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Bolsa Island Nuclear Power and Desalting Project Facilities (Cost and Description) and Cost of Desalted Water

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UNITED STATES DEPARTMENT OF THE INTERIOR • Walter J. Hickel, Secretary
Carl L. Klein, Assistant Secretary for Water Quality and Research

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FOREWORD

This is one of a continuing series of reports designed to present accounts of progress in saline water conversion and the economics of its application. Such data are expected to contribute to the long-range development of economical processes applicable to low-cost demineralization of sea and other saline water.

Except for minor editing, the data herein are as contained in a report submitted by the contractor. The data and conclusions given in the report are essentially those of the contractor and are not necessarily endorsed by the Department of the Interior.

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CHAPTER 1

INTRODUCTION

PURPOSE

Subsequent to the decision by the Bolsa Island Project Participants to terminate their respective agreements on September 30, 1968, and the decision by the Board of Directors of the Metropolitan Water District of Southern California on December 10, 1968 to consider sea water desalting as part of their long range plan, it was considered necessary and desirable by Metropolitan and the U.S. Government Agencies participating in the Bolsa Project to prepare a comprehensive report which would provide a detailed description of the nuclear desalting facility. The report would include total Project costs and develop unit costs for desalted water.

This report represents a compilation of the principal information prepared during the course of the Bolsa Project prior to the termination of the agreements between the Participants.

PROJECT BACKGROUND

Metropolitan's interest in sea water desalting began in 1958 with exploratory studies for producing potable water from the ocean. In 1964, negotiations were completed between Metropolitan, the Office of Saline Water, and the Atomic Energy Commission resulting in a subcontract to Bechtel Corporation to perform engineering and economic studies of nuclear power and desalting plants.

In the spring of 1965, the principal electric utilities of Southern California (Southern California Edison Company, San Diego Gas and Electric Company, and the Los Angeles Department of Water and Power) offered to participate in the design and construction of the nuclear power and desalting facility. The Engineering and Economic Feasibility Report of December 1965(1) concluded that a dual-purpose nuclear desalting plant located on a man-made island was technically feasible. The report also concluded that the participation of Electric Utilities would provide the lowest cost to Metropolitan.

In the period from January 1966 to August 1966, Metropolitan's staff and Board of Directors considered participation in a combined nuclear power and desalting plant basically as described in the 1965 Feasibility Report and also considered variations which included construction of the desalting plant in two phases; namely the construction of a desalting facility with a capacity of 50 million gallons per day (mgd) in conjunction with a two-unit nuclear power plant, followed by an expansion of 100 mgd, resulting in a total installed capacity of 150 mgd completed four to five years after the construction of the first facility. The concept for building an 1,800 gross megawatt electrical (Mwe) nuclear power plant and a 150-mgd desalting plant in two stages (phased plant) was approved by the Metropolitan Board of Directors for construction subject to consummation of contractual arrangements in August 1966. Concurrently, a hydraulic model study of the proposed island was made at the California Institute of Technology Hydraulic Laboratories under supervision of Bechtel Corporation to verify wave defense design parameters[2].

In October 1966 negotiations were initiated between Metropolitan, U.S. Government (OSW and AEC), and Electric Utilities (DWP, SCE, and SDG&E) to develop contracts for the purpose of designing and constructing the phased nuclear power and desalting plant. In addition, Bechtel was authorized to conduct a detailed site investigation program to determine the geologic, seismic, and soils characteristics for a man-made island site and to develop design and construction criteria.

In May 1967 a Congressional Bill authorizing participation by the Government was signed by President Johnson. Beginning in the spring of 1967 and continuing through July 1967, specifications for nuclear steam supply systems and turbine-generator equipment were issued by the Electric Utilities and Metropolitan and bids for this equipment were received. Evaluation of the major equipment bids continued during the summer and fall of 1967.

In August 1967, Assembly Bill 1782 granting tidelands to Metropolitan for use as a site for the man-made island and causeway was signed by Governor Reagan. On November 20, 1967 contract documents were signed by all Project Participants. Early in 1968 studies were initiated by the Participants to define design concepts and to update estimates of the costs of each Participant's responsibility in the Project.

REPORT CONTENT

This report provides a description of the phased plant concept, the total costs associated with this concept based on scheduled completion as anticipated in April 1968, and estimates of unit costs for desalted water. The report is presented in seven chapters.

— Chapter 1 is the introduction.

— Chapter 2 summarizes the principal items presented in the body of the report.

— Chapter 3 describes the Project organizational and economic bases for determination of the plant concepts, the cost estimates, and unit costs associated with the production of desalted water.

— Chapter 4 provides descriptions of the plant facilities including drawings and is arranged to describe the dual-purpose power and desalting plant by its principal components.

Chapter 5 presents the capital and investment costs for the total plant by principal facilities. The information contained in this chapter includes assumptions made by the Participants and Bechtel in the development of cost estimates, a list of the contingencies, and a description of the necessary adjustments.

Chapter 6 details the annual cost items that are considered in developing the costs of desalted water and presents the basis for determination of Metropolitan's share of the plant investment costs.

Chapter 7 presents a reconciliation and explanation of the cost increases incurred during the period between the 1965 Feasibility Report (1) and the 1968 studies to update Project cost estimates.

This report summarizes the reference design and cost estimates for the phased nuclear power and desalting plant, incorporating pertinent information from previous studies.

Additional studies and consultant reports were utilized to define basic site criteria and plant design criteria. These studies included detailed investigation of the geologic, seismic, and soil characteristics of the Bolsa site; meteorology of the Bolsa site; effect of the island on littoral sand movements; tsunami potential at the site; island and causeway planning studies; and evaluation of desalting plant performance ratio.

DEFINITIONS

To aid the reader in identifying certain abbreviations and terms used extensively in this report, the following list of principal definitions is provided:

Bolsa Project (Project) - The design, construction, and operation of a two-unit, nuclear power plant in combination with a desalting plant, located on a man-made island (Bolsa Island) offshore of Bolsa Chica State Beach in Orange County, California, including transmission of electric power and desalted water to points of connection with the respective systems.

Participants

Metropolitan or MWD - The Metropolitan Water District of Southern California

SCE - The Southern California Edison Company

SDG&E - The San Diego Gas & Electric Company

DWP or LADWP - The Department of Water and Power of the City of Los Angeles

OSW - The Office of Saline Water of the United States Department of Interior

AEC - United States Atomic Energy Commission.

Owners or Owning Participants - The Bolsa Project Participants who will own and hold title to their agreed upon share of the Bolsa Project facilities. The Owners are MWD, SCE, SDG&E, and DWP.

PMB or Project Management Board - The Project Management Board consists of one member and one alternate from each participant. The PMB is responsible for the timely and successful completion of the Project and for guidance and control of the Project Coordinator's work.

PEC or Project Engineers Committee - The PEC consists of members appointed by each participant. The PEC is responsible for coordination of the detailed design and construction of each Owner's facility in close cooperation with the Project Coordinator.

Project Coordinator or PC - The Project Coordinator is responsible for providing coordination, scheduling, cost control, administrative services, and other services as directed by the PMB. Metropolitan, as contractor for the Participants, engaged Bechtel Corporation to perform Project Coordinator services.

Architect-Engineer or MWD's A/E - Metropolitan selected Bechtel Corporation to perform Architect-Engineer services in relation to Metropolitan's design and construction responsibilities in the Bolsa Project. These responsibilities include the island and causeway, backpressure turbine, and the desalting plant.

CHAPTER 2

SUMMARY

GENERAL

The Bolsa Island Nuclear Power and Desalting Plant concept is summarized in this chapter. The plant facilities are described to the extent they were defined for the purpose of establishing acceptable concepts, interrelationships, and cost estimates and are not the result of final design efforts. The total Project cost estimate is based upon the facilities described and includes allowances for design to meet anticipated criteria, contingencies, and Owners' costs. Pertinent agreements and understandings among the Participants are cited to provide bases for allocations of Project costs among the Owners.

Metropolitan's investment cost in the Bolsa facility is determined and estimates of the annual costs associated with the production of desalted water are developed. The unit costs of producing desalted water at the plant site and delivered to the Robert B. Diemer Filtration Plant are calculated.

The increase in the estimates of total Project costs between 1965 and 1968 is discussed and the factors causing the increase are identified and presented for each major facility in the Bolsa Project.

The sections of the summary which follow are arranged in the order of the subsequent chapters.

BASES FOR COST OF WATER

Metropolitan's capital costs, operation and maintenance costs, and the resultant cost of desalted water at the Bolsa Island plant site are based on the economic ground rules, criteria, and plant parameters presented in Chapter 3 and on the following desalting plant operation dates:

— The 150-mgd, phased, multistage flash evaporator desalting plant will consist of three trains. The construction will be phased for commercial operation of the first 50-mgd train on September 1, 1974; the second 50-mgd train on March 1, 1978; and the third 50-mgd train on September 1, 1978.

In addition, certain ground rules on which the cost of desalted water was based in the report entitled Engineering and Economic Feasibility Study for a Combination Nuclear Power and Desalting Plant(1), prepared by Bechtel Corporation in December 1965, have been updated to reflect current conditions and those forecasted to the time the 150-mgd phased desalting plant would be constructed and placed into commercial operation.

Metropolitan's investment costs in the Project are based upon the Agreement between Metropolitan and the Electric Utilities dated November 20, 1967 which provides, in part, that the cost to Metropolitan for its entitlement in the nuclear power plant would be determined by the difference in the estimated cost of the dual-purpose power plant and the estimated cost of a power only plant having a net capacity equivalent to the Electric Utilities entitlement in the dual-purpose plant.

The principal economic factors used as a basis for Metropolitan's investment and annual costs include cost of money at 4.25 percent; sinking fund depreciation based on 30-year nominal plant life; no ad valorem taxes or State, local, and federal income taxes; California sales tax of 5 percent; and nuclear insurance based on normal commercial and Government indemnification with MWD self-insured for all other insurance costs.

Operating and maintenance expenses are based on incremental power plant O & M costs, estimates of operating and maintenance personnel and materials for the desalting plant, 1968 prices for sulfuric acid, desalting plant load factor of 90 percent, and nuclear fuel costs calculated from vendor data and adjusted for Metropolitan's cost of money.

FACILITIES DESCRIPTION

The Bolsa Island Nuclear Power and Desalting Project includes a combination nuclear power and desalting facility producing approximately 1,900 Mw of gross electrical power and 150 mgd of desalted water, with an initial installation of 50 mgd and appropriate provisions for expansion of the desalting plant to a capacity of 150 mgd in four years.

The facility will be located on an island to be constructed offshore from Bolsa Chica State Beach in Orange County, California as shown on Plate 4.1, with a 2,400-foot causeway connecting the island to the mainland.

The Project also includes an onshore electrical switchyard with connecting lines to the plant complex and an underground electrical transmission facility.

The nuclear power plant portion of the Project comprises two nuclear reactor systems that will generate and supply steam to two condensing turbine-generators and one backpressure turbine-generator. Steam supplied to the condensing turbine-generators will be used solely for the production of electric power. Steam supplied to the backpressure turbine-generator will serve a dual function: generating electric power from part of the energy and conveying the remaining energy in turbine exhaust steam to the desalting plant brine heaters.

The desalting plant concept is a multistage, long tube, horizontal flash evaporator utilizing three trains of 50 mgd. The initial installation of 50 mgd is designed for expansion to 150 mgd by the addition of two 50-mgd trains.

The desalted product water will be conveyed to Metropolitan's distribution system at the Robert B. Diemer Filtration Plant through a six-foot diameter line about 24 miles long. The conveyance system includes an island pumping station, an intermediate pumping station and reservoir, and a blending structure.

Electric transmission to the SCE system connection point at Del Amo Substation is provided by four circuits of 220 kv underground pipe-type, naturally cooled cable approximately 11 miles long. Electric transmission to the DWP system at Station "C" in Wilmington is accomplished with 3 circuits of underground pipe-type, 230-kv cable approximately 18 miles long.

COST ESTIMATES

The cost estimates presented in Table 2.1 were determined by the Participants to be representative of the total Bolsa Island Project costs including the estimated cost of electric transmission and product water conveyance facilities required to deliver electric power and desalted water to the point of interconnection with the distribution system of the respective Utilities. The costs shown are for the complete two-unit nuclear power plant and the full 150-mgd phased desalting plant.

TABLE 2.1

BOLSA ISLAND PROJECT COSTS
(Millions of Dollars)

ISLAND AND PLANT FACILITIES		
Island and Causeway	$ 45.3	
Power Plant - Unit 1	197.6	
Power Plant - Unit 2	189.6	
Backpressure Turbine Plant	43.4	
Desalting Plant	159.8	
Land for Switchyard and Right-of-Way for Cable	2.8	
Project Coordinator	8.6	
Subtotal	$647.1	
OTHER FACILITIES		
Product Water Conveyance System (MWD)	$ 41.5	
Power Transmission System (DWP)	34.4	
Power Transmission System (SCE/SDG&E)	42.5	
Subtotal	$118.4	
TOTAL PROJECT COSTS		$765.5

Method of Compiling Costs

The cost estimates were received from the Owners and are the Owners' estimates of their share of the total Project cost. These costs are based on phased construction of the desalting plant and the power generating units.

Each Owner's estimates of cost were reviewed by the Project Coordinator as received, reconstructed for consistency, and evaluated for completeness. The costs were then reviewed by the Project Engineers and adjustments were made to assure that the costs presented in Table 2.1 and Chapter 5 reflect the total estimated Project costs.

Schedule

The cost estimates prepared by the Owners are based upon the following commercial operation schedule:

Unit 1 Condensing Power Plant	September 1, 1974
Backpressure Turbine	September 1, 1974
First 50-mgd Water Plant	September 1, 1974
Unit 2 Condensing Power Plant	September 1, 1975
Second 50-mgd Water Plant	March 1, 1978
Third 50-mgd Water Plant	September 1, 1978

Design Criteria

The estimates of constructed cost reflect the current design concepts. These designs are based on criteria presented in the Preliminary Safety Analysis Report (PSAR)[3] and recommended by consultants to the Project based upon the detailed site investigation work and hydraulic model studies of the island [2]. The design concepts also reflect the safeguards provisions that have been required by AEC Regulations in current license applications.

Allowances for the cost of redesign of the island, causeway, and plant facilities to meet potential additional design criteria are provided for in the "Design Allowances" and are included in the total Project costs compiled in this report.

COST OF WATER

The elements that determine MWD's annual costs are annual fixed charges on investment, operating and maintenance costs for both the desalting plant and the power plant, desalting plant sulfuric acid costs, nuclear insurance costs, fuel costs, and power credits.

Annual fixed charges are calculated based on 4.25 percent annual rate for non-depreciable items and 5.86 percent and 6.30 percent for depreciable items with 31- and 27-year economic life, respectively. Annual fixed charges rate on the conveyance system is 4.49 percent, which is a weighted average based on 50- and 75-year lifetime for pumping stations and pipelines, respectively.

Metropolitan's investment cost in the Project including the product water conveyance system is 278.2 million dollars. This investment is assumed to be allocated to the facilities as listed in Table 2.2 in which Metropolitan would own the island and causeway, desalting plant, and conveyance system with the remainder of its cost responsibility in power and related facilities.

TABLE 2.2

METROPOLITAN'S INVESTMENT COST
(Millions of Dollars)

Facility	150-Mgd Phased Plant
Island and Causeway	45.3
Desalting Plant	159.8
Power and Related Facilities	31.6
TOTAL COST AT BOLSA	236.7
Conveyance System	41.5
TOTAL COST AT DIEMER	278.2

The annual costs associated with the production of 150 mgd of desalted water are developed in detail in Chapter 6. The annual costs and associated annual production of desalted water are levelized by dividing the present worth of annual costs by the present worth of annual production to develop an equivalent equal annual unit cost which considers the variable annual production and variable annual costs. The resulting unit water cost is shown in Table 2.3 at the Bolsa plant site and at the Diemer Filtration Plant.

TABLE 2.3

UNIT COST OF DESALTED WATER

	At Bolsa	At Diemer
Cents per 1,000 Gallons	36.5	43.7
Dollars per Acre-Foot	119	142

FACTORS CAUSING PROJECT COST CHANGES

The material presented in Chapter 7 is concerned with the increase in Project costs based on the differences in estimates made in 1965 and those made in April 1968. The basis of the April 1968 estimate is discussed in detail in Chapter 5 of this report.

The cost estimates presented by Bechtel Corporation in the 1965 Engineering and Economic Feasibility Study(1) were based on an unphased 150-mgd desalting plant and on 1965 labor and material prices without allowance for escalation. An adjustment to the basic 1965 estimate was made on March 4, 1966 based on phasing the construction of a 150-mgd desalting plant with a total elapsed time of five years between commercial operation of the first 50-mgd train and commercial operation of the second and third trains of 50 mgd each. The adjustment of March 1966 was made without specific allowance for the escalation that would occur in the period of time between the completion of the first 50-mgd unit and completion of the 150-mgd plant.

The Bolsa Island Project cost estimates are shown in Table 2.4, Summary of Project Cost Changes. The increase in estimated costs, by facility, from the 1965/1966 estimate to the April 1968 estimate is also shown.

TABLE 2.4

SUMMARY OF PROJECT COST CHANGES
(Millions of Dollars)

Island and Plant Facilities	Estimate Based on 1965 Prices	1965 Estimate with Escalation to 1974-1978	Increase
Island and Causeway	$ 23.6	$ 45.3	$ 21.7
Power Plant - Unit 1	108.8	197.6	88.8
Power Plant - Unit 2	101.3	189.6	88.3
Backpressure Turbine Plant	25.4	43.4	18.0
Desalting Plant	107.4	159.8	52.4
Land for Switchyard and Right-of-Way for Cable	0.5	2.8	2.3
Project Coordination	-	8.6	8.6
Subtotal	$367.0	$647.1	$280.1
Other Facilities			
Product Water Conveyance	$ 33.5	$ 41.5	$ 8.0
Power Transmission System - (DWP)	33.5	34.4	0.9
Power Transmission System - (SCE/SDG&E)	10.0	42.5	32.5
Subtotal	$ 77.0	$118.4	$ 41.4
TOTAL COST - PHASED PLANT CONSTRUCTION	$444.0	$765.5	$321.5

The principal factors which contributed to the increase in Project costs of 321.5 million dollars are summarized in Table 2.5, Factors Causing Project Cost Changes.

TABLE 2.5

FACTORS CAUSING PROJECT COST CHANGES
(Millions of Dollars)

1965/1966 Estimates (Based on 1965 Price Levels)			$444.0
Factors Contributing to Cost Increase:			
Column Numbers from Table 7.4			
IV	Escalation of Island and Plant Facilities	$152.7	
V	Increase in California Sales Tax	3.0	
VI	Higher Power Plant Output	16.0	
VII	Market Changes in Nuclear Steam Supply Systems	23.7	
VIII	Changes in Design Criteria	17.4	
IX	Allowance for Anticipated Project Requirements	35.5	
X	Change in Project Responsibility	25.2	
XI	Higher Costs for Interest During Construction (IDC)	16.9	
XII	Savings over the Original Estimate	(25.3)	
XIII	Increase in Offsite Facilities		
	A. Product Water Conveyance	8.0	
	B. Power Transmission Systems	33.4	
XIV	Additional Owners' Contingency	15.0	
	TOTAL COST INCREASE		321.5
	APRIL 1968 ESTIMATE (Escalated to Project Completion)		$765.5

The single most significant factor contributing to the cost increase is the escalation of labor and material prices projected to the time of completion of the Project in September 1978. The change in design criteria and the allowance for anticipated Project requirements together account for an increase of 52.9 million dollars. A third major item is the increase in offsite facilities (electric transmission and product water conveyance), most of which is due to the assumption of placing the SCE/SDG&E transmission lines underground.

CHAPTER 3

BASES FOR COST OF WATER

GENERAL

Metropolitan's capital costs, operation and maintenance costs, and the resultant cost of desalted water at the Bolsa Island plant site are based on the economic ground rules, criteria, and plant parameters presented in this chapter and on the following desalting plant operation dates:

— The 150-mgd, phased, multistage flash evaporator desalting plant will consist of three trains. The construction will be phased for commercial operation of the first 50-mgd train on September 1, 1974; the second 50-mgd train on March 1, 1978; and the third 50-mgd train on September 1, 1978.

BASIC AGREEMENTS AND UNDERSTANDINGS

The cost of desalted water is based upon the contractual documents and agreements set forth in Metropolitan-United States Government Contract No. 14-01-0001-1290 and in the Agreement between Metropolitan and the Electric Utilities dated November 20, 1967.

In addition, certain ground rules on which the cost of desalted water was based in the report entitled Engineering and Economic Feasibility Study for a Combination Nuclear Power and Desalting Plant(1), prepared by Bechtel Corporation in December 1965, have been updated to reflect current conditions and those forecasted to the time the 150-mgd phased desalting plant would be constructed and placed into commercial operation.

The costs of water shown in Chapter 6, Table 6.3, for the phased desalting plant are based on MWD's investment costs in a dual-purpose power and desalting plant at the island site, and include the costs for the conveyance system and for pumping the product water from the plant site to the Diemer Filtration Plant. Metropolitan's investment costs are based on the contractual agreements, wherein SCE/SDG&E and DWP agreed to construct, own, and operate two nuclear power plants for the purpose of generating electric energy for their respective customers and providing steam through a backpressure turbine to the desalting plant. It was further agreed that MWD would own the island and causeway, the backpressure turbine, the desalting plant, and the desalting plant sea water intake structure and pumps, together with all related facilities identified with each of these items. The Electric Utilities would pay the estimated cost of a single-purpose plant of the same general type, and having electrical capacity equivalent to the Utilities' share of the dual-purpose plant with MWD paying the incremental costs between the single-purpose and the dual-purpose plants. MWD would have an entitlement in the NSSS for the steam required for the backpressure turbine and desalting plant. MWD would own nuclear fuel required for the generation of power in the backpressure turbine for its own use and steam to the desalting plant.

The nuclear power plant portion of costs used in determining the difference in costs between a two-unit, single-purpose and a two-unit, dual-purpose power plant was furnished by the Utilities. These costs were based on each utility performing the engineering and construction of its respective power plant unit. For the purpose of this report, it has been assumed that SCE/SDG would design and construct the first operable power plant unit for commercial operation on September 1, 1974.

The allocation of costs for the nuclear power facilities and the island and causeway are based on preliminary discussions between the Owners. Although no final agreement was reached, the allocations presented are believed to be a reasonable assessment of MWD's cost responsibility.

ECONOMIC FACTORS

The cost of money to MWD used in the report is 4.25 percent. Fixed charges are based on the cost of this money, plus sinking fund depreciation based on a nominal 30-year plant life. Fixed charges on non-depreciable investments, such as the island and causeway, are calculated at 4.25 percent.

Taxes

Ad Valorem Taxes

It is assumed that the ad valorem taxes assessed to MWD are zero.

California Sales and Use Tax

The California sales tax of 5 percent is included as a tax on the materials and equipment purchased for MWD's facilities.

Income Taxes

The District is exempt from all State, federal, and local corporate income taxes.

Insurance

Property Damage and Public Liability (Non-Nuclear)

For the purpose of this study, it is assumed that MWD's self-insurance will be extended to cover its investment in the nuclear power plant and the desalting plant. Any increase in the cost of this insurance is not reflected in this study.

Nuclear Insurance

Nuclear insurance is computed for MWD's share of the nuclear facility, based on commercial coverage of public liability insurance, government indemnification under the Price-Anderson Act, and property damage insurance for nuclear hazards (computed on MWD's share of power plant capital cost).

Distributable Costs

Distributable costs incurred during engineering and construction includes the following:

— Interest During Construction

— MWD Engineering and Other Expenses Including Spare Parts

— Project Accountant

— Land Grant.

OPERATING AND MAINTENANCE EXPENSE

Power Plant

MWD's share of the power plant operating and maintenance expense is based on information furnished by the Electric Utilities to determine the incremental O & M cost differential between the Utilities' single-purpose and dual-purpose power plants.

Desalting Plant Labor and Material Costs

The operating and maintenance labor of the desalting plant is based on an estimate of the number of personnel required. Wage information was furnished by MWD and includes payroll additives and general and administrative expense. The operating and maintenance material and supplies are based on experience of seacoast power plants and on estimates compiled by OSW and other agencies.

SULFURIC ACID COSTS

Estimated delivered costs were developed from a March 1968 quoted price of $34.55 per ton for commercial 100-percent acid at a supplier's plant in the Los Angeles area, transportation by 20-ton trucks at $1.55 per ton, and a predicted volume discount of $5.50 per ton.

VALUE OF ELECTRIC POWER

The values shown here are based on information supplied by MWD. These values are used to calculate the credits for replacement of Colorado River Aqueduct pumping power and for product water pumping power as described in Chapter 6.

COLORADO RIVER AQUEDUCT PUMPING (110 Mw)*

September 1, 1974 to January 1, 1980	5.125 mills/kw
January 1, 1980 through end of economic life	
MWD's Cost for Capacity and O & M**	1.50 mills/kwhr
MWD's Cost for Fuel @ Condensing Turbine Heat Rate**	1.30 mills/kwhr
Total	2.80 mills/kwhr

PRODUCT WATER PUMPING POWER (28 Mw)*

	Island Pumping Plant	Intermediate Pumping Plant
Phase I - 50 mgd	4 Mw @ 2.8 mills	4 Mw @ 7.9 mills
Phase II - 100 mgd	9 Mw @ 2.8 mills	9 Mw @ 7.1 mills less $40,000 annually
Full 150-mgd plant	14 Mw @ 2.8 mills	14 Mw @ 7.1 mills less $40,000 annually

*The electrical power requirement shown is installed or rated capacity. For calculating annual cost or credit, a capacity factor of 0.90 is used.

**Assumed for purpose of evaluating power credit.

LOAD FACTOR

The desalting plant is assumed to be base-loaded throughout the economic life of the plant. A load factor of 0.9 is used, which takes into consideration plant outages both for preventive maintenance and emergency shutdowns.

COPPER-NICKEL PRICE

It was initially assumed that Government copper-nickel could be purchased at a fixed price of 38 cents per pound for Phase I (50 mgd) of the phased desalting plant. Subsequent changes in Project schedule and uncertainty regarding the continued availability of copper-nickel scrap resulted in a PMB decision to base the cost estimate for the desalting plant on commercially available tubing. Consequently, tubing costs are based on market prices for tubing, escalated to the appropriate (centroid of) expenditure.

PROJECT COORDINATOR COST

MWD's share of Project Coordinator costs for this project are assumed to be $3,300,000, and are included in the calculation of MWD costs.

NUCLEAR FUEL COSTS

Fuel costs are based on NSSS vendor data and on fuel cost analyses based on MWD's cost of money.

SCHEDULE

Unit 1 Condensing Power Plant	September 1, 1974
Backpressure Turbine	September 1, 1974
First 50-mgd Water Plant	September 1, 1974
Unit 2 Condensing Power Plant	September 1, 1975
Second 50-mgd Water Plant	March 1, 1978
Third 50-mgd Water Plant	September 1, 1978

CHAPTER 4

FACILITIES DESCRIPTION

GENERAL

Acceptable design concepts were established to define project costs and interrelationships. The descriptions of plant facilities presented in this chapter reflect these concepts but are not the result of final design efforts by the participating owners.

The Bolsa Island Nuclear Power and Desalting Plant includes a combination nuclear power and desalting facility producing approximately 1,900 Mw of gross electrical power and 150 mgd of desalted water, with an initial installation of 50 mgd and appropriate provisions for expansion of the desalting plant to a capacity of 150 mgd in four years.

The facility will be located on an island to be constructed offshore from Bolsa Chica State Beach in Orange County, California with a 2,400-foot causeway connecting the island to the mainland as shown on Plate 4.1.

The project also includes an onshore electrical switchyard with an underground transmission connection to the plant complex. Plate 4.2, Site Arrangement, depicts the facilities located on the island.

The nuclear steam supply systems comprise two nuclear reactor systems that will generate and supply steam to two condensing turbine-generators and one backpressure turbine-generator. Steam supplied to the condensing turbine-generators will be used solely for the production of electric power. Steam supplied to the backpressure turbine-generator will serve a dual function: generating electric power from part of the energy and conveying the remaining energy in turbine exhaust steam to the desalting plant brine heaters.

The desalted product water will be conveyed to Metropolitan's system at the Robert B. Diemer Filtration Plant through a six-foot diameter line approximately 24 miles long with an island pumping station, an intermediate pumping station and reservoir, and a blending structure.

Electric transmission to the SCE system connection point at Del Amo Substation is provided by four circuits of 220 kv underground pipe-type, naturally cooled cable approximately 11 miles long.

Electric transmission to the DWP system at Station "C" in Wilmington is accomplished with 3 circuits of underground pipe-type, 230-kv cable approximately 18 miles long.

The following data serve to define the scope of facilities for the 150-mgd installation.

		SCE/SDG & E	DWP
1.	Nuclear Steam Supply System		
	Reactor Output - Mwt	3,250	3,250
	Steam Generator Output:		
	Flow - 10^6 lb/hr	14.0	14.2
	Pressure - psia	805	805
	Moisture - percent	0.25	0.25
2.	Condensing Turbine-Generator Plant		
	Type	TC6F	TC6F
	Gross Output - Mwe	798	811
	Net Effective Operating Capacity - Mwe	755	771
	Steam Conditions:		
	Flow - 10^6 lb/hr	10.1	10.3
	Pressure - psia	760	775
3.	Electrical Transmission		
	Type	Underground	Underground
	Cooling	Natural	Natural
	Voltage, kv	220	230
	Destination	Del Amo Sub-Station	Station "C", Wilmington
	Distance, miles	11	18
4.	Backpressure Turbine-Generator Plant	MWD	
	Type	TC2F	
	Gross Output - Mwe	356	
	Steam Conditions:		
	Flow - 10^6 lb/hr	7.8	
	Inlet Pressure - psia	760	
	Exhaust Pressure - psia	35	
5.	Desalting Plant (MWD)		
	Type	Multistage Flash System	
	Product Water Output - mgd	150	
	Performance Ratio - lb/1,000 Btu	10.6	
6.	Island		
	Usable Area, Acres	35.5	
	Elevation Grade, ft.	20 above MLLW	
	Type Construction	Rock revetment enclosing a dredged sandfill	

7. Causeway

Type	Concrete box girders on concrete pile bents with approximately 60-ft spans
Length, ft.	2,400
Width Deck, ft.	Approx. 45; including walkway
Elevation, ft. above MLLW	30 at island, 10 near shore

8. Conveyance System

Flow Capacity, mgd	150
Conduit Diameter, ft.	6'-0"
Number of Conduits	One
Stages of Pumping	Two
Distance from Plant to Diemer Filtration Plant, miles	24

The design of structures, equipment, and systems will be based on the basic criteria outlined in Bolsa Island Nuclear Power and Desalting Plant, Preliminary Safety Analysis Report, Part B, Volume I(3).

