I.

ENERGY VALUE ASSESSMENT

All of the above options include sale of energy to NU. In order to determine the value of such energy, an assessment of NU system make-up, costs, and marketing rates and policies has been made and is summarized in the following paragraphs.

Northeast Utilities System

The project site is located within the service area of the Hartford Electric Light Company, a wholly owned subsidiary of Northeast Utilities (NU). Figure V-1 shows both the project location and the NU system. NU is composed of four operating companies:

1. The Connecticut Light and Power Company (CL&P)
2. The Hartford Electric Light Company (HELCO)
3. Western Massachusetts Electric Company (WMECO)
4. Holyoke Water Power Company (HWP)

NU is also the holding company for Northeast Nuclear Energy Company and Northeast Utilities Service Company. The service company provides centralized accounting, administration, engineering, financial, legal operational, planning and purchasing services for the other NU companies.

NU was formed in 1966 and is a fully integrated electric utility in the business of producing, transmitting and selling electricity in Connecticut and Massachusetts.

NU is also a member of the New England bulk power system which includes over 99% of generating capacity in New England. The pool became operational in 1970. NU generation and transmission are planned and operated as a part of the New England Power Pool (NEPOOL). Generation scheduling for all members is conducted by the New England Power Exchange. NEPOOL was formed primarily to increase system reliability, which results in savings due to reduced reserve requirements. Operational savings are also achieved by an economic dispatching of electricity among all members.

The Northeast Utility system generating capacity, by type, as of January 1, 1979, is summarized on Table V-15. These figures are net and represent system capacity often accounting for sales to other systems.

TABLE V-15

NU CAPACITY BY ENERGY SOURCE (1/1/79)

Fuel Source	Net Capacity	% of Total
Nuclear	1949 MW	32%
Fossil (mostly petroleum)	2970	48%
Conventional Hydro	241	4%
Pumped Storage	1025	17%
	6185	100 (Rounding)

The contribution of those generation sources and interchange power to system energy requirements over the last five years is shown on Table V-16.

The scheduling of these services to meeting system energy demands is shown in Figure V-2. This figure indicates that fossil-fired plants are operating in the NU system nearly 100% of the time.

TABLE V-16

NU SYSTEM ENERGY MILLION OF KWH

Source	1973	1974	1975	1976	1977	% of 1977
Nuclear	3,926	6,553	7,107	11,654	12,349	56
Fossil	14,029	12,854	10,128	7,740	7,494	34
Conventional Hydro	1,916	2,067	1,986	1,646	1,520	7
Purchased & Interchanged	1,804	17	2,016	940	815	4
Pumping	(1,248)	(1,492)	(1,323)	(992)	(876)	(4)

Northeast Utilities Energy Costs

Fossil and nuclear fuel costs for the recent past are shown on Table V-17.

TABLE V-17

NU SYSTEM AVERAGE FUEL COST (¢/KWH)

Fuel	1973	1974	1975	1976	1977	1978	1979 (est)
Nuclear	.30	.82	.31	.29	.30	.32	---
Fossil	.89	1.95	2.31	2.04	2.31	2.27	2.53

The 1979 estimates are based on NU actual oil cost as of January 1979 of $15.25 per barrel of #6 oil with .5% sulfur.

The company's fuel outlook may change in the near future due to a Prohibition Order, issued by the U.S. Department of Energy, against burning oil in six oil-fired generation units. The aggregate capacity involved is 919 MW. NU is appealing this order, which is estimated to cost in excess of $300 million in conversion costs. If NU is unsuccessful in this appeal, the coal conversion would reduce the energy cost (not necessarily total cost) of electricity generated by these plants. As of 1978, the cost of coal in New England is approximately $1.50/MMBtu (U.S. Department of Energy, Monthly Energy Reports, November 1978).

This yields an energy cost of electricity of 1.5¢/KWH. The effect of this would be to make coal the marginal energy source approximately 50% of the time.

NU's most recent forecasts put the expected peak demand growth at 2.9% per year and energy sales to grow at 3.0% per year. To meet these growing needs, NU will reduce its currently large reserve margin and is planning to add one additional nuclear generating unit in the 1979-1986 time frame. This unit is Millstone #3 scheduled to be on line in 1986. With 1150 MW of installed capacity, NU's 65% share of the plant will add 748 MW to the system. Until this unit comes on line, no additional output from nuclear units is possible since NU's nuclear plants are currently operating at approximately 68% capacity factor (% of maximum possible energy output), which is above the national average. The system peak demand and capacity are shown in Figure V-3.

Since the system nuclear plants will be unable to increase their output to meet the increased system requirements, additional generation from existing fossil plants will be required. When Millstone #3 comes on line in 1986 the energy output from the plant will allow fossil-fired generation to be scaled back. However, the maximum output from Unit #3 will not completely offset the expected growth in energy sales from 21,708 GWH in 1978 to 29,076 GWH in 1988 (10% forecast). Consequently, at least the current level of fossil utilization can be expected through 1988.

Northeast Utilities Proposed Cogeneration Rate 90

The Public Utility Regulatory Policy Act of 1978, part of the National Energy Plan, requires electric utilities to sell and buy electricity from cogeneration facilities. The definition of a cogeneration facility includes small hydroelectric projects. In response to this requirement, HELCO, CL&P, and other NU system companies have filed proposed rates, such as HELCO's Rate 90, included in Appendix E.

This rate applies to facilities with less than 1000 kw of installed capacity and which will sell less than 1.5 million kwh per year. Larger facilities, such as the Canton project, that do not qualify, will be negotiated separately; however, the proposed rate will serve as a basis for such negotiation.

Rate 90 has three major provisions of concern here:

1. The company proposes to pay for energy received at their average fossil fuel energy cost less 20%.

2. Backup/standby service will be provided under existing rates or at the rate of $3.50 per kw.
3. On six hours notice the company may refuse to purchase energy when its incremental cost of electricity is less than the price being paid.

NU's justification of the 20% discount is summed up in testimony by Dr. Overcast, included in Appendix E.

"This discount is comprised of a 10% reduction due to the expected cogeneration facilities' contribution during the off-peak periods, and of an approximately 10% reduction due to recognition of the opportunity to purchase economy power (New England Power Exchange)."

Since market Option 1 is based on the sale of all of the project energy to NU, and not just the surplus, the first 10% reduction should not apply. It is recognized, however, that the project's production will not exactly coincide with the NU or HELCO demand as shown in Figure V-4. The entire 20% reduction may apply to Options 2 and 3.

In view of the decreasing NU capacity margin and escalating costs, it is felt that the refusal provision of Rate 90 would not be utilized to a great enough extent to affect the economic analysis of the project.

Initial Energy Value - Conclusions

For purposes of economic assessment of this project an energy value of 22 mils/kwh is selected. It is felt that this value realistically reflects current NU system fuel costs, the criteria contained in the proposed Rate 90, and the potential for some conversion to coal.

For Option 2, a current energy value of 20 mils/kwh was used because the project would supply surplus energy to NU.

Energy Value Escalation

Continuing escalation of fossil fuel costs is anticipated. The "California Clean Fuel Study" by Arthur D. Little, Inc. for the California Energy Commission estimates the following probability for world oil price escalation relative to general inflation (Table V-18).

Coal prices are anticipated to escalate at a rate at least equal to inflation.

Considering the potential for a future fuel mix an energy value inflation of 8 percent, compared to 6 percent inflation, has been adopted for economic analysis purposes. The project feasibility will also be tested for energy value escalation rates of 6 and 10 percent.

TABLE V-18

CRUDE OIL PRICE OUTLOOK - 1990 AND 2000

Scenario	Range Dlrs/Bbl)	Midpoint of Range	Probability 1990	Probability 2000
Price decreases	5-10	7.5	2%	1%
Price constant (i.e., increases with inflation)	10-15	12.5	15%	5%
Price increases average 2.5%/year	15-20	17.5	31%	17%
Price increases average 4.5%/year	20-25	22.5	27%	22%
Price increases average 6.1%/year	25-30	27.5	15%	27%
Price increases average 7.5%/year	30-35	32.5	7%	19%
Price increases average 8.7%/year	35-40	37.5	3%	9%

ECONOMIC ANALYSIS

The economic analysis of the project included the determination of internal rates of return, benefit-cost ratios, and cash flow for the various project alternatives and marketing options as discussed previously. Ten project alternatives were analyzed for marketing Option 1, while two selected alternatives were analyzed for Options 2 and 3.

The economic analysis compares the time value of the cost stream with the benefit stream. Evaluation criteria such as the internal rate of return (IRR), net present value and gross benefit cost analysis are used. Both the IRR and benefit-cost criteria were used. The IRR is defined as the interest rate at which the present value of the discounted cost and benefit streams, excluding capital recovery, are zero. If the cost of capital used to finance the project is less than the internal rate of return, then implementing the project will benefit its owner.

The benefit-cost ratio compares the project life cycle benefits to costs. The benefit-cost ratio as determined in this study is the ratio of the present value of all discounted annual revenue to the present value of all discounted annual costs plus the capital costs.

The economic analysis was performed by use of a computer model that incorporated the project costs, energy production and revenues. The basic criteria used are given in the following paragraphs.

Criteria for Option 1

-- The project was analyzed as a stand-alone venture receiving the full economic value for the energy produced. No secondary benefits were considered.
-- The cost of the fish facilities allocated to the program were taken as the estimated project costs minus the cost of the facilities planned by the Connecticut Department of Environmental Protection for the sites without the power facilities. These values were $94,000 for the Upper Dam Fishway and $50,000 for the Lower Dam removal as shown in Appendix D.
-- Inflation in both the cost and revenue streams has been explicitly incorporated. A 6% general inflation was used and an 8% escalation rate for energy was evaluated.
-- The sensitivity internal rate of return of benefit-cost ratios was also assessed, based on energy value escalation rates of 6% and 10%.
-- The project has been assumed to be both owned and financed by the town of Canton. A 40-year life and 7% interest for project amortization were used.
-- Construction was assumed to start in 1981 and operations in 1983.
-- Average annual energy production has been assumed. The fluctuations which will occur in energy production and their potential impact on availability and revenues are a point which must be recognized.
-- The energy production was assumed to decline uniformly throughout the project life due to increased river diversions by the Metropolitan District as was discussed in Section IV. The effect of the declining production was determined by reduction of the energy value escalation rate.
-- A two-year construction period with escalation in capital costs at the general inflation rate has been used. Capital expenditures have been split 40% in the first year, 1982, and 60% in the following year.
-- A sinking fund has been calculated which will provide sufficient funds in future dollars to perform major repairs and replacements. The sinking fund requirements were determined by the following method:

1. Using this replacement schedule, included in the capital costs portion of this section, and the 1979 values of the asset classes, the total replacement required in the 20th and 30th years of operation is determined.

2. These values are then escalated (the general inflation rate was used here) to the year of occurrence. To do so, the anticipated length of the construction period must be included.

3. Since it is desired to calculate one sinking fund with value equal to the replacements, the present value of the future cost of these replacements is calculated in the first year of project generation. The appropriate discount rate to use is the rate at which the project owner can invest funds. In this case, this was assumed to be 7%, the same as the bonding.

4. The duration of the sinking fund is based on maintaining sufficient funds so that equipment replacement can be made to provide a 40-year project life.

-- A 1979 energy value of 22 mils/KWH was adopted based on analysis of NU energy costs and the proposed cogeneration Rate 90. The sensitivity of the internal rate of return was also tested for lower and higher energy values, the results of which are shown in Table V-23.
-- The project will operate on a run-of-the-river basis and no firm power value was included.

Criteria for Option 2

-- The criteria used in evaluating Option 2 were the same as for Option 1 with the following exceptions.
-- The provisions of NU-proposed cogeneration Rate 90 were used.
-- All of the town facilities were assumed to fall under the provisions of HELCO Rate 22 for large general service. It should be noted that currently the town schools fall under HELCO Rate 23 which does not include the demand charge required by Rate 22.
-- The 1979 value of surplus energy to be sold to NU was taken as 20 mils/KWH in accordance with Rate 90.
-- The current energy cost to the seven town facilities was calculated and considered as benefits in the option assessment.

-- The surplus energy value, the backup energy charges and the energy charges for the existing service were assumed to escalate at 8% per year.
-- The backup demand charges and the current service demand charges were assumed to escalate at the same rate as general inflation or 6%.
-- The backup demand charge as determined in accordance with Rate 90 and Rate 22 was $3.78 per kw for the maximum backup demand, which was found to occur during the month of January.

