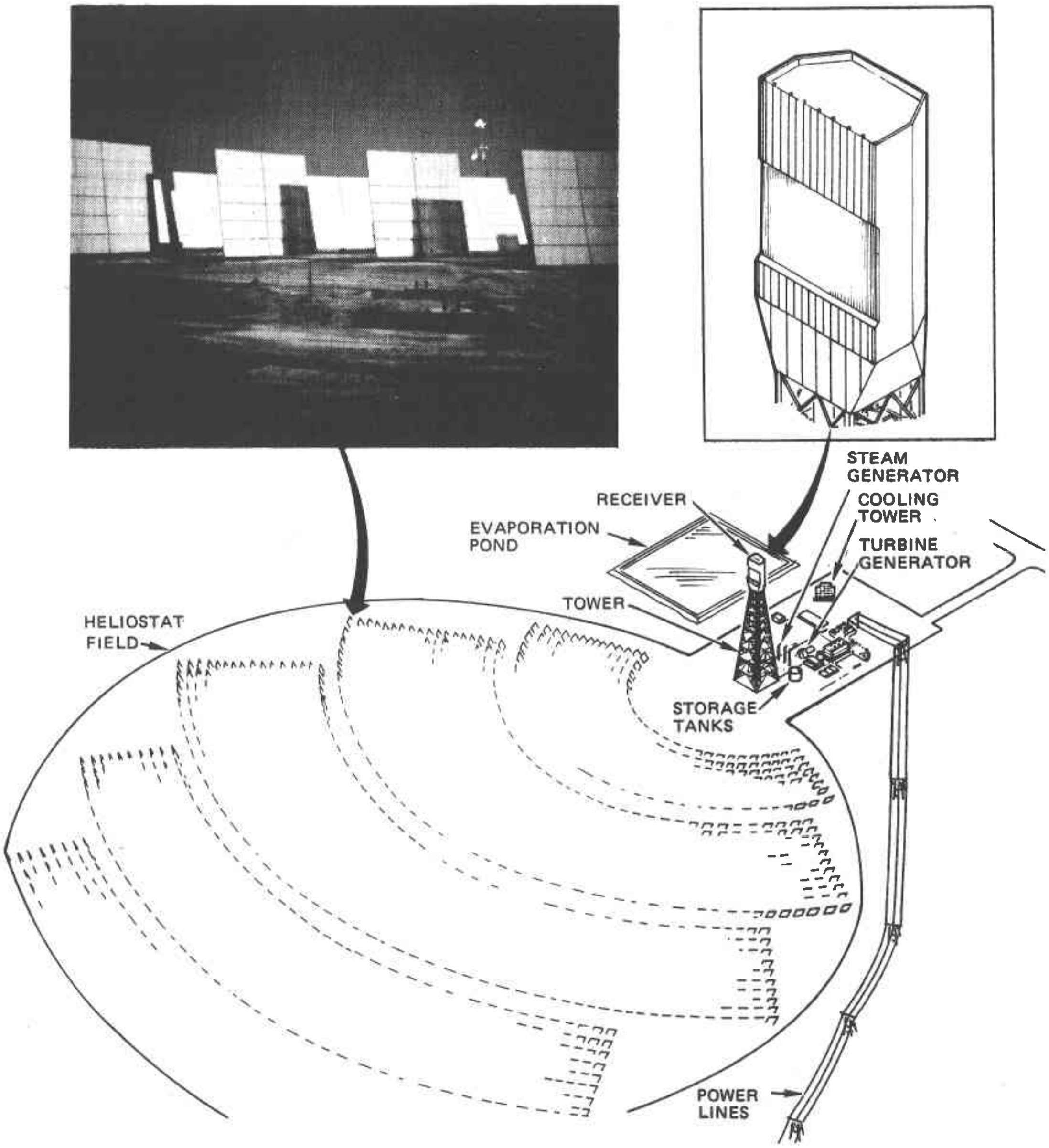
ESG-84-14

THE CARRISA PLAINS SOLAR CENTRAL RECEIVER PROJECT

PROJECT INFORMATION DOCUMENT



ARCO Solar Industries

BECHTEL

PG and E

Rockwell International

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FOREWORD

This project information document describes the proposed Carrisa Plains Solar Thermal Power Project. It is part of the application for a land use permit submitted to the San Luis Obispo County Planning Department by Bechtel National, Inc. (Bechtel).

In processing the land use permit application, the Planning Department will distribute this report to other agencies and county departments whose jurisdictions may be affected. These are expected to include, but are not limited to, the following:

Air Pollution Control District (APCD)

County Engineering Department

County Environment Coordinator

State Division of Transportation (Caltrans)

County Health Department

Atascadero Unified School District

Regional Water Quality Control Board

California Valley Community Services District

Pacific Bell

State Fish and Game Department

The proposed use is classified by the San Luis Obispo County Land Use Element as an allowable special use (S-1). According to the Land Use Ordinance (Section 22.08.120b.), this proposed use requires a Development Plan review in accordance with Section 22.02.034 of the Land Use Ordinance.

A Development Plan is a land use permit which, because of the nature or magnitude of the proposed project, should have public review and input before decisions to approve are reached. That input is given in a public hearing before the Planning Commission. The purpose of a Development Plan is to ensure proper integration into the community of uses that may only be appropriate in specific locations, or only if such uses are designated or laid out in a particular manner on the site.

When the Planning Department accepts a Development Plan for processing, it is transmitted to the Environmental Coordinator for completion of an environmental determination, as required by the California Environmental Quality Act (CEQA). In the interests of expediting the environmental review, Bechtel has waived its right to a determination of whether or not an environmental impact report (EIR) is required. Consequently, it is contemplated that the Environmental Coordinator will proceed with preparation of an EIR. It is understood that the Environmental Coordinator's policy is to obtain the services of a third-party consultant, otherwise having no interest in the project, to assist in preparation of the EIR. This consultant will determine both the environmental setting in which the project will be built and the impacts on that setting that the project will have. A draft EIR will be made available for public review and comment. All public comments are required by CEQA to be addressed in the final EIR.

The project design and operating plans incorporate mitigating features to reduce certain potential impacts to insignificant and, therefore, acceptable levels. These include planned arrangements providing for increased school enrollments; a construction camp providing temporary housing for construction workers; minimal ground water consumption; seismic design criteria appropriate to the proximity of the San Andreas Fault; and sodium containment and handling procedures to prevent atmospheric, surface, and ground water contamination. In the event other potentially significant adverse environmental impacts are identified as the EIR preparation goes forward, appropriate changes will be incorporated into the project to either eliminate the impacts or reduce the impacts to acceptable levels.

CONTENTS

CONTENTS

TABLES

FIGURES

FIGURES

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1.0 INTRODUCTION

1.1 PROPOSED FACILITY

The proposed facility is a 30-megawatt electrical (MWe) solar central receiver power plant that will sell electricity, as an independent power producer, to the Pacific Gas and Electric Company (PGandE). The solar plant will be located in PGandE's service territory at Carrisa Plains, San Luis Obispo County, California. The site (Section 35, T29S, R18E, MDBM) is located 50 miles east of San Luis Obispo on Highway 58 and is on the Morro Bay transmission corridor. This is an excellent solar resource area.

The concept and arrangement for this solar power plant is shown on the front cover. The plant uses a solar receiver located at the top of a tower to collect solar energy redirected by the field of mirrors, called heliostats, located to the north of the tower. The solar energy heats liquid sodium, pumped from ground level, from 610°F to 1050°F. The hot sodium is returned to ground level, where its heat is used in steam generation. The sodium is then returned to the receiver to be reheated. The steam is used in a turbine to generate electricity exactly as in a conventional power plant. Sodium is also stored in tanks so that power production is not limited to daylight hours. The facility is expected to produce enough electricity for 20,000 homes, or 75,700 MWhe/year.

A solar central receiver pilot plant, called Solar One, has been sponsored by the U.S. Department of Energy (DOE) at Daggett, California. This 10-MWe plant is shown in operation in Figure 1. Solar One's success has opened the way to the proposal for the Carrisa Plains plant.

1.2 PROJECT PARTICIPANTS

The project sponsors are Bechtel National, Inc., Rockwell International's Energy Systems Group, ARCO Solar, Inc., and PGandE. All of these are headquartered in California. Bechtel National, Inc., will provide overall project

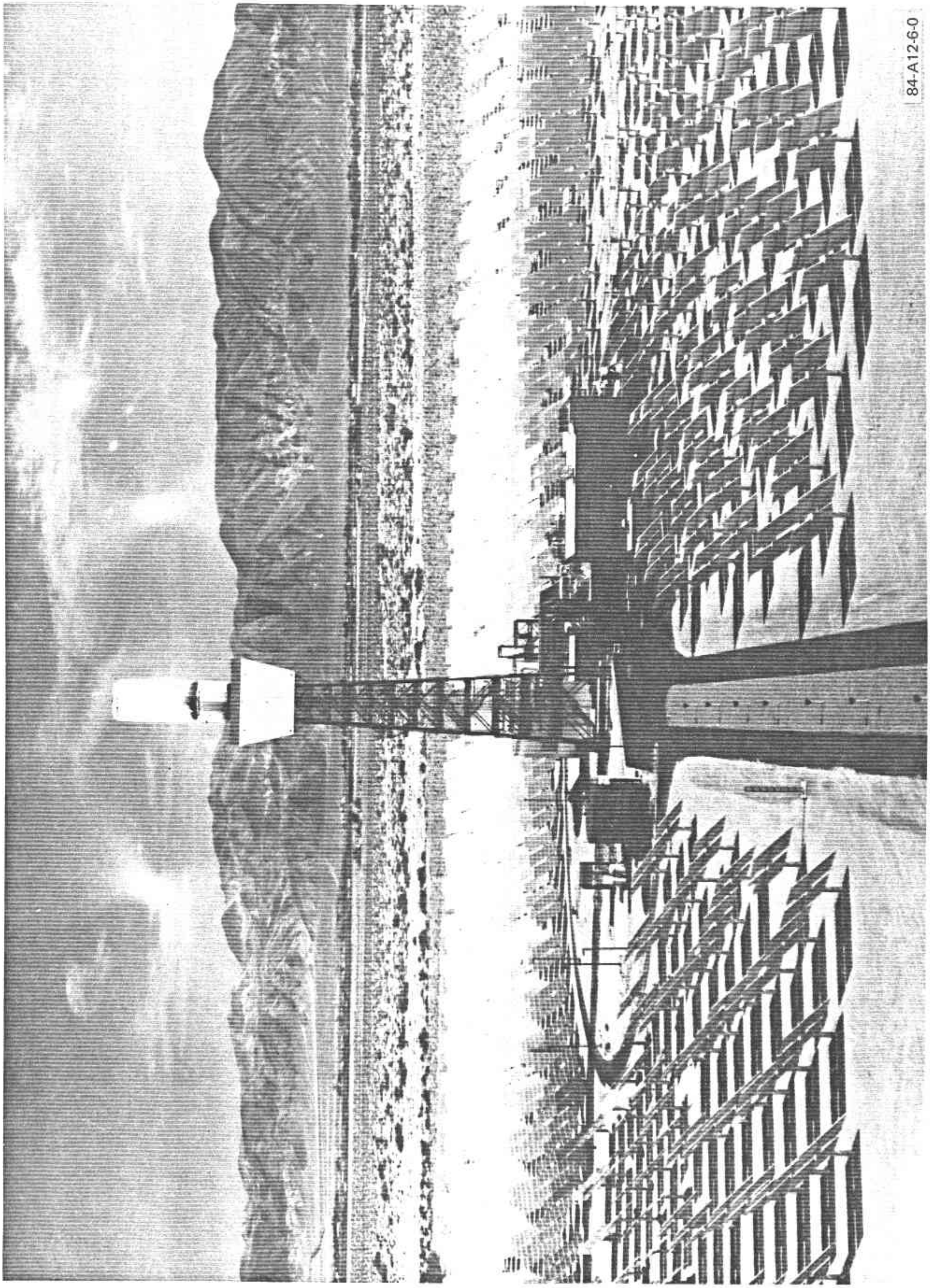

Figure 1. Solar One in Operation at Daggett

direction and construction management. Bechtel will also design and procure the electrical generating equipment, plant controls, and general facilities. Rockwell International will supply the solar energy handling equipment (heat transport system), and ARCO will supply the heliostat field. PGandE has provided financial and engineering support to the project, and a Power Sales Agreement with PGandE is in preparation for submittal to the California Public Utilities Commission.

Ultimately, the facility will be financed in the private sector capital market, probably as a limited partnership. The partnership will be the owner and operator of the plant. Currently, Bechtel is acting as the primary project agent. Bechtel is obtaining all discretionary permits in its name and will eventually transfer these permits to the limited partnership when it is formed.

The project is an outgrowth of an ongoing program by DOE to promote alternate energy sources. DOE joined with the project sponsors in cost sharing the preliminary plant design and currently is cost sharing the final design as well. DOE is not expected to contribute directly during the detailed design, construction, or operating phases. Instead, the project must be marketable as an attractive investment to the private venture capital market and to lending institutions. Therefore, the project will utilize existing tax incentives intended to promote the development of alternate renewable energy sources.

1.3 PROJECT OBJECTIVES

The Carissa Plains project has focused on the objective of demonstrating that solar central receiver power plants can become a major energy contributor in the United States and worldwide. The size and nature of this plant are typical of demonstration-type projects. This 30-MWe facility is a prudent scaleup from a simlar 10-MWe pilot test facility built near Barstow, California, by DOE, Southern California Edison, and Department of Water and Power in corroboration with the California Energy Commission. Commercial-size power plants of this type are expected to be somewhat larger, in the 50-MWe to 500-MWe range. This plant is an important stepping stone in demonstrating the cost, performance, and reliability of solar central receivers. The project participants have no long-term development plans for the Carrisa Plains area. If the project successfully demonstrates technical and economic features attractive to electric utilities, PGandE and other utilities will have the option of locating future plants of this generic type in areas where such development is favored by economic and environmental concerns.

1.4 SITE SELECTION

Potential siting areas considered were limited to the PGandE territory as shown in Figure 2. The selection criteria used were:

- The site should have high insolation.
- There should be close proximity for access to the PGandE grid.
- Water should be sufficiently available in both quantity and quality.
- There must be ready access to the site via railroad or highway.
- Site topography should be such that excessive grading is not required and mountain ranges do not block early morning or late night sun.
- Land must be available for purchase.
- The site should not have excessive weather extremes, particularly wind.
- The site should be sited away from major fault zones.

The primary sites considered were: Carrisa Plains, Cuyama Valley; and the San Joaquin Valley. Carrisa Plains was selected as the preferred site. The site selection rationale follows:

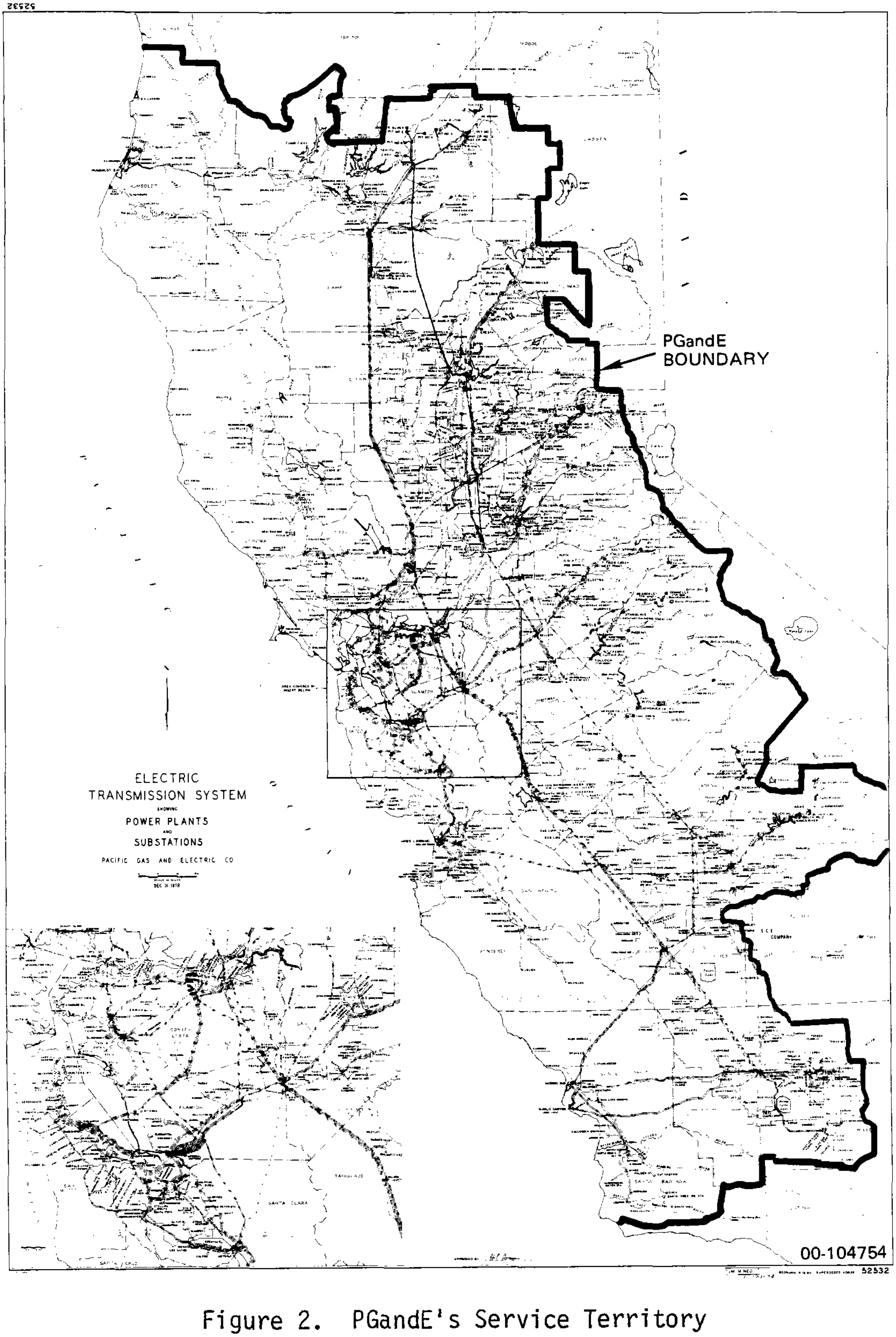

Figure 2. PGandE's Service Territory

- The site receives high average annual solar insolation due to its clear, dry, and relatively fog-free climate. Carrisa Plains has generally better solar insolation in the winter than the San Joaquin Valley, since its higher elevation reduces the incidence of tule fog. In the summer, it is protected from the ocean fog and clouds by coastal mountain ranges. Cuyama Valley has a similar climate.

- Access to PGandE's grid is provided either by a 115-kV circuit from San Luis Obispo to Midway in the San Joaquin Valley or by the two 230-kV circuits from the Morro Bay power plant to Midway. The plant site is 1 mile from this Morro Bay transmission corridor. No transmission line was available in Cuyama Valley.

- Adequate quality groundwater is available for power plant use. Using state-of-the-art plant design, plant water consumption can be held to 120 gal/min (185 acre-ft/yr), well within the instaneous average flows of groundwater wells in the Carrisa basin. Cuyama Valley's water supply was considered inadequate in both quality and quantity, while the Carrisa basin groundwater storage capacity, as listed by the California Department of Water Resources in 1975, is 400,000 acre-ft.

- Access to the site is available on Highway 58. This highway is built to adequate state standards. No limitations on project equipment sizes are foreseen for this project due to site access.

- Site topography is such that no extensive grading is required. The local mountain ranges do not block site insolation.

- The approximately 300 acres required for the plant are available from private landowners.

- Weather extremes, including wind and hail, are acceptable.

- The selected site is about 4 miles from the San Andreas fault. The cost and risk of locating this type of power plant close to an earthquake fault were judged to be small. Alternative sites were subject to earthquakes almost as severe as Carrisa Plains.

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2.0 PLANT DESCRIPTION

2.1 SITE DESCRIPTION

The plant location, shown in Figure 3, is at 35.3° north latitude and 120.0° west longitude. The plant site, shown in Figure 4, is Section 35, T29S R18E, MDBM, near the town of Simmler, California. On behalf of the project, PGandE holds a lease and an option to purchase on this section.

Access to the site from the east is along Highway 58 for about 64 km (40 miles) from Interstate 5 in the San Joaquin Valley. Access from the west is along Highway 58 for 80 km (50 miles) from State Highway 101 at Atascadero near San Luis Obispo. Highway 58 is built to adequate state standards, and no limitations are imposed on the equipment sizes for this project. The nearest sizeable populations and road distances from Carrisa Plains are given in Figure 3.

Access to the grid will be via the 115-kV circuit from San Luis Obispo to Midway in the San Joaquin Valley. The 115-kV circuit does not need reinforcement for this 30-MW installation. This circuit will be accessed with a new branch line approximately 3.2 km (2 miles) in length.

Section 27, directly northwest of this project, is being developed by ARCO for a 16.5-MWe photovoltaic system. The Carrisa Plains school is located on the southwest corner of Section 34 and will be 1-1/2 miles from the receiver tower.

