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ENVIRONMENTAL EFFECTS OF SOLAR-THERMAL POWER SYSTEMS

ENVIRONMENTAL CONSIDERATIONS IN SITING A SOLAR-COAL HYBRID POWER PLANT,

I, ENVIRONMENTAL ASSESSMENT

FEBRUARY 1981

PREPARED FOR

U.S. DEPARTMENT OF ENERGY

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LABORATORY OF BIOMEDICAL AND ENVIRONMENTAL SCIENCES
UNIVERSITY OF CALIFORNIA, LOS ANGELES

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ABSTRACT

The purpose of this study was to identify environmental concerns and uncertainties unique to siting a solar-coal hybrid power plant. A conceptual design for such a plant prepared by Rockwell International was arbitarily chosen as a representative technology. A location selected by San Diego Gas and Electric Company for the one-time proposed Sundesert Nuclear Power Plant was chosen as the study site because of its desert location, level of insolation, and the availability of extensive environmental assessment documentation prepared in anticipation of developing the Sundesert facility.

Environmental concerns were examined in the perspective of the facility's impact on the environment; the environment's impact on the facility; and intraplant impacts arising from the interaction of subsystems. This study identified several impact categories as significant but common to any type of power plant that might be constructed at the site (e.g., water supply, vegetation and wildlife, and socioeconomics).

The effect of the facility on the environment was dominated by the large area of land required which in turn produced significant environmental concerns in the areas of air quality, geology, hydrology, vegetation and wildlife, and aesthetics. Health and safety concerns unique to solar were associated primarily with fluid releases and misdirected heliostat reflections.

The effect of the environment on the facility was dominated by air quality concerns which also dominated solar-hybrid subsystem interactions. Emissions from coal combustion and coal handling were viewed as significant problems which could compromise the efficiency of the facility.

While possible mitigating action can be identified for most concerns, the diffuse nature of solar insolation precluded mitigation of the large area of land required for the defined technology. Some mitigating actions actually increased land-use (e.g., exclusion area surrounding the facility).

Because environmental impacts are site specific, some siting criteria not considered limiting for this study could be limiting for a solar plant sited elsewhere.

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1.0 INTRODUCTION

Since the 1800's when remotely-generated electricity was first sold in the United States, commercial electricity has played important roles in American society. Historically, there has been a strong correlation between economic development and growth of electrical demand. Even with recent declines in the rates of growth, one utility in southern California has recently projected an increase in electrical demand of twenty-seven percent between 1990 and 2000 (1.1). Satisfying these demands in both an economically and environmentally optimal manner has become a matter of paramount importance aggravated by the fact that oil and gas are no longer either cheap or reliable sources of energy. In the decade of the 1990's it is anticipated that solar thermal energy systems may begin to fill the traditional role of oil and gas in the production of electricity. Such systems, however, can only operate when the sun is shining and must be backed by either energy storage systems or more conventional power sources to guarantee delivery of their rated electrical capacity. A proposed solution to this problem is to design hybrid facilities which utilize solar energy when it is available, and conventional fuels such as coal or oil when it is not, to produce electrical energy in a shared turbo-generator subsystem. Such solar hybrid systems are still in early stages of conceptual design; their economics are unproven; subsystem choices are many; and potential sites are poorly identified. Nevertheless it is an appropriate time to search for environmental constraints likely to effect their deployment.

We chose a solar-coal hybrid system designed by Rockwell International for the purpose of this study (1.2). The choice was made arbitrarily on the basis of the rated capacity of the design (430 MWe), which probably represents the largest single central receiver facility that is practical, and the completeness of design. It cannot be overemphasized that the discussions in this report are neither intended as an endorsement nor a criticism of the Rockwell design. The system concept is shown in Figure 1-1. The system utilizes a fluid-cooled receiver located atop a tower. Surrounding the tower is a field of heliostats. The heliostats direct the sun's energy onto the receiver surface. This energy is conducted away by a fluid (molten sodium) pumped through the receiver. The heated fluid is used to generate steam to drive turbines which generate electricity. Part of the fluid's thermal energy is stored and used to maintain power production during brief interruptions in insolation, such as occurs with transient cloud cover. Coal is burned to heat the working fluid at night or when solar-powered system operation is impossible (e.g., during storms), or when peak insolation is temporally mismatched with peak electrical demand.

The primary purpose of this effort was to identify environmental constraints unique to siting a solar-coal hybrid power system. A site in the eastern Mojave desert near Blythe, California was selected for the study. The choice was again arbitrary based on the facts that the site was located in the desert where land and the required level of insolation were available; the site was conditionally approved for a power plant by the U.S. Bureau of Land Management; and environmental assessments had been

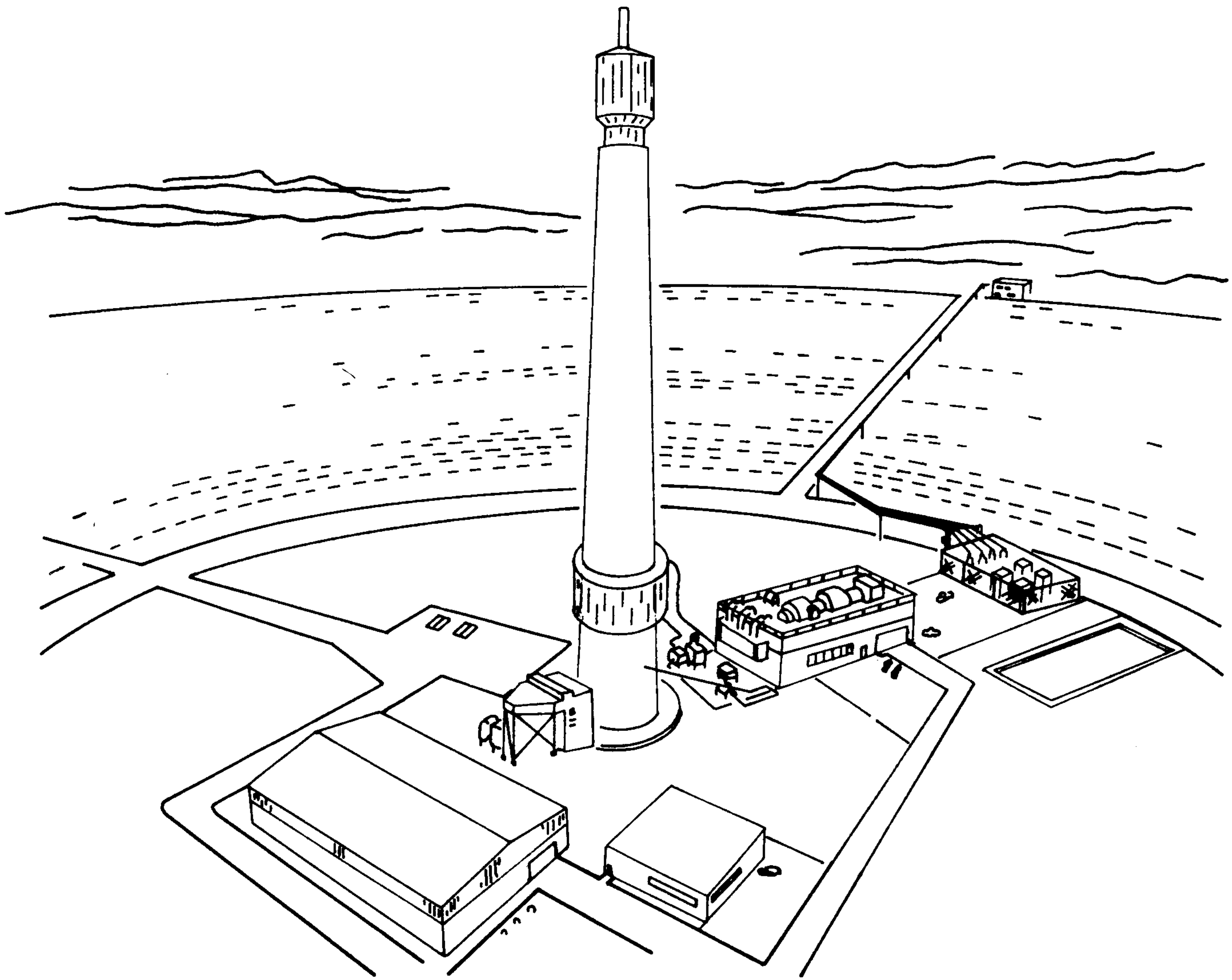


Figure 1-1 Solar Central Receiver Hybrid Power System (1.2)

prepared by the sponsors of the proposed Sundesert Nuclear Power Plant (1.3, 1.4, 1.5). Thus the technology as described in Reference 1.2 and the site as described in Reference 1.3 were the points of departure for the study.

The study plan assumed that environmental assessment required knowledge of the technology--how it worked, how it failed--and what the technology required. Chapter 2.0 describes the solar-coal hybrid system in some detail; Chapter 3.0 describes the Blythe-Palo Verde site. Consideration of environmental concerns was broadened to include the environment's effect on the technology (i.e. fugitive dust), and intraplant impacts of one subsystem on another (i.e. coal emissions on heliostats). The environmental aspect most effected by this broadening of perspective was Air Quality, which is summarized in Chapter 4.0 and presented in more detail in Volume II of this report. Chapters 5.0 through 9.0 discuss selected environmental concerns. The resources allotted to this exploratory study precluded detailed analyses of all environmental uncertainties. As a consequence those concerns judged to be unique to solar thermal systems received the most attention. Chapter 10.0 summarizes the environmental impacts.

1.1 References

1.1 Southern California Edison "Long Range Forecast", Appendix, June 10, 1980.

1.2 Rockwell International. "Solar Central Receiver Hybrid Power Systems Sodium-Cooled Receiver Concept Final Report". Volume 1, p. 6 and 8, January 1980.

1.3 San Diego Gas and Electric Company. "Sundesert Nuclear Plants, Units One and Two: Early Site Review Report." 1975.

1.4 San Diego Gas and Electric Company. "Sundesert Nuclear Plants, Units One and Two: Notice of Intention." June 1976.

1.5 San Diego Gas and Electric Company. "Sundesert Nuclear Plants, Units One and Two: Environmental Report." August 1977.

2.0 SYSTEM TECHNOLOGY

This chapter is comprised of two principal parts. The first briefly describes a Solar Central Receiver-Coal Hybrid Power System (as designed by the Energy Systems Group of Rockwell International) and the environmental concerns associated with each subsystem. The second part of the chapter presents questions and comments raised by our study specifically concerning the Rockwell design.

The Rockwell concept of a solar-fossil hybrid power system is one of several extant designs. Other designs differ in various details and choice of subsystems, as well as in economic assumptions and models. Because of its scale and degree of definition, the Rockwell design, hereafter called the baseline design, was chosen as the starting point for our investigation to search for environmental impacts unique or of unusual importance to a solar-coal hybrid system. The assumptions made by Rockwell have been adopted for the purpose of preparing this report. Alternative subsystems are discussed in Section 10.4, but analysis of differing economic assumptions and models lie beyond the scope of this investigation.

2.1 Description of System

The purpose of the Solar Central Receiver Coal Hybrid Power System is to generate electricity reliably and consistently, regardless of time or meteorological conditions, in a manner that uses inexhaustible solar energy to reduce consumption of nonrenewable fuels.

Several facts are important when designing and operating solar or solar-coal hybrid power systems.

1) Electrical demand exists throughout the day and year.

2) Electrical demand tends to be greatest during afternoons.

3) Maximum insolation power occurs hours before the peak in electrical demand.

4) Clouds can greatly and quickly decrease insolation and hence power. This phenomenon is sometimes called the "loss of sun" transient.

5) From a cold start, several hours are usually required to ramp a coal-fired generator to full power. But to ramp to full-load from a level only 20 percent of maximum takes just three to five minutes.

6) Storage of any significant quantity of electrical energy for any significant duration is costly, and commercial scale methods are not presently available. Storage of thermal energy for electricity generation may not be so costly and may be simpler to develop.

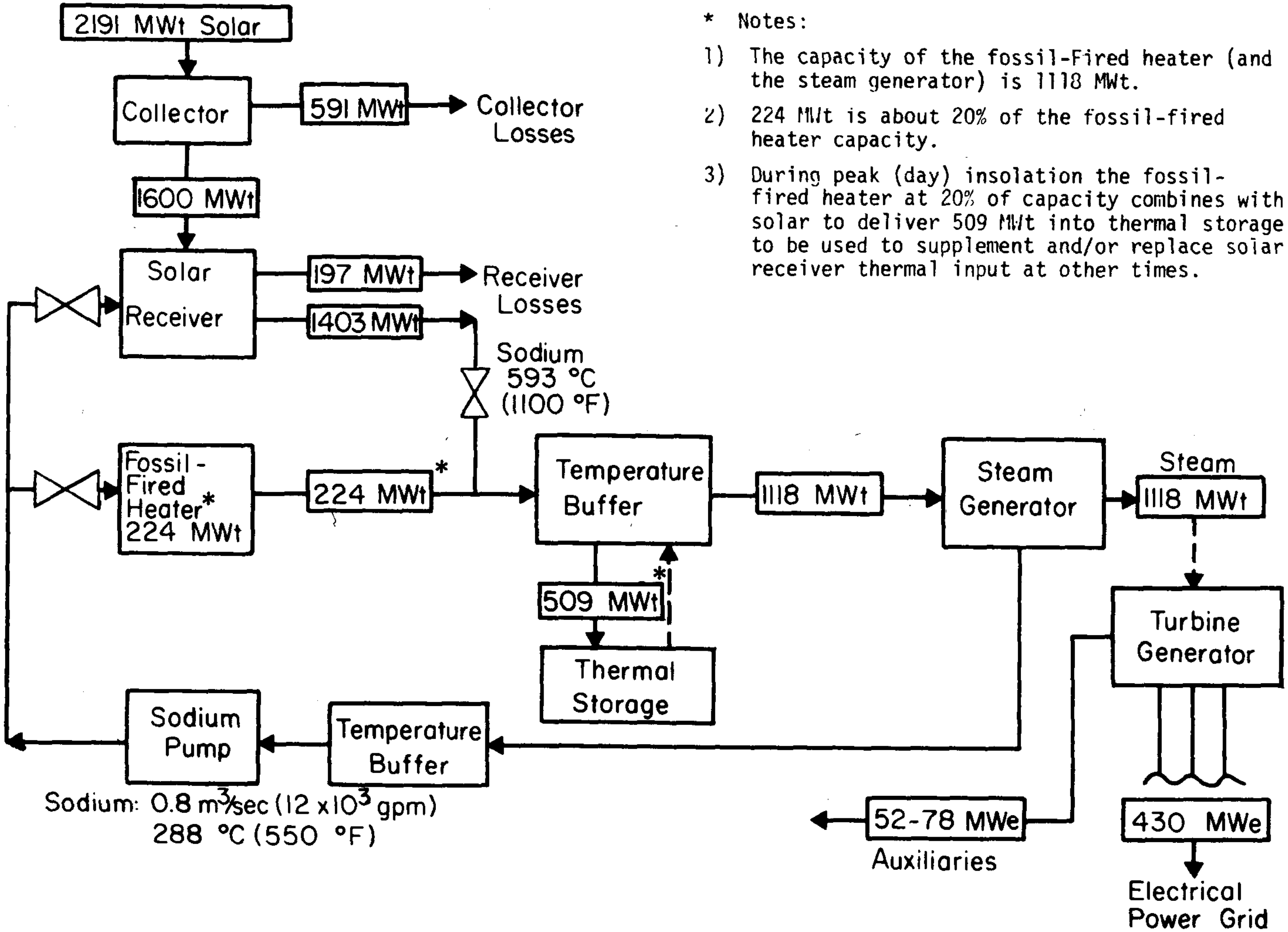
In response to these facts, certain design features and operating procedures have been developed for the solar-coal hybrid system. Figure 1-1 showed a conceptual view of the system. Figure 2-1 illustrates the power flow in a plant.

A field of heliostats, or mirrors, the major components of the collector subsytem, focuses the relatively diffuse energy from insolation onto a central receiver. The solar energy warms pure sodium flowing through the receiver. The sodium has three purposes: 1) it acts as an energy absorption medium, 2) it transports the thermal energy to a steam generator for further conversion to electricity; and 3) it functions as a thermal energy storage medium, since sodium in storage can retain great quantities of thermal energy for some time.

In the baseline design there is sufficient thermal energy stored in the sodium to routinely provide 1290 megawatt-hours of electricity; i.e., three hours at full plant power of 430 MWe. This amount of storage can maintain constant maximum plant power output in the event of loss-of-sun transients or other losses of solar power lasting less than three hours, even if the system were built as a stand-alone solar facility.

The baseline design also includes a coal-fired sodium heater operating in parallel with the solar receiver. This heater is never turned down below twenty-percent of its full rating. It is thus able to ramp to full power within five minutes. Should the plant operator decide that a loss of solar energy will last over some critical duration (more than three hours), he would be able to switch to coal-heating of the sodium within five minutes, maintaining the plant's power output. Loss of solar energy may be due to any one of many reasons, such as extensive cloud cover, collector and/or receiver subsystem maintenance, or nightfall. Similarly, should peak electrical demand be temporarily mismatched with peak insolation, the plant operator can increase the thermal input to the sodium from the coal-fired heater and/or from the sodium storage. Operating experience will probably best determine the insolation power threshold levels which will trigger alterations in the ratios of solar: storage: coal thermal input. Figure 2-2 shows the interactions of varying insolation power levels, durations, storage, and coal ramping. Table 2-1 summarizes baseline power system characteristics, and Figures 2-3 and 2-4, respectively, present the plot plan and plant layout.

Another fact concerning the system as adapted from Rockwell should be noted at this point. The power flow as sketched--1118 MWt fed to the steam generator and as much as 482 MWe gross drawn from the turbines as electricity--represents a highly optimistic efficiency near 43 percent. Using sodium and such approaaches as cascading turbines to enhance energy recovery, the optimistic figure might be achieved. Should typical efficiencies such as 35 percent be appropriate, however, the net electical output for the system would drop to a value such as 340 MWe rather than the 430 MWe indicated.



* Notes:

1) The capacity of the fossil-Fired heater (and the steam generator) is 1118 MWt.

2) 224 MWt is about 20% of the fossil-fired heater capacity.

3) During peak (day) insolation the fossil-fired heater at 20% of capacity combines with solar to deliver 509 MWt into thermal storage, to be used to supplement and/or replace solar receiver thermal input at other times.

Figure 2-1 Hybrid Plant Power Flow (2.1) (Numbers scaled from Rockwell's figures, and are approximate)

Figure 2-2 Example Power System Interactions

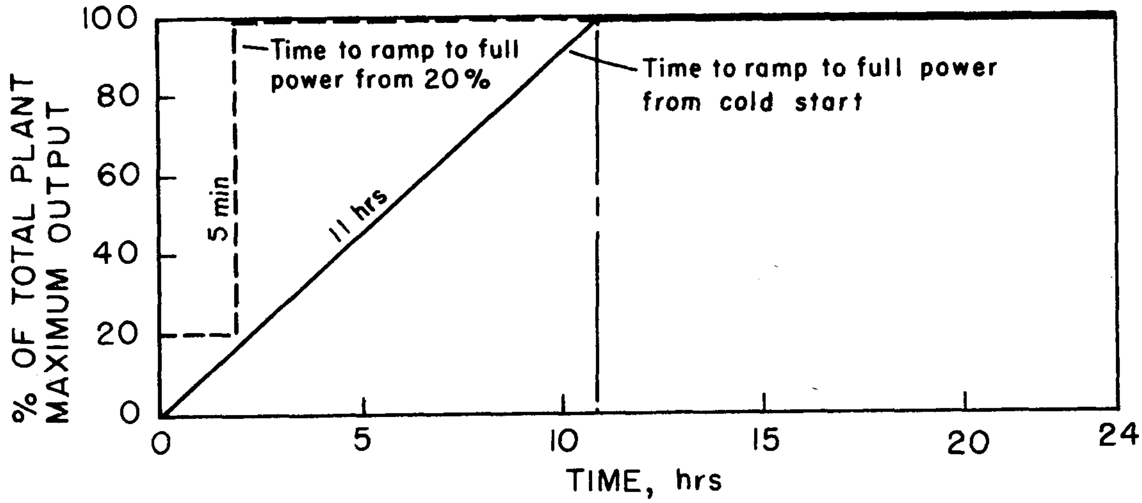


Figure 2-2(a) Time Needed to Ramp Coal-Fired Sodium Heater to Full Power From Cold Start and From 20% Load Level (Reference 2.2)

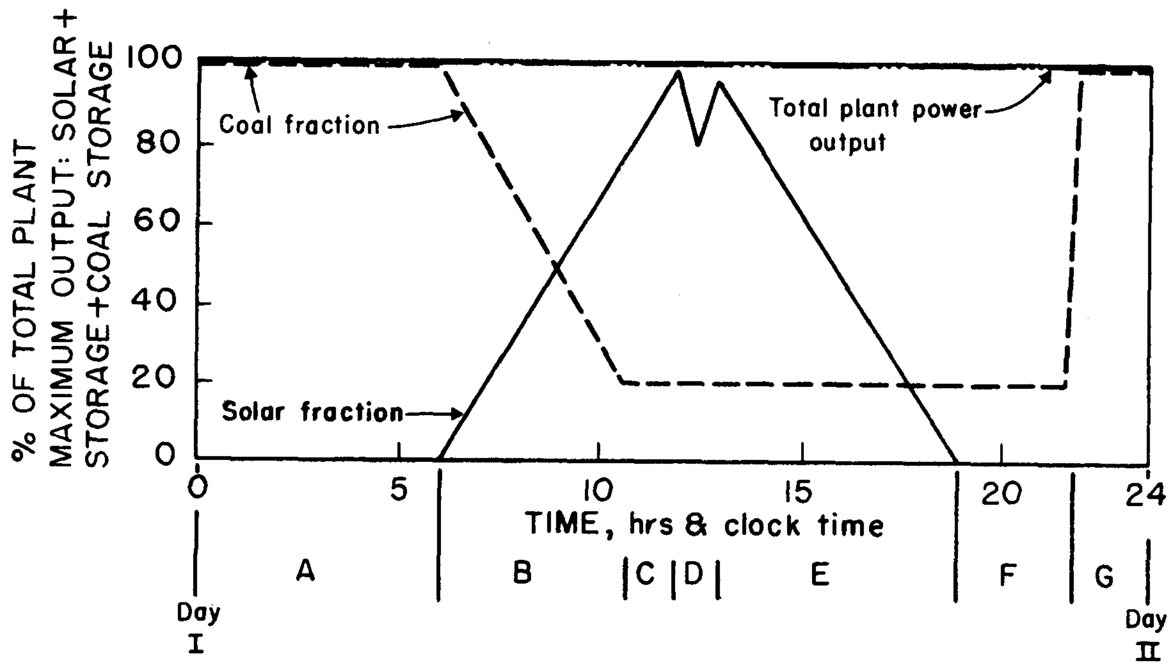


Figure 2-2(b) Solar-Coal Hybrid with Thermal Energy Storage Hypothetical Routine Daily Operation (Reference 2.3)

Figure 2-2: Explanation

Zone A: negligible storage to total plant output; essentially all plant output from coal; no insolation.

Zone B: solar fraction of total plant output increases as insolation increases; coal fraction decreases 20 percent which is the maximum coal turn-down (minimum coal fraction) allowing 3-5 minute ramp time to full power; quantity of thermal energy in storage increases, as at all times, solar + storage + coal fractions add up to 100 percent of plant maximum output.

Zone C: solar fraction still increasing; coal stable at 23 percent of full power; storage increasing.

Zone D: loss-of-sun transient lasting one hour; insolation has passed maximum; coal stable at 20 percent; solar + coal thermal input short-fall filled in by thermal energy storage.

Zone E: solar fraction decreasing; coal stable at 20 percent; coal consumption and emissions reduced by use of storage to fill in solar + coal thermal input short-fall.

Zone F: essentially zero insolation; coal stable at 20 percent; coal consumption and emissions reduced by use of storage to fill in solar + coal thermal input short-fall.

Zone G: solar fraction is zero; decision is made to keep remaining storage as emergency reserve; coal ramped to full power, continues as sole thermal input through Zone A.

NOTES: Partial or total losses of solar power may be due to extensive cloud cover, collector and/or receiver subsystem maintenance, or nightfall. Decreases in solar power deemed to last more than some critical duration (over three hours) would trigger alterations in the ratios and timing of solar storage coal thermal input.