Option 3 Criteria

-- The criteria used in evaluating Option 3 were the same as for Option 1 with the following exceptions.
-- The value and escalation of the surplus energy and the energy and demand costs and escalation for the existing town facilities were evaluated the same as for Option 2.
-- The energy cost for the diesel backup unit was determined from manufacturers' fuel consumption data and an assumed fuel cost of 65 cents per gallon in 1979.
-- The fuel cost was assumed to escalate at 8% per year.
-- The replacement cost for the diesel units was based on 100 percent replacement after a 12,000-hour operating life.

Result of Economic Analysis

The economic analysis results for Option 1 are summarized on Table V-20 while Options 2 and 3 are shown on Table V-21. The sensitivity of feasibility to initial energy value and escalation of energy values are shown on Tables V-22 and V-23.

All options and alternatives investigated were economically feasible on a life cycle basis, with benefit-cost ratios ranging between 1.4 and 1.93 and internal rates of return between 8.8 and 11.7 percent. However, all alternatives and options produce negative net funds in the first year of operation based on uniform annual bond amortization and anticipated operating costs and revenues.

Typical annual net funds curves for the entire project life are shown on Figures V-5. This early funding shortage will have to be remedied by means of short-term financing, adjustments in the project bonding, or adjustment in energy revenues.

Options 1 and 3 proved to be nearly equal with regard to life cycle economic feasibility; however, Option 1 (due to lower initial costs) will result in lesser short-term funding shortages. Option 2 proved to be less attractive both economically and financially. This development was due to the relatively low demand factors of the seven town facilities, resulting in substantial demand charges for backup/standby service from the utility.

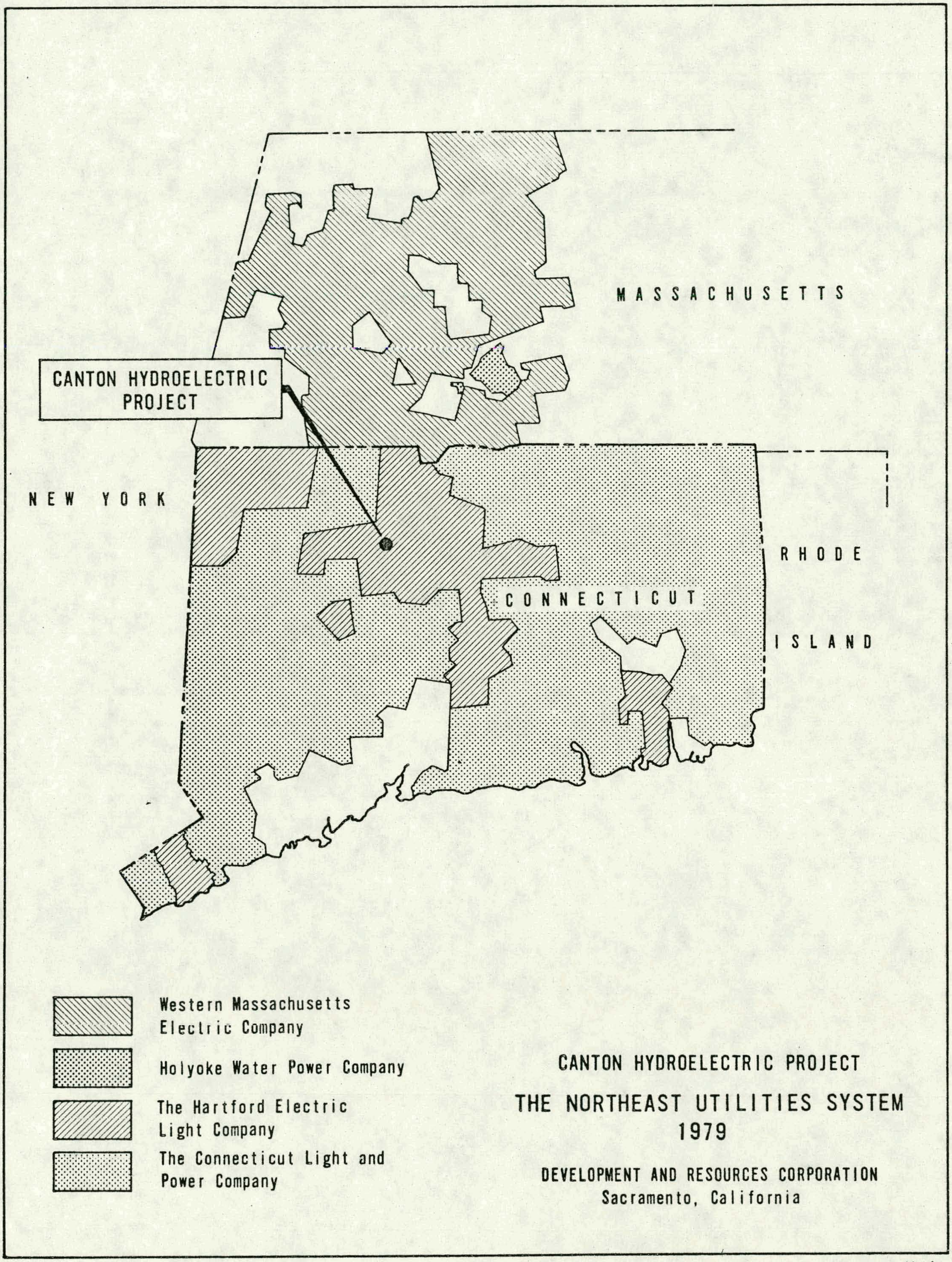
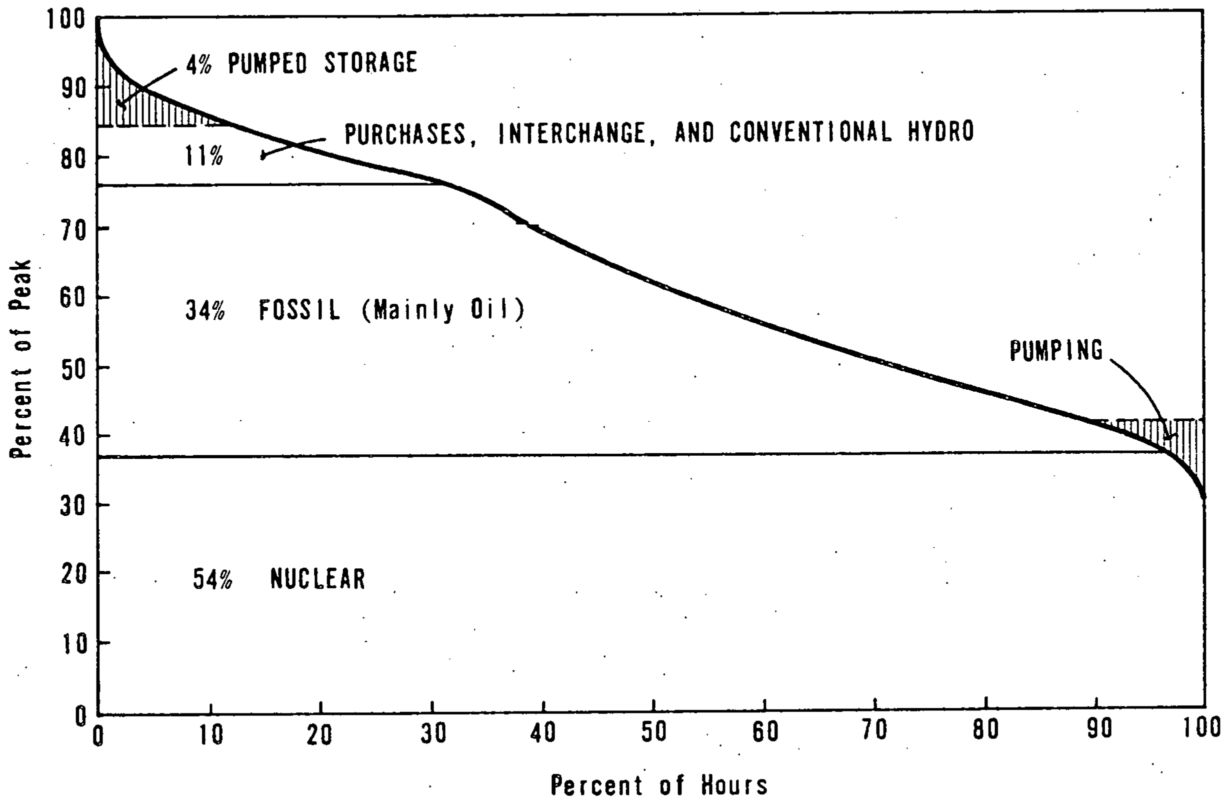

MASSACHUSETTS
CANTON HYDROELECTRIC PROJECT
NEW YORK
RHODE ISLAND
CONNECTICUT
Western Massachusetts Electric Company
Holyoke Water Power Company
The Hartford Electric Light Company
The Connecticut Light and Power Company
CANTON HYDROELECTRIC PROJECT
THE NORTHEAST UTILITIES SYSTEM
1979
DEVELOPMENT AND RESOURCES CORPORATION
Sacramento, California

Figure V-1



Source: 'Northeast Utilities System - Electrical Energy Demand 1978-88' Vol. 3 of 3, March 1, 1979.

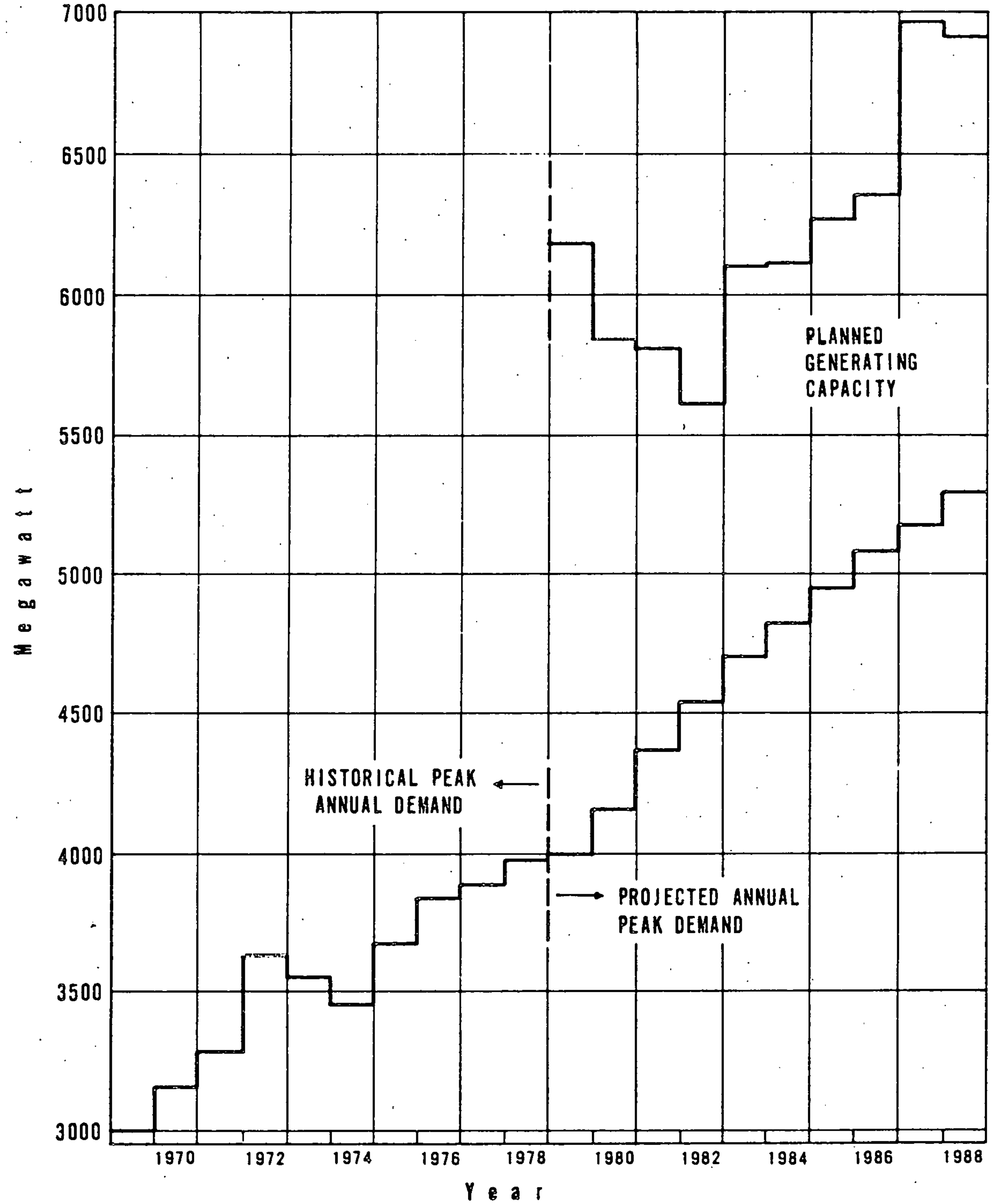
Note: Percent of Energy by Source Superimposed.
Based on 1977 Energy Production by Source.