Carrisa Plains (also known as Carrizo Plains) is a sparsely populated, enclosed valley, about 65 km (40 miles) long and 13 km (8 miles) wide in southeastern San Luis Obispo County. The floor of the valley is about 600 m (2000 ft) above sea level. The site is flat, has been recently used for farming, and has a slope of about 0.5% to the southwest. The soil load-bearing capacity is suitable for supporting the plant equipment. The site is treeless, and no trees will be removed during construction.

CITY	DISTANCE km	(mi)	POPULATION
ATASCADERO	80	(50)	10,000
BAKERSFIELD	97	(60)	75,000
SAN LUIS OBISPO	80	(50)	30,000
TAFT	64	(40)	5,000

Figure 3. Location of Carrisa Plains Solar Power Plant

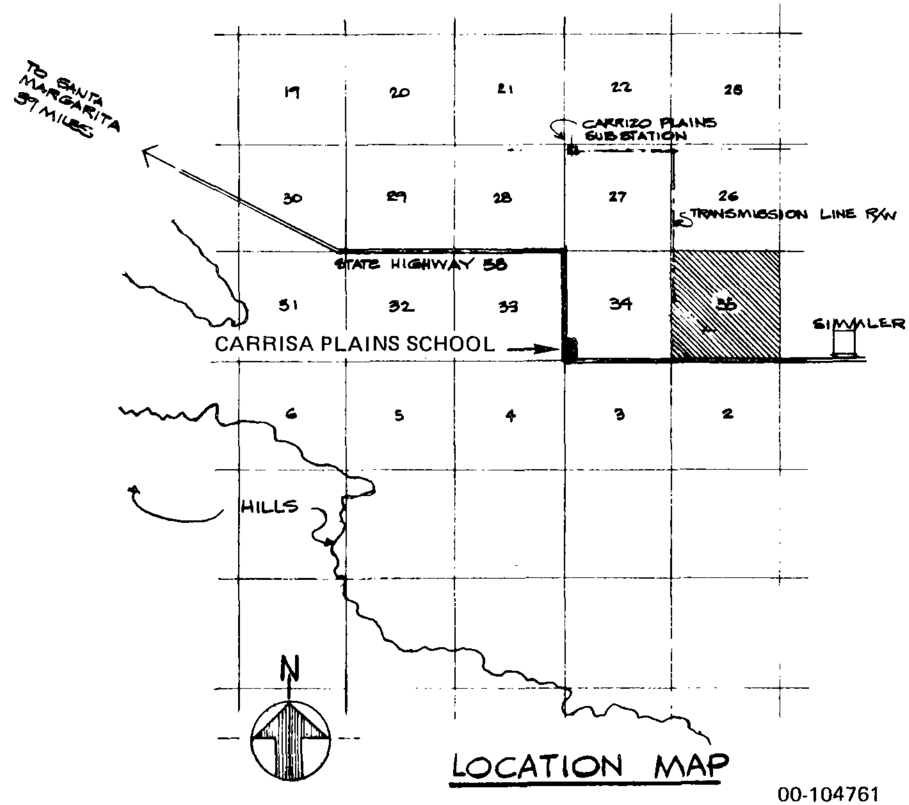

Figure 4. Site for Carrisa Plains Solar Power Plant

The site is 4 miles southwest of the San Andreas active fault zone. It is also 6 miles northeast of the San Juan and Chimeneas fault zone classed as showing evidence of Quaternary activity.(2-1) Two short faults are mapped in the southwest portion of the area with pre-Quaternary activity.

A solar resource measurement program at Carrisa Plains was instituted by PGandE in early 1982. In late 1982, this program was augmented to include direct normal insolation measurements.

Two methods were used to estimate the long-term average direct normal insolation at Carrisa Plains. The first was to average the three closest stations – Fresno, Santa Maria, and China Lake – which form a triangle around Carrisa Plains. China Lake is about the same latitude and elevation as Carrisa Plains and has a similar desert-type atmosphere. The second method involves a seasonal adjustment to Fresno and Santa Maria conditions, since Carrisa Plains' weather is similar to Santa Maria's coastal weather from October through March and is like Fresno's valley weather the remainder of the year. Table 1 gives the results of the two methods. The three-station average gives an annual total of 2552 kWh/m^2, and the seasonal adjustment gives an estimated 2524 kWh/m^2 yr. Since these estimates are quite close, the estimated annual direct normal insolation will be taken at the lower value. The daily average is 6.9 kWh/m^2.

The Carrisa basin groundwater storage capacity, as listed by the California Department of Water Resources (DWR) in 1975, is 400,000 acre-ft. Estimates of current water usage in the Carrisa basin range between 600 and 1000 acre-ft/yr.(2-2,2-3) Deep groundwater wells (300 to 600 ft) in the Carrisa basin yield instantaneous average flows of 0.03 m^3/s (500 gpm) with maximum flows of 800 gpm. The proposed solar power plant has been designed to minimize water use and will require an average flow of 120 gpm, or 185 acre-ft/yr. Available groundwater quality data for the eight state-numbered wells show the water quality to be acceptable.

TABLE 1

ESTIMATED DIRECT NORMAL INSOLATION AT CARRISA PLAINS

Location	Latitude/ Longitude (deg)	Elevation (ft)	Direct Normal Insolation (kWh/m^2 month)												Total
			Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	
Fresno	36.77/119.72	336	95	126	195	229	273	279	285	262	224	186	122	79	2356
Santa Maria	34.93/120.42	234	149	149	199	211	221	225	239	225	188	178	149	148	2281
China Lake	35.65/117.00	2440	182	181	249	272	297	297	285	272	248	218	190	179	2870
Carrisa Plains (three-station average)	35.30/120.00	2020	142	152	214	237	264	267	270	253	220	194	154	185	2552
Carrisa Plains (seasonal correction)	35.30/120.00	2020	149	149	199	229	273	279	285	262	224	178	149	148	2524

Source (except for Carrisa Plains): P. Berdahl et al., California Solar Data Manual, California Energy Commission (CEC) Publication (March 1981)

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Site specific soil and groundwater evaluation testing was initiated in February 1984. The objectives of these tests are to characterize the site soil engineering properties, groundwater availability, and groundwater quality. The results of these tests will be provided to San Luis Obispo County as they become available.

2.2 FACILITY DESIGN SUMMARY

The 30-MWe Carrisa Plains plant is similar in concept to the 10-MWe Solar One plant being successfully operated at Barstow, California. A perspective view of the plant and its major features are shown on the cover. The plant layout (Figure 5) covers 295 acres. The fan-shaped collector field is approximately 3600 ft deep by 4600 ft at the widest point. The plant uses a north-facing vertical flat panel solar receiver of a tested design supported on top of a 378-ft steel truss tower. The receiver intercepts the solar energy redirected from 1883 ARCO heliostats. The receiver is approximately 40 ft high by 52 ft wide. The solar energy heats liquid sodium flowing through the receiver tubes. Figure 6 is a flow diagram of the system. The cold (610°F) sodium is pumped to the receiver by conventional sodium pumps from a 40-ft-diameter by 54-ft-high atmospheric pressure storage tank located at ground level. As the sodium passes through the receiver tubes, it is heated to 1050°F. The heated sodium then drains by gravity to a second (hot) storage tank located at ground level. From the hot storage tank, it is pumped through the steam generators, cools to 610°F, and returns to the cold storage tank. The three once-through-to-superheat steam generators are connected in parallel to deliver 270,000 lb/h of steam at 1000°F and 1450 psig to the turbine, which generates approximately 33 MWe (gross). The three parallel steam generator units provide redundancy to 90% of full power with one unit out of service. The modern steam conditions employed in this plant yield high conversion efficiency with conventional turbine equipment.

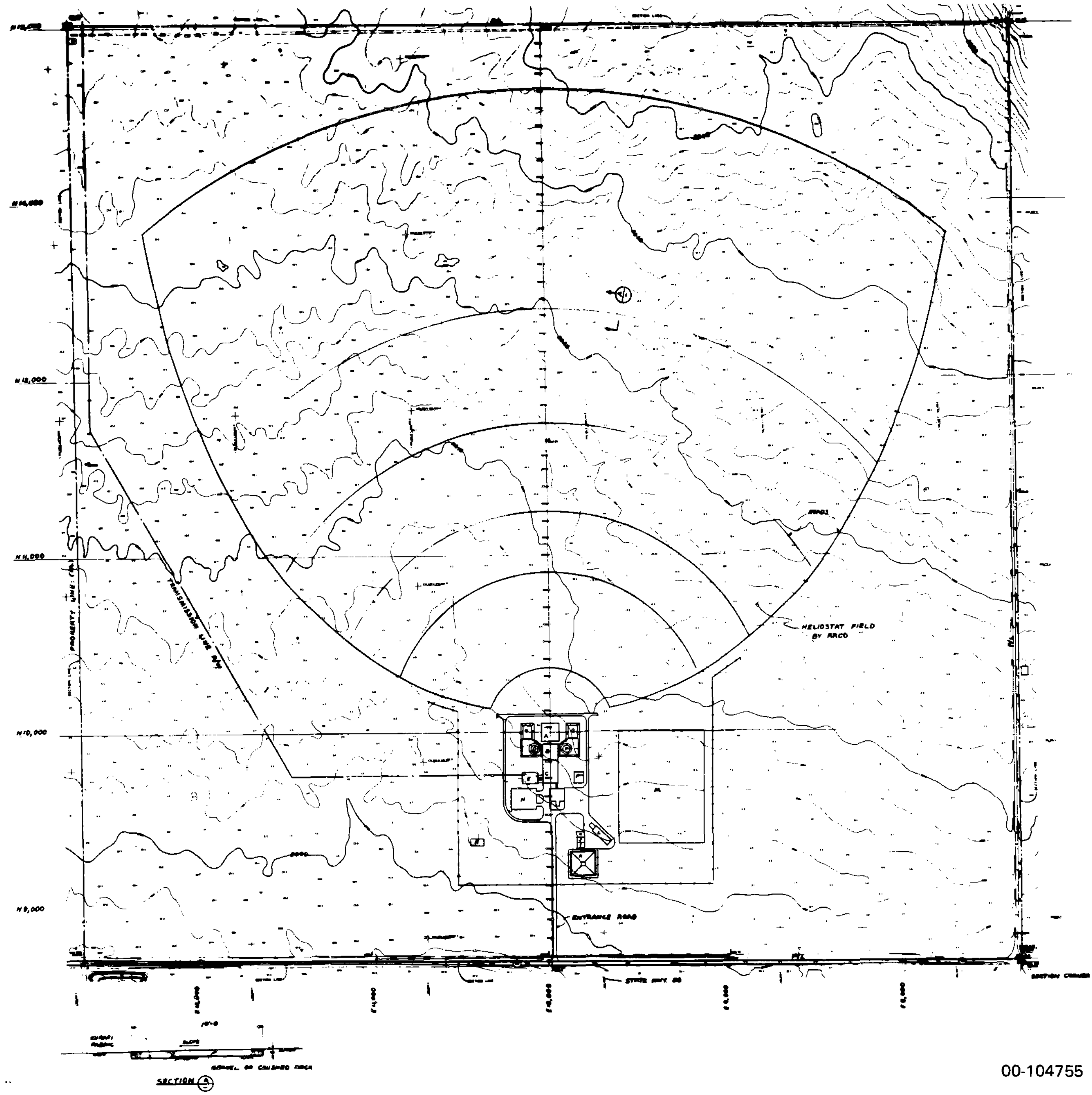

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Figure 5. Carrisa Plains Solar Plant Layout

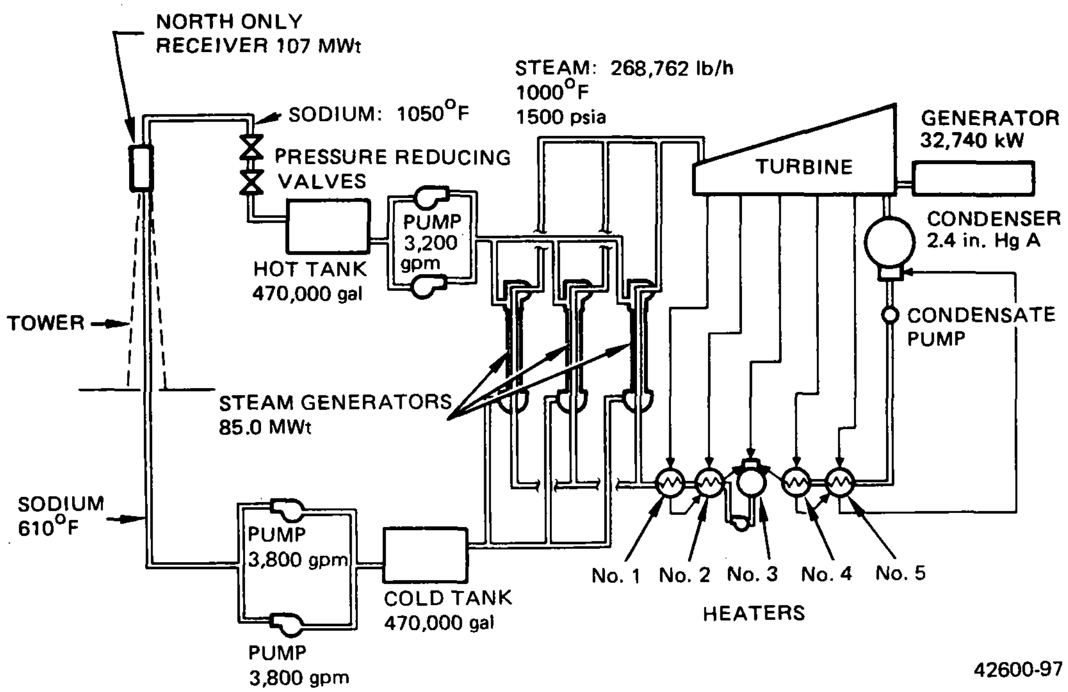

Figure 6. Carrisa Plains Solar Plant Flow Diagram

The plant design uses proven components and systems, giving the plant high availability and low operating and maintenance costs. Redundancy has been provided at critical points to ensure that a single component failure will not compromise plant availability or safety requirements. The plant is designed to meet all appropriate engineering codes and standards.

Incorporation of thermal storage permits the solar portion of the plant, the collector and receiver, to start up and operate independently from the electric power generation portion of the plant, the steam and turbine generators. In addition, the thermal storage mitigates the effects of clouds and other transients, thus simplifying plant operation. The plant will be operated so that plant revenues are maximized.

Each major plant system will be described in more detail in the next three sections.

2.2.1 Collector System

The collector system comprises the computer-controlled heliostats which redirect and concentrate sunlight so that it may be collected by the solar receiver at high temperature. To provide the solar receiver 107-MWt,* peak power requirements of the plant, the collector system requires 1883 third-generation ARCO heliostats. The heliostat field pattern is shown in Figure 7 and a typical heliostat in Figure 8.

The heliostat is the latest in a design evolution from ARCO's second-generation heliostat. The ARCO heliostat has 95 m^2 of reflective area, divided into 32 mirror modules 4 ft by 8 ft. The heliostat support structure is composed of open-web steel beams connected to a horizontal tubular axis and drive unit and is identical to the ARCO structures for photovoltaic units currently installed at Carrisa Plains. The entire heliostat and drive assembly is mounted on a pedestal and foundation, which is planted in an augered hole grouted in place.

*MWt is the thermal power rating of the solar portion of the plant.

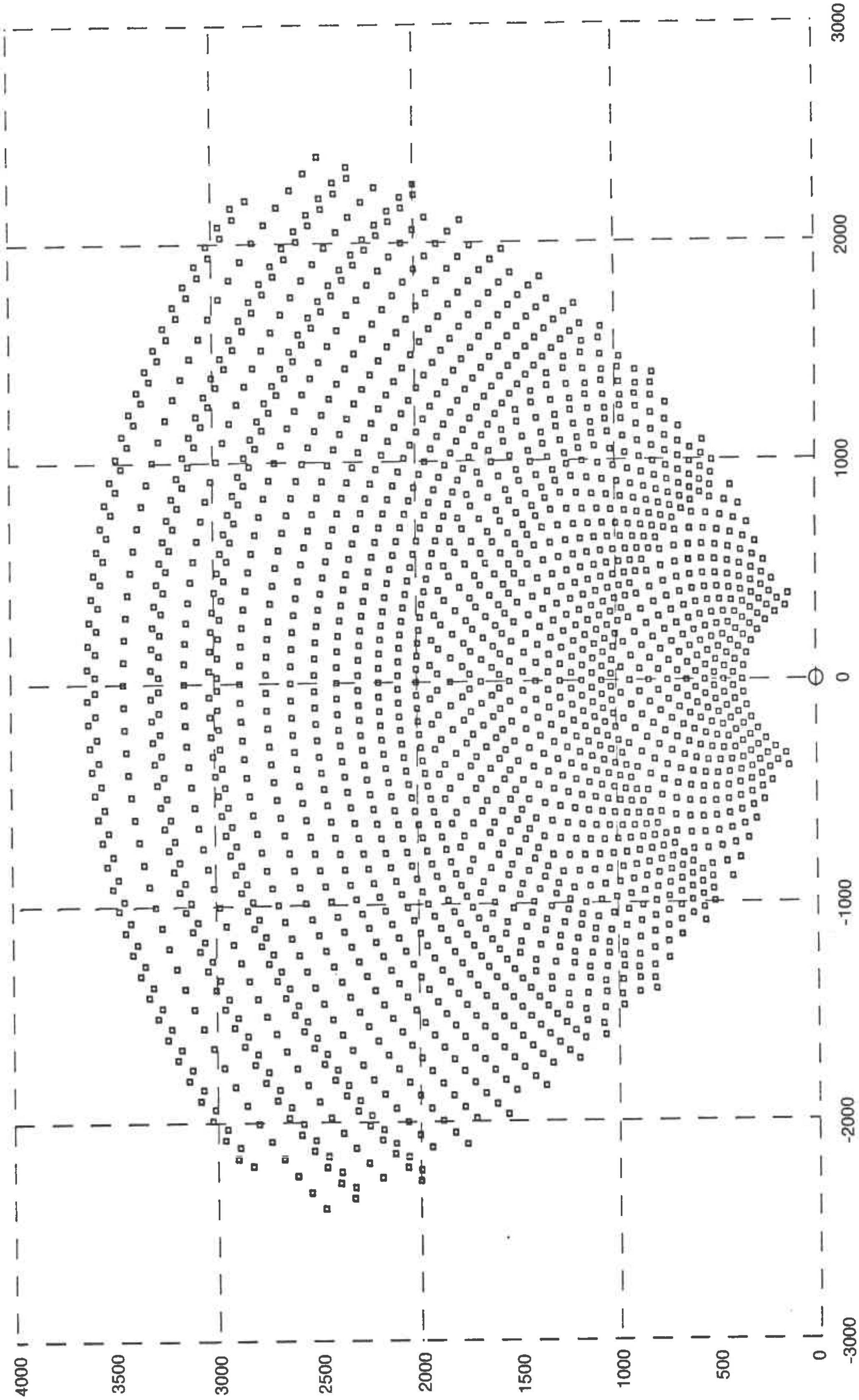

Figure 7. Carrisa Plains Solar Plant Collector Field Layout

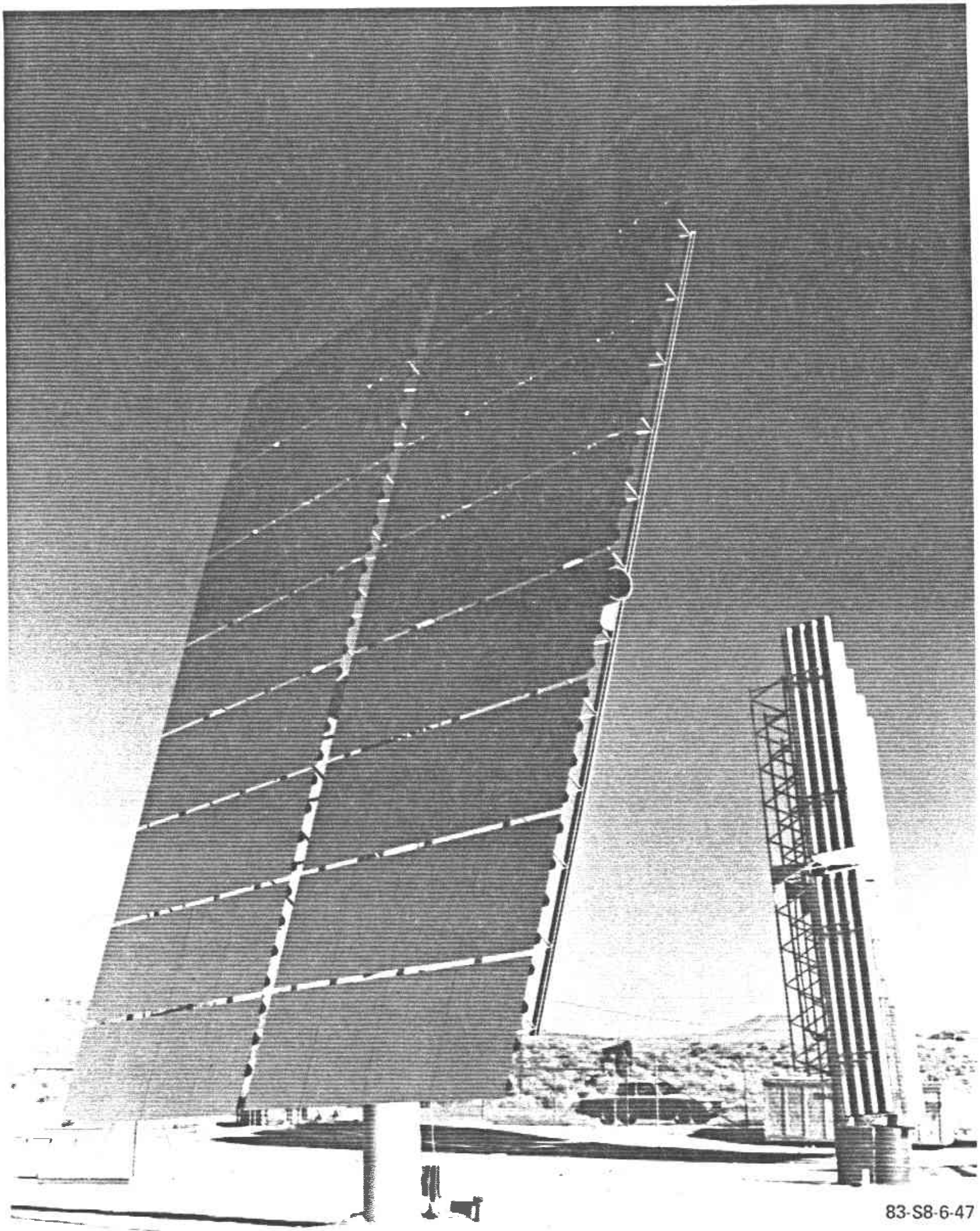

Figure 8. ARCO's Third Generation Heliostat

Power and control wiring is placed in trenches throughout the field. The drive unit, under computer control, orients the heliostat continuously to track the sun and reflect the sunlight on the receiver. The maximum rate of heliostat motion is 11°/min (22°/min for the reflected beam). In an emergency the reflected energy can be removed from the receiver in less than 20 s.