Class I and Class II systems and structures are defined with respect to the degree that they affect public safety and continuity of operation and specific criterion for seismic loading, are contained at the end of this chapter.

The design concepts presented are based on ocean bottom soil bearing strengths of 8,000 pounds per square foot. For structures founded on compacted fill material, a soil bearing pressure of 5,000 pounds per square foot is used.

ISLAND AND CAUSEWAY

Bolsa Island design concept is a man-made structure approximately 1,500 feet by 1,100 feet, with a usable surface area of about 35.5 acres. The island is constructed with a rock revetment enclosing a dredged sandfill. Finished grade of the island is 20 feet above mean lower low water (MLLW). The island is connected to the mainland by a causeway approximately 2,400 feet in length. A barge unloading facility is provided as part of the island construction to facilitate handling of large pieces of equipment.

Criteria

The island is designed to meet the criteria established in previous studies. The wave protection armor stone is sized using Hudson's Formula considering special placement of the quarry stone. The berm height provides five feet of free board against the overtopping from the predominate 14-second period wave and one foot of freeboard from the remote probability 16-second period wave. Under earthquake loading, the wave protection is designed to Class I criteria. The slopes are stable under the no-loss-of-function (NLF) earthquake.

The island sandfill is designed to prevent liquefaction in both the Class I (nuclear) and Class II (remainder of the island) area. In the Class I area the sandfill will be dewatered, excavated, and after construction of the power facilities, compacted in the dry to a density that precludes liquefaction under the NLF earthquake. The costs for this compaction are included in estimates for the nuclear power plants. For the remainder of the island, the fill will be compacted using explosives to a density that precludes liquefaction under the design earthquake. The causeway is designed to support an H-20 AASHO Highway Loading and to resist a 20-percent gravity acceleration. Storm wave forces on the pile bents are also considered in the design but not simultaneously with seismic forces.

Design Concept

The island concept, similar to that presented in the 1965 Feasibility Report(1), is the free-standing island and comprises a perimeter wave protection system, an island interior sandfill, and an open bent causeway that connects the island to the mainland. The wave protection system is the flexible rubble mound type similar to that used for breakwater construction and the island fill is hydraulically placed dredged and compacted sand. This concept has been reviewed by island contractors experienced in both wave protection construction and offshore dredging operations and the Office of the Harbor and Waterways Chief, Los Angeles District, U.S. Army Corps of Engineers. The free-standing island concept is considered appropriate for construction at the Bolsa site. Plate 4.3 shows the free-standing island concept in plan and section.

The island comprises 35.5 acres with a surface elevation of 20 feet above MLLW. The wave protection system has an attack face slope of 1 on 3 and extends to a height of 40 feet above MLLW on the three sides exposed to storm waves. The leeward side wave protection stops at 20 feet above MLLW. The causeway is an open pile bent concrete structure with a superstructure approximately 45 feet wide. Provisions are made for carrying the 150-mgd water line and oil-filled pipe-type electrical transmission cables from the island to the mainland. Plate 4.4 shows the causeway design concept.

NUCLEAR POWER PLANT

Each unit of the two-unit nuclear power plant consists of a nuclear steam supply system (NSSS), a condensing turbine-generator unit, and auxiliaries comprising a single, operable electric power generating unit. Since several common facilities and systems are shared by the two nuclear power units, the layout and arrangements shown assume mirror image design; therefore, these facilities will also be employed for the second unit. The descriptions which follow are based on the first unit of a two-unit plant. The construction of the plant will be arranged so that the SCE/SDG & E owned NSSS and condensing turbine would be completely in phase with construction of the MWD-owned backpressure turbine and 50-mgd desalting plant and be ready for operation on September 1, 1974. The DWP-owned nuclear power plant would be constructed based on a schedule to allow operation approximately twelve months later. The additional 100-mgd desalting plant would be in operation four years later.

Plant Arrangement

The proposed arrangement for the Bolsa Island Nuclear Power and Desalting Plant is depicted on Plate 4.2, Site Arrangement. The nuclear power plant comprises two nuclear reactor areas separated by a common building housing the control room and other supporting facilities as well as separate new and spent fuel storage facilities, and three turbine-generator areas in a tee arrangement. The two condensing turbine-generator areas are essentially mirror images. The arrangement is based on principal criteria developed from a site arrangement study selected by the Bolsa Island Project Engineers Committee (PEC). Arrangement of the equipment within the plant is shown in Plates 4.5 and 4.6.

Circulating Water System

The circulating water system concept for the plant consists of two separate intake structures, one serving the desalting plant and temporary condenser of the backpressure turbine and the other serving the two condensing turbines and nuclear facilities. A common outfall and discharge system is provided for all facilities. Plate 4.2 shows the separate intake structures and plate 4.11 shows the portion of the circulating water system within the scope of the estimate for the first nuclear unit. For the purpose of developing an overall estimate, portions of the circulating water system are included in the scope of the back pressure turbine and the desalting plant.

Site Preparation

Hydraulic fill is to be placed by the island contractor to about elevation +8 feet. The entire power block area is than excavated and dewatered to the ocean bottom. Additional excavation is performed as required for the foundations of the containment vessels. Structural backfill is placed and densified when construction of below grade power plant facilities permits. All fill material has an in-place relative density of at least 90 percent, in accordance with the U.S. Bureau of Reclamation Method E12; or 95 percent maximum density, in accordance with ASTM Specification 1557-58T.

Excavation and placing of compacted backfill is required for construction of containment foundations below the ocean bottom and a firm foundation for the other power block structures, including the turbine pedestal. The construction of a two-unit plant, as planned, necessitates simultaneous excavation and backfill for both units. All major construction up to grade will be completed for both units before completion of the backfill. The proposed excavation plan is shown on Plate 4.7.

Yard Utilities

Fire, domestic, and service water are obtained from the supply at the island terminus of the causeway. A service water tank and pumps are provided to furnish service and fire protection water. Two screen wash pumps in the intake structure are used as backup fire pumps.

Domestic and service water systems and industrial waste and sewage disposal systems are installed to service the administration building, control building, shop and warehouse. Fire protection piping loops are located to avoid interference with Unit 2 construction. The lines are sized for the later addition of Unit 2 hydrants.

Reactor Plant

The NSSS consists of a reactor and four closed coolant loops connected in parallel to the reactor vessel, each containing a reactor coolant pump and a steam generator. The system also contains an electrically heated pressurizer and necessary auxiliary systems.

High pressure, light water circulates through the reactor core to remove heat generated by the nuclear reaction. The heated water exits from the reactor vessel and passes to the steam generators, where it gives up its heat to feedwater to generate steam for the turbine-generator. The cycle is completed when the condensate is heated by regenerative heaters and pumped back to the steam generator.

Complete supervision of both the nuclear and turbine-generator plants is accomplished from the central control room.

The NSSS will be capable of normal performance, with the standard control and auxiliary systems proposed, under the following conditions:

PERFORMANCE AT WARRANTED RATING

Thermal Output of NSSS, each	3,250 Mwt
Steam Flow from NSSS, each	14,040,000 lb/hr
Steam Pressure at Steam Generator Outlet	805 psia
Maximum Moisture Content	0.25%
Estimated Feedwater Temperature at Steam Generator Inlet	430 F

A core loading consists of 193 fuel assemblies containing approximately 192,000 pounds of uranium (87,210 kg), or about 218,000 pounds of UO_2.

The steam generators are vertical U-tube units containing inconel tubes. Integral moisture separation equipment reduces the steam moisture to 0.25 percent or less.

The reactor coolant pumps are vertical, single stage, centrifugal pumps of the shaft seal type.

Containment

The reactor containment consists of a prestressed concrete, vertical, cylindrical structure with a shallow dome roof and a reinforced concrete mat foundation. The interior of the containment structure is lined with a 1/4-inch (minimum) welded carbon steel liner to ensure leak tightness of the structure.

The containment structure houses all the high pressure, high temperature, radioactive systems of the primary plant. In addition to providing confinement of stored energy and fission products released during a maximum credible accident, the containment structure supplies adequate biological shielding for both operating and post-accident conditions.

The containment structure is designed for an internal pressure of 59 psig coincident with a temperature rise of approximately 290 F based on a free volume of approximately 1,900,000 cubic feet. The proposed allowable gross leak rate is 0.25 percent of the contained air per day.

A 160-ton polar crane on a circular track services the reactor head, reactor coolant pumps, and other equipment.

Fuel Handling System

The fuel rod assemblies are removed by means of equipment that handles spent fuel under water from the time it leaves the reactor vessel until it is placed in a cask for shipment from the site.

Spent fuel is removed from the reactor vessel by a manipulator crane and placed into the fuel transfer system. In the spent fuel pool, the fuel rod assemblies are placed into storage racks. After a suitable decay period, the fuel is removed from storage and loaded into a cask for shipment to a reprocessing plant.

Waste Disposal System

The waste disposal system collects, processes, and disposes of radioactive liquid and gaseous and solid wastes produced as a result of reactor operation.

Liquid wastes are collected and processed. Radioactive residue is fixed in demineralizer resins which are shipped offsite for ultimate disposal.

Gaseous radioactive wastes are collected and stored until their activity level is sufficiently small for discharge to the environment. They are then released through the plant stack at infrequent intervals when atmospheric conditions ensure maximum dilution. Design of radioactive facilities will be based on discharge to the environment within the guidelines of AEC 10 CFE 20.

Solid wastes such as demineralizer resins are collected, stored, and finally shipped from the site for ultimate disposal at an authorized location.

Engineered Safeguards Systems

A. Containment Spray System

The containment spray system reduces the pressure in the containment caused by steam and/or heat buildup resulting from an accident. The system consists of two pumps, each discharging to a separate spray header. Each pump is full-capacity and capable of pumping water at 2,600 gpm and 500 ft TDH. Pump suction may be from either the refueling water tank or from the outlet of the residual heat exchangers.

B. Containment Cooling System

The containment cooling system cools the reactor building by suppressing and limiting the reactor building peak pressure following the design basis accident (DBA). This is presently defined as a complete double-ended rupture of the largest reactor coolant loop piping. This system serves as a full-capacity, redundant heat removal system along with the containment spray system. System components consist of three containment emergency cooling units, each supplying 30,000 cfm with an emergency cooling capacity of 82.3 x 10^6 Btu/hr at 290 F, 57.5 psia saturation, with a cooling water flow of 2,000 gpm at 95 F. These components are designed to operate under the adverse conditions existing during such an accident.

C. Containment Isolation System

When a predetermined rise of the containment pressure is reached, the containment isolation system closes all fluid penetrations not required for operation of the engineered safeguards system. Valves isolating penetrations that are directly open to the containment atmosphere also close on high radiation level signal.

All isolation systems are provided with redundant valving and associated apparatus.

D. Containment Leak Detection System

All personnel access and equipment hatches are interlocked and alarmed by fail-safe devices. Double seals with pressure test points for leakage between the seals are provided.

Each penetration with resilient seals and expansion bellows is provided with pressure test connections, allowing leakage testing during normal operation.

E. Salt Water Cooling System

The salt water cooling system supplies ocean water, which acts as the final heatsink for the component cooling water system through the component cooling heat exchangers.

Four one half-capacity, vertical, single column, motor-driven, cooling pumps of 8,500 gpm capacity at 70 feet TDH take suction from the circulating water intake structure as shown on Plate 4.8 and discharge to two full-capacity, component cooling water heat exchangers, and then through individual discharge lines into the circulating water discharge piping.

1. Component Cooling Water System

The component cooling water system removes heat from the residual heat removal, spent fuel pool, seal water, non-regenerative, excess letdown and sample heat exchangers, the reactor building normal and emergency air coolers, the reactor coolant pumps oil and air coolers, thermal barrier heat exchanger, and components of the radwaste system.

System components consist of three one half-capacity component cooling water pumps, two full-capacity component cooling water heat exchangers, one component cooling water surge tank, and a chemical pot feeder for adding corrosion inhibitor.

Two pumps and one heat exchanger are used for normal operation, while three pumps and two heat exchangers are used for plant cooldown or for an emergency condition. One pump and one heat exchanger are used during plant shutdown.

2. Refueling Water System

The refueling water system includes a refueling water tank containing approximately 325,000 gallons of borated water. This water is used in the containment for flooding the refueling cavity prior to refueling, or for safety injection in the event of a nuclear accident. The boron solution is supplied to the chemical and volume control system and pumped into the refueling cavity to the required depth for the routine refueling operation.

Reactor Building Ventilating and Purge System

The reactor building ventilation system is a closed, self-contained air recirculation system. The system will supply 148,000 cfm of cooled, circulating air at 105 F, with a cooling water flow of 780 gpm at 95 F. These units are equipped with a normal filter with an average efficiency of 95 percent NBS, together with a high-efficiency filter rated at 99-97 percent DOP test in removing 0.3 or larger micron particles. In addition, an activated charcoal filter will collect radioactive iodine from the recirculating air stream.

Radiation Levels

Design criteria for zone radiation levels during full power operation at designated areas within the plant are:

Zone	Zone Description	Radiation Level (mrem/hr)
I	Occupied by personnel on an uncontrolled basis, where normal work and/or maintenance is required.	Less than 1.0
II	Periodic occupancy on a 40-hour week basis. Contains all potentially radioactive equipment.	Less than 2.5
III	Limited to occasional work for short periods of time. This category includes the fuel handling area, access area, and the operating deck of the containment building.	Less than 15
IV	Inaccessible during reactor operation or before sufficient decay and decontamination	Greater than tolerable personnel levels

Condensing Turbine-Generator Plant

The condensing turbine-generator plant is comprised of one nominal 800,000-kw tandem compound turbine-generator supported by a reinforced concrete, rigid frame pedestal with mat foundation together with accessory systems including lubricating oil, cooling water, hydrogen, gas coolers, feedwater heaters and associated piping, and controls. Accessory equipment is mounted adjacent to the turbine-generator on and below the turbine deck extensions. Electric power is transmitted through an isolated phase bus to a bank of two 3-phase main transformers and to the unit auxiliary transformer. Startup power is supplied from a startup transformer supplied from the 68-kv switchyard. Station auxiliary power is supplied through 6,900-volt and 4,160-volt sectionalized buses complete with necessary switchgear, instrumentation, wire, and cable as shown on Plate 4.9.

Turbine-Generator

The turbine-generator is an 1,800 rpm, tandem compound, impulse reaction, condensing, reheat type machine with an approximate capacity of 800,000 kw. It consists of a double flow, high pressure cylinder and three double flow, low pressure cylinders with 38-inch last stage buckets. Accessories furnished with the turbine-generator include four high pressure steam chest assemblies, emergency and normal interceptor valves, moisture separators and live steam-fed reheaters, turbine supervisory controls, lubricating oil system, seal oil system, gland seal system, hydrogen coolers, insulation, turning gear, and miscellaneous standard accessories.

The generator is a hydrogen-cooled unit rated at approximately 890,000 kva, 22,000 volts at 0.9 power factor, 0.52 short circuit ratio, 60-cycle, with an alternator and silicon-controlled rectifier excitation system.

Lube Oil System

A turbine lubricating system complete with reservoir, oil coolers, pumps, level controls, and motor-driven vapor extractor is supplied by the turbine manufacturer. To maintain oil quality, a continuous filtering and conditioning unit is interconnected to the turbine lubricating system.

Steam System

The steam system, shown on Plate 4.10, has the main steam lines from the four steam generators brought out individually through the containment wall. Outside the containment, steam dump valves and code-required safety valves are installed on each line. Downstream of the safety valves, a quick-closing valve and a check valve are installed ahead of the equalizing crossover. Four main steam lines feed the condensing turbine through turbine stop and throttling valves. Four connections are provided to permit connection of the steam supply to the MWD backpressure turbine. The steam dump valves are sized to permit dumping of 80 percent of full steam flow from the NSSS to the atmosphere.

Steam to the turbine seals, air ejectors, and other auxiliaries are taken off upstream of the steam generator quick closing valves. The high pressure steam supply to the reheaters is taken off from the steam lines supplying the turbine stop valves.

Extraction steam for the first-point heater is taken from the high pressure turbine. The second-point heater extracts steam from the high pressure turbine exhaust upstream of the moisture separators. The remaining heaters take extraction steam from the low pressure turbines.

The fifth- and sixth-point heaters are located in the necks of their respective condensers.

All heaters are of the U-tube type and have carbon-steel shells. The tubes in the two highest pressure heaters are 90-10 copper-nickel. The low pressure heater tubes are Admiralty.

Main Condensers

Three separate shells are provided, one for each of the three low pressure turbines. Each condenser is a deaerating, single-pass type, with a vertically divided water box and a sectionalized hotwell, arranged for a double-flow, down-exhaust turbine. Designed for sea water service, it maintains an absolute pressure of 1.5 inch of mercury at full load, with a circulating water flow of approximately 193,000 gpm at 62 F and a tube cleanliness factor of 85 percent. The circulating water system is shown on Plate 4.11.

Each condenser contains 180,000 square feet of one inch, 18 BWG, 90-10 copper-nickel tubes rolled into the tube sheets. The design water velocity in the tubes is about seven feet per second.

Feedwater System

The feedwater system comprises two heater trains with an equalizing header downstream of the first-point feedwater heaters. This header distributes feedwater from the two heater trains and from the MWD backpressure turbine unit to the four feedwater regulators controlling the water level in their respective steam generators. The system is shown on Plate 4.12.

The main feedwater pumps are of the horizontal, multistage, centrifugal type, and operate in series with the condensate pumps. Each is rated at approximately 773 psi total differential pressure and 5,575,000 pounds of water per hour. Drive motors are approximately 7,000 hp at 3,600 gpm.

One 800-gpm, turbine-driven auxiliary feedwater pump and two 400-gpm, motor-driven auxiliary feedwater pumps provide emergency means of pumping water from the condensate storage tanks into the steam generators.

Makeup Water Treatment System

Demineralized water is used for reactor and turbine plant makeup. Demineralization is accomplished through a 325,000-gpd multi-bed train, composed of a full-flow primary cation exchanger, a full-flow vacuum degassifier, a full-flow weak-base anion exchanger, and a full-flow mixed-bed ion exchanger. The demineralizer unit has sufficient capacity for polishing the MWD water for makeup of both units.

Instrumentation and Control

A centralized control room is provided in the control building at elevation 47'-0". Approximately one-half of the room contains the centralized control systems for the reactor and turbine-generator. All controls and instrumentation required for startup, shutdown, and normal power operation are located on the unit console. The remainder of the plant auxiliary system is supervised and controlled from the vertical board. Miniaturized control devices are utilized throughout, except where control requirements dictate use of special equipment.

Miscellaneous local controls are provided as follows:

- Chemical control board
- Heating and ventilating board
- Intake structure control board
- Pressurizer instrumentation racks (3)
- Turbine plant sample station
- Turbine-generator protective relay panels
- Turbine test shelf
- Auxiliary control relay panel.

Radiation Protection System

The process radiation monitoring systems and area monitoring systems are to be supplied by the NSSS supplier. The radiation monitoring equipment includes beta-gamma detectors and air particulate and radioactive gas detectors. The beta-gamma detectors are located as follows:

— At control access door

— Inside the reactor building near the personnel access hatch

— Near the in-core instrument space inside the reactor building

— At the fuel handling bridge in the spent fuel building

— In the auxiliary building sump pump area

— At the steam generator blowdown

— At the auxiliary building in the decay heat cooler area

— Near the component cooling water heat exchangers

— In the radio-chemistry laboratory

— In the primary loop

— In the control room

— In the reactor building.

The air particulate and radioactive gas detectors are located as follows:

— At the plant vent stack

— Inside the reactor building

— In the radio-chemistry laboratory

— In the control room and auxiliary building.

Change room facilities are provided so personnel may obtain clean protective clothing required for plant work.

The plant includes a health physics facility to accommodate equipment for detecting, analyzing, and measuring various types of radiation and for evaluating any radiological problem which may be anticipated. An appropriate shielded counting room for detecting and measuring radiation is provided.

Temporary Auxiliary Steam Generating System

A temporary auxiliary steam generator system is provided for steam blowing, initial startup, and test operation of the turbine-generator.

A battery of 16 package boilers, each rated at 200,000 pounds per hour at 975 psi saturated, are provided. The boilers, mounted on temporary cribbing, contain individual combustion controls including flame monitoring. They also employ steam atomization, operate on light fuel oil, and are connected to a common steam header leading to the main steam lines.

Emergency Diesel Generating System

The nuclear unit is provided with three emergency diesel engine generators, any two of which are capable of providing adequate shutdown power for the reactor in the event of loss of power or loss of power plus a nuclear accident. Each engine generator unit is rated 2,300 kw at 4,160 volts, three-phase, and is skid-mounted. The generators are enclosed in a building with separators for the units.

Each diesel engine generator unit has a day tank and an underground oil storage tank, sized to provide up to 48 hours of continuous use for each unit.

Switchyard and Pipe-Type Power Cables

The 230-kv and 69-kv switchyard are located on the mainland at a point approximately 610 feet east of the intersection of Los Patos Avenue and Algonquin Streets in Orange County, as shown on Plate 4.1. The switchyard area includes a 230-kv section and a 69-kv section, with a tie transformer to the 230-kv section, as indicated on the Main Single-Line Diagram, Plate 4.9.

The 230-kv section is constructed to provide three operating positions. The design is based on breaker-and-a-half operation. The switchyard positions are as follows:

Position	Incoming	Outgoing
1	MWD Main Unit	230/69-kv Transformer
2	SCE/SDG & E Main Unit	Line 1
3		Line 2

The 69-kv section provides four operating positions. The design is based on double-breaker operation for the pipe cable feeds to the MWD desalting plant and the SCE/SDG & E startup transformer. A 69-kv line source supplies power to one bus. The 230/69-kv transformer supplies power to the other bus through disconnect switches.

Switchyard positions are as follows:

Position	Service
1	MWD desalting plant
2	SCE/SDG & E startup transformer
3	69-kv line
4	230/69-kv transformer

An 800-square foot concrete block relay house similar to the SCE standard relay house for unattended 66-kv substations is provided for 230- and 69-kv switchyard relaying and local control.

Air conditioning, a 125-volt d-c battery, and sanitation facilities are provided. A closed-circuit television system is provided for yard security supervision and for instrument and annunciator scanning.

Pipe-type cable systems are provided for each power feed between the island and the switchyard. Four separate systems are installed, consisting of five power cable pipes and five return oil lines.

Manholes for cable splices are installed at three locations along the route: On the island, on the mainland north of Bolsa Bay, and in the switchyard. Handholes for pulling telephone and control cables are provided at additional points as required.

Pipe cable system requirements are:

	Conductor, MCM	Nominal Pipe Size, Inches	Circuit Length, Feet	Pothead Rating, Amperes	Disconnect Switch, Amperes	Heat Exchanger, Btu/Hr
MWD Desalting Substation	1,500	6	7,830	800	1,200	225,000
MWD Main Unit	2,500	10	7,480	1,500	2,000	900,000
SCE/SDG & E Startup Transformer	750	6	7,810	600	1,200	225,000
SCE/SDG & E Main Unit	2-2,500	2-10	7,890	1,500	3,000	2-900,000

Conductor sizes and heat exchanger ratings may be subject to change after required burial depths and soil thermal resistivity have been more clearly defined.

Other Plant Supporting Services

The following plant services and systems are provided:

- Turbine plant cooling water system
- Hydrogen and carbon dioxide gas system
- Compressed air system
- Service and domestic water system
- Fire protection system
- Heating, ventilating, and air conditioning
- Cathodic protection
- Lighting
- Communication system
- D-C battery system
- Condensate makeup and storage
- Plant sampling system.

BACKPRESSURE TURBINE PLANT

The backpressure turbine plant is designed to match the requirements of the phased desalting plant for heating steam and to maintain the electric power output at approximately 360 Mwe during both Phase I and Phase II operation. During Phase I (50 mgd) operation of the desalting plant, the requirements for heating steam at 35 psia are approximately 1.64 billion Btu/hr (one-third of future 150-mgd requirements) and results in an electrical output of approximately 120 Mwe. In order to generate the Utilities' entitlement, the backpressure turbine is designed to operate with a portion of the low pressure section acting as a condensing unit to generate an additional 240 Mwe of electrical power for Phase I and will be equipped with a temporary condenser and low pressure feedwater heating cycle. When the additional 100 mgd of desalting capacity is added in 1978, the backpressure turbine will be modified to operate normally with all of the steam exhausting to the desalting plant at 35 psia. The temporary condensing equipment will be left in place to provide some standby electrical generating capacity in the event the desalting plant is not operated for long periods. Table 4.1 shows the principal backpressure turbine plant data and design criteria.

Plant Arrangement

The backpressure turbine plant structure joins the condensing turbine plant structure to form a tee arrangement as shown on Plate 4.5. The turbine pedestal and heater decks (located on either side of the turbine pedestal) are at the same elevation as those of the condensing turbine plants. All auxiliary equipment, exclusive of the feedwater heaters, is located at or near grade elevation under the turbine and heater decks.

A common control building is located between the two nuclear containment structures. Intermediate levels are utilized for mechanical and electrical control equipment and electrical switchgear. The control room is at the turbine deck elevation and provides convenient access to the turbine-generators for plant operators.

The backpressure turbine-generator main, auxiliary, and startup transformers are located outside the turbine pedestal adjacent to the turbine deck. Power is supplied through the main transformer to a 230-kv and 69-kv switchyard located on the mainland through cables included in the SCE scope of work. Plate 4.13 depicts the electrical power system associated with the backpressure turbine.

TABLE 4.1

BACKPRESSURE TURBINE PLANT
DATA AND DESIGN CRITERIA

	150-mgd Phased Desalting Plant	
	Phase I	Phase II
MWD Thermal Entitlement, Mwt, each NSSS	660	660
Gross Backpressure Turbine Output, Mwe	356	356
MWD Power Entitlement, Mwe	194	194
Electric Utilities Power Entitlement, Mwe	162	162
Steam Conditions at Turbine		
Flow, 10^6 lb/hr	5.7	7.8
Pressure, psia	760	760
Feedwater Temperature, F	403	430
Turbine Exhaust Pressure, psia	35	35

Turbine-Generator and Auxiliary Systems

The backpressure turbine-generator produces approximately 360 Mw of electric power from a portion of the total energy contained in the main steam supplied and exhausts steam, with its residual energy, to the desalting plant brine heaters for use in the production of desalted water. The turbine is furnished with standard accessories including main steam stop and control valves, intercept valves, moisture separators, turbine supervisory controls, lubricating and seal oil systems, hydrogen coolers, insulation, and miscellaneous accessories.

The generator is rated at 415,000 kva, 22,000 volts, 0.9 power factor, and 60 cycles with shaft-driven exciter.

A turbine lube oil conditioning system is included to maintain turbine lube oil in a condition free from foreign material and moisture. This system serves the turbine lubricating oil system to supply oil for turbine bearing lubrication and turbine hydraulic control system operation. To maintain oil quality, a continuous filtering and conditioning unit is connected to the turbine lubricating system. Two lube oil tanks provide oil storage and sufficient capacity for draining the complete oil system. Motor-driven transfer pumps, with interconnecting piping and valves, enable transfer of the lubricating oil for batch treatment when required. Central hydrogen and carbon dioxide storage and supply systems are supplied. The hydrogen system is required to supply hydrogen gas to cool the generator of the backpressure turbine during normal operation. The carbon dioxide system permits the purging of hydrogen from the generator during maintenance outages.

Circulating Water System

A portion of the circulating water system, (exclusive of intake structure, outfall structure, and screen well equipment) is included for Phase I operation. This system consists of circulating water conduits connecting the desalting plant intake structure, the temporary condenser at the backpressure turbine, and a junction box located in the sea water discharge line. The portion of the sea water discharge line between the junction box and the outfall structure is sized to handle the additional capacity of the Phase I condensing facilities. A Phase II desalting plant raw sea water pump, modified for Phase I operation, supplies circulating water for the temporary condenser.

Feedwater and Condensate System

The feedwater and condensate system transfers condensate from the temporary condenser and brine heaters through two parallel trains of feedwater heaters where it is heated by turbine extraction steam and pumped by two, one half-capacity feedwater pumps to the nuclear steam supply system. The feedwater pumps are horizontal, multistage centrifugal pumps rated approximately 9,000 gpm at 2,140 ft. TDH at 385 F with 5,500-hp motor drives.

Major elements of this system are shown diagrammatically in Plates 4.14 and 4.15, respectively, for Phases I and II. The condenser, steam jet ejectors, vacuum pumps, condensate pumps, and the fifth and six point heaters located in the condenser neck, are required for Phase I operation only. The condenser is designed for 180,000 sq. ft. with 90-10 copper-nickel tubes complete with three, one half-capacity condensate pumps rated 2,660 gpm at 860 ft. TDH with 700-hp vertical motor drives.

Turbine Plant Cooling Water System

The turbine plant cooling water system serves as a heatsink to remove the waste heat for all turbine plant equipment except the temporary condenser. The system forms a closed circuit in which treated condensate is pumped in series through the shell side of a water-to-water heat exchanger, through individual coolers of equipment requiring cooling water, and through return piping to a storage tank. Sea water from the circulating water system is used on the tube side of the exchangers as the cooling medium.

The treated condensate section of the system includes two motor-driven cooling water pumps rated 10,000 gpm at 100 ft. TDH and two heat exchangers with each set sized to meet the full cooling demand of the backpressure turbine plant. Normally one pump and heat exchanger combination are in service, with the other combination on standby. System piping and valve arrangements are designed to provide a means of simultaneously aligning one heat exchanger for operation while the standby exchanger is being heat treated with warm sea water for periods of four to six hours to control marine growth.