CANTON HYDROELECTRIC PROJECT

LOAD DURATION CURVE 1979
NORTHEAST UTILITIES SYSTEM

DEVELOPMENT AND RESOURCES CORPORATION
Sacramento, California

Figure V-2



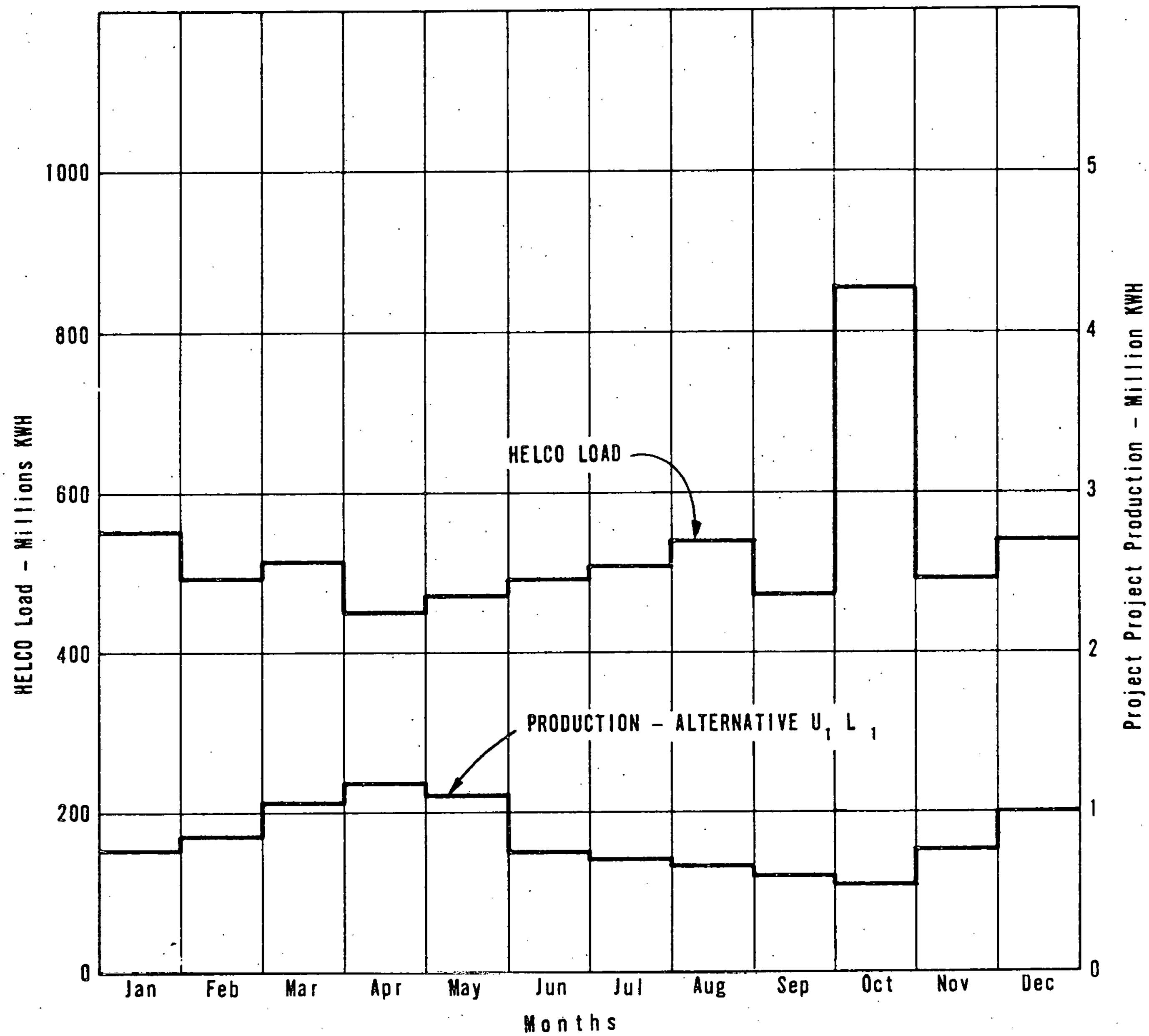
SOURCE: NORTHEAST UTILITIES SYSTEM, FORECAST OF LOADS AND RESOURCES 1979-1986, March 1, 1979

CANTON HYDROELECTRIC PROJECT

DEMAND AND GENERATING CAPACITY
NORTHEAST UTILITIES SYSTEM

DEVELOPMENT AND RESOURCES CORPORATION
Sacramento, California

Figure V-3



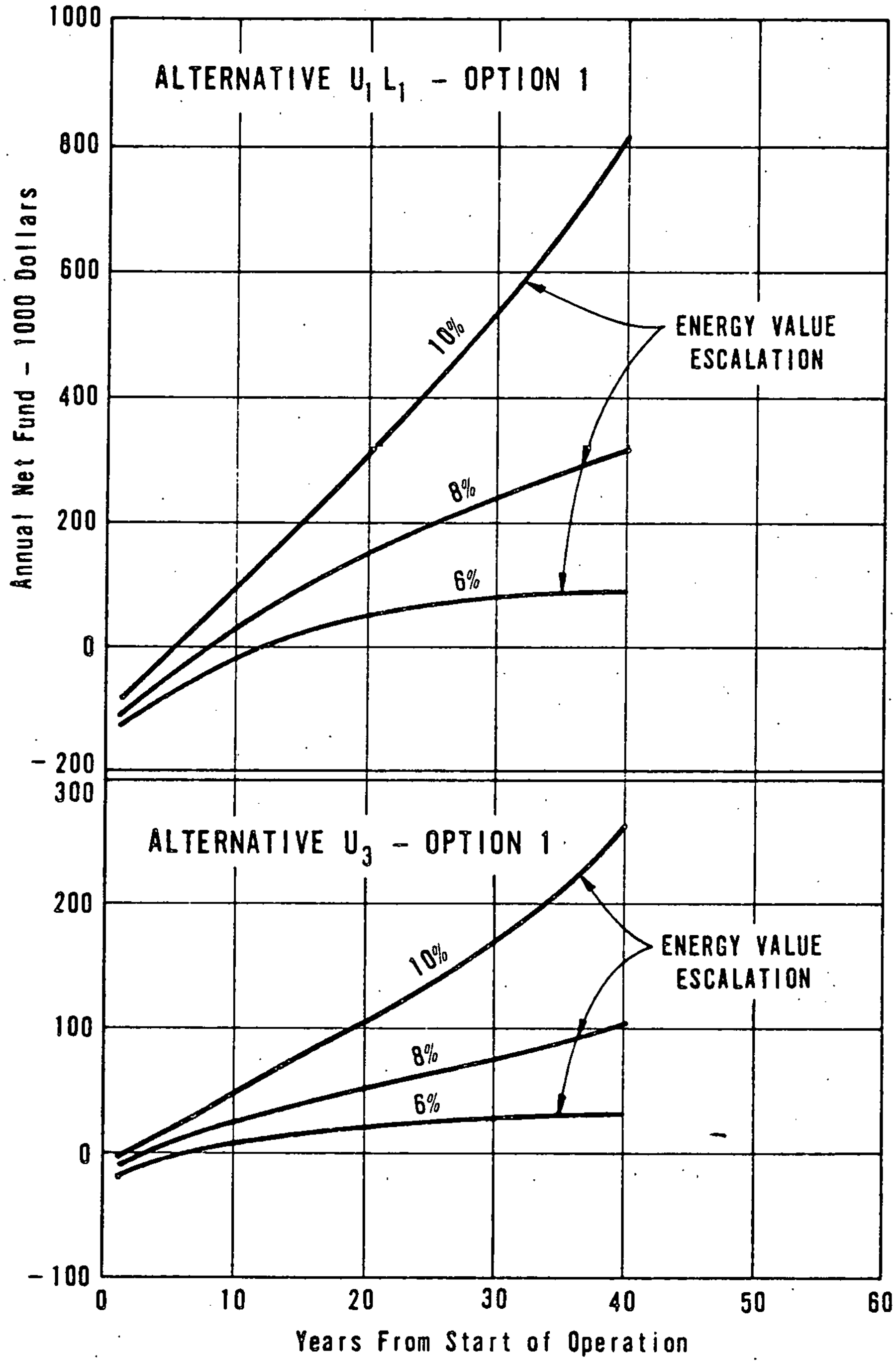
Source: HELCO LOAD - 1978 Monthly Power Report to the Conn. PUCA.

CANTON HYDROELECTRIC PROJECT

HELCO LOAD Vs PROJECT PRODUCTION

DEVELOPMENT AND RESOURCES CORPORATION
Sacramento, California

Figure V-4



Notes:
1. Initial Energy Value 2.2%
2. Cost Escalation - 6%
3. Interest Rate - 7%

CANTON HYDROELECTRIC PROJECT

CASH FLOW - 1979 DOLLARS

DEVELOPMENT AND RESOURCES CORPORATION
Sacramento, California

Figure V-5

TABLE V-1A
UPPER POWER PLANT
ALTERNATIVE NUMBER 1 - LEFFEL 1
MECHANICAL AND ELECTRICAL

ITEM	UNIT	QUANTITY	UNIT COST		ITEM COST		
1/ Furnish Turbine and Governor	EA	1	103,500	00		103	500
		1	189,000	00		189	000
Install Turbine and Governor	EA	2	15,800	00		31	600
Furnish and Install:							
Generators	EA	1	176,200	00		176	200
Generators	EA	1	386,600			386	600
Switchgears and controls	LS					94	000
Excitation equipment	LS					23	840
Station Service	LS					2	230
Transformer	EA	1				30	180
Miscellaneous Electrical -							
grounding, raceways, wiring							
lighting	LS					14	300
Control system	LS					25	000
Rehabilitate Maintenance Crane	LS					2	500
Ventilation fan and duct	LS					2	500
Service pump and piping	LS					1	500
Subtotal					1	082	950
Contingencies 20%						158	090
Total Construction Cost					1	241	040
1/ Not included in contingency							
determination							

TABLE V-1B
UPPER POWER PLANT
ALTERNATIVE NUMBER 2 - LEFFEL
MECHANICAL AND ELECTRICAL

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST
1/ Furnish Turbine and Governor	EA	2	103,500 00	207 000
Install Turbine and Governor	EA	2	15,800 00	31 600
Furnish and Install:				
Generators				
Generators	EA	2	176,210	352 420
Switchgears and controls	LS			94 000
Excitation equipment	LS			23 840
Station Service	LS			2 230
Transformer	EA	1		24 320
Miscellaneous Electrical - grounding, raceways, wiring lighting	LS			12 670
Control system	LS			25 000
Rehabilitate Maintenance Crane	LS			2 500
Ventilation fan and duct	LS			2 500
Service pump and piping	LS			1 500
Subtotal				779 580
Contingencies 20%				114 520
Total Construction Cost				894 100
1/ Not included in contingency determination				

TABLE V-1C
UPPER POWER PLANT
ALTERNATIVE NUMBER 3 - LEFFEL
MECHANICAL AND ELECTRICAL

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST
1/ Furnish Turbine and Governor	EA	1	103,500 00	103 500
Install Turbine and Governor	EA	1	15,800 00	15 000
Furnish and Install:				
Generators				
Generators	EA	1	176,210	176 210
Switchgears and controls	LS			50 310
Excitation equipment	LS			23 840
Station Service	LS			2 230
Transformer	EA			7 730
Miscellaneous Electrical - grounding, raceways, wiring lighting	LS			9 260
Control system	LS			25 000
Rehabilitate Maintenance Crane	LS			2 500
Ventilation fan and duct	LS			2 500
Service pump and piping	LS			1 500
Subtotal				420 380
Contingencies 20%				63 380
Total Construction Cost				483 760
1/ Not included in contingency determination				