Each evening, the heliostats are placed in the normal stow position; the mirror assembly is near vertical and facing southwest. Shortly before sunrise, the heliostats are focused on the standby aim points. These are points in space above the receiver. This procedure prevents reflected beams from the heliostats striking the ground, highway, or plant buildings during morning startup. When the plant is ready to operate, the heliostat beams are shifted from the standby point to the receiver. If a heliostat must be defocused from the receiver during the day for maintenance or cleaning, its movement will be controlled such that its reflected beam follows a predetermined safe path. Also, in the interest of reflected beam safety, the position of each heliostat is periodically checked by the computer to ensure that it is aimed in the proper direction. When the receiver is to be shut down each evening, the heliostat beams are shifted to the standby aim points, and the heliostats are brought to their stow position after sunset.

The heliostats will be cleaned both by rainwater and, when necessary, with distilled water from a water spray truck. No chemicals will be used in the distilled water spray. The heliostats will probably require cleaning two to six times per year, depending on the seasonal rainfall and local dust. Based on six washings per year, the annual water consumption will be less than 0.1 acre-ft. At the Barstow Solar One plant, heliostat washing occurs approximately four times a year.

2.2.2 Heat Transport System

The heat transport system (HTS) collects the sunlight focused by the collector system and uses this energy to generate steam. The HTS is divided into six parts: the receiver subsystem, heat transport loop, thermal storage, steam generation subsystem, auxiliaries, and electrical instrumentation and controls (EI&C). The entire heat transport system utilizes hardware tested at full-scale or prototype level. The total sodium inventory of the HTS is about 3.25×10^6 lb or 450,000 gal.

2.2.2.1 Receiver Subsystem

The receiver subsystem, shown in Figure 9, absorbs the redirected solar energy from the collector field. The energy absorbed raises the sodium coolant temperature from 610°F to 1050°F. The receiver is supported on a structural steel tower 378 ft high with receiver centerline elevation at 410 ft high.

The receiver faces north and forms a flat panel approximately 40 ft high by 52 ft wide. It consists of eight panels. Each panel consists of 102 3/4-in.-diameter, Type 316 stainless steel tubes with a wall thickness of 0.049 in. Predicted panel life exceeds 30 years. Table 2 summarizes the receiver subsystem design parameters.

Care has been taken to provide maximum protection for this essential plant component. For example, if receiver coolant flow is lost, an emergency supply (accumulator) tank will automatically provide coolant flow to the receiver until the collector solar beam is redirected away from the receiver. In the event of a simultaneous collector field power and pump failure, the heliostat beams will be moved off the receiver by a combination of sun image drift and heliostat slewing powered from an emergency battery power supply.

The receiver has been designed to stringent requirements from two national engineering codes — Section VIII Division 1, and the creep-fatigue requirements of Addendum N-47 to Section III of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (B&PVC) and Section B31.1 of the American National Standards Institute.

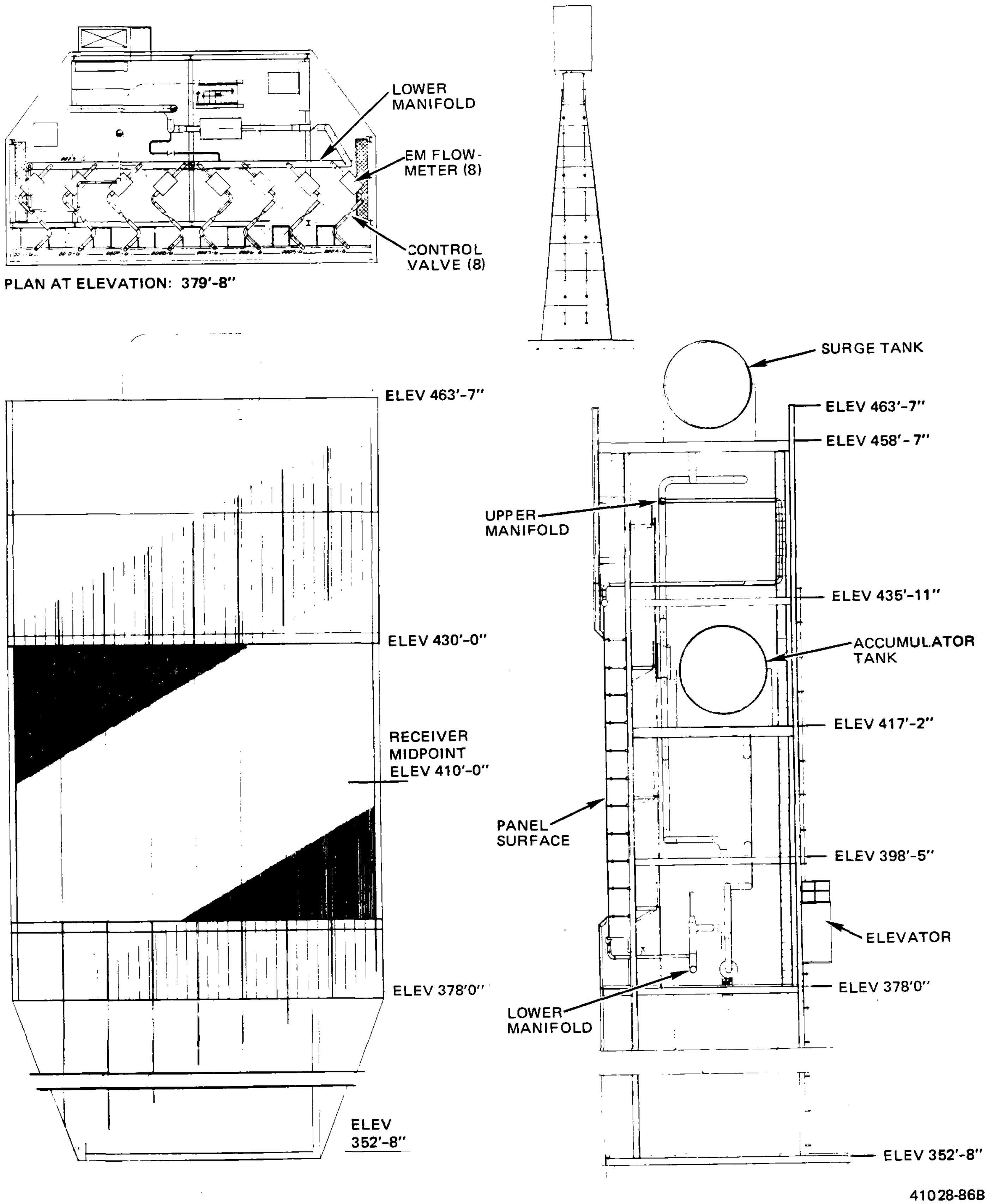

Figure 9. Receiver Subsystem Layout

TABLE 2

RECEIVER SUBSYSTEM DESIGN SUMMARY

Key Design Parameters	
Midplane elevation	410 ft
Receiver aperture	
Width	52 ft
Height	40 ft
Number of panels	8
Panel characteristics	
Width	6.6 ft
Height	50 ft
Number of tubes	102
Tube diameter	0.75 in.
Tube wall	0.049 in.
Material	Type 316 stainless steel
Performance	
Incident power	116 MWt
Absorbed power	107 MWt
Inlet temperature	610°F
Outlet temperature	1050°F
Maximum flux	111 kWt/ft^2
Average flux	55.8 kWt/ft^2
Pump flow/head	6200 gpm/650 ft

Rockwell has conducted a successful test of the sodium-cooled prototype receiver at DOE's central receiver test facility. The peak solar flux on the prototype, which causes the main stress in the tubes, was more than 25% above the Carrisa Plains plant flux, thus providing a 25% margin on stress and a 100% margin on stress cycles. The test unit was operated at an outlet temperature of 1100°F compared with the plant unit temperature of 1050°F, providing additional design margin.

2.2.2.2 Heat Transport Loop

The heat transport loop consists of two independent flow paths — one starting from the cold storage tank through the receiver and terminating at the hot storage tank for solar operations, and another starting from the hot storage tank through the steam generators and back to the cold tank (see Figure 6). Two pumps are used in parallel for each flow path to provide a 20% design margin and redundancy to 70% of operating flow for coolant circulation.

Plant safety is protected by designing components to Section VIII Division 1 of the ASME Code and designing the piping to ANSI Standard B31.1. The heat transport loop layout, including thermal storage and steam generators, is shown in Figure 10.

2.2.2.3 Thermal Storage

Thermal storage consists of two storage tanks, with foundations and insulation. The hot and cold thermal storage tanks are 40 ft in diameter and 54 ft high. The hot tank is Type 304 stainless steel and operates at 1050°F; the cold tank is mild steel and operates at 610°F. The tanks operate at atmospheric pressure with an argon cover gas. The tank foundations include provisions for cooling. The tanks have electric heaters for preheating and maintaining temperature as required. The total plant sodium inventory of approximately 3,250,000 lb can be contained by either tank.

2.2.2.4 Steam Generation Subsystem

The steam generation subsystem utilizes three once-through sodium-heated steam generators (Figure 11), operating in parallel to generate the 270,000 lb/h of 1000°F, 1450-psig steam needed for full-power operation. The steam generator subsystem performance is summarized in Table 3. Plant reliability is enhanced by the ability of two steam generator units to deliver 90% of full plant power without derating steam conditions. This will allow one unit to be repaired or examined without a major impact on plant operations.

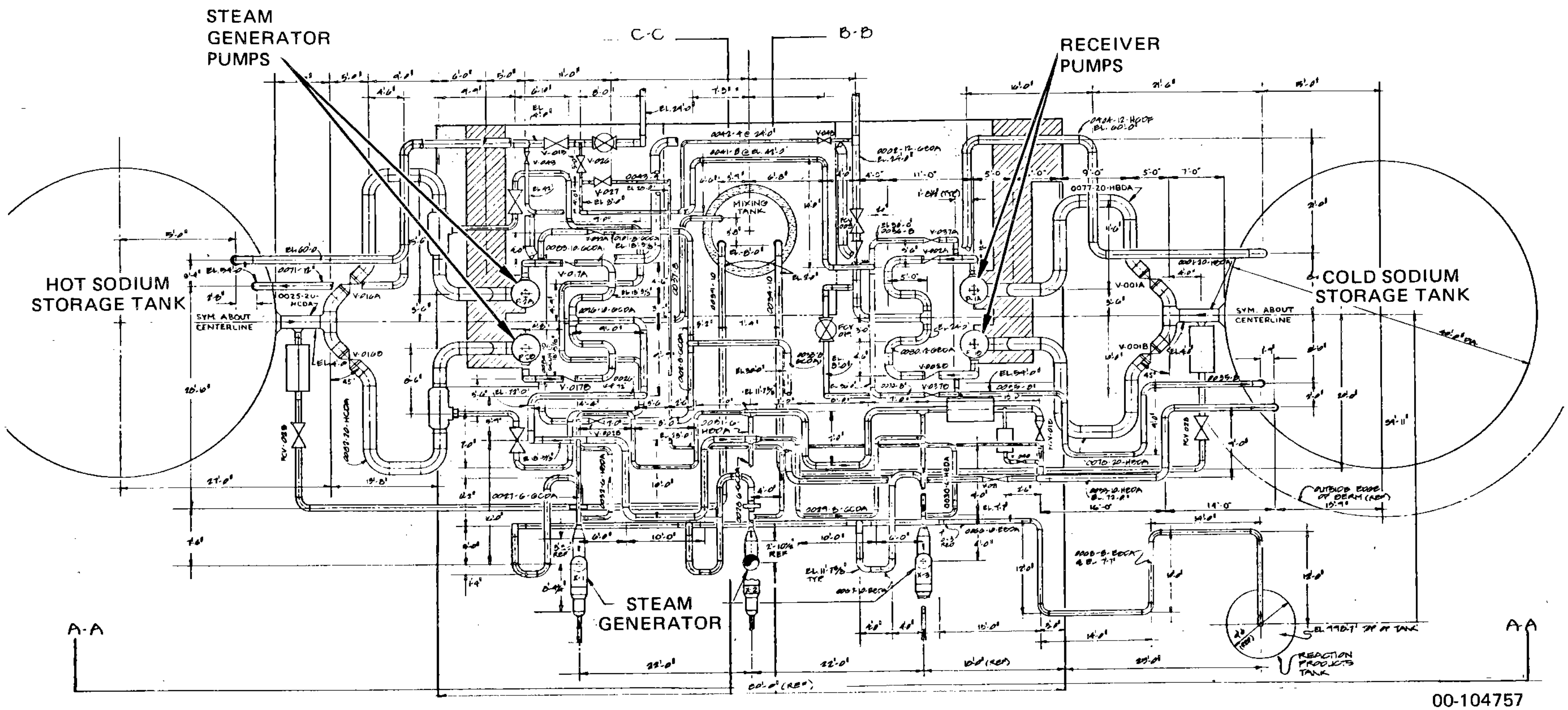

Figure 10. Piping Layout

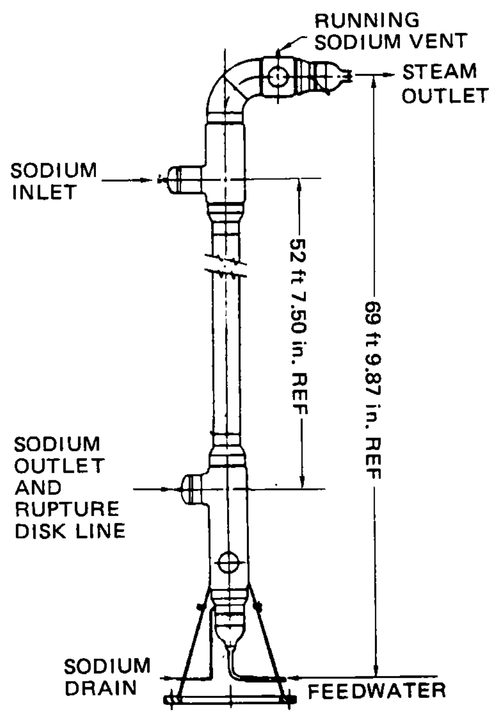

Figure 11. Steam Generator Unit Configuration and Physical Interfaces

TABLE 3

STEAM GENERATION SUBSYSTEM DESIGN SUMMARY

Key Design Parameters	
Number of units	3
Size	
Diameter	18 in.
Length	69.3 ft
Number of tubes per unit	158
Tube dimension	
OD	0.625 in.
Wall	0.109 in.
Heat transfer area per unit	1,500 ft^2
Performance	
Design power per unit	28.3 MWt
Steam conditions	
Pressure	1515 psia
Temperature	1000°F
Feedwater temperature	436°F
Sodium conditions	
Inlet temperature	1050°F
Outlet temperature	587°F
Inlet pressure	100 psia
Flow rate per unit	
Steam	89,820 lb/h
Sodium	684,200 lb/h
Pressure drop	
Steam side	61 psia
Sodium side	10 psia
Pump flow/head	5,300 gpm/190 ft

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The steam generators are constructed of Croloy (2-1/4 Cr - 1 Mo) steel, a material widely used in conventional boilers. The steam generator has a 30-year design life and meets or exceeds the design requirements of Section VIII Division 1 of the ASME B&PV Code. It will be Code stamped. A prototype model was tested by Rockwell for over 9000 hours and fully satisfied its design requirements.

2.2.2.5 Sodium Auxiliaries

The sodium auxiliaries include: (1) the sodium receiving and purification stations, (2) the argon supply and handling equipment, (3) the sodium mixing tank, and (4) the sodium/water reaction products tank.

Sodium will be shipped to the plant in tank trucks and unloaded at the receiving station through a low-temperature (300°F) filtration system. Sodium purity is maintained during operation by flowing a side stream through a cold trap where impurities are deposited. The resulting low oxygen concentration, below 6 ppm, will keep the corrosion rate below 0.2 mil per year throughout the HTS.

The mixing tank is provided to match the sodium supply temperature to steam generator conditions and to prevent excessive steam temperature excursions on startup.

The argon system provides an inert gas blanketing for the tanks, vessels, and pumps. The argon is recycled to conserve it.

Although care is taken to ensure steam generation tube integrity, a flaw could lead to a steam or water leak into the sodium. A stainless steel rupture disk assembly, installed in the steam generator outlet piping, protects against overpressurizing the steam generator shell and discharges the steam generator contents safely to a tank in the event of a leak. Hydrogen produced is vented through a safety stack.

2.2.3 Electric Power Generation System

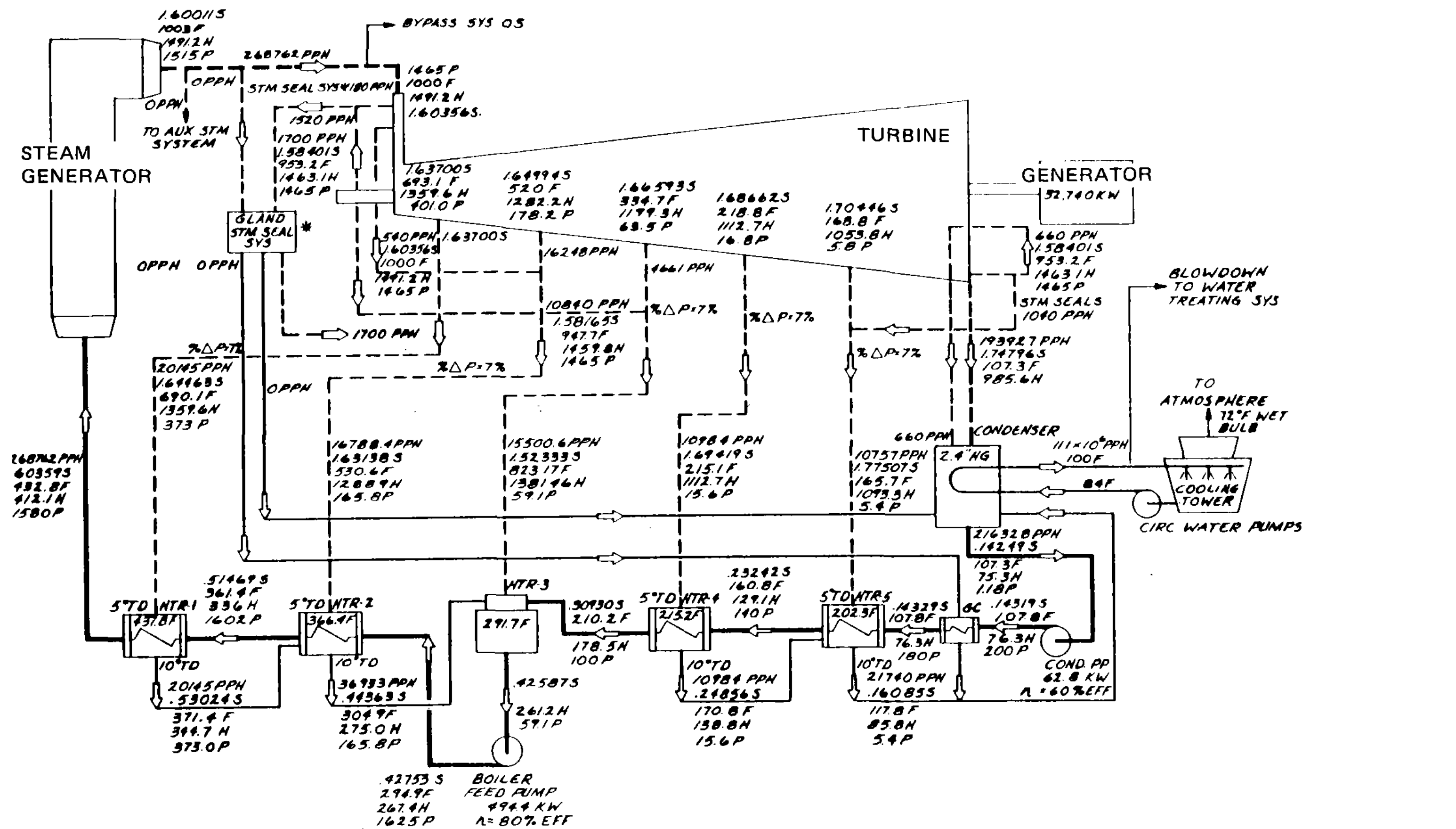
The electric power generation system consists of the turbine-generator set, the feedwater equipment, the condenser, and cooling tower. It converts the energy in the steam supplied by the steam generating system into electric power for the plant and the grid. The system utilizes a conventional regenerative Rankine cycle turbine as shown in Figure 12. The turbine is a single-shell machine with five extraction points. The steam conditions at the turbine inlet are 1450 psig at 1000°F. The final feedwater temperature is 436°F. The rated condenser pressure is 2.4 in. Hg and the condenser is cooled by water from an evaporative cooling tower.