Table 2-1

Summary of the Baseline Solar Receiver-Coal Hybrid Power System Characteristics (Reference 2.4)

Design Point Power Levels:	
During receiver operation	430 MWe net
Operation exclusively from thermal storage	430 MWe net
Thermal Storage Capacity at 100% Load	3 hours
Plant Availability (exclusive of sunshine)	0.9
Land area	12.34 km^2 (4.77 mi^2)
Exclusion area	site dependent
Glass area	2.98 km^2 (1.15 mi^2)
Number of heliostats	60,676
Heat rejection method	mechanical draft, wet cooling towers
Number of wet cooling towers	2
Tower height	330 m (1083 ft)
Distance to cooling towers	1568 m (5140 ft)
Electric Power Generation Subsystem Feedback Conditioning	
Dissolved solids	20 - 50 ppb
pH	9.5
Water consumption	
Heliostat cleaning	1.47×10^7 l/yr(3.88×10^6 gal/yr; 12AF/yr)
Cooling towers	7.68×10^9 l/yr(2.03×10^9 gal/yr; 6227AF/yr)
Flue gas Desulfurization	4.04×10^9 l/yr(1.07×10^9 gal/yr; 3282AF/yr)
Coal consumption at 100% load	203 MT/hr (223 tons/hr)
Coal storage capacity	
Dead	52 days at 100% capacity factor equal to 258,000 MT (283,800
Live	19,544 MT (21,500 tons)
Transmission lines (assumed)	115kV

Table 2-1, (Continued)

Nominal design wind at reference height of 10m (30ft)............................3.5 m/s (8 mi/hr)

Maximum operating wind at reference height including gusts..........................16 m/s (36 mi/hr)

Maximum survival wind at reference height including gusts..........................40 m/s (90 mi/hr)

Seismic environment..........Uniform Building Code Zone 3 (see A-1)

survival earthquake horizontal and vertical..............................0.25 g

Rain survival

average annual.................................750 mm (30 in)
maximum 24-hour rate.............................75 mm (3 in)

Operating lifetime...30 years

Operating ambient air temperature......-30° to 50°C (-20° to 120°F)

Air quality control standards, 1979 EPA — lbs/million BTU

Emission limits	SOx	NOx	Particulates
coal fired	0.8	0.7	0.1
oil fired	0.8	0.3	---

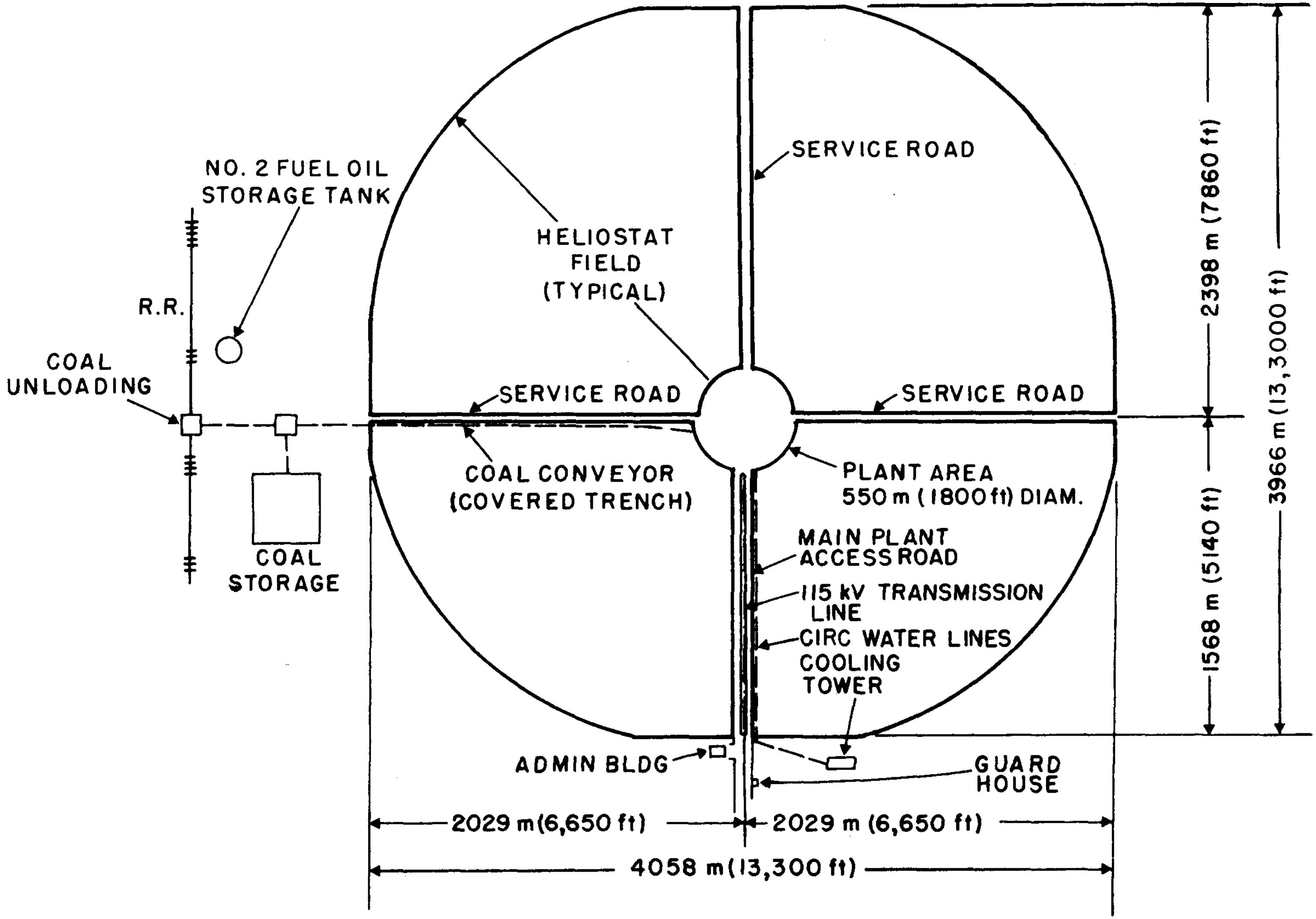


Figure 2-3 Preliminary Plot Plan for 430 MW(e), 1.44 Solar Multiple Commercial Plant (Reference 2.5)

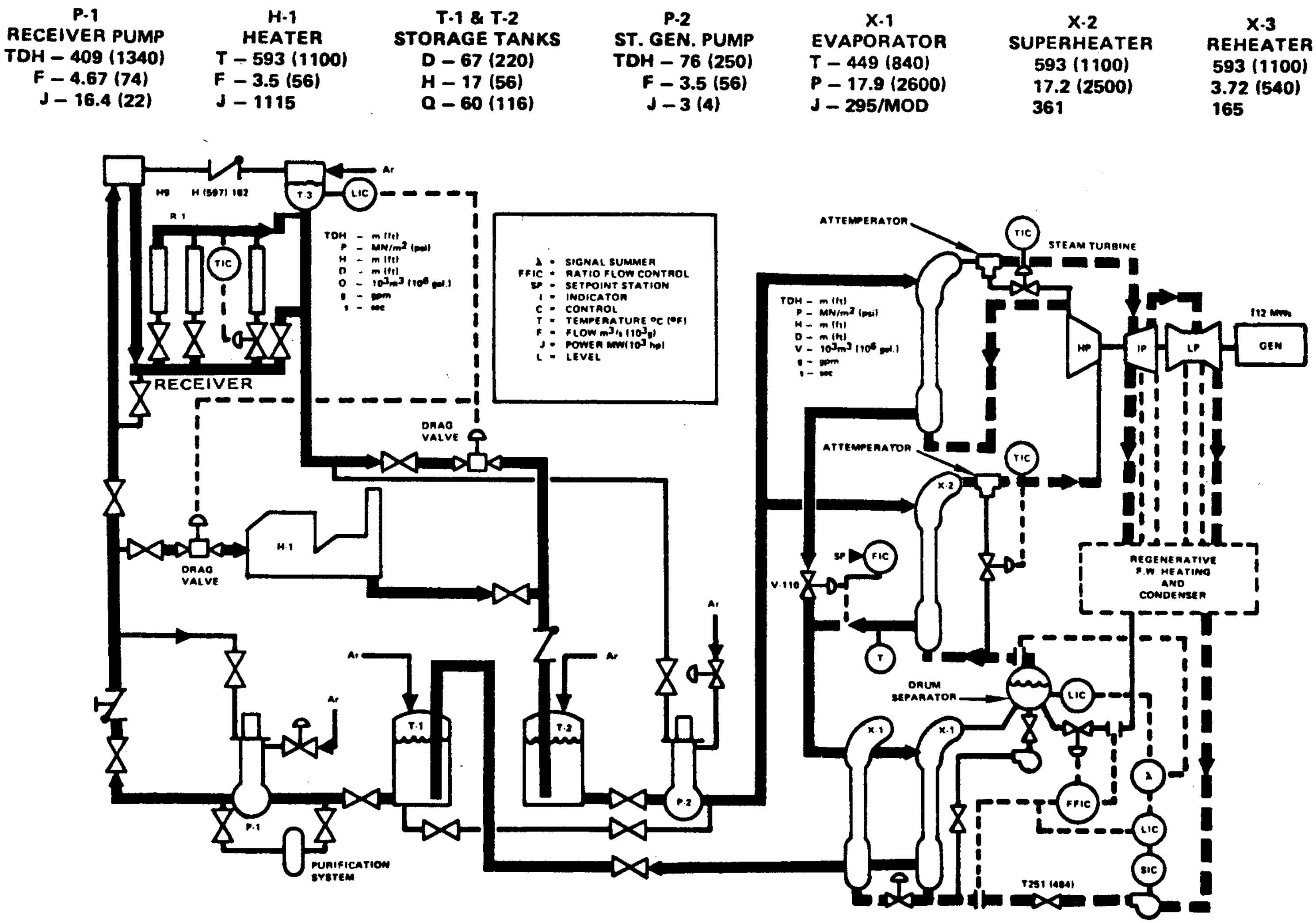


Figure 2-4 430 MW(e) (1.44-Solar Multiple) Plant Layout (Ref. 2.5)

2.2 Subsystems

2.2.1 Collector Subsystem

The collector subsystem includes the individual heliostats and all the power and control equipment for their operation.

Each heliostat will be composed of twelve mirror modules. Each module will be 1.22 m (48 in) by 3.35 m (132 in), and made of a 1.5 mm (0.06 in) pane of Corning fusion glass (0.05% wt Fe) mirrored on its inner face and laminated to a 4.8 mm (0.1875 in) float glass back lite. Six modules will be mounted on a support frame to consitute a reflector subassembly. A central facility will fabricate the subassemblies. Final assembly will occur near the site in a building designed to be used later for general plant maintenance. Clean reflectivity is estimated to be 0.92.

The reflective unit is driven about the azimuth and elevation axes by two 480V, three-phase motors, drawing 249W and 186W respectively. The 61,000 heliostats will thus require abut 15 MWe and 11 MWd for each of these operations. Azimuth travel is ±270 degrees to avoid the need for configuring the drive unit as a function of position in the field. Elevation travel is ±90 degrees to permit inverted mirror storage. The mirror can be stowed face down within 15 minutes to prevent meteorological damage, for protection from deposition, and to facilitate cleaning.

The heliostat will be supported by a pedestal about 3.18 m (125 in) tall. A heliostat assembly is shown in Figure 2-5. The deployment of heliostats is shown in Figures 2-6 and 2-7.

Environmental concerns specific to the collector subsystem are: 1) salt deposition on heliostats from cooling tower drift; 2) combustion emission deposition; 3) dust deposition; 4) land loading; and 5) misdirected reflections. Degradation of reflecting surfaces may increase cleaning frequency and the quantity of costly deionized cleaning water, with the possible release of cleaning solvents. Control of fugitive dust and reduction in off-site glare hazards may require a large exclusion area.

2.2.2 Receiver Subsystem

The receiver subsystem contains the receiver, receiver pump, steam generator units, the main sodium piping, hot and cold sodium storage tanks, steam generator sodium pump, and the associated sodium piping and drag valve. The plant flow diagram is shown in Figure 2-8.

The receiver subsystem operates essentially as two independent loops. The first loop transfers sodium, the single-phase receiver coolant and energy storage fluid, from the cold storage tank, T-1, through the receiver, which heats the fluid. The sodium then flows by gravity through the drag valve to the hot storage tank, T-2. The second loop transports the sodium from the hot storage tank through the sodium-heated steam superheater and reheater, through the evaporator, and back to the cold storage tank.

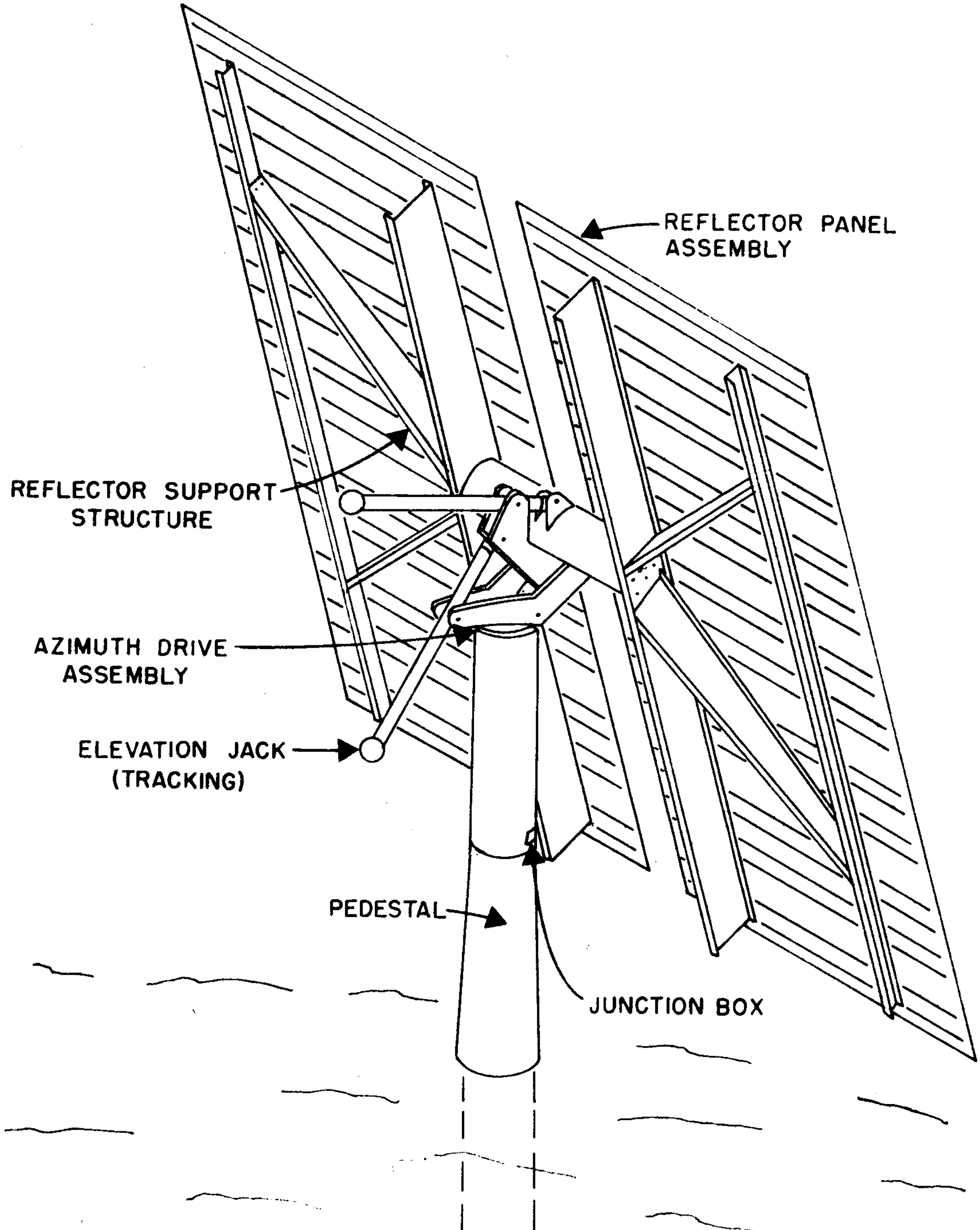
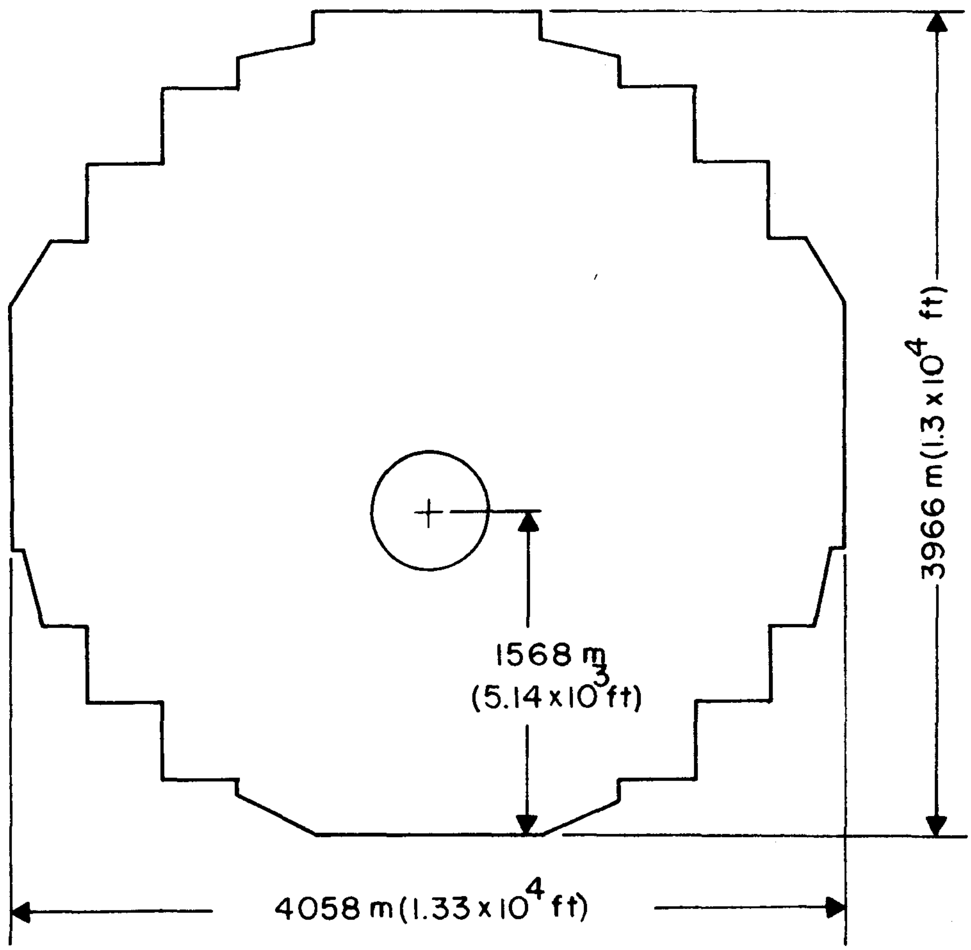


Figure 2-5 Primary Baseline Heliostat (Reference 2.7)



NUMBER OF HELIOSTATS = 60,676

GLASS AREA = 2,976 x 10^6 M^2
(1.15 mi^2)

LAND AREA = 12,344 x 10^6 M^2
(4.77 mi^2)

ANNUAL ENERGY = 3.91 x 10^6 MW-HR

TOWER HEIGHT = 330 M (OPTICAL)
(1083 ft)

RECEIVER SIZE = 28.5 M (H) x 25.0 M (D)
(93.5 ft x 82 ft)

Figure 2-6. Preferred Commercial System (Reference 2.8)

			175	364	372	364	175			
		383	423	449	460	449	423	383		
	394	458	515	561	578	561	515	458	394	
282	454	544	636	721	753	721	636	544	454	282
414	510	632	792	969	1057	969	792	632	510	414
437	552	714	960	1180	891	1180	968	714	552	437
445	569	754	1070	896		896	1070	754	569	445
326	552	723	997	1214	1196	1214	997	723	552	326
	501	632	820	1037	1144	1037	820	632	501	
		530	643	750	784	750	643	530		
			248	412	422	412	248			

Figure 2-7 Number of Heliostats per Cell - Preferred Commercial System (Reference 2.9) (Each cell is 369 m (1211 ft) on a side.)

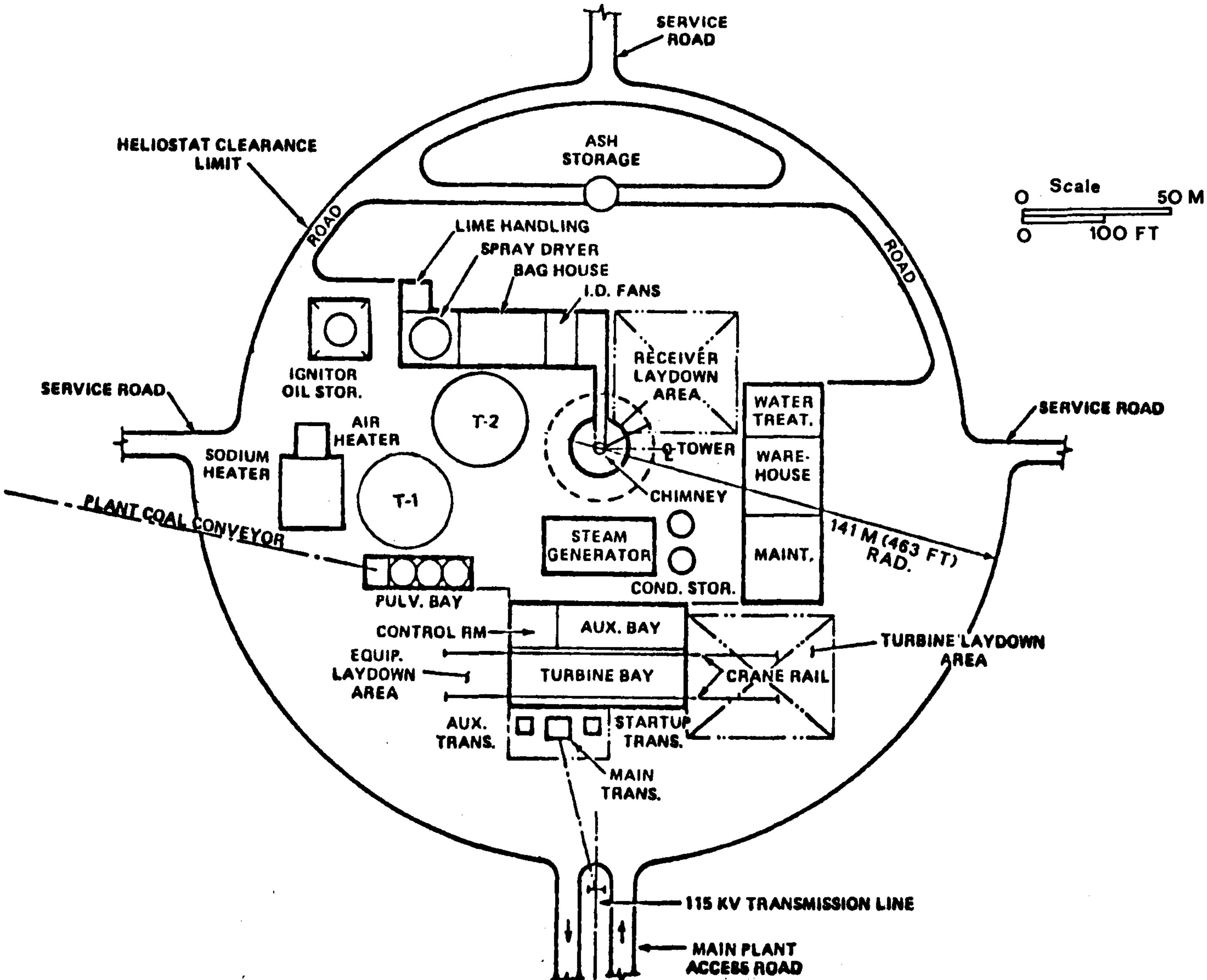


Figure 2-8 430 MW(e) (1.44-Solar Multiple) Plant Flow Diagram

With some reserve in T-1, the first loop operates to transfer all of the energy from the receiver to storage independently of the steam generator requirements. As the insolation varies, the flow is modulated to maintain a constant receiver outlet temperature. The second system, after some storage accumulation in T-2, operates independently of the insolation. Being in series, the storage functions act as thermal inertia and capacitance, protecting the pumps and the steam generating equipment from thermal shocks transported by the sodium. Since the second loop is independent the power output can be leveled. This minimizes the thermal cycling of the steam generators. Stored energy accumulates or is automatically drawn upon, representing the difference between the inflow and outflow of T-1.

Sodium circulation is accomplished by the P-1 and P-2 pumps. The fluid level in the pumps is controlled by argon pressurization. Sodium flow through the receiver is modulated by the control valves on each panel to maintain the panel outlet temperature constant. The storage tank is maintained at atmospheric pressure, and the drag valve reduces the sodium pressure to near atmospheric to match that of the tank.

As designed, the control system provides a constant temperature to the steam generator under conditions of variable sodium flow, or power rates. The buffer system of T-1 and T-2 tanks also provides passive protection against both the loss of P-1 pump and the loss-of-sun (cloud passage) transients.

Environmental concerns specific to the receiver subsystem are associated with uncontrolled releases of molten sodium.

2.2.3 Thermal Energy Storage Subsystem (TES)

The TES subsystem utilizes sodium as the stage medium and consists of low-pressure storage tanks with a height of about one-half their diameter, and all the equipment necessary for their operation. The hot tank operating at 593°C (1100°F) is made of stainless steel; the cold tank at 288°C (550°F) is made of carbon steel. Storage at atmospheric pressure minimizes cost. This requires a pressure-reducing drag valve. The tanks measure 30.5 m (100 ft) in diameter and 13.6 m (45 ft) in heighth for the hot storage tank, and 12.3 m (41 ft) in heighth for the cold. Sodium tanks of these sizes have not yet been built, but there are no particular difficulties expected in their fabrication, installation, or operation. The all-sodium thermal storage allows the electric power generation subsystem (EPGS) to operate independently of receiver subsystem transients.

Closed-loop television and sodium-sensitive aerosol detectors will be used to detect leaks. Catch pans under major components will confine any leaked sodium to a local controlled area for later drainage. The steam generator catch pans will have a sump and pump to keep the catch pans dry. Nitrogen gas will flood the catch pans in the event of sodium combustion. Approved fire suppressant extinguishers will be placed throughout the facility.

Environmental concerns specific to the thermal energy are associated with uncontrolled releases of molten sodium.

2.2.4 Coal Storage and Handling Subsystem

The coal storage and handling subsystem consists of all the equipment to supply pulverized coal at rates up to 203 MT/hr (223 tons/hr) at 100 percent load. The coal handling schematic is shown in Figure 2-9. Coal delivery will be by train in 90.9 MT (100 ton) bottom-dump cars. An enclosed track hopper with a dust collection system to control fugitive dust emissions will receive the coal from the cars. Conveyor B will deliver the coal to the crusher building.

Live storage of 19,544 MT (21,500 tons) of coal will be in a silo equipped with a dust collection system. Conveyor D will deliver the coal from storage to the crusher building as needed. A dead storage pile will provide coal to the plant in cases of unscheduled disruptions of supply. The pile will have a capacity of 258,000 MT (283,800 tons), equivalent to 52 days' burn at 100 percent capacity. A wet dust suppression system will be used.

Coal from the track hopper and live storage silo will thus be delivered to the crusher building, where it will be pulverized to coal of firing size. The building will have a dust collection system. The crushed coal will travel in an underground Conveyor E to the Transfer Building, and on to the Plant Coal Silos which will be equipped with a dust collection system and hold the equivalent of twelve hours of coal burn.

Environmental concerns associated with the coal handling and storage subsystem are fugitive dust emissions (as they interfere with solar collector subsystem efficiency), and water or other chemical dust suppressant use and release to the environment.

2.2.5 Oil Storage and Handling Subsystem

The oil storage and handling subsystem consists of all the equipment to supply oil to the ignitor system. Number 2 fuel oil will be used. The fuel oil storage and unloading facility will be designed to handle both rail tank car and tank truck deliveries. The primary fuel oil storage facility will be located at the rail line outside the collector field. A fuel oil transfer pump will transfer oil from the primary fuel oil storage tank to the secondary above-ground tank within the plant area. Fire supression equipment will be everywhere.

Except for fires and possibly resultant heliostat soiling and breakage, there are no apparent environmental concerns associated with the oil storage and handling subsystem.