TABLE V-1D
UPPER POWER PLANT
ALTERNATIVE NUMBER 4 - OSSBERGER
MECHANICAL AND ELECTRICAL

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST
1/ Furnish Turbine and Governor				
Speed Increaser, Flywheel,				
Generator and Controls	EA	1	321,300 00	321 300
Install Turbine and Governor				
Speed Increaser, Flywheel,				
Generator and Controls	EA	1	24,000 00	24 000
Furnish and Install:				
Generators				
Generators				
Switchgear	LS			47 710
Excitation equipment				
Station Service	LS			2 230
Transformer	EA			20 120
Miscellaneous Electrical -				
grounding, raceways, wiring				
lighting	LS			9 510
Control system	LS			25 000
Rehabilitate Maintenance Crane	LS			2 500
Ventilation fan and duct	LS			2 500
Service pump and piping	LS			1 500
Sump pump and piping	LS			1 200
Subtotal				457 570
Contingencies 20%				275 550
Total Construction Cost				484 820
1/ Not included in contingency				
determination				

TABLE V-1E
UPPER POWER PLANT
ALTERNATIVE NUMBER 5 - OSSBERGER
MECHANICAL AND ELECTRICAL

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST
1/ Furnish Turbine and Governor Speed Increaser, Flywheel and Controls	EA	2	321,300 00	642 600
Install Turbine and Governor Speed Increaser, Flywheel, Generator and Controls	EA	2	24,000 00	48 000
Furnish and Install:				
Generators				
Generators Switchgear	LS			83 780
Excitation equipment				
Station Service	LS			2 230
Transformer	EA			23 430
Miscellaneous Electrical - grounding, raceways, wiring lighting	LS			12 170
Control system	LS			25 000
Rehabilitate Maintenance Crane	LS			2 500
Ventilation fan and duct	LS			2 500
Service pump and piping	LS			1 500
Sump Pump and Piping	LS			1 200
Subtotal				845 210
Contingencies 20%				40 520
Total Construction Cost				885 730
1/ Not included in contingency determination				

TABLE V-1F
UPPER POWER PLANT
ALTERNATIVE NUMBER 6 - ALLIS-CHALMERS
MECHANICAL AND ELECTRICAL

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST
1/ Furnish Turbine and Governor				
Speed Increaser, Generator and		1	482,000 00	482 000
Controls	EA	1	720,000 00	720 000
Install Turbine and Governor				
Speed Increaser, Generator and				
Controls	EA	2	43,000 00	86 000
Furnish and Install:				
Generators				
Generators				
Switchgears	LS			93 730
Excitation equipment				
Station Service	LS			2 230
Transformer	EA			26 840
Miscellaneous Electrical -				
grounding, raceways, wiring				
lighting	LS			4 880
Control system	LS			25 000
Rehabilitate Maintenance Crane	LS			2 500
Ventilation fan and duct	LS			2 500
Service pump and piping	LS			1 500
Subtotal				1 447 180
Contingencies 20%				49 040
Total Construction Cost				1 496 270
1/ Not included in contingency				
determination				

TABLE V-1G
UPPER POWER PLANT
ALTERNATIVE NUMBER 7 - ALLIS-CHALMERS
MECHANICAL AND ELECTRICAL

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST
1/ Furnish Turbine and Governor				
Speed Increaser, Generator and				
Controls	EA	1	482,000 00	482 000
Install Turbine and Governor				
Speed Increaser, Generator and				
Controls	EA		43,000 00	43 000
Furnish and Install:				
Generators				
Generators				
Switchgears and controls	LS			50 940
Excitation equipment				
Station Service	LS			2 230
Transformer	EA			20 120
Miscellaneous Electrical -				
grounding, raceways, wiring				
lighting	LS			2 480
Control system	LS			25 000
Rehabilitate Maintenance Crane	LS			2 500
Ventilation fan and duct	LS			2 500
Service pump and piping	LS			1 500
Subtotal				632 270
Contingencies 20%				30 050
Total Construction Cost				662 320
1/ Not included in contingency				
determination				

TABLE V-2A
LOWER POWER PLANT
ALTERNATIVE NUMBER 1 - LEFFEL
MECHANICAL AND ELECTRICAL

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST
1/ Furnish Turbine and Governor	EA	1		103 500
		1		189 000
Install Turbine and Governor	EA	2		31 600
Furnish and Install:				
Generators	EA	1	305,080 00	305 080
Generators	EA	1	176,210 00	176 210
Switchgears and controls	LS			88 390
Excitation Equipment	LS			23 840
Station Service	LS			2 230
Transformer	EA	1		24 330
Miscellaneous Electrical -				
grounding, raceways, wiring				
lighting	LS			12 860
Control system	LS			25 000
Rehabilitate Maintenance Crane	LS			3 000
Ventilation Fan and Duct	LS			3 500
Service Pump and Piping	LS			1 500
Subtotal				990 040
Contingencies 20%				139 510
Total Construction Cost				1 129 550
1/ Not included in contingency				
determination				

TABLE V-2B
LOWER POWER PLANT
ALTERNATIVE NUMBER 2 - LEFFEL
MECHANICAL AND ELECTRICAL

ITEM	UNIT	QUANTITY	UNIT COST		ITEM COST	
1/ Furnish Turbine and Governor	EA	2	103,500	00	207	000
Install Turbine and Governor	EA	2	15,800	00	31	600
Furnish and Install:						
Generators	EA	2	152,540	00	305	080
Generators						
Switchgears and controls	LS				83	780
Excitation equipment	LS				23	840
Station Service	LS				2	230
Transformer	EA	1			18	840
Miscellaneous Electrical - grounding, raceways, wiring lighting	LS				11	790
Control system	LS				25	000
Rehabilitate Maintenance Crane	LS				3	000
Ventilation fan and duct	LS				3	500
Service pump and piping	LS				1	500
Subtotal					717	160
Contingencies 20%					143	430
Total Construction Cost					860	590
1/ Not included in contingency determination						

TABLE V-2C
LOWER POWER PLANT
ALTERNATIVE NUMBER 3 - OSSBERGER
MECHANICAL AND ELECTRICAL

ITEM	UNIT	QUANTITY	UNIT COST		ITEM COST	
1/ Furnish Turbine and Governor						
Speed Increaser, Flywheel,						
Generator and Controls	EA	2	321,300	00	626	600
Install Turbine and Governor						
Speed Increaser, Flywheel,						
Generator and Controls	EA	2	24,000	00	48	000
Furnish and Install:						
Generators						
Generators	EA				83	780
Switchgears and controls						
Excitation equipment						
Station Service	LS				2	230
Transformer	EA				23	430
Miscellaneous Electrical -						
grounding, raceways, wiring						
lighting	LS				12	040
Control system	LS				25	000
Rehabilitate Maintenance Crane	LS				3	000
Ventilation fan and duct	LS				3	500
Service pump and piping	LS				1	500
Sump Pump and Piping	LS				1	200
Subtotal					839	280
Contingencies 20%					40	740
Total Construction Cost					871	020
1/ Not included in contingency						
determination						

TABLE V-2D
LOWER POWER PLANT
ALTERNATIVE NUMBER 4 - ALLIS-CHALMERS
MECHANICAL AND ELECTRICAL

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST
1/ Furnish Turbine and Governor	EA	1	482,000 00	482 000
Speed Increaser, Generator, and				
Controls	EA	1	720,00	720 000
Install Turbine and Governor				
Speed Increaser, Generator and				
Controls	EA	2	43,000	86 000
Furnish and Install:				
Generators				
Generators	EA			93 730
Switchgears and controls				
Excitation equipment				
Station Service	LS			2 230
Transformer	EA			23 430
Miscellaneous Electrical -				
grounding, raceways, wiring				
lighting	LS			5 040
Control system	LS			25 000
Rehabilitate Maintenance Crane	LS			3 000
Ventilation fan and duct	LS			3 500
Service pump and piping	LS			1 500
Subtotal				1 351 700
Contingencies 20%				29 940
Total Construction Cost				1 381 640
1/ Not included in contingency				
determination				

TABLE V-2E
LOWER POWER PLANT
ALTERNATIVE NUMBER 5 - ALLIS-CHALMERS
MECHANICAL AND ELECTRICAL

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST
1/ Furnish Turbine and Governor				
Speed Increaser, Generator and				
Controls	EA	2	482,000 00	964 000
Install Turbine and Governor				
Speed Increaser, Generator and				
Controls	EA	2	43,000 00	86 000
Furnish and Install:				
Generators				
Generators				
Switchgears	LS			93 730
Excitation equipment				
Station Service	LS			2 230
Transformer	EA			21 580
Miscellaneous Electrical -				
grounding, raceways, wiring				
lighting	LS			4 600
Control system	LS			25 000
Rehabilitate Maintenance Crane	LS			3 000
Ventilation fan and duct	LS			3 500
Service pump and piping	LS			1 500
Subtotal				1 205 140
Contingencies 20%				48 230
Total Construction Cost				1 253 370
1/ Not included in contingency				
determination				

TABLE V-3A
UPPER POWER PLANT
ALTERNATIVE NUMBERS 1 AND 2
CIVIL WORKS

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST
Cofferdam upstream	LF	80	20 00	1 600
Cofferdam downstream	LF	100	50 00	5 000
Dewatering	LS			28 000
Excavation - Str earth	CY	950	6 00	5 700
Excavation - Str rock	CY	90	40 00	3 600
Excavation - Tailrace	CY	480	3 00	1 440
Backfill - Str	CY	600	6 00	3 600
Concrete Removal	CY	75	60 00	4 500
Concrete - Walls	CY	170	250 00	42 500
Concrete - Deck slabs	CY	85	270 00	17 850
Concrete - Footings and base slabs	CY	110	130 00	14 300
Reinforcing steel	LB	48 000	0 40	19 200
Rebuild Trashracks	LS			10 000
Inlet gates and hoist	EA	2	8,000 00	16 000
Bulkhead and lifting beams	EA	1	12,000 00	12 000
Maintenance platforms	SF	75	30 00	2 250
Hatches	EA	2	1,500 00	3 000
Ladders	LF	40	30 00	1 200
Building Rehabilitation				
General	LS			3 000
Roof	SF	800	2 00	1 600
Doors and windows	LS			4 500
Building expansion	SF	350	62 00	21 700
Dam modification opening	CY	100	40 00	4 000
Dam - Flashboards	LF	330	10 00	3 300
Parking Area - Surfacing	SF	50	10 00	500
Subtotal				230 340
20% Contingencies				46 070
Subtotal				276 410

TABLE V-3B
UPPER POWER PLANT
ALTERNATIVE NUMBER 3
CIVIL WORKS

ITEM	UNIT	QUANTITY	UNIT COST		ITEM COST	
Cofferdam upstream	LF	80	20	00	1	600
Cofferdam downstream	LF	70	50	00	3	500
Dewatering	LS				23	000
Excavation - Str earth	CY	20	6	00		120
Excavation - Tailrace	CY	480	3	00	1	440
Concrete removal	CY	5	60	00		300
Concrete - Walls	CY	5	250	00	1	250
Concrete - Footings and base slabs	CY	5	130	00		650
Reinforcing steel	LB	200	0	40		80
Rehabilitate Trashracks	LS				6	000
Inlet gates and hoists	EA	1	8,000	00	8	000
Hatches	EA	1	1,500	00	1	500
Ladders	LF	20	30	00		600
Powerhouse rehabilitation						
General structural	LS				3	000
Roof	SF	800	3	00	1	600
Doors, windows and finish	LS				4	500
Dam modification opening	CY	100	40	00	4	000
Dam - Flashboards	LF	330	10	00	3	300
Parking area - Surfacing	SY	50	10	00		500
Subtotal					64	940
20% Contingencies					12	990
Subtotal					77	930