The generator produces electric power at 13.8 kV, three phase, 60 Hz. It is connected through a generator breaker to a 115-kV step-up transformer. A circuit switcher connects the 115-kV transformer to the 115-kV SLO-to-Midway transmission line. The connection to the transmission line will be a single tap to the existing 115-kV transmission line.

Plant operational noise will be extremely low at the site boundary. No noise protection will be required for operating personnel under normal conditions. The cooling towers represent the greatest noise source with a decibal rating of 69 dbA at the site boundary. Occasional plant trips above 70% power will result in steam release to the atmosphere through the steam relief valve. The noise level for this steam release is of short duration and at approximately the same noise level as the cooling towers. Steam releases from safety valves would constitute an infrequent noise source, occurring no more than a few times per year. The noise will be predominately in the low frequency range (i.e., under 500 cps).

2.2.4 Plant Layout

The collector field extends approximately 3600 ft north from the plant reference at the receiver tower center. Its east-west extent is approximately 4600 ft. The field is enclosed by a 7-ft chain-link fence. Roadways are



LEGEND	
(heavy dashed line)	MAIN STEAM LINE
(dashed line)	STEAM LINES
(heavy solid line)	MAIN FEEDWATER LINES
(solid line)	WATER LINES
PPH	FLOW, LBS PER HOUR
S	ENTROPY, BTU PER FT PER POUND
F	TEMPERATURE, DEGREES FAHRENHEIT
H	ENTHALPY-BTU PER POUND
P	ABSOLUTE PRESSURE (PSIA)
%ΔP	FRICTION LOSS
°TD	TERMINAL TEMPERATURE DIFFERENCE

LOSS BALANCE

SINK TEMPERATURE OF 70° = 529.67°R

NET WORK	31,283.3 KW
PUMP LOSS	92.8 KW
TURBINE LOSS	4907.4 KW
HEAT ADDED LOSS	41,395.9 KW
LINE PRESSURE LOSS	1,665.4 KW
HEAT EXCHANGER LOSS	624.2 KW
SHAFT LOSS	316.5 KW
GENERATOR LOSS	316.5 KW
PLANT AUXILIARIES	900.0 KW
AVAILABILITY REJECTED (CONDENSER)	3,498.0 KW
TOTAL	85,000.0 KW
STEAM GENERATOR HEAT INPUT	85,000.0 KW
HEAT ADDED EFFICENCY	51.3%
CYCLE EFFECTIVENESS	71.7%

PERFORMANCE

THROTTLE FLOW	268,762 PPH
GENERATOR ELECTRICAL OUTPUT	32,740 KW
POWER CONVERSION SYSTEM AUXILIARY POWER	
FEEDWATER AND CONDENSATE PUMPS	557.1 KW
CIRC WATER AND COOLING TOWER FANS	550 KW
OTHER	350 KW
TOTAL	1457.1 KW
SYSTEM NET OUTPUT	31,283 KW
POWER CONVERSION SYSTEM HEAT RATE	9271 BTU/KWH
POWER CONVERSION SYSTEM EFFICENCY	36.8%

CONDITIONS

CONDENSER BACKPRESSURE	2.4 G
AMBIENT AIR TEMPERATURE	70°

00-104758

Figure 12. Solar Plant Preliminary Heat Balance

graded and minimally drained. Only minimal grading and surface treatment is planned for the collector field. After the plant enters commercial operation, control of vegetation may be required.

Other than the heliostat field, plant equipment is located to the south of the receiver tower as shown in Figure 13 (more detailed layouts are shown in Appendix A). The evaporation pond is sized for disposal of 18.4 acre-feet per year. The raw water pond is 90 ft by 90 ft in size. The cooling tower is located in the southeast sector. Removal of major equipment, including pumps and steam generators, is provided for through lanes provided to the west, east, and north of the steam generator area and turbine generator building. Roads and parking areas will be unpaved. Approximately 40,000 ft^2 of gravel surface will be provided at the entrance roadway, parking lot, perimeter road, and turbine building.

Landscaping will be minimal and will consist of no more than a small amount of decorative plants near the entry to the administration section of the combined administration-warehouse building.

A temporary sign near the driveway at Highway 58 may be erected during construction and would be no more than approximately 12 ft by 12 ft. Wording has not been determined. A permanent sign probably will be erected comparable in size to the existing nearby ARCO sign. Wording of this sign cannot be determined until the owner/operator entity for the facility is organized and named.

The 115-kV branch line is approximately 2 miles long from the tap to the switchyard at the plant. The branch line takes off from the power plant's 13.8 to 115-kV main step-up transformer. The transmission line routing is as shown in Figure 4. In PGandE's property, the branch line taps the Midway-SLO 115-kV transmission line.

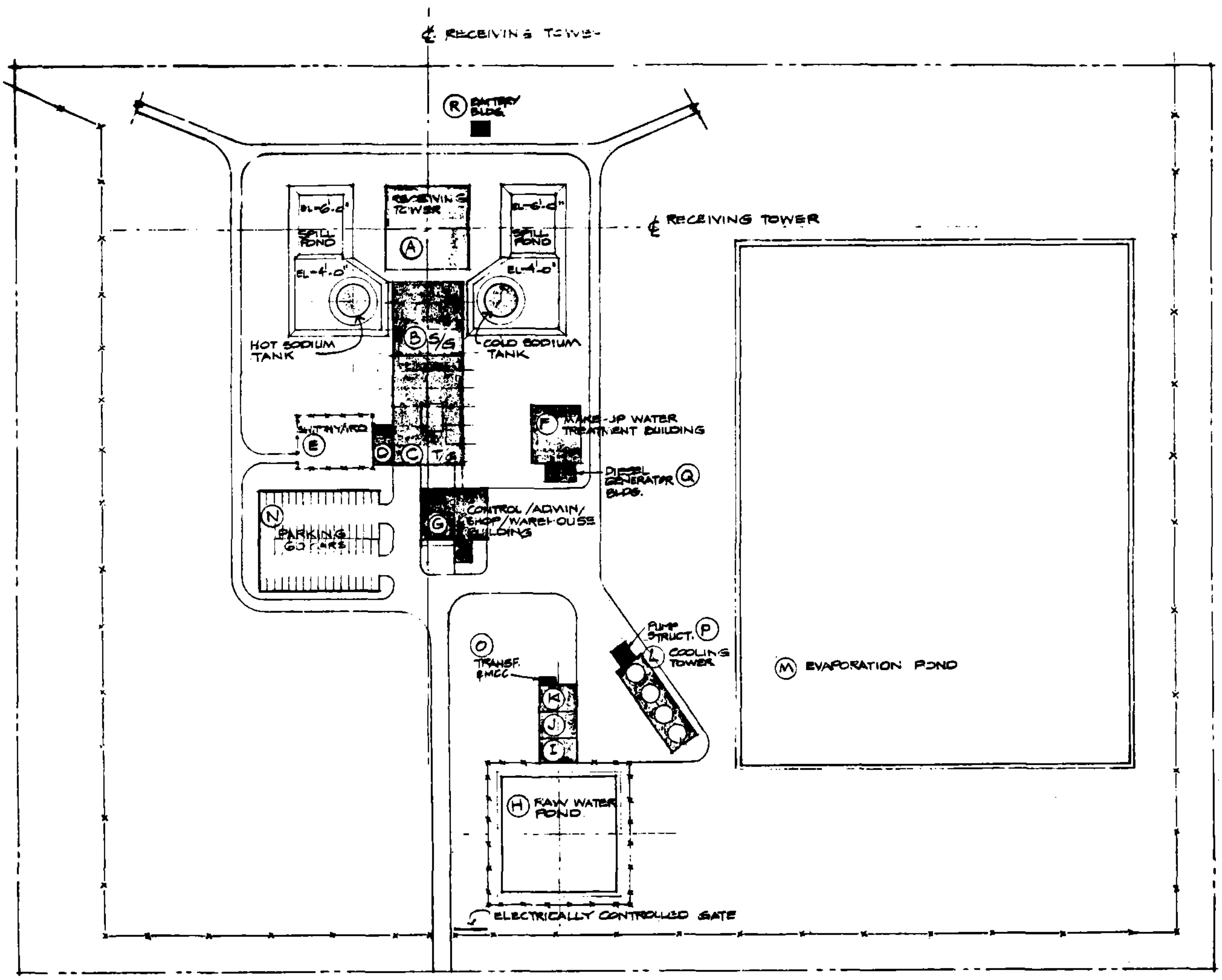


Figure 13. Major Site Improvements

The branch line is supported by 55- to 60-ft wood poles spaced 450 ft apart. It consists of three 715-kcmil aluminum conductors.

A disconnect switch is located at the point where the branch line connects to the existing 115-kV line. The disconnect switch is wood pole mounted, gang operated, and will be used to separate the branch line from PGandE's 115-kV Midway-to-SLO transmission line.

A circuit switcher will be provided for separating the plant from the branch line. This circuit switcher is located in the plant's switchyard. PGandE's revenue meter will also be located in the plant's switchyard. Additional items included in the interconnection facility are the ground distance and negative sequence relaying, telemetry, and transfer trip devices.

The auxiliary power system for the plant will receive power from the unit auxiliary transformer, which will transfer to lower voltages (4160 V, 480 V, and 208 V/120 V) for utilization. An emergency diesel generator will be provided for the plant emergency loads. A 125-Vdc system will be provided to supply an inverter for the heliostats, another inverter for the master control system, and other 125 Vdc uninterruptible loads. A single line diagram is shown in Figure 14.

The heat transport and electric power generation system equipment is arranged in the power complex located immediately south of the receiver tower. The power complex is subdivided into a steam generator building (80 ft x 85 ft x 75 ft high) and turbine building (80 ft x 132 ft x 20 ft high). Proceeding from north to south in this complex, one finds sodium pumps and tanks, the steam generators, main steam piping, the turbine/generator and associated equipment, and the electrical equipment room and support facilities. The condenser is beneath the turbine. Access to the switchyard is controlled by a 7-ft chain-link fence. The electrical switchgear is located toward the transmission line tap.

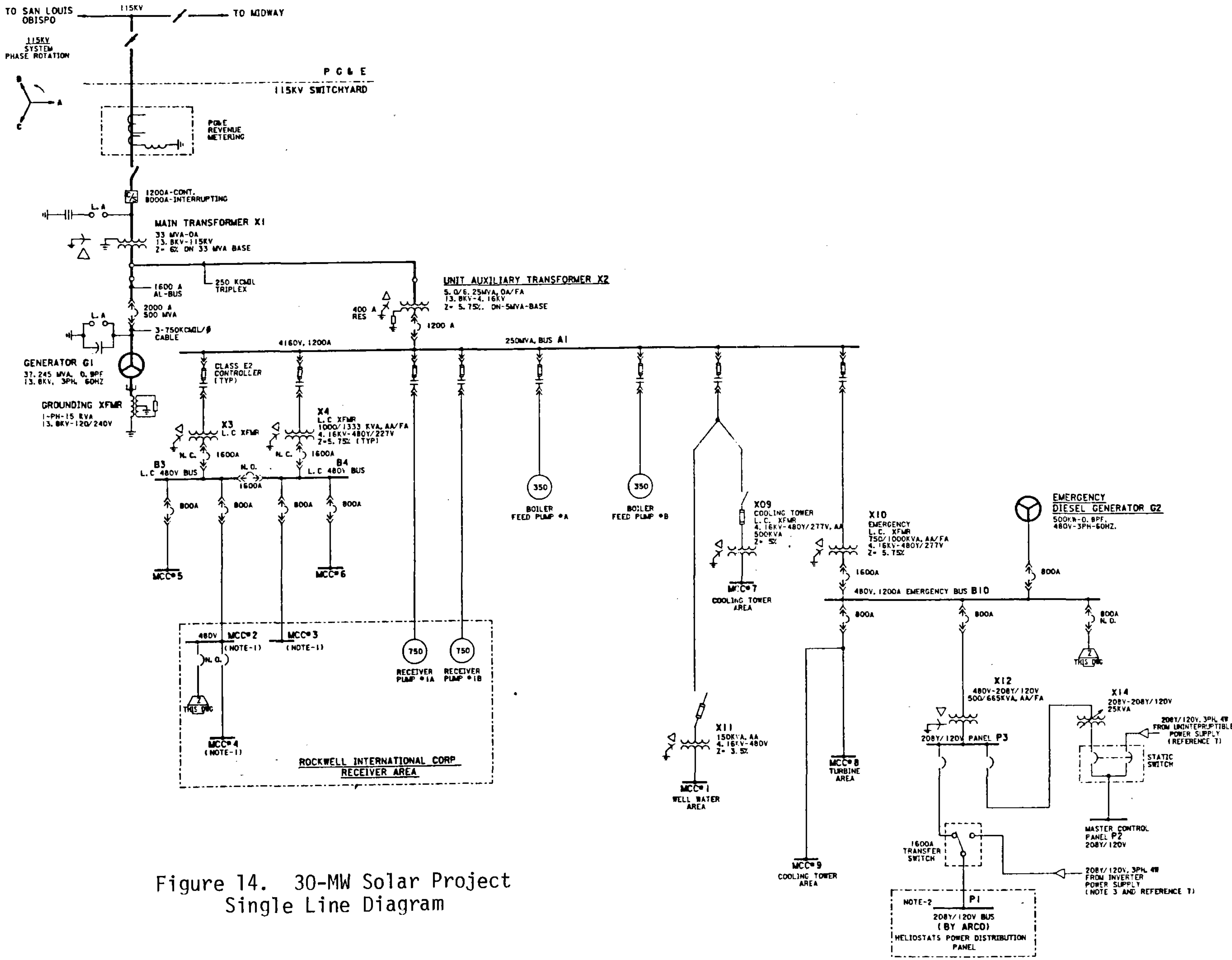


Figure 14. 30-MW Solar Project
Single Line Diagram

The power complex is a semi-open structure with a concrete slab floor at grade and a partial deck at the 20-ft turbine operating level. Siding will be provided in equipment areas where a freezing hazard to piping exists. A permanent crane is installed for T-G maintenance when it is required. The control/administration/shop/warehouse building, located south of the power complex, has two levels and is approximately 72 ft wide, 107 ft long, and 31 ft high. The upper level houses the control room, computer room, and offices. The lower level houses support facilities, shops, and warehouse.

The receiver tower structure is a steel truss design resembling a transmission tower. The tower corner foundations are supported by piling. The ground-level cross section is a 100-ft square. The tower is equipped with passenger elevator and stairway. The receiver centerline is located at the 410-ft elevation, with the tower top at 475 ft. FAA-approved aircraft warning lights will be provided on the receiver tower.

Exposed structural framing of the receiver tower, the steam generator structure, open platforms, and stairway will be galvanized steel of a silver grey color. The exterior finish of the turbine/generator and the other plant buildings will be shop-finished, ribbed metal siding, and the colors will be neutral tones selected from the manufacturer's standard palate. The exterior carbon steel surfaces of certain process components will be painted with carefully selected accent colors to enhance the industrial forms; component examples are: turbine/generator, gantry crane, steam generators, sodium storage tanks, receiver tower elevator enclosure, and the receiver panel enclosure.

Hot and cold sodium storage tanks are located east and west of the steam generator building, respectively. Each tank is 40 ft in diameter and approximately 50 ft high.

The makeup water treatment/auxiliary boiler building and diesel generator room is a prefabricated steel building 60 ft wide, 80 ft long, and 16 ft high.

The cooling tower is approximately 30 ft wide, 144 ft long, and 50 ft high.

Other miscellaneous structures and areas include pump houses, electrical switchgear buildings, battery building, water treatment and softener equipment building, raw water storage pond, evaporation pond, sodium spill ponds, switchyard, and a parking lot.

Exterior yard lighting will be provided to illuminate working areas around plant equipment and will comply with the requirements of Section 22.04.320 of the Land Use Ordinance. Shielded high-pressure sodium flood lights, similar to street lights, will be used for general area illumination. Additional high-pressure sodium fixtures will be used as needed to provide direct lighting on equipment platforms and in operating areas.

Illumination levels will range from approximately 1 footcandle at ground level in general areas to 5 footcandles on equipment platforms. Supplemental local lighting, 30 footcandles, will be used in specific areas where needed.

The heliostats are 120-V, single-phase loads, fed by 208-V/120-V, three-phase load distribution through 10 distribution panels in the field. A ground grid underlays the plant area and collector field for personnel safety.

2.2.5 Water Requirements

The plant design has been guided by a need to keep water use as low as practical with the constraints of current technology. The plant water balance is shown in Figures 15 and 16. Water consumption is set based on the following considerations:

- Evaporative cooling will consume about 150 acre-ft of water per year;

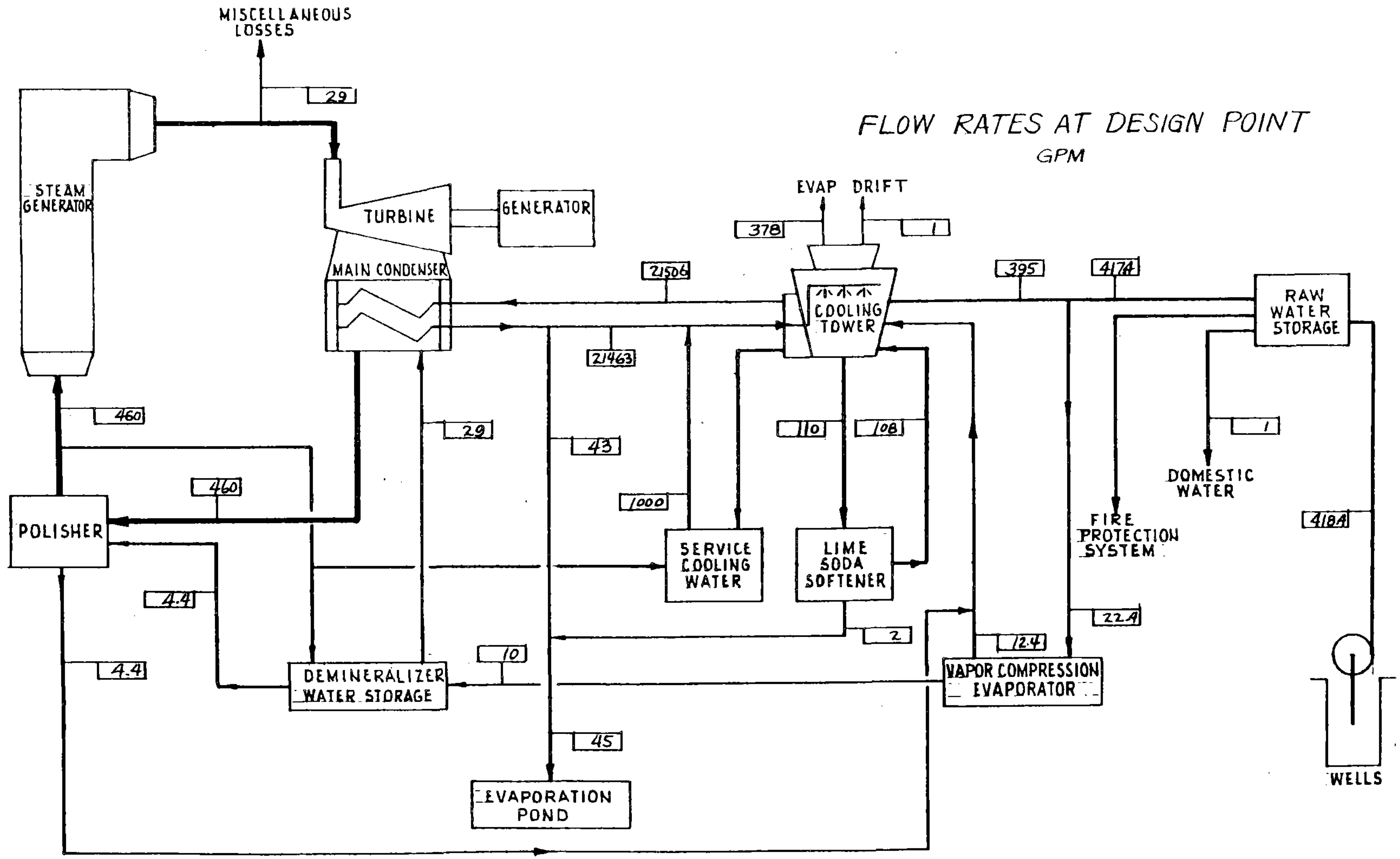


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Figure 15. Preliminary Water Balance — Design