2.2.6 Solid Waste Control Subsystem

The solid waste control subsystem consists of all the equipment to reduce the flue gas particulate emissions produced by the combustion of coal. A

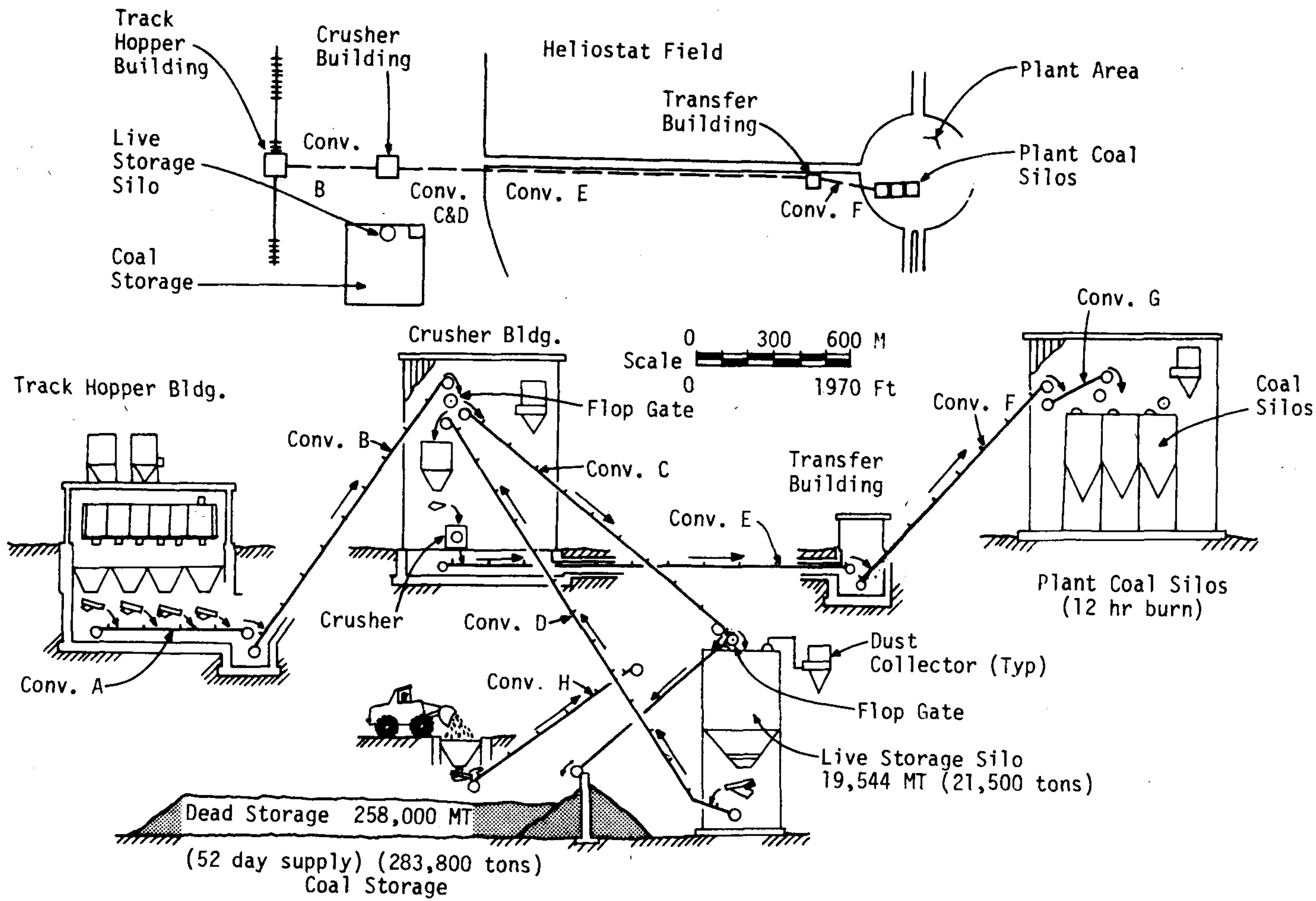


Figure 2-9 Coal Handling Schematic

Reference: Numbers are scaled from Ref. 2.1 and are approximate negative-pressure pneumatic ash conveying system will handle both bottom ash from the sodium heater ash hopper, and fly ash and SO_2 absorbent from the baghouse ash hoppers. Ash storage will be in the central area of the plant; covered trucks will remove the ash.

The stack for the coal-fired sodium heater will be located within the reinforced concrete receiver tower structure. The plume from the stack and its possible impacts are evaluated in some detail in Chapter 4.0.

Environmental concerns associated with the solid waste control subsystem are associated with dusting and possibly resultant degradation of heliostat performance, and development of waste disposal sites.

2.2.7 Electric Power Generation Subsystem (EPGS)

The EPGS consists of the turbine, heat rejection system, air quality control equipment, and all the components necessary for their operation.

The EPGS will use a standard tandem compound, double flow, reheat, condensing turbine, rated at 480 MWe (gross). The generator is a synchronous type, hydrogen cooled. The baseline design assumes a transmission system rated at 115 kV (2.12). At all times, the sodium heater provides at least 20 percent of the steam generator requirements from combustion of coal. The fraction of the steam generator requirements satisfied by coal increases during periods of low or no insolation. A Babcock and Wilcox dual register pulverized coal burner will be used with the sodium heater; its design promotes complete combustion with low NO_x generation and with control of furnace and convection surface slagging and fouling.

The maximum practical fossil turndown ratio is about 5:1. It is estimated that about 4 minutes is required to make the load ramp from 20 percent to full load. An emergency power diesel engine generator will provide AC power for safe shutdown and emergency service.

Government regulations have required lower burner zone heat release rates to control NO_x generation. Heat input relative to furnace plan area has also been trending downward, consistent wth the ash characteristics of western coals. Conventional boilers of current design conform to these characteristics, and consistently satisfy the Environmental Protection Agency's 1979 limits of 0.7 lbs NO_x per million BTU heat input to the furnace, measured as NO_2.

Feed heating and condensing equipment will be of conventional design, the former in accordance with ASME Boiler and Pressure Vessel Code Section VIII, and the latter in accordance with the Heat Exchange Institute's "Standards for Steam Surface Condensers".

Heat rejection will be by two evaporative (wet) mechanical draft cooling towers. Figure 2-10 shows a typical transverse cross-section of a Marley double-flow cooling tower. Cooling tower water consumption has been estimated at 7.7×10^9 l/yr (2×10^9 gal/yr, 6227 AF/yr).

The Rockwell design studied the possibility of using a combination wet-dry cooling tower (shown schematically in Figure 2-10) as a way to reduce plume problems and conserve water. Cooling is accomplished by both sensible cooling (in the dry section), and evaporative cooling (in the wet section). Using Barstow, California as their reference site, Rockwell designed a wet-dry tower for plume abatement for a 100 MWe baseline plant. A design wet-bulb temperature of 23°C (73.4°F) and dry-bulb temperature of 42°C (107°F) maximum and -1°C (30°F) minimum for plume abatement were used. Wet and wet-dry cooling tower performance and cost data were provided by the Marley Company. Table 2-2 compares the two systems, and indicates that the wet-dry tower requires forty percent more fan power at approximately double the cost of a wet tower. On the basis of this study, for their baseline plant, Rockwell concluded that wet cooling towers should be used and located outside the collector field, the actual location being determined by the predominant wind conditions at the site. Rockwell reported that "it may also be desirable to provide some degree of wet-dry cooling for plume abatement and water conservation reasons" (2.15). A more detailed analysis of cooling tower options is provided in Chapter 5.

Water treatment will consist of several steps. Pretreatment will remove suspended material, reduce turbidity and the concentrations of manganese, phosphate, calcium, magnesium, silica, alkalinity, and other constituents of the water, accomplished by clarification equipment and filtration. Pretreatment prevents: a) the physical fouling of ion exchange resins, membranes, or cartridge filters; b) the formation of deposits of some colloidal material in the steam generator and turbines; and c) the interference with heat transfer at the condenser and other heat exchangers due to concentration of the constituents of the cooling tower makeup water. Final treatment consists of demineralization via ion exchange, of boiler makeup water and heliostat washing water. The Rockwell report presents a list of final water treatment equipment required for their 100 MWe base plant, but does not report the quality of the input water assumed as a source. The EPGS feedwater conditioning is designed to achieve 20-50 ppb dissolved solids at pH 9.5.

Environnmental concerns associated with the EPGS are: 1) potential hazards of heat transfer between the sodium cooling and the water of the EPGS; 2) heliostat degradation by cooling tower drift; and 3) the high cost of deionizing water for both the EPGS and heliostat cleaning.

2.2.8 Air Quality Provisions

The Rockwell study reported the current EPA emissions standards for new fossil-fueled emission sources listed below (2.16); (EPA Emission Standards for New Fossil Emission Sources, as of 1 January 1980):

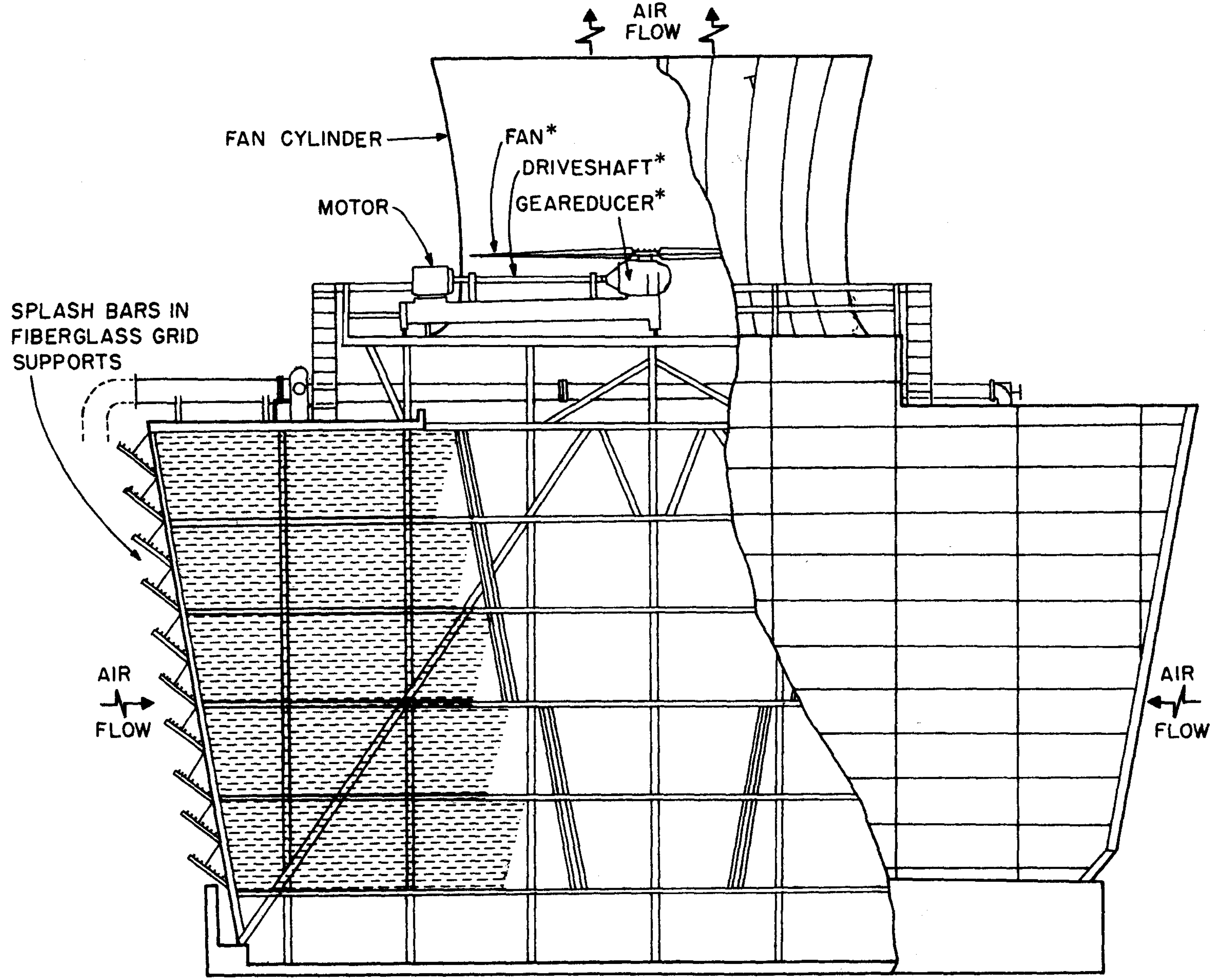


Figure 2-10 Transverse Cross Section, Marley R Wet Cooling Tower (Reference 2.13)

Table 2-2

Wet vs Wet/Dry Cooling Tower Comparison
(*100% Plume Abatement at 30°F Ambient - Barstow, California)

	Wet	Wet/Dry*
Circ Water Flow, GPM	96000	96000
Heat Duty 10 BTU/hr	555	555
Approach °F	10	10
No. of Cells	5	7
HP Per Cell	200	200
Length Ft.	201	253
Width Ft.	72	70
Pumping Head Ft.	41	38
Estimated Cost, $ 1979**	$900,000	$1,750,000

** Excluding Basin
(Reference 2.14)

NO_x..0.5 lb/MMBTU

SO_2........90% removal, 0.6-1.2 lb/MMBTU; 70% removal, 0.6 lb/MMBTU

Particulates...0.03 lb/MMBTU

The design selected to meet these standards includes: dual register burners operating with 115 percent theoretical air in the furnace for NO_x formation suppression, a dry flue gas desulfurization (FGD) system for SO_2 removal, and a Wheelabrator-Frye fabric filter for particulate removal. The B & W dual register burners were mentioned earlier in the EPGS description. The dry FGD and particulate control system are shown schematically in Figure 2-11. A more detailed analysis of air quality impacts is provided in Chapter 4.

2.2.9 The Master Control Subsystem

The Master Control Subsystem will sense, detect, monitor, and control all system and subsystem parameters necessary to insure safe and proper operation of the Solar Central Receiver Hybrid Power System, and will be similar to that currently used by utilities. Figure 2-12 illustrates this subsystem.

Environmental concerns associated with the Master Control Subsystem are: 1) loss of control of heliostats, possibly resulting in injury to workers

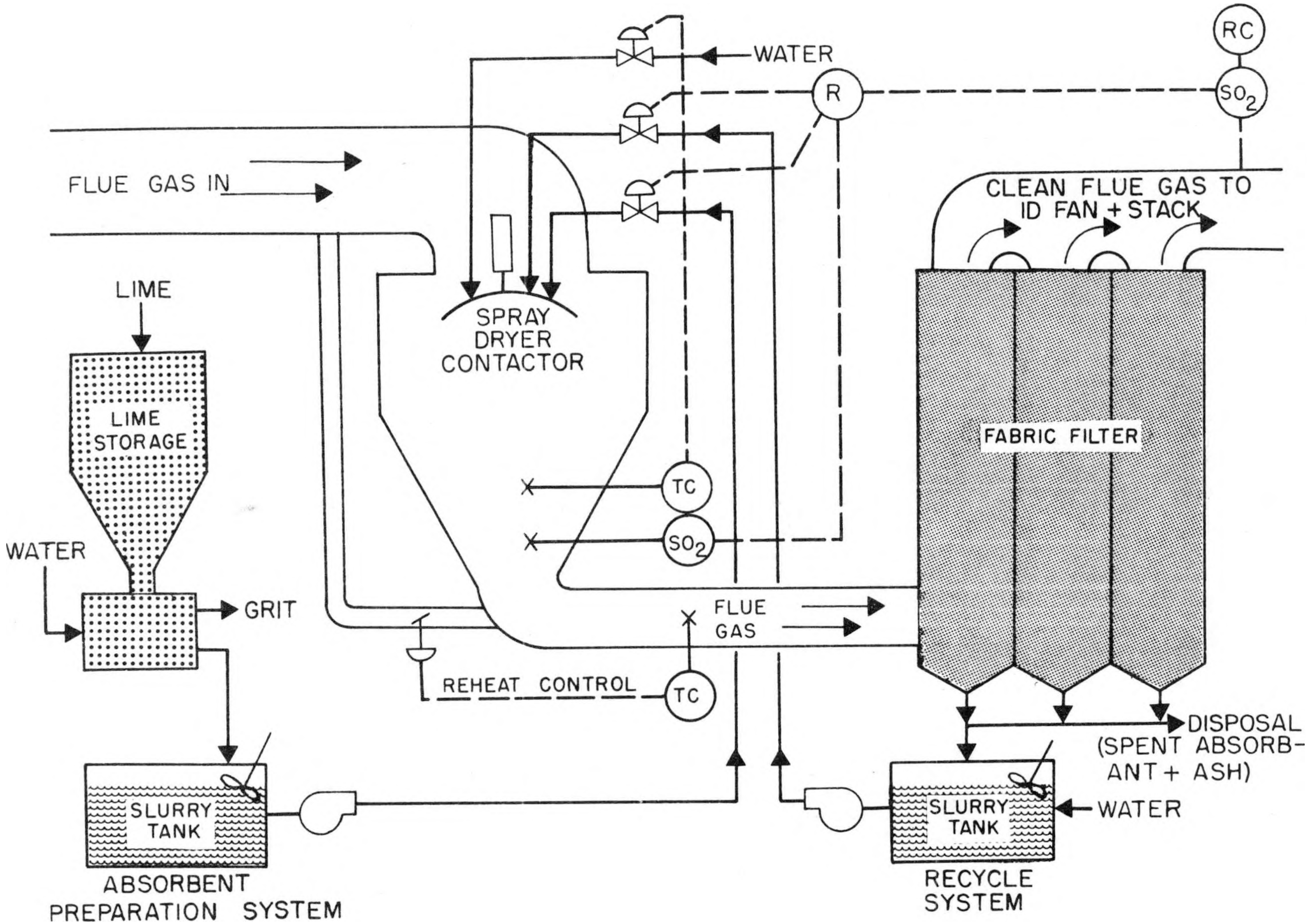


Figure 2-11 Process Flow Diagram: Two-Stage Dry FGD and Particulate Control System (Reference 2.17)

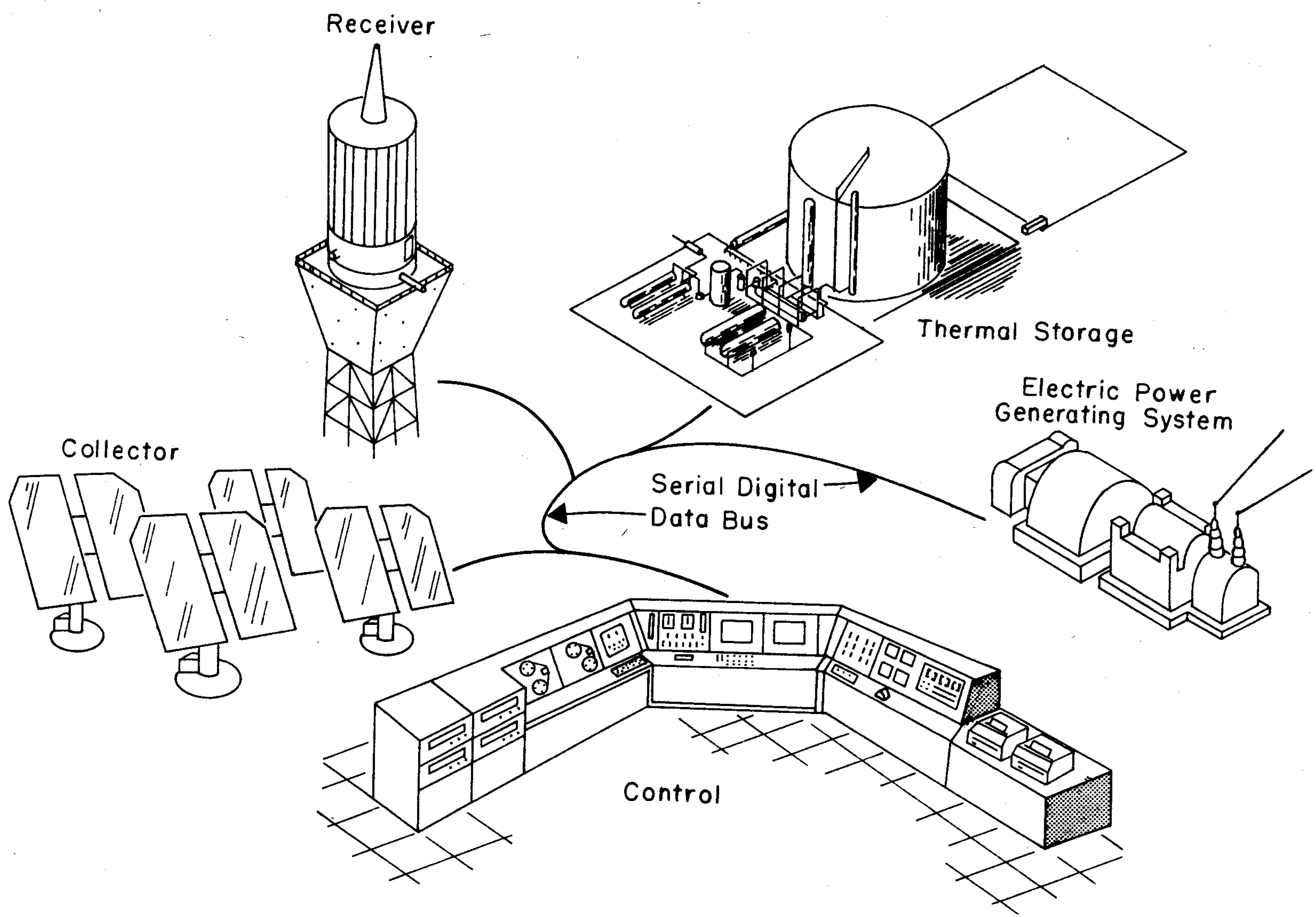


Figure 2-12 Distributed Control Concept (Reference 2.18)

or uncontrolled thermal excursions; 2) loss of control of sodium flows; and 3) loss of control of emission control equipment.

2.3 Environmental Questions Raised by the Baseline Design

Review of the Rockwell design raises several questions as to potential environmental impacts which may require mitigation or design modification. Several of these are outlined below.

2.3.1 Transmission Lines Rated at 115 kV

The Rockwell study assumed transmission lines rated at 115 kV. According to current practice, transmission lines are rated at voltages equal to about half the wattage ratings of the power they carry. Since the solar-coal plant will generate 430 MWe, the transmission lines will have to be minimally rated at 215 kV (the closest conventional rating is 230 kV). This upgrading of the transmission lines has several environmental impacts. First, a larger transmission corridor will be required. A greater amount of land and air space will be impacted. Second, larger, more massive towers will be required, again impacting a greater quantity of land and air space. Third, the impacts associated with construction will be increased. Finally, the upgrading will result in a greater resource requirement for materials used directly and indirectly, e.g. for the towers and lines themselves, and necessary transportation and installation activities.

2.3.2 Dust from Coal Handling

Details of the coal dust suppression and collection systems are not presented in the Rockwell study. Further details of the dust suppression and collection systems are needed to allow finer analysis of their biotic and abiotic impacts; whether water or other chemicals are used for the wet dust suppression, and the details of suction, filtration, and disposal methods will determine the types of impacts from the system. For this study, we assume a wet dust suppression systems using water, which will increase the plant's water consumption, and a dust suppression system using very fine, dry filters which will pass only a negligible quantity of very fine dust in a controlled area. The particulate material will be collected and disposed of off-site.

2.3.3 Utility Operation

Several questions regarding utility operation may be currently unanswerable, but are matters of concern and deserve consideration. What is the schedule for increasing coal combustion as insolation decreases? Is there some insolation threshold level below which power will necessarily be generated exclusively from coal combustion, even if there is some low level of solar power? The answers to these questions may have importance to plume-insolation considerations, particulate deposition rates on heliostat surfaces, and heliostat cleaning frequency and load, and the resultant environmental impacts.

2.3.4 Seismic Environment

The Rockwell study placed their base plant in a UBC Zone 3, and designed accordingly. (A map of seismic zones for the U.S. is included at the end of this chapter as Appendix Figure A2-1.) Our conceptual hybrid plant is sited essentially where the Sun Desert Nuclear Plant was to have been built. According to the Sun Desert "Early Site Review Report" (2.19), the nuclear plant's Safe Shutdown Earthquake specification reported horizontal accelerations of 0.35g and vertical accelerations of 0.25g. This is in contrast with the baseline design of horizontal and vertical accelerations of 0.25g. The question is whether the solar-coal system needs to be designed to meet the nuclear facility's design standards. A case can be made to assume that it does not, but the consequences of an earthquake of magnitude equal to or greater than designed for needs to be analyzed.

2.3.5 Heliostat Fabrication/Construction

The baseline design does not include details concerning the fabrication and construction of the 61,000 heliostats. The Martin-Marietta scenario (2.20) assumes a large market for heliostats, of which the 61,000 required for this solar-coal system is a part. A central facility, optimally located for employment, materials, transportation, and all other pertinent parameters, would fabricate heliostat modules. The modules would be transported by the optimal means (truck or train) to the sites. A building would be constructed at the site for final assembly of the heliostats, and designed to be used later for general plant maintenance. This scenario would require 100 to 150 construction workers working five years to install the 61,000 heliostats. The environmental impacts of this scenario include the feeding and housing of 100 to 150 workers and their families and support personnel in the vicinity of the site, and impacts of the transportation system and its operation and maintenance personnel.

The McDonnell-Douglas scenario envisions centralized fabrication and full assembly, and the transporting of fully assembled heliostats. The two approaches can have different environmental impacts at the power plant site.

The McDonnell-Douglas scenario would not necessarily need 150 people at the site to install the pre-assembled heliostats. But whereas the Martin Marietta heliostats would be transported in less fragile modular form, it is possible that a more automated means of unloading the modules could result at this stage in a smaller work force than would be required in the McDonnell-Douglas scenario. The final installation methods will probably be very similar. The environmental impacts of a larger total work force would probably accrue to the Martin Marietta scenario, but the potentially larger unloading and unpacking work force of the McDonnell-Douglas scenario could decrease the difference.

Whereas the Martin Marietta scenario specifies the transporting of smaller, less fragile heliostat modules which can be packed relatively densely, the McDonnell-Douglas scenario calls for the transporting of larger, fully-assembled, more fragile heliostats, which could result in a relatively low packing density. As such, the McDonnell-Douglas approach can be more transportation intensive, requiring more vehicle-miles, more emissions, and greater transportation impacts per heliostat than the Martin Marietta approach. For the purpose of this stuy, we have assumed the Martin Marietta scenario.

2.3.6 Plume-Insolation Calculation

A "plume-solar insolation" calculation was computed for a particulate deposit concentration presumed to result from spreading of emissions over the entire elliptical heliostat area (2.21). Our study disagrees with the Rockwell approach because it leads to an overly great dilution of the deposit concentration. The concentration should be calculated using as a receptor the area over which the plume actually passes. For the Blythe-Palo Verde site this would represent just 20% of the area of the ellipse 80 percent of the time. A more detailed analysis of emission impacts is presented in Chapter 4.

2.3.7 Mirror Materials, Cleaning, Oversizing

The baseline design specifies Corning fusion glass mirrored on its inner face and laminated to a float glass back lite (2.22). Cleaning frequency averages to about once per month. The method of cleaning proposed uses essentially "an inverted car wash without brushes." But studies have raised questions about the conditions assumed by Rockwell (2.23). Rain tends to wash off particles from mirror surfaces when the particles are more than 5 μm in diameter; particles less than 5 μm in diameter tend to accumulate. Particles 0.1 μm and smaller are not removed by simple spraying; they must be physically scrubbed off, a labor-intensive activity. Particles 0.1 μm and smaller are generally halides, which dissolve during the relatively high humidity of night-time and recrystallize in the day into larger particles. The larger particles, when they become 0.5 μm and larger, increase scattering and shift the energy loss to 500 nm (the peak of the solar spectrum), reducing the reflectivity of the mirror. Reflectivity has been seen to drop to 26 percent of the incident light intensity (from a high of 88 percent) in one month of natural exposure, and to only 2 percent reflectivity in two months of exposure (data are given in Tables A2-1 to A2-4 as an appendix at the end of this chapter) (2.24).

There are at least three major environmental concerns derived from these facts. The first is field oversizing, i.e., compensating for the loss of reflectivity due to soiling by increasing the number of heliostats and possibly concomitantly enlarging the area of the heliostat field. Increased environmental impacts would occur in both the construction and operation phases if field oversizing proved to be required to maintain power levels in conditions of heavy soiling and infrequent cleaning.

The second concern is for cleaning solution(s). If only deionized water is used, the studies suggest that more frequent cleaning than Rockwell reported will be necessary. This means that more water will be consumed than was reported. If other cleaning solvents are used, the environment can be impacted by their release.

The third concern is for the method of cleaning. Experience has shown that physical scrubbing is necessary to remove the smaller particles. This suggests that the cleaning procedure may be more labor intensive than the proposed Rockwell scheme. And the increased maintenance force, with their transportation and living requirements could increase environmental impacts.

For the purpose of this study, we assume simple high-pressure deionized water spraying of the heliostats. Cleaning frequency would be based upon deposition rates; heliostats that are more affected by the stack plume and/or cooling tower drift and/or fugitive dust emissions would be cleaned more frequently. The result of this assumption and condition would be increased water consumption relative to the Rockwell estimate.