Compressed Air System

A compressed air system is included to provide a continuous supply of pressurized air for instruments, controls, and other service requirements. The system is comprised of motor-driven air compressors, air receivers, instrument air filters and dryers, and the necessary piping, valves, and controls to supply oil-free, compressed air at a rate of approximately 500 scfm, with 300 scfm dried and filtered for instrument supply.

Chemical Feed System

The chemical feed system includes the necessary mixing and dispensing pumps and tanks to inject chemicals in controlled amounts into the feedwater and condensate, turbine plant cooling water, and circulation water systems to maintain proper chemical conditions in lines and equipment.

Auxiliary Power System

The auxiliary power system receives power from the backpressure turbine-generator and/or the startup transformer to supply power to motors and other loads within the plant as shown on Plate 4.13, Electrical Single-Line. The system includes 4,160 and 480-volt indoor, drawout type switchgear which supplies power to the larger loads, and 480-volt motor control centers to supply small motors and miscellaneous equipment.

Cathodic Protection System

A cathodic protection system is included to inhibit corrosion of steel storage tank bottoms and subsurface pipe in contact with earth or water.

Lighting System

Lighting transformers provide power for lighting in the backpressure turbine plant area. Emergency lighting power will be obtained from the 125-volt d-c battery system by means of automatic throwover equipment located in the lighting distribution switchboard.

Conduit and Tray

Whenever possible, extensive use will be made of cable tray within the turbine plant instead of conduit. Barriers to separate cables will be provided where necessary. Underground systems are encased in concrete. All exposed conduit is rigid, galvanized iron except at the intake and discharge structures where rigid, plastic coated iron conduit is used. Within the plant, all exposed and embedded metallic conduit in sizes up to and including two inches is electrical metallic tubing. Conduits larger than two inches are galvanized rigid iron.

Miscellaneous Systems

The following miscellaneous systems and facilities are either wholly or partly within the limits of the backpressure turbine plant. Those systems and facilities shared with the condensing turbine plant are indicated by asterisks. Only that portion lying within the limits of the backpressure turbine plant has been included in the cost estimate.

- Distilled water makeup and drawoff system (main condensate tanks used for storage)*
- Turbine plant sampling system*
- Service water system (supplied from plant system)*
- Fire protection system (supplied from plant system)*
- Sanitary drains and sewage disposal facilities (collection only)*
- Oily waste water facilities (collection only)*
- Outside area communication system (tie into power plant system)*
- Grounding system (tie in with plant grounds where applicable)
- D-C controland emergency lighting system (separate system, crosstie for backup)
- Annunciator system (tie into power plant system).

The 96-inch diameter exhaust steam lines connecting the backpressure turbine and the desalting plant brine heaters, the brine heater condensate pumps and condensate return lines including the necessary instrumentation and controls, are included in the backpressure turbine plant estimate. The brine heaters are included in the desalting plant estimate.

For Phase I, one 96-inch diameter steam line with two 2,230-gpm brine heater condensate pumps will be installed complete with a condensate return line and necessary instrumentation and controls. One additional 96-inch diameter steam line and four 2,230-gpm condensate pumps will be added for Phase II.

DESALTING PLANT

Phased construction and operation of the 150-mgd desalting plant was originally considered by Metropolitan's Board of Directors in January 1966. The following concept of procurement, construction, and operation of the 150-mgd desalting plant was adopted by Metropolitan as a basis for proceeding with the Bolsa Project:

— Phase I - the initial stage (50-mgd) in full operation with the nuclear power plant

— Phase II - the second stage (100 mgd), in full operation four years later.

Ancillary equipment such as the sea water intake structure, acid storage, and electrical supply from the switchyard will be installed for the full 150-mgd capacity during Phase I construction. Certain other facilities such as foundations, electrical switchgear, and sea water pumps for the two future 50-mgd trains will be added at a later date. The product water conveyance system to the Diemer Filtration Plant will be installed for the full 150-mgd capacity except for pumps and motors not required during the initial period.

Conditions of Operation and Design Criteria

The desalting plant operates in conjunction with the backpressure turbine plant, from which it receives steam for the brine heaters at about 35 psia. The desalting plant is designed to produce 10.6 pounds of distillate for every 1,000 Btu's of thermal energy received from the backpressure turbine. Makeup feed from the Pacific Ocean contains 34,000 ppm total dissolved solids and the product water contains 50 ppm or less total dissolved solids.

The temperature range through which the plant is designed to operate is from a sea temperature of 62 F to a steam temperature of 258 F. Product water design temperature is 82 F, brine effluent temperature is 84 F, and maximum temperature of the recirculating brine is 250 F. The principal flow streams are depicted on Plate 4.16. Table 4.2 summarizes the principal desalting plant design data for an in-tube velocity of six feet per second and 82 F product temperature.

The design concept described in the following sections was used as a basis for the cost estimates developed early in 1968. Additional engineering and criteria development resulted in improvements in the desalting plant design which are discussed in a separate report[4].

Plant Arrangement

The 150-mgd multistage flash sea water conversion plant, a part of a dual-purpose nuclear power and desalting plant, is located adjacent to the nuclear power plant on the island site as shown in Plate 4.2. The plot area for the desalting plant is approximately 800 feet by 630 feet, at an elevation of 20 feet above MLLW. The initial 50-mgd desalting plant with auxiliary equipment occupies an area of approximately 800 feet by 250 feet, thereby allowing the remaining area for construction and laydown of the nuclear power plant. This available space allows a decrease of the island size from the originally contemplated 40 acres to about 35.5 acres.

TABLE 4.2

PRINCIPAL DESALTING PLANT DESIGN DATA
(Based on 6 fps brine velocity and 82 F product temperature)

	150 mgd	50 mgd
Performance ratio, lb/1,000 Btu	10.6	10.6
Total recovery tube length, ft.	404	404
Total rejection tube length, ft.	68	68
Total tube area, 1,000 sq. ft.	11,040	3,680
Total plot length, ft.	800	800
Total plot width, ft.	630	270
No. 1 stage heat transfer coefficient, U	638	638
No. 41 stage heat transfer coefficient, U	362	362
Recycle brine concentration, ppm	68,000	68,000
Brine blowdown concentration, ppm	79,300	79,300
Makeup feed flow, 10^6 lb/hr	91.2	30.4
Acid flow rate, lb/hr	10,950	3,650
Seawater flow, 10^6 lb/hr	240	80
Recycle brine flow, 10^6 lb/hr	363	121
Brine blowdown flow, 10^6 lb/hr	39.0	13.0
Product water flow, 10^6 lb/hr	52.05	17.35
Condensate flow, 10^6 lb/hr	6.0	2.0
Makeup feed pump hp	900	300
Seawater pump hp	4,500	1,500
Recycle pump hp	36,000	12,000
Brine blowdown pump hp	900	300
Product water pump hp	15,000	5,000
Condensate pump hp	2,100	700
Total pump hp	60,000	20,000

The evaporators and associated components are arranged in three parallel lines or trains, each of which represents a module capable of supplying one-third of the total output, and each capable of independent operation. Equipment general arrangement plan and section are presented in Plates 4.17 and 4.18, respectively.

Equipment and Facility Description

Equipment and principal design conditions utilized in the development of the cost estimate for the 150-mgd multistage flash desalting plant are indicated in Tables 4.3 and 4.4. Equipment numbers in these tables are identified on Plate 4.17. An additional description of the desalting plant subsystems is presented below, based on the complete 150-mgd desalting plant.

TABLE 4.3

MAJOR EQUIPMENT LIST
150 MGD PHASED DESALTING PLANT

PHASE I - 50 MGD

Item*	Description
D-1	Sulfuric Acid Storage Tank, carbon steel, 250,000 gal. capacity for 98% acid, with dehydrator on vent.
D-2	One Atmospheric Decarbonator, tray-type, wood construction, with concrete subgrade reservoir, with forced air blower for removal of free carbon dioxide.
E-1	One Heat Rejection Section, three stages; tubes 3/4 in. x 18 gauge iron-modified 70-30 cupronickel; tube sheets approximately 96 in. x 20 in. x 2 in. thick steel, with 90-10 cladding; tube area approximately 345,000 square feet; one vessel.
E-2	One Heat Recovery Section, 38 stages; tubes 3/4 in. x 18 gauge iron-modified 90-10 cupronickel; tube sheets approximately 96 in. x 30 in. x 2 in. thick steel with 90-10 cladding; tube area approximately 3,097,000 square feet; four vessels.
E-3	Two Brine Heaters, shell pressure 34.2 psia, single pass; tubes 3/4 in. x 18 gauge iron-modified 90-10 cupronickel; duty 818.4 x 10^6 Btu/hr each; tube area approximately 80,000 square feet each.
G-1	Two Raw Sea Water Pumps, each 157,000 gpm, submerged suction, TDH 33 feet, 88% efficiency, motor-driven, vertical, 1,750 horsepower each, stainless steel impeller, Ni-resist case, Monel shaft. (Note: One pump is intended for water service; the other will serve the backpressure turbine plant at reduced capacity.)

TABLE 4.3 (Continued)

Item	Description
G-2	Two Makeup Feed Pumps, 66,000 gpm, submerged suction, TDH 15 feet, 88% efficiency motor-driven, vertical, 300 horsepower, stainless steel impeller, Ni-resist case, Monel shaft.
G-3	Two Recycle Brine Pumps, each 128,000 gpm, submerged suction, TDH 170 feet, 88% efficiency, motor-driven, vertical, 7,000 horsepower each, stainless steel impeller, Ni-resist case, Monel shaft.
G-4	One Concentrated Brine Blowdown Pump, 27,000 gpm, submerged suction, TDH 40 feet, 88% efficiency, motor-driven, vertical, 350 horsepower, stainless steel impeller, Ni-resist case, Monel shaft.
G-7	One Acid Injection Pump and One Spare, 98% Sulfuric acid, up to a maximum of 20 gpm each, TDH 40 feet, motor-driven, 1.0 horsepower each.
G-8	Two Screen Wash Pumps With Strainers, each 500 gpm, submerged suction, TDH 275 feet, motor-driven, vertical, 100 horsepower.
G-9	Two Traveling Water Screens, 8 ft. x 45 ft., type 304 SS frame with guides.
G-10	One Trash Handling System, complete with trash racks and stop gates.
H-1	Two Air Ejectors and Condensers, each to remove approximately 10 lb. per minute of noncondensables saturated with water vapor; complete with air leakage meters.
H-2	One Startup Air Ejector, capable of pumping the evaporator system down to 26 in. Hg vacuum in six hours or less.
H-3	One Vacuum Deaerator, tray-type, integral with last rejection stage, for release of air and residual noncondensables from feed and ejection of infiltrated air from shell side of heat rejection vessel.
K-1	Two Air Compressors, 150 scfm each, discharge pressure 125 psig, complete with coolers, air dryers, receiver vessels, and 40-horsepower electric motor drives.
R-1	Operations and Control Building, including laboratory and office space, 40 ft. x 60 ft.
T-1	Circulating Water Chlorine Injection Facilities, complete with 8,000 lb. per day chlorinator, 6 one-ton storage cylinders, and necessary ancillary equipment and piping.

*Item numbers refer to Plate 4.17

TABLE 4.4

MAJOR EQUIPMENT LIST
150-MGD PHASED DESALTING PLANT

PHASE II - 100 MGD

Item*	Description
D-2	Two Atmospheric Decarbonators, one per train, tray-type, wood construction, with concrete subgrade reservoir, each provided with a forced air blower for removal of free carbon dioxide.
E-1	Two Heat Rejection Sections, three stages; tubes 3/4 in. x 18 gauge iron-modified 70-30 cupronickel; tube sheets approximately 96 in. x 20 in. x 2 in. thick, of steel, with 90-10 cladding; tube area per train approximately 345,000 square feet; one vessel in each of two trains.
E-2	Two Heat Recovery Section, 38 stages; tubes 3/4 in. x 18 gauge iron-modified 90-10 cupronickel; tube sheets approximately 96 in. x 30 in. x 2 in. thick, of steel with 90-10 cladding; tube area per train approximately 3,097,000 square feet, four vessels in each of two trains.
E-3	Four Brine Heaters, shell pressure 34.2 psia, single pass; tubes 3/4 in. x 18 gauge iron-modified 90-10 cupronickel; duty 818.4 x 10^6 Btu/hr each; tube area approximately 80,000 square feet each.
G-1	One Sea Water Pump, 157,000 gpm capacity, submerged suction, TDH 33 feet, 88% efficiency, motor-driven, vertical, 1,750 horsepower, stainless steel impeller, Ni-resist case, Monel shaft. (With the addition of Phase II, the second sea water pump serving the backpressure turbine plant at reduced capacity for Phase I will be returned to full capacity operation.)
G-2	One Makeup Feed Pump, 66,000 gpm capacity, submerged suction, TDH 15 feet, 88% efficiency, motor-driven, vertical, 300 horsepower, stainless steel impeller, Ni-resist, Monel shaft.
G-3	Four Recycle Brine Pumps, each 128,000 gpm, submerged suction, TDH 170 feet, 88% efficiency, motor-driven, vertical, 7,000 horsepower each, stainless steel impeller, Ni-resist case, Monel shaft.
G-4	Two Concentrated Brine Blowdown Pumps, each 27,000 gpm, submerged suction, TDH 40 feet, 88% efficiency, motor-driven, vertical, 350 horsepower each, stainless steel impeller, Ni-resist case, Monel shaft.

TABLE 4.4 (Continued)

Item*	Description
G-7	Two Acid Injection Pumps and Two Spares, 98% sulfuric acid, up to a maximum of 20 gpm each, TDH 40 feet, motor-driven, 1.0 horsepower each.
G-8	Two Screen Wash Pumps with Strainers, each 500 gpm, submerged suction, TDH 275 feet, motor-driven, vertical, 100 horsepower.
G-9	Two Traveling Water Screens, 8 ft. x 45 ft., type 304 SS frame with guides.
G-10	One Trash Rack, for trash handling system.
H-1	Four Air Ejectors and Condensers, two per train, each to remove approximately 10 lb. per minute of noncondensables saturated with water vapor; complete with air leakage meters.
H-3	Two Vacuum Deaerators, one per train, tray-type, integral with last rejection stage, for release of air and residual noncondensables from feed and ejection of infiltrated air from shell side of heat rejection vessels.
K-1	Two Air Compressors, 150 scfm each, discharge pressure 125 psig, complete with coolers, air dryers, receivers vessels, and 40-horsepower electric motor drives.

*Item numbers refer to Plate 4.17

Multistage Flash Evaporators

Three identical, parallel, evaporator trains that use the recirculation, long-tube, horizontal configuration of evaporator design are provided. Each train consists of four vessels in the heat recovery section and one in the heat rejection section. All vessels are 150 feet wide. Heat recovery section vessels are approximately 100 feet long and heat rejection vessels are about 70 feet long.

The evaporator shells, interstage bulkheads, internal structural members, water boxes, and internal piping are of steel. The vessels house the condensing tube surface in the upper portion and flashing brine stream in the lower portion. Distilled water is collected in open trays under the tube bundles within the evaporator sections.

All evaporator tubes are 3/4-inch OD and 18 gauge (0.049 inch wall thickness). Rejection section tubes are made of 70-30 copper-nickel, per ASTM B-111. Recovery section tubes are 90-10 copper-nickel, per ASTM B-111. Tube sheets are steel with 90-10 copper-nickel cladding and water boxes are lined internally with 90-10 copper-nickel.

Six brine recirculation pumps are provided, each designed for 128,000 gpm at 170 feet TDH with submerged suction and equipped with 7,000-hp vertical electric motors. The recycle brine pumps take suction from the rejection section deaerating stage and pump the brine through the tube bundles of the heat recovery sections, emerging from the hottest end of the recovery section (first stage) at 235 F. The brine is further heated in the brine heaters to 250 F and is then discharged into the flashing section of the first stage.

Brine Heaters

Two, single-pass, shell and tube type brine heaters for each train are included in the estimate. Heat transfer surface consists of 3/4-inch OD, 18 gauge, 90-10 copper-nickel tubes. Steam condensed in the brine heaters is returned to the backpressure turbine-generator feedwater circuit by six motor-driven condensate pumps. The brine heater steam supply and condensate return lines are included in the scope for the backpressure turbine plant.

Sea Water Pretreatment System

Dissolved and internally generated carbon dioxide and other noncondensable gases are removed by a two-stage operation. To prevent the formation of calcium carbonate and magnesium hydroxide scale in the evaporators and heaters, sulfuric acid is injected into the makeup feed stream at the rate of 120 ppm. The feed then flows to an atmospheric decarbonator where a large percentage of the carbon dioxide is liberated.

Chlorine is added to the sea water intake stream to retard the growth of marine organisms. Complete chlorine injection facilities with chlorinator and storage cylinders are included in the scope.

Air Removal System

Six steam jet air ejectors and condensers, two for each evaporator train, are included. Each system is capable of removing approximately 10 pounds per minute of air and other noncondensable gases which may enter the evaporators with the sea water feed, through leakage from the atmosphere, or which are generated in the process. Ejector steam is supplied from the backpressure turbine plant at approximately 125 psig.

Sea Water Intake and Discharge System

The intake structure is designed to accommodate three motor-driven, vertical, sea water pumps with a capacity of 157,000 gpm each and the necessary equipment for trash removal, screen washing, chlorination, and for dewatering the intake structure. Circulating water supply and discharge ducts between the intake structure of the desalting plant and the discharge structure are included in the desalting plant scope. A common discharge structure serves both the power and desalting plants. The common discharge line and discharge structure are included in the scope of the Unit 1 condensing power plant.

Auxiliary Power System

The auxiliary power system depicted in Plate 4.19 receives power from the 69-kv switchyard to supply the energy for the desalting plant motors and other power requirements within the desalting plant, and also feeds the backpressure turbine startup transformer. The system includes 13,800; 4,160; and 480-volt indoor, drawout-type switchgear which supplies power to the larger loads; 480-volt motor control centers are utilized to supply the small motors and miscellaneous equipment.

Cathodic Protection

A cathodic protection system is included to control corrosion of storage tank bottoms and subsurface pipe in contact with earth and water.

Lighting System

Lighting transformers provide power for lighting at the desalting trains, the control and equipment buildings, and the desalting plant yard area. Emergency lighting power is obtained from a 125-volt d-c battery system by means of automatic transfer equipment.

Conduit

Underground conduit systems are encased in concrete. All exposed conduit is rigid galvanized iron except at the intake and discharge structures where rigid plastic-coated iron conduit is used. All exposed and embedded metallic conduit in sizes up to and including two inches is electrical metallic tubing within the plant; conduits larger than two inches are rigid galvanized iron.

Control Building

A control and operations building is provided to house the instrument control panel and electrical controls and provide space for plant operators. A laboratory section houses analytical instrumentation and testing equipment for routine control tests.

Other Facilities

Allowances have been made in the cost estimates for instrumentation and process control systems, compressed air facilities, an electrical grounding system, a d-c control system, an annunciator system, a communications system, and other miscellaneous components and facilities.

PRODUCT WATER CONVEYANCE SYSTEM

The product water conveyance system is sized to transport 150 mgd of desalted water approximately 24 miles from the dual-purpose plant to the Robert B. Diemer Filtration Plant for introduction and blending with imported water.

A two-lift system is used for conveying the desalted water. The first lift, from the desalting plant to an intermediate reservoir approximately 23 miles from the plant, is about 250 feet. The second lift to the delivery point, approximately two miles from the intermediate reservoir, is about 550 feet.

The product water conveyance system is divided into seven basic components. In the direction of water flow these components are:

— Product water sump

— Pumping plant 1

— Transmission pipe 1

— Intermediate reservoir

— Pumping plant 2

— Transmission pipe 2

— Blending structure.

Product Water Sump

The product water sump receives product water from the last stage of each heat recovery section and serves as a pumping pool for pumping plant 1. Connections from the sump to the heat recovery sections and the pumping plant are gated. The sump is steel pipe that runs underground.

Pumping Plant 1

Pumping plant 1 receives product water from the sump and delivers it to transmission pipe 1 at sufficient pressure to transmit water to the intermediate reservoir. Eight pumping units, including one standby, are installed. Pumps are motor-driven and are of the vertical turbine type. A gantry crane is provided for servicing.

Transmission Pipe 1

Transmission pipe 1 starts at the manifold into which the pumps of pumping plant 1 discharge and terminates at the intermediate reservoir which is assumed to be adjacent to East Orange County feeder 2 at a point approximately two miles from Diemer.

The 72-inch steel pipe is assumed to be lined with hot-applied coal tar enamel and the exterior is coated with cement mortar. Total length of this line is approximately 121,000 feet.

Intermediate Reservoir

The intermediate reservoir construction is of reinforced concrete, earth covered. Its capacity is 25 million gallons at a water depth of 25 feet. A division wall may be provided to separate the reservoir into two equal parts for maintenance purposes. Water-contact surfaces are to be lined.

Pumping Plant 2

Pumping plant 2 is located, either adjacent to, or is part of, the intermediate reservoir. The structure is of reinforced concrete, lined as the reservoir. Pumps and motors are similar to pumping plant 1.

Transmission Pipe 2

Transmission pipe 2 starts at the manifold into which the pumps of pumping plant 2 discharge. It continues along the alignment of East Orange County feeder 2 to Diemer. The pipe is designed and constructed according to the same principles as transmission pipe 1. Total length of this line is approximately 11,000 feet.

Blending Structure

Product water is delivered by transmission pipe 2 directly into one or more of the existing connections provided at Diemer for the future introduction of softened water into the effluent conduit at the dividing weir.

SEISMIC CRITERIA

Design and analysis for seismic loading of structures and systems will follow accepted engineering procedures. The various structures, systems, and components that constitute the power plant affect public safety in varying degrees. They can be classified in three categories:

Class I

Class I are those structures and components essential to safe and orderly shutdown of the reactors and apparatus will be designed to prevent or minimize uncontrolled release of fission products. Class I includes structures, systems, and components vital to the containment of radioactivity.

Class I structures, systems and components will be designed based on a spectrum normalized at 0.30 g ground acceleration as shown in Figure 4.1 with appropriate damping factors as shown in Table 4.5. Class I items will be analyzed for no-loss-of-function (NLF) using a response spectrum normalized at 0.45 g ground acceleration, as shown in Figure 4.2.

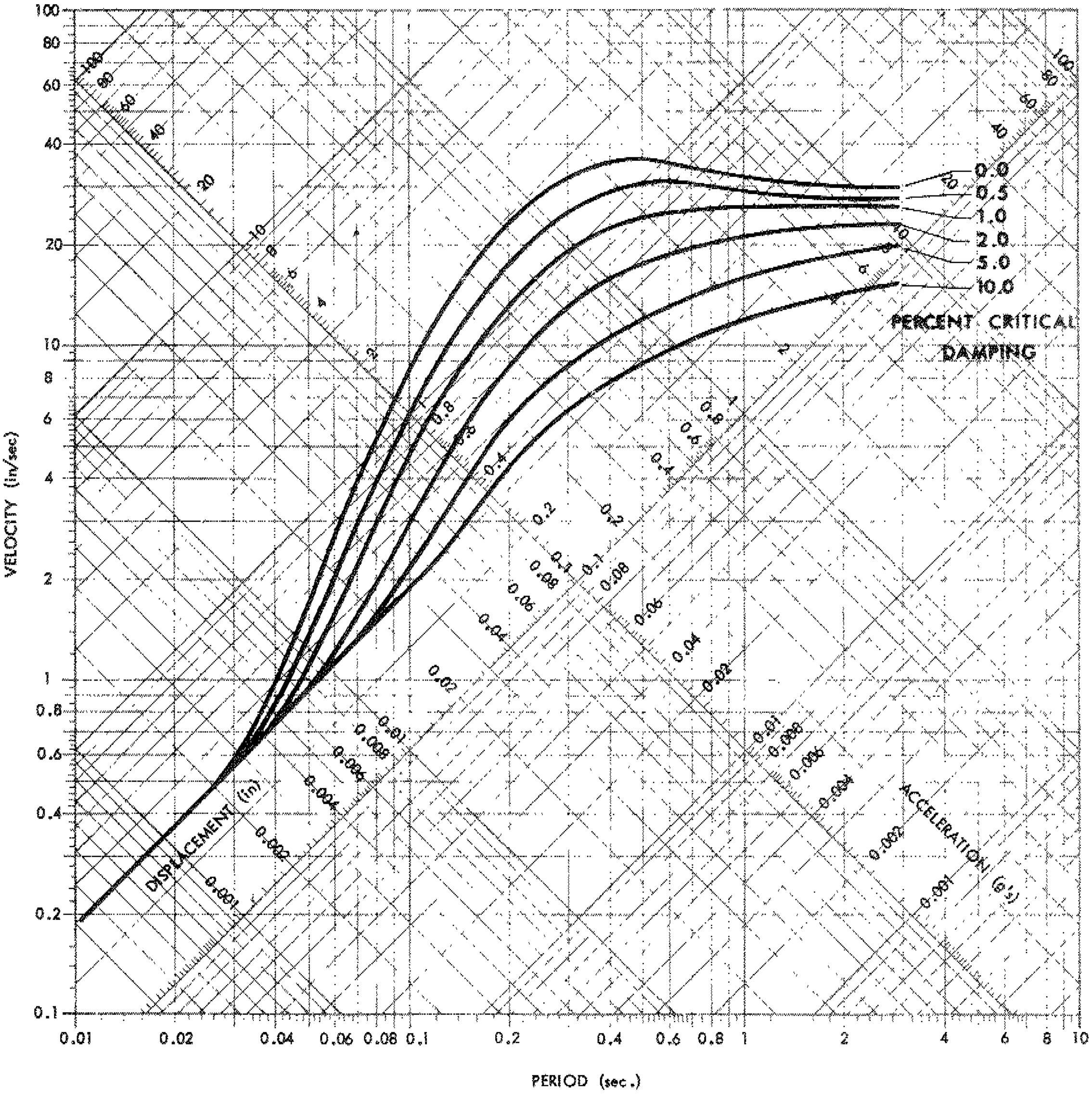


FIGURE 4.1

HORIZONTAL RESPONSE SPECTRUM
NORMALIZED TO 0.3g

TABLE 4.5

DAMPING FACTORS

Stress Level	Type and Condition of Structure	Percentage of Critical Damping
Low, well below proportional limit, stresses below 1/4 yield point	Vital piping	0.5
	Steel, reinforced or prestressed concrete, no cracking, no joint slip	0.5 to 1.0
Working stress, no more than about 1/2 yield point	Vital piping	0.5 to 1.0
	Welded steel, prestressed concrete, well reinforced concrete (only slight cracking)	2
	Reinforced concrete with considerable cracking	3 to 5
	Bolted and/or riveted steel	5 to 7
At or just below yield point	Vital piping	2
	Welded steel, prestressed concrete (except as noted below)	5
	Prestressed concrete structures in which the compressive concrete stresses have been reduced to zero by other forces, such as internal pressure in a prestressed containment vessel	7
	Reinforced concrete	7 to 10
	Bolted and/or riveted steel	10 to 15
All ranges	Rocking of entire structure	5 to 9*

*5 Percent for Design Response Spectrum
9 Percent for Safe Shutdown Response Spectrum

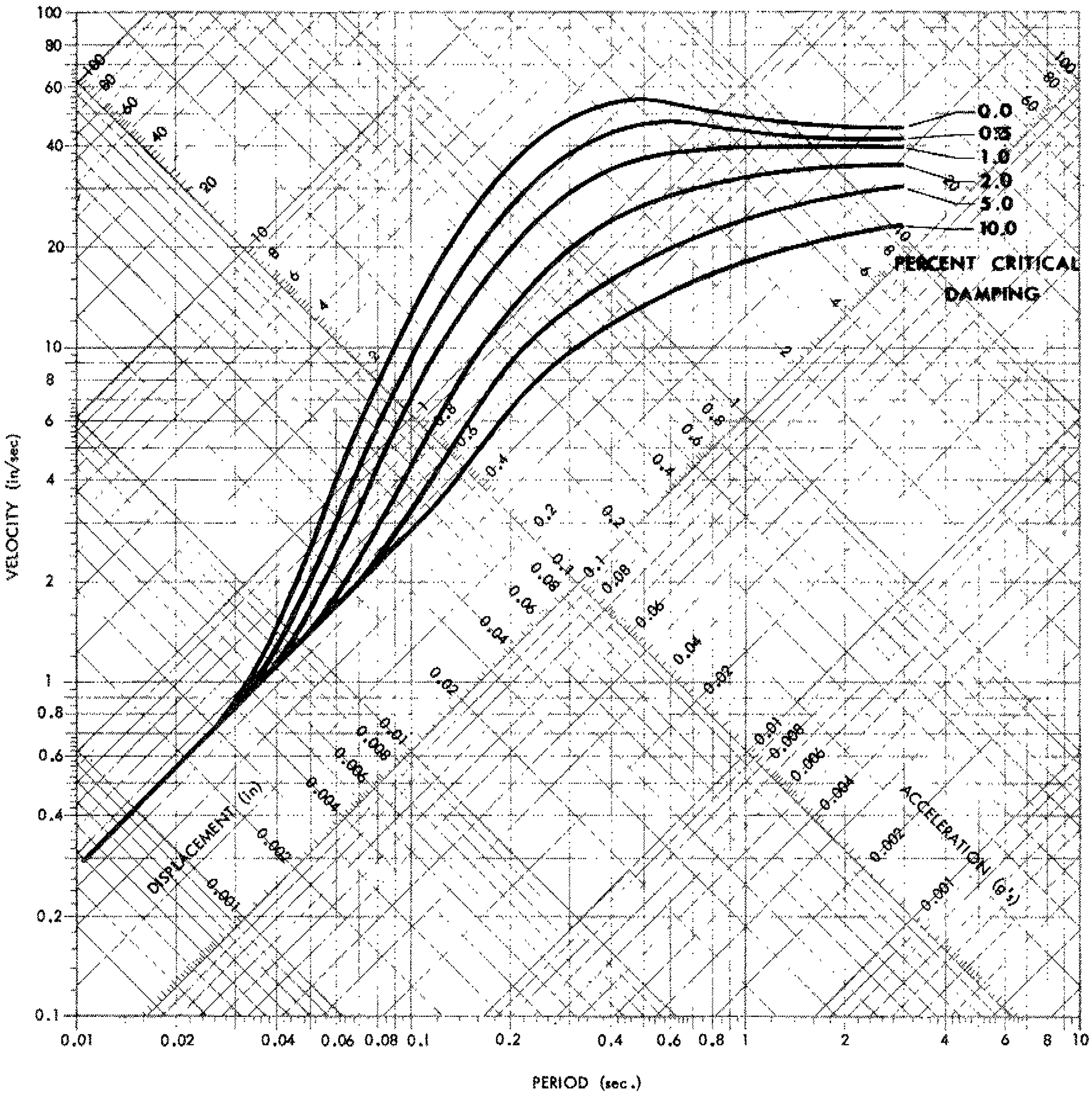


FIGURE 4.2

HORIZONTAL RESPONSE SPECTRUM
NORMALIZED TO 0.45g

Class II

Class II are those structures, systems, and components important to the continuity of power generation and reactor operation, but not essential to safe shutdown operations; the loss of which could not result in the release of significant amounts of radioactivity.