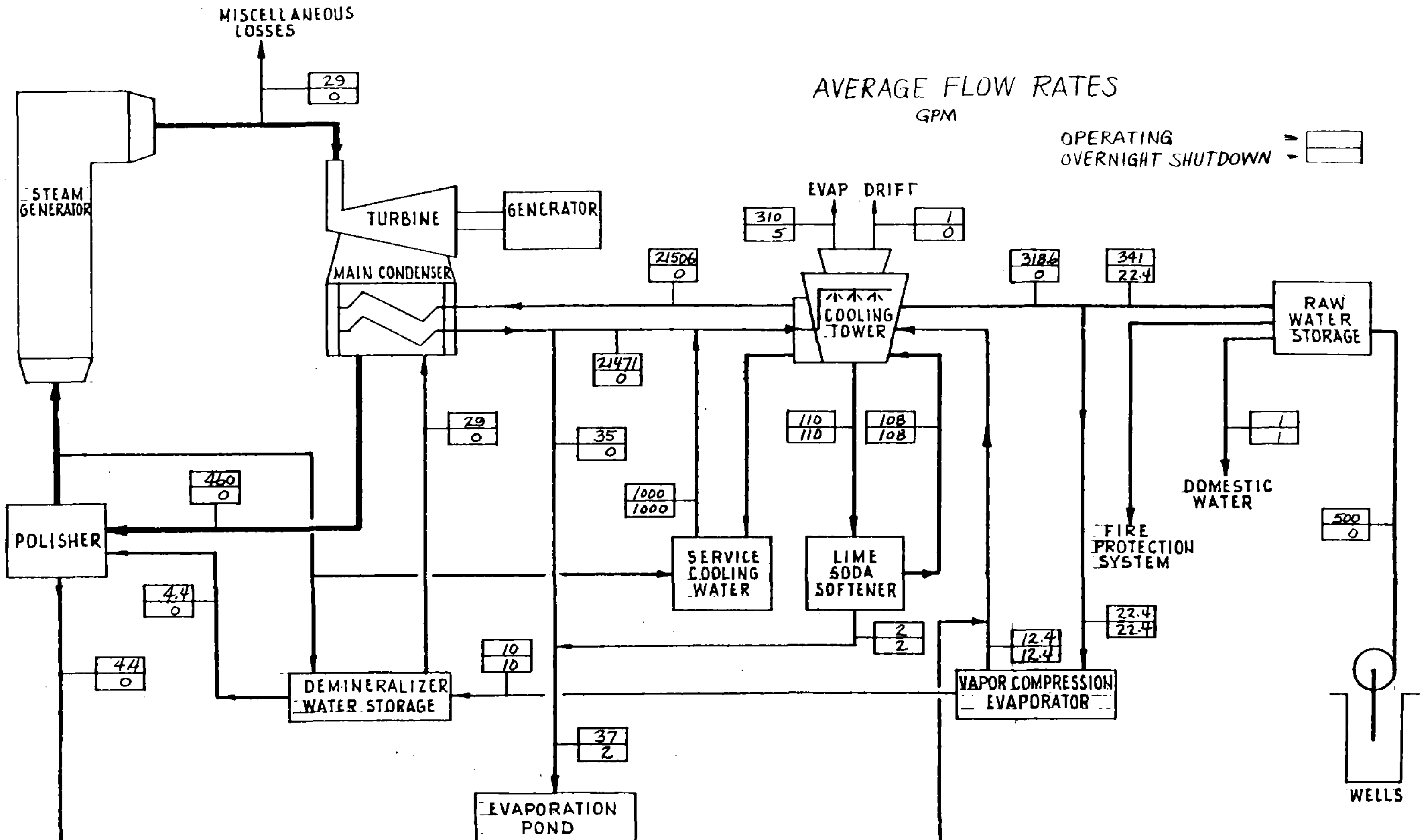

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Figure 16. Preliminary Water Balance — Average

- Limits on dissolved solids in circulating cooling water of about 2500 ppm (and more specific limits on individual species) must be maintained to inhibit scale formation;
- Water discharge rates must be consistent with mineral analysis of the groundwater available;
- Boiler makeup requirement of about 7 gpm (annual average) must be satisfied; and
- Disposal of blowdown must be provided for with an evaporation pond.

Within these constraints, overall plant water consumption has been reduced to 185 acre-ft/yr, which is the lowest practical consumption.

The water flow network consists primarily of the circulating water (main cooling) loop, the steam-condensate-feedwater loop, and the service cooling loop. These are illustrated in Figures 15 and 16. Evaporation and blowdown in the circulating water system are made up with raw water. Side stream cold lime-soda softening is provided on this loop. Purified water is made in vapor-compression evaporators and stored for boiler-feed makeup and for demineralizer regeneration.

The circulating water system operates at the highest impurity concentration possible without danger of scaling in condenser or cooling tower. Salts entering the network in raw water are disposed of in the evaporation pond, either directly in blowdown or indirectly via the lime-soda softener. The amount of blowdown can be used to control the total dissolved solids concentration and the side-stream softener to control calcium-magnesium hardness and silica. The cooling tower will operate at 9 to 10 cycles of concentration of raw water. In this plant, the blowdown is about 18 acre-ft per year, requiring a 7-acre evaporation pond. Operating at only 3 cycles of concentration would allow the elimination of the softening system, but would increase the blowdown to 50 acre-ft per year. This option was rejected due to the increased water consumption.

2.2.6 Plant Utilities and Other Auxiliary Equipment

The Carrisa Plains Solar Central Receiver Power Plant utilities requirements are expected to be similar to those of a typical fossil-fired plant of equivalent rating. These utilities include electricity, fuel oil, gasoline, petroleum products, hydrogen, water, sanitary sewer, telephones, and waste disposal. There are also a number of auxiliary equipment items described in this section.

2.2.6.1 Plant Utilities

Plant electrical utility requirements will be supplied from plant output during operation and from the PGandE grid during nonoperating hours. During nonoperating hours, the peak total plant load is approximately 2400 kWe and occurs during plant startup, most often in the early hours of the morning. The average nonoperating plant load is approximately 800 kWe, of which the biggest single element is the electrical trace heating required to keep the sodium-containing components above the 220°F freezing point of sodium.

Number 2 fuel oil (19,600 Btu/lb LHV) will be required by the plant on a daily demand for the auxiliary steam supply system (see Section 2.2.5.2). This system is rated at 3 MWt and requires a flow of 65 gal/h of oil at full power. Full power operation is expected to occur less than 700 h per year. A small oil tank of 9000-gal capacity will be on the plant site and is expected to be refilled by a commercial fuel oil supplier five times per year. Average fuel oil usage is expected to be 45,500 gal per year.

Number 2 fuel oil will also be required for the emergency diesel generator set (see Section 2.2.6.2) during periods when the grid connection to PGandE is interrupted or the grid is blacked out for any reason. This condition is expected to occur no more than four times per year with the duration of each occurrence typically less than 1 h. The diesel generator is sized to provide all vital plant loads during these outages and to allow the plant to achieve and maintain a safe shutdown status should the plant be operating during a grid outage. The diesel generator is equipped with a 750-gal day tank. Fuel flow at full power operation is 12 gal/h. The fuel for this day tank will come from the same tank that supplies the auxiliary steam supply boiler. This fuel tank will also supply diesel-fueled plant vehicles and maintenance equipment. This use will turn over the tank inventory on a regular basis and help assure that the fuel in the tank is always usable in the diesel generator. The average diesel fuel usage is expected to be less than 1000 gal per year.

A diesel-driven fire pump will be provided as backup to the electric-motor-driven pump. It will be equipped with a 200-gal day tank. Annual consumption of fuel, mostly for periodic testing, will be less than 10 gal per year.

Miscellaneous petroleum products will be required by the plant to lubricate, cool, and insulate certain plant equipment. The largest demand for these products will be for lubricating oils and greases for rotating equipment, especially the turbine generator. The turbine has its own lubricating oil transfer and storage system. Dirty oil will be disposed of by a commercial disposal service via truck to approved disposal or reclaiming facilities. Makeup oil will be supplied by a commercial source. Other miscellaneous petroleum products include greases and lubrication oils which will be supplied as needed from commercial sources, stored in appropriate containers such as 55-gal drums, and, when used, hauled offsite for disposal by a commercial disposal service. Transformers and other high-voltage switchgear located on the plant site will require insulating and cooling oils. It is anticipated that these fluids will be supplied with the transformers and switchgear and will not require replenishment or disposal during the life of the plant.

The Carrisa Plains Power Plant is expected to consume 185 acre-ft of raw water per year. The usage of this water was discussed in Section 2.2.4. Disposal of waste water will be via evaporation from a 7-acre sealed-bottom evaporation pond located onsite. A 17-in. buildup of sludge (salt) will occur over the life of the plant.

A cryogenic nitrogen supply will be stored onsite for use in filling the turbine and condenser each night to prevent corrosion. This nitrogen will be discharged in gaseous form to the atmosphere each morning. Annual consumption is estimated to be 5×10^6 scf.

Fifty-gallon containers of hydrazine and ammonium hydroxide will be maintained onsite for injection into the condensate, feedwater, and steam systems for corrosion control.

Sanitary sewer service will be required by the plant for the disposal of nonhazardous sewage. This service will be supplied by a package sewage treatment plant in full compliance with all applicable regulations.

Hazardous waste will not be disposed of onsite. It will be hauled offsite by licensed commercial disposal firms for disposal at approved sites. Sodium and its combustion products are discussed in Section 4.1. Feedwater treatment chemicals are discussed in Sections 2.2.4 and 2.2.6.2. Transformer fluids and petroleum products have already been discussed in this section. Nonhazardous waste will also be hauled offsite for disposal in approved county land fills by a commercial disposal service. The volume of nonhazardous waste is expected to be modest during plant operations.

Telephone service to the plant will be supplied by the local telephone company (Pacific Bell). It is not yet known whether the in-plant phone system will be leased or purchased. Additional communications at the plant will be via portable radio and public address system.

2.2.6.2 Auxiliary Equipment

Several auxiliary equipment items will be required by the plant which are not described in other sections. These include the auxiliary steam supply system, condensate polishing system, plant emergency electric power system, and compressed air system.

The auxiliary steam supply system supplies steam to plant auxiliary equipment, including feedwater heating during startup, deaerator pegging steam, hotwell deaeration, building heating, and main turbine shaft sealing. The output of this system is saturated steam at 455 psig (460°F). Two boilers are anticipated, each with the capability of providing 3.4 million lb/h of 470 psia steam.

The function of the condensate polishing system is to remove practically all the impurities from the condensate, thereby protecting the steam system from scaling, corrosion, and failure. The system consists of two mixed-bed demineralizers, acid and caustic storage tanks, acid and caustic regenerant pumps, acid and caustic day tanks, a neutralization tank and pump, and distilled water transfer pumps. The beds will contain a mixture of anion, cation, and inert resin beads. As the condensate passes through these mixed beds, the resins will release hydrogen ions and hydroxide ions in exchange for the water's impurities. These ions will combine to form pure water, further increasing the condensate purity. The beds will be periodically regenerated at night by back flushing and regeneration fluids. Regeneration waste water will be neutralized and then mixed with the cooling water supply.

The purpose of the extraction, drain, and vent system is threefold. It extracts steam from various stages of the turbine and transports this steam to feedwater heaters. It drains condensed steam from the feedwater heaters, and it vents noncondensible gases which accumulate in the steam system due to dissolved gases in makeup water and in-leakage. Each leg of the extraction and drain system handles between 11,000 and 20,100 lb/h of steam or condensate. The vent system collects and transports noncondensible gases from each feedwater heater to the condenser or the deaerator where the gas is removed from the cycle and vented to the atmosphere.

The lube oil transfer and storage system provides for oil transfer to the lube oil reservoir for use in the turbine generator operating system and purifies the oil to protect the turbine from impurities and water contamination. The turbine-generator reservoir storage capacity is 1800 gal. Lube oil purifier flow is 225 gal/h. The system is surrounded by a gravel blotter to retain minor spills and a berm to retain the entire system contents in case of tank rupture or spill.

The plant emergency electric power system consists of a 500-kW, 480-V, 3-phase, 60-Hz diesel generator which is appropriately connected to supply emergency power to the following loads in the event of loss of normal AC power: the heliostat inverter power supply, master control, and other essential loads.

The plant's compressed air system will provide a clean, dry, oil-free pressurized source of air for the instrument and service air systems. The air will be supplied at a minimum pressure of 80 psig. The instrument air system will have an uninterruptible supply. The service air will be used for cleaning, maintenance, and for powering pneumatic tools. The compressed air system consists of two 105-scfm, 100-psig compressors, two aftercoolers, and one air dryer. The compressors will be cooled with service water and equipped with inlet silencers. The system will also include an air receiver to reduce the compressor duty cycle. The air compressors will be housed in a completely enclosed room.

REFERENCES

2-1 Jennings, C. W., Fault Map of California: California Division of Mines and Geology, Geologic Data Map No. 1, 1975

2-2 The Land Use Element of the San Luis Obispo County General Plan, September 22, 1980

2-3 San Luis Obispo County Engineering Department Report, "Hydrologoic & Climotological Data," December 1976

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3.0 ANCILLARY FACILITIES

Ancillary facilities are defined as all offsite facilities either temporary or permanent. For this plant, the only offsite facility will be the high-voltage transmission line connecting with the existing 115-kV line running east-west 1 mile north of the site. The interconnection tap will be described in Section 2.2.4. The transmission line routing is as shown in Bechtel Drawing SKA-001 (Appendix). The right of ways are in the process of being negotiated with the owner of Section 26 (Mr. Beck) and with PGandE as part of their current access.

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4.0 PLANT ENVIRONMENTAL CONCERNS

Although the environmental impact report (described in the foreword to this document) will provide a comprehensive analysis of impacts, the consideration of the effects of the Carrisa Plains Power Plant on the environment has been an integral concern throughout the design phase. Where feasible and justified, impacts have been mitigated to the extent technically and economically possible. The following sections discuss these impacts.

4.1 SODIUM HANDLING

The presence of substantial quantities of sodium in the Carrisa Plains Solar Power Plant is a unique design aspect which can have potential environmental impacts. The decision to use sodium as the plant coolant was made in full awareness of the need to maintain stringent safeguards to protect the environment, plant employees, and the local populace. Even with the need for these safeguards, sodium remains the choice for this application. Attributes of sodium which influence this choice include the following:

- Excellent thermal properties: allows a compact and highly efficient solar receiver design and smaller and less costly heat transfer equipment.
- Excellent thermal stability: makes possible high temperature operations and high plant efficiences and eliminates the need for costly materials of construction and reprocessing or replacement.
- Extensive technical experience base: major plant components previously tested and available having predictable performance and high reliability.

All of these factors contribute to making the plant economical. Sodium has been used in other facilities with an excellent safety record. The Rockwell Energy Technology Engineering Center in Canoga Park utilizes sodium at similar temperatures and pressures. It should be understood that the sodium in this plant is, under normal circumstances, completely isolated from the environment by a welded containment (pressure) boundary. Releases of sodium to the environment can occur only under infrequent abnormal conditions. As a design goal, these conditions are to be avoided both for environmental and safety reasons. For example, one can envision a sodium release occurring when a weld in the containment boundary develops a crack and begins to leak. The leaking sodium can begin to burn in air and release sodium oxides to the environment. While such events are rare, they are not impossible and must be taken into account in designing a plant using sodium.

Sodium hazards are caused by sodium's formation of a highly caustic reaction product, sodium hydroxide, on reaction with air and water. This caustic can cause damage to skin, particularly mucuous membranes, and equipment. Occupational exposure limits have been established at 2 mg/m^3 for routine (long-term) exposure, and 80 mg/m^3 at Rockwell's test facilities for acute (short-term) exposure. Exposure at 2 mg/m^3 will cause noticeable discomfort, for example on the skin, so the individual who may be exposed requires no external warning device of a potentially hazardous condition. The caustic is readily washed off; hence, the first step in treatment is to flush exposed areas with water. The resulting skin burns or lesions should receive medical treatment. There is no continuing toxicity or other hazard associated with exposure to sodium-derived caustics.

Release of sodium to the environment causes some short-term impacts but no long-term effects. The sodium oxides and hydroxides formed on release are converted to sodium carbonate, a generally innocuous material, by reaction with the carbon dioxide naturally found in the air.

A two-pronged approach has been adopted to reduce the potential impact of sodium releases in the environment. The first is to reduce the likelihood of a release occurring. The second is to reduce the consequences of a release if it does occur. These factors together produce a safe plant and one which does not burden its environment unduly.

Reduced likelihood of sodium release is generally achieved through careful design. Design practices which have led to safe operation relatively free of sodium releases in similar facilities in the past have been incorporated, and active attention to plant safety has been made in equipment arrangement, operations planning, and other design activities. The second step in sodium safety is to be prepared to deal with an emergency if it occurs. This requires that the necessary planning be done, the needed equipment be made available in the plant, and the plant personnel be given the right training to cope with these emergencies.

To implement these objectives, a complete sodium safety plan has been developed for the Carrisa Plains Plant.[4-1] This plan provides a description of safety and control provisions to be implemented for sodium systems. Some of the major items are discussed below. Most address the need to reduce the impact of sodium flammability.

The sodium loop is designed so that components can be easily isolated or shut down in case of emergency and drained of sodium. This will allow an on-going leak to be stopped rapidly by removing the supply of sodium. A special below-grade dump tank is provided to make drainage of components rapid and complete.

Drip pans, berms, and vessels will be provided to control sodium leaks and protect nearby personnel and equipment. The leaking sodium is thereby restricted to a confined area where fire-fighting procedures can be brought to bear effectively to stop further release of sodium oxide combustion products to the environment.

Ventilation of the enclosed sodium operating area is required when a sodium fire occurs. The only enclosed area that will be directly subject to sodium leaks is the receiver area on the tower. A complete ventilation system will be installed on the tower to disperse sodium oxide smoke and to protect workers in case of a leak. Although not a sodium operating area, the control room will be adequately sealed and ventilated so that smoke will not collect in the room and endanger plant operating personnel during a sodium leak.

Sodium leak detectors will be placed near each critical component, both at ground level and in the solar receiver tower. This will help pinpoint sodium leaks rapidly and allow countermeasures to be taken to stop releases to the environment. Smoke and heat detectors will be placed on the ceiling of the enclosed tower area, as well as at each metal-grating floor level. All detectors will be tied into an alarm system in the control room, and the detectors in the tower will activate a warning light at the tower entrance to caution unprotected workers to stay out.

Leak detectors within the plant boundaries will also identify leaks that might endanger public safety in the surrounding area. An atmospheric model study[4-2] has shown that, for a major leak, sodium combustion products can be deposited out to about 300 m downwind of the release point, which, depending on wind direction, could be beyond the plant boundary. Plant operating personnel will notify local law enforcement officials if evacuation of areas outside the plant boundaries appears to be necessary. A pre-planning session will be held with local officials to develop an evacuation plan. Evacuation of the public from the area surrounding the plant is expected to be an extremely unlikely event.

Repair personnel working in the vicinity of the sodium loop will be required to wear protective clothing, including goggles, face shield, hard hat, leather shoes, and flameproof coveralls. A half-face filter mask will be carried for escape use in emergencies. Workers in other sections of the plant will not be required to wear special sodium protective clothing, although they will have hard hats, safety glasses, and leather shoes as one would expect at any industrial facility. Safety showers will be located in the vicinity of the sodium loop for removal of sodium from skin and eyes.

Controlling a sodium fire requires some specialized equipment but is generally not very different from putting out other kinds of fires. All required specialized equipment will be stored in conspicuous locations at the Carrisa Plains Power Plant, and training will be provided in their use. A Class D fire-fighting agent (Na-X) should be used, as opposed to more common types. Na-X fire extinguishers provide sufficient powder that quickly and safely brings a sodium fire under control. While fighting a sodium fire, fire fighters should be protected with coveralls and gloves to avoid contact with fumes from the fire. Safety showers and eyewash stations are provided in the event of skin contact.

Lastly, disposal of the fire residue is performed after the sodium has cooled and solidified, as solid sodium is essentially nonflammable in air. Specially marked storage bins are used to collect and ship offsite any residues collected.