2.3.8 Final Water Treatment

The Rockwell report states, "The ion exchange demineralizer configuration is subject to many variations. The quantity of the water to be treated will determine the appropriate one" (2.25). Actually, the quantity and quality of the input water should determine the appropriate final water treatment equipment. The Rockwell study provides no details of the final water treatment equipment for input water of various qualities. The equipment could dictate the quality and quantity of input water, and thus affect the area's water resources.

For the purpose of this study we have assumed input water of the quality and quantity originally planned for the Sun Deseret Nuclear facility. Except for the high cost of deionizing the large quantity of water necessary for cooling and increased heliostat cleaning, no particular problems should arise from the final water treatment procedure using conventional equipment and the water allocated for the Sun Desert nuclear facility.

2.4 References

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2.4 Rockwell, op. cit. Volumes I, II, and III.

2.5 ibid, Volume II Book 2, page 210.

2.6 ibid, page 211.

2.7 ibid., page 20.

2.8 ibid., page 64

2.9 ibid., page 65.

2.10 ibid., Volume I, page 30.

2.11 ibid., Volume II, Book 2, page 132.

2.12 ibid., page 187.

2.13 ibid., page 174.

2.14 ibid., page 179.

2.15 ibid., page 177.

2.16 ibid., page 181.

2.17 ibid., page 182.

2.18 ibid., page 192.

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2.20 Oldham, Lloyd. Staff scientist at Martin Marietta Corporation in Denver, Colorado. Contacted 8 August 1980 at (303) 789-2960. Personal communication.

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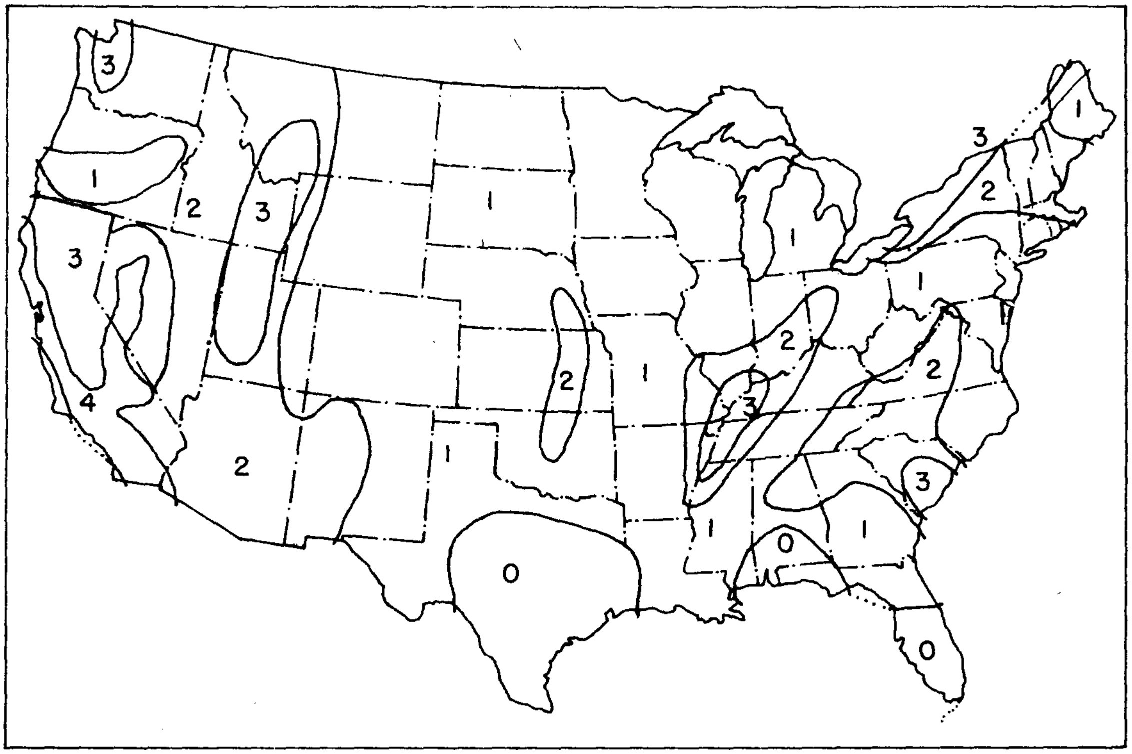


SEISMIC RISK MAP OF THE UNITED STATES

Based on:

Modified Mercalli Intensity Scale of 1931 (M.M.)

ZONE 0	No damage
ZONE 1	Minor damage: distant earthquakes may use damage to structures with fundamental periods greater than 10 sedond; corresponds to Intensities V and VI of the M.M. Scale
ZONE 2	Moderate damage: corresponds to Intensity VII of the M.M. Scale
ZONE 3	Major damage: corresponds to Intensity VIII and higher of the M.M. Scale
ZONE 4	Those areas within Zone No. 3 determined by the proximity to certain major fault systems

Figure A2-1 Seismic Risk Map of the United States (Reference 2.19)

Table A2-1

Description of Industrial Sites Utilized for the 12-Month Environmental Degradation of Solar Collector Surfaces (2.24)

Industrial Partner Participant	Site Location	Industrial Process	Typical Meteorological Factors
Southern Union Refining Company	Lovington, NM	Oil Refinery	Arid Climate with high wind velocities
Stauffer Chemical Company	Hendeson, NV	Chemical Processing - Chlorine	Very arid climate with moderate wind velocities
Lone Star Brewing Company, Inc.	San Antonio, TX	Beer Brewery	Moderate climate with moderate rainfall
Ore-Ida Foods, Inc.	Ontario, OR	Food Processing	Very cold climate with heavy snow, ice and heavy rainfall
Dow Chemical Company	Dalton, GA	Chemical Processing - Styrene Monomer	Cold climate with moderate snow, ice and heavy rainfall

Table A2-2

Environmental Degradation of Mirror Surfaces, Second Surface Glass Mirror Samples (2.24)

Industrial Site	Exposure Time (months)	Position of Sample on Exposure Rack[1]	Specular Reflectivity Measurements (%)			Change in Specular Reflectivity (%)	
			A Original	B Soiled	C Cleaned	Δ AB	Δ AC
Stauffer Chemical Company	1	X	90	38	90	52	00
		Y	88	26	88	62	00
		Z	90	90	90	00	00
	2	X	90	05	85	85	05
		Y	90	02	87	88	03
		Z	90	85	89	05	01
Southern Union Refining Co.	1	X	89	59	87	30	02
		Y	89	49	87	40	02
		Z	90	88	90	02	00
	2	X	90	71	82	19	08
		Y	90	57	83	33	07
Lone Star[2] Brewing Company	2	X	89	69	84	20	05
		Y	90	51	77	39	13
		Z	90	86	89	04	01
Ore-Ida Foods, Inc	1	X	90	73	90	17	00
		Y	90	56	89	34	02
		Z	90	83	90	07	00
Dow Chemical Company	1	X	90	90	90	00	00
		Y	89	89	88	08	01
		Z	90	90	90	06	00

1 Position X = 45° fixed angle facing south; Y = horizontal, facing sun; Z = horizontal, facing earth.
2 Month 1 data were not available for Lone Star Brewing Company

Table A2-3

Environmental Degradation of Mirror Surfaces,
FEK-244 Aluminized Acrylic Mirror Samples (2.24)

Industrial Site	Exposure Time (months)	Position of Sample on Exposure Rack[1]	Specular Reflectivity Measurements (%)			Change in Specular Reflectivity (%)	
			A Original	B Soiled	C Cleaned	Δ AB	Δ AC
Stauffer Chemical Co.	1	X	84	43	82	41	02
		Y	83	25	83	58	00
		Z	82	82	82	00	00
	2	X	83	10	65	73	10
		Y	84	04	66	80	36
		Z	84	76	80	08	04
Southern Union Refining Company	1	X	84	60	81	24	03
		Y	81	50	75	31	06
		Z	83	83	82	00	01
	2	X	73	54	70	19	03
		Y	83	64	77	19	06
Lone Star[2] Brewing Company	2	X	81	65	76	16	05
		Y	83	53	73	30	10
		Z	84	80	79	04	05
Ore-Ida Foods, Inc.	1	X	78	64	78	14	00
		Y	83	57	80	26	03
		Z	72	60	70	12	02
Dow Chemical Company	1	X	80	72	77	08	03
		Y	82	75	82	07	00
		Z	73	70	72	03	01

[1] Position X = 45° fixed angle facing south; Y = horizontal, facing sun; Z = horizontal, facing earth.
[2] Month 1 data were not available for Lone Star Brewing Company.

Table A2-4

Environmental Degradation of Mirror Surfaces, Alzak Mirror Samples (2.24)

Industrial Site	Exposure Time (months)	Position of Sample on Exposure Rack[1]	Specular Reflectivity Measurements			Change in Specular Reflectivity (%)	
			A Original	B Soiled	C Cleaned	Δ AB	Δ AC
Stauffer Chemical Co.	1	X	60	34	54	26	06
		Y	61	21	54	40	07
		Z	62	62	62	00	00
	2	X	59	10	37	49	22
		Y	60	04	38	56	22
		Z	58	56	58	02	00
Southern Union Refining	1	X	56	42	53	13	02
		Y	59	43	58	16	01
		Z	57	57	57	00	00
	2	X	62	51	57	11	05
		Y	64	44	51	20	03
Lone Star[2] Brewing	2	X	54	45	52	09	02
		Y	60	42	54	18	06
		Z	62	61	62	01	00
Ore-Ida Foods, Inc.	1	X	56	49	55	07	01
		Y	52	41	51	11	01
		Z	53	52	53	01	00
Dow Chemical Company	1	X	62	59	59	03	03
		Y	60	53	60	07	00
		Z	61	60	61	01	00

[1] Position X = 45° fixed angle facing south; Y = horizontal, facing sun; Z = horizontal, facing earth.
[2] Month 1 data were not available for Lone Star Brewing Company.

3.0 ENVIRONMENTAL SETTING

3.1 Area Description

The documents prepared for the Sundesert Nuclear Plant Project (by its sponsor, the San Diego Gas and Electric Company) contain extensive information on the proposed plant site. A number of consulting agencies contributed to the collection and compilation of results from experiments and surveys. We have adopted much of this information in helping to identify the problems of siting a hybrid coal/solar power plant at that site. The following environmental parameters have largely been abstracted from these documents.

3.1.1 Site Location and Description

The proposed plant site Palo Verde South (Blythe site), is located approximately 5.5 miles west of the Colorado River in Riverside County, California. The area occupies 7,040 acres (10 m^2) at the southern end of the Palo Verde Valley commonly referred to as the Palo Verde Mesa (which lies westerly of and on the order of 100-200 feet above the Palo Verde Valley). The Mule and Palo Verde Mountains bound the site on the west and southwest respectively, and it is bounded on the east by the Colorado River Floodplain. The nearest agricultural area is the Palo Verde/Cibola Valley located just east of the site along the Colorado River. The town of Palo Verde (population <300) lies 3 miles to the southeast and the city of Blythe (1979 population 7,250) is 16 miles northeast of the site (3.1). State Highway 78 runs north-south, approximately 3 1/4 miles east of the site. The closest population center (>25,000) is the city of Yuma, Arizona (1970 population 29,000) about 50 miles south of the Blythe site.

3.1.2 Geography and Demography

The Blythe site lies immediately north of the Riverside - Imperial County line at 33° 30' N latitude and 114° 40' W longitude. The Mule Mountains lie approximately 5 miles west of the site and the Palo Verde Mountains about 6 miles southwest of the site (Figure 3-1). The ground surface ranges from an elevation of about 350 feet on the east side to 400 feet on the west side. The Mesa slopes eastward at approximately 40 ft/mi toward the Colorado River Floodplain where it terminates in a 70 foot high bluff. In the southern part, the Mesa grades off at 40-80 ft/mi.

Aside from major urban areas in the extreme western portions of Riverside and San Bernardino Counties, the area to a distance of hundreds of miles is sparsely populated. Populated areas are generally limited to the development in the Palo Verde/Cibola, Imperial, and Yuma irrigated agricultural valleys. Located within a 10 mile radius of the site are two communities, Palo Verde and Ripley (1970 population of 600 and 350 respectively).

The area attracts two distinct transient groups: recreationists and farm workers. Recreationists visit the area primarily during the winter season setting up in travel trailers and mobile homes. Rock-hounding and

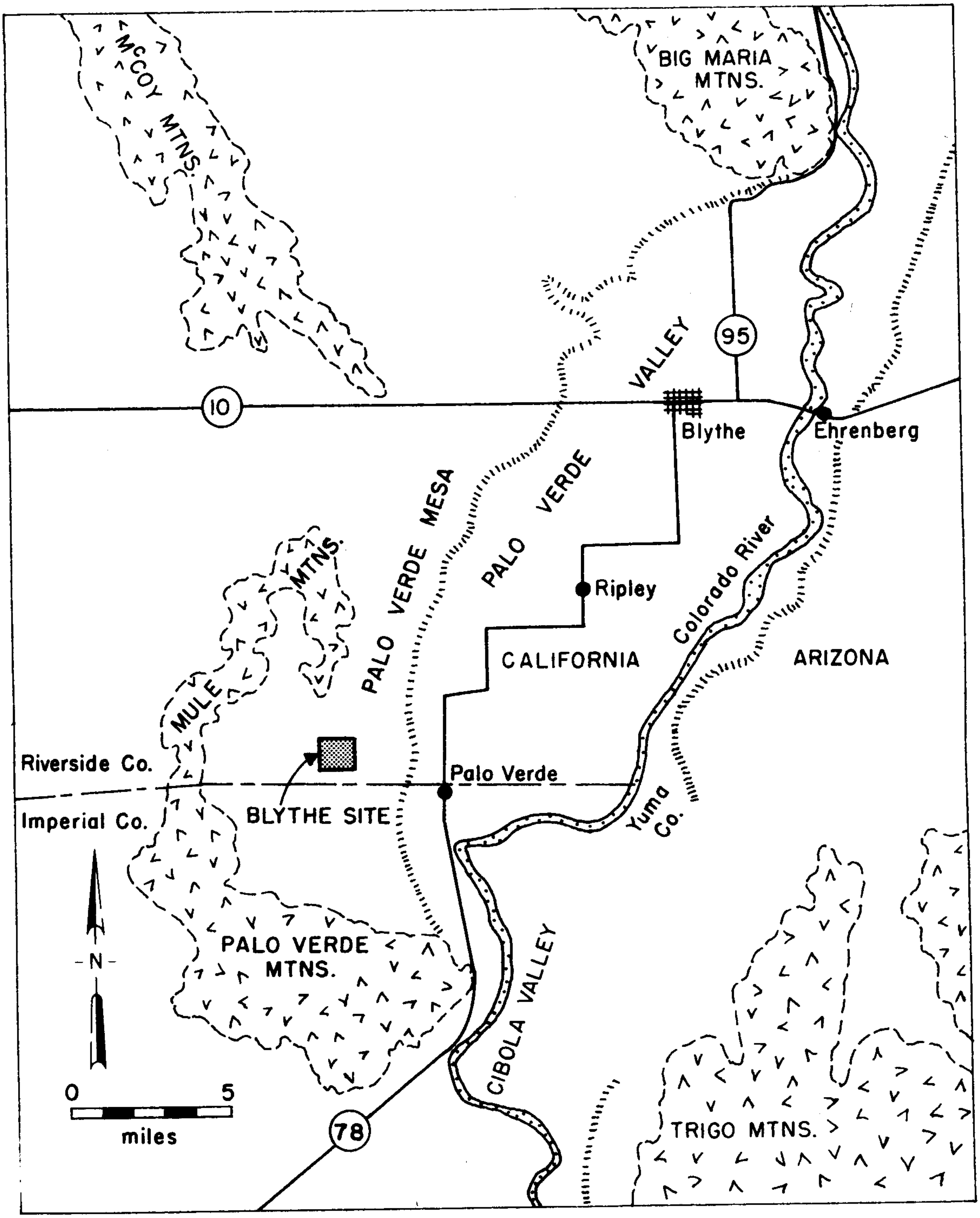


Figure 3-1 Location Map (Reference 3.2)

exploring the region in desert vehicles are the principal activities. The high temperatures during July and August limit recreational use during mid-summer months.

The second major transient group is composed of farm workers. The peak agricultural work force is employed during cultivation and harvest periods for the Palo Verde/Cibola Valley which occurs in March and April, June and July, and November and December. Normally there are only a few transients within a 5 mile radius of the site.

There are several military installations within the Blythe siting area. The closest facility is 11 miles east of the site (Yuma Proving Ground) where the population is 1,360.

3.1.3 Geology and Seismology

Screening to identify sites meeting the United States Nuclear Regulatory Committee geologic/seismic siting criteria and subsequent field evaluation revealed the Blythe site to be most favorable. Extensive drilling and down-hole geophysical investigations uncovered no subsurface cavities. No extraction of petroleum, coal, or geothermal resources has taken place at or near the site. No known reserves have been identified within the site vicinity and therefore no extraction activities are expected in the future. Considerable mining has occurred in the Palo Verde and Mule Mountains, north, west, and south of the site. However, all mining within the district ceased in 1960. The United States Bureau of Reclamation operates two quarries to provide material for maintenance of the Colorado River Channel. Three miles north of the site is an operation producing rip-rap material from granitic rocks and four miles southeast of the site is a small gravel quarry.

3.1.4 Climatology

The climate of the Blythe site is classified as arid (maximum and minimum temperatures recorded during 1973 were 122°F and 22°F, respectively). The average annual temperature is 72°F. During the summer, the prevailing winds are from the south-southeast and from the north-northwest during winter. Based on six years of data (Blythe, California) the strongest winds occur in July (9.4 mph), the weakest in October (6.1 mph) with an average annual wind speed of 7.7 mph. The area receives very little precipitation; the monthly average is less than one inch (average annual rainfall is 3.96 inches). The maximum amount of precipitation occurs in August and the minimum amounts in May and June. Severe weather in the vicinity of the Blythe site is primarily due to local thunderstorms which are responsible for intense, short duration rainfall, hail, and strong winds. These thunderstorms are most likely to occur during the months of July, August, and September. Strong winds produced by the thunderstorms occur occasionally at the site. Hail may be expected in the vicinity about once each year.

Site resources for a solar thermal power plant necessarily require "appropriate quantity and quality of insolation" (3.3). Average daily solar radiation for Blythe, California is presented in Table 3-1. Also of significant importance is the mean sky cover (cloudiness) at the principle site. When overcast conditions occur, the diffuse solar radiation cannot be concentrated to obtain usable energy. The most useful data were those obtained for Yuma, Arizona (Table 3-2). A condition of a high number of sunshine days strongly favors the siting of solar energy collection in the eastern desert provinces of southern California (3.5).

3.1.5 Socioeconomics

The economy of the Palo Verde Valley and adjacent lands are based on agriculture and recreation.

Agriculture is represented by a variety of products including alfalfa, wheat, cotton, citrus crops, melons, and vegetables. The Valley's top agricultural products (by value in dollars of output) are alfalfa, lettuce, lemons, melons, and cotton (3.6).

Blythe is the largest surface vehicle port of entry in California (over one million motor vehicles enter annually). Much of the recreation income is based on water-related activities and desert vehicle recreation. Overall revenues of motels, retail stores, restaurants, and recreational firms have been increasing each year. Other operations include cattle and sheep feedlot operations, food processing, agricultural chemicals and cotton ginning. Table 3-3 summarizes the labor force of the Palo Verde Valley.

There is only one hotel (40 room capacity) and nineteen motels (806 total room capacity) in the Blythe community area. One and two bedroom apartments and duplexes are available at $150 to $250 per month. Home rentals (2 and 3 bedroom) range from $200 to $450 per month.

3.1.6 Land Use

Land use patterns in the Palo Verde Valley are predominantly rural and agricultural. Only about 2.5 percent of the total Palo Verde land area is devoted to urban development. The urban areas include the city of Blythe, the East Blythe unincorporated area, the town of Ripley, and the unincorporated urban settlement of Palo Verde. Approximately 125 acres within the city limits of Blythe are zoned for light and heavy industry. Of this total, about 60 percent is vacant and available in parcels ranging from 1/10 to 20 acres. The remaining 97.5 percent of the Valley is taken up by rural agricultural use. The area receives roughly 4 inches of precipitation per year, and all crops are grown using irrigation.

Water is diverted from the Colorado River and distributed for irrigation within the Palo Verde Irrigation District (irrigated area of 92,000 acres). The district diverts about 900,000 acre-feet of water per year for irrigation, and about 400,000 acre-feet per year is carried out by the Palo Verde Outfall Drain and returned to the Colorado River.

Table 3-1

Average Daily Solar Radiation (by months)
for Blythe, California
(In Langleys Per Day)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
1976				308	349	501	589	660	708	613	641	471
1977	419	330	271									
Mean	419	330	281	308	349	501	589	660	708	613	641	471
Mean Annual Average 488												
					DIRECT*							
1976				543	453	613	681	727	814	696	496	
1977	598	576	479									
Mean	598	576	479	543	453	613	681	727	814	696	817	496
Mean Annual Average 624												

*DIRECT SOLAR RADIATION - Solar Radiation coming from the solid angle of the sun's disc on a surface perpendicular to the axis of this cone, comprising mainly unscatterd and unreflected solar radiation.

Reference 3.4

Table 3-2

Mean Sky Cover (Cloudiness), Sunrise to Sunset
Yuma, Arizona

Years of Record	Mean Percentage of Cloud Cover												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	AUG
25	41	36	35	23	18	12	27	24	14	21	30	37	27

Reference 3.4

Table 3-3

Palo Verde Valley Labor Market (1970)
Includes Blythe and Ripley Area Population - 12,250
Total Employment - 4,349

Construction	227
Manufacturing	253
Transportation/Commerce/ Utilities	453
Retail Trade	585
Wholesale Trade	96
Finance/Real Estate/ Insurance	129
Services	582
Education, Public Administration	618
Other (including agriculture	1,133

Reference 3.7

The plant site occupies land that has never been developed. No residential, industrial, or recreational structures, highways, railways, or water ways are found within the site area. Lands to the north, south, and west are undeveloped and similar to the plant site lands. However, land to the east, within 5 miles of the site, is developed and supports intensive irrigation agriculture.

3.1.7 Vegetation

The vegetation is characterized as a Creosote Scrub community which is typical of the Colorado Desert (Figure 3-2). Tree species in the area exhibit their greatest growth and are most concentrated along the sandy arroyos that traverse the mesa. There are also several low, wide-spaced perennial grass species like the Big galleta (Hilaria rigida) primarily found in sandy soils of mesa and basin regions. Annual blooms are seasonal and dependent on rainfall. This specie of grass forms large open clumps and is associated with the Creosote bush. The dominant speciea are the very resinous Creosote bush (Larea tridentata) and the salt bush (Atriplex canescens), a plant of the Goosefoot family. Tamarisk thickets (Tamarix pentandra) are often found at an elevation of 70-75 m. Tamarisk are frequently used as wind breaks, but salt deposits on the under-side of the leaves are a potential source of contaminant which would preclude their use around heliostat arrays.

3.1.8 Sensitive Areas and Endangered Species

The nearest sensitive area is the Cibola National Wildlife Refuge approximately 12 km southeast of the site. No threatened or endangered plant

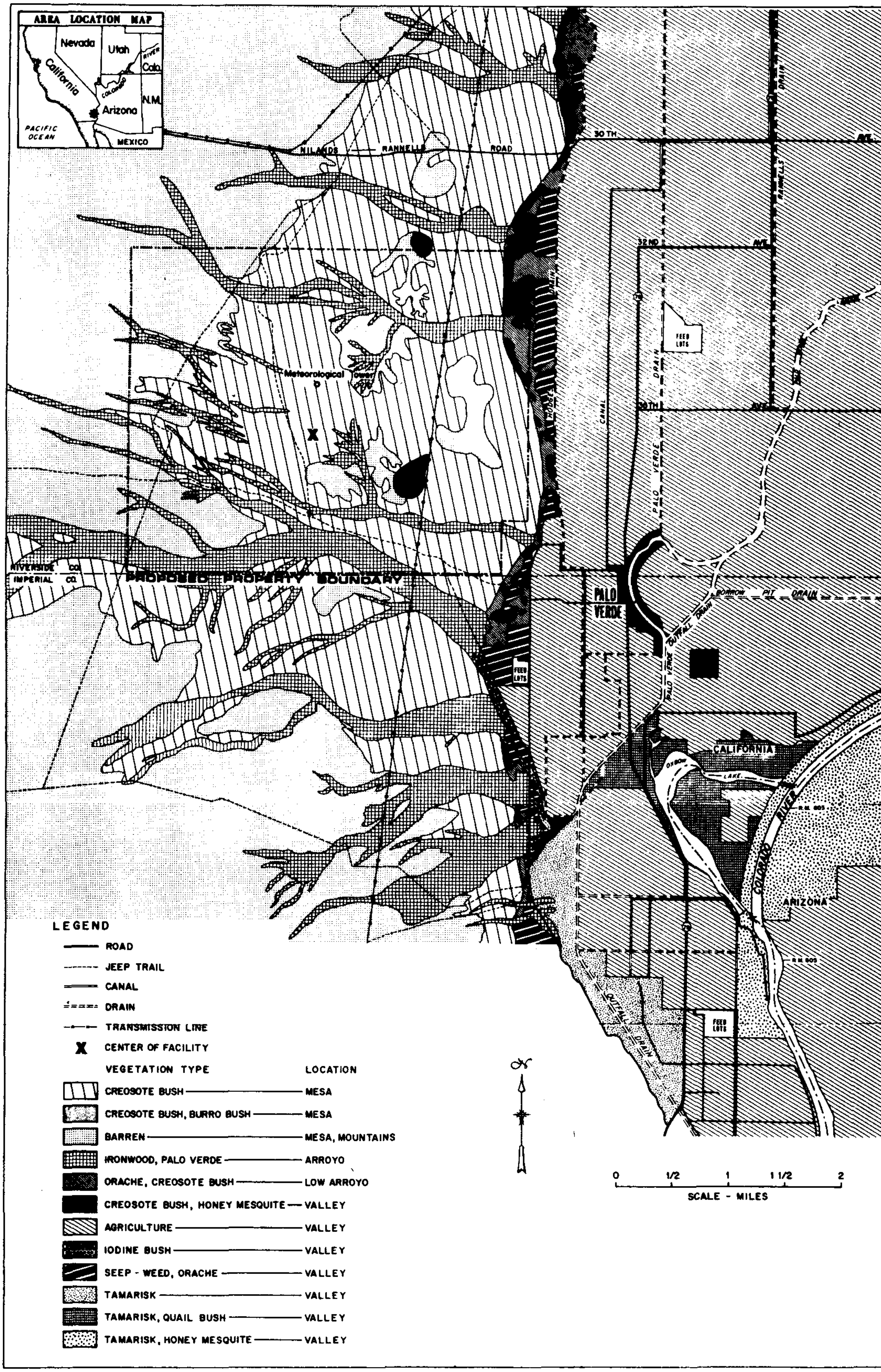


Figure 3-2 Vegetative Cover Types of Area (Reference 3.8)

species, dependent on the Blythe site have been identified. Twelve rare and/or endangered plant species were found existing within 50 miles of the site. A wide variety of bird species were identified as either seasonal transients or permanent residents. Six animal species were listed as rare, threatened, and/or endangered and have ranges that encompass the Blythe site. These terrestrial species are expected to occur only sporadically because the area lacks their preferred habitats (one of the six species could be expected to breed near the Blythe site).