TABLE V-3C
UPPER POWER PLANT
ALTERNATIVE NUMBER 4
CIVIL WORKS

ITEM	UNIT	QUANTITY			UNIT COST		ITEM COST	
Cofferdam upstream	LF			80	20	00	1	600
Cofferdam downstream	LF			70	50	00	3	500
Dewatering	LS						23	000
Excavation - Str earth	CY			20	6	00		120
Excavation - Tailrace	CY			480	3	00	1	440
Concrete removal	CY			110	60	00	6	600
Concrete - Walls	CY			10	250	00	2	500
Concrete - Deck slabs	CY			90	270	00	18	900
Concrete - Footings and base slabs	CY			5	130	00		650
Reinforcing steel	LB		8	000	0	40	3	200
Rebuild trashracks	LS						6	000
Roller or slide gates and hoist	EA			1	8,000	00	8	000
Bulkhead and lifting beams	EA			1	12,000	00	12	000
Maintenance platforms	SF			160	30	00	4	800
Hatches	EA			1	1,500	00	1	500
Ladders	LF			20	30	00		600
Building Rehabilitation								
General	LS						3	000
Roof	SF			800	2	00	1	600
Doors and windows	LS						4	500
Dam modification- opening	CY			100	40	00	4	000
Dam - Flashboards	LF			330	10	00	3	300
Parking area surfacing	SF			50	10	00		500
Subtotal							111	310
20% Contingencies							22	260
Subtotal							133	570

TABLE V-3D
UPPER POWER PLANT
ALTERNATIVE NUMBER 5
CIVIL WORKS

ITEM	UNIT	QUANTITY			UNIT COST		ITEM COST		
Cofferdam upstream	LF			80	20	00		1	600
Cofferdam downstream	LF			100	50	00		5	000
Dewatering	LS							28	000
Excavation - Str earth	CY		2	430	6	00		14	580
Excavation - Str rock	CY			120	40	00		4	800
Excavation - Tailrace	CY			480	3	00		1	440
Backfill - Str	CY		1	380	6	00		8	280
Concrete removal	CY			210	60	00		12	600
Concrete - Walls	CY			260	250	00		65	000
Concrete - Deck slabs	CY			50	210	00		10	500
Concrete - Footings and base slabs	CY			145	130	00		18	850
Reinforcing steel	LB		74	000	0	40		29	600
Rebuild trashracks	LS							10	000
Roller gate and hoist	EA			2	8,000	00		16	000
Bulkhead and lifting beams	EA			1	12,000	00		12	000
Maintenance platforms	SF			220	30	00		6	600
Hatches	EA			2	1,500	00		3	000
Ladders	LF			40	30	00		1	200
Building Rehabilitation									
General	LS							3	000
Roof	SF			800	2	00		1	600
Doors and windows	LS							4	500
Building expansion	SF			660	44	00		29	040
Dam modification - opening	CY			100	40	00		4	000
Dam - Flashboards	LF			330	10	00		3	300
Parking area surfacing	SF			50	10	00			500
Subtotal								294	990
20% Contingencies								59	000
Subtotal								353	990

TABLE V-3E
UPPER POWER PLANT
ALTERNATE NO. 6
CIVIL WORKS

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST
Cofferdam Upstream	LF	80	20 00	1 600
Cofferdam downstream	LF	100	50 00	5 000
Dewatering	LS			28 000
Excavation - Str. earth	CY	950	6 00	5 700
Excavation - Str. rock	CY	210	40 00	8 400
Excavation - Tailrace	CY	480	3 00	1 440
Backfill - Str.	CY	650	6 00	3 900
Concrete Removal	CY	200	60 00	12 000
Concrete - Walls	CY	190	250 00	47 500
Concrete - Deck Slabs	CY	65	210 00	13 650
Concrete - Footings and Base Slabs	CY	80	130 00	10 400
Reinforcing Steel	LB	45 000	40	18 000
Rebuild Trashracks	LS			10 000
Roller Gates and Hoist	EA	2	25,000	50 000
Bulkhead and Lifting Beams	EA	1	8,000	8 000
Maintenance Platforms	SF	110	30 00	3 300
Hatches	EA	2	1,500 00	3 000
Ladders	LF	40	30 00	1 200
Building Rehabilitation				
General	LS			3 000
Roof	SF	800	2 00	1 600
Doors and Windows	LS			4 500
Building Expansion	SF	280	70 00	19 600
Dam Modification - Opening	CY	100	40 00	4 000
Dam - Flashboards	LF	330	10 00	3 300
Parking Area Surfacing	SF	50	10 00	500
Subtotal				267 590
20% Contingencies				53 520
Subtotal				321 110

TABLE V-3F
UPPER POWER PLANT
ALTERNATE NO. 7
CIVIL WORKS

ITEM	UNIT	QUANTITY		UNIT COST		ITEM COST	
Cofferdam Upstream	LF		80	20	00	1	600
Cofferdam Downstream	LF		70	50	00	3	500
Dewatering	LS					23	000
Excavation - Str. Earth	CY		20	6	00		120
Excavation - Tailrace	CY		480	3	00	1	440
Concrete Removal	CY		90	60	00	5	400
Concrete - Walls	CY		30	250	00	7	500
Concrete - Deck Slabs	CY		5	210	00	1	050
Concrete - Footings and Base Slabs	CY		5	130	00		650
Reinforcing Steel	LB	3	600	0	40	1	440
Rehab. Trashracks	LS					6	000
Roller Gates and Hoist	EA		1	25,000		25	000
Bulkhead and Lifting Beams	EA		1	8,000		8	000
Maintenance Platforms	SF		110	30	00	3	300
Hatches	EA		1	1,500	00	1	500
Ladders	LF		20	30	00		600
Building Rehabilitation							
General	LS					3	000
Roof	SF		800	2	00	1	600
Doors and Windows	LS					4	500
Dam Modification - Opening	CY		100	40	00	4	000
Dam - Flashboards	LF		330	10	00	3	300
Parking Area Surfacing	SF		.90	10	00		500
Subtotal						107	000
20% Contingencies						21	400
Subtotal						128	400

TABLE V-4A
LOWER POWER PLANT AND DAM
ALTERNATIVE NO. 1 AND 2
CIVIL WORKS

ITEM	UNIT	QUANTITY		UNIT COST		ITEM COST	
Cofferdam Upstream	LF		100	50	00	5	000
Cofferdam Downstream	LF		170	30	00	3	600
Dewatering and Clean-up	LS					12	000
Excavation - Tailrace	CY		570	3	00	1	710
Concrete Removal	CY		15	60	00	1	900
Concrete - Walls	CY		17	250	00	4	250
Concrete - Deck Slabs	CY		12	210	00	2	520
Concrete - Footings and Base Slabs	CY		10	130	00	1	300
Reinforcing Steel	LB	7	200		40	2	880
Rehab. Trashracks	LS					7	500
Inlet Gates and Hoist	EA		2	9,000		18	000
Bulkhead and Lifting Beams	EA		1	12,000		12	000
Maintenance Platforms	SF		180	30	00	5	400
Hatches	EA		2	1,500	00	3	000
Ladders	LF		40	30	00	1	200
Powerhouse Rehab.							
General Refurbish	LS					2	500
Roof	SF	2	100	2	00	4	200
Doors and Windows	LS					2	500
Gatehouse Rehab.							
General	LS					1	000
Roof	SF		200	2	00	2	400
Doors and Wikdows	LS					12	500
Gates	GA		6	2	00	18	000
Dam - Rehabilitation	LF		300	75	00	22	500
Dam - Flashboards	LF		300	22	00	6	600
Access Road							
Grading	SY	3	000	0	25		750
Gravel Surfacing	SY	3	000	4	50	13	500
Subtotal						150	610
20% Contingencies						30	120
Subtotal						780	730

TABLE V-4B
LOWER POWER PLANT AND DAM
ALTERNATIVE NO. 3
CIVIL WORKS

ITEM	UNIT	QUANTITY		UNIT COST		ITEM COST	
Cofferdam Upstream	LF		100	50	00	5	000
Cofferdam Downstream	LF		120	30	00	3	600
Dewatering	LS					15	000
Excavation - Tailrace	CY		570	3	00	1	710
Concrete Removal	CY		210	60	00	12	600
Concrete - Walls	CY		55	250	00	13	750
Reinforcing Steel	LB	6	500		40	2	600
Rehab. Trashracks	LS					7	500
Inlet Gates and Hoists	EA		2	3,000		16	000
Outlet Bulkheads & Lifting Beams	EA		1	12,000		12	000
Maintenance Platforms	SF		430	30	00	12	900
Hatches	EA		2	1,500	00	3	000
Ladders	LB		40	30	00	1	200
Powerhouse Rehabilitation							
General Refurbish	LS					2	500
Roof	SF	2	100	2	00	4	200
Doors and Windows	LS					2	500
Gatehouse Rehabilitation							
General Refurbish	LS					1	000
Roof	SF	1	200	2	00	2	400
Doors and Windows	LS					1	500
Gates	EA		6	2	00	12	000
Dam - Rehabilitation	LF		300	75	00	22	500
Dam - Flashboards	LF		300	22	00	6	600
Access Road							
Grading	SY	3	000	0	25		750
Gravel Surfacing	SY	3	000	4	50	13	500
Subtotal						175	310
20% Contingencies						35	060
Subtotal						210	370

TABLE V-4C
LOWER POWER PLANT AND DAM
ALTERNATIVE NO. 4 AND 5
CIVIL WORKS

ITEM	UNIT	QUANTITY		UNIT COST		ITEM COST	
Cofferdam Upstream	LF		100	50	00	5	000
Cofferdam Downstream	LF		120	30	00	3	600
Dewatering and Clean-up	LS					25	000
Excavation - Rock	CY		80	40	00	3	200
Excavation - Tailrace	CY		570	3	00	1	710
Backfill	CY		50	6	00		300
Concrete - Removal	CY		170	60	00	10	200
Concrete - Walls	CY		60	250	00	15	000
Concrete - Deck Slabs	CY		48	210	00	10	080
Concrete - Footings and Base Slabs	CY		42	130	00	5	460
Reinforcing Steel	LB	24	000		40	9	600
Rehab. Trashracks	LS					7	500
Roller Gates and Hoists	EA		2	25,000		50	000
Bulkheads and Lifting Beams	EA		1	12,000		12	000
Maintenance Platforms	SF		180	30	00	5	400
Hatches	EA		2	1,500	00	3	000
Ladders	LB		40	30	00	1	200
Powerhouse Rehabilitation							
General Refurbish	LS					2	500
Roof	SF	2	100	2	00	4	200
Doors and Windows	LS					2	500
Gatehouse Rehabilitation							
General Refurbish	LS					1	000
Roof	SF	1	200	2	00	2	400
Doors and Windows	LS					1	500
Gates	EA		6	2 000		12	000
Dam - Rehabilitation	LF		300	75	00	22	500
Dam - Flashboards	LF		300	22	00	6	600
Access Road							
Grading	SY	3	000	0	25		750
Gravel Surfacing	SY		000	4	50	13	500
Subtotal						237	700
20% Contingencies						47	540
Subtotal						285	240

TABLE V-5
FISH FACILITIES

UPPER DAM AND POWER PLANT

ITEM	UNIT	QUANTITY			UNIT COST		ITEM COST	
Cofferdamming	LF			180	30	00	5	400
Dewatering	LS						12	000
Concrete Removal	CY			28	60	00	1	680
Excavation - Rock	CY			80	40	00	3	200
Str Backfill	CY			50	6	00		300
Concrete - Walls	CY			130	250	00	32	500
Concrete - Footing and slabs	CY			90	150	00	13	500
Reinforcing Steel	LB		23	000		40	9	200
Louvers	LF			140	680	00	95	200
Maintenance Platform	SF			480	25	00	12	250
Roller Gates and Hoists	EA			3	15,000	00	45	000
Slide Gates	EA			2	300	00		600
Pump and Piping	LS						2	700
Gabion Barrier Wall	LF			140	80	00	11	700
Float Well	EA						5	000
Stand-by Power System	LS						5	000
Miscellaneous Metal Work	LB		1	000	3	00	3	000
Ice Prevention Bubbler System	LS						5	500
Subtotal							263	730
20% Contingencies							52	750
Total Construction							316	480

TABLE V-6
FISH FACILITIES

LOWER DAM AND POWER PLANT

ITEM	UNIT	QUANTITY			UNIT COST		ITEM COST		
Cofferdamming	LF			170	50	00		8	500
Dewatering	LS							15	000
Concrete Removal	CY			40	60	00		2	400
Excavation - Rock	CY			250	40	00		10	000
Excavation - Earth	CY			150	6	00			900
Str Backfill	CY			120	6	00			720
Concrete - Walls	CY			80	150	00		12	000
Reinforcing Steel	LB		19	000		40		7	600
Louvers	LF			180	550	00		99	000
Maintenance Platform	SF			640	25	00		16	000
Roller Gates and Hoists	EA			3	15,000	00		45	000
Slide Gates	EA			2	300	00			600
Pump and Piping	LS							2	700
Barrier Dam and Walls	LF			250	125	00		37	250
Float Well	EA							5	000
Stand-by Power System	LS							5	000
Miscellaneous Metal Work	LB		1	000	3	00		3	000
Ice Prevention Bubbler System	LS							6	000
Subtotal								300	670
20% Contingencies								60	130
Total Construction								360	800