4.2 SOLAR REFLECTIVITY AND HEAT ZONES

A single heliostat mirror presents little or no reflection hazard, since it can deliver sunlight only at about the intensity of the sun. Hazardous conditions can occur only when multiple mirrors focus on the same spot. Taken together, these can generate 1000 times or more the sun's intensity. The solar safety strategy to be used at the Carrisa Plains Plant is based on the control of zones at which this intensification will occur within the plant site and air space. In that way, the public will not be exposed to high-intensity sunlight. During nonoperating periods, heliostats are stored in a nearly vertical position facing southwest. This arrangement in parallel rows aligns the heliostats with the prevailing wind. In this position, any reflected sunlight is directed into the ground during the early morning hours, and, from mid-morning on, the mirror surfaces are shaded.

On operating days, the heliostats will be programmed to focus together and follow an imaginary line offset to the east of the tower from below ground to a series of aim points above the receiver. This procedure is called a "wire walk" and has been used safely both at the Solar One facility near Barstow and the Central Receiver Test Facility near Albuquerque. This approach ensures that the beams diverge beyond the focal point until the reflected energy is no greater than the incident sunlight. This point is the same distance from the focal point as the focal point is from the heliostat. The heliostats are programmed to follow the wire walk in a sequential fashion, with outer rows operated first and inner rows last. By using this sequence, the inner rows tend to block the reflected beams from the outer rows until the focus points are well above ground level. The standby focus points near the top of the tower form a circular segment (partial ring) to the east and north of the tower with a radius of 200 ft. This partial ring standby aim arrangement gives a distributed focus region and has reduced energy density near the top of the tower compared with a focused-point aiming used at other facilities. The lowered energy density will reduce the potential danger to insects and birds. Once the heliostats are at the standby ring, movement is by straight line to the receiver target. Movement between the target and the ring occurs as necessary to provide the power to the receiver. At the end of the day, the heliostats are programmed to move down the wire walk to the vertical stow position. During good weather, the wire walk movement will occur before sunrise and after sunset; hence, frequently no focused energy will be present when such focusing could be close to ground level. The standby focus location will cause the beam intensity to drop to that of incident sunlight at approximately twice the tower height. Aircraft flying above the legal altitude with respect to the tower will, therefore, face no hazard.

For high wind conditions, an alternative face-up stow position may be provided. Movement to this position from the normal stow position is accomplished by moving all heliostats in unison until the heliostats are in the horizontal position. During this operation, the heliostat beams remain parallel.

Solar One has looked carefully at the effect of the receiver reflectively and the heat zones around the receiver. Addressed specifically in this section is receiver reflectivity. Heat zones are covered in the next section under wildlife interaction.

The values of maximum retinal irradiance for the Solar One receiver image were found in Reference 4-3 to be sufficiently low that no retinal damage could occur. In all cases that the reference considered, the maximum irradiance was less than 0.016 W/cm^2. This is a factor of 60 below the recommended maximum permissible exposure (MPE = 1.0 W/cm^2) for a momentary glance (0.15 sec) for any image size; furthermore, it is a factor of 6 below the MPE for continuous viewing (0.1 W/cm^2).

For the Carrisa Plains 30-MWe Power Plant, the analysis would be similar. The maximum possible retinal irradiance would be proportional to the maximum flux incident on the receiver. The resultant irradiance would be

$$Irr = 0.016 \frac{W}{cm^2} \times \left(\frac{1200\ W/m^2}{300\ \ W/m^2}\right)$$

$$Irr = 0.048\ W/cm^2$$

The maximum irradiance would be a factor of 2 below the recommended continuous viewing range of 0.1 W/cm^2. It is not recommended, however, that the receiver be looked at continuously. In addition, the receiver will be facing north away from the road which will provide extra protection.

4.3 WILDLIFE INTERACTION

Wildlife interaction at the Carrisa Plains Plant is expected to be limited to slightly increased mortality of local birds and insects.

The experience at Solar One has indicated that the impact of this type of plant on birds is minimal. The primary impact is due to avian collisions with structures. Incineration of birds in the standby points contributed fewer mortalities than did collisions. In all, it was concluded that as many as 60 birds may have died as a result of Solar One operation over a 14-month observation period. It is expected that this number will represent an upper limit of avian mortality at Carrisa Plains. Solar One is located in close proximity to about 123 acres of open water and to irrigated fields which attract a large, diverse population of birds to the area. Carrisa Plains is not expected to attract many birds due to the relative scarcity of open water in the area. The only open water anticipated in the area will be the 7-acre evaporation pond for the plant. Due to its high salinity, the evaporation pond is not expected to be attractive to birds. Most cultivation in the area around Carrisa Plains is dry farming. The two plants are comparatively equivalent in terms of the size, type, and number of structures. Therefore, the incidence of avian collisions is expected to be no greater at Carrisa Plains than at Solar One. The size of the small birds that could be killed and their quantity would not constitute carrion that would attract Condors.

Two endangered species are of particular concern at Carrisa Plains — California Condors and Sandhill Cranes. Condors do not nest in the Carrisa Plains area, but they have been known to forage in the southern Carrisa Plains (to the south of the plant site) and in the San Juan Creek area (to the north of the plant site). However, condors tend to follow the foothills or ridgelines to take advantage of thermal updrafts, so it is more likely that they would traverse the hilly areas to the east or west of the plant than fly over the plant itself when travelling from one foraging area to the other. Two areas in the Panza Range to the west have been set aside as potential condor nesting areas, should the species ever recover sufficiently to expand its nesting range.

The height at which the condor flies can vary depending on weather condition, but it can be assumed that at various times it will be both above and below the 500-ft tower height. It is possible that a condor could fly into the receiver tower, but it is not very probable since condors are not known to collide with large objects. It is more likely that a condor might strike an electrical transmission line, which has been known to happen in the past. However, two transmission lines already pass through Carrisa Plains, so the construction of the solar plant, including the addition of 2.0 miles of a 3-wire transmission line, will not significantly change the probability of collison.

It has been noted that most of the bird fatalities at Barstow were due to collisons with structures (the remainder were incinerated by the solar beam). However, virtually all of these birds feed on flying insects, so their flight patterns are significantly different from those of the condor. Condors feed on carrion, so they would not be expected to fly through the heliostat field in search of food. Any carrion found in or near the plant will be removed to avoid attracting condors.

Condors are not water fowl and are not expected to be attracted by the ponds associated with the power plant. They are usually frightened by vehicles and people, so they would probably be hesitant to land even if they sighted any carrion, and no carrion is likely at the plant site.

Sandhill Cranes, the other endangered species of interest, use Soda Lake on the southern Carrisa Plain as a major wintering area. They may also winter in any wetlands, streams, or ditches in the project area. While these birds are not particularly rare, their habit of wintering in concentrated flocks in a few areas makes them susceptible to conversion of these habitats to other uses. Similar migratory birds (Canada Geese for example) have been observed at the Barstow solar facility, and none have been known to be killed due to power plant operation (i.e., collison or incineration). The Carrisa Plains Solar Thermal facility will not provide wetlands, streams, or ditches that are considered attractive to Sandhill Cranes or similar migratory birds. The raw water pond and the evaporation pond are not expected to attract cranes or other water fowl due to the proximity of human activities.

With regard to insect interactions, the experience at Solar One is directly applicable. "Almost all cases of incineration at Solar One involved aerial insects. These incinerations appear as small flashes of light within the standby points (four areas in close proximity to the receiver where the beams of sunlight are concentrated) accompanied by a brief trail of white vapor."(4-4) The concentration of sunlight in the standby ring at Carrisa Plains is expected to be lower than Barstow due to its larger volume. Insect incineration rates as high as 7059 insects per hour have been recorded at Solar One. It is expected that, based on the experience of Solar One, many thousands of insects will be incinerated during the warmer months of the year. The rate of insect incineration is expected to be proportional to the concentration of insects in the vicinity of the receiver and the presence of the standby ring.

4.4 SEISMIC DESIGN CRITERIA

The Carrisa Plains Plant is being designed to a seismic standard more stringent than that required by applicable codes and regulations. To develop this standard, geologic and seismologic investigations were conducted, and site-specific vertical and horizontal ground motion spectra were developed for an earthquake of Richter magnitude 7.5 occurring on the San Andreas fault at its closest approach to the site. Detailed design of equipment critical to plant safety and integrity after an earthquake will be performed to this standard. The equipment includes the following:

1) Equipment whose prompt operation is required to bring the plant to a safe shutdown following a seismic event

2) Equipment that cannot be placed back in partial or full service within 90 days in the event of its significant damage due to a seismic event

3) Equipment that could be expected to cause substantial secondary damage to the plant and/or significant risk to the local population and/or plant personnel

4) Equipment for which industrial or utility experience in performance during a seismic event has been either too limited to assess their impact on plant operations or has been generally negative.

Other equipment and structures will be designed in accordance with national consensus standards, generally the Uniform Building Code for Seismic Zone 4.

4.5 ONSITE EMERGENCY EQUIPMENT AND PERSONNEL

All plant personnel will be trained in standard fire emergency procedures (evacuation routes, use of fire extinguishers, basic first aid, etc.) as well as in the specific techniques required to extinguish sodium fires and to administer first aid for sodium burns. It is important that fire fighters practice controlling sodium fires, since the materials and techniques involved are unusual. Therefore, each employee will have the opportunity to participate in training drills involving burning sodium. Local (State Division of Forestry) fire fighters will also be requested to participate in these drills.

Protective gear for fire fighting will be available at a central location such as the control room. Protection for fire fighters will include eye protection, head protection, foot protection, body protection, gloves, and self-contained respiratory protection. Only those individuals wearing complete firefighting gear will be allowed in the vicinity of a sodium fire; all others will be evacuated to a safe location. Escape routes and exits will be clearly marked, and evacuation drills will be conducted on a periodic basis.

A sodium fire is generally extinguished by the removal of oxygen and cooling of the sodium below the melting point. Extinguishing agents normally used in conventional firefighting must not be applied to sodium fires because violent reaction may result. Therefore, common extinguishing agents will not be placed in the vicinity of the sodium loop.

The required extinguishing agent for sodium fires is Na-X powder, which is composed of sodium carbonate, stearates, attaclay, and nylon. Na-X will extinguish sodium fires at temperatures up to 1400°F. The Na-X powder is applied first in a thin layer since it tends to fuse and form a crust over the burning sodium. Additional layers are then added to further blanket the fire.

Na-X fire extinguishers will be located near the sodium pumps and steam generators, on elevated walkways in the vicinity of all valves, near the sodium storage tanks, and at all levels in the enclosed portion of the solar receiver tower. The Na-X available for initial application to a sodium fire will be supplied in 30-lb extinguishers since they are light and easy to handle in an emergency. Additional Na-X will be stored in covered drums or buckets, or in 150-lb or larger extinguishers stored at the facility.

An onsite water spray fire protection system will be provided for the nonsodium portion of the plant, using the cooling tower basin for storage.

An electric-motor-driven pump will start automatically from a pressure signal due to the drop in line pressure when any water spray device is actuated. A small jockey pump will keep the system pressurized under nonfire conditions. A diesel-driven fire pump will be provided as a backup to the motor-driven pump.

The main underground fire header will loop the plant, serve strategically placed fire hydrants, and supply deluge or sprinkler systems for the main transformer, cooling tower, steam turbine lube oil, and control and maintenance building.

4.6 OFFSITE EMERGENCY SERVICES

An accident at the power plant could potentially affect local fire, police, and medical emergency services. All plant personnel will be trained to extinguish sodium fires as well as minor conventional fires, but it is anticipated that the California Division of Forestry's California Valley-Simmlar Station will be called for assistance on all but the most minor incidents. Local fire personnel will also be requested to participate in sodium fire-training sessions, and it is expected that they will conduct periodic fire safety inspections of the power plant.

The fire station may be expected to provide emergency first aid services in the event of accidental injury or sudden employee illness (heart attack, etc.). County ambulance services may also be required in some cases. It is presumed that emergency ambulances will come from San Luis Obispo or Bakersfield.

As mentioned in Section 4.1, no sodium fire reactants are ever expected to disperse beyond the site boundaries. However, the participants will work with the local sherriff's department and California Highway Patrol on procedures for notification of any large sodium spill or any other event that might cause a hazard in the immediate vicinity, particularly the Carrisa Plains school and neighboring residences.

4.7 WATER AVAILABILITY

The project will not use water in a way that interferes with or adversely affects existing users in the plains. This is not a prediction. This is a project guideline. A preliminary evaluation of available hydrologic information has been conducted. On this basis, there is no reason to assume existing users will be adversely affected. The Carrisa Plains plant will consume approximately 185 acre-ft of groundwater per year. Estimates of current groundwater usage in the Carrisa basin range between 600 and 1000 acre-ft/yr;[4-5,4-6] therefore, total usage including the power plant would increase this range to between 800 and 1200 acre-ft/yr. The recharge rate in the Carrisa basin has been estimated to be equal to the "maximum safe yield" of 1000 acre-ft/yr,[4-6] presumably because water levels in the basin have not declined over a 25-year period[4-6] (p. 214). However, inasmuch as water levels in the basin are quite shallow and have not declined over time with continued water usage, it is expected that additional usage can be accommodated without significant detrimental effects.

Nevertheless, the plant will increase the rate of use of groundwater and therefore contribute to the demand on a limited resource. Accordingly, plant water consumption has been minimized by design. Further, all technically reasonable options to the baseline cooling approach, i.e., evaporative cooling, have been considered and evaluated. Evaporative cooling is the best approach based on available information.

A survey of available geological groundwater and water quality data will be conducted by the project sponsors to attempt to better define aquifer characteristics and groundwater conditions in the site area. The planned well at the site is at least 3/4 mile from the nearest existing well. Several additional wells occur within a radius of about 1 mile. If further study results indicate that existing users may be adversely affected, design changes or other remedial action to the extent justified will be implemented.

Because project participants have an interest in future plants of this generic type, they are actively studying advanced designs that reduce water requirements of central receiver power generating systems to negligible amounts. The concepts under study are not technically ready for implementation and require several years of active research and development before they could be considered for a demonstration plant.

4.8 CONSTRUCTION RUNOFF

The area to be disturbed during construction is approximately 300 acres. It includes the heliostat area and the plant area. The latter is defined as the area within the perimeter road and includes the cooling tower. Earthwork will be balanced with respect to cut and fill, i.e., site material will be used for backfill except for granular material. Granular material will be imported and used for backfill around buried piping and around sumps and pits, and for surfacing.

The heliostat area will receive a minimum of earthwork. The top soil will be compacted in place with sheepsfoot and rubber tire rollers except under the roads. Minor grading if any will be done in approximately one-third of the heliostat area for drainage control. Existing drainage patterns will be left largely intact as explained later.

Approximately 2 ft of top soil will be removed from the plant area. It will be replaced with an average of 4 ft of fill (primarily clay) obtained from excavation for the evaporation pond and the raw water storage pond. Top soil will be stockpiled in a strip running north-south along the west side of the property. Finish grade will be from 1 to 3 ft above existing grade in the plant area.

In a hydrologic evaluation of the site, no well-defined channels were observed, contrary to the indications on the USGS California Valley topographic map. A small, shallow swale does cross the boundary between sections 26 and 35. However, there is no evidence that the swale has conveyed discharges of more than a few cfs. The swale separates into two parts: one toward the southwest corner of the site and the other toward the southeast corner.

Drainage of the site will be maintained in a fashion resembling its natural state. It will be diffused, yet controlled. Grading in the heliostat area will direct runoff to the swales. This runoff could reach Highway 58 by following existing patterns as it now does during infrequent periods of rainfall sufficient to saturate the soil and exceed its storage capacity. The area in question is relatively flat with no more than a 2 percent slope. In these conditions, neither erosion nor suspended solids from disturbed areas are expected to be a problem. Runoff patterns will remain basically unchanged.

4.9 CARRISA PLAINS SCHOOL

Discussions have been initiated with the Atascadero Unified School District regarding possible increased enrollments at the Carrisa Plains school (K-8) that might result from the project. These discussions are expected to result in an agreement between the project and the school district for the mitigation of potential impacts on the school capacity that are caused by the project.

REFERENCES

4-1 McDade, C. E., and Scofield, P. A., "Sodium Safety Plan - Carrisa Plains Solar Central Receiver Power Plant," Rockwell International Report 079TI000007 (1983)

4-2 Wang, I. T, and Lauer, G., "A Mathematical Model for the Fallout of Particulate Matter and Its Application to the Combustion of Sodium Aerosols," Rockwell International EMSC Report (1980)

4-3 Brumleve, T. D., "10 MWe Solar Thermal Central Receiver Pilot Plant: Beam Safety Tests and Analyses," SAND 83-8035, to be published

4-4 McCrarym, M. D., et al., 84-RD-5, "Wildlife Interactions at Solar One: Final Report," January 1984, Southern California Edison Co., Rosemead, California

4-5 The Land Use Element of the San Luis Obispo County General Plan, September 22, 1980

4-6 San Luis Obispo County Engineering Department Report, "Hydrologic Climatological Data," December 1976

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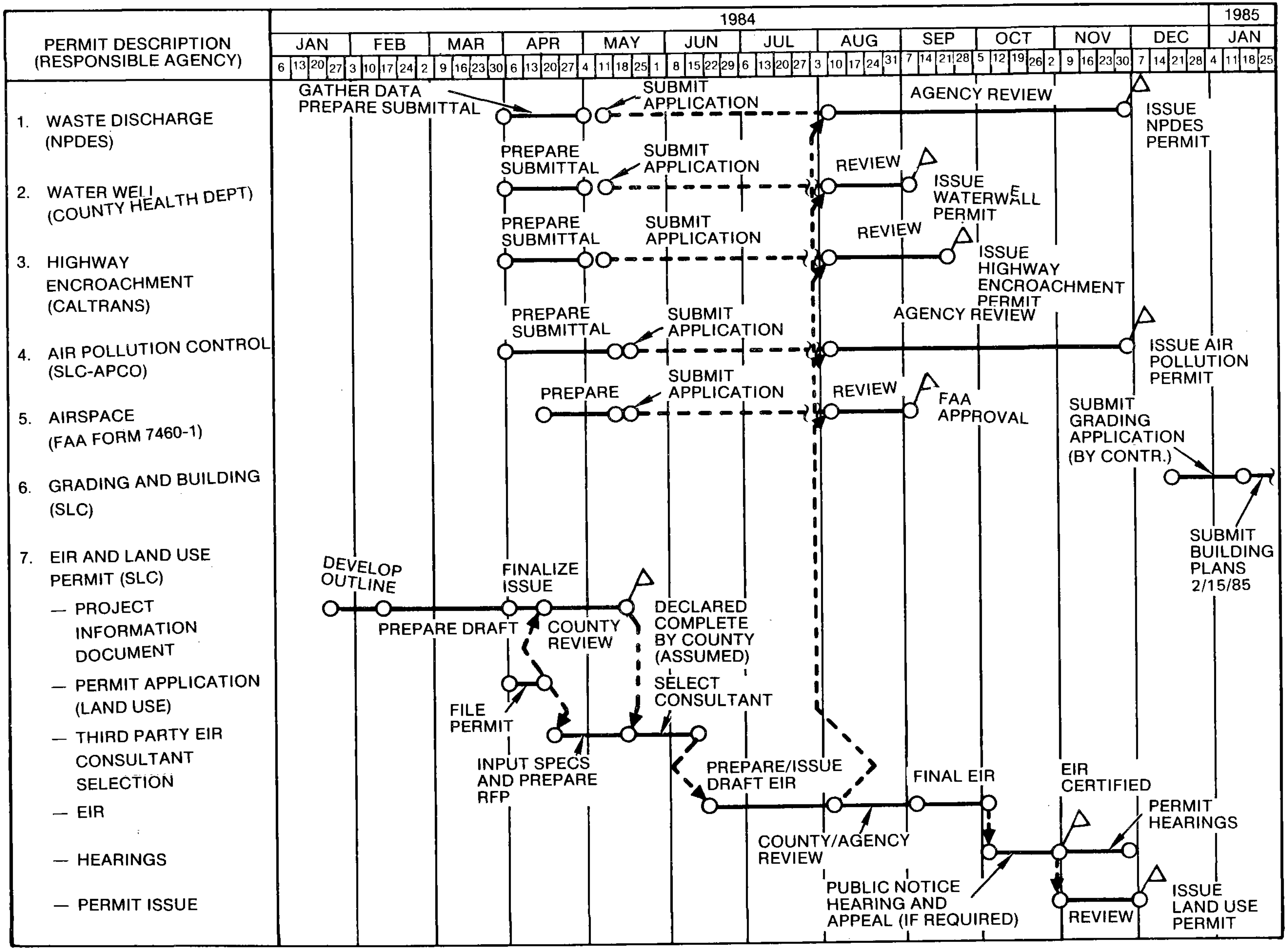
5.0 SCHEDULE

The overall project schedule is planned for initial power delivery to the grid in December 1986 and commercial operation by May 1987. Actual onsite construction would not begin until February 1985. The accelerated schedule is mandated by the fact that certain energy tax credits under existing legislation will expire on December 31, 1986, and on the need to be able to begin depreciation in the same fiscal year as construction is completed. As the plant is a demonstration-type plant rather than commercial size (100 MW), it is paramount that tax benefits be maximized in order to reduce utility or other subsidies required to demonstrate the capabilities of this second-generation solar power plant.