3.1.9 Archaeology

An archaeological survey (24 quarter sections) revealed two quarter sections having high concentrations of artifactual materials. It has been recommended that these two sites be converted to workshop sites preserved and protected in their natural state. The scattered artifacts would be collected, cataloged, and stored. Presumably location of the actual heliostat field could avoid these sites.

3.2 Assessment Checklist (Riverside County)

The site under construction in this report comes under the jurisdiction of the Riverside County Planning Department. The Environmental Quality Section, Riverside County Planning Department utilizes a convenient Initial Study form containing questions of critical environmental concern to evaluate project proposals (included as an appendix to this chapter). Utilizing the survey questions as a criterion, the present study indicates that the project may have a significant effect on the environment. (The forms have been completed using plausible answers.) It is not too difficult to identify or even quantify environmental impacts for conventional projects (data and experience are available). However, for innovative energy projects it is difficult to identify potential new problem areas.

3.3 References

3.1 Department of Finance, State of California, Budget Division. "California Statitics Abstract 1979," p. 14.

3.2 San Diego Gas and Electric Company. "Notice of Intention for Sundesert Nuclear Project." Vol. 1, Figure II B-2, June 1976.

3.3 Holbeck, H.J. and S.J. Ireland. "Siting Issues for Solar Thermal Power Plants with Small Community Applications." Jet Propulsion Laboratory. California Institute of Technology. Pasadena, California. p. 17 (1979).

3.4 Department of Water Resources. "California Sunshine - Solar Radiation Data. Bulletin 187." State of California, Sacramento, August 1978.

3.5 Aerospace Corporation. "Solar Thermal Conversion Mission Analysis Vol. V: Area Definition and Siting Analysis." PB-232 672 (1974).

3.6 Office of Riverside County Agricultural Commissioner. "Riverside County Acreage and Crop Report, 1978 and 1979" District - Palo Verde Valley.

3.7 Riverside County Department of Development. "Community Economic Profile. Blythe, Riverside County, California", January 1980.

3.8 San Diego Gas and Electric Company. "Environmental Report, Construction Permit Stage, Sundesert Nuclear Plants, Units 1 and 2." Vol. 1, Figure 2.2-2, August 1977.

3.4 Appendix: Environmental Impact Survey

This appendix of four pages presents the Riverside County Planning Department Environmental Impact Survey, completed with plausible entries for the present hypothetical solar/coal facility.

INITIAL STUDY: COMPREHENSIVE
(Generally for large or complex projects)

ADDITIONAL INFO REQUESTED:
DATE 9/12/80
INITIALS RGL

DETERMINATION:

Negative Declaration: ___
Positive Declaration: X
Other: ___
(See Determination & Findings)

BACKGROUND

Applicant/Representative: Tres Equis Power
Address: c/o 405 Hilgard, Los Angeles, California 90024
Project Description: Coal/Solar hybrid power plant
Project Location: Palo Verde South
___ of the ___ of Sec ___ T ___ R ___
District/Area: Riverside County, California
Environmental Setting: Desert

EVALUATION

1. Is the site subject to any of the following hazards? Yes X No ___

none	Surface fault rupture	N/A	Ground Subsidence	none	Fire
none	Liquefaction	limited	Flood or drainage	none	Expansive soil
none	Significant Groundshaking	none	Ground cracking	yes	Noise (over 60 dBA) 100 dBA constr.
none	Landslide or mudslide	not likely	Erosion	___	other

2. Does the site encompass or is it adjacent to any biologically sensitive area? Yes X No ___

Cibola National Wildlife Refuge, 12 km SE of site.

3. Does the site encompass or is it adjacent to any archaeologically sensitive areas or historical site? Yes X No ___

2 quarter sections revealed high concentrations of artifacts.

4. Will the site be modified to prepare it for development? Yes X No ___
If so, will the modification create any hazards or impact any sensitive areas?
Not likely

5. What is the agricultural potential of the site?

Land not used for agriculture or any other purpose.

6. Is the site within or adjacent to an Agricultural Preserve? Yes X No ___

Lands to the east, within 5 mi of site center are developed (intensive irrigated agriculture)

7. Is the project consistent with General Plan Elements?

no	Land Use	no	Open space	yes	Scenic Highways
no	Circulation	yes	Seismic Safety	no	Public Services & Facilities
no	Housing	yes	Safety	yes	Recreation
yes	Conservation	yes	Noise	___	Other

8. Could the project encourage the development of surrounding properties?
Yes X No ___

9. If the project involves a division of land, are the size of the parcels proposed consistent with surrounding lot sizes.
N/A

Are the following facilities available at the site; if not, how far is the site from these services? Yes ___ No X

___	Public Road	___	Sewer
___	Water	___	Other

Applicant responsible for the necessary services

11. Impact on facilities and services:

- o The scope of the project is such that it will not have a significant effect on facilities or services.
- o Detailed analysis of maximum development potential (if applicable) Potential "Boom Town" effect on Blythe or Palo Verde.

Type of Facility/Service	Demand/Generation (Max)	Service of Facilities Capability/Capacity
Water Heliostat cleaning	3,878,400 gal/yr 2.03×10^9 gal/yr	
Sewer		plant to have wastewater treatment facilities
Schools	dependent upon out-of-community work force	

What are the response times of the following services?

Police: applicant to provide services
Fire: applicant to provide services
Other:

What will the maximum traffic generation figure? Not known

What are the capacities of the roads serving the site?
Railroads and highways to be constructed

12. Could the project have a significant impact on groundwater resources in terms of overdraft and/or pollution?
Possible impact, depth to groundwater table - 140'

13. If septic tanks are proposed, are the soils capable of supporting the use?
Yes ___ No ___ No septic tanks proposed

14. Will the project create any hazardous or annoying conditions?
_X_ Dust _X_ Noise _X_ Traffic _X_ Other
Likely increase in fugitive dust during construction

15. What will be the energy demand of the project? Negligible _X_
Gas: negligible

Electricity: from plant

Could the project be redesigned to make it more energy efficient?
N/A

16. Will the project have a significant impact on the air quality of the area or region? Yes X No ___
If so, what are the emission figures? Potential exists

17. Will the project have any significant visual impacts? Yes X No ___
Heliostat field, cooling tower plume, central receiver, cooling towers will be visible from great distances

18. Community issues:
    stress on present economy
    housing problems
    increased demand on public utilities and services
    impact on local work force

19. Other design considerations:
    flood drainage system
    exclusion area
    transmission corridors
    highways and railroads

20. Project or area controversy:
    change of land zoning necessary
    jeopardizing of agriculture or tourist industry

21. Other issues or further explanations:

MITIGATION MEASURES

Facility will be well planned and operated, and will meet all existing regulations

AGENCIES CONSULTED

South Coast Air Quality Management District, California State Energy Commission, California Public Utilities Commission

FINDINGS

EIR essential

DETERMINATION

Based on this Initial Study, the Planning Department has determined that:

___ The project will not have a significant effect on the environment and a Negative Declaration may be prepared.

_X_ The project may have a significant effect on the environmental and an Environmental Impact Report is required.

RGL
(Name)

September 13, 1980
(Date)

4.0 AIR QUALITY AND METEOROLOGY IMPACTS

This chapter discusses the air quality and meteorological concerns associated with a 430 MW(e) coal/solar hybrid power plant, developed from the Rockwell design. Due to limitation of resources, not all relevant air quality and meteorology issues were addressed in this study. Impacts of one plant subsystem on another and impacts of the environment on the plant are stressed; the more "traditional" impact assessment of the plant on the environment is only addressed for specific topics. Recommendations for future work are discussed where appropriate. For more detailed discussions, the reader is referred to Volume II of this study, entitled: "Air Quality and Meteorology Impacts". This chapter is a summary of that volume.

4.1 Impact of Emissions from Coal Combustion on Heliostat Performance

We were interested in addressing the issue of heliostat degradation caused by coal combustion emissions for two reasons:

- to determine the potential of the problem in a worst-case situation, since accumulation of appreciable quantitites of particles on the surface of the heliostats may require increased washing frequency, thereby requiring greater dependence on coal or increasing water demands above those of a solar plant;
- to determine how the problem might effect siting and/or plant design.

4.1.1 Worst Case-Emissions

The first step in assessing the impacts of emissions from the coal components is to quantify the emission rates of all regulated pollutants. Because any coal-fired power plant would have to meet air quality emissions standards, we assumed that emissions from the proposed plant will take place at rates established by the standards.

The Sundesert site is located in Riverside County, and is therefore under the jurisdication of the South Coast Air Quality Managment District (SCAQMD). Table 4-1 presents the applicable emissions standards for a 430 MW(e) power plant located in the SCAQMD. These data were derived as a proportionate fraction (430/500) of the emissions for a 500 MW(e) plant in the same region (4.1).

Treating the standards as emissions assumes that the plant will be operating at maximum capacity [430 MW(e)]. This is a worst-case assumption, because as discussed in Chapter 2.0, the coal portion of the plant is intended to operate at 20 percent capacity during the day, while the solar component is supplying the rest of demand. The "worst-case" approach is used frequently in air quality impact analysis. If the worst-case" analysis does not suggest undesirable results, one can usually assume that no problem will exist.

Table 4-1

Emissions Standards Applicable to 430 MW(e) Coal Power Plant in Riverside County, California

SCAQMD Rule No.	Pollutant	Maximum Allowable Emissions
405	Particulate Matter	2.9 g/sec (23 lb/hour)
431.3	Sulfur Dioxide	319 g/sec (2530 lb/hour)
475/1135.1	Nitrogen Oxides	92 g/sec (730 lb/hour)
407	Carbon Monoxide	1484 g/sec (11780 lb/hour)

SCAQMD = South Coast Air Quality Mangement District

Given the emissions from the proposed facility, the next step is to identify which pollutants will impair heliostat efficiency through dry deposition. Wet deposition will not be considered because it would be accompanied by rainfall which would help clean the heliostats and improve efficiency. The emissions in Table 4-1 are either gases or particles when emitted from the power plant stack. Because we are looking at deposition, we will focus only on particulate matter, assuming that gases will not settle out of the atmosphere or degrade on the heliostat surface within the heliostat field. Particulate matter in the plume from the coal stack is composed of primary particulates directly emitted from the stack and secondary particulates formed by chemical reactions between liquid and gaseous aerosols. Secondary particulates were shown not to be a significant problem affecting heliostat performance, because reaction rates were too slow for them to form in appreciable quantities before passing beyond the outer boundary of the heliostat field.

Assessing the impact of primary particulates on heliostat efficiency through dry deposition consists of the following steps:

- determine the emission rate and size of emitted particles;
- use dispersion modeling to predict ambient particulate levels within air parcels reaching the heliostats;
- compute particle impaction rates;
- determine impairment of heliostat efficiency based on calculated mass loading.

The proposed facility was assumed to emit particulate matter at a rate of 2.9 g/s (23 lbs/hour). The particulate control technology proposed for the facility is a baghouse or fiber filter. Baghouses exhibit a minimum removal efficiency for particles with diameters in the 0.1 to 1.0 m range (4.2). Therefore, we will assume that most of the time (when control equipment is operating properly) the particulate emissions will be in the 0.1-1.0 μ diameter size range. Temporary failure of particulate control equipment can change both the size distribution and emission rates of emissions.

4.1.2 Worst-Case Meteorology

Three types of meteorological conditions can cause worst-case ground-level ambient concentrations given an elevated source (4.3):

- a turbulent and well-mixed unstable atmosphere;
- trapping of the plume by the base of an inversion located above the plume stack;
- fumigation when the plume is emitted into a stable inversion layer and is then entrained into the mixed layer when the inversion is broken up due to surface heating;

As shown in Volume II, the first set of conditions listed above--a turbulent and well-mixed atmosphere--was selected as being most representative of the particular questions being addressed in this study.

Pasquill Stability class A, the most unstable, is used for the analysis. It is generally characterized by strong incoming solar radiation and low wind speeds (4.4). Wind speed and atmospheric stability are the two meteorological parameters required to implement Gaussian models. As far as wind speed is concerned the upper level winds are of most interest because we are concerned with the elevated release of pollutants. From the standpoint of developing a worst-case scenario, we are interested in whatever wind speed is likely to occur at the site that will give the highest ground level concentration. In general, the lower the wind speed, the more pollutants that can build up to produce high ground level concentrations. Extensive wind data have been collected at the Sundesert site, and at two levels: 30 feet and 190 feet above the ground. The data taken at 190 feet most closely represent the height of the emissions for our proposed case.

The wind data collected at the site are broken down by stability category, which is determined by wind speed and incoming solar radiation. Generally, six stability classes are reported, A to F, with A being the most unstable atmosphere and F the most stable. As shown previously, we have selected A stability for our worst-case analyses.

The lowest wind speed that was observed at 190 feet at the site under stability A was in the range 1 to 3 mph (4.5). The midpoint of the range, 2 mph, will be used for the modeling. The wind is assumed to be from the south in order to maximize the heliostats exposed to the plume.

4.1.3 Atmospheric Model

A simple Gaussian model was selected for this study for three reasons:

- we are interested in the dispersion of primary pollutants, and therefore need not address chemical transformations in the atmosphere;
- the terrain within the site is relatively flat, and complex terrain models need not be used;
- we are interested in only one source, so multiple source models are not needed.

Volume II contains a detailed description of the model. Basically, it is a Gaussian dispersion model for predicting downwind and crosswind ambient concentrations of inert pollutants, as described in Turner (4.3). The modeling exercise was done to provide estimates of ambient particulate levels expected to result from the worst-case emissions and meteorological data described in the previous sections, as a function of both downwind and crosswind distances from the coal stack. The model predicted 24-hour average ambient ground level particulate levels in the range of 0.33 to 3.7 $\mu g/m^3$, for downwind distances ranging from 700 m to 2400 m. The maximum concentration (3.7 $\mu g/m^3$) was predicted to occur at approximately 1100 m downwind from the stack. More detailed plume modeling results can be found in Volume II.

4.1.4 Aerosol/Heliostat Impaction Model

A model was developed that estimates the mass deposition rates of suspended aerosols on the surface of heliostats. A detailed description of the model appears in Volume II. The model uses ambient pollutant levels predicted by a dispersion model as input data. Multiplying the ambient particulate concentration in $\mu g/m^3$ by the ground level wind speed (m/s) produced a particle impaction rate in $\mu g/m^2$-s. This is the rate of particle impaction on the row of heliostats first impacted by the plume. The impaction rates for heliostats located further downwind are influenced by how much the upwind heliostats have reduced the ambient particle concentrations, although this is a small correction. The model assumes (arbitrarily as an approximation) that 10 percent of the total mass of particles computed as impacting a heliostat surface stick to that surface, and are thus effectively removed from the air. In reality, this "sticking coefficient" will most likely not remain constant; rather, it will probably vary depending on wind speed and direction, particle size and chemical composition, temperature, humidity, degree of soiling of the heliostat surface, and other factors. The model also assumed that all heliostats were at a 45° angle from the vertical and thus somewhat reducing the cross-section from impact; in reality the heliostat angle will vary in both space and time.

Other assumptions upon which the impaction model is based are documented in Volume II. The capabilities of the model should thus be viewed as providing first-cut, order-of-magnitude estimates of particle impaction rates on heliostat surfaces. Figure 4-1 presents the predicted mass of particulates (grams) deposited on a single heliostat in a cell within a 30-day month. The model predicts that as a worst-case a maximum of 229 g would be deposited in a 30-day period; this translates into 6.5 grams of particulate matter per square meter area. These and other data should not be used without considering the limitations and assumptions of the model.

4.1.5 Conclusions and Recommendations

Finalizing the impact assessment of coal combustion emissions on heliostat performance is difficult at present because the final data needed--heliostat performance as a function of mass loading of particles on its surface--are not available. Conversations with scientists and engineers in the solar energy field have indicated that some data of the type needed should be available within six months. However, because sample surfaces of very small size are being utilized, it is likely that scaling relations for flow, deposition, and "sticking" will be substantially different than for full-scale heliostats. Thus some data obtained may well be of limited validity and usefulness.

One major result from the modeling exercise is that the deposition rate of particles on the heliostats is seen to be dependent on the location of the heliostat in the field. Therefore, it is quite possible that not all heliostats will require the same washing schedule; i.e., some will have to be washed more frequently than others.

A second result from the modeling study is that the worst-case intra-plant air quality impacts can be mitigated through changes in the facility design. Mitigating the worst-case intra-plant air quality impacts can be done by judicious juxtaposition of the emitting susbystems (coal stack, cooling towers) and receiving subsystem (heliostats). The minimum heliostat area should be placed downwind of the emitting subsystems along the vector of the prevailing wind; by so doing, most of the time a minimal heliostat area would be adversely impacted by the plume. In this regard a very effective design change would be to eliminate one quarter of the heliostat field, and increase the number of heliostats in the remaining three quarters to compensate for the loss. This "open" quarter would then be aligned with prevailing wind at the site, and would be placed downwind of the coal stack and cooling towers; consequently, most of the time emissions would not impact the heliostats. It is important to note that this mitigation measure would only work a given percentage of the days during the year, as described by wind direction frequency data for the site (wind roses). For example, if the prevailing wind blows from the southwest 80 percent of the time, then siting the open quadrant to the northeast of the coal stack and cooling towers will mitigate the problem on 80 percent of the days in a year, on the average. On the other 20 percent of the days, operation of the solar subsystem may be adversely impacted by emissions from the coal stack and cooling towers.

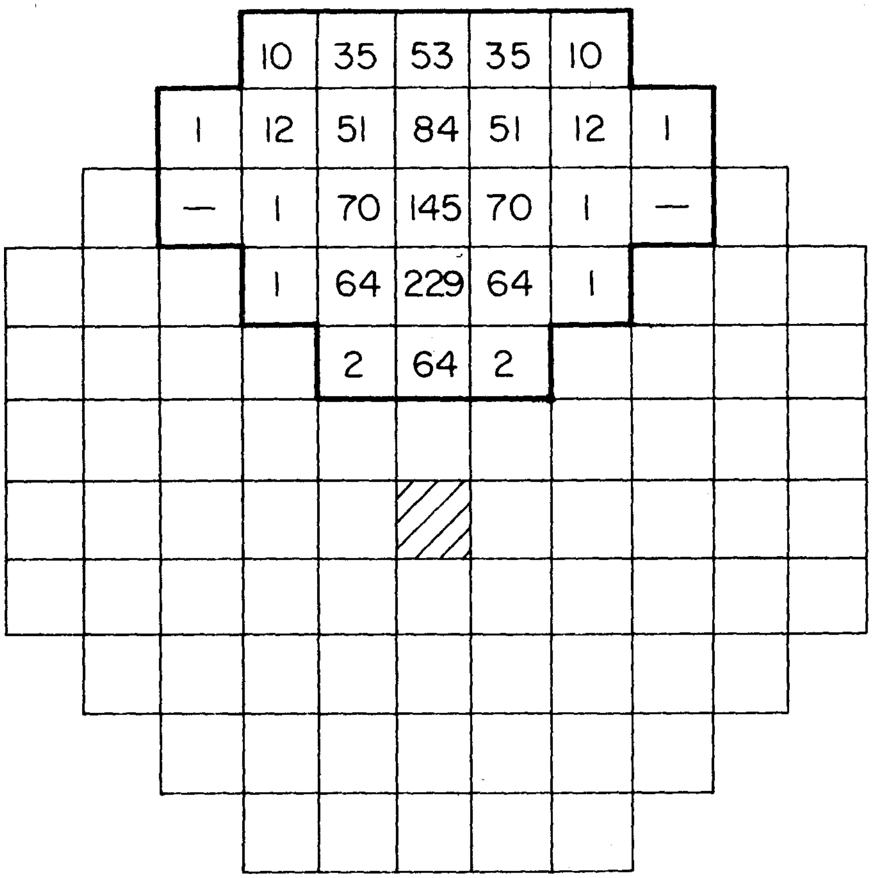


Figure 4-1 Predicted Particulates Mass Deposited per Heliostat in Each 30-Day Month (in grams)

The most important recommendation regarding this portion of the present study is that the heliostat impaction model should be refined to produce more accurate results. Increased efficiency would come from use of available computer models for the plume modeling. Developing a computer code specifically for the heliostat impaction model is also desirable. The ambient concentrations of particulates could be pinpointed at each heliostat; combining this with the wind data, heliostat angle at each heliostat, and other factors which should be allowed to vary would allow one to trace the change in concentration in the plume accurately as it moves downwind from the source. A figure for the quantity of particles re-entrained into the plume could also be calculated, based on the size and density of the particles and the wind speed on the ground surface. A detailed analysis of wind flow around the heliostats and particle behavior in that flow is also needed.

4.2 Impact of Salt Emissions From Cooling Tower Operation on Heliostat Performance

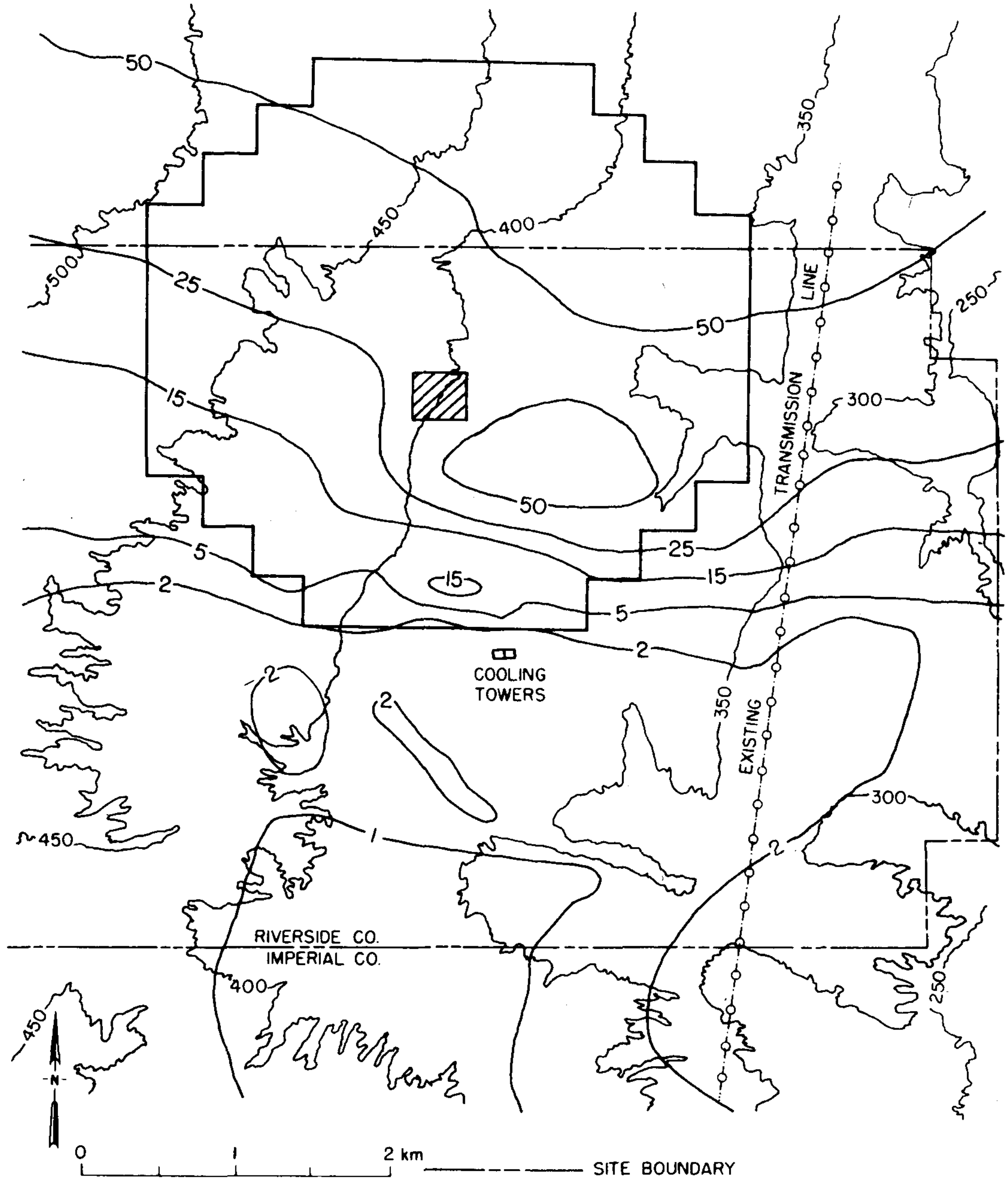
Estimating the impacts of cooling tower emissions on heliostat performance was done using atmospheric modeling work performed for the Sundesert nuclear plant. The approach used for coal emissions was not extended because the Sundesert modeling work presumably provided the data we needed--salt deposition rates per unit area for the Sundesert site--with only minor modifications.

The cooling towers proposed for the Sundesert plant were expected to meet local emission regulations for particulate emissions; there are no corresponding federal new source performance standards (4.6). Wet mechanical draft cooling towers were proposed for the Sundesert plant. The proposed coal/solar hybrid plant will most likely use wet-dry towers (see Section 2.2.7). However, the assumed wet cooling towers represent a worst-case scenario from the standpoint of salt deposition impacts, because the wet towers emit a moist plume which upon evaporation yields salt particles. A wet-dry tower has no significant amounts of such emissions when operated in the dry mode. The two cooling towers are each expected to emit 37.5 kg salt/hour as a worst-case emission rate.

The worst-case meteorological conditions assumed for the Sundesert modeling exercise were not documented in the original reference. The same worst-case conditions used for the previous portion of this study can be assumed here because we are dealing with elevated point sources: unstable atmosphere and low wind speed.

A Gaussian-type model was used to estimate salt deposition rates. The drop concentration, diameter, velocity (horizontal and vertical) and trajectory as a function of time as the drop travels from the top of the cooling tower to the ground were determined by solving a set of simultaneous differential equations as a function of time (4.7). A more detailed description of the model can be found in Volume II.

Figure 4-2 presents isopleths of salt deposition rates in kg/km^2/month, for the month of July, superimposed on a map of the proposed facility.



NOTES: DRIFT RATE = 0.002% (75.1 kg SALT/HR/GENERATING UNIT), NUMBER OF TOWERS: 2, EACH HOUR COUNTED AS DRY HOUR

Figure 4-2 Predicted Salt Deposition Rates

The data in Figure 4-2 were obtained directly from the Sundesert Report with the following modifications (4.8):

- the location of the cooling towers within the proposed facility was placed at the planned center of the Sundesert facility;
- the values of the isopleths for the Sundesert plant were divided by four to obtain the predicted results for the proposed coal/solar plant.

Reasons for these choices included the fact that atmospheric modeling for cooling tower emissions from the proposed Sundesert plant were based on 8 cooling towers while the proposed coal/solar hybrid will have two cooling towers. We assume that emission and salt deposition rates are both proportional to unit size. Lastly, we are also assuming that the proposed hybrid plant will have identical cooling towers (type, size, etc.) located in the same place as those proposed for Sundesert plant. (These last assumptions do not represent a Rockwell design choice.)

The maximum salt deposition rate predicted by the model is 50 kg/km^2/month for July; equivalent to 0.05 gm/m^2/month and considerably less than the maximum particulate deposition rate predicted for the coal emissions (6 gm/m^2/month). Because the data were derived using two different models, different assumptions of plant location and meteorology, their respective results should not necessarily be expected to agree. Rather, the data in Figure 4-2 should be used to determine the relative areas of expected high salt deposition rates in the heliostat field. As can be seen, the highest salt deposition rates are predicted to occur in the southeast quandrant. Considering only salt deposition rates, this area of the field would require a higher cleaning frequency than the other areas.