TABLE V-7

CAPITAL COST SUMMARY

Alternative	Construction Costs: Power Plant Mechanical/Electrical	Power Plant Civil Work	Fish Facilities Net Cost	Total	Engineering and Administration (10%)	Total Capital Costs
UPPER SITE						
1	1,241,040	276,410	315,880	1,883,330	188,330	2,071,650
2	894,100	276,410	315,880	1,802,270	180,230	1,982,500
3	483,760	77,930	315,880	877,570	87,760	965,240
4	484,600	133,570	315,880	934,050	93,410	1,027,460
5	893,240	353,990	315,880	1,563,110	156,310	1,719,420
6	1,496,220	321,110	315,880	2,133,210	213,330	2,346,540
7	662,320	128,400	315,880	1,106,600	110,660	1,217,260
LOWER SITE						
1	1,129,550	180,730	360,800	1,671,080	157,110	1,838,190
2	860,590	180,730	360,800	1,402,120	140,210	1,542,330
3	879,010	210,370	360,800	1,450,180	145,020	1,595,200
4	1,381,640	285,240	360,800	2,027,680	202,770	2,230,450
5	1,253,370	285,240	360,800	1,899,410	139,940	2,089,350

TABLE V-8
OPTION 2 - 5 KV DISTRIBUTION LINE - UTILITY BACKUP
UPPER AND LOWER POWER PLANTS

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST
1000 kva transformer, motor and protection	LS			30,000
5 kv distribution line	LS			106,820
Distribution transformers	LS			36,220
Services	EA	7	500.00	3,500
5 kv connection	LF	25	12.40	310
23 kv connection	LF	250	30.68	7,670
Trench excavation	CY	2,000	0.65	1,300
Trench backfill	CY	2,000	0.70	1,400
Road repair	LS			3,500
Subtotal				190,720
20% Contingencies				38,140
Total Construction Cost				228,860

TABLE V-9
OPTION 2 - 5 KV DISTRIBUTION LINE WITH UTILITY BACKUP
UPPER POWER PLANT

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST
1000 kva transformer, motor and protection	LS			30,000
5 kv distribution line	LS			86,450
Distribution transformers	LS			36,220
Services	EA	7	500.00	3,500
5 kv connection	LF	25	12.40	310
23 kv connection	LF	250	30.68	7,670
Trench excavation	CY	1,365	0.65	890
Trench backfill	CY	1,365	0.70	960
Road repair	LS			3,000
Subtotal				169,000
20% contingencies				33,800
Total Construction Cost				202,800

TABLE V-10

OPTION 3 - 5 KV DISTRIBUTION LINE WITH DIESEL BACKUP

UPPER POWER PLANT

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST
500 kva diesel generator set	EA	2	60,000.00	120,000
Auto sequencers with breakers	EA	2	22,000.00	44,000
Generator set building and enclosure	LS			106,820
5 kv distribution line	LS			86,450
Distribution transformer	LS			36,220
Services	EA	7	500.00	3,500
480 v connection	LF	40	69.00	2,760
Trench excavation	CY	1,365	0.65	870
Trench backfill	CY	1,365	0.70	960
Road repair	LS			3,500
Subtotal				298,260
20% Contingencies				59,650
Total Construction Cost				357,910

TABLE V-11
OPTION 3 - 5 KV DISTRIBUTION LINE WITH DIESEL BACKUP
UPPER AND LOWER POWER PLANTS

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST
500 kva diesel generator set	EA	2	60,000.00	120,000
Auto sequencers with breakers	EA	2	22,000.00	44,000
Generator set building and foundation	LS			3,550
5 kv distribution line	LS			106,820
Distribution transformers	LS			36,220
Services	EA	7	500.00	3,500
480 v connection	LF	40	69.00	2,760
Trench excavation	CY	2,000	0.65	1,300
Trench backfill	CY	2,000	0.70	1,400
Road Repair	LS			3,500
Subtotal				323,050
20% Contingencies				64,610
Total Construction Cost				387,660

TABLE V-12

TOWN FACILITIES - ENERGY REQUIREMENTS

		Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec	Annual
High School	E	207.6	239.4	151.2	88.8	79.2	58.8	29.4	21.6	60.6	60.0	98.4	164.4	1259.4
	D	930	1088	834	606	492	384	264	120	534	540	642	918	1088
Middle School	E	17.3	19.2	19.8	15.4	18.1	14.6	8.9	5.6	14.9	11.9	17.4	17.4	180.5
	D	94	96	91	90	84	84	60	48	84	84	90	101	101
Elementary School	E	8.1	7.6	8.2	6.8	8.5	6.6	2.9	2.6	7.4	6.7	9.5	8.4	83.3
	D	50	50	50	53	48	48	30	16	50	48	48	50	53
Town Hall	E	14.0	14.4	12.7	13.8	13.2	21.5	24.2	29.3	18.2	13.6	16.6	13.6	205.1
	D	40	46	41	59	71	86	85	84	72	42	43	41	86
Sewer Plant	E	10.0	10.0	11.0	9.2	11.2	9.4	8.8	9.1	9.7	9.0	11.0	9.6	118.0
	D	28	30	33	32	25	31	26	31	32	32	22	32	33
Town Garage	E	1.5	1.5	0.9	0.5	0.5	0.4	0.5	0.5	0.6	0.6	0.7	0.9	8.6
	D	8	8	6	5	6	4	5	5	5	5	6	7	6
Park E. Hill Road	E	0.7	0.7	0.7	0.7	0.8	6.0	13.0	13.3	6.8	0.8	0.9	1.0	44.7
	D	4	4	3	7	11	33	40	42	46	10	10	11	46
Total	E	259.1	297.7	203.5	135.2	137.7	117.4	87.6	82.1	118.2	102.6	154.5	215.2	1972.6
	D	1153	1240	1059	852	736	671	510	345	819	751	862	1160	1059

E - Energy - 1000 KWH
D - Peak Demand - KW

TABLE V-13

TOWN FACILITIES ENERGY DEMAND - DURATION
IN PERCENT OF MONTHLY PEAK

Month	Number of Hours - Weekdays				No of Hours-Weekend/Holidays	
	1	10	4	9	12	12
January	100	51	31	19	19	19
February	100	56	34	22	22	22
March	100	42	25	16	16	16
April	100	38	23	15	15	15
May	100	40	24	16	16	16
June	100	38	23	15	18	15
July	100	37	22	14	18	14
August	100	31	31	20	24	20
September	100	32	20	13	14	14
October	100	29	18	11	11	11
November	100	43	26	17	17	17
December	100	46	28	18	18	18

TABLE V-14

TOWN SELF SERVICE AND
COGENERATION ENERGY ANALYSIS

	ALTERNATIVE	
	U_1L_1	U_1
Production - Million KWH Annually	10.33	5.88
Load - Million KWH Annually	1.97	1.97
Utilized - Million KWH Annually	1.69	1.58
Surplus - Million KWH Annually	8.64	4.31
Backup - Million KWH Annually	0.29	0.39
Maximum Peak Backup Demand-KW	663	883
Number of Day Backup Required	108	175

TABLE V-19

PROJECT ALTERNATIVES

Alternative	Generation Unit Alt. and Capacity - KW		Total Installed Capacity	Ave. Annual Energy Production Million-KWH		Energy Production Variation - 1965-77 Million KWH		Capital Cost Million $	Cost $ Per KW
	Upper	Lower	KW	1983	2023	High	Low	1979	1979
U_1L_1	1-570	1-1160	2730	10.33	8.90	14.8	4.2	3.91	1430
U_2L_2	2-1060	2-760	1820	8.81	7.63	12.0	3.8	3.52	1930
U_3L_2	3-530	2-760	1290	7.11	6.20	9.1	3.4	2.51	1950
U_4L_3	4-457	3-650	1102	6.72	7.08	8.0	3.9	2.62	2380
U_5L_3	5-904	3-650	1554	8.45	7.55	10.7	4.4	3.31	2130
U_6L_4	6-1232	4-888	2121	10.02	8.82	13.3	4.7	4.58	2160
U_7L_4	1-347	4-888	1235	6.77	6.07	8.4	3.5	3.45	2790
U_1	1-1570	-----	1570	5.89	5.06	8.5	2.3	2.07	1320
U_2	2-1060	-----	1060	5.03	4.34	6.9	2.2	1.98	1870
U_3	3-530	-----	530	3.33	2.91	4.1	1.7	0.97	1830

TABLE V-20

SUMMARY OF ECONOMIC ANALYSIS - OPTION 1

	Alternatives									
	U_1L_1	U_2L_2	U_3L_2	U_4L_3	U_5L_3	U_6L_4	U_7L_4	U_1	U_2	U_3
Capital Costs[1]	4298.3	3514.1	2735.0	2922.6	3654.0	5121.9	3827.9	2477.9	1782.8	1003.5
Bonds Required[2]	4414.4	3609.1	2809.0	3001.5	3752.7	5259.3	3931.4	2544.9	1831.0	1030.5
Annual Costs - O&M[3]	61.9	48.0	36.6	31.6	41.7	51.8	36.6	42.9	34.1	22.7
Administration	12.4	9.6	7.3	6.3	8.3	10.4	7.3	8.6	6.8	4.8
Insurance	9.3	7.6	5.9	6.4	7.8	11.1	8.3	5.4	3.9	2.1
License Fee	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Repairs and Replacement Sinking Fund	26.1	22.8	17.8	18.8	22.6	31.8	23.6	21.6	11.5	6.6
Annual Bond Payment	331.1	270.7	210.7	225.1	281.5	394.5	294.9	190.9	137.3	77.3
First Year Cost of Service[3] (¢/KWH)	4.3	4.1	4.0	4.3	4.3	5.0	5.5	4.8	3.9	3.5
Cost of Service 1979 Value (¢/KWH)	3.4	3.2	3.2	3.4	3.4	4.0	4.4	3.8	3.1	2.7
Net Funds in First Year of Service[3]	-139.0	-101.6	-71.8	-92.8	-115.5	-206.0	-173.9	-92.2	-48.1	-18.1
Internal Rate of Return-%	10.4	10.7	11.0	10.4	10.4	9.4	8.8	10.9	10.8	11.7
Benefit-Cost Ratio	1.71	1.80	1.87	1.76	1.76	1.54	1.40	1.70	1.79	1.93

Notes:
1. Completed cost escalated to year of payment
2. Fully amortized for 40 year life
3. For first year of service - 1983
4. All cost are in thousands of dollars except as noted
5. Cost of money (7%)

TABLE V-21

SUMMARY OF ECONOMIC ANALYSIS

Options 2 and 3

	Option 2		Option 3	
	Alternative		Alternative	
	U_1L_1	U_1	U_1L_1	U_1
Capital Costs[1]	4591.2	2477.9	4794.7	2676.4
Bond Required[2]	4715.3	2544.9	4924.9	2748.7
Annual Costs - O&M[3]	63.1	42.9	65.6	44.2
Administration	12.6	8.6	13.1	8.8
Insurance	10.0	5.4	10.5	5.7
License Fee	2.8	2.8	2.8	2.8
Repairs and Replacement Sinking Fund	353.7	21.0	34.9	29.1
Annual Bond Payment	34.9	190.9	369.4	206.2
First Year Cost of Service (¢/KWH) [3]	4.6	4.8	4.4	4.4
Cost of Service 1979 Value (¢/KWH)	3.6	3.8	3.5	3.5
Net Fund in First Year of Service [3]	-162.0	-92.2	-148.5	-73.2
Internal Rate of Return-%	10.2	10.5	10.4	11.1
Benefit-Cost Ratio	1.60	1.50	1.71	1.70

Notes:

1. Completed cost escalated to year of payment
2. Amortized for 40 year life
3. For first year of service 1983
4. All cost are in thousands of dollars except as noted
5. Cost of money (7%)