Class II structures, systems, and components will be designed on the basis of a static analysis using a horizontal seismic coefficient of 0.20 g with a one-third increase in basic allowable stress, as determined by applicable codes.

Class III

Class III are those structures, systems, and components not included in Classes I or II, applied to items not directly affecting safe plant shutdown or continuity of electrical power production.

Class III items will be designed in accordance with the earthquake requirements of the Uniform Building Code.

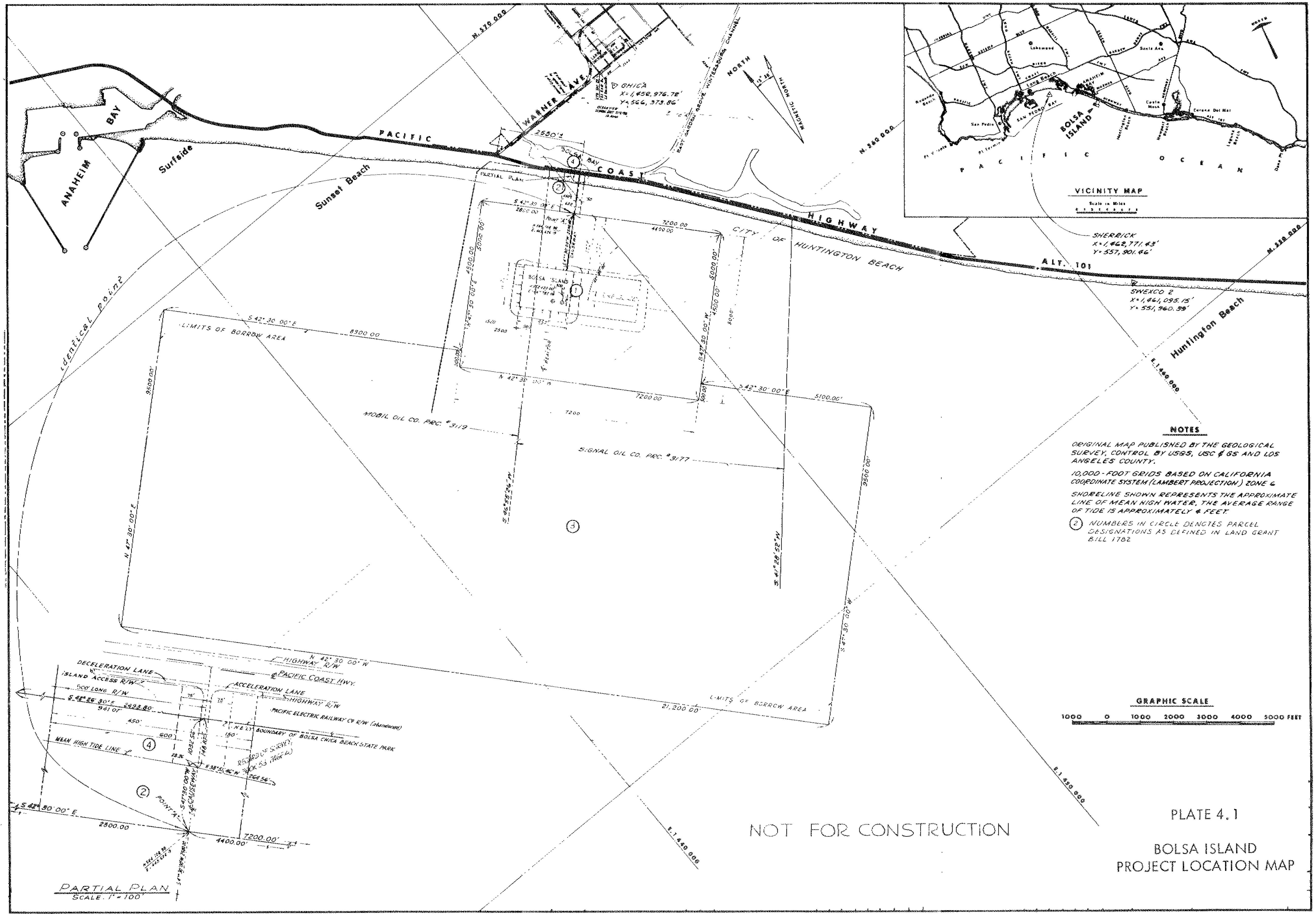


PLATE 4.1

BOLSA ISLAND
PROJECT LOCATION MAP

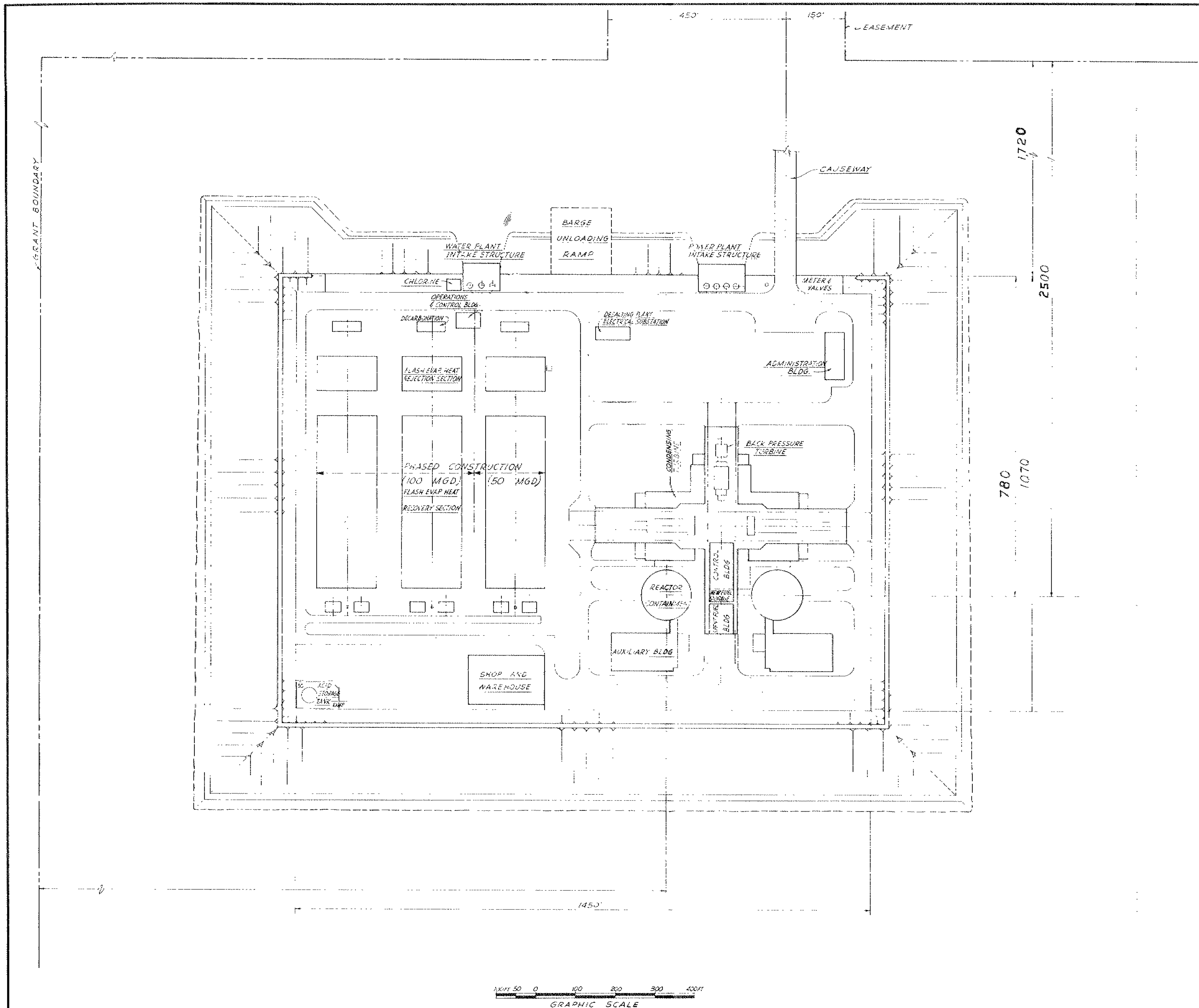


PLATE 4.2

SITE ARRANGEMENT

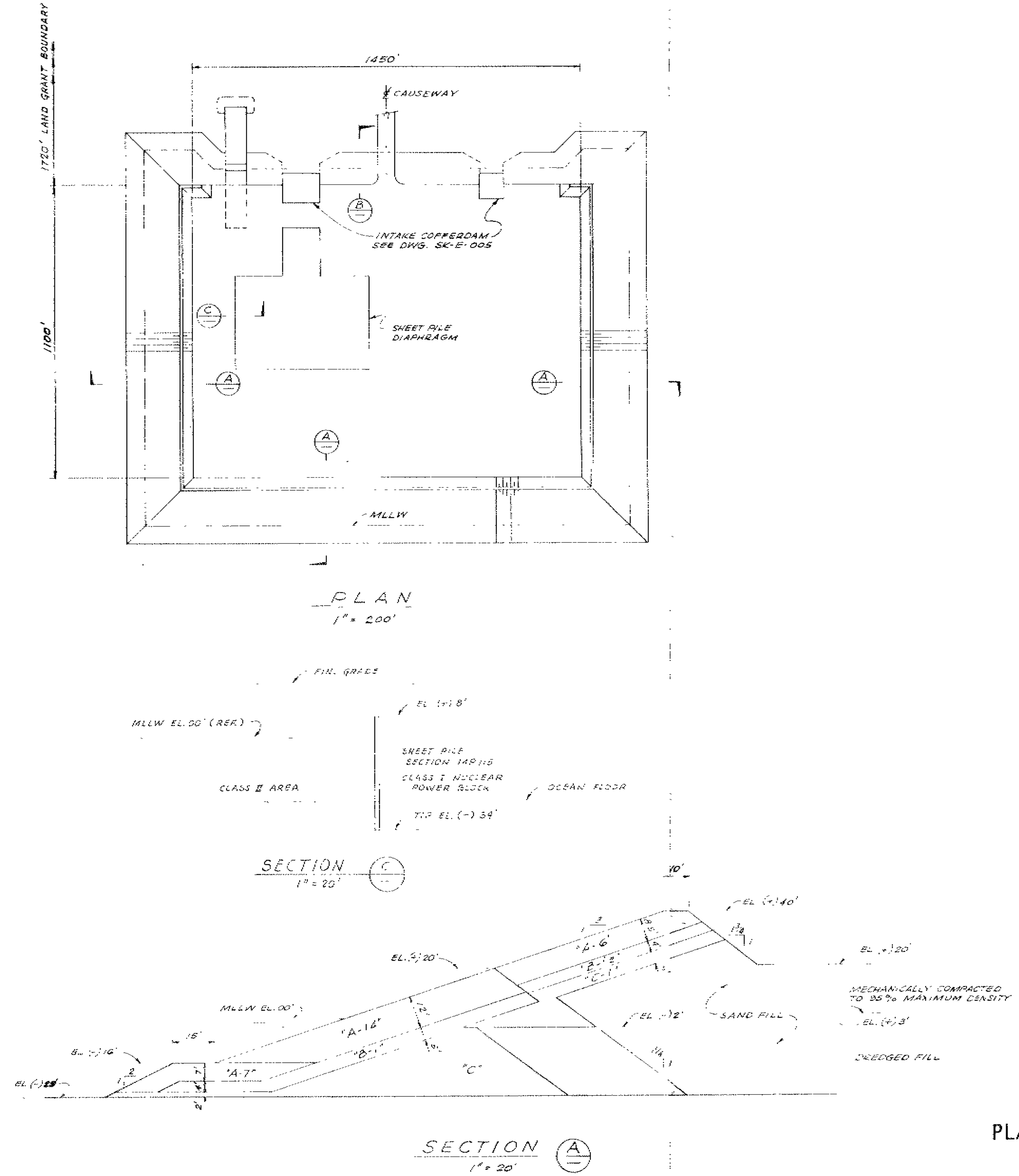
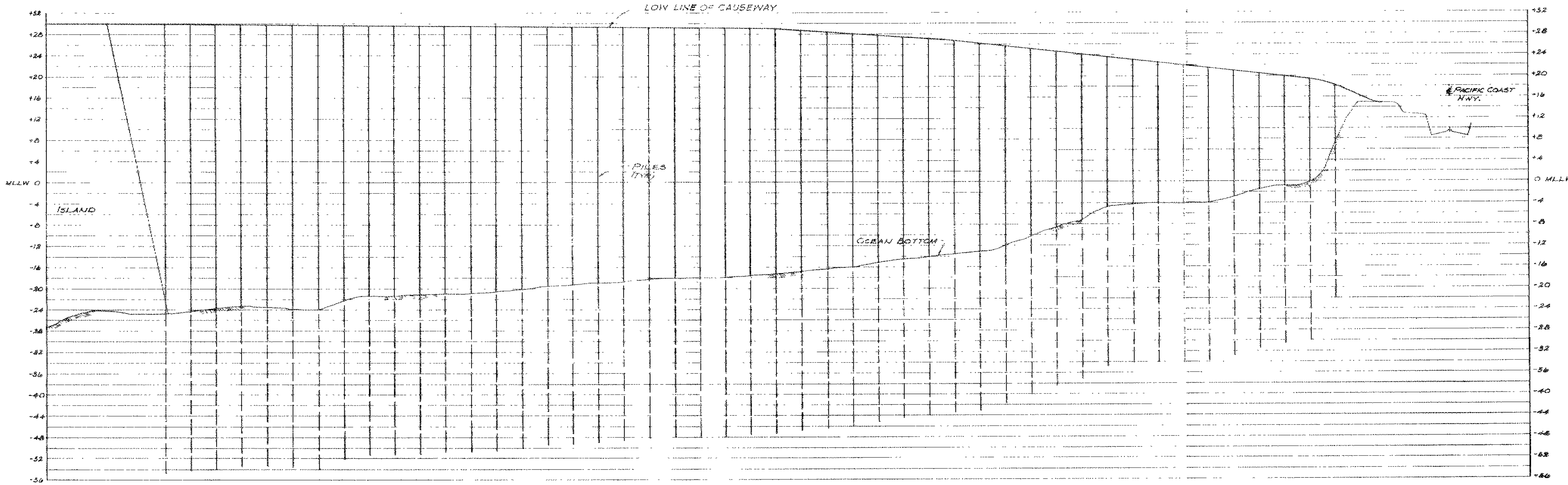
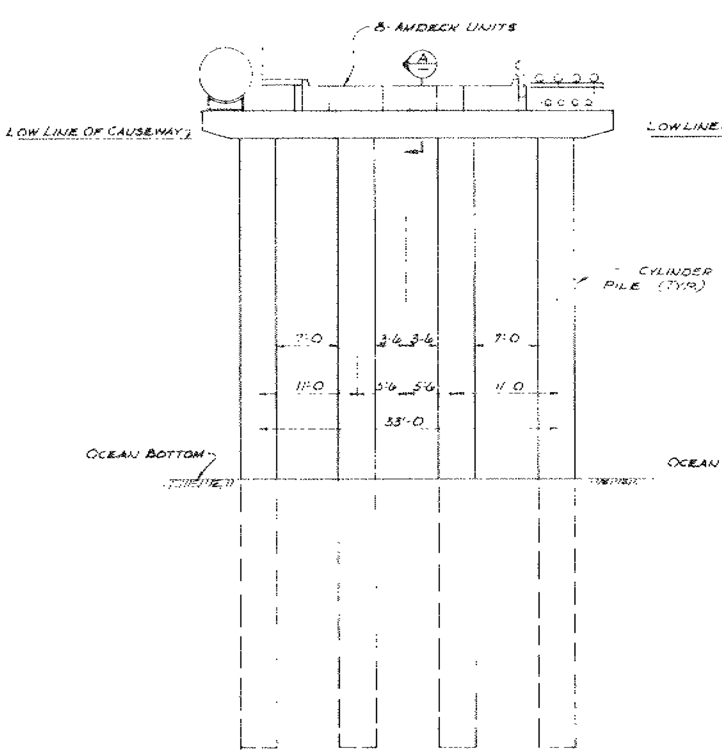


PLATE 4.3

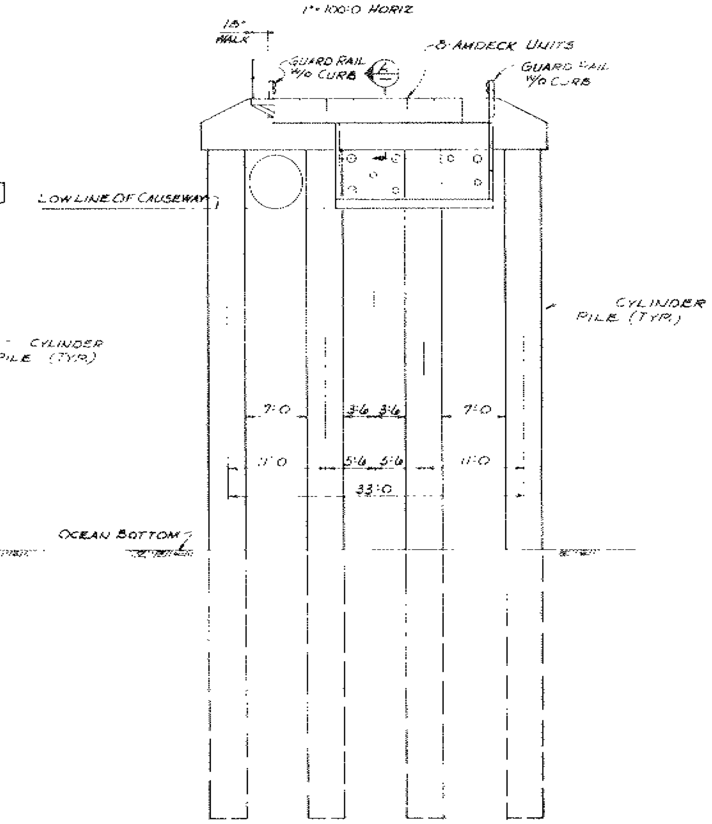
ISLAND
PLAN & SECTION



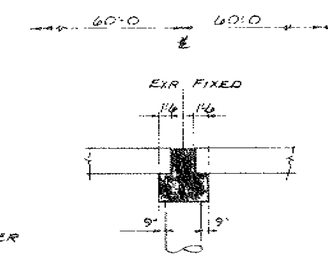
PROFILE
1" = 8'0 VERT
1" = 100'0 HORIZ



TYPICAL CROSS SECTION
UTILITIES ABOVE
1" = 8'0



TYPICAL CROSS SECTION
UTILITIES BELOW
1" = 8'0



SECTION (A)
1" = 8'0

PLATE 4.4

CAUSEWAY PROFILE
AND TYPICAL CROSS SECTIONS

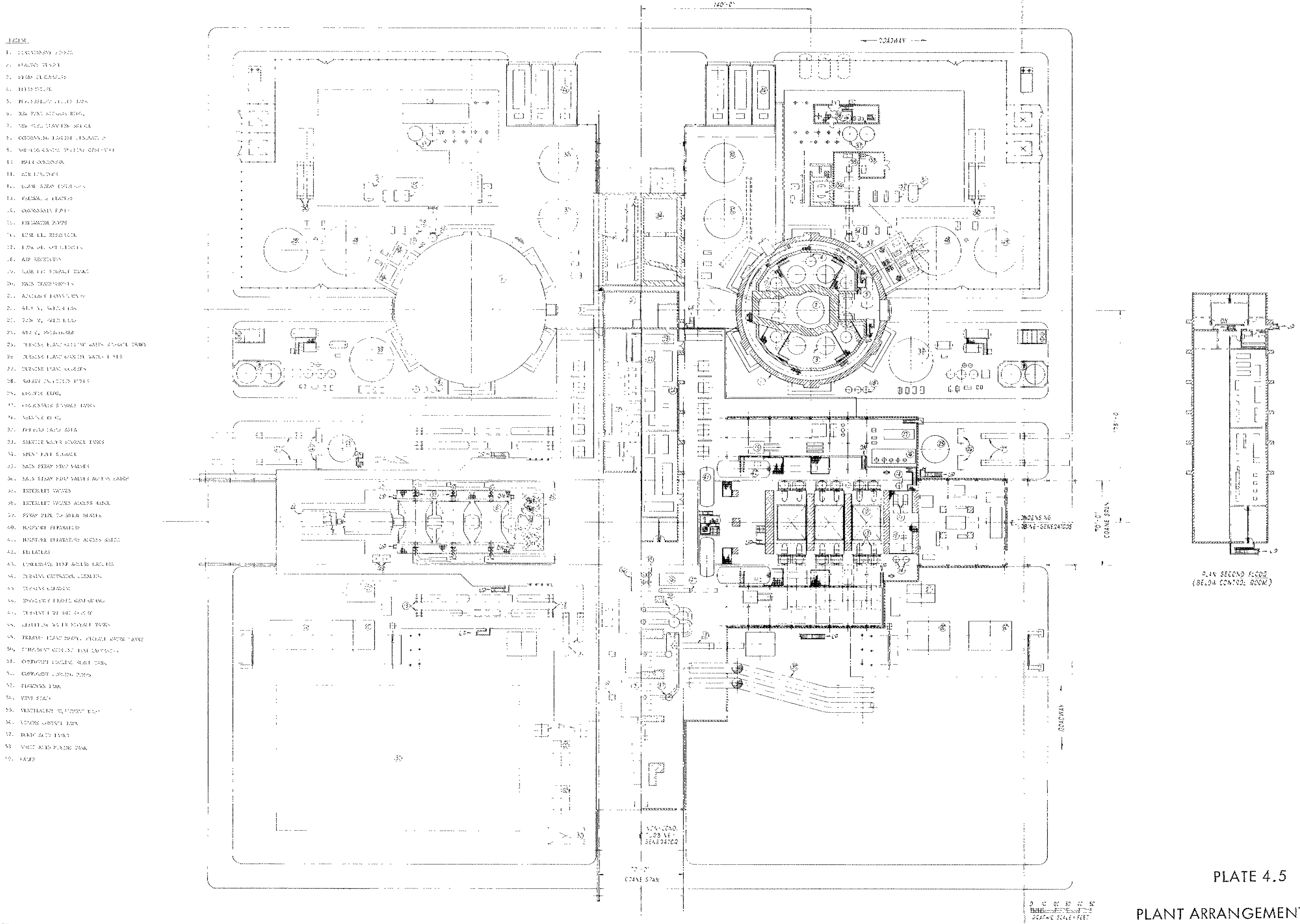


PLATE 4.5

PLANT ARRANGEMENT (PLAN)

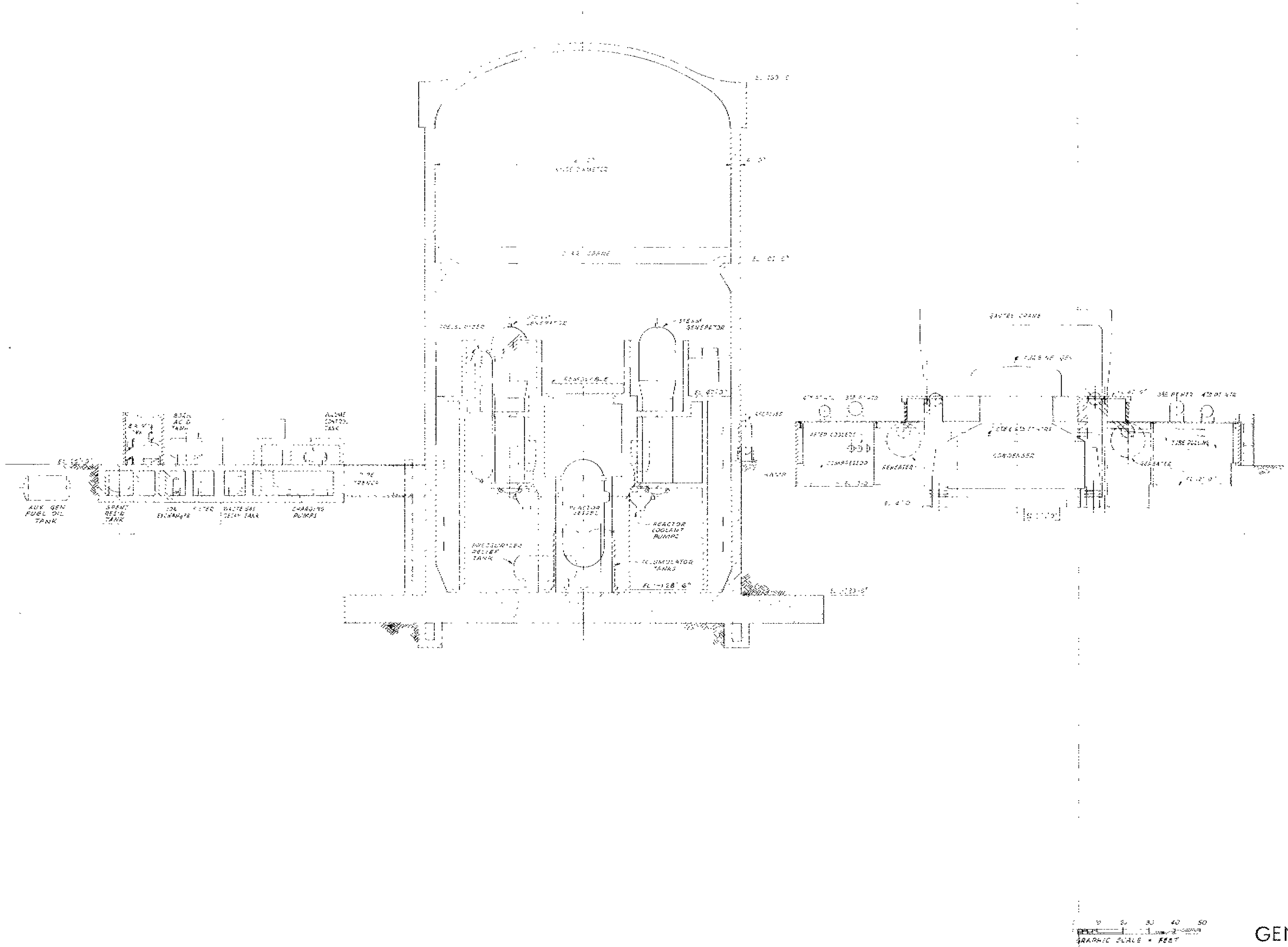
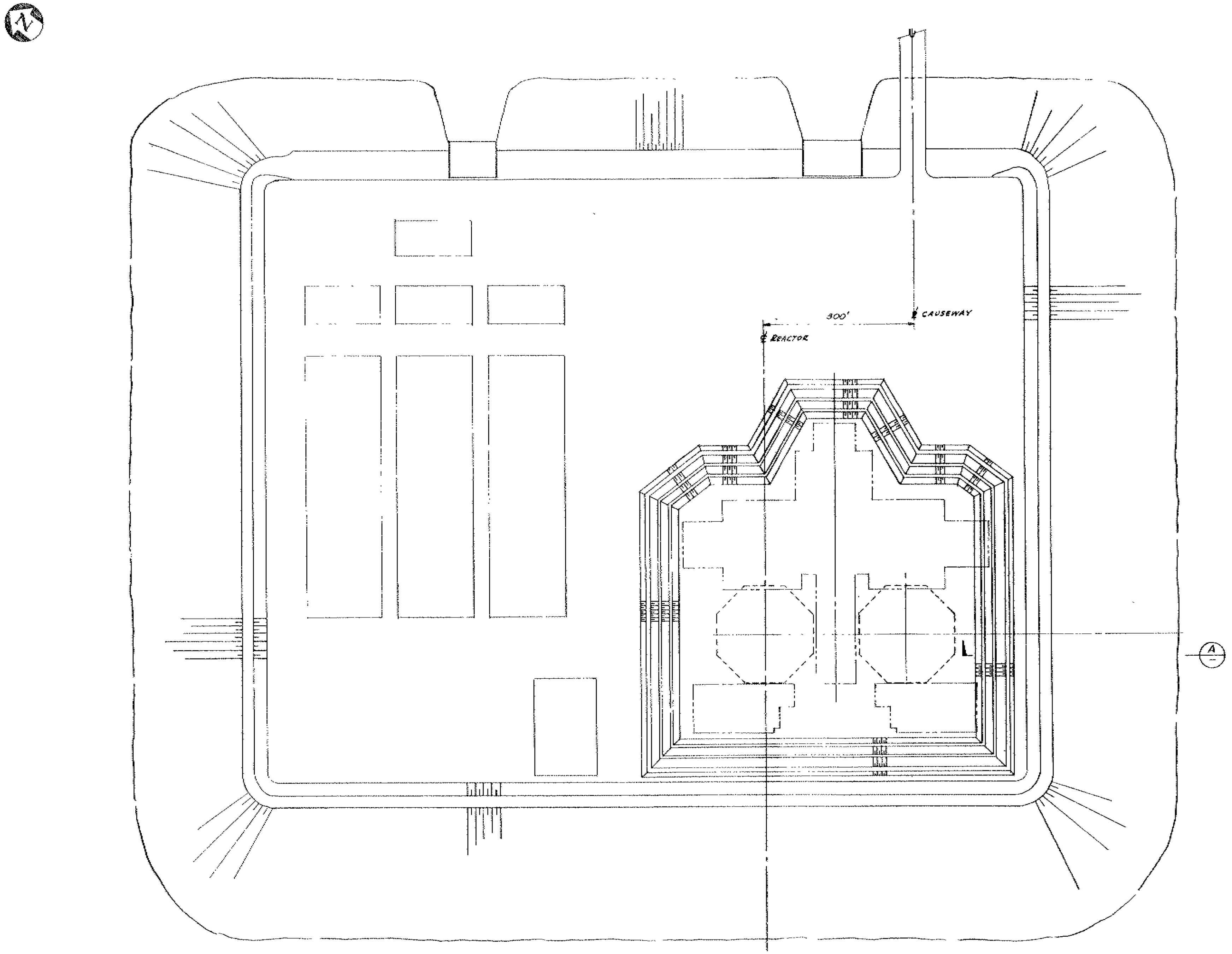
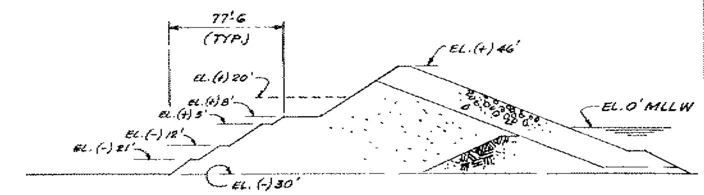