The modified Sundesert modeling results indicate that two wet cooling towers at the proposed facility will produce salt deposition rates that are insignificant compared to particulate deposition rates. These results do not appear logical. Two cooling towers of the type proposed for the Sundesert plant were estimated to emit approximately 38 kg salt per hour, which is equivalent to about 11 g/sec. The emission rate for the particulates from coal combustion was assumed to be 3 g/sec (the emission standard for particulates). Consequently, if the same model were used for both salt and coal particulate emissions, the mass of salt expected to deposit on the heliostat surfaces should be of comparable magnitude to the levels of coal particulates.

In order to use the heliostat impaction model on salt emissions from cooling towers, one must assume that the salt-containing particles are small enough (less than 1 μ) so that gravity does not modify deposition. The cooling towers can affect the entire heliostat field. This is a worst case compared to the coal stack, which only influences half of the field at any given time. It also would not be expected to produce maximum deposition rates in the same area as the coal emissions. Most likely the maximum salt deposition rates, as predicted with the heliostat impaction model, (assuming a southeastern wind to expose the largest part of the field to the plume), would be in the southern hemisphere of the field. The coal particulate deposition rates reached a maximum in the northern half of the field. Hence the worst-case total particulate deposition rates will be averaged out over both halves of the heliostat field, thereby requiring approximately the same cleaning schedules for the entire field.

As was the case in the previous section, we cannot quantify the effects of salt emissions on solar plant performance, because data are not available describing heliostat efficiency as a function of mass loading of the heliostat surfaces.

4.3 Attenuation of Insolation by Emissions from the Coal Stack and the Cooling Tower

Simultaneous operation of both the coal and solar components of the proposed hybrid plant is the normal operating mode. At any given time during the day, the coal component will contribute a minimum of 20 percent of the 430 MW(e) output of the plant. Temporary ($\leq$3 hours) reductions in available insolation during the day will be replaced by thermal energy storage. Losses in available insolation that are expected to last for more than three hours will be replaced by increased operation of the coal component (4.9).

The issue to be addressed here is whether or not operation of the coal component will produce a plume that will reduce the intensity of insolation reaching the heliostats, thereby reducing the solar component's contribution to the total output. A potential "Catch-22" situation could in theory exist: increasing the contribution of the coal component could reduce the insolation available to the solar component, thereby reducing the solar contribution to total output, which in turn requires increased operation of the coal component, etc.

At the present time we do not know if the operational decision-maker for the hybrid plant, faced with a many-hour daytime loss in insolation intensity, will elect to shut down the solar component completely and replace it with the coal component, or to operate the solar component at a reduced efficiency and use the coal only as needed.

In order to mathematically predict the loss of available insolation due to operation of the coal component, three tasks need to be performed:

- estimate the ambient concentrations of gases and particles in the plume resulting from coal combustion;
- estimate the reduction in insolation intensity resulting from gases and particles scattering and absorbing the incoming solar radiation;
- estimate the loss of heliostat efficiency and solar component contribution to total output due to reduction in insolation intensity.

Rockwell performed a plume insolation study for a 100 MW(e) design of a coal/solar hybrid plant to be located in Barstow, California. The plant is essentially a scaled-down version of the 430 MW(e) used for the environmental assessment in this study (4.10). The remainder of this subsection will summarize the Rockwell plume insolation study, and evaluate the study noting meaningful difference between the present hypothetical plant and the 100 MW(e) plant used by Rockwell. It will also make recommendations for future work in this area.

4.3.1 Ambient Pollutant Concentrations

The worst-case emissions for the 100 MW(e) plant assumed by Rockwell for the modeling study are presented in Table 4-2. (Note that particulate emissions assumed exceed those permitted by SCAQMD rates.)

The worst-case meteorology assumed for the plume modeling study was a wind speed of 2 meters/second under class B stability. The wind was assumed to be from the south, which would maximize the heliostat area exposed to the plume. These conditions are likely to occur at the Blythe site and will give worst-case predicted concentrations.

The Rockwell study used a Gaussian dispersion model to estimate the concentrations of pollutants in the plume. The basic equation for the dispersion model, taken from Turner, is described in greater detail in Volume II. Ambient pollutant concentrations predicted by the model were not summarized because they represent intermediate results used in predicting attenuation of insolation.

Table 4-2

Emission Rates
100 MW(e) Coal Plant, Full Capacity

Stack Exhaust Component	Mass Emission Rate (g/s)
N_2	1.028×10^5
CO_2	4.416×10^4
H_2O	8.209×10^3
O_2	8.224×10^3
SO_2	2.379×10^1
Particulates	8.56

(Reference 4.9)

4.3.2 Pollutant/Insolation Interaction

The gases and particles in the plume reduce insolation through the processes of absorption and scattering. In absorption, energy taken up by the particle or gas causes changes in the internal energy levels of the absorbing species; following absorption, the energy can be reemitted at a different intensity and wavelength. In scattering, energy merely "bounces off" of the gas or particle, and is changed in wavelength and intensity. Both gases and particles can absorb and scatter radiation; however, Rockwell assumed that molecular scattering and particle absorption are not significant processes in attenuating insolation. This is probably valid.

Beer's Law was used to determine the amount of insolation scattering and absorption as a function of concentration of the absorbing and scattering species:

$$\log \left(\frac{I}{I_0}\right) = - \sum_i \varepsilon_i \, c_i \, l_i$$

where:

- I_0 = initial light intensity at source
- I = light intensity at observer, a path length l away from source
- ε_i = extinction coefficient for species i
- c_i = concentration of species i
- l_i = length of the light path through species i.

For the present purposes insolation entering the plume will be represented by I_0 and insolation of the plume and incident upon heliostats will be represented by I. The ratio I/I_0 thus gives the fraction remaining after passage through the plume. With power plant plumes the concentration c_i changes within the effective path length (l) in accordance with the Gaussian dispersion model. Also, path length changes with distance downwind from the plant and is not well defined because the plume does not have explicitly defined boundaries. Further, it would depend on sun angle.

The approach taken by Rockwell to calculate I/I_0 was to use the dispersion model to calculate $(cl)_i$ for incremental distances downwind from the plume and then use numerical integration techniques to arrive at an overall value of cl for the plume. The value of cl thus calculated was divided by the area of the heliostat field. A computer code termed SOLAR was used to perform these calculations. Values of ε_i for each exhaust gas component were obtained from the chemical literature. Given values for the product $(cl)_i$ and ε_i, Beer's Law was used to estimate the value of I/I_0, summing the $\varepsilon_i(cl)_i$ values for all gases and particle for both scattering and absorption processes.

Table 4-3 summarizes these data. As can be seen, the data suggest a minor effect on insolation at most wavelengths. These results can be attributed to emissions from the coal plant in the following manner (4.9):

- below 2 μ, light scattering by particles is the dominant process reducing insolation; results indicate that particle scattering is not important;

- above 2 μ, absorption by water vapor becomes significant, contributing about 10 percent to the total reduction at 2.5 μ and increasing to 50 percent at 5.0 μ;

- molecular nitrogen, oxygen and sulfur dioxide do not contribute significantly to the reductions at any wavelength;

- the greatest reduction in insolation, which occurs at 4.2 - 4.4 μ and around 2.7 - 2.8 μ, is due to molecular absorption by carbon dioxide.

4.3.3 Conclusions and Recommendations

The overall technical approach used by Rockwell has much in its favor. However, the data in Table 4-3 probably do not reflect actual insolation reductions expected to occur at the Blythe site with the proposed 430 MW(e) hybrid plant. Improved analyses are needed.

A primary change would be to subdivide the heliostat field into small areas within the total area expected to be covered by the plume, each affected differently. For given stack, meteorological and sun conditions, the effective concentration-path length product for each such area at a given time would be computed. This would avoid the optimism inherent in the Rockwell method of averaging over total area, and more closely indicate possible worst-case impacts.

A second change would include the pollutants carbon monoxide (CO) and nitrogen oxides (NO_x) which were not considered by Rockwell. Nitrogen dioxide, for example, has a continuous absorption spectrum and absorbs strongly in the ultraviolet and near ultraviolet, as shown by its critical importance in formation of photochemical smog and by intense coloration (4.11). In addition, secondary pollutants such as ozone and sulfates could be of some importance. Ozone, in particular has been shown to absorb ultraviolet radiation (4.11).

The Rockwell study also ignored particulate (salt) and water vapor emissions from the cooling towers and their possible impact, assuming these to be located downwind of the heliostat field. Such a choice may not always be available. The SOLAR program (modified) should be run adding impacts from these sources.

Finally, the study did not relate reduction in insolation to changes in heliostat and overall plant performance; i.e., the reduction in energy input due to loss of insolation. Data describing heliostat performance as a function of radiation intensity at each wave length must be incorporated. In addition, data describing the solar component output as a function of heliostat performance are needed. For example, studies have shown that a 25 percent change in insolation may cause a 40 percent change in annual energy collection (4.12).

Table 4-3

Transmittance vs. Wavelength

γ(μ)	I/I_0	γ(μ)	I/I_0
0.35	0.981	2.5	0.997
0.40	0.982	2.6	0.996
0.45	0.982	2.7	0.923
0.50	0.983	2.8	0.935
0.55	0.984	2.9	0.964
0.60	0.985	3.0	0.998
0.65	0.986	3.1	0.998
0.70	0.986	3.2	0.998
0.8	0.987	3.3	0.999
0.9	0.989	3.4	0.999
1.0	0.990	3.5	0.999
1.1	0.991	3.6	0.999
1.2	0.992	3.7	0.999
1.3	0.992	3.8	0.999
1.4	0.993	3.9	0.999
1.5	0.994	4.0	0.999
1.6	0.994	4.1	0.999
1.7	0.995	4.2	0.879
1.8	0.995	4.3	0.741
1.9	0.996	4.4	0.796
2.0	0.996	4.5	0.953
2.1	0.997	4.6	0.999
2.2	0.997	4.7	0.999
2.3	0.997	4.8	0.999
2.4	0.997	4.9	0.999
		5.0	0.999

(Reference 4.9)

4.4 Impact of Fugitive and Natural Emissions on the Solar Subsystem

If fugitive and natural emissions are as important as those generated by facility subsystems, then a potentially difficult problem exists because these sources can be difficult to control. Fugitive emissions are defined as those whose discharge to the atmosphere does not represent a confined flow stream (4.13). The most significant desert environment example is particulate matter or fugitive dust. Natural emissions, as their name implies, are those not resulting from man's activities: organic gases and particulates given off by vegetation, water, blowing sand, etc. At times the distinction between fugitive and natural emissions is difficult to discern; for example, a short-term impact of a vehicle traveling on a desert road is the production of fugitive dust. A long-term impact may be that the vehicle has exposed more fine material to wind action so that natural emissions have increased.

This section examines the impacts of the plant on itself, the adjacent environment on the plant and the plant on the adjacent environment. Not all topics are covered in sufficient depth to allow finalization of impacts; therefore, recommendations for future work are discussed where appropriate.

4.4.1 Fugitive Dust Emissions Outside the Plant Boundary

One issue of concern is the impact of fugitive dust emissions from desert traffic on heliostat performance. Studies have shown that fine particles will collect on heliostat surfaces even when they are turned face down (4.14). When face up larger particles as well are likely to collect. Buildup of natural dust on heliostat surfaces can be aggravated by man's activities. Specifically, the widespread use of off-road vehicles (ORV's) is a potentially significant source and could potentially impact operation of the solar subsystem. The only feasible control is establishing an exclusion area; i.e., fencing off an area large enough so that any dust generated would settle out before reaching the heliostat field. The problem is further complicated by the fact that the hybrid plant will likely attract people because of its appearance and uniqueness. Therefore, the size of the exclusion area necessary to mitigate the impacts of ORV operation is of interest. If concern is justified it could significantly increase land use attributable to the plant.

Quantifying the impacts of ORV operation on heliostat efficiency is difficult at best because of many complicating factors; e.g., vehicle size and type, speed, location, meteorology, etc. The most significant impact may be near-permanent destruction of a stable soil surface. In addition, the data gap discussed previously--lack of quantitative descriptions of heliostat efficiency as a function of mass deposition--prevents final quantification of the impacts. As was done before, a worst-case approach was used in estimating impacts, including a number of simplifying assumptions.

Worst-Case Emissions

Using techniques (4.15) and assumptions documented in Volume II, a worst-case ORV emission rate of 6.43 lb/vehicle mile travelled (VMT) was calculated. This rate assumes a vehicle speed of 40 mph when in use on a roadbed of 25 percent silt, with an average vehicle weight of 1 ton.

Worst-Case Meteorology

Meteorological conditions expected to produce maximum ground-level concentrations from ground-level sources are a stable atmosphere and low wind speed (4.16). The most stable atmosphere considered by Turner, Pasquill Class F, has been reported to occur at the site; the lowest ground-level wind speed associated with that class is 0.9 m/s (4.17).

Atmospheric Modeling

ORV's are here considered to be a ground-level line source at the north edge of the heliostat field. Assuming the wind to be from the north will expose the greatest part of the field to the emissions, and thus represents a worst-case situation. An appropriate model for predicting ambient concentrations in this situation is the ground-level line source model described in Turner (4.3). Volume II contains a complete description of the modeling exercise. The dispersion model output--predicted 24 hour average levels of suspended fugitive dust--was used as input to the aerosol/heliostat impaction model introduced in Section 4.1.

Figure 4-3 illustrates modeling assumptions. Two exclusion areas were used: circles of 1 mile and 2 miles beyond the border of the heliostat field. Larger circles than 2 miles were not addressed because of the tremendous area required (see Chapter 6). Figures 4-4 and 4-5 show predicted mass of fugitive dust (kg) deposited per heliostat cell in a 30-day period for 1- and 2-mile exclusion areas, respectively.

4.4.2 Fugitive Emissions from Coal Handling

Chapter 2 described the coal handling processes proposed for the hybrid plant (see Figure 2-9). This section describes preliminary work done to assess impacts of coal handling on heliostat performance.

Worst-Case Emissions

Table 4-4 sumarizes the types of coal handling processes, factors for calculating emissions, uncontrolled emissions, control techniques proposed by Rockwell, percent reduction resulting from the techniques, and lastly, estimated emissions after application of the control techniques. Note that emissions for all processes were not computed, pending definition of coal handling procedures.

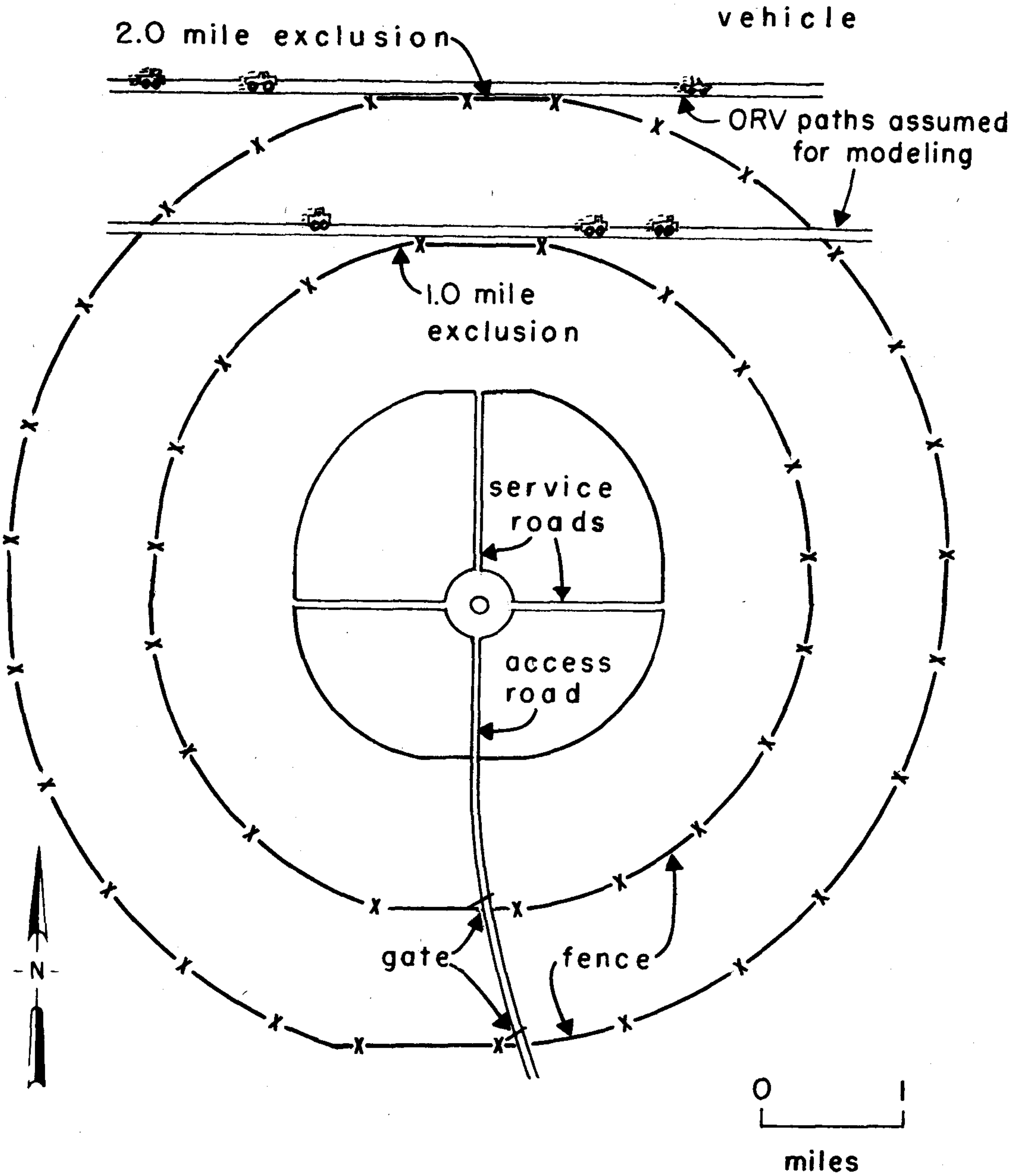


Figure 4-3 Diagram of Scenarios Used in Modeling Fugitive Dust Emissions From the Use of Off Road Vehicles (ORV) Near the Proposed Power Plant

			17	35	35	35	17			
		33	37	39	40	39	37	33		
	32	37	41	45	47	45	41	37	32	
22	35	42	49	56	58	56	49	42	35	22
30	37	46	57	70	77	70	57	46	37	30
29	37	48	65	80	60	80	65	48	37	29
29	37	49	70	59		59	70	49	37	29
21	35	46	63	77	76	77	63	46	35	21
	30	38	49	62	68	62	49	38	30	
		31	37	43	45	43	37	31		
			14	23	24	23	14			

Figure 4-4 Predicted Fugitive Dust Deposition Rates per Cell for a One-Mile Exclusion Zone around the Hybrid Plant (kg/30 days per cell)

			13	26	27	26	13			
		26	29	30	31	30	29	26		
	26	30	34	37	38	37	34	30	26	
18	29	34	40	46	48	46	40	34	29	18
25	30	38	47	58	63	58	47	38	30	25
25	32	41	56	68	52	68	56	41	32	25
25	32	43	61	51		51	61	43	32	25
18	30	40	55	67	68	67	55	40	30	18
	27	34	44	56	62	56	44	34	27	
		27	33	38	40	38	33	27		
			12	21	21	21	12			

Figure 4-5 Predicted Fugitive Dust Deposition Rates per Cell for a Two-Mile Exclusion Zone Around the Hybrid Plant (kg/30 days per cell)

Table 4-4

Summary of Emissions from Coal Handling Processes

Process	Emissions Factor	Uncontrolled Emissions	Proposed Control	Percent Reduction	Emissions
Receiving Coal	0.05 lbs/T		Enclosure/ collection	70%(?)	*
Primary Crushing Secondary Crushing	0.05 lbs/T 0.15 lbs/T	45 lbs/day	Enclosure/ collection	70%(?)	*
Screening	0.15 lbs/T				*
Conveying	0.05 lbs/T	11 lbs/day	Enclosure (some)		*
Transfer Point	0.15 lbs/T	33 lbs/day	Enclosure/ collection	70%(?)	*
Stockpile Maintenance	$EF=0.10K(\frac{s}{1.5})(\frac{d}{235})$ lb/ton $= 0.29$ lb/ton	82,300 lbs	wet dust	50%	41,150 lbs
Stockpile Wind Erosion	$EF=0.05(\frac{s}{1.5})(\frac{D}{90})(\frac{d}{235})(\frac{f}{15})$ lb/ton=.095 lb/ton	27,000 lbs	wet dust	50%	13,500 lbs
Batch LOAD IN/LOAD OUT (i.e., where bucket or truck size is known in Yd3)	$EF=0.0018\,\frac{(\frac{s}{5})(\frac{U}{5})}{(\frac{M}{2})^2(\frac{Y}{6})}$ $=8.3\times10^{-3}$ lb/ton		None	--	*

Table 4-4, (Continued)

KEY:

s = silt content (coal or road surface) % = 25

S = average vehicle speed (mph)

W = average vehicle weight (tons)

d = dry days per year = 345

M = surface moisture content % = 1

U = mean wind speed (mph)

Y = effective loader capacity (yd^3) = 5

X = activity factor = 1

D = duration of storage (days) = 52

f = % of time wind speed exceeds 12 mph = 16.8

e = surface erodibility = 220

PH = Precipitation/Evaporation Index = 4

* Waiting further data

Reference 4.16

Worst-Case Meteorology

The various coal sources at the plant include ground and elevated sources, and worst-case meteorology is different for each. For ground level sources (loaders, stockpiles, transfer points) it is F stability and wind speed of 0.9 m/sec. For elevated sources (hopper building, crusher building, live storage building, and plant coal silos) it is A stability with 0.9 m/sec wind speed.

Atmospheric Model

Once all emissions are computed, each process could be modeled as an individual point source using appropriate models described in Volume II. As an alternative to modeling each source individually the following approach could be used without sacrificing accuracy.

- compute an average emission height for groups of sources located near one another;
- if this average height is greater than 100 m, model all these sources as one source with a physical stack height of 100 m;
- if the average height is less than 100 m, then the sources should be modeled as one ground source.

Regardless of which approach is selected, the wind direction should be selected to maximize the heliostat area exposed to the emissions.

Once the model has predicted ambient concentrations, the heliostat particle deposition model could be used to estimate the mass of particles deposited on the heliostat surfaces.

4.4.3 Vehicle Operation Within the Plant

Rockwell proposed to pave all roads to minimize fugitive dust emissions. Some dust still is generated by vehicle traffic on paved roads through re-entrainment. Tire wear and vehicle exhaust also contribute particulates, but these are non-fugitive sources. Average emissions of entrained dust on paved roads are about 3.2 g/km-vehicle. Exhaust and tire wear contribute about 0.3 g/km-vehicle more. Wet days need no correction because mud will be deposited which on drying will contribute to dust re-entrainment (4.18).

The emissions from vehicle activity on access and service roads can be calculated using the model described in Section 4.4.1. Detailed data on the use of vehicles are needed to estimate ambient dust levels resulting from vehicle operation. The simplified model assumes wind perpendicular to the road, but other models can treat winds at acute angles to the line source studied (4.19).

4.4.4 Fugitive Dust Impacts on the Environment

Construction of the proposed facility will adversely impact the surrounding desert environment. Two major types of activities will cause fugitive dust emissions:

- clearing the land of natural vegetation so construction can begin; including grading and excavation.
- construction of the facility.

As indicated in Chapter 2, the plant will need about 3000 acres not including the exclusion zone. An exposed area of that size in the desert is expected to lose about 4 million tons of dust per year (see Volume II). This large amount of material would undoubtedly be deposited mostly on the northeastern side of the site because the prevailing low-level wind is from the southwest. Similar effects have been observed during the construction at the Barstow Solar Plant site; aerial photographs show a "corona" of sand formed from wind erosion (4.20). Concern is not for material "lost" from the site, but rather for the possibility that the same light particles could easily blow back onto the site (and heliostats) when gusts of wind not in the direction of the prevailing wind occur. Hence unless the corona is stabilized to prevent wind erosion, it represents a potential area source of pollution that could contribute to heliostat degradation. Also, the eroded dust could have adverse impacts on the ecology of site surroundings.

Once the site is cleared, construction activity itself can be a further source of fugitive dust. Construction activity is estimated to produce 1.2 tons of dust per acre of construction per month (4.21). Assuming that the 3000 acre plant will take 60 months to construct and that essentially all surface area is affected, about 216,000 tons of dust will be carried from the site to adjacent land over the five-year period, with potential adverse impacts like those discussed above.

Fine soil material is abundant in the desert, but it is formed at the surface into a thin crust which protects the underlying fines from erosion. The crust may be up to 6 mm (0.2 inches) thick. Disturbance of the "desert crust" by construction operations would result in a fugitive dust increase and degradation of soil quality due to erosion. "Desert pavement" is formed by densely packed pebbles and stones. These stones are cemented together or encrusted with various salts, gypsum, lime, and silicates, and are often coated with a "desert varnish". The pavement retards erosion and surface water runoff. The breaking of desert pavement by construction would result in increased fugitive dust emissions and water erosion of soils. Rainwater penetration or recharge to groundwater would be decreased (4.22). Such damage is very long term, and unlikely to be repaired by natural processes within a useful lifetime.

4.4.5 Phytogenic Emissions

This section estimates the rates at which gaseous hydrocarbons are emitted from natural desert vegetation. Some desert plants also "emit" particulates in the form of salt particles, but because little data are available on emission rates they cannot be addressed. The primary concern is whether or not large enough amounts of natural organics will be emitted by vegetation and will travel to the heliostats and condense on the cool heliostat surface to possibly degrade reflectivity themselves, or more likely, to enhance the sticking of fine dust particles which could affect reflectivity.

The most prevalent vegetation type around the site is laria (creosote bush) (4.23). Very little information on hydrocarbon emission rates for this plant exists in the literature. However, it is highly resinous, and emissions would be seasonal. It was assumed that the creosote bush would most likely resemble conifers in terms of emission rates Table 4-5 summarizes the data that have been collected for vegetation of different types on the biome level. (4.24). Therefore, a worst-case emission rate for Larrea would be estimated as 222 g/m^2-hour.

A rough inspection of the vegetation distribution map (Figure 3-2) indicates that about 4 mi^2 of creosote bush exist to the north of the site, and another 4 mi^2 area of creosote bush exists to the south of the site. Assuming a stand density such that 1 m^2 of leaf surface area corresponds to about 1 m^2 of land area, four square miles results in a worst-case emission factor of 0.63 g/s. This corresponds to relatively sparse vegetation. The ambient levels resulting from these emissions could be estimated by treating the creosote bush as a ground level area source. As a worst-case, one could than assume that most or all of the vapors would condense on the heliostat surface, following the heliostat particle impaction model.

4.4.6 Natural Dust Emissions

Natural dust "emissions" may also adversely impact on heliostats. Sandstorms and dust storms will not only force shutdown of the solar component, but probably will also deposit significant amounts of sand and dust on the heliostats. If the plant operator receives advance warning of such storms, mirrors will be stowed in the face down position before storm arrival. However, as noted earlier, even mirrors stowed face down collect fine particulates on their surfaces.

Table 4-6 presents the occurrance of dust storms and sandstorms at the site. The impacts of these phenomena can't be quantified easily. However, storms will most certainly deposit enough fine particulates on heliostat surfaces to require cleaning before the solar component can be operated at capacity.