TABLE V-22

BENEFIT COST RATIO AND
INTERNAL RATE OF RETURN

INITIAL ENERGY VALUE SENSITIVITY

1979 ENERGY VALUE - CENTS

	2.0		2.2		2.4		2.6	
Alternative	B/C	IRR-%	B/C	IRR-%	B/C	IRR-%	B/C	IRR-%
U_1L_1	1.54	9.7	1.71	10.4	1.87	11.0	2.02	11.6
U_2L_2	1.62	10.0	1.80	10.7	1.96	11.3	2.13	11.9
U_3L_2	1.68	10.3	1.87	11.0	2.04	11.6	2.21	12.2
U_4L_3	1.58	9.7	1.76	10.4	1.92	11.0	2.08	11.5
U_5L_3	1.58	9.7	1.76	10.4	1.92	11.0	2.08	11.5
U_6L_4	1.49	8.8	1.54	9.4	1.68	10.0	1.82	10.5
U_7L_4	1.26	8.2	1.40	8.8	1.53	9.4	1.65	9.9
U_1	1.53	10.2	1.70	10.9	1.86	11.6	2.01	12.2
U_2	1.61	10.1	1.79	10.8	1.95	11.5	2.12	12.1
U_3	1.74	10.9	1.93	11.7	2.10	12.4	2.06	13.1

Notes:

1. Option 1 marketing
2. Interest - 7%
3. Energy value escalation - 8%
4. Annual cost escalation - 6%
5. Project life - 40 years

TABLE V-23

ENERGY VALUE ESCALATION SENSITIVITY

	Escalation					
	6%		8%		10%	
Alternative	IRR-%	B/C	IRR-%	B/C	IRR-%	B/C
U_1L_1	7.5	1.10	10.4	1.71	12.9	2.73
U_3L_2	8.9	1.20	11.0	1.76	13.5	2.99
U_3	8.5	1.24	11.7	1.93	14.4	3.08

Notes:

1. Interest - 7%
2. Initial (1979) energy value - 2.2¢
3. Annual cost escalation - 6%
4. Project Life - 40 years
5. Option 1 marketing

VI. SOCIOECONOMIC AND ENVIRONMENTAL ASSESSMENTS

SOCIOECONOMIC

The Town of Canton is a semi-rural suburban community. Local economic activities primarily consist of commercial services and a few light "cottage" type industries.

The project site is located in the Collinsville section of the town, which is listed in the National Register of Historical Sites. The town is currently working to obtain a historical district designation for this area.

The Farmington River provides significant recreational and aesthetic benefits. The river is used for canoeing, water skiing, and fishing, and also serves as a natural open space area.

Local Economy

The proposed hydroelectric generation program can contribute to the local enonomy in several ways:

1. It will reduce the town's annual expense for electric power.

2. It can, through the availability of low cost power, provide inducement to a power-consuming industry to locate in Canton, thus increasing the property tax base.

3. The program will result in short-term employment opportunities during the construction phase and long-term opportunities for a few operating personnel during the life of the program.

4. Through its potential for attracting new industry to the area, the program can provide significant long-term industrial employment opportunities.

Historical Enhancement

The proposed program is a further step in the preservation of historic Collinsville. Local efforts, both public and private, have led to a number of restoration and preservation projects in the past several years. The former Collins Company buildings have been maintained by the Collinsville Company as a viable industrial complex, the Canton Town Hall has been enlarged and renovated, the Valley House

Hotel is currently being renovated as an apartment building, the Canton Historical Society operates an excellent museum with outstanding displays of the Victorian era, Collinsville sites are listed in the National Historic Register, and efforts have been made to establish a historic district in Collinsville. These enterprises have been designed to preserve the atmosphere of the late 1800's when Collinsville was a prosperous industrial town, with its existence dependent upon the water power of the Farmington River. What could be more appropriate than to resume use of water power to benefit the community?

Recreation

The Upper Reservoir at Collinsville is currently used for water skiing, canoeing, rowing, and fishing. A small grassy park with benches and a boat launching ramp is located near the south end of the pond. Flashboards are installed and maintained each year by a water ski organization to maintain sufficient depth for outboard motors. The proposed generation program would not impede any of the existing uses but would improve conditions by providing deeper water. In addition, the installation and maintenance of flashboards would become the responsibility of the generator operator. The water skiers would be relieved of this effort and expense.

The Lower Reservoir is now essentially unused for any recreational purpose. Access is difficult and water elsewhere is more convenient. The proposed program would increase water depth and improve fishing and boating conditions. It is questionable whether public demand is sufficient to justify establishment of public recreation facilities at this location. However, the proposed hydro generation program in no way reduces the potential for recreational use.

The project also includes the fish facilities that will provide for implementation of the State of Connecticut Migratory Fisheries Restoration Program. As is outlined in the Connecticut Department of Environmental Protection Report, "Farmington River Atlantic Salmon Program and Fish Passage Requirements at Collinsville Dam," Appendix D, significant recreational and economic benefits will accrue from the sport fishing provided by this program.

ENVIRONMENTAL IMPACT ASSESSMENT

An environmental inventory of the site has been made and is included as Appendix F to this report.

The environmental impact of the proposed power generating facilities has been assessed in the following areas:

1. Visual impact of flow diversions and of modifications to the dam, intake and powerhouse structures.

2. Temporary and long-term impacts relating to construction efforts.

3. Effects of the project on plants, fish, and wildlife.

4. Environmental benefit of fossil fuel replacement.

Visual Impact

The major visual changes to the proposed generating sites will be the added fish facilities structures and flashboards at each dam. At the Upper site it will be necessary to expand the size of the existing powerhouse for those alternatives requiring the installation of two generation units. These expansions will use materials and a design visually identical to the existing building, thereby minimizing the visual impact of the project. No other significant external construction or modification is anticipated at the Lower site. Addition of flashboards to the dams, while visible, should not be detrimental to the appearance of the area. Both dams have been fitted with boards in the past and the Upper Dam now has boards installed each summer by a local water ski organization. The fish ladder structures will also be quite conspicuous but should harmonize with the functional appearance of the existing dam and powerhouse structures. It is anticipated that materials used for all visible new construction will be chosen for their ability to blend with the colors and textures of existing structures.

Water flow patterns will be altered significantly in the area between the dam and the turbine outflow at each site. At the Upper Dam, little or no water will normally flow in the steep rocky bed immediately below the dam. This will be most conspicuous when viewed from the west bank along Route 179 just south of the powerhouse. At the Lower site a backwater area will exist between the base of the dam and the turbine discharge even when no water passes over the dam. No section of riverbed will be exposed.

In summary, while there will be a change of appearance at both sites, the character will remain the same and no significant visual detriment can be identified.

Impact Related to Construction

In any construction such as that proposed there will be a short-term impact upon adjacent land and water areas. Blasting and excavating will release a finite amount of sediment into the river. Construction equipment will tend to break down stream banks. There is a potential for fuel or other chemical spillage into the river. Good engineering practice and close supervision of the construction program can reduce risk to a minimum. Short-term effects of construction should cause no significant harm to the river ecology. No long-term effects have been identified.

Effects on Fish and Wildlife

The proposed program will not interfere with the existing river flow pattern which has been traditionally controlled by other agencies. This generating facility will operate on "run-of-the-river" and will not hold back or release water. Addition of flashboards to the dams will create deeper water, thus providing an improved environment for fish, particularly in the summer months when water temperatures rise. The higher water levels will result in flooding of a few low islands and sandbanks. Because these low areas contain nesting sites of several bird species, including the Canada goose, the reservoir behind the flashboards should be scheduled for initial filling before or after the nesting season. Reduction of the nesting area is not considered to be significant as potential sites are abundant in the area. The initial rise in water level could also have a detrimental effect on the spawning pattern of native fish. Proper scheduling should eliminate any such problem.

The major environmental effect of this program will be upon migratory fish that must pass the site in an upstream direction to spawn, and those that pass, for one reason or another, in a downstream direction. The Connecticut Department of Environmental Protection currently proposes to construct a fish ladder at the Upper Dam and to provide a breach in the Lower Dam to permit fish passage. The proposed hydro generation program includes construction of fish passage facilities at both dams as described elsewhere in this report. It is to be expected that even the best possible fish passage facilities will hinder the movement of fish in the river. However, with proper design and management, the proposed facilities should not impose any limitation on the successful passage of Atlantic salmon and shad at the generator sites.

In considering effects of the project upon migratory fish, it must be noted that no fish have been able to pass upstream and beyond the Collinsville dams for over 100 years. This program is designed to work in conjunction with the Atlantic salmon restoration program and actually improve upon existing conditions.

Impact of Fossil Fuel Replacement

Establishment of hydroelectric power generation at the Collinsville sites will result in a net reduction of atmospheric pollution by the reduction of the amount of fossil fuel required for power generation in Connecticut. This will be a distributed benefit affecting air quality in general and may not be observed in the vicinity of the generating sites.

Summary

In summary, the environmental impact of this project is primarily in the area of migratory fish passage. Facilities for such passage are proposed as part of the hydroelectric generation facility so that the environmental problem becomes an economic one which can be treated in the financial plan.

Other identified negative environmental factors are minor and are balanced by the benefit of hydroelectric generation in the reduction of fossil fuel contamination of the atmosphere.

VII. LEGAL AND INSTITUTIONAL ASPECTS

Implementation of the Canton Hydroelectric Project will require review by coordination with, agreement with, and/or approvals by various local, state, and federal governmental agencies, and quasi-public and private entities. Various state and federal statutes and administrative regulations must be complied with and agreement must be reached with several interested entities. These factors are discussed in the following paragraphs.

LOCAL GOVERNMENT - TOWN OF CANTON

It is proposed that the hydroelectric generation facility be operated by the Town of Canton in a manner similar to the Town Highway Department or Sewage Treatment Plant.

For the construction and planning phase it is recommended that a Building Committee be appointed by the Town Meeting. The responsibilities of this committee shall be to conduct on behalf of the town, all negotiations and contracts with private, state, and federal agencies as required to establish the physical plant, distribute or sell the power, and to plan and supervise construction of the generation facilities. Upon completion of the construction phase, the Building Committee shall deliver the operating physical system to the Board of Selectmen with complete operating instructions. At this time the Building Committee shall be dissolved and operation shall be the responsibility of the Board of Selectmen or such other agency as shall be determined by the Town Meeting.

Implementation of the option of the town providing service to the town-owned facilities will require coordination by the town engineer to assure that all street and road repairs are properly made, and that the use of the affected facilities is not impaired or disrupted during construction of the project facilities. The town school officials will also be involved in a coordinating and review capacity.

The potential option of procuring an industry user for the project power would be the responsibility of the Town Economic Development Commission with reviews and guidance by the Board of Selectmen and approval by the Town Meeting.

STATE OF CONNECTICUT

Various agencies and offices of the state shall be involved in the project implementation process as outlined below.

Facilities Ownership

The existing dams and powerhouse are owned by the state and are maintained by the Farmington Office of the Department of Environmental Protection. An agreement transferring ownership of the facilities to the Town of Canton will be required.

Fish Facilities and Water Rights

The Fisheries Restoration Program is under the jurisdiction of the Department of Environmental Protection, Division of Conservation and Protection, Fish and Wildlife. This agency will have review and approval authority for the proposed project fish passage facilities.

The state also has water rights in Colebrook Reservoir (Appendix A) for fisheries enhancement purposes. This water will be used in maintaining flows in the Farmington River.

Dam Safety

The Water Resources Unit of the Department of Environmental Protection has jurisdiction in the area of Dam Safety. As outlined in Appendix G, the state authority to inspect and require modification of existing dams, review and approve designs, supervise construction, and issue certificates of approval as related to dam safety lies with the Water Resources Unit.

Water Quality

The Water Compliance Unit of theDepartment of Environmental Protection administers the Connecticut Clean Water Act and has the authority to review the project relative to any potential effects on the Farmington River water quality.

Wetlands and Water Courses Act

The Department of Environmental Protection will review the project relative to any potential adverse affects on the natural environment, including fish, wildlife, soils, and vegetation; recreational or other public uses and the aesthetic values of the river in accordance with Connecticut Inland Wetlands and Water Courses Act.

Power Facilities Evaluation

The Power Facilities Evaluation Council, in accordance with the Public Utility Environmental Standards Act, reviews and certifies all new public utility power facilities. Formal certification by the Council will probably not be required since the town will not fall under the legal definition of a public utility; however, some review and assessment by the Council is anticipated.

Public Utilities Control Authority (PUCA)

The PUCA currently has under consideration a proposed general rate adjustment and a proposed cogeneration rate (Rate 90) by Northeast Utilities. Their assessments and determinations regarding these proposals may affect any agreement between the town and Northeast Utilities.