PLATE 4.6

GENERAL ARRANGEMENT
SECTION A-A



BOLSA ISLAND PLAN
1" = 100'



SECTION A

PLATE 4.7

POWER COMPLEX
EXCAVATION AND BACKFILL PLAN

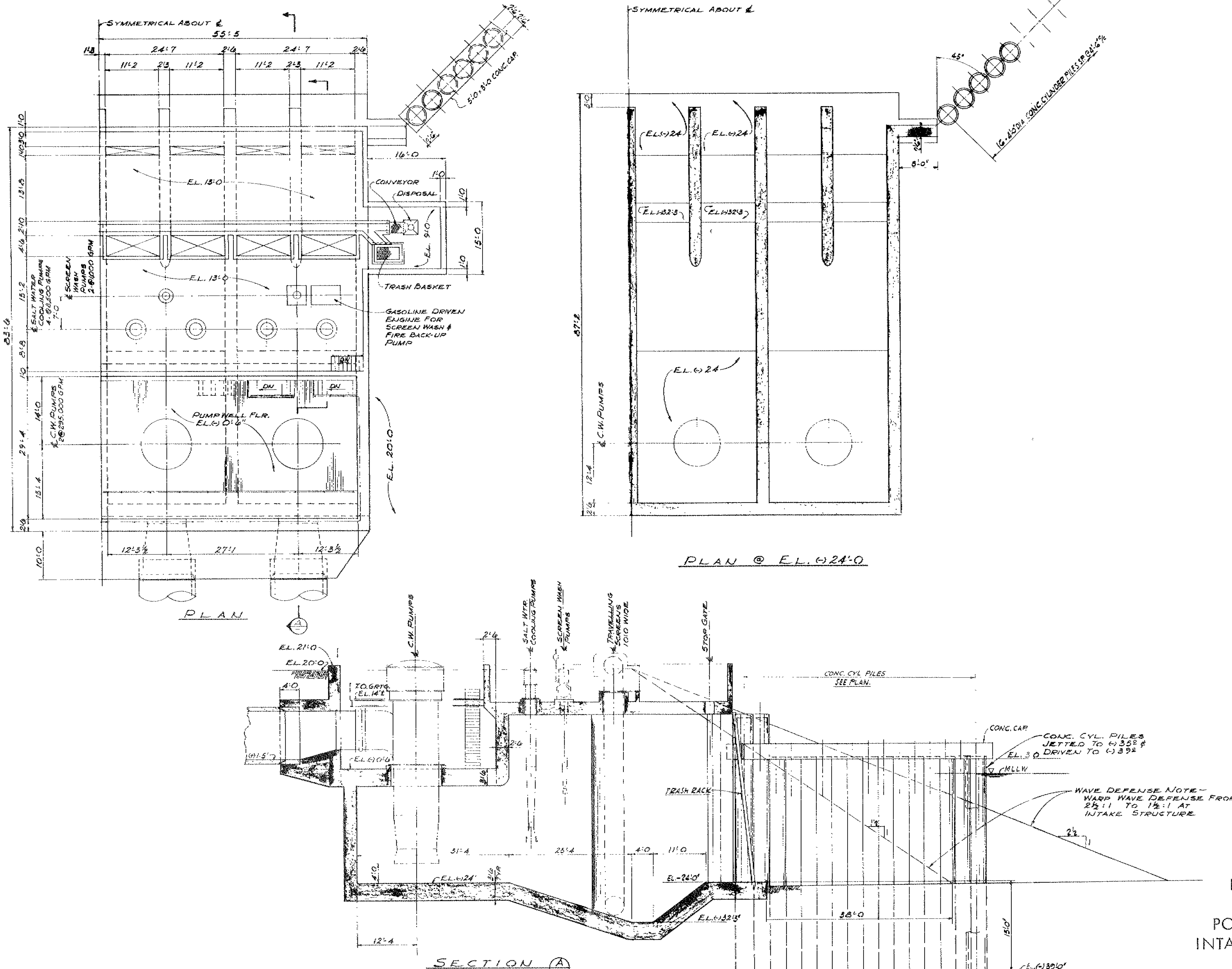


PLATE 4.8

POWER PLANT
INTAKE STRUCTURE

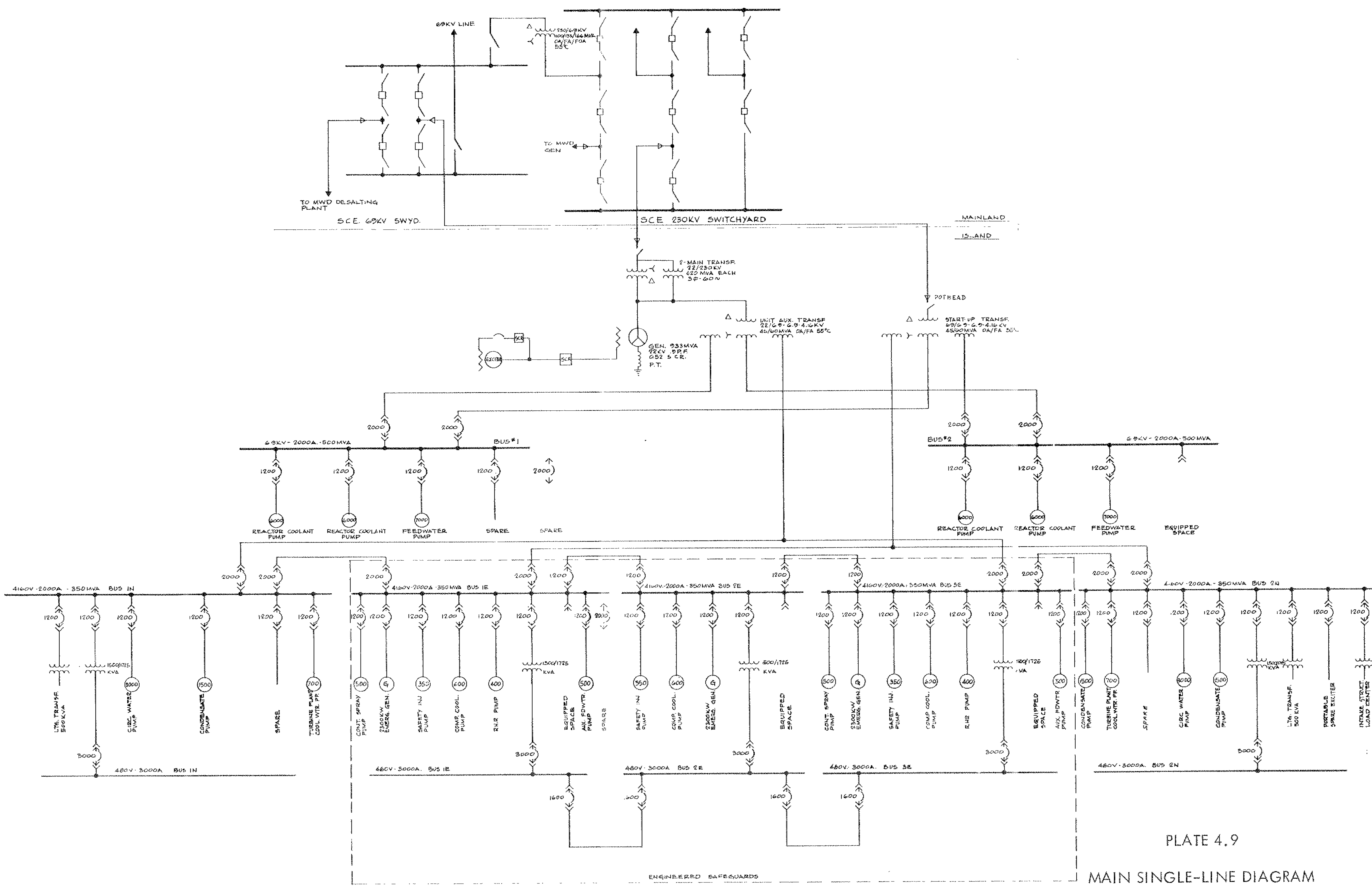


PLATE 4.9

MAIN SINGLE-LINE DIAGRAM

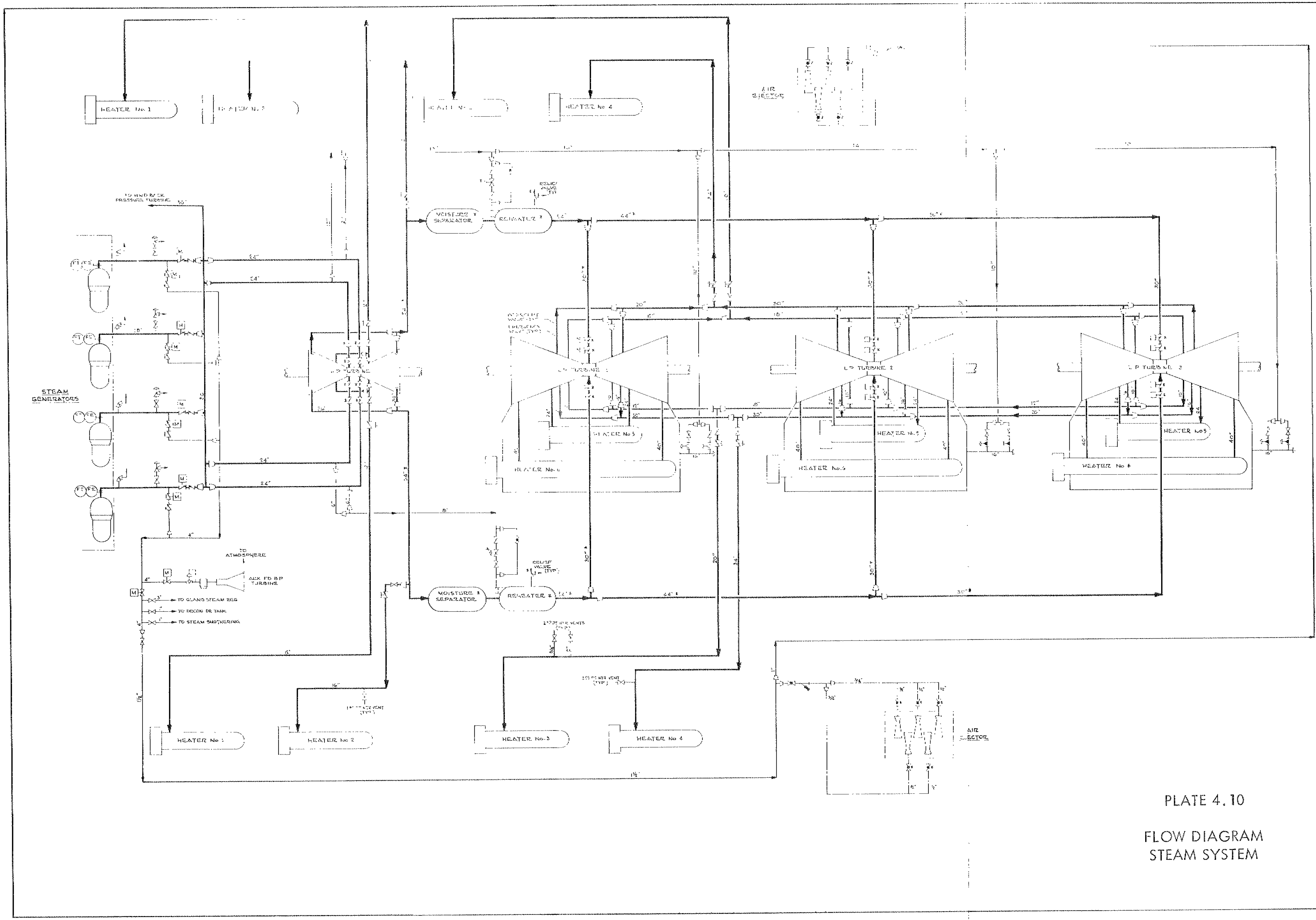


PLATE 4.10

FLOW DIAGRAM
STEAM SYSTEM

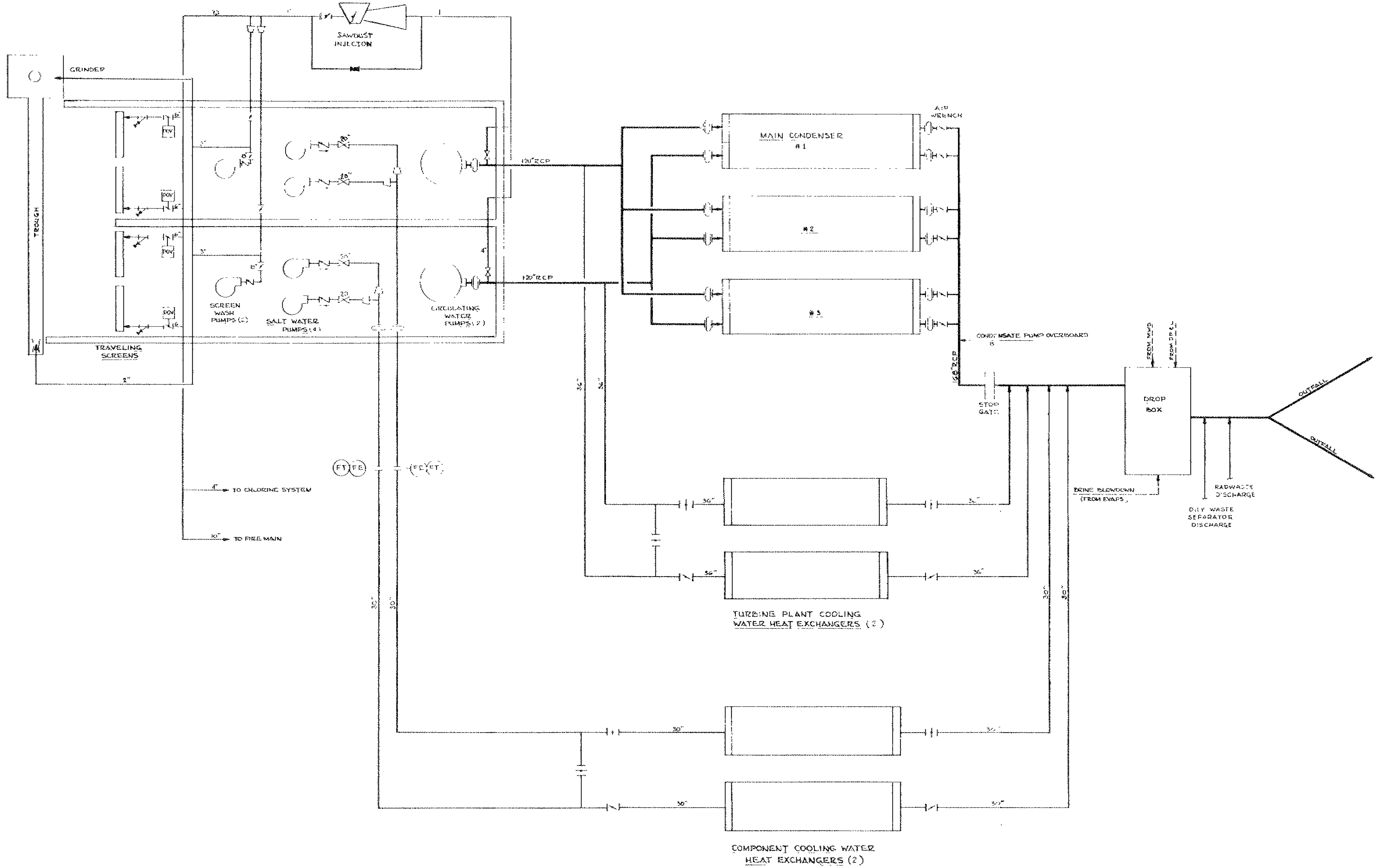


PLATE 4.11

FLOW DIAGRAM
CIRCULATING WATER SYSTEM

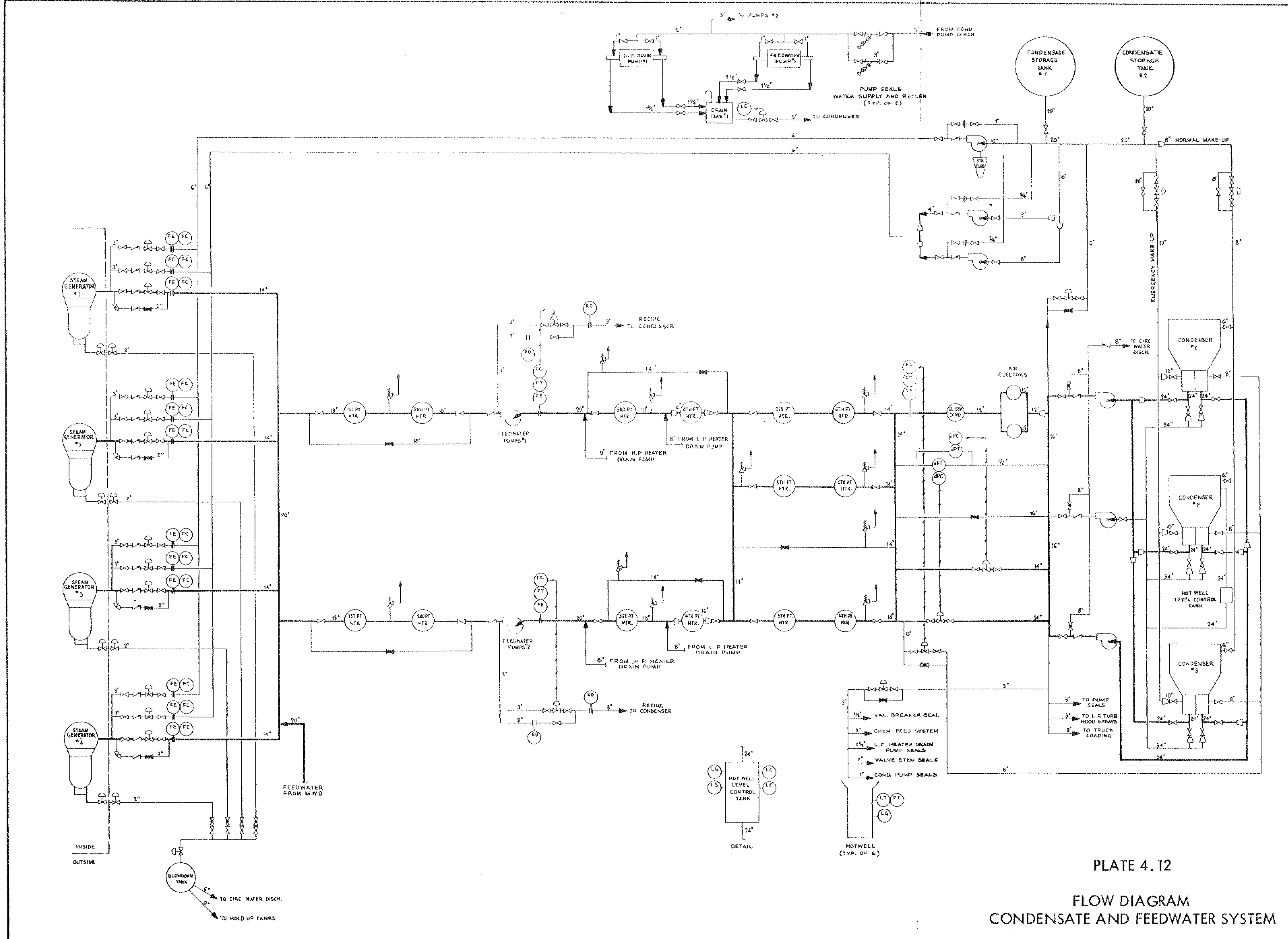
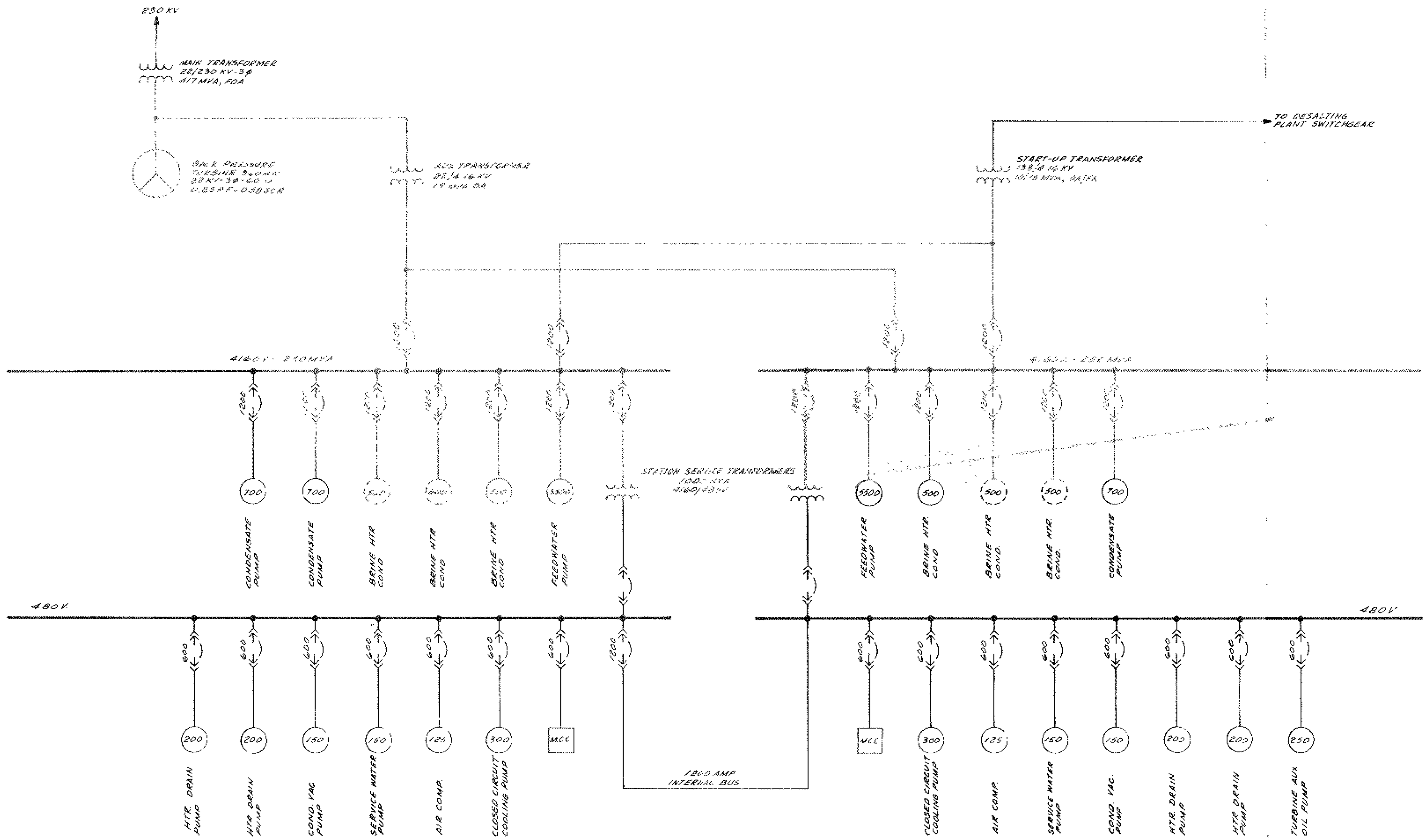


PLATE 4.12

FLOW DIAGRAM
CONDENSATE AND FEEDWATER SYSTEM



NOTES:
1. SOLID LINES INDICATE PHASE I INSTALLATION
2. DASHED LINES INDICATE PHASE II INSTALLATION

PLATE 4.13

BACKPRESSURE TURBINE
ELECTRICAL SINGLE-LINE DIAGRAM

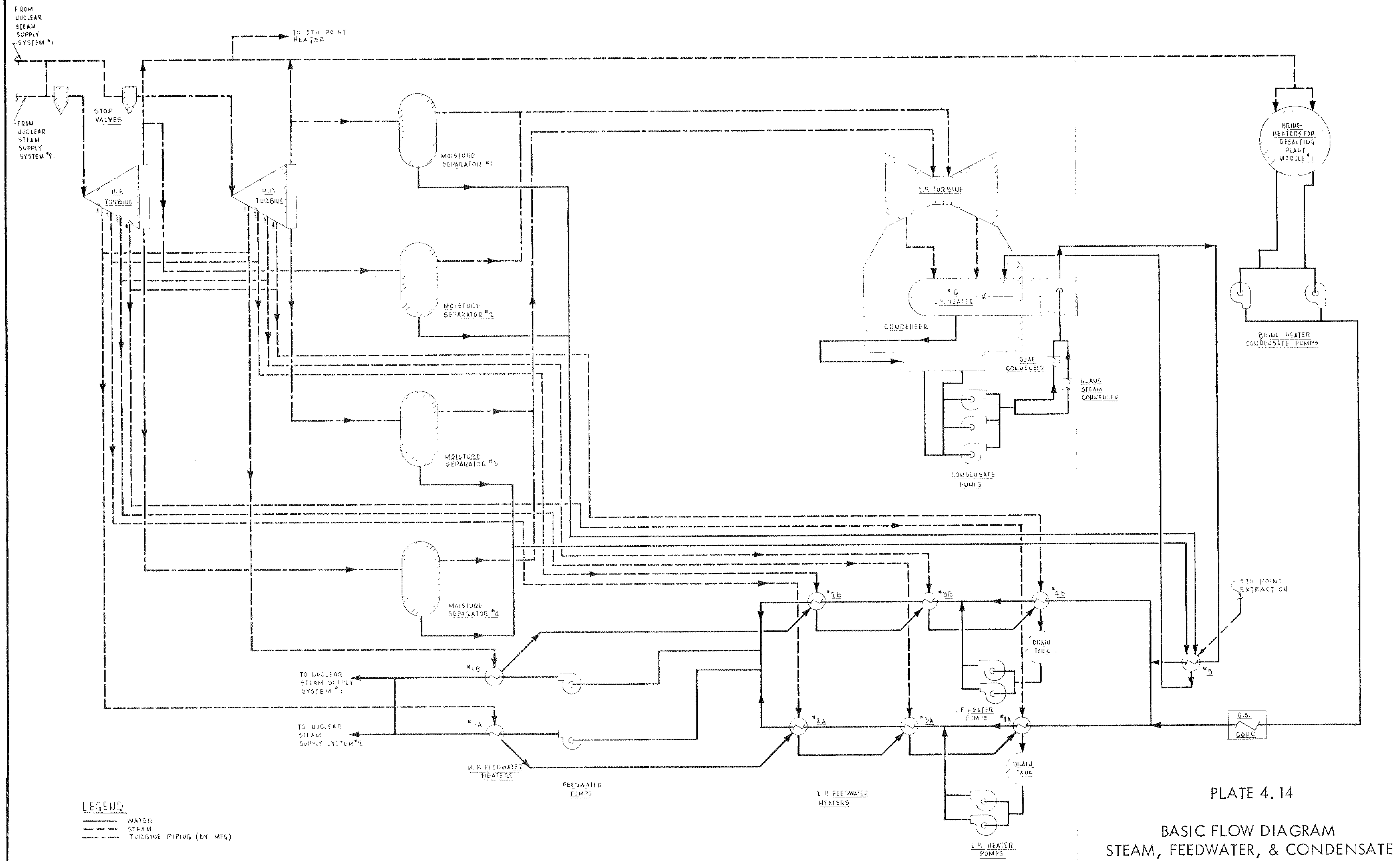


PLATE 4.14

BASIC FLOW DIAGRAM
STEAM, FEEDWATER, & CONDENSATE
PHASE I BACKPRESSURE TURBINE

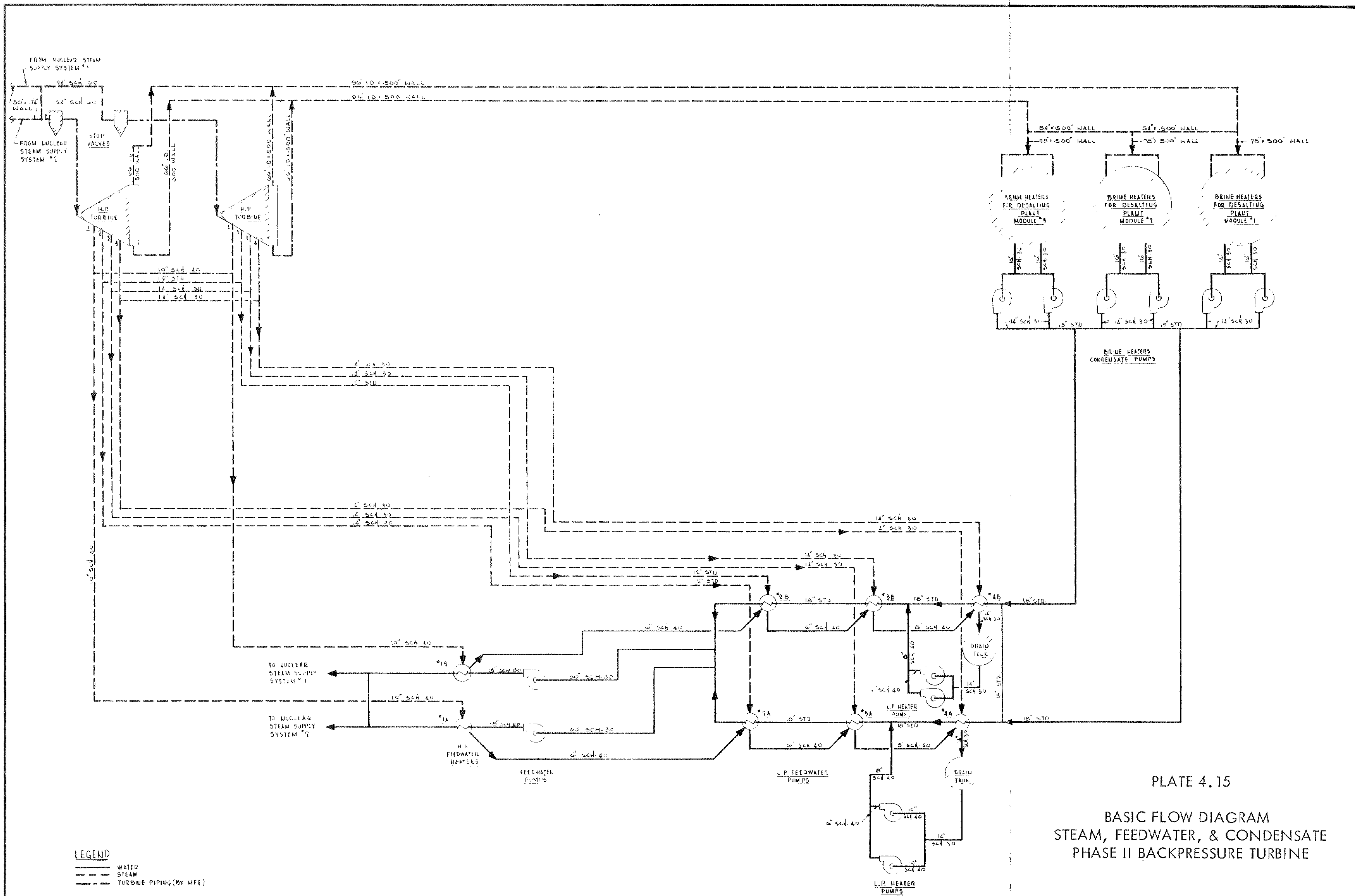


PLATE 4.15

BASIC FLOW DIAGRAM
STEAM, FEEDWATER, & CONDENSATE
PHASE II BACKPRESSURE TURBINE

KEY	
D-2	Atmospheric Decarbonators
E-1	Heat Rejection Sections
E-2	Heat Recovery Sections
E-3	Brine Heaters
G-1	Raw Sea Water Pumps
G-2	Makeup Feed Pumps
G-3	Recycle Brine Pumps
G-4	Concentrated Brine Blowdown Pumps
G-5	Product Water Pumps
G-6	Brine Heater Condensate Pumps
G-7	Acid Injection Pumps
H-1	Air Ejectors and Condensers
H-2	Startup Air Ejector
K-1	Air Compressors
R-1	Operations and Control Building
S-1	Desalting Plant Electrical Substation