5.1 PERMITTING SCHEDULE

The schedule for the acquisition of all known discretionary and selected ministerial permits is shown in Figure 17. In order to achieve this schedule, the project participants are working with the county to expedite the permitting process. A Land Use Permit is essential for issuing the prospectus for raising the necessary capital for completion of engineering and construction activities. Not all the other permits are necessarily required in the time period shown but would be required before construction begins. The project participants reserve the right to delay acquisition of selected permits of lesser importance until after the Land Use Permit Hearing. We do not see this as a hindrance in Development Plan approval or in raising the necessary capital, as these permits are contingent on technical matters and do not have any significant potential for disapproval.



00-104762

Figure 17. Licensing and Permitting Schedule

5.2 CONSTRUCTION SCHEDULE

Figure 18 is an overall project summary schedule. Project go-ahead is not expected until February 1985, with the successful completion of capital subscription. Onsite mobilization will proceed immediately upon project go-ahead. The bulk of the actual construction activity is expected to occur over slightly less than a 2-year time period, peaking at approximately the mid-point. The last 7 months of the schedule will be mainly checkout activities, with only very minor construction activities going on during this time period. Sections 6.1 and 7.0 address workforce and traffic issues during construction.

Removal of construction equipment and temporary facilities will be completed in as expeditious a schedule as reasonable. Construction equipment will be removed from the site as soon as their use is completed. All temporary facilities will be removed upon completion of performance verification and the area restored to its original condition inasmuch as possible.

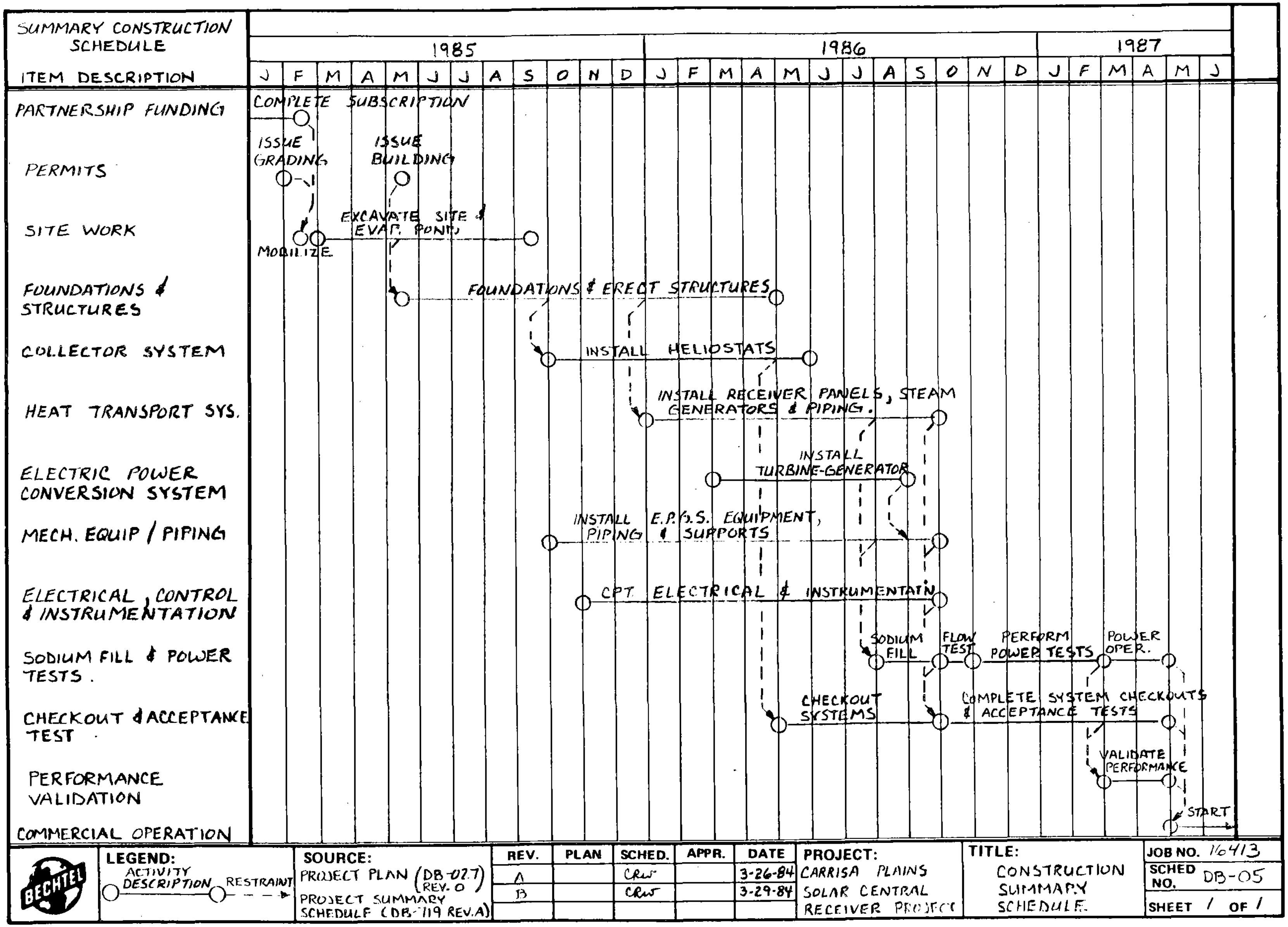


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Figure 18. Carrisa Plains Solar Central Receiver Project Plan

6.0 WORK FORCE

The work force has been broken into two aspects; the temporary construction work force and the permanent operating staff. Due to the rural nature of the area, the project sponsors will mitigate the impact of the additional labor force where and when possible if within reasonable cost.

6.1 CONSTRUCTION WORK FORCE

Table 4 is a schedule of the expected construction force that will be onsite. The work force is expected to peak out at 250 people at approximately two-thirds of the way through construction. It is expected that the work force will be drawn from the San Luis Obispo area or from the Taft area. However, some construction specialties may come from as far as the Bakersfield area or further.

TABLE 4

LEVEL OF CONSTRUCTION WORK FORCE BY TIME

Year	Quarter	Number of Workers
1985	1	100
	2	120
	3	180
	4	180
1986	1	220
	2	250
	3	250
	4	200
1987	1	40

As some commuting distances may be too far for daily commutes, it is expected that there will be a need for temporary housing. Spaces will be provided on the project site for construction workers who wish to provide their own mobile homes and recreational vehicles (RVs) for temporary living quarters. Approximately 40 spaces will be provided with water and electrical hookups. Either an RV sanitary dump facility or sewage hookups will be provided. A nominal fee will be charged for the spaces having hookups. Additional area will be without hookup and will be available free to any worker. Dumpsters will be provided free for use to the workers for all waste disposal, and the construction manager will be responsible for removal and general cleanup of the area. This free access will limit the incentive for workers to set up mobile trailers in unauthorized areas.

Because construction camp amenities on the site would be removed at completion of construction, Bechtel will explore with the San Luis Obispo County General Services Department the alternative of putting the construction camp on suitable county property. Should this be feasible, and should the county so desire, the amenities could be left intact after construction for use as a permanent RV and camping park.

6.2 OPERATING AND MAINTENANCE STAFF

It is expected that a total of 30 operating and maintenance personnel will be required for the plant during its operational phase. Six of these personnel will be supervisory or technical professionals. An operating and maintenance personnel breakdown is shown in Table 5.

TABLE 5

OPERATING AND MAINTENANCE PERSONNEL
REQUIRED FOR CARRISA PLAINS

Supervisory and Technical	6
Operations	10
Maintenance	12
Clerical	2
Total	30

It is expected that half of these personnel and their families will settle in the Carrisa Plains area and that the other half will settle in either the Bakersfield, Taft, or San Luis Obispo areas. Conversations have been held with the San Luis Obispo County Board of Education, and it has been concluded that 1.1 students will be added to the local school system for every family settling in the Carrisa Plains area, resulting in an increased enrollment of about 17 students.

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7.0 TRAFFIC ACCESS AND TEMPORARY EQUIPMENT

All access to the site will be via Highway 58. Equipment weights and dimensions have been reviewed, and Highway 58 has been determined adequate to carry all equipment. It is expected that the major traffic will be east of the construction site, although a significant portion of the labor force may come from the San Luis Obispo area. Heavy equipment and construction supplies are expected to come almost entirely from the east, either from the Taft or Bakersfield area. Figure 19 is an approximate timetable of major traffic activities. Table 6 is a summary of the extent of expected traffic. This is very preliminary but should be sufficient for purposes of the Land Use Permit.

The most noise-intensive phase of plant construction will be the period of site preparation, during which earthmoving equipment scrapes aside any unsuitable surface soils and specification grade fill material is hauled in and placed. Typical equipment involved in these tasks and associated sound levels is indicated on Table 7.

REFERENCES

7-1 Edison Electric Institute, 1978, Electric Power Plant Environmental Noise Guide, New York, New York

7-2 National Cooperative Highway Research Program, 1971, Highway Noise: A Design Guide for Engineers

7-3 U.S. Environmental Protection Agency, 1971, Noise from Construction Equipment and Operations, Building Equipment, and Home Appliances, Report NTIS 300.1, Washington, D.C.

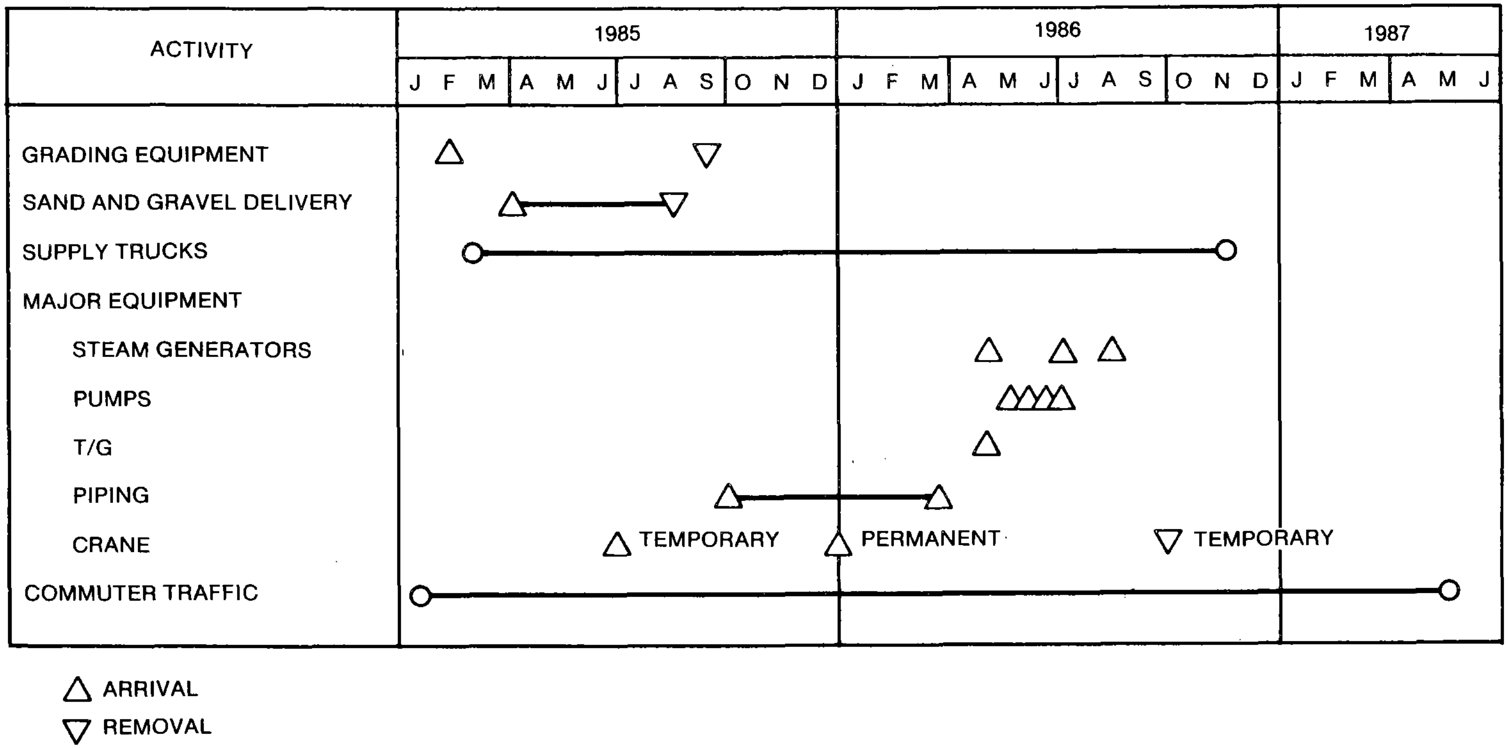

Figure 19. Time Table for Major Traffic Activities

TABLE 6

SUMMARY OF TRAFFIC ACTIVITIES

Grading Equipment	
Type (No.)	Scraper (2) Front shovel excavator (1) Grader (3) Front-end loader (2) Bulldozers (2) Dump trucks (3)
Concrete Batch Plant and Related Equipment	
Volume	22,000 yd^3
Type (No.)	Dump trucks (1000 trips) Front-end loader (1) Cement trucks (2)
General Equipment	
Type (No.)	Mobile crane (2) Forklifts (2) Supply trucks (3) Vans (2) Steel erection cranes (2)
Supply Trucks	
Type (No. of trips)	Semi (100) Flat bed (120) Small trucks (100)
Major Equipment Size Envelope and Weight	
Steam Generators	65 ft long x 10 ft high x 2 ft wide/21 tons
Pumps	20 ft long x 5 ft high x 5 ft wide/10 tons
Turbine Generators	20 ft long x 10 ft high x 12 ft wide
Pipe Spool Pieces	20 ft long x 10 ft high x 8 ft wide
Crane (permanent)	80 ft long (beams)
Commuter Traffic	
Number of vehicles, max/day	150 (one way)
Number or vehicles, avg/day	100 (one way)
Time of day, arrival	7:00 a.m.
Time of day, departure	3:30 p.m.

TABLE 7

SOURCES OF CONSTRUCTION NOISE

Equipment Item	Sound Level at 50 ft (dbA)	Reference
Scraper	87	Edison Electric Institute, 1978 (7-1)
Front Shovel Excavator	83	Edison Electric Institute, 1978 (7-1)
Grader	81	Edison Electric Institute, 1978 (7-1)
Front-end Loader	84	Edison Electric Institute, 1978 (7-1)
Concrete Truck	84	NCHRP, 1969 (7-2)
Backhoe	84	US EPA, 1971 (7-3)
Bulldozer	85	US EPA, 1971 (7-3)
Material Truck	84	NCHRP, 1969 (7-2)
Heavy Steel Erection Crane	91 (max)	Edison Electric Institute 1978 (7-1)

APPENDIX A
EQUIPMENT AND PLANT LAYOUT

The following are reduced copies of the plant drawings. Full-size copies are on file with the San Luis Obispo County Planning Department. Included are:

Drawing SKA-001	Location, Site, and Plot Plans
Drawing POL-001, Rev. A	Equipment Location Steam Generator/Turbine Generator Building Plan at Elevation 0 ft 0 in.
Drawing POL-002, Rev. A	Same at Elevation 20 ft 0 in.
Drawing POL-003, Rev. A	Same at Section A-A
Drawing POL-004, Rev. A	Same at Section B-B and C-C

The drawings reflect the current status of the engineering in progress. There may be some minor discrepancies as they exist. As engineering is completed, revised drawings will be supplied.

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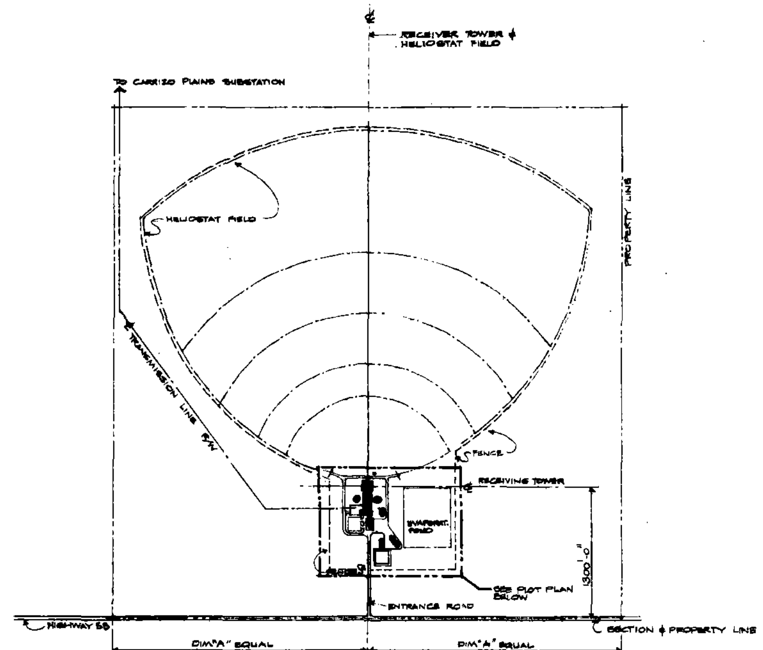
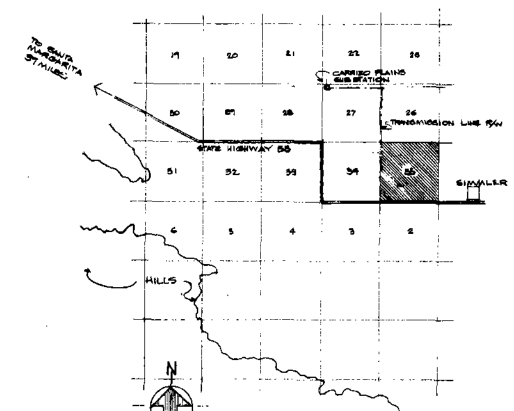
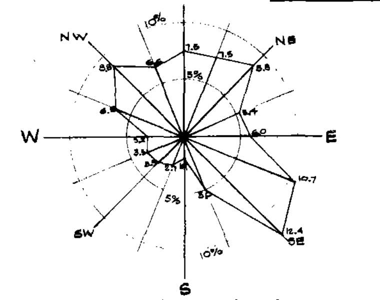


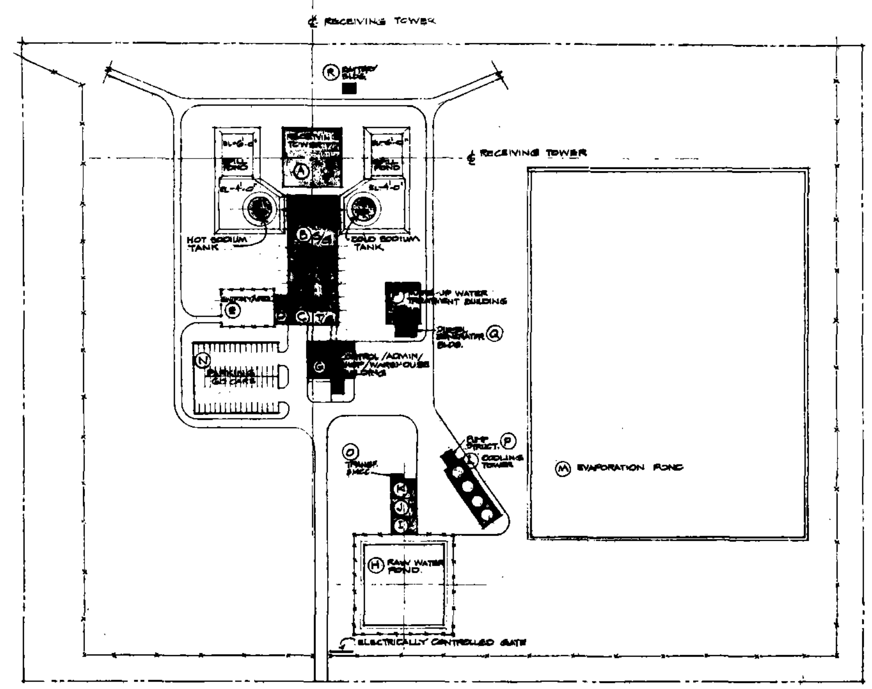
SITE PLAN SCALE 1"=600'-0"
SECTION 35



LOCATION MAP



WIND ROSE
JUNE THRU DECEMBER (7 MONTHS)
24 HOUR WINDS



PLOT PLAN SCALE 1"=100'-0"

LEGEND

- (A) RECEIVING TOWER
- (B) STEAM GENERATOR STRUCTURE
- (C) TURBINE GENERATOR BUILDING
- (D) SWITCHGEAR BUILDING
- (E) SWITCHYARD
- (F) MAKE-UP WATER TREATMENT BUILDING
- (G) CONTROL/ADMIN/SHOP/WAREHOUSE BUILDING
- (H) RAW WATER POND
- (I) PUMP HOUSE
- (J) WATER TREATMENT AREA
- (K) SOFTENER EQUIPMENT
- (L) COOLING TOWER
- (M) EVAPORATION POND
- (N) PARKING LOT
- (O) TRANSF. & MCC
- (P) PUMP STRUCTURE
- (Q) DIESEL GENERATOR BLDG.
- (R) BATTERY BLDG.