Additionally, the PUCA will likely review the project with regard to its relationships with the Northeast Utilities and Hartford Electric Light Company facilities and operations over which the PUCA has jurisdiction.

Environmental Impact Assessment

It is anticipated that a comprehensive Environmental Impact Report will be required by the Department of Environmental Protection. This report would satisfy the environmental assessment requirements of the various agencies discussed in the above paragraphs, and would include all environmental impacts (short and long-term), mitigation measures and alternatives to the project.

FEDERAL

Various federal agencies shall be involved in the implementation process in both a formal review and approval capacity, and shall also undertake informal review and coordination responsibilities.

Federal Energy Regulatory Commission (FERC)

Licensing of the project by the FERC is required under Title 18 of the Federal Code of Regulations.

Should each of the sites be licensed separately, they would fall under the category of "minor projects," (less than 2,000 horsepower capacity) and would require only a "short form" license application in accordance with Title 18.

The application would basically consist of:

1. Exhibit K - Project Lands and Boundaries. A map showing the project location, boundaries and land ownerships, all project work and other important and related physical features.

2. Exhibit L - Project Structures and Equipment. Drawings of proposed project facilities including plans and sections of power plants, diversion structures and related facilities.

3. Environmental Report shall include:

   -- Brief project description
   -- Environmental setting description
   -- Expected environmental impacts
   -- Alternative means of obtaining equivalent power
   -- Description of coordination with federal, state, and local agencies during environmental report preparation.

4. Copies of the State Water Quality Certificate pursuant to Section 40 of the Federal Water Pollution Control Act and other state approvals necessary for project implementation.

The "minor project" licensing process should normally require about six to 12 months for completion.

If both sites are licensed jointly the project would fall under the current FERC definition of a "major project", which will necessitate a much more detailed and comprehensive application, and a review and approval period of up to 18 months. However, efforts are currently being made to redefine a "major project" to one with a capacity of 15 megawatts or more. The major project application would require the following:

-- Exhibit A - Municipality Certification
-- Exhibit B - Certification of Filing Authorization
-- Exhibit C - Municipality Authority for Construction and Operation
-- Exhibit D - Evidence of Compliance with Applicable State Laws
-- Exhibit E - Water Rights
-- Exhibit F - Lands Owned by Applicant
-- Exhibit G - Statement of Financial Capability
-- Exhibit H - Proposed Project Operations
-- Exhibit I - Estimate of Dependable Capacity
-- Exhibit J - Project Area Map
-- Exhibit K - Boundary Survey

-- Exhibit L - Design Drawings
-- Exhibit M - Description of Major Equipment
-- Exhibit N - Cost Estimates
-- ExhibitiO - Construction Schedule
-- Exhibit R - Recreation Plan
-- Exhibit S - Fish and Wildlife Report
-- Exhibit V - Protection and Enhancement of Natural, Historic and Scenic Values
-- Exhibit W - Environmental Report

The FERC will also inspect the project during implementation and require periodic construction, and maintenance and operation reports.

Corps of Engineers

A Form 404, "Application for Department of Army Permits for Activities in Waterways" may be required by the Corps under the provisions of the U.S. Harbors and Waterways Act. This application would include a brief project description and details of activities within the waterway. Hearings and Corps' approval would be required prior to project construction.

Additionally, the Corps operates the Colebrook River, Mad River, and Sucker Brook Dams and Reservoirs upstream of the project.

U.S. Fish and Wildlife Service

The Fish and Wildlife Service will provide technical review assistance to the state in the review and approval of the project fish facilities.

Historic Preservation Act

The Upper Dam and powerhouse areas are listed in the National Register of Historical Sites and the town is working toward obtaining a "historical district" designation for the area. Compliance with the provisions of this act may be necessary.

NORTHEAST UTILITIES (NU) - HARTFORD ELECTRIC LIGHT COMPANY (HELCO)

A sale or cogeneration agreement will be required between NU and the town. NU will also review the project facilities design to assure compatibility with their system. Local coordination of project construction and operations will be with HELCO, a subsidiary of NU.

METROPOLITAN DISTRICT - WATER RIGHTS

The Farmington River water rights are generally the property of the Metropolitan District in accordance with the state legislation and agreement included in Appendix A. Cooperation between the district and the town will be required during the project implementation and operation phases.

Current legislation requires that the district maintain a minimum flow of only 50 cfs in the river while a current agreement exists between the district and the Farmington River Power Company for a flow of 150 cfs as indicated in Appendix A.

FARMINGTON RIVER WATERSHED ASSOCIATION AND OTHER ENTITIES

Various other local, regional and state, and possibly national organizations and interested groups may be involved in the project review process. Included would be various groups interested in the Farmington River's fisheries, recreational and aesthetic values.

The Farmington River Watershed Association is a privately funded member organization interested in maintaining the environmental, scenic and recreational values of the river. This organization will be a key participant in the project implementation process.

VIII. PROJECT IMPLEMENTATION PLAN

A proposed implementation schedule for this project is shown on Figure VIII-1. This schedule includes the major steps necessary for project implementation. The schedule provides for approximately a 42-month implementation period. The initial and most important components of the implementation program will be power marketing and project financing. The schedule provides for the completion of these aspects prior to the commitment of large funds for detailed final designs, contract preparation, manufacturing and construction. The schedule provides for a period of project feasibility review during the power marketing and financing stages, since the final determination will be affected by the results of these activities. A one-year period has been provided for completion of the marketing and financing; however, this period may be extended due to delays in finalizing a power sale agreement which may be required prior to obtaining project financing.

A one-year period has been allowed for preparation and approval of Federal Energy Regulatory Commission licensing. This timing envisions the preparation of separate license applications for each of the sites. Each project would then qualify as a "minor project" in accordance with current FERC regulations. Should it be necessary to include both sites under a single application, the project would then be considered a "major project" and the licensing approval period would probably be increased by six to nine months. A one-year period is also provided for obtaining other federal, state, and local project reviews, permits and approvals, as are discussed in Section VII, Legal and Institutional Aspects, of this report.

The schedule provides for some overlap of the FERC licensing and other administrative approvals with the final design activities; however, it is predicated upon completion of all permit and licensing aspects prior to commitment to any manufacturing or construction contracts.

The implementation schedule is predicated on utilizing three major manufacturing and construction contracts.

1. A contract for the fabrication and installation of the turbines and generators. This would be the first contract awarded since the fabrication time required for the turbines will likely be the most critical factor governing project completion. Based on preliminary information from manufacturers, 14 months has been allowed for the delivery of the turbines and generators. This time requirement could be shortened depending on the selected type of equipment and

the manufacturer. The turbine and generator have been included in one contract so that the bidding will not be overly limited with regard to type of equipment and manufacturers, thus providing for the selection of the equipment best suited for the project. Some manufacturers have established policies of bidding for a combined generation unit while others prefer bidding the turbine or generator only. The latter firms will form joint ventures for this project.

Since the type and capacity of generation units selected will affect both civil works and appurtenant equipment costs, a four-week period has been provided for the evaluation of the turbine and generator proposals. The selection of the equipment type and manufacturer shall be based on the following factors.

a. Equipment cost and quality of manufacture.
b. Equipment performance - capacity and efficiency.
c. Civil works and appurtenance costs.
d. Delivery time.
e. Assessment of the manufacturer's capability to meet all contractual obligations.
f. Compatibility with the site.

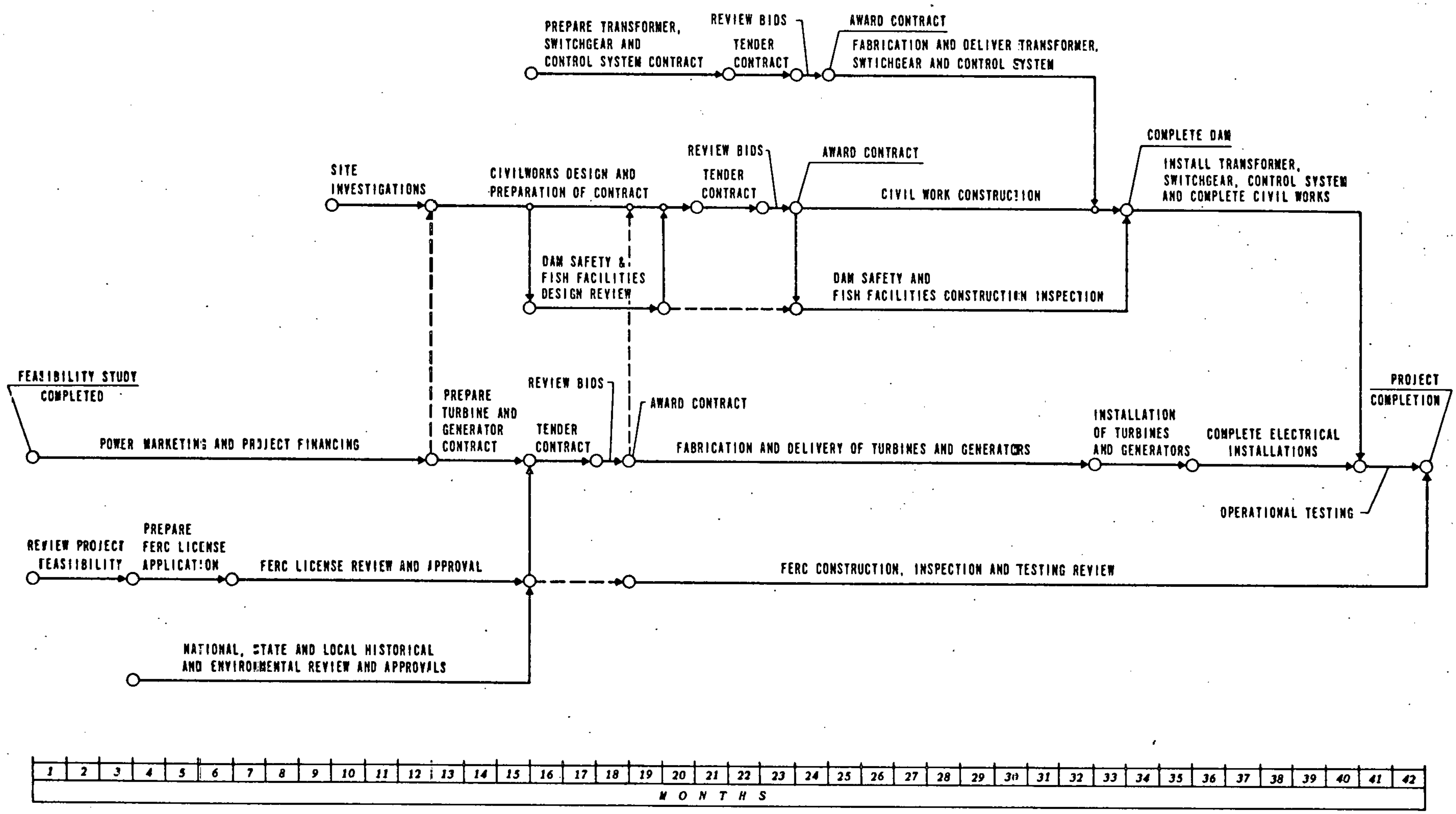
2. A contract for the fabrication and delivery of the switchgear, controls, transformer, and control system equipment. The equipment will be selected on the basis of its cost, quality and compatibility with the generation units. This equipment will be installed by the civil works and completion contractor.

3. A civil works and equipment completion contract. The contract would include all the project civil works such as the dam and power plant restoration work, installation of the transformer and switchgear, and furnishing and installation of miscellaneous and appurtenant facilities such as conduit, wiring, transmission lines, grounding, lighting, and water supply. This contract would be of the competitive bid unit price type.

All the contract tendering provisions shall require a complete qualifications submittal by the bidders. The tender documents shall include qualification requirements, and only qualified bidders will be accepted.

The schedule includes provisions for continuing review by and cooperation with the State of Connecticut and the FERC during the project design and construction phases. Cooperation with interested state and federal agencies will be of particular importance in the design of the project fish facilities and the dam safety appraisal.

The schedule also provides for a two-month operational testing program before the project would be considered complete and ready for commercial operations.



CANTON HYDROELECTRIC PROJECT

IMPLEMENTATION SCHEDULE

DEVELOPMENT AND RESOURCES CORPORATION
Sacramento, California

Figure VIII-1

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