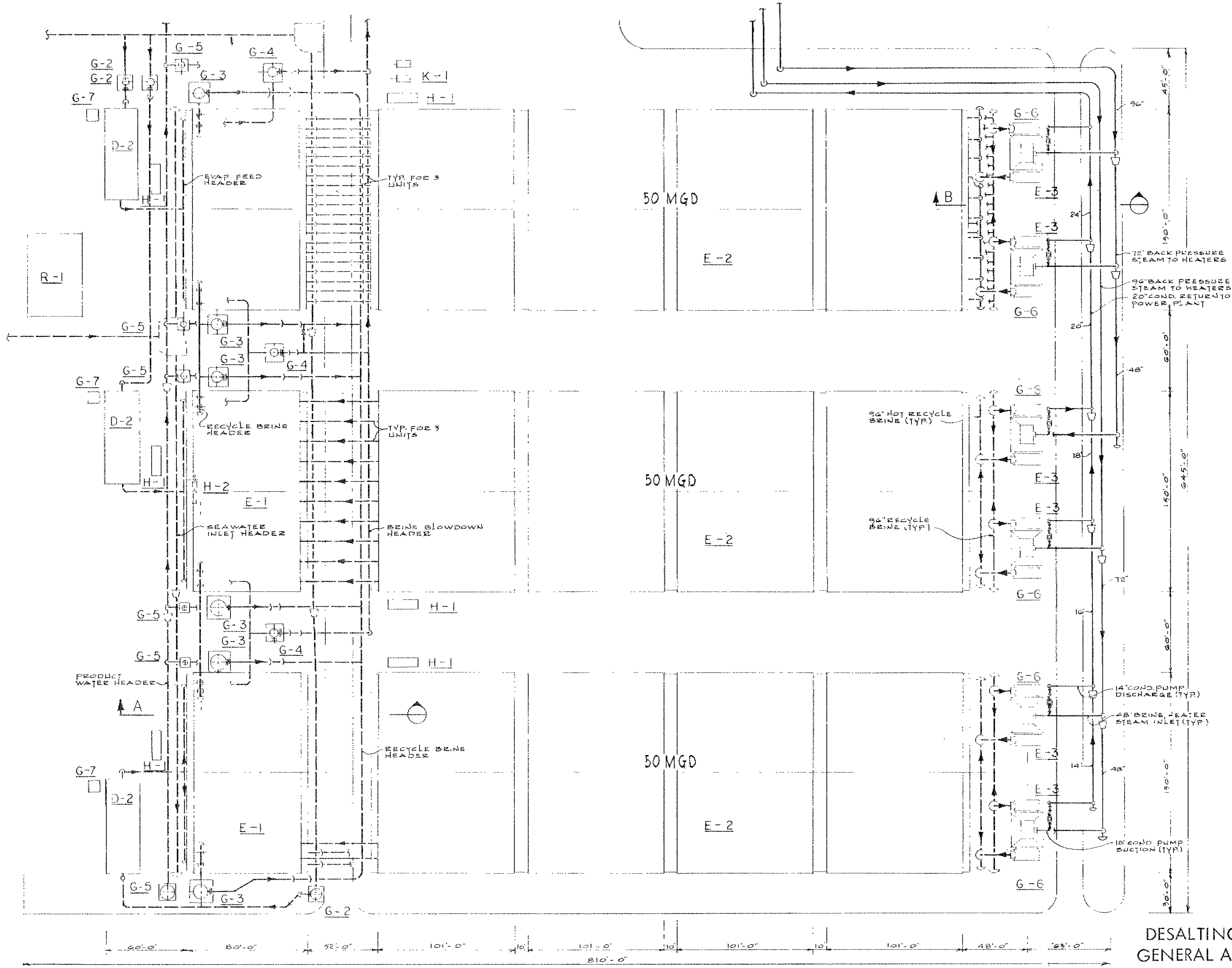


PLATE 4.17

DESALTING PLANT EQUIPMENT GENERAL ARRANGEMENT - PLAN

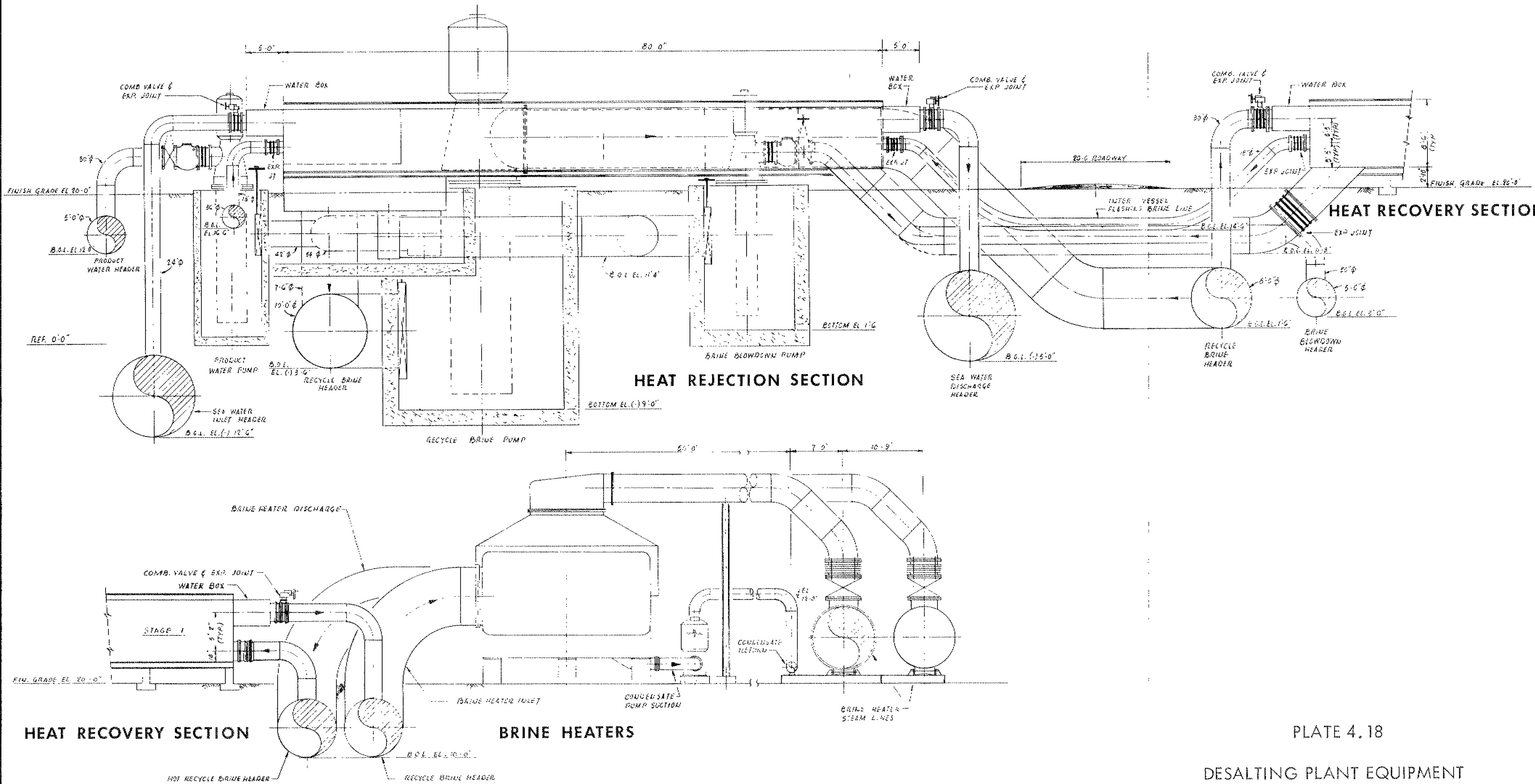
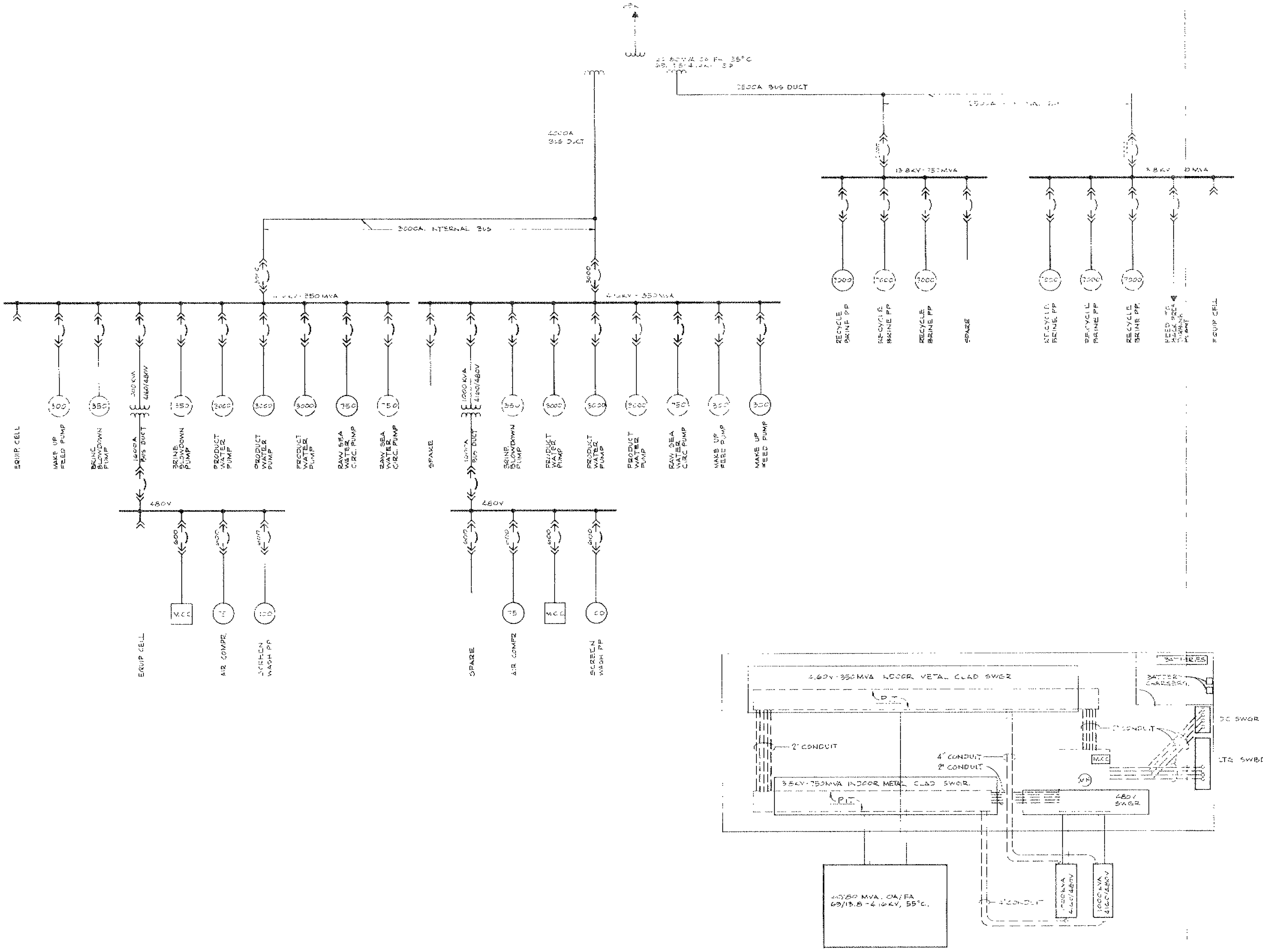


PLATE 4.18

DESALTING PLANT EQUIPMENT
GENERAL ARRANGEMENT - SECTIONS



PARTIAL PLAN
SCALE
DESALTING PLANT SWGR ROOM

NOTES:

1. ALL BREAKERS HAVE 1200AMP FRAMES UNLESS OTHERWISE NOTED
2. PROVIDE ONE SPARE 4.16KV 3000AMP BREAKER.
3. PROVIDE ONE SPARE 13.8KV 2000AMP BREAKER.
4. SOLID LINES INDICATE PHASE I INSTALLATION.
5. DASHED LINES INDICATE PHASE II INSTALLATION
6. PROVIDE ONE SPARE 480V 2000AMP BREAKER.

Prepared and issued for the purpose of updating the desalting plant cost estimate, 1968 Price Basis.

PLATE 4.19

AUXILIARY POWER SINGLE-LINE DIAGRAM
150 MGD DESALTING PLANT

The common facilities are:

- Control building
- Spent fuel building
- Circulating water intake structure
- Outfall structure and discharge lines
- Fuel service crane
- Gantry crane
- Administration building, shop, and warehouse
- Compressed air system
- Service and domestic water
- Makeup water
- Fire protection
- Nitrogen and hydrogen systems
- Switchyard and pipe-type cable systems
- Excavation, dewatering, and backfill
- Spare main transformer.

Table 5.7 summarizes the estimated capital costs for both Units 1 and 2. The Estimated Constructed Costs include the NSSS, the turbine-generator, balance of plant costs including common facilities, and engineering management. Owners' Contingency and Design Allowances include provisions for engineered safeguards and additional AEC criteria requirements for licensing, pollution control and abatement, steam generation for plant shakedown, a permanent barge loading facility, a visitor's center, testing and inspection of plant equipment, and general contingency. Interest During Construction and Other Owners' Costs reflects the Utilities cost of money and internal expenses.

TABLE 5.6

BOLSA ISLAND AND CAUSEWAY INVESTMENT COST SUMMARY
JULY 1971 COMPLETION
(Thousands of Dollars)

Capital Cost	
Rock Revetment	$16,660
Sandfill	5,555
Compaction	450
Barge Ramp	420
Subtotal	$23,085
Contingency Allowance	3,070
Engineering and Construction Management	1,785
Littoral Drift Bypass	495
Protect Union Oil Line	125
Causeway	2,150
Power Plant Intake Structure Cofferdam	620
Desalting Plant Intake Structure Cofferdam	340
Sheet Metal Membrane	530
Total Constructed Cost	$32,200
Owners' Contingency and Design Allowance	5,600
IDC and Other Owners' Costs	7,533
TOTAL INVESTMENT	$45,333

NUCLEAR POWER PLANTS

Capital cost estimates for the nuclear power plants were provided by the Electric Utilities. SCE prepared the estimate for Unit 1 and LADWP prepared the estimate for Unit 2. Units 1 and 2 are identical 3,250 Mwt pressurized light water reactors with 800 Mwe turbine-generators.

Each Owner has responsibility for engineering and construction of his own facilities where practicable. Those facilities common to more than one Owner will be constructed with Unit 1; however, only one-half of the costs for all two-unit power plant common facilities required to make up a fully operational unit are included in the Unit 1 estimate. Correspondingly, one-half of the cost of common facilities are included in the Unit 2 estimate.

Overtopping Wave Height

No criteria have been established for waterproofing the facilities and the removal of the water should overtopping occur. An allowance was included for this item. $1,000,000

Contingency for Liquefaction

The compaction method included is expected to reach the now-contemplated density requirement. Should the density requirement increase or should testing of the method result in increased requirements, an allowance equal to that in the reference estimate is included. $ 500,000

Contingency for Littoral Drift

Until agreement has been reached with the involved agencies and the requirements for bypassing sand is established, a contingency has been included over the allowance in the basic estimate. $ 500,000

Island Landscaping and Decorative Lighting

The cost of landscaping will vary with the requirements of the Owners. An allowance is included for landscaping similar to that provided on the THUMS Islands in Long Beach. $100,000 has been deferred to Phase II for landscaping and decorative lighting for the desalting plant. $ 800,000

Pacific Coast Highway Interchange

An allowance to provide rapid exit of construction and employee vehicles and for a permanent level interchange. $ 300,000

Interest During Construction and Other Owners' Cost

Interest during construction, is based on MWD financing the island and causeway during construction. Upon completion of the island construction, allocation of these costs will be made and each Participant will carry interest during construction until commercial operation of their respective plants. $7,533,000

Table 5.6 summarizes the detailed development presented above.

Item	Contingency and Design Allowance
Protection for 30-foot Tsunami	$ 500,000
Causeway Redesign	1,500,000
Contingency for Union Oil Line	500,000
Overtopping Wave Height	1,000,000
Contingency for Liquefaction	500,000
Contingency for Littoral Drift	500,000
Island Landscaping and Decorative Lighting	800,000
Pacific Coast Highway Interchange	300,000
TOTAL	$5,600,000

Protection for 30-foot Tsunami

	Total
Assuming a requirement to design for 30-foot Tsunami, the island is already protected on three sides and it is necessary to build a wall on the shore side of the island	$ 500,000

Causeway Redesign

The State Land Grant was interpreted to require the oil-filled cables and product water line to be placed below the causeway deck. This raised the height of the bridge as did the criteria for minimum wave requirements. Access to cables and pipeline in the reference design was inexpensive compared to the cost of providing access to the cables and pipeline located under the causeway. An allowance was included for these additional criteria.	$1,500,000

Contingency for Union Oil Line

Should the island have to be moved seaward to avoid the Union Oil Line, quantities would increase. An allowance was included to cover this possibility. The amount included in the estimate for protecting the line would still be required.	$ 500,000

Coordinator subcontract. To be resolved were the requirements of the State Land Grant, provisions for future oil filled cables and product water conveyance, and the minimum width required for construction traffic. The 1965 Feasibility Study(1) estimate was updated by applying escalation to the new completion date and by reducing the length due to the island being moved closer to the shore $2,150,000

Intake Structure

Although the estimates for the intake structures are contained in the estimates for the power plants and the desalting plant, it was considered that it would be more economical to have the cofferdams for these structures included with the island contractors' scope of work. The estimates for these items are:

Intake structure cofferdam (Power Plant) $ 615,000

Intake structure cofferdam (Desalting Plant) $ 345,000

Sheet Metal Membrane

The power plant area being compacted in the dry has a greater density than the remainder of the island. To prevent propagation of liquefaction, it was considered necessary to separate these two areas. The most economical means is by use of a sheet pile membrane driven to the ocean floor. $ 530,000

Total Constructed Cost

Total constructed cost for the island, causeway, and miscellaneous structures. $32,200,000

Owners' Contingency and Design Allowances

Bechtel reviewed the estimates for contingency and design allowances provided by the Participants. The items which are applicable to the Island and Causeway cost estimates are summarized below and then each item is discussed briefly in the following pages.

	Quantity (cubic yds)	Total
Estimate for the Compaction Described Above	2,600,000	$ 450,000

Barge Ramp

A temporary barge ramp suitable for unloading equipment and materials has been included in the base estimate.	$ 420,000

Contingency Allowance

The basic estimate presented above excludes contingency for overruns in quantities and settlements. An allowance was made to cover contractors' normal contingencies including overruns. No allowance was made for delays or damage due to unusually severe storms.

$3,070,000

Engineering and Construction Management

An evaluation of construction management costs plus that portion of the A&E subcontract applicable to the island and causeway.	$1,785,000

Littoral Drift Bypass

Until the littoral drift bypass requirements can be resolved, an allowance for periodically bypassing sand by the use of a suction dredge during the total plant construction period has been included.	$ 495,000

Protect Union Oil Company Line

It was assumed that by cutting off one corner of the island or by moving the island upcoast enough to miss the Union Oil line, that the line would not have to be relocated. However, it would require protection during the placement of rock. An allowance has been included for protection of this line.	$ 125,000

Causeway

By December 1967, no new criteria had been established on which to base an updated design of the causeway. Work had started on a planning study under the Project scows. Below elevation -7 feet MLLW the material would be bottom dumped. Above this elevation, the sand is agitated by a jet and pumped from the scow by a dredge pump.

The fill is topped out at elevation +8 feet MLLW on the power plant side of the island, with the sand required to bring this area to elevation +20 feet MLLW stockpiled in the desalting plant area.

SANDFILL COSTS

	Quantity (cubic yds)	Cost
Drag-Type Dredge Loaded into Scows	3,200,000	$2,900,000
Haul to Site by Scow		770,000
Below Elevation - 7 Using Bottom Dump Scow	1,280,000	-
El -7 to El +20 Unload with 24" Dredge Pump and Distribute to Fill by Pipeline (Included Stockpiling)	1,920,000	1,160,000
Neat Line Volume	3,200,000	$4,830,000
Allowance for Waste & Shrinkage (15%)	480,000	725,000
TOTAL	3,680,000	$5,555,000

Compaction

Compaction in the desalting plant area below elevation +5 is accomplished using explosives. The basic method uses vertical blast holes drilled on a 16-foot square pattern to the original ocean floor, loaded with about six pounds of explosives per hole. Piezometer type drains are installed on the same pattern, interspersed with the blast holes. The holes are fired individually, allowing several minutes between shots. This method will compact all the fill in this zone in one lift, without dewatering. The fill in the power plant requiring excavation to the ocean floor is not compacted by this method. The power plant estimates include dewatering, excavation, backfill, and compaction by mechanical means in their area of responsibility.

Compaction above elevation +5 is accomplished by conventional means, using a 10-ton vibratory roller with four passes on an 18-inch lift. The MWD portion of the island is compacted to elevation +20 while the remainder of the island, excluding that area requiring excavation to the ocean floor, is compacted only to elevation +8. The balance of the compaction is included in the power plant estimates.

TABLE 5.5

BOLSA ISLAND DREDGING OPERATIONS
COMPARISON OF SALIENT CONSTRUCTION FACTORS AND DREDGING CONTRACTORS

	Contractors		Engineer's Estimate
	A	B	
1. Type of Dredge	Hopper	Suction	Drag-Type
2. Method of Transporting Fill to Island	Dredge	Pipeline	Scow
3. Method of Placing Fill:			
Below (-) 7 feet MLLW	Pump from Dredge	Pipeline	Bottom Dump
(-) 7 feet to (+) 20 feet MLLW	Pump from Dredge	10	Bottom Dump and Repump
4. Allowance for Waste and Shrinkage, %	15	10	15
5. Pumping Loss, %	-	15	-
6. Estimate (December 1967)	$4.5 Million	$4.0 Million (Excluding allowance for storm contingency)	$4.6 Million

TABLE 5.4

BOLSA ISLAND WAVE DEFENSE
COMPARISON OF SALIENT CONSTRUCTION FACTORS AND ISLAND CONTRACTORS

	Contractors					Engineer's
	A	B	C	D	E	Estimate
1. Schedule, Months	24	24	18	18	18	18
2. Include Causeway in Island Contract	Yes	Yes	Yes	Yes	Yes	Yes
3. Construction Methods						
Core Rock:						
Below (-) 5 feet MLLW	Barge Dump					
(+) 5 feet to (+) 8 feet MLLW	Clam Shell					
Armor Rock:						
Below (-) 10 feet MLLW	Normal Placement					
Above (+) 10 feet MLLW	Special Placement					
4. Rock Source						
Core	Catalina & Inland	Catalina	Catalina & Inland	Catalina & Inland	Catalina & Inland	Catalina & Inland
Armor	Riverside	Catalina	San Marcos	Inland	Riverside	Catalina & Inland
5. Include Dredging in Island Contract	Yes	Yes	Yes	Yes	Yes	Yes
6. Mobilization by Advance Notice	No	No	Yes	Yes	Yes	Yes
7. Allowance for Waste and Overage						
Armor, %	15	15	15	15	15	15
Core, %	24	24	24	24	24	24
8. Precast Armor Sections	Not Competitive with Rock					
9. Estimate (December 1967)	Range: $13.4 Million to $16.4 Million					$14.4 Million

Cost Estimates

Estimate Approach

To develop the estimated cost for constructing the dual-purpose island, two approaches were taken. First, estimates were solicited from potential island contractors. The bid requests were accompanied by island plan and sections, material specifications, material quantity, and schedules. Second, an independent estimate was prepared by Bechtel to the same design requirements. Quarry owners were contacted for prices on armor stone and core rock and the remaining prices were developed from an analysis of the construction methods, procedures and equipment required. This approach provided cost information from the contractors and the engineer's estimate provided a base for comparing the contractor's estimates.

Tables 5.4 and 5.5 present a comparison of salient construction factors for each of the contractors participating in the island cost estimate including the engineer's estimate.

The preliminary estimate of time required to complete island construction is 18 months. This was reviewed with potential island contractors and found to be acceptable in most cases. Where the scheduled time for construction was satisfactory, the contractor requested mobilization time of about three months prior to start of construction.

Rock Revetment

Based on the quantities and specifications for rock and concrete armour, estimates of in-place prices were developed based on both contractors and Bechtel's estimates. Refer to Plate 4.3 for details on rock zones and sandfill areas.

ROCK COSTS

Rock Revetment	Quantity Tons	Total
Zone "C"	820,000 T	$ 3,780,000
Zone "B"	338,000 T	2,140,000
Zones "A-4" to "A-7"	393,000 T	5,450,000
Zone "A-14"	340,000 T	5,290,000
TOTAL ROCK	1,891,000 T	$16,660,000

Sandfill

Methods of placing sandfill were discussed with dredging contractors prior to making an estimate. Storms prohibiting dredging of any type would also preclude rock placement. However, large swells would allow rock placement when suction type dredging could not continue. Therefore, Bechtel's estimate was based on a drag-type dredge using bottom dump and conventional

ISLAND AND CAUSEWAY

This portion of the report provides the bases for developing the cost estimates for the island and causeway. Cost items identified by the Project Engineers Committee and the Project Coordinator are shown in order to document the island and causeway total costs consistent with the overall Project cost estimate. The concept is defined and design criteria presented. In addition, construction methods are described, estimating methodology is set forth, and cost summaries are presented below.

Construction Method

Various methods of constructing the island were reviewed with island construction contractors and as a result the following description of island construction was selected as being representative.

The first major operation in construction of the island is placement of filter material and rock at the toe of the perimeter. This operation would begin at one or more locations near the seaward side of the island. As the toe rock is completed in a particular location, the placement of dike rock begins and is continued until sufficient height is reached to allow placement of cover stone and armor stone. This sequence of operations continues at each beginning location until dike rock reaches an elevation of about two feet below MLLW. The rock dike from two feet below MLLW to eight feet above MLLW consists principally of scalped dike rock which acts as a filter blanket to prevent loss of sandfill from hydraulic action.

These operations will continue around the perimeter of the island until the island is essentially enclosed. During this period, placement of the dredged sand will take place behind the revetment to approximately five feet above MLLW. Compaction of the non-nuclear portion of the island will utilize an explosive method. Upon completion of the explosive compaction, the island fill will continue to eight feet above MLLW in the nuclear plant area and to 20 feet above MLLW on the remainder of the island. Compaction of this material will be in the dry, by conventional methods.

It will be necessary to begin excavation and construction of some facilities prior to completion of the island; specifically, the reactor containment buildings. The upcoast section will be brought to eight feet above MLLW and the balance of the required fill material will be placed on the downcoast side of the island to 30 feet above MLLW to minimize excavation for the containment. This plan will allow the dredging contractor to complete his contract without significant interruption and resulting standby costs.