Table 4-5

Phytogenic Biome Emission Factors
(Standardized to 30°C)

	Leaf Biomass Density (g/m^2)	Emission Rate (ER) Day µg/m^2 hr	Night µg/m^2 hr	Winter µg/m^2 hr
Conifer	25	222.5	222.5	88
Oaks	25	617.5	117.5	0
NC-Ni	40	172.0	172	0
NC-I	10	103.0	24	0
LL	--	162	162	0
	100	1277	698	88

Key: NC-Ni = non-conifer, non-isoprene emitting species

NC-I = non-conifer, isoprene emitting species

LL = leaf litter

m^2 = leaf area

(Reference 4.24)

Table 4-6

Distribution of Occurrence of Blowing Sand or Blowing Dust Storms at Blythe, California Relative to Wind Speed and Visibility*

Wind Speed (mph)	Number of Occurrences	Visibility (miles)	Number of Occurrences
6-10	2	0 - 0.25	4
11-15	10	0.26 - 0.50	9
16-20	34	0.51 - 0.75	1
21-25	28	0.76 - 1.00	12
26-30	23	1.01 - 1.50	3
31-35	17	1.51 - 2.00	5
36-40	5	2.01 - 3.00	24
41-45	3	3.01 - 5.00	51
>45	0	≥5.00	13

* Based on Blythe Airport observations for the period 1948-1954

(Reference 4.25)

4.4.7 Summary

Preliminary estimates from fugitive particulate sources indicate that impacts can be comparable to those from non-fugitive sources. Further studies should be done to refine the estimates given, since by their nature, fugitive emissions are even less accurate than their counterparts. Uncertainties in fugitive emission factors can range from a factor of two to ten (4.26). Uncertainty is compounded by modeling, accurate to about a minimum of a factor of five (4.27). If fugitive dust proves significant, the potential utility of large-scale solar plants may prove very difficult. Measures such as screening off the solar plant with an air foil to inhibit near surface fugitive dust transport perhaps deserve further study.

4.5 Weather Modification

Discussion, conjecture, and some modeling of possible weather modification from power plants and cooling towers in general, and large scale solar thermal conversion facilities in particular, have appeared in the literature. Local heat islands (cities and industrial parks) are known to modify weather or generate clouds (4.28).

4.5.1 Cooling Towers

The total energy release from a single cooling tower is much smaller than any natural events except the tornado. If energy fluxes are compared, it appears a cooling tower is able to influence atmospheric conditions, but only on a small scale: a small, intense thermal which could produce a cloud or "dust devel" (whirlwind). Studies indicate that a single cooling tower has too much buoyancy relative to its size to permit the development of vorticity needed to produce a tornado. Recorded cases of altered precipitation related to power plant operation do exist (4.29), but require appropriate relative humidity. Speculation indicates the heated plume from dry-cooling towers could result in cloud formation, modification of precipitation patterns, fog dispersal, local heating, and air exchange in a stagnant air basin. Kearney and Boyack (4.30) discuss plume behavior and potential environmental effects of dry-cooling towers for a 1,000 MW(e) power plant.

In unstable atmospheric situations, plumes from large towers can rise to 3000 meters (10,000 feet) and occasionally produce a visible cloud. Horizontal velocity of air just 20 meters (70 feet) from the tower would be less than eight kilometers per hour (five miles per hour), and undetectable beyond 150 meters (500 feet). Penetration into an inversion layer would be marginal. A 3°F air temperature rise could occur within a 1.6 kilometer (1 mile) radius of the tower while a 0.1°F temperature rise could occur within an 8 kilometer (5 mile) radius. A more likely cause for local air temperature increase would be fumigation. This could result in a maximum temperature rise at ground level of 20°F. It is concluded that dry-cooling tower heat discharges for a 430 MW(e) power plant would not significantly modify local meteorological conditions.

A general understanding of many aspects of cooling tower plume behavior exists, but is neither complete nor quantitative enough to predict in detail certain critical characteristics of plumes. Typical heights and lengths of visible plumes can be estimated and their relationship to mean properties of the atmosphere are generally understood (4.32). The Committee on Atmospheric Emissions and Plume Behavior from Cooling Towers concluded, "with regard to drift deposition, ground fog, and weather effects we have inadequate data and analytical capability for detailed prediction. No capability for modeling ground fog and weather effects with any accuracy has been demonstrated."

4.5.2 Solar Power Plant--Central Tower Configuration

A solar thermal power plant has the potential for affecting local and regional climate through the following mechanisms:

- Changes in the surface energy balance, resulting from change in the reflectivity (albedo) of the surface or its thermal characteristics.
- Changes in surface roughness caused by power plant ancillaries and installation of heliostats.
- Changes in surface moisture.
- Dissipation of waste heat into the atmosphere from cooling systems.

Figure 4-6 shows the distribution of solar energy at the earth's surface before and after installation of a solar power plant.

<u>Regional Effects</u>

Surface amd atmospheric anomalies are present prior to installation of a solar power plant. In combination, these give rise to complex patterns of atmospheric convergence, divergence, and convection. Natural influences are as great or much greater than the localized heat source of a power plant.

Meteorological impacts from a 30 GWe solar thermal power plant (central tower) assumed to be located in southern Spain have been modeled (4.32). The heliostats for such a plant would extend for eight kilometers. Figure 4-7 shows predicted land surface temperatures before and after installation. The surface temperature immediately above the heliostat field was predicted to be significantly lower than surrounding surface temperatures. The temperature difference (before and after construction) was between 4 and 8°C. With the plant more moisture was postulated, and therefore clouds formed. Heliostats captured solar radiation that would otherwise be absorbed by the ground surface, causing a decrease in natural convective (buoyant) activtity over the mirror-covered area. Results suggest possibly more pronounced and persistent formation of clouds and rain if a large-scale solar thermal power plant is installed in an area

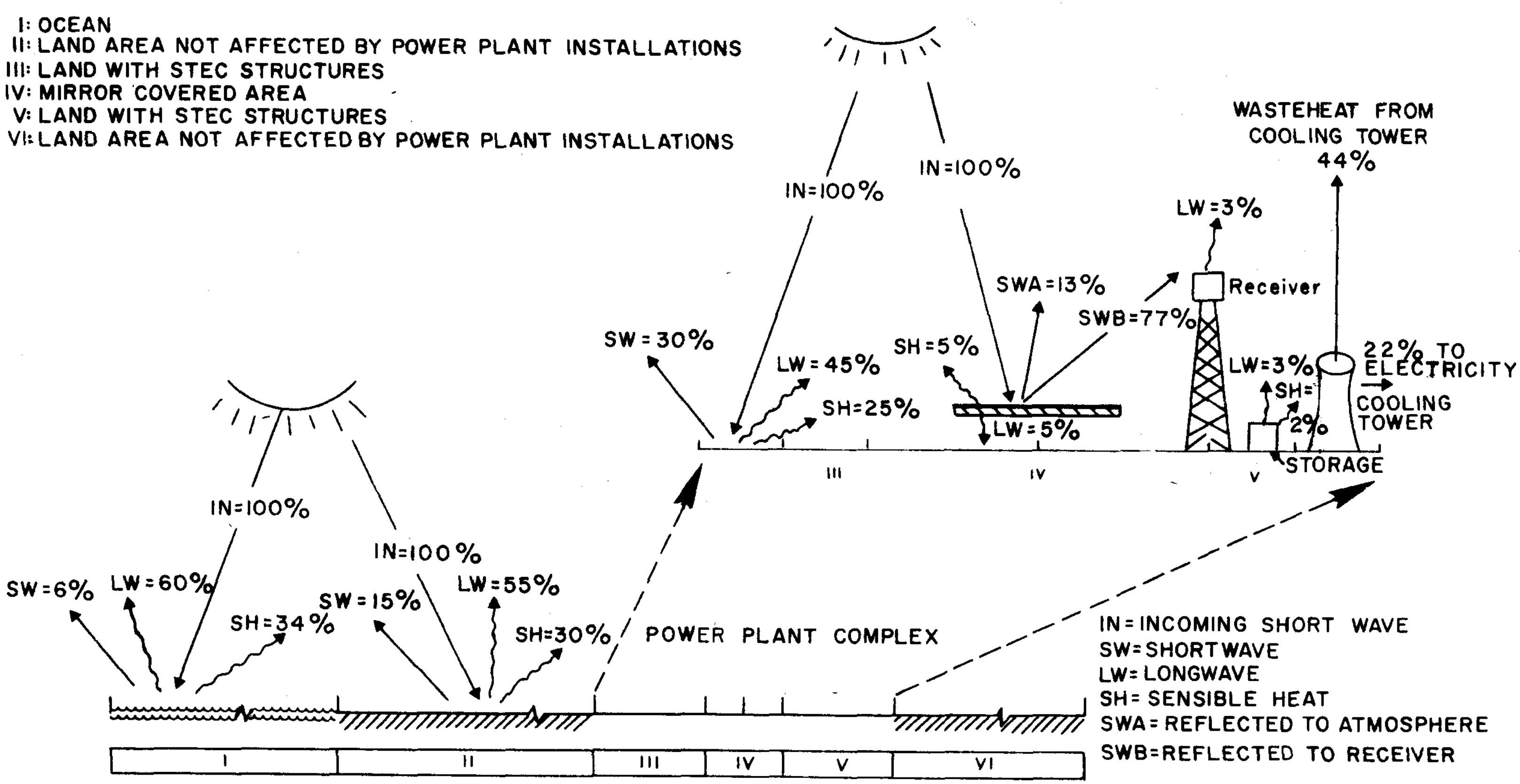


Figure 4-6 Distribution of Solar Energy at the Earth's Surface Before and After Installation of a Solar Power Plant (Reference 4.33)

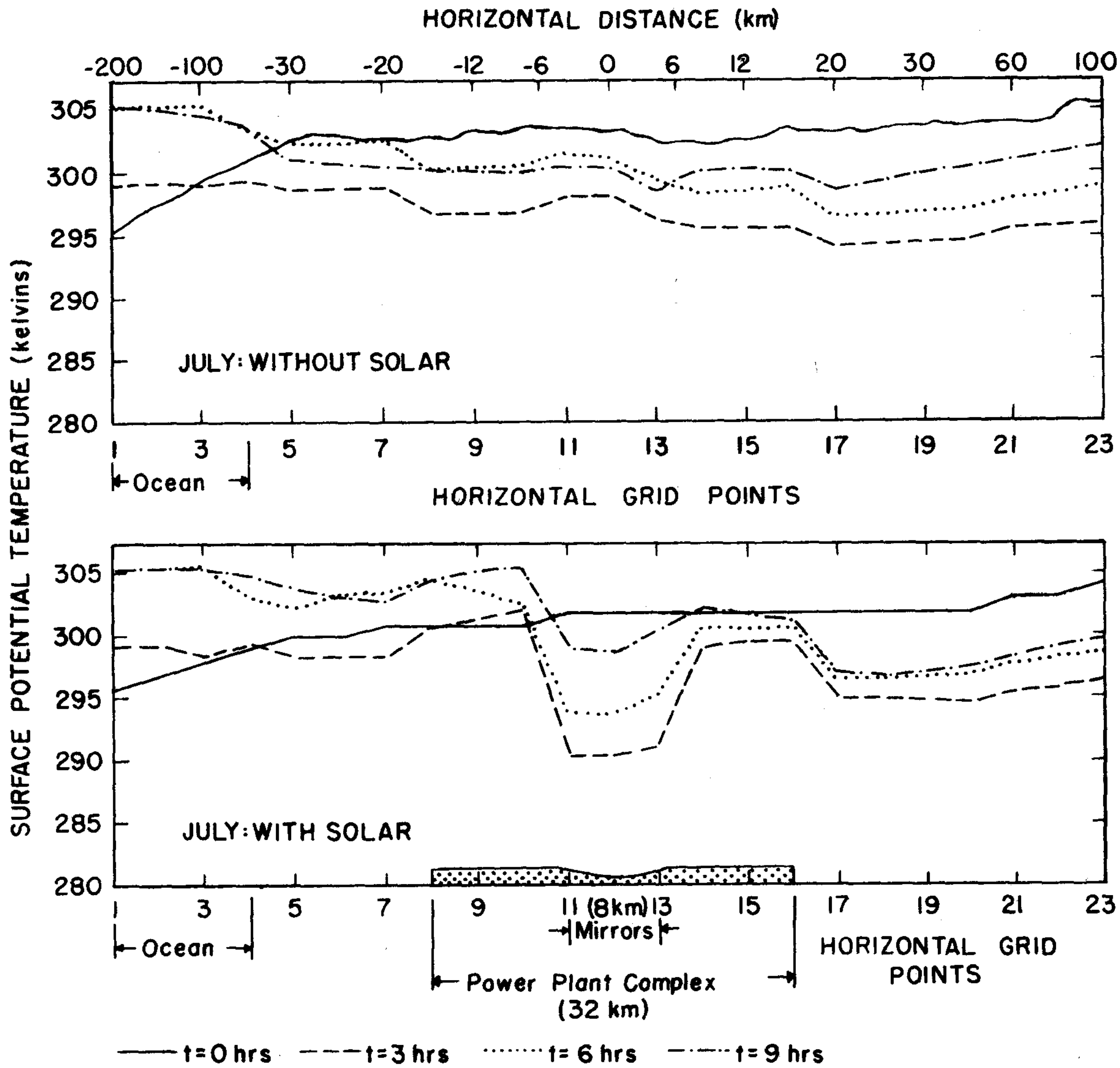


Figure 4-7 Surface Potential Temperature at T = 0, 3, 6 and 9 Hours in Summer Before and After Solar Power Plant Installation T = 0 is 0800 Local Time (Spain) (Reference 4.34)

with summer meteorological conditions such as those assumed for southern Spain. These effects would extend to a distance of a few hundred kilometers from the power plant (4.32).

Microscale Effects

The effect of heiostats on atmospheric and soil moisture conditions is a localized or site-specific effect important for evaluating possible species changes that might occur within the heliostat array. Heliostats would shade the ground underneath them. A 25% coverage would probably result in a 50% decrease in total radiation incident to the ground surface. Radiant temperature (temperature that a black body would require to produce thermal radiation equal to the downward reradiation of the sky), surface temperature, and soil temperature are expected to be reduced under the heliostat field; these predictions are based on temperatures measured under desert vegetation. Ambient air temperatures would probably not be significantly reduced. Soil moisture under the heliostat field would probably be greater than in open desert, especially if heliostat wash water is allowed to fall on the ground (4.34).

Heliostats would disturb low-level air flow patterns. Patten (4.34) states that wind deflection would probably not affect air temperatures, whereas another study states that wind speeds below the heliostat surfaces would decrease and possibly reduce air and surface temperatures (4.35). Light wind speeds and cooler temperatures beneath the heliostats would probably reduce evapotranspiration within the field significantly (4.34, 4.35). Microclimate conditions beneath the heliostats might approach those for a north-facing slope.

Some measurements have been taken under heliostats with some results contradictory to impacts hypothesized. Air movement at 20 cm (8 inches) above ground surface has been observed to be reduced within the mirror array by 34%-86%. Reduced air movement appeared to become more significant as total air movement decreased. Air temperatures measured under the heliostat array at heights of 10, 30, and 10 cm (4, 12, and 39 inches) were higher than in the open desert. This may be caused by reduced long-wave radiation loss and air movement. Soil temperatures in the shaded gaps between helisotats were lower than soil temperatures immediately under heliostats (4.35).

4.5.3 Conclusions

Small heat sources such as single cooling towers would affect only the local site area. Climate changes from a 430 MW(e) coal/solar hybrid power plant would not be significant on a regional scale. With proper atmospheric conditions, heat release could induce cloud formation and downwind precipitation. Cloud formation could reduce solar insolation and affect the efficiency of the solar portion of the plant (intra-plant impact). Climate modifications within the heliostat field would result in a cooler and more moist habitat with some change in species type and diversity by comparison with the surrounding desert.

4.6 Future Work

Additional work needs to be done before evaluation of the air quality issues associated with a coal/solar hybrid plant can be completed. This section discusses such recommendations which go beyond those presented within the preceding subsections.

4.6.1 Crop Dusting

Because agriculture could exist close to the heliostat field, crop dusting could inadvertently result in the spraying of chemicals which are then deposited to the surface of heliostats, adversely affecting performance. To estimate the impact of crop dusting on heliostat operation, the following tasks need to be accomplished:

- determine proximity of agricultural areas to the heliostat field;
- determine crop types near the sites;
- determine frequency of crop dusting in these areas;
- estimate pesticide coverage of the heliostat field with a suitable model (4.36).
- relate deposition of pesticide on heliostats to degree of impairment of efficiency.

4.6.2 Effects of the Solar Beam on the Coal Plant Emissions

A possible concern is whether or not secondary pollutants would form more rapidly if the plume from the coal stack crosses the solar beam than if no solar beam were present. Specific tasks to address this problem include:

- determine under what conditions the plume from coal combustion could enter the solar beam;
- determine if sufficient time could elapse before the plume enters the beam so that significant amounts of nitric oxide can be converted to nitrogen dioxide (NO_2 is needed for the photochemical smog mechanisms);
- determine the wavelengths of radiation needed for the photochemical smog mechanism;
- identify possible reactions that could be accelerated if the proper conditions are met;
- estimate the concentrations of reaction products;
- determine the impacts of these products on the plant and on the surrounding environment.

4.6.3 Impacts of the Plant on Surrounding Air Quality

Most of the air quality impact assessment discussion in this chapter dealt with intra-plant impacts; i.e., the effect of one plant subsystem on another. A "traditional" air quality impact assessment should be performed to show that its operation will not prevent attainment or maintenance of national ambient air quality standards. The South Coast Air Quality Management District has published a document entitled "Handbook for the Preparation of Environmental Impact Reports," which may prove to be of some value in the impact assessment required (4.37).

4.7 References

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4.2 National Research Council, Comittee on Particulate Control Technlogy. "Controlling Airborne Particles," Published by the National Academy of Sciences, Washington, D.C., pages 45-65 (1980).

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4.4 Reference 4.3, pages 35-36.

4.5 San Diego Gas and Electric Company. "Environmenal Report, Construction Permit Stage, Sundesert Nuclear Plant, Units 1 and 2." Volume 2, (June 1977). Presents wind speed data by stabiltiy class by month for 190 and 33 ft; Table 2.3-142 presents data for July 1975, indicated 8 observations of 1-3-mph at 130 ft under A stability. Because A represents an unstable atmosphere, low wind speeds are not usually found as was the case with many of the months of wind data.

4.6 Reference 4.5, page 10.1-8.

4.7 Reference 4.5, Volume 10, Appendix L, page L2-2-6.

4.8 Reference 4.5, Volume 2 Figure 5.1-7, with modifications as discussed in text.

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4.15 U.S. Environmental Protection Agency, Region VIII. "Emission Factors for Mining Operations." Two-page Worksheet, Denver, Colorado (March, 1978).

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4.17 Reference 4.5, Figure 2.3-9. The lowest speed observed at the nearest station -- Blythe -- was 0-6 knots. A wind speed of 0 knots would not facilitate the desired calculation, so the midpoint of the range, 3 knots, was chosen as a worst-case wind speed.

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4.19 Reference 4.3, page 40.

4.20 Personal Communication, Robert G. Lindberg, Laboratory of Nuclear Medicine and Radiation Biology, UCLA, (August 1980).

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4.25 Reference 4.5, Table 2.3-7, Volume 2.

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5.0 WATER QUALITY AND WATER SUPPLY

5.1 Water Rights

The western states have the appropriation system of water rights--the first person to initiate a water use has the first or prior right over all subsequent users of water from a given stream. Most surface waters accessible to southern California such as the Colorado River are already fully allocated and regulated. The use of most surface waters to meet power needs is further complicated by the general policy of the Department of Water Resources (DWR) which precludes the use of State Water Project and Metropolitan Water District (MWD) water for power plant cooling. This non-use policy does not include transfers of water to replace use of irrigation return flows which would normally be returned to the original source. Recognizing this, the recent Lanterman Act of 1974 allows the transaction of Colorado River water for cooling water use in desert sites (5.1).

Less water is being used at the present time than has been allocated in the Colorado River Basin. The situation is stated succinctly by the Bureau of Reclamation in its report on energy in the Colorado River Basin (5.2):

> "From the available data, it is obvious that the water supply exceeds that which is presently being utilized in the Basin. However, it is also apparent that the supply is in turn exceeded by the presently recognized rights to utilize water which have been granted by most of the states of the Basin. The obvious conclusion is that many appropriative rights granted to private parties by the various states are not being fully utilized. However, these appropriative rights remain as charges against the use of water in the Basin. Potential developers of energy resources also seem to understand that they must so proceed and that they have, for some time, been obtaining water rights in the Basin for the development of their particular oil shale or coal projects with earlier priority dates than could be obtained by current filings. In fact, there has been considerable speculative activity in some states in buying and selling water rights and much of this speculation has involved the purchase of land as well as the pertinent water rights, with the intention of transferring water rights to energy development sites (sometimes some distance away)."

In some areas water for energy development will be obtained through purchase of existing water rights and through changes in intended allocations. This means diversion of waters from agriculture to industrial use. While state law confirms public ownership of the corpus of the water itself, the appropriation doctrine generally grants rights in perpetuity to the use of that water. Individual owners of water rights may sell those rights or sell the land to which that right pertains. Thus by individual consent and presumably in response to an appropriate economic incentive individual transactions provide a suitable exchange in accordance with current social values. It may be argued that the market place does not provide appropriate incentives in terms of the prevailing social order; i.e., that there are collective values not represented by individual market transactions. A sale of a water right will be permitted by the courts only when others who depend on that same body of water may not be injured. Society may prefer to retain irrigation agriculture because of certain social values associated with irrigation farming and rural towns, despite the higher-valued use of water for industry or energy (5.3).

Water rights in the Lower Colorado River Basin (below Lees Ferry) are controlled by the Colorado River compact, the Water Treaty of 1944 with the United Mexican States, the Decree entered by the Supreme Court of the United States in Arizona vs. California, numerous acts of Congress, and the administration of many contracts between the Secretary of the Interior and users of water from the Colorado. These documents are known collectively as "the law of the River" and control the quantity , type, and usage of Colorado water to be diverted (5.4).

The Indian tribes have a vital stake in the outcome of all decisions with respect to water in western states and have the potential weapon in the Winter vs. United States decision [207, U.S. 564 (1908)] to vastly reorder priorities with respect to water rights and usage.

The decision-making system for water politics in the West is "distributive" in character--decision-making takes place through interaction between multiple sets of local or regional actors who seek to form a coalition. This coalition aggregates and to some extent modifies the separate and sometimes conflicting interests of its members through a process of bargaining. Organizations such as the Western Governors' Conference, the Western Governors' Regional Energy Policy Office, the Committee of Fourteen, the Salinity Control Advisory Council, the Federation of Rocky Mountain States, and the Western States Water Council are manifestations of this political mechansim (5.3).

Much growth in arid portions of the west has been based on water transfer from one basin to another. The issue of interbasin transfers was temporarilly laid to rest in 1968 when Congress forbade the Secretary of the Interior of interbasin transfers as a means of solving the water problems of the Colorado River for a period of ten years. This moratorium ended in 1978. Interbasin transfers are now a permitted solution to water supply and quality problems in the Colorado River Basin, especially since alternative means of supply (e.g., weather modification, large-scale desalination, phreatophyte control) have lost some of their hypothesized luster. As noted by Mann (5.3), one may view such transfers as a way of avoiding serious problems of tradeoffs and limited resources by externalizing the impact to all the nation's taxpayers. However, one may also question the wisdom of any further externalizaton of energy (or other resources) costs which, if imposed directly, could well lead to a solution by means of more efficient (and less costly) resource allocation and use.

Although MWD's allotment of Colorado River water will be cut back to 6.8 x 10^8 cubic meters per year (550,000 acre feet per year, AF/yr) when California's allotment is reduced to 5.4 x 10^9 cubic meters per year (4.4 million acre feet per year, MAF/yr) in 1985, MWD has agreed to supply 1.2 x 10^8 cubic meters per year (100,000 AF/yr) to various utilities for power plants in the desert area. Irrigation return flow from the Palo Verde outfall drain accounts for 7.4 x 10^7 cubic meters (60,000 AF) of this allocation. Southern California Edison will recieve 652,000 cubic meters per year (50 AF/yr) of the 1.2 x 10^8 cubic meters per year (100,000 AF/yr), Los Angeles Department of Water and Power will receive 4.1 x 10^7 cubic meters (33,000 AF/yr), and San Diego Gas and Electric will receive 2.1 x 10^7 cubic meters (17,000 AF/yr) (5.4). The Palo Verde Irrigation District (PVID) has existing Colorado River water delivery contracts for farmland irrigation in the Palo Verde Valley. The district also has first priority on California's 4.4/MAF yr allocation of water from the Colorado River.

The Metropolitan Water District Act (Section 131) allows MWD to provide no more than 1.2 x 10^8 cubic meters (100,000 AF) of water per year from the Colorado River, and no more than 7.4 x 10^7 cubic meters (60,000 AF) per year from the State Water Resources Development Systems for use in connection with generation of electrical power. This Act also directs the use of agricultural wastewater, brackish groundwater, and other water not suitable for urban or agricultural purposes to be used for power plant cooling when practical (5.5).

If the California allocation of Colorado River water is reduced to 4.4 MAF/yr some of the wells currently drawing water from alluviium where the Colorado River is known to be the source may be shut down. The Bureau of Reclamation, however, considers that wells on Palo Verde Mesa are not pumping groundwaer derived from the Colorado River (5.4). For groundwater to be used as a significant water-source would likely require groundwater overdraft "mining" (the withdrawal of groundwater faster than it is recharged). Such mining of water would contravene prohibitive statues such as the National Water Comission rules, and thus would have to be preceded by legislative action for their modification.

5.2 Water Supply

Two problems as related to water are paramount in the development of new energy facilities. One is the physical availability of water at the times and locales needed for energy development, and the other what might be called the legal availability of water; i.e., the obtaining of the water for the specific purpose of developing energy facilities under legal and institutional requirements relating to the waters of western states (5.6). Two possible water supply sources exist for power plant usage at the site considered in this study--groundwater and agricultural runoff. These two sources are addressed in the following sections.

5.2.1 Groundwater

The perennial flow of the Colorado river accounts for most of the groundwater recharge to the aquifer beneath its floodplain. Most alluvial basins in the lower Colorado River region have ephemeral surface drainage, and groundwater is recharged principally by infiltration of surface runoff during infrequent storms. Annual recharge of less than one percent seriously limits the use of groundwater unless legal concessions allowing for this use are made for offsetting groundwater recharge. Groundwater in the lower Colorado River Basin is being mined at the rate of about 3.3 billion cubic meters per year (2.7 million AF/year)(5.7).