ASSUMPTIONS

1. PLANT IS LOCATED ON SECTION 35, LA PANZA QUADRANGLE, 15 MINUTE SERIES, T29S, R18E
2. TRANSMISSION LINE RIGHT OF WAY ALONG WEST SIDE OF SECTIONS 35 AND 26 TO PG&E SUBSTATION AT NORTHWEST CORNER OF SECTION 27.
3. SWITCHYARD TO BE LOCATED AT THE WEST SIDE OF T/G BUILDING.
4. CONTROL ROOM TO BE CLOSELY CONNECTED TO THE T/G BUILDING, BUT AT SOME DISTANCE FROM THE SWITCHYARD (OPPOSITE SIDE OF T/G BUILDING).
5. YARD ON EAST SIDE OF T/G BUILDING TO BE LEFT OPEN TO ACCEPT CERTAIN EXTERIOR PROCESS EQUIPMENT, SUCH AS: TANKS, ETC.
6. COOLING TOWER TO BE LOCATED SO THAT THE TOWER DRIFT WILL NOT ADVERSELY AFFECT SWITCHYARD EQUIPMENT, HELIOSTATS, PARKING LOT, ROADS, AND PLANT BUILDINGS. RAW WATER POND, SOFTENER, WATER TREATMENT, AND PUMP EQUIPMENT BUILDING ARE TO BE LOCATED NEAR THE COOLING TOWER.
7. TWO BAYS OF T/G BUILDING HAVE BEEN DELETED FROM THE ORIGINAL PLANT ARRANGEMENT TO OPTIMIZE COST.
8. CONTROL/ADMINISTRATION BUILDING AND SHOP/WAREHOUSE BUILDING ARE COMBINED INTO ONE BUILDING.

G		REVISED CONTROL/ADMIN/SHOP/WAREHOUSE BLDG.
F		RELOCATED CONTROL/ADMIN/SHOP/WAREHOUSE BLDG
E		ISSUED FOR COOLING TOWER BIDS
D		ISSUED FOR CLIENT REVIEW & APPROVAL
C		INCORPORATED DINNER COMMENTS
B	1/3/84	ISSUED FOR CLIENT REVIEW & COMMENT
A		ISSUED FOR PROJECT REVIEW

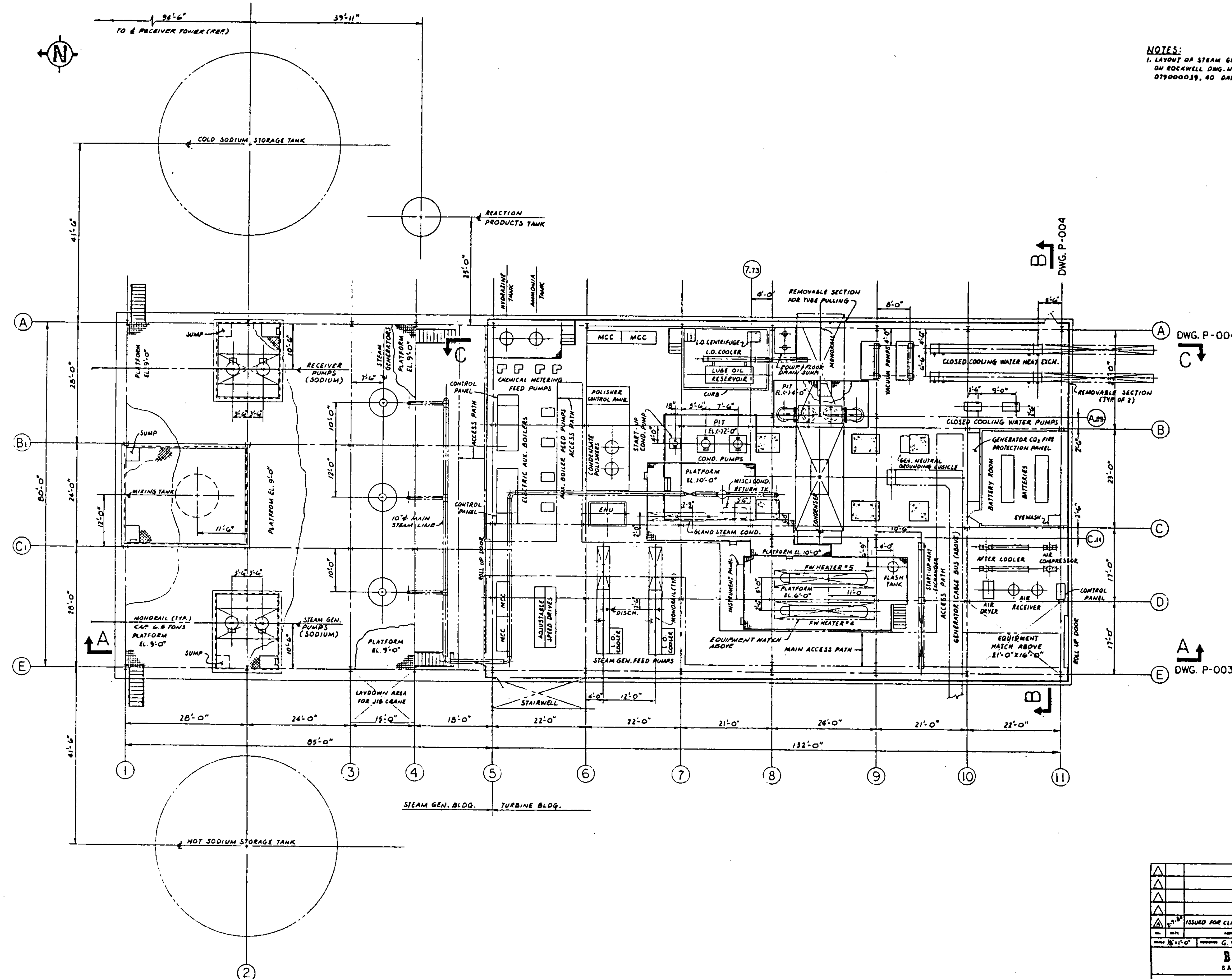
SCALE AS NOTED — AHG — AHG

BECHTEL
SAN FRANCISCO

CARRISA PLAINS SOLAR CENTRAL RECEIVER PROJECT

LOCATION, SITE, AND PLOT PLANS

JOB No.	DRAWING No.	REV.
16413	SKA-001	G



NOTES:

1. LAYOUT OF STEAM GENERATOR BUILDING IS BASED ON ROCKWELL DWG. № 079000011, DATED 6-6-83, 079000039, 40 DATED 5-4-83

ESG-84-14

A-5

No.	Date	Revision						
A	2-7-84	ISSUED FOR CLIENT REVIEW						

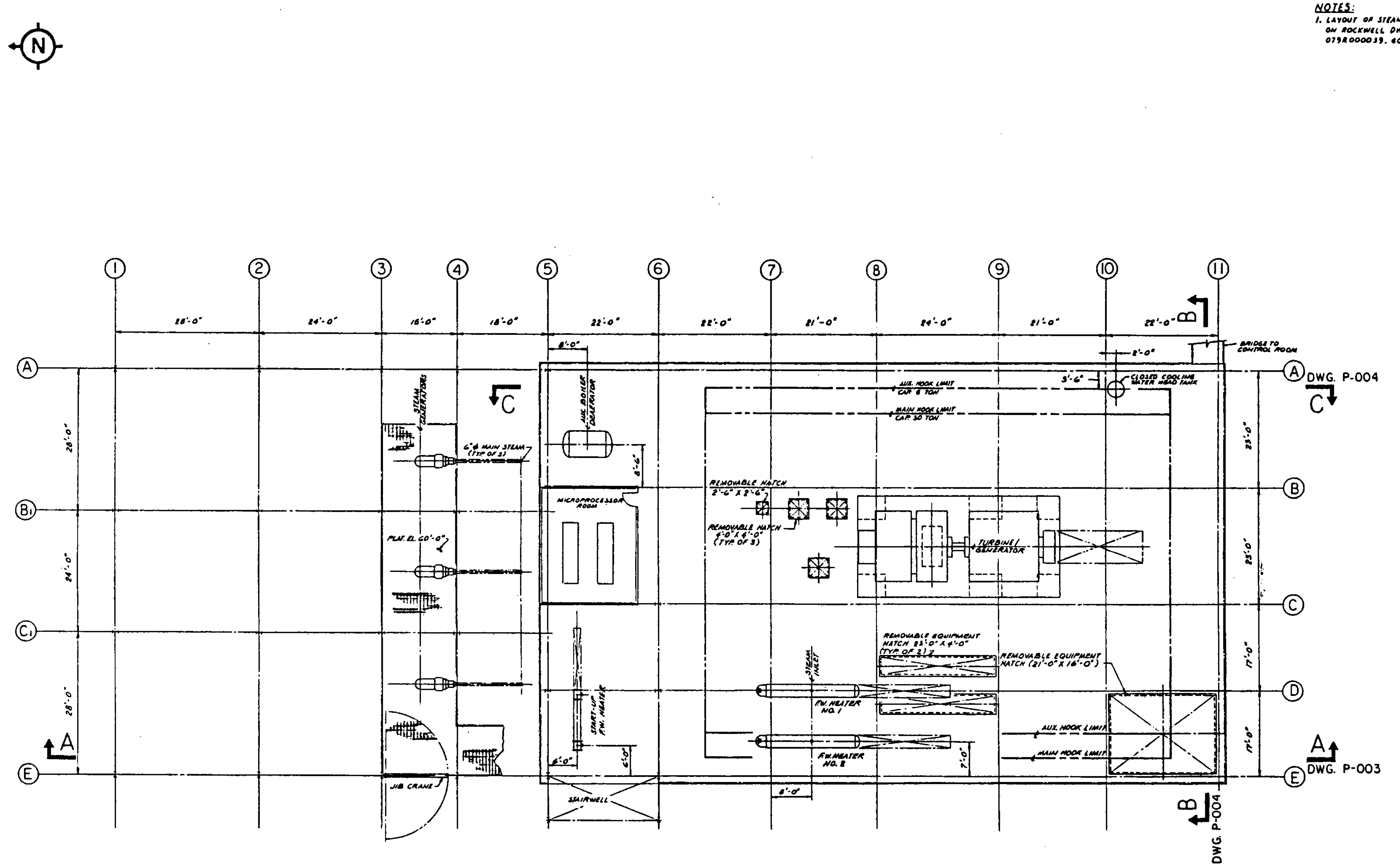
Scale 1/8" = 1'-0" | G. YEE | G. YEE | R.H. ELIAS

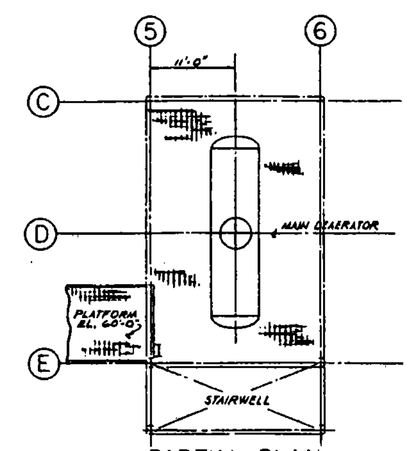
BECHTEL
SAN FRANCISCO

CARRISA PLAINS
SOLAR CENTRAL RECEIVER PROJECT

EQUIPMENT LOCATION
STEAM GEN./ TURBINE GEN. BLDG.
PLAN AT EL. 0'-0"

Job No.	Drawing No.	Rev.
16413	POL-001	A





PARTIAL PLAN
EL. 48'-0"

NOTES:
1. LAYOUT OF STEAM GENERATOR BUILDING IS BASED ON ROCKWELL DWG. Nº 079000011, DATED 6-6-83, 079R000039, 40 DATED 5-4-83

ESG-84-14

A-7

A	ISSUED FOR CLIENT REVIEW	

SCALE 1/8" = 1'-0" — C.S. BERENA — C.S. BERENA — R.H. ELIAS

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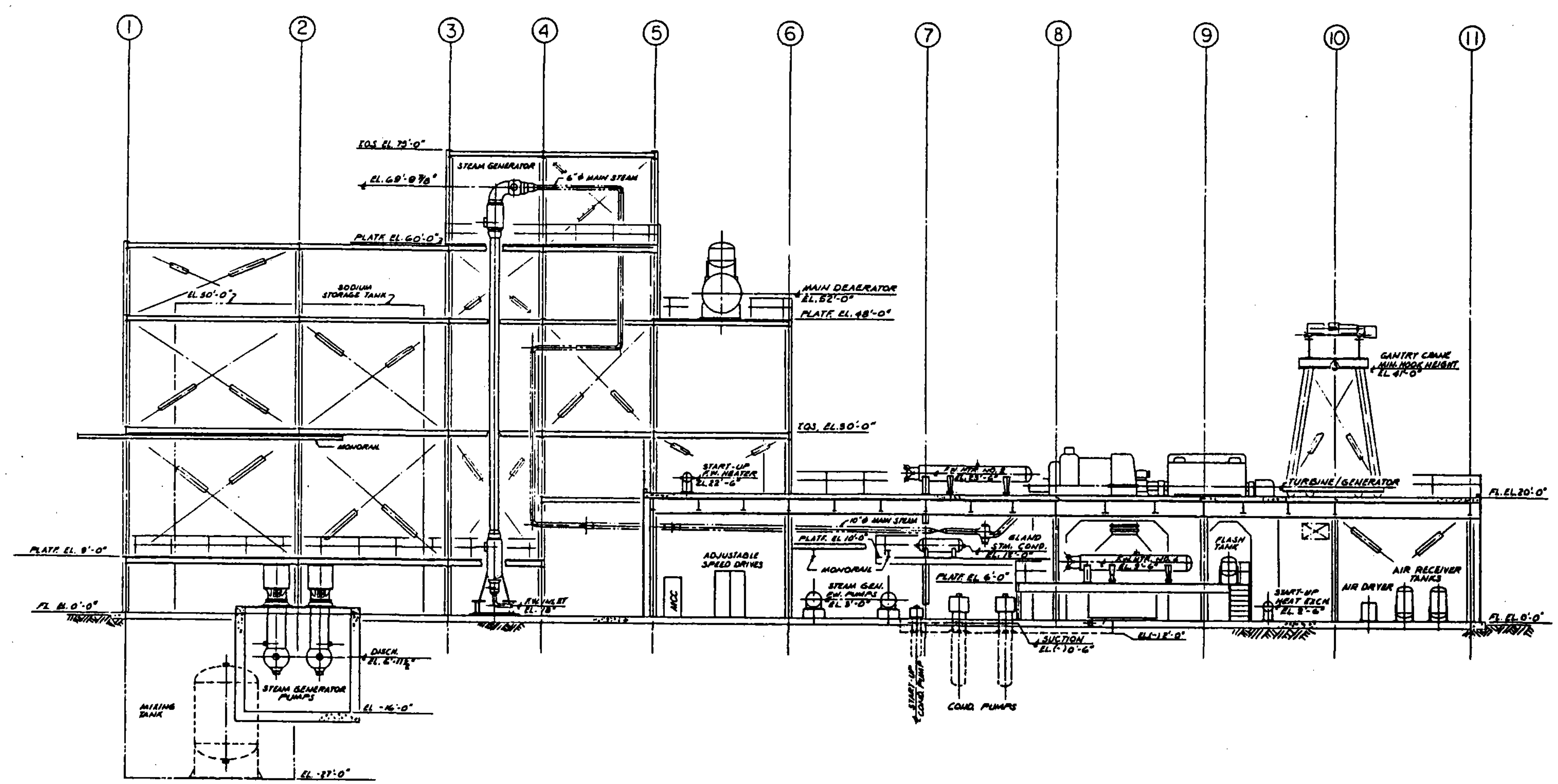
CARRISA PLAINS
SOLAR CENTRAL RECEIVER PROJECT

EQUIPMENT LOCATION
STEAM GEN./TURBINE GEN. BLDG.
PLAN AT EL. 20'-0"

JOB No.	DRAWING No.	REV.
16413	POL-002	A



SECTION A-A

NOTES:
1. LAYOUT OF STEAM GENERATOR BUILDING IS BASED ON ROCKWELL DWG. NO 079000011, DATED 6-6-83. 079R000039, 40 DATED 5-6-83

ISSUED FOR CLIENT REVIEW

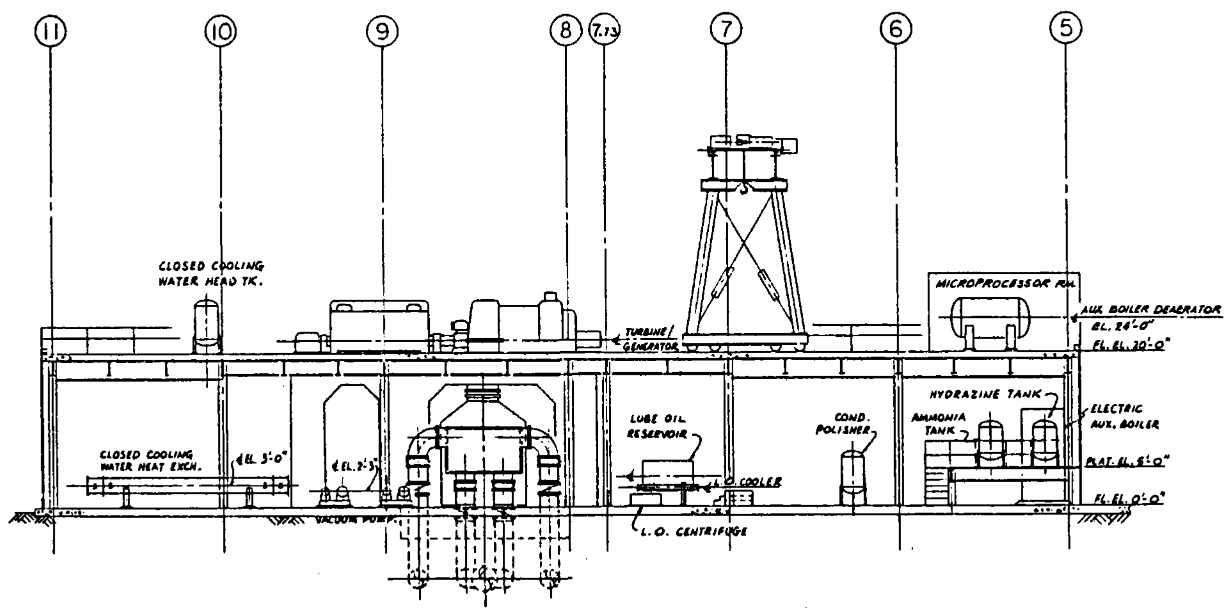
BECHTEL
SAN FRANCISCO

CARRISA PLAINS
SOLAR CENTRAL RECEIVER PROJECT

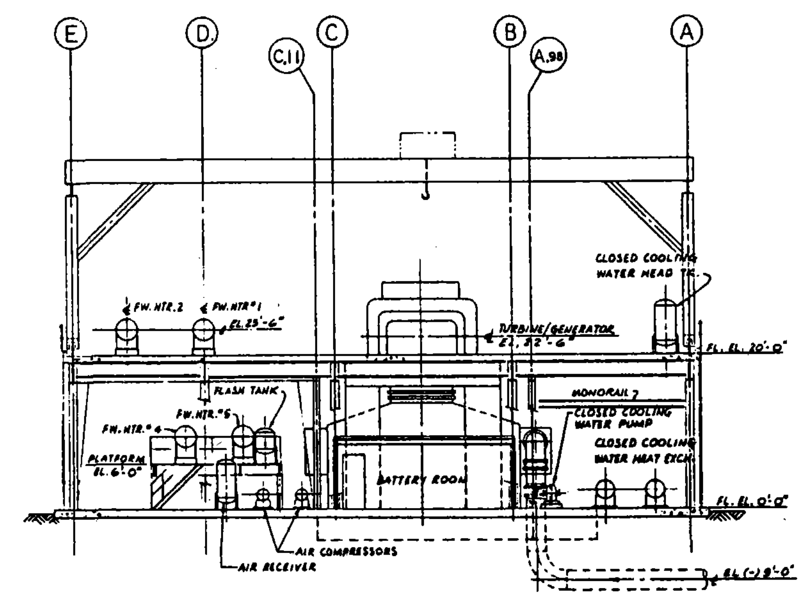
EQUIPMENT LOCATION
STEAM GEN./TURBINE GEN. BLDG.
SECTION A-A

JOB No.	DRAWING No.	REV.
16413	POL-003	A

ESG-84-14



SECTION C-C



SECTION B-B

ESG-84-14

A-11

No.	Date	Revision	By					
A	2-7-84	ISSUED FOR CLIENT REVIEW						

Scale 1/8"=1'-0" · Designed G. YEE · Drawn G. YEE · R.H. ELIAS

BECHTEL
SAN FRANCISCO

CARRISA PLAINS SOLAR CENTRAL RECEIVER PROJECT

EQUIPMENT LOCATION
STEAM GEN./TURBINE GEN. BLDG.
SECTION B-B AND C-C

JOB No.	DRAWING No.	REV.
16413	POL-004	A