TABLE 5.3

SUMMARY OF TOTAL PROJECT COSTS
PHASED PLANT CONSTRUCTION
(Thousands of Dollars)

Island and Plant Facilities	Estimated Constructed Costs	Owners' Contingency and Design Allowances	IDC And Other Owners' Costs	Total Estimated Costs
Island and Causeway	$ 32,200	$ 5,600	$ 7,533	$ 45,333
Power Plant - Unit 1	151,300	19,000	27,328	197,628
Power Plant - Unit 2	151,100	20,900	17,606	189,606
Backpressure Turbine Plant	38,890	800	3,705	43,395
Desalting Plant	141,690	9,350	8,790	159,830
Land for Switchyard and Right-of-Way for Cable	-	-	2,780	2,780
Project Coordinator	5,000	3,000	540	8,540
Subtotal - Phased Plant Construction	$520,180	$58,650	$68,282	$647,112

Other Facilities	
Product Water Conveyance System (MWD)	$ 41,502
Power Transmission System (DWP)	34,356
Power Transmission System (SCE/SDG&E)	42,500
Subtotal - Other Facilities	$118,358
TOTAL COST-PHASED PLANT CONSTRUCTION	$765,470

Design Criteria

The estimates of constructed cost reflect the design concepts presented in Chapter 4. These designs are based on criteria presented in the Preliminary Safety Analysis Report (PSAR)[3] and recommended by consultants to the Project based upon the detailed site investigation work and hydraulic model studies of the island.[2] The design concepts also reflect the safeguards provisions that have been required by AEC Regulations in current license applications.

Allowances for the cost of redesign of the island, causeway and plant facilities to meet potentional additional design criteria are provided for in the "Design Allowances" and are included in the total Project costs compiled in this report.

Equipment Pricing

The cost estimates are based on prices quoted to the Participants on the nuclear steam supply systems, condensing turbine-generators, and backpressure turbine-generator. The estimate for the desalting plant is based on information received from multistage flash system equipment suppliers in February 1968.

Sales Tax

The current estimates of costs are based upon State sales tax of 5 percent.

Cost of Money

The current estimates of cost which include interest during construction are based on the cost of money to each Participant.

FACILITY COST SUMMARY

Table 5.3 is a summary of costs by facility. In the following sections of this chapter, details of the costs of each major facility are presented to the extent they are available. In addition, a summary of the method of estimate development is presented for the island cost estimate and the desalting plant cost estimate.

Schedule

The cost estimates prepared by the Owners are based upon the following commercial operation schedule:

Unit 1 Condensing Power Plant	September 1, 1974
Backpressure Turbine	September 1, 1974
First 50-mgd Water Plant	September 1, 1974
Unit 2 Condensing Power Plant	September 1, 1975
Second 50-mgd Water Plant	March 1, 1978
Third 50-mgd Water Plant	September 1, 1978

Plant Operation

The Utilities plan to operate the two nuclear power units with separate operating crews, which does not permit maximum use of common facilities considered in the 1965 study. This method of operation results in the need for some duplication of facilities, such as two nuclear auxiliary buildings, two spent fuel pits, and increased control room facilities.

Engineering and Construction Responsibility

The Owners' estimates were presented based on the division of engineering and construction as follows:

SCE/SDG&E
- Power Plant - Unit 1
- Power Transmission System for Power Plant - Unit 1
- Power Transmission System for Backpressure Turbine

DWP
- Power Plant - Unit 2
- Power Transmission System for Power Plant - Unit 2

MWD
- Island and Causeway
- Backpressure Turbine Plant
- Desalting Plant
- Water Conveyance System

Project Coordinator

The estimated cost for the Project Coordinator's services is a summation of the Owners' estimates for this service.

Product Water Conveyance System

The estimated cost for the product water conveyance system was obtained from MWD.

Power Transmission System Including Land and Right-of-Way

The estimated cost for the power transmission systems was obtained from DWP and SCE. Cost of transmission facilities from the SCE system to the SDG&E system are not included.

Phased Plant Construction

There is a four-year interval between commercial operation of the first 50-mgd desalting plant module and commercial operation of the third 50-mgd module. Completion of the second 50-mgd module is scheduled six months prior to the third.

Dual-Purpose Plant

The dual-purpose plant produces both electricity and water as opposed to a single-purpose (or power production only) plant.

BASIS OF ESTIMATES

Site Location and Arrangement

The location and arrangement of the island used in preparing these cost estimates are shown on the island location and site arrangement plates in Chapter 4.

Description of Facilities

The scope of the cost estimates provided by the Participants encompasses all facilities needed to produce and deliver electric power and desalted product water to the point of interconnection with the distribution systems of the respective Utilities as described in Chapter 4.

Onshore facilities include the product water line to the Diemer Filtration Plant and underground electric cable systems to the electric system connection points specified by the Utilities.

Interest During Construction and Other Owners' Costs

Costs which include miscellaneous construction expenses, administrative and general expenses, ad valorem taxes and interest during construction, and land for switchyard and right-of-way for the electric cables.

Total Estimated Costs

The total estimated cost of each facility regardless of ownership or financial participation.

Total Investment

The extent of ownership in the Project.

Island and Causeway

The island and causeway costs shown reflect the Owners' estimates of their costs in these facilities.

Power Plant - Unit 1

The costs for Power Plant - Unit 1 are a summation of the SCE/SDG&E estimated costs for the Utilities' single-purpose plant and their estimate of MWD's costs in a dual-purpose power plant.

Power Plant - Unit 2

The costs for Power Plant - Unit 2 are a summation of DWP estimated costs for a single-purpose plant and their estimate of MWD's costs in a dual-purpose power plant.

Backpressure Turbine Plant

The estimated costs of the backpressure turbine plant were obtained from MWD.

Desalting Plant

The estimated costs for the desalting plant were obtained from MWD.

Land for Switchyard and Right-of-Way for Cable

The estimated costs for switchyard land and right-of-way for cables were obtained from SCE and DWP.

TABLE 5.2

SUMMARY OF TOTAL PROJECT COSTS BY OWNER
PHASED PLANT CONSTRUCTION
(Millions of Dollars)

	Total Investment			
	SCE/ SDG&E Costs*	DWP Costs	MWD Costs	Total Estimated Costs
Island and Plant Facilities	$205.7	$204.7	$236.7	$647.1
Other Facilities	42.5	34.4	41.5	118.4
TOTAL - PHASED PLANT CONSTRUCTION	$248.2	$239.1	$278.2	$765.5

*Excludes transmission costs from the SCE system to the SDG&E system.

METHOD OF COMPILING COSTS

The costs estimates were received from the Owners and are the Owners' estimates of their share of the total Project cost. These costs are based on phased construction of the desalting plant and the power generating units. Each Owner's estimates of cost were reviewed by the Project Coordinator as received, reconstructed for consistency, and evaluated for completeness. The costs were then reviewed by the Project Engineers and adjustments were made to assure that the costs shown in the tabulations reflect the total Project costs.

DEFINITIONS

The following terminology is used in presenting the cost estimates:

Estimated Constructed Costs

The estimated costs of engineering, procurement, and construction of the facility to a plant design reflecting known and accepted criteria. The normal contingency inherent in a contractor's or a construction organization's estimate is included.

Owners' Contingency and Design Allowances

The Owners' estimates of costs to cover changes in design criteria and design growth.

CHAPTER 5

COST ESTIMATES

GENERAL

The cost estimates presented in this chapter were determined by the Participants to be representative of the total Bolsa Island Project costs including the estimated cost of electric transmission and product water conveyance facilities required to deliver electric power and desalted water to the point of interconnection with the distribution system of the respective Utilities. A summary of the total project costs and the basis on which these costs were compiled by Bechtel Corporation under the Letter of Intent for Project Coordinator services is presented.

The total project costs are summarized by facility in Table 5.1 and allocated between Owners in Table 5.2. The balance of the chapter describes in detail the estimates by major facilities.

TABLE 5.1

SUMMARY OF PROJECT COSTS BY FACILITY
(Millions of Dollars)

ISLAND AND PLANT FACILITIES		
Island and Causeway	$ 45.3	
Power Plant - Unit 1	197.6	
Power Plant - Unit 2	189.6	
Backpressure Turbine Plant	43.4	
Desalting Plant	159.8	
Land for Switchyard and Right-of-Way for Cable	2.8	
Project Coordinator	8.6	
Subtotal	$647.1	
OTHER FACILITIES		
Product Water Conveyance System (MWD)	$ 41.5	
Power Transmission System (DWP)	34.4	
Power Transmission System (SCE/SDG&E)	42.5	
Subtotal	$118.4	
TOTAL PROJECT COSTS		$765.5

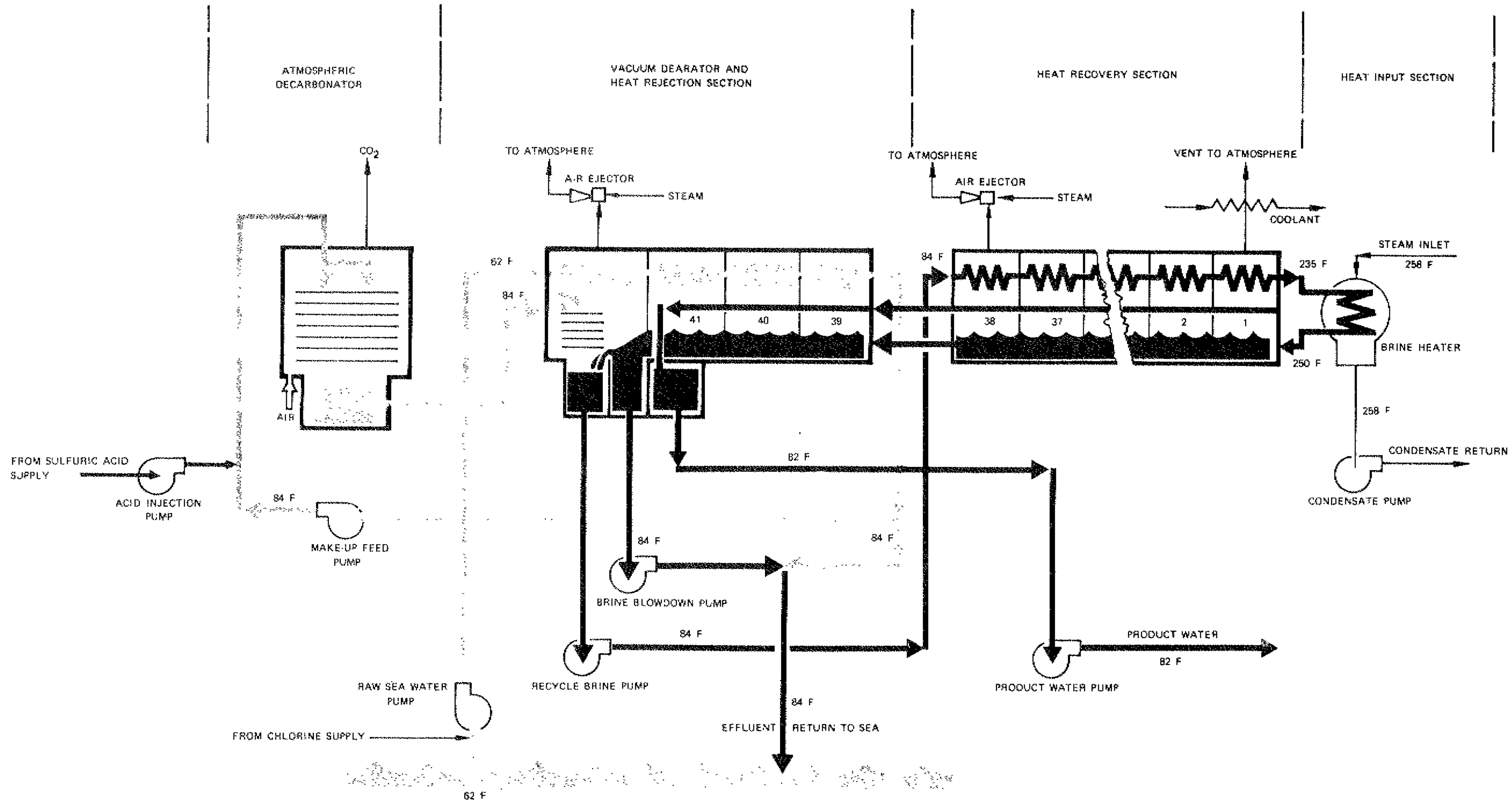


PLATE 4.16

MSF DESALTING PLANT
PROCESS FLOW DIAGRAM

TABLE 5.7

NUCLEAR POWER PLANTS
(Thousands of Dollars)

	Unit 1	Unit 2
Estimated Constructed Costs	$151,300	$151,100
Owners' Contingency and Design Allowances	19,000	20,900
Interest During Construction and Other Owners' Costs	27,328	17,606
TOTAL	$197,628	$189,606

BACKPRESSURE TURBINE PLANT

The capital cost estimate for the backpressure turbine plant was prepared by Bechtel for MWD. The estimate is based on quotations solicited and received by MWD for turbine-generator equipment and accessories. For the purpose of this estimate, a concept was selected from the many alternative proposals which offered the opportunity of separation of the steam supply from each NSSS after conversion for operation with the full 150-mgd desalting plant (Phase II).

The scope of the estimate includes the turbine-generator and accessories with feedwater, steam, and other equipment as described in Chapter 4. The main steam lines are included to the header located at each reactor containment. Principal excavation and compacted backfill for the backpressure turbine plant is included in the Power Plant - Unit 1 estimate.

Table 5.8 summarizes the backpressure turbine plant estimate. The Estimated Constructed Cost includes all labor and materials, engineering and normal contractor's contingency.

The Owner's Contingency and Design Allowances reflect the degree of engineering completed. Interest During Construction and Other Owners' Costs reflect Metropolitan's cost of money and distributable costs.

TABLE 5.8

BACKPRESSURE TURBINE PLANT
(Thousands of Dollars)

	Phase I (50 mgd)	Phase II (100 mgd)	Total (150 mgd)
Turbine Generator	$15,585	$ 275	$15,860
Process Mechanical Equipment	4,145	265	4,410
Electrical	3,270	295	3,565
Civil-Structural	4,105	45	4,150
Piping and Instrumentation	6,830	1,210	8,040
Yardwork and Miscellaneous	420	-	420
A-E Services	2,240	205	2,445
Total Estimated Const. Cost	$36,595	$2,295	$38,890
Owners' Contingency & Design Allow.	755	45	800
IDC & Other Owners' Costs	3,485	220	3,705
TOTAL	$40,835	$2,560	$43,395

DESALTING PLANT

The capital cost estimate for a 150-mgd desalting plant was prepared by Bechtel Corporation for the Metropolitan Water District. The estimate was based on the concept of phasing construction; i.e., only a plant capacity of 50 mgd would be constructed initially and the remaining 100 mgd capacity would be added four years later.

The division of scope between the desalting plant estimate and other facility estimates is as follows:

Costs for sea water supply and discharge ducts are included for those sections between the intake structure of the desalting plant and the discharge structure. The intake structure is included in the scope, but the discharge structure is excluded. The cofferdam for the intake structure is included in the island estimate. The brine heaters for the flash evaporators are included, but their required steam supply and condensate return lines are excluded. All electrical work required for the desalting plant up to the auxiliary transformer high voltage bushings is included. Specifically excluded is the island pumping station and the product water conveyance system.

Quotations were received from four vendors for the multistage flash evaporator system and formed the basis for the estimate.

The cost estimate prepared was predicated on the use of U.S. Government coinage scrap, furnished at a fixed price of 38 cents per pound, in the manufacture of all tubing for Phase I. However, $3.6 million was applied as a contingency in the event that the government coinage scrap was not available. Tubing costs for Phase II (100 mgd) were based on market prices escalated to the appropriate expenditures centroid. Table 5.9 presents the estimated costs for the desalting plant package installed, and includes all support facilities required. The estimate assumes that the island fill will be compacted by the island contractor to accommodate the required bearing capacity.

TABLE 5.9

DESALTING PLANT
(Thousands of Dollars)

	Phase I (50 mgd)	Phase II (100 mgd)	Total (150 mgd)
Estimated Constructed Costs			
Evaporator			
Tubing and Bundles	$15,080	$ 37,070	$ 52,150
Vessels	11,300	23,220	34,520
Moisture Separators	2,190	4,520	6,710
Water Boxes	480	990	1,470
Lining and Coating	10	40	50
Insulation	650	1,340	1,990
Total Evaporator	$29,710	$ 67,180	$ 96,890
Brine Heaters, w/Tubes	1,740	3,470	5,210
Brine Pumps	1,420	2,830	4,250
Miscellaneous Equipment	730	990	1,720
Piping and Insulation	2,540	4,730	7,270
Access Structures and Supports	380	750	1,130
Instruments and Controls	550	1,100	1,650
Sea Water Pumps and Land Lines	3,410	4,060	7,470
Steam and Misc. External Piping	330	160	490
Electrical	1,190	1,530	2,720
Foundations, Control & Operations Building, and Civil Work	4,680	3,940	8,620
Architect-Engineer Services incl. Construction Management	1,790	2,480	4,270
Total Estimated Constructed Cost	$48,470	$ 93,220	$141,690
Owners' Contingency and Design Allowance	6,020	3,330	9,350
IDC & Other Owners' Costs	3,350	5,440	8,790
TOTAL	$57,840	$101,990	$159,830

LAND FOR SWITCHYARD AND RIGHT-OF-WAY FOR CABLE

A $2,780,000 allowance was included by the Electric Utilities for land for the switchyard and right-of-way for the pipe-type cable across the Bolsa property.

PROJECT COORDINATOR

It was decided that a Project Coordinator would be required to coordinate the work between the Owners, to develop criteria, and define interfaces. The costs allocated to this function are $8,540,000.

PRODUCT WATER CONVEYANCE SYSTEM

The scope of the cost estimate for the product water conveyance system provides conveyance for 150 mgd of product water from the desalting plant product water sump to the outlet of the blending structure at the Robert P. Diemer Filtration Plant. This system comprises a six-foot diameter transmission line about 24 miles long, island pumping station, intermediate pumping station, 25-million gallon intermediate reservoir, and a blending structure. Table 5.10 provides the estimate summary.

TABLE 5.10

PRODUCT WATER CONVEYANCE SYSTEM
(Thousands of Dollars)

	Phase I	Phase II	Total
Estimated Constructed Costs			
Land & Right-of-Way	$ 370	$ -	$ 370
Pipeline	23,875	-	23,875
Reservoir	3,760	-	3,760
Pumping Stations	3,220	3,075	6,295
Engineering Management	1,565	155	1,720
Estimated Construction Costs	$32,790	$3,230	$36,020
Owners' Contingency & Design Allowance	3,175	310	3,485
IDC and Other Owners' Cost	1,765	232	1,997
TOTAL	$37,730	$3,772	$41,502

LADWP TRANSMISSION FACILITIES

The LADWP provided the following estimate for transmission from the switchyard to Receiving Station "C," three circuits, 18 miles:

Direct Cost	$32,335,000
Contingency	2,021,000
TOTAL	$34,356,000

SCE/SDG&E TRANSMISSION FACILITIES

SCE provided the following estimate for transmission from the switchyard to the Del Amo Substation, four 220-kv underground circuits, 11 miles.
Total Estimated Cost - $42,500,000

ITEMS NOT INCLUDED IN ESTIMATED TOTAL PROJECT COST

- SDG&E Transmission Lines for Bolsa Project
- Allowance for Incorporating Provision for "Minimum Cost" Repair of Steam Generator Tube Leaks
- Working Capital for First Core Loading of Nuclear Fuel
- Provisions for Future Expansion (Except for SCE and DWP Right-of-Way for Transmission.)

CHAPTER 6

COST OF WATER

GENERAL

Information developed in the previous chapters is applied in this chapter to calculate the cost of producing desalted water. The elements of annual costs are developed and added to obtain the total annual costs to MWD for producing the appropriate amounts of desalted water and electric power for desalting plant auxiliaries, product pumping, power plant auxiliary power, and exchange power for Colorado River pumping. From the total annual costs the value of the 110 Mw of Colorado River exchange power is deducted to determine the cost of water at the Diemer Filtration Plant. The annual costs associated with the product water conveyance system are then deducted to determine the cost of product water at the Bolsa site.

The elements that determine MWD's annual costs are annual fixed charges on investment, operating and maintenance costs for both the desalting plant and the power plant, desalting plant sulfuric acid costs, nuclear insurance costs, fuel costs, and power credits.

METROPOLITAN'S COST RESPONSIBILITIES AND OWNERSHIP

Metropolitan's cost responsibilities and ownership are based on preliminary discussions between the Owners. While no final agreement was reached between the Owners respective to cost responsibility and ownership within the contract definitions, the following allocations are believed to represent a reasonable assessment for the purpose of this report.

— Cost responsibilities for Metropolitan are shown in Table 6.1. Metropolitan's costs for their share of the nuclear power and backpressure turbine plant were developed from the estimate made by the Electric Utilities based on a single-purpose plant having a power output equivalent to the Utilities' share of the dual-purpose plant.

TABLE 6.1

METROPOLITAN'S PROJECT COST RESPONSIBILITY
(Millions of Dollars)

Facility	Phase I (50 mgd)	Phase II (100 mgd)	Total (150 mgd)
Island and Causeway	$ 9.1	$ 0.1	$ 9.2
Nuclear Power and Backpressure Turbine Plant	61.8	2.6	64.4
Desalting Plant	57.8	102.0	159.8
Project Coordinator	3.3	-	3.3
Product Water Line	37.7	3.8	41.5
TOTAL	$169.7	$108.5	$278.2

— Tabulation of facilities owned by Metropolitan is shown in Table 6.2 and this assessment is used to determine the annual costs for Metropolitan's capital investments and cost of water. Metropolitan would own the desalting plant and the island and causeway, thereby reducing their ownership in the power and related facilities.

TABLE 6.2

PHASED PLANT (50-100 MGD)
MWD INVESTMENT COSTS AND ANNUAL FIXED CHARGES
BASED ON 4.25% COST OF MONEY
(Millions of Dollars)

	Total MWD	Annual Fixed Charges	
Phase I - 50 mgd	Investment	Rate (%)	Amount
Island and Causeway	$ 45.2	4.25	1.921
Desalting Plant	57.8	5.86	3.387
Power and Related Facilities	29.0	5.86	1.699
Conveyance System	37.7	4.49*	1.694
TOTAL	$169.7		8.701
Phase II - 100 mgd			
Island and Causeway	$ 0.1	4.25	0.004
Desalting Plant	102.0	6.30	6.426
Power and Related Facilities	2.6	6.30	0.164
Conveyance System	3.8	4.98	0.189
TOTAL	$108.5		6.783
Phase I Plus Phase II - 150 mgd			
Island and Causeway	$ 45.3		**
Desalting Plant	159.8		**
Power and Related Facilities	31.6		**
Conveyance System	41.5		**
TOTAL	$278.2		

*Based on $33.8 million @ 4.45% for line and reservoir and $3.9 million @ 4.86% for pumping station

**The levelized annual fixed charges are calculated on an equivalent equal annual basis for the phased plant using the present worth method as described later in this chapter and as shown in Table 6.3

FIXED CHARGES

To facilitate calculation of water costs for the phased desalting plant, the plant is assumed to operate for 30 years after commercial operation of Power Plant - Unit 2. The annual fixed charge rates for the phased plant are based on 31 years for Phase I and on 27 years for Phase II. Table 6.2 summarizes the annual fixed charges for MWD's investment in Phase I and Phase II. The levelized annual fixed charges are shown in Table 6.3 for the phased plant.

DESALTING PLANT OPERATION AND MAINTENANCE COSTS

The annual operating and maintenance costs are shown for 50 mgd and 150 mgd.

OPERATING AND ROUTINE MAINTENANCE LABOR AND MATERIALS

	50 mgd	150 mgd
Number of Personnel	24	31
Annual Labor Cost	$518,000	$730,000
Operating and Maintenance Material and Supplies		
Tubing @ 0.15% of Capital	87,000	240,000
Balance of Desalting Plant @ 0.45% of Capital	260,000	720,000
Operating Supplies & Consumables	80,000	180,000
TOTAL	$945,000	$1,870,000

DESALTING PLANT SULFURIC ACID COSTS

Annual sulfuric acid cost is $1,320,000 for 150-mgd production. This cost is based on an annual consumption of 43,200 tons of acid and an estimated delivered cost of $30.60 per ton at the Bolsa Island site. Annual usage is based on adding 120 ppm of 100-percent sulfuric acid to the sea water makeup and a 90-percent load factor. Acid consumption for 50 mgd is one-third the amount shown for 150 mgd.

POWER PLANT OPERATING AND MAINTENANCE COSTS

Labor and Materials

MWD's portion of power plant operating and maintenance costs is based on the difference in O & M costs between dual-purpose and single-purpose power plants. The differential was established using information furnished by the Electric Utilities. MWD's share of the power plant O & M costs are estimated to be $390,000 annually.

Nuclear Insurance

Nuclear insurance costs have been estimated for MWD's share of the nuclear facility, based on commercial coverage of property damage insurance (NEPIA), public liability insurance (NELIA), and on government indemnification under the Price-Anderson Act. MWD's estimated annual premium for nuclear insurance is $240,000. This estimate is based upon a property damage insurance premium rate of $4 per $1,000 applied to 80 percent of MWD's share of the power plant investment, and Price-Anderson indemnification at $30 per Mwt applied to MWD's thermal megawatt entitlement. The premium rate change, if any, resulting from the dual-purpose plant concept, as compared to a single-purpose plant, has not been determined. An allowance of $25,000 annually is included in the nuclear insurance costs to provide for a possible differential premium rate of $0.40 per $1,000 of public liability insurance (NELIA).

NUCLEAR FUEL CYCLE COSTS

MWD's nuclear fuel cycle costs were calculated for use in determining the cost of water. The basic criteria and parameters used in the fuel cost analysis are outlined below. For purposes of this estimate, a pressurized water reactor has been assumed. The fuel cost analysis results in levelized unit fuel costs to MWD of approximately 12.65 cents per million Btu. The annual fuel cycle costs are tabulated in the cost of water summary tables in this report.

Basic Parameters

The basic plant operating and economic parameters used were:

— The fuel cost evaluations are carried out over a 31-year period. In the case of the phased plant construction, Phase I (50 mgd) is assumed to extend over the first four years of operation and Phase II (150 mgd) over the next 27 years. The capacity factor of the desalting plant is assumed constant at 90 percent over the evaluation period.

— Annual carrying charges for non-depreciable items and present worth rates are assumed to be identical for MWD. Analyses were conducted using 4.25 percent cost of money.

— A 5 percent sales tax was included for appropriate fabricated materials.

— Bid prices and unit cost factors were escalated based on the commercial operating date.

Fuel Management Program

The fuel management program used is the one proposed by the reactor manufacturer and is assumed to exist in the analysis throughout the evaluation period. These data include the initial and final uranium weights and enrichments for each batch of fuel, the plutonium content of each spent fuel batch, and the expected energy output from each fuel batch.

Unit Cost Projections

Unit cost projections for materials and services required for various parts of the fuel cycle are essentially those developed by DWP and SCE during the NSSS evaluation and were used to develop total reactor core cycle costs based on 4.25 percent cost of money. These costs are adjusted for sales tax and for MWD's share of the total reactor core.

ANNUAL POWER DEDUCTIONS

Power deductions are calculated using the criteria set forth in Chapter 3. The power deductions comprise 110 Mw exchange power, excess power, and product water pumping power.

The phased plant includes temporary condensing facilities during Phase I and the full 110 Mw of exchange power is available as well as excess power. The excess power is limited to 15 Mw until after the second nuclear power plant becomes operative and then increases to 50 Mw for three years. The excess power is deducted at a value corresponding to the estimated cost of producing this power.

	Time Period	Generation (Mw)	Value of Energy (Mills/kwhr)
PHASED PLANT			
Phase I (50 mgd)			
Exchange Power	Sept. 1, 1974 to Sept. 1, 1978	110	5.125
Excess Power	Sept. 1, 1974 to March 1, 1975	15	2.800
Excess Power	March 1, 1975 to Sept. 1, 1978	50	2.800
Phase II (100 mgd)			
Exchange Power	Sept. 1, 1978 to Sept. 1, 1979	110	5.125
Exchange Power	Sept. 1, 1979 to Sept. 1, 2005	110	2.800
Excess Power	-	None	-

UNIT COST OF DESALTED WATER

The unit cost of desalted water including the costs of conveying the product water to the Diemer Filtration Plant, is derived from the net annual costs at Diemer divided by the annual production of desalted water at 90-percent load factor. Net annual costs at the plant are calculated by deducting annual cost of conveying product water to Diemer from the annual cost at Diemer divided by the annual production. Since the production of both desalted water and power is variable in the early years of operation, and since fuel cycle costs decline in later years, adjustments are made to levelize both the variable costs and the deductions for the phased plant. Levelized unit cost of desalted water as developed in this report is defined as the present worth of annual costs divided by the present worth of annual production.

The annual cost and associated annual production for phased construction were considered in two increments: 4 years at 50-mgd production and 27 years at 150-mgd production. These increments were then added together on the present worth basis. The annual costs and deductions shown in Table 6.3 have been converted to a levelized annual cost basis.

The annual production of desalted water, based on 0.90 plant load factor is:

$$16.425 \times 10^9 \text{ gallons for } 50 \text{ mgd}$$
$$49.275 \times 10^9 \text{ gallons for } 150 \text{ mgd}$$

The comparable equal annual production (levelized) with the variable production taken into consideration is:

$$42.32 \times 10^9 \text{ gallons}$$

The levelized unit costs of desalted water are obtained by dividing the total levelized annual cost at the plant by the levelized annual production.

TABLE 6.3

PHASED PLANT
COST OF PRODUCT WATER

COSTS AT DIEMER	Levelized Annual Cost (millions of dollars)	Unit Cost of Water
Fixed Charges		
Island and Causeway	1.93	
Desalting Plant	8.45	
Power and Related Facilities	1.83	
Conveyance System	1.84	
Desalting Plant O & M		
Labor & Materials	1.50	
Acid Treatment	1.13	
Power Plant O & M		
Labor, Materials, and Nuclear Insurance	0.63	
Conveyance System O & M		
Pumping Station, Pipeline, & Reservoir	0.34	
Nuclear Fuel		
31-Year Levelized	4.01	
Subtotal - Annual Costs	21.66	
Deduct Exchange and Excess Power	3.17	
NET ANNUAL COST AT DIEMER	18.49	
COST OF WATER AT DIEMER		
Cents per 1,000 gallons		43.7
Dollars per acre-foot		142.0
COSTS AT BOLSA		
Conveyance System		
Fixed Charges	1.84	
O & M Pumping Stations, Pipe, and Reservoir	0.34	
Product Pumping		
Island Stations	0.26	
Intermediate Stations	0.63	
Subtotal, Deduct from Net Annual Cost at Diemer	3.07	
NET ANNUAL COST AT PLANT	15.42	
COST OF WATER AT PLANT		
Cents per 1,000 gallons		36.5
Dollars per acre-foot		119.0

CHAPTER 7

FACTORS CAUSING PROJECT COST CHANGES

GENERAL

The material presented in this chapter is concerned with the increase in Project costs based on the differences in estimates made in 1965 and those made in April 1968. The basis of the April 1968 estimates are discussed in detail in Chapter 5 of this report.

The cost estimates presented by Bechtel Corporation in the 1965 Engineering and Economic Feasibility Study(1) were based on an unphased 150-mgd desalting plant and on 1965 labor and material prices without allowance for escalation. An adjustment to the basic 1965 estimate was made on March 4, 1966, based on phasing the construction of a 150-mgd desalting plant with a total elapsed time of five years between commercial operation of the first 50-mgd train and commercial operation of the second and third trains of 50 mgd each. The adjustment of March 1966 was made without specific allowance for the escalation that would occur in the period of time between the completion of the first 50-mgd unit and completion of the 150-mgd plant. No estimate was made for possible technological improvements which might offset the increased escalation.

The Bolsa Island Project cost estimates are shown in Table 7.1, Summary of Project Cost Changes. The increase in estimated costs, by facility, from the 1965/1966 estimate to the April 1968 estimate is also shown.

TABLE 7.1

SUMMARY OF PROJECT COST CHANGES
(Millions of Dollars)

Island and Plant Facilities	Estimate Based on 1965 Prices	1968 Estimate with Escalation to 1974 - 1978	Increase
Island and Causeway	$ 23.6	$ 45.3	$ 21.7
Power Plant - Unit 1	108.8	197.6	88.8
Power Plant - Unit 2	101.3	189.6	88.3
Backpressure Turbine Plant	25.4	43.4	18.0
Desalting Plant	107.4	159.8	52.4
Land for Switchyard and Right-of-Way for Cable	0.5	2.8	2.3
Project Coordination	-	8.6	8.6
Subtotal	$367.0	$647.1	$280.1

TABLE 7.1 (Continued)

Other Facilities	1965/1966 Estimate	April 1968 Estimate	Increase
Product Water Conveyance - (MWD)	$ 33.5	$ 41.5	$ 8.0
Power Transmission System - (DWP)	33.5	34.4	0.9
Power Transmission System - (SCE/SDG&E)	10.0	42.5	32.5
Subtotal	$ 77.0	$118.4	$ 41.4
TOTAL COST - PHASED PLANT CONSTRUCTION			$321.5

The increase in total Project cost of 321.5 million dollars is the subject discussed in this chapter. The principal factors which contributed to the increase in Project costs are summarized in Table 7.2, Factors Causing Project Cost Changes.

TABLE 7.2

FACTORS CAUSING PROJECT COST CHANGES
(Millions of Dollars)

1965/1966 Estimate (Based on 1965 Price Levels)			$444.0
Factors Contributing to Cost Increase:			
Column Numbers from Table 7.4			
IV	Escalation of Island and Plant Facilities	$152.7	
V	Increase in California Sales Tax	3.0	
VI	Higher Power Plant Output	16.0	
VII	Market Changes in Nuclear Steam Supply Systems	23.7	
VIII	Changes in Design Criteria	17.4	
IX	Allowance for Anticipated Project Requirements	35.5	
X	Change in Project Responsibility	25.2	
XI	Higher Costs for Interest During Construction (IDC)	16.9	
XII	Savings over the Original Estimate	(25.3)	
XIII	Increase in Offsite Facilities		
	A. Product Water Conveyance	8.0	
	B. Power Transmission Systems	33.4	
XIV	Additional Owners' Contingency	15.0	
	TOTAL COST INCREASE		321.5
	APRIL 1968 ESTIMATE (Escalated to Project Completion)		$765.5

The total increase of Project investment for each Owner is shown in Table 7.3, Summary of Increase in Project Investment by Owner.

TABLE 7.3

SUMMARY OF INCREASE IN PROJECT INVESTMENT BY OWNER
(Millions of Dollars)

Owner	1965-1966 Estimate	Current Estimate	Project Increase
SCE/SDG&E	$120.3	$248.2	$127.9
DWP	136.3	239.1	102.8
MWD	187.4	278.2	90.8
TOTAL	$444.0	$765.5	$321.5

The balance of this chapter concerns a detailed discussion of the cost increases developed in relation to the factors causing the increase and the facilities affected by the increases. Table 7.4, is a foldout located at the end of this chapter. Each column of the table is discussed separately. The final section of this report recaps the increase in the cost of phasing.

Millions of Dollars

1965 ESTIMATE - (Column I)

The 1965 estimate is presented by facility.

TOTAL COST - 1965 PRICING LEVEL	$434.4

1966 COST OF PHASING - (Column II)

In 1966 an estimate for additional facilities required for phased plant construction was prepared.

COST OF ADDITIONAL FACILITIES REQUIRED FOR PHASED PLANT CONSTRUCTION - 1965 PRICING LEVEL	$ 9.6

	Millions of Dollars

1965/1966 ESTIMATE - (Column III)

By adding Columns I and II, the base estimate for phased plant construction is shown by facility. It is to these figures that the cost increases are applied to obtain the current estimate of $765.5 million

TOTAL COST - PHASED PLANT CONSTRUCTION - 1965 PRICING LEVEL	$444.0

ESCALATION OF ISLAND AND PLANT FACILITIES - (Column IV)

The single most significant factor contributing to the cost increases is the escalation of labor and material prices projected to the time of construction of the project. The estimate contained in the feasibility studies considered an unphased project of approximately four years' duration, to be completed in 1971 and was based on 1965 prices excluding any allowance for escalation. The effect of phasing the construction of the water plant to allow four years between the first 50-mgd desalting unit and the second 100-mgd desalting unit, the extended lead time for the delivery of nuclear components, and the schedule stretchout resulted in a project of about 10 years total duration, with the first nuclear plant operating in September 1974 and the second phase operating in 1978. Based upon presently available and projected estimates for escalation of labor and materials averaging between 4-1/2 and 6 percent, total escalation costs for this project were $152.7 million. It should be noted that the original cost estimate included equipment cost for phasing and not the effects of escalation caused by phasing the construction. The following breakdown shows escalation costs by facility based on the current schedule:

	Millions of Dollars	Millions of Dollars
Island and Causeway	$ 8.5	
Power Plant - Unit 1	43.1	
Power Plant - Unit 2	37.8	
Backpressure Turbine Plant	10.3	
Desalting Plant	53.0	
TOTAL ESCALATION		$152.7

	Millions of Dollars

INCREASE IN CALIFORNIA SALES TAX - (Column V)

The California State Sales Tax and Use Tax increased from 4 percent in 1965 to 5 percent in 1968. This resulted in an increase to the project costs of $3 million. A breakdown by facility appears in Table 7.4.

CHANGE IN STATE SALES TAX	$3.0

HIGHER POWER PLANT OUTPUT - (Column VI)

The 1965 cost estimate was based on standard turbines and nuclear steam supply systems available at that time, capable of supplying a gross plant capacity of 1,790 Mwe. The original condensing turbine for power output was a four-flow machine. Subsequently, vendors offered nuclear steam supply systems with increased thermal power ratings of about 10 percent and specific steam conditions giving a potential increase in net electrical capacity of 165 Mwe to the Utilities. To take advantage of the increased capability required, a change from tandem-compound, four-flow to tandem-compound, six-flow turbines resulted in a price increase for the turbine-generators. The six-flow turbine is more expensive than the four-flow because it consists of three rather than two complete low pressure casings.

In addition to the change in the turbine-generator equipment, auxiliary turbine plant equipment and structures had to be increased in size to conform to the additional plant output. The turbine pedestals are larger and the circulating water piping to the condensers is more complicated. These changes resulted in a higher capital cost of $16 million. Since the larger turbines added an additional 165 Mw(e), the overall installed cost per kilowatt was reduced.

The following shows a breakdown of costs associated with this item.

	Millions of Dollars	Millions of Dollars
Turbine-Generators	$8.6	
Balance of Plant	4.9	
Transformers and Switchyard	0.3	
Miscellaneous	0.3	
IDC, Tax, and G&A	1.9	
TOTAL INCREASE DUE TO HIGHER PLANT OUTPUT		$16.0

This cost increase was divided between Power Plants 1 and 2, as shown in Table 7.4.

MARKET CHANGES IN NUCLEAR STEAM SUPPLY SYSTEMS - (Column VII)

Design and price information for nuclear steam supply systems was solicited and received from four suppliers of light water reactor systems in the summer and fall of 1965. The largest light water power reactors offered at that time by two of the major NSSS vendors were approximately 3,000 Mwt. This information was analyzed and adjusted where required to correspond with cost quotations offered in 1965 to several electric utilities throughout the United States.

The 1965 market price level for the dual-purpose size nuclear steam supply systems (nominal 3,000 Mwt each) was in the range of $52 to $60 million for two units, depending on the vendor. Comparable prices solicited separately by SCE and DWP for nuclear steam supply systems (nominal 3,300 Mwt each) in July 1967 were in the range of $90 million for two units, a dollar increase of approximately 50 percent over the 1965 market level. The increase over the 1965 price levels results from the following factors:

— The rush of orders for NSSS's placed in 1966 and 1967 (over 50 large reactors sold) filled the manufacturers' order books for delivery in 1972 through 1974, and the quoted prices were not discounted in 1967 and 1968 to the extent offered in 1965.

— Manufacturers offered a discount for the second similar reactor in 1965, but their offers in 1967 did not reflect a similar discount for the second unit.

— The net result to the project for this increase was $23.7 million and is split between Power Plants 1 and 2 as shown in Table 7.4.

TOTAL COST INCREASE DUE TO MARKET CHANGES IN NUCLEAR STEAM SUPPLY SYSTEMS --- $23.7 million.

CHANGES IN DESIGN CRITERIA - (Column VIII)

The cost estimates developed in the 1965 Feasibility Study were based on criteria for design of the nuclear facility which were consistent with the requirements of nuclear plants which had been licensed or were being licensed at that time. In addition, the design of the island and causeway was based upon criteria developed during the preliminary site investigation which was accomplished in the summer of 1965, upon wave criteria anticipated from statistical analysis, and from existing data available from the Corps of Engineers and knowledgeable consultants in their respective fields of endeavor. In the intervening period, additional imposed AEC requirements as exemplified by more recent applications and licensing proceedings have resulted in known criteria changes resulting in cost increases reflected in the Utilities present cost estimates.

EFFECT OF CHANGES IN DESIGN CRITERIA
(Millions of Dollars)

Island and Causeway	$ 5.7
Power Plant - Unit 1	3.7
Power Plant - Unit 2	3.8
Backpressure Turbine Plant	6.0
Desalting Plant	(1.8)
TOTAL	$17.4

Island and Causeway

The hydraulic model study of the Bolsa Island wave defense verified the stability of the wave defense against the maximum design wave but indicated a need for a higher revetment (change from 30 feet to 40 feet) as a protection against overtopping due to wave runup.

In addition, the work authorized by MWD during 1967 to perform a detailed site investigation of the Bolsa Island site, including dynamic tests of saturated soil, has resulted in more stringent criteria with respect to seismic design, liquefaction potential, and slope stability.

The decision to phase construction of the desalting plant resulted in changing the island from 38 to approximately 35 acres due to reduced laydown area requirements.

Island and Causeway	Millions of Dollars	Millions of Dollars
Provisions for new wave runup criteria: 30 feet to 40 feet revetment on three sides	$4.7	
Provisions for New Seismic Criteria: liquefaction and slope stability	3.1	
Adjustments for Differences in Scope: island size, location, and cofferdams	(2.1)	
Total for Island and Causeway		$5.7

Nuclear Power Plants - Units 1 and 2

The change in the design criteria effecting the cost of the two nuclear power plants includes redundancy in NSSS vendor-furnished engineered safeguards systems, additional emergency diesel generator requirements, change in design energy release, redundancy in Owner-furnished engineered safeguards systems, and cost of quality control requirements. The costs associated with the change in criteria are tabulated below and are split between Units 1 and 2 on Table 7.4.

Nuclear Power Plants - Units 1 and 2	Millions of Dollars	Millions of Dollars
NSSS Scope of Supply Adjustment	$1.6	
Additional Diesel Generator Requirements	1.2	
Additional Engineered Safeguards	1.4	
Design Energy Release and Seismic Criteria	2.0	
Redundancy in Reactor Auxiliaries	0.7	
Fuel Cask	0.6	
Total for Nuclear Power Plants		$7.5

Backpressure Turbine Plant

The current estimate includes costs for major design differences attributed to a change in the thermodynamic cycle which resulted in an overall gain in plant efficiency. The cycle change resulted in an increased main steam flow which required larger feedwater heaters and associated equipment, pumps, and extraction lines. In addition, the accompanying exhaust steam flow increased the size of the exhaust steam lines, condensate return lines, and associated condensate pumping equipment.

In the Phase III Study, estimated costs for the main power transformers were included with estimated costs developed for the switchyard. Transformers and associated electrical costs were separated from the Phase III estimate, adjusted where necessary, and included with the backpressure turbine plant to provide a more complete cost breakdown. Estimated cost is $2.3 million.

Estimated costs of yard services for the dual-purpose nuclear power and desalting plant were included under Miscellaneous Facilities for the Phase III Study. The yard services associated with the backpressure turbine plant are included in the current estimate as $0.3 million.

All costs associated with the steam and condensate lines, which are provided to convey steam from the exhaust of the backpressure turbine to the brine heaters of the desalting plant and return the condensed steam to the feedwater system of the backpressure turbine plant, were included in the desalting plant account for the Phase III Study cost estimates. For the current cost estimates, these costs were included within the scope of the backpressure turbine plant for ease of adjustment of costs developed for the various conceptual designs. Transfer of Scope from Desalting Plant is estimated at $1.9 million.

In lieu of detailed design engineering, an allowance was included in the current estimate for backpressure turbine control system considerations for operation of two interconnected nuclear steam supply systems and three turbine-generator plants operating in combination with the desalting plant. Intertie Allowance is estimated at $1.0 million.

The overall project estimate developed for the Phase III Study was based upon maximum utilization of common facilities. Therefore, certain facilities were intended for the use of all owning Participants. Operating philosophies developed by the owning Participants subsequent to the preparation of this study have resulted in duplication of certain equipment for facilities such as service water system, turbine plant cooling water system, compressed air system, and nitrogen and hydrogen gas systems. Costs associated with the added scope for these systems were developed and included in the current cost estimates as $0.5 million.

Total for Backpressure Turbine Plant is estimated at $6.0 million.

Desalting Plant

For ease of adjustment, costs developed for various conceptual lines from the backpressure turbine exhaust to the desalting plant brine heaters and the condensed steam return lines to the feedwater system of the backpressure turbine plant were transferred from the desalting plant to the backpressure turbine plant. Cost is estimated at $1.9 million.

The specification for portions of the tubing material has been changed from 70-30 to 90-10 CuNi. The 90-10 CuNi tubing will be used in the heat input and heat recovery sections for the desalting plant. Cost is estimated at $1.2 million.

Estimated costs of yard services for the dual-purpose nuclear power and desalting plants were included under Miscellaneous Facilities in the Phase III Study. The yard services associated with the desalting plant are now included in the current desalting plant estimate along with other minor scope changes in the supporting facilities. Cost is estimated at $1.3 million.

Total for Desalting Plant is estimated at $1.8 million.

TOTAL FOR CHANGE IN DESIGN CRITERIA IS ESTIMATED AT $17.4 MILLION.

ALLOWANCE FOR ANTICIPATED PROJECT REQUIREMENTS - (Column IX)

There are a number of items of potential cost exposure for which additional contingencies and allowances have been made in the current estimate. They include allowances for additional requirements that may be imposed by the AEC and by consultants as the result of the completion of detailed studies of such items as tsunamis, wave height, liquefaction of the island fill as a result of seismic activity, design of the plant for increased seismic and geologic requirements and containment augmentation. They also include contingencies and allowances for other items subject to the regulation of State and local agencies such as fish preservation, intersection of the causeway and the coastal highway, and atmospheric, chermal, and saline pollution. Contingencies and allowances have also been provided for a number of miscellaneous items not covered elsewhere.

The following detailed items are the contingencies and allowances in the 1968 estimate. In order to arrive at a measure of the cost increase from 1965 to 1968, allowances totaling $9.7 million included in the 1965 estimate are subtracted as applicable from each facility.

Island and Causeway	Millions of Dollars	Millions of Dollars
Contingency for Protection for 30-foot Tsunami	$0.5	
Contingency for Causeway Redesign for Future Units	1.5	
Additional Contingency for Protection of the Union Oil Line	0.5	
Contingency for Overtopping Wave Height	1.0	
Additional Contingency for Liquefaction	0.5	
Additional Contingency for Littoral Drift	0.5	
Additional Island Landscaping and Decorative Lighting	0.8	
Contingency for Pacific Coast Highway Interchange	0.3	
Less Allowances Included in 1965 Estimate	(0.6)	
Total - Island and Causeway		$5.0

Nuclear Power Plant - Unit 1	Millions of Dollars	Millions of Dollars
Contingency for Possibility of Increased Seismic and Geologic Requirement	$4.0	
Contingency for Containment Augmentation	1.3	
Contingency for Interfaces Between Units 1 and 2	0.5	
Contingency for Additional Engineered Safeguards	1.0	
Allowance for Atmospheric, Thermal, and Saline Pollution Abatement and Control	0.9	
Allowance for Plant Shakedown Facilities Prior to Nuclear Fuel Loading	2.0	
General Contingency	3.0	
Allowance for Provisions to Assure Fish Preservation	0.3	
Third-Party Inspection of NSSS Equipment	0.2	
ASME Turbine Test Provision	0.1	
Owners' Allowances for Power Plant - Unit 1	1.4	
Less Allowances Included in 1965 Estimate	(3.0)	
Total - Power Plant Unit 1		$11.7
Nuclear Power Plant - Unit 2		
Contingency for Possibility of Increased Seismic and Geologic Requirement	$3.7	
Contingency for Containment Augmentation	0.8	
Contingency for Interfaces Between Units 1 and 2	0.2	
Contingency for Additional Engineered Safeguards	4.9	

	Millions of Dollars	Millions of Dollars
Allowance for Atmospheric, Thermal, and Saline Pollution Abatement and Control	$0.2	
General Contingency	3.1	
Third-Party Inspection of NSSS Equipment	0.2	
ASME Turbine Test Provision	0.1	
Owners' Allowances for Power Plant Unit 2	3.4	
Less Allowance Included in 1965 Estimate	(2.9)	
Total - Power Plant Unit 2		$13.7
Desalting Plant		
General Contingency	$4.7	
Allowance for Provisions to Assure Fish Preservation	0.6	
Less Allowances Included in 1965 Estimate	(2.5)	
Total - Desalting Plant		$2.8
Allowance for Additional Cost of Land for the Switchyard and for Cost of Right-of-Way for Pipe-Type Cable		$2.3

TOTAL ALLOWANCE FOR ANTICIPATED PROJECT REQUIREMENTS, $35.5

CHANGE IN PROJECT RESPONSIBILITY - (Column X)

The 1965 Feasibility Study was based on the concept that the engineering and construction would be performed as a single undertaking to obtain the lowest total Project cost. In this concept, one agency would be responsible for the design, construction, and management of the total Project.

This concept was presented and accepted as the ground rule in the preparation of the 1965 Feasibility Study by both the Metropolitan Water District and the Electric Utilities Task Force which was formed to provide guidance to the study.

Subsequently, Participating Owners considered that it would be necessary to divide the responsibility for engineering and construction of the Project in order to meet charter and corporate limitations on their respective participation in a joint facility. The potential for labor difficulties due to differences in construction labor organizations was also a consideration in the decision by the Participants to divide Project construction responsibilities.

It was recognized that the decision by the owning Participants to divide engineering and construction responsibility for the Project would increase the total Project cost. The savings in construction of the second unit of the power plant on an optimum construction schedule in terms of increased productivity, reuse of forms, use of common construction equipment, and other construction items would not be possible. The increase in cost due to divided responsibility of the two power plants is estimated at $12.8 million.

It was also determined that the two power plants would be operated with separate operating crews. The 1965 Study envisioned only one operating organization so that maximum use of common facilities could be achieved. The change by the Participants to two separate operating crews for the power plants makes it necessary to duplicate certain facilities which had been common in 1965. The current design has two nuclear auxiliary buildings, two spent fuel pits, and increased control room facilities. The estimated increase in cost for the duplication of facilities is $6.8 million.

Divided responsibility for engineering and construction of the Project contributed to the desire for additional Project coordination in order to assist in assuring that the Project schedule be maintained.

Additional coordination will be required for the interfaces between the two power plants and the desalting plant, agreement on plant and facility arrangements, and the island, in both design, scheduling, and other planning and construction activities. The estimated cost of coordination is $5.6 million.

The sum of the above three factors indicates that the change in the cost from undivided to divided responsibility for engineering, construction, and operation is $25.2 million.

The Participants, in a continuing effort to reduce costs and improve design and construction schedules proposed a division of engineering and construction responsibilities in which SCE/SDG&E would design and construct both nuclear systems with structures and auxiliaries and DWP would design and construct the turbine-generator plants. MWD would be responsible for the island, causeway, and desalting plant. This proposed change in responsibility together with a proposed joint operating crew offered promise of savings which would reduce the total Project costs and the magnitude of the change in costs attributed to divided Project responsibility.

Nuclear Power Plants - Units 1 and 2	Millions of Dollars	Millions of Dollars	
Loss of Carryover Savings in Second Power Unit	$12.8		
Reduced Use of Common Facilities	6.8		
Total for Nuclear Power Plants		$19.6	
Project Coordination		5.6	
TOTAL COST INCREASE DUE TO CHANGE IN PROJECT RESPONSIBILITY			$25.2

HIGHER COSTS OF INTEREST DURING CONSTRUCTION - (Column XI)

The 1965 Feasibility Study contained $22.9 million in Interest During Construction. When the 1965 cost estimate is adjusted for escalation and design changes, the 1965 cost of money would indicate IDC of $35 million. The present Owners' estimates contain $51.9 million for this item, $16.9 million dollars more than the adjusted 1965 IDC.

The following tabulation shows the percentage change in Interest During Construction rates for each facility. The rates are a function of both the cost of money and time. While the cost of money increased for each owning Participant, Interest During Construction is less in 1968 for the desalting plant due to phased plant construction.

IDC CHANGE: 1965 to 1968

	Change in IDC Rates	Change in Millions of Dollars	
Island and Causeway	54%	$2.5	
Power Plant - Unit 1	35%	5.3	
Power Plant - Unit 2	109%	8.2	
Backpressure Turbine Plant	88%	1.5	
Desalting Plant	(10%)	(0.6)	
TOTAL COST INCREASE DUE TO THE HIGHER COST OF IDC			$16.9

	Millions of Dollars	Millions of Dollars

SAVINGS OVER THE ORIGINAL ESTIMATE - (Column XII)

There were two specific items which showed a net savings over the original cost estimate. The most important of these was the savings due to purchase of the large condensing turbine-generators which, according to the 1965 cost estimates, were $46.2 million. In 1967, the utilities received firm bids which resulted in a net savings of about $20.1 million on the purchase of these turbines.

	Millions of Dollars	Millions of Dollars
Power Plant - Unit 1	$(10.0)	
Power Plant - Unit 2	(10.1)	
Total Savings on Turbine-Generators	$(20.1)	

A further item which resulted in a savings to the Project was the possible availability of the copper-nickel material which is used in great quantity for evaporator tubing from the U.S. Treasury at a fixed market price, which when compared to the current price available at the time of the estimate indicated a possible savings of about $5.2 million for the Phase I portion of the plant.

	Millions of Dollars	Millions of Dollars
Desalting Plant - Savings on Government-Furnished Copper-Nickle Coinage Scrap	$(5.2)	
TOTAL SAVINGS OVER THE ORIGINAL ESTIMATE		$(25.3)

INCREASE IN OFFSITE FACILITIES - (Column XIII)

With regard to the facilities required offsite such as the conveyance water system and the electric transmission lines, there was included in the $444 million an estimated figure of $77 million for the combined water conveyance and power transmission facilities. Because the possibility exists that the electric transmission facilities which were scheduled to be built aboveground would have to be placed underground, an adjustment to the estimated costs was required. This, in conjunction with escalation of the water conveyance facility, resulted in an increase of $41.4 million for the conveyance and transmission facilities.

	Millions of Dollars	Millions of Dollars
Product Water Conveyance - (MWD)	$ 8.0	
Power Transmission System - (DWP)	0.9	
Power Transmission System (SCE/SDG&E)	32.5	
TOTAL COST INCREASE IN OFFSITE FACILITIES		$41.4

ADDITIONAL OWNERS' CONTINGENCY - (Column XIV)

As a result of the March 25, 1968 Project Management Board meeting, $15 million of additional contingency was added to provide for unknown imposed licensing requirements, the possible unavailability of Government coinage scrap material for the desalting plant, and additional Project coordination.

Power Plant - Unit 1	$4.2	
Power Plant - Unit 2	4.2	
Desalting Plant	3.6	
Project Coordination	3.0	
TOTAL FOR ADDITIONAL CONTINGENCY		$15.0

COST OF PHASING CONSTRUCTION

Throughout this chapter reference has been made to phased plant construction. The costs associated with phasing have been included in the previous sections, and this section is but a review of the cost of phasing and not an incremental cost estimate.

The concept in the 1965 Feasibility Study involved engineering, procurement, and construction of an unphased 150-mgd desalting plant as one operation. In 1966, MWD elected to proceed with the Bolsa Island Project based on phasing the construction of a 150-mgd desalting plant with the first phase of 50-mgd constructed and placed into operation concurrently with the first nuclear unit. In 1968, MWD set the time differential between Phases I and II at four years.

The 1966 estimate of $9.6 million for the cost of additional facilities exclusive of escalation covered temporary condensing and circulating water facilities for the backpressure turbine and two separate engineering, procurement, and construction efforts for the desalting plant. Subsequent engineering performed in 1967 and 1968 resulted in a smaller island and a more complex backpressure turbine plant, increasing the facility costs $0.5 million for a total cost of phasing increase of $10.1 million, excluding escalation. The $53.0 million for escalation of the desalting plant

(Column IV, Line 5 of Table 7.4) includes $7.4 million for escalation of Phase II over a four-year period and results from the decision to phase the desalting plant.

SUMMARY OF COST OF PHASING
(Millions of Dollars)

Cost of Additional Island and Plant Facilities	$10.1
Escalation for a Four-Year Span Between Phases I and II	7.4
TOTAL COST OF PHASING CONSTRUCTION	$17.5

TABLE 7.4

FACTORS CONTRIBUTING TO CHANGES
IN PROJECT COST RECONCILIATION
OF 1965 AND 1968 COST ESTIMATES
(Millions of Dollars)

ISLAND AND PLANT FACILITIES	I 1965 Estimate	II 1966 Cost of Phasing	III 1965/ 1966 Estimate	IV Escalation Of Island And Plant Facilities	V Increase In California Sales Tax	VI Higher Power Plant Output	VII Market Changes in NSSS's	VIII Changes in Design Criteria	IX Allowance For Anticipated Project Requirements	X Change In Project Responsibility	XI Higher Costs of IDC	XII Savings Over The Original Estimate	XIII Increase In Offsite Facilities	XIV Additional Owners' Contingency	XV Total Project Costs 4-19-68
1. Island and Causeway	$ 23.6	-	$ 23.6	$ 8.5	-	-	-	$ 5.7	$ 5.0	-	$ 2.5	-	-	-	$ 45.3
2. Power Plant - Unit 1	108.8	-	108.8	43.1	$1.1	$ 8.0	$11.9	3.7	11.7	$ 9.8	5.3	$(10.0)	-	$ 4.2	197.6
3. Power Plant - Unit 2	101.3	-	101.3	37.8	1.1	8.0	11.8	3.8	13.7	9.8	8.2	(10.1)	-	4.2	189.6
4. Backpressure Turbine Plant	22.3	$3.1	25.4	10.3	0.2	-	-	6.0	-	-	1.5	-	-	-	43.4
5. Desalting Plant	100.9	6.5	107.4	53.0	0.6	-	-	(1.8)	2.8	-	(.6)	(5.2)	-	3.6	159.8
6. Land For Switchyard and Right of Way for Cable	0.5	-	0.5	-	-	-	-	-	2.3	-	-	-	-	-	2.8
7. Project Coordination	-	-	-	-	-	-	-	-	-	5.6	-	-	-	3.0	8.6
Subtotal	$357.4	$9.6	$367.0	$152.7	$3.0	$16.0	$23.7	$17.4	$35.5	$25.2	$16.9	$(25.3)	-	$15.0	$647.1
OTHER FACILITIES															
8. Product Water Conveyance (MWD)	33.5	-	33.5	-	-	-	-	-	-	-	-	-	$ 8.0	-	41.5
9. Power Transmission System-(DWP)	33.5	-	33.5	-	-	-	-	-	-	-	-	-	0.9	-	34.4
10. Power Transmission System-(SCE/SDG&E)	10.0	-	10.0	-	-	-	-	-	-	-	-	-	32.5	-	42.5
Subtotal	$77.0	-	$77.0	-	-	-	-	-	-	-	-	-	$41.4	-	$118.4
TOTAL ESTIMATED COST	$434.4	$9.6	$444.0	$152.7	$3.0	$16.0	$23.7	$17.4	$35.5	$25.2	$16.9	$(25.3)	$41.4	$15.0	$765.5

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