A specific capacity of about 220 liters per minute per meter (18 gallons per minute per foot) of drawdown was obtained from test and observation wells on the proposed site. A test well was capable of producing at least 3785 liters per minute (1,000 gallons per minute) with a drawdown of about 17 meters (55 ft). Temperatures of water produced during testing ranged from 31 to 32°C. Specific conductance of groundwater ranged from 2800-3100 micromohs per cm at 25°C. The groundwater level elevation is 70 meters (230 ft) in the site vicinity. Annual pumpage from wells on Palo Verde Mesa ranged from 1.6 x 10^5 to 3.8 x 10^6 cubic meters per yer (128 to 3,117 AF) in 1973, and the total pumpage from all wells in 1973 was 3.3 x 10^7 cubic meters (26,514 AF)((5.4). Palo Verde Mesa has an average well yield of 2.0 x 10^6 cubic meters per year (1,650 AF/yr), while Palo Verde Valley (including Cibola Valley) has an average well yield of 8.3 x 10^5 cubic meters per year (670 AF/yr). The storage capacities of the Palo Verde Mesa aquifer and the Palo Verde Valley aquifer are both estimated to be 5.0 MAF. Present water uses are for domestic purposes and irrigation. Groundwater in this area is hard, has moderate total dissolved solids (730-3100 mg/l), has a high sulfate level,and a low to moderate chloride content (5.1, 5.8).

The Department of Water Resources evaluated 142 groundwater basins in the southern California desert to determine suitabiltiy for cooling water to supply a 1,000 MW power plant. Palo Verde Valley Basin was considered unsuitable because the basin's water quality meets requirements for domestic and agricultural uses and this water supply has been extensively developed.

The Palo Verde Mesa Basin (see Figure 5-1) was classified as suitable (with qualifications) for power plant cooling water development. The qualifications depend on the development in the area near the floodplain boundary west of Blythe. Groundwater recharge is by underflow from Chuckwalla Valley at a rate of 493,400 cubic meters per year (400 AF/yr).

The Arroyo Seco Valley groundwater basin in Imperial and Riverside Counties was evaluated as having a moderate to high potential for development. This groundwater basin is about 32 kilometers (20 miles) from the proposed site and could provide water for the plant's various needs. The storage capacity of this basin is 8.6 billion cubic meters (seven million acre feet) with an average annual replenishment rate of 1.8 million cubic meters (1,500 acre-feet). Current use of the basin water is limited to

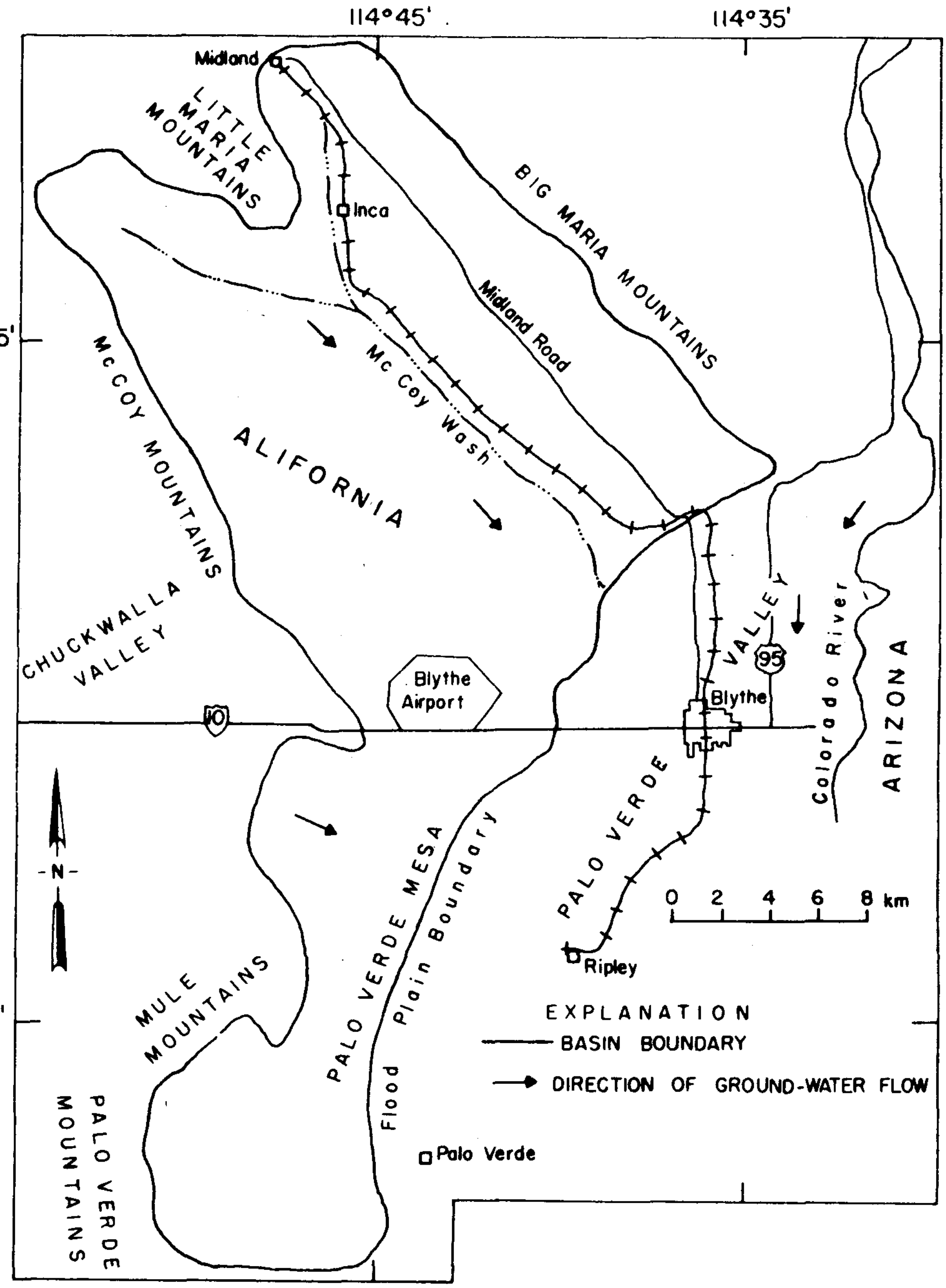


Figure 5-1 Ground Water Basin Palo Verde Mesa

domestic use although the quality is poor, at 280-2,000 mg/l of total dissolved solids (5.10). If groundwater is used for power plant cooling, it would be extracted from the basin more rapidly than it is replaced, lowering the water table and increasing pumping lift. Groundwater quality might decrease as the water table is lowered. Groundwater would have to be treated by a method similar to that described under "Water Treatment Systems" for it to be used for plant cooling or heliostat washing.

5.2.2 Agricultural Runoff

The proposed makeup water source for the plant is irrigation wastewater from the Palo Verde Outfall Drain. This water would be treated as described in "Water Treatment Systems". During periods when water is not available from the drain, a backup connection to the Colorado River would be utilized. Flow in the drain is primarily surface water and groundwater from the Palo Verde Irrigation District and groundwater seepage from the Colorado River. Palo Verde Outfall Drain water has a total dissolved solids content of 1,800 mg/l, which is high. Drain water is very hard, has a very high sulfate concentration, and a high chloride concentration. Table 5-1 contains water quality data for the drain during the summer season (5.11).

Approximately 7.6 x 10^6 cubic meters per year (6,200 AF/yr) of cooling water would be taken from the outfall drain. An addtional 4.1 x 10^6 cubic meters per year (3,300 AF/yr) of water would be required for flue gas desulfurization. Approximately 12 million cubic meters per year (10,000 AF/yr) of water would be purchased from the MWD, and MWD would reduce its diversion into the Colorado River Aqueduct at Parker Dam by 10,000 AF/yr. This volume of relatively clean water (750 mg/l total dissolved solids) would be left in the reservoir for release downstream, and thereby, the amount of dissolved solids in the Colorado River downstream of the Palo Verde Valley would be reduced. This replacement of water diverted from the drain is necessary because the Palo Verde Drain water is subject to downstream water rights (5.1).

Flows in the Palo Verde Outfall Drain downstream of the plant intake would be reduced due to usage by the plant. The maximum withdrawal rate of water from the drain would be about 0.4 cubic meters per second (14 cubic feet per second, cfs). Drain outflows normally peak in the summer; lower flows typically occur in January and February when diversion to the Palo Verde Main Canal is halted to allow maintenance of the diversion works and canal system. The 10-year (1966-1975) mean annual flow for the drain is 17 cubic meters per second (570 cfs). Flows in the drain at the proposed plant intake location ranged from a low of 10 cubic meters per second (332 cfs) to a high of 24.5 cubic meters (812 cfs). Plant water requirements would be a small portion of drain flows even when flows are low. If a wet-dry cooling tower system is used, summertime use of the wet-cooling system would correspond to peak flows in the drain. It would also lower water requirements for the plant because dry-cooling tower use would occur during winter months when drain flows are low. An auxillary source of water would be provided by groundwater pumping or Colorado River water. This auxillary water source would only be used

Table 5-1 Water Quality Data for Palo Verde Outfall Drain During Summer (July-September 1975)

Property (units)	Number of Samples	Mean and 95% Confidence Limits	Maximum	Minimum	Range	Standard Error	Coefficient of Variation, %
Depth at Station (ft)	6	6.17±0.43	7	6	1	0.167	6.62
Depth Sampled (ft)	6	3.08±0.21	3.5	3.0	0.5	0.0833	6.62
Dissolved Oxygen, in sity (mg/l)	6	6.48±0.96	8.0	5.6	2.4	0.372	14.0
pH, in sity (pH units)	6	7.81±0.29	8.2	7.4	0.80	0.117	3.6
Water Temperature, in sity (°C)	6	26.2±1.6	28.5	24.3	4.2	0.605	5.65
Mineral Acidity, total (mg/l as $CaCO_3$)	6	None					
Alkalinity, total (mg/l as $CaCO_3$)	6	259±50	356	229	127	19.6	18.5
Alkalinity, phenolphthalein (mg/l as $CaCO_3$)	6	<1					
Bacteria:							
Fecal Coliform (no./100 ml)	6	603±414	1,390	320	1,070	161	65.4
Total Coliform (no./100 ml)	6	TNTC	TNTC	42,500			
Biochemical Oxygen Demand$_5$ (mg/l)	6	1.53±0.73	2.7	0.7	2.0	0.285	45.5
Chemical Oxygen Demand (mg/l)	6	11.9±1.8	15.0	10.4	4.6	0.699	14.4
Chloride, total (mg/l)	6	359±15	371	339	32	5.79	3.95
Color:							
Luminance (%)	6	99.3±0.9	100	97.7	2.3	0.338	0.834
Dominant Wave Length (nm)		None					
Putity (%)	6	0					
. Hue	6	Clear					
Conductivity at 25°C (μmhos/cm)	6	2,543±120	2,700	2,400	300	46.7	4.50
Cyanide (μg/l)	6	<5					
Hardness, total (mg/l as $CaCO_3$)	6	419±41	485	381	104	16.0	9.35
Metals:							
Aluminum, total (μg/l)	6	1,615±931	3,000	730	2,270	362	54.9
Aluminum, dissolved (μg/l)	6	<100	101	<100			
Arsenic, total (μg/l)	6	4.5±0.96	5.9	3.4	2.5	0.372	20.3
Arsenic, dissolved (μg/l)	6	3.52±0.93	4.5	2.4	2.1	0.362	25.2
Cadmium, total (μg/l)	6	<2					
Cadmium, dissolved (μg/l)	6	<2					
Calcium, total (μg/l)	6	146,500±3,300	150,000	143,000	7,000	1,285	2.15
Chromium, total (μg/l)	6	<20					
Chromium, dissolved (μg/l)	6	<20					
Copper, total (μg/l)	6	12.0±12.0	31	<10	28.5	5.03	102.7
Copper, dissolved (μg/l)	6	<10	23.0	<10			
Iron, total (μg/l)	6	805±265	1,280	625	655	103	31.4
Iron, dissolved (μg/l)	6	296±298	660	34	626	116	96.3

Table 5-1, (Continued)

Property (units)	Number of Samples	Mean and 95% Confidence Limits	Maximum	Minimum	Range	Standard Error	Coefficient of Variation, %
Lead, dissolved (μg/l)	6	21.2±2.7	24	18	6	1.05	12.1
Magnesium, dissolved (μg/l)	6	42,700±542	43,000	42,000	1,000	211	1.21
Manganese, total (μg/l)	6	63.3±64.8	150	17.2	132.8	25.2	97.4
Manganese, dissolved (μg/l)	6	26.2±20.2	55	11	44	7.85	73.5
Mercury, total (μg/l)	6	<0.2					
Mercury, dissolved (μg/l)	6	0.20±0.12	0.4	<0.2	0.3	0.0447	54.8
Nickel, total (μg/l)	6	46.3±76.4	163	<1	163	29.7	157
Nickel, dissolved (μg/l)	6	34.0±55.0	113	<1	113	21.4	154
Potassium, total (μg/l)	6	8,817±193	9,000	8,500	500	74.9	2.08
Potassium, dissolved (μg/l)	6	8,750±643	10,000	8,500	1,500	250	7.00
Sodium, total (μg/l)	6	368,000±16,900	385,000	340,000	45,000	6,576	4.37
Sodium, dissolved (μg/l)	6	373,000±18,700	400,000	355,000	45,000	7,265	4.77
zinc, dissolved (μg/l)	6	<5					
Nitrogen:							
Ammonia, dissolved (μg/l)	6	18.2±11.7	40	<10	32	4.57	61.6
Kjeldalhl, dissolved (μg/l)	3	470±538	600	220	380	125	46.1
Nitrate, dissolved (μg/l)	4	224±10.7	233	217	16	3.35	2.99
Nitrite, dissolved (μg/l)	4	8.75±5.44	13	5.5	7.5	1.71	39.2
Organic, dissolved (μg/l as N)	3	457±529	590	210	380	123	46.8
Oil and Grease, total (μg/l)	6	1,751±1,527	3,580	333	3,247	594	83.1
Organochlorine Pesticides:							
Aldrin (μg/l)	6	<1					
BHC	6	<1					
pp'-DDE (μg/l)	6	<1					
op'-DDT (μg/l)	6	None					
pp'-DDT (μg/l)	6	None					
Dichloran (μg/l)	6	None					
Dieldrin (μg/l)	6	<1					
Endosulfan I (μg/l)	6	None					
Endosulfan II (μg/l)	6	<1					
Endrin (μg/l)	6	None					
Heptachlor (μg/l)	6	<1					
Heptachlor Epoxide (μg/l)	6	<1					
Lindane (μg/l)	6	<1					
Methoxychlor (μg/l)	6	None					
Mirex (μg/l)	6	None					
PCNB (μg/l)	6	<1					
Treflan (μg/l)	6	<1					

Table 5-1, (Continued)

Property (units)	Number of Samples	Mean and 95% Confidence Limits	Maximum	Minimum	Range	Standard Error	Coefficient of Variation, %
Organophosphorus Pesticides:							
DDVP (µg/l)	6	<1					
DEF (µg/l)	6	None					
Demeton (µg/l)	6	<1					
Diazinon (µg/l)	6	<1					
Dimethoate (µg/l)	6	<1					
Disulfoton (µg/l)	6	<1					
Disyston (µg/l)	6	<1					
EPN (µg/l)	6	None					
Ethion (µg/l)	6	None					
Malathion (µg/l)	6	None					
Merphos (µg/l)	6	None					
Methyl Paration (µg/l)	6	None					
Parathion (µg/l)	6	<1					
Phosdrin (µg/l)	6	<1					
Ronnel (µg/l)	6	<1					
Thimet (µg/l)	6	<1					
Trithion (µg/l)	6	None					
Polychlorinated Biphenyls	6	None					
Triazine Pesticides	6	None					
O-Aryl Carbamate Pesticides	6	None					
N-Aryl Carbamate Pesticides	6	None					
Urea Pesticides	6	None					
Chlorinated Phenoxy Acid Herbicides:							
2,4-D (µg/l)	6	None					
Diacamba (µg/l)	6	None					
Silvex (µg/l)	6	None					
Phenols, total (µg/l)	6	12.3±6.4	24	8	16	2.51	49.9
Phosphorus:							
Orthophosphate, dissolved (µg/l as P)	6	26.4±12.8	34	2.2	31.8	4.99	46.3
Total Phosphate, dissolved (µg/l as P)	5	32.0±17.1	46	11	35	6.16	43.0
Silica:							
Dissolved (µg/l as SiO_2)	2	12,800±851	14,800	10,800	4,000	2,000	22.1
Total (µg/l as SiO_2)	6	9,550±25,400	11,100	8,800	2,300	331	8.50
Solids:							
Suspended (mg/l)	6	17.0±8.0	28	8	20	3.10	44.6
Total dissolved (mg/l)	6	1,583±285	1,860	1,240	620	111	17.1
Volatile (mg/l)	6	169±76	308	114	194	29.6	42.9
Sulfate, dissolved (mg/l as $SO_4^=$)	6	563±27	598	526	72	10.5	4.56
Surfactants, total (MBAS) (µg/l)	6	<25					
Turbidity (JTU)	6	16.3±2.0	19.5	13.5	6.0	0.825	12.4

Reference 5.11

during "emergencies"--e.g., flow in the drain ceases because of maintenance work or is not sufficient to supply plant needs.

Construction water would be needed for dust control, building services, concrete production, soil compaction, fire protection, and domestic uses. Two possible sources of construction water are the Outfall Drain and groundwater.

5.3 Water Requirements

5.3.1 Cooling Subsystem: Wet Cooling Tower

The use of once-through cooling in new power plants has been avoided because of concern for allowable temperature increases in natural water bodies, as indicated in California's "Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California" and U.S. Environmental Protection Agency guidelines. The California State Water Resources Control Board (SWRCB) adopted the "Water Quality Control Policy on the Use and Disposal of Inland Waters for Powerplant Cooling" in June of 1975. This policy identified inferior quality water supplies and ocean water as highest priority waters for use in power plant cooling. In August 1976, the California Water Commission adopted Resolution No. 76-16 stating: "...the California Water Commission urges the maximum use of agricultural waste waters unsuitable for agricultural reuse, brackish water from natural sources, and inland wastewaters of high total dissolved solids for power plant cooling purposes in the San Joaquin Valley and Colorado desert region of California..."

The cooling system selected for the hypothetical facility utilizes mechanical draft wet-cooling towers for several reasons. A wet-cooling tower system represents a worst-case scenario in many respects. Intra-plant impacts (impacts of a plant subsystem on another part of the plant) result because of plume drift and salt deposition on the heliostat field. A wet-cooling system also represents the greatest environmental impact--water requirements, evaporation basin land requirements, and salt deposition. The greatest possibility for interaction between the coal stack emissions and the cooling-tower plume (e.g., formation of acid mist) exists with this system. A mechanical draft wet-cooling system is both a proven technology and is economically attractive; therefore it is the most likely cooling system to be chosen for a new power plant. Furthermore, modeling for wet-cooling tower plumes and salt deposition is available for the proposed site. A dry-cooling tower system and a combination wet/dry-cooling tower system are evaluated in Section 5.7 as alternatives to the proposed system. These systems appear attractive from the standpoint of reduced intra-plant impacts (important for a hybrid coal/solar power plant) and environmental impacts. As discussed earlier, approximately 7.6 x 10^6 cubic meters (6,200 AF/yr) of cooling water would be required.

Cooling towers can be either natural draft or mechanical draft. A natural-draft tower relies on increased temperature (reduced density) to create draft or convective currents to cause air flow up through the tower. Air flow rate is proportional to the density difference between ambient air and warmer humid air in the tower stack. A totally natural-draft tower is not considered feasible for the proposed site because of high ambient air temperatures and the large size and therefore materials cost required for a natural-draft tower. In a mechanical-draft tower a fan either forces (at bottom) or induces (at top) air movement through the tower.

5.3.2 Heliostat Washing

Water Requirements and Washing Methods for the Rockwell Design

Numerous washing schemes have been proposed for heliostats. A labor intensive method using essentially hand-cleaning of the heliostat surface would require the least amount of water. A water intensive method using a drive-through washing-and-rinse truck system is proposed for the Barstow facility. Collection and reuse of wash-and-rinse water would reduce water requirements. Water requirement estimates for heliostat washing vary from 1-15 gallons per heliostat per wash, depending on the washing method used.

If each heliostat is washed once a month, water requirements for heliostat washing would range form 490 to 4,200 cubic meters per year or 122, 000 to 11 million gallons per year (0.4-3.4 AF/yr). This is a small portion of the total plant water requirements. However, deionized water might be required for heliostat washing to prevent fouling of the surface by dried minerals left from evaporation of wash water. Possible demineralization systems are discussed under "Water Treatment Systems."

Heliostat Soiling

Figure 5-2 shows estimated mass deposition rates for coal combustion particulates and fugitive dust per square meter of heliostat over a 30-day month (see Chapter 4.0 for methods used to derive these values). The values for salt deposition should not be added directly to coal combustion particulates and fugitive dust values because different modeling techniques were used in obtaining values. However, until further and consistent modeling can be done, it is assumed that relative values are useful for comparative purposes. The deposition mass of salts from the cooling towers appeared not significant (0.05 gm/m^2/month) when compared to coal combustion particulates and fugitive dust. Although the computed deposition of salts on the heliostats appears low, the addition of even this small amount of salts may be significant in terms of reactions on the heliostat surface and necessary cleaning.

Figure 5-2 represents deposition rates for the northern fraction of the heliostat field under the assumptions given in Chapter 4.0 (fugitive dust generated in an area adjacent to the northern side of the field and worst-case conditions for dust plume modeling). It is assumed that the other portions of the heliostat field (east, west, and south) would have a similar mass deposition pattern--highest fugitive dust deposition on the outermost cells, and high coal combustion mass deposition rates on the two inner cells. The highest mass loading for the modeled portion--about 6

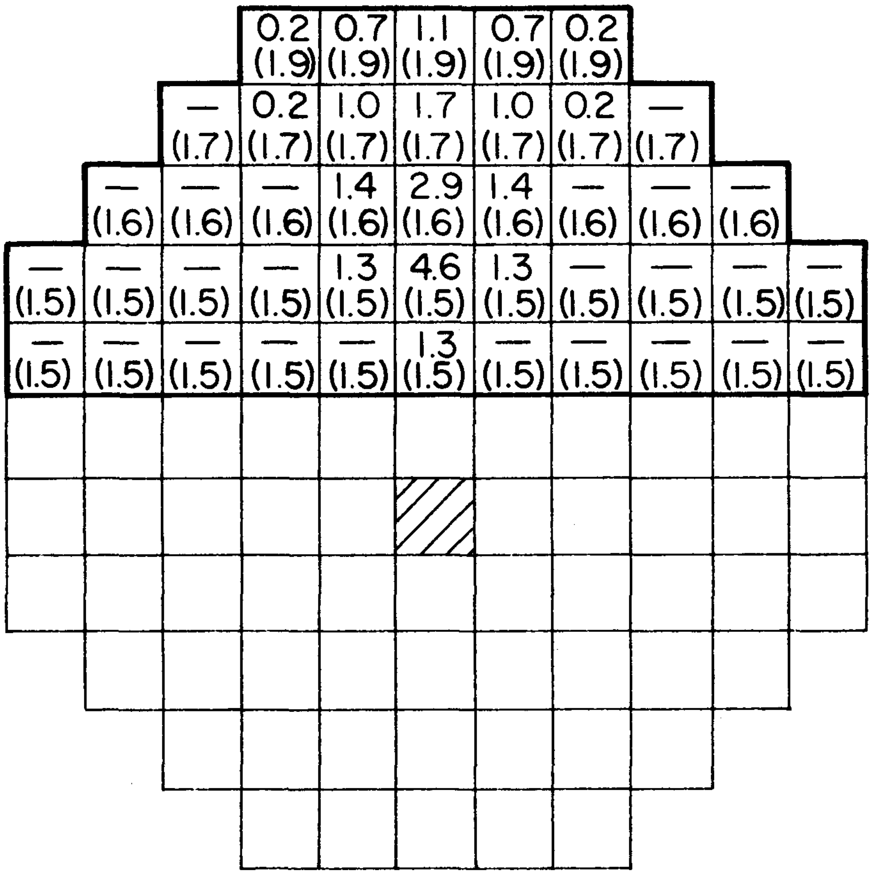


Figure 5-2 Combined Coal and Fugitive Dust Deposited on Heliostats Over a 30-Day Month

gm/m^2-month--could increase substantially from greater RV action. It is assumed that two cells (cells C and D in the north quadrant) per quadrant or eight cells in the total field would require cleaning twice a month. This amounts to 7,386 heliostats.

Fugitive dust values used in Figures 5-2 derive exclusively from vehicle disturbance and do not include dust generated by natural causes such as high winds. Measurements for Blythe Airport indicate 122 observations of blowing sand or dust in six years. Each year averages 20 observations. If one assumes equal distribution of dust storms throughout the year, one or two dust storms occur per month (5.12).

The site area receives about four inches of rain per year (see Table 5-2). The month of August has the highest average rainfall at 21 mm (0.84 inches) and December has the next highest at 14 mm (0.55 inches). The months of July through September are likely to have two to three thunderstorms each based on six years of data taken at the Blythe Airport (5.14).

Figure 5-3 presents reflectance data for heliostats at the Central Receiver Test Facility at Albuquerque, New Mexico, over an 80-week period. For the vertical position reflectance averaged about 3% below the clean value without cleaning or rainfall washing. Heliostats exposed for 68 weeks were cleaned overnight to their original reflectance value by 17 mm (0.5 inches) of rain (5.15). These mirrors were not exposed to salts and chemicals from cooling towers or coal combustion emissions, and therefore material deposited on the Albuquerque mirrors is probably not as difficult to remove as the material expected to be deposited on the study heliostats.

McDonnell Douglas (5.16, 5.17) studied soiling and washing of mirrors in different locations throughout the country. Findings from these studies are discussed below. The relative abundance of all mineral contaminants on the mirror specimens was approximately the same as that found in surface materials from the ground. Hence, it is believed that the largest proportion of mirror soil is simply wind-carried mineral grains from the ground surface.

Quartz, feldspars, and micas were the most abundant minerals, and montmorillonite was the most common clay. Wind-blown grains are 1-25 μ in diameter with most in the 1-5 μ range. Grains less than 10 μ in size adhere firmly to the mirror surface after the first wetting/drying cycle, and spotting of the mirrors results from surface tension pulling condensed moisture and dust into droplets that subsequently evaporate. Repeated wetting and drying of rain and dew results in the build-up of chemical precipitates--calcite, gypsum, halite, and sylvite. This precipitate chemically bonds the wind-blown rains to the mirror.

Nonreversible adsorption reduced the specular reflectance of glass mirrors by about 2%. Spraying with tap water at 1000 pounds per square inch (psi) restored the glass to 98% of the original specularity even after eight months of exposure. The glass mirror could be restored to 100% of its original reflectance by either scrubbing with detergent or by a spray and

Table 5-2

Maximum, Minimum, and Average Values of Temperature and Average Precipitation Amounts Near the Site

Month	Temperature (F)[1]			Temperature (F)[2]	Precipitation (in.)[2]
	Extreme Maximum	Extreme Minimum	Average	Average	Average
January	84.0	24.0	51.4	52.6	0.48
February	89.0	30.0	58.4	57.0	0.48
March	92.0	33.0	63.1	63.4	0.40
April	104.0	45.0	73.7	70.9	0.13
May	114.0	51.0	80.2	77.6	0.02
June	118.0	59.0	87.7	85.1	0.03
July	117.0	72.0	94.7	92.1	0.21
August	118.0	65.0	93.0	91.0	0.84
September	120.0	61.0	88.6	85.5	0.33
October	105.0	43.0	76.4	73.4	0.27
November	92.0	33.0	62.6	60.1	0.22
December	82.0	30.0	53.2	53.8	0.55
ANNUAL	120.0	24.0	73.2	71.9	3.96

NOTES:

1. Based on Blythe Airport observations for the period November 1, 1948 - December 31, 1954.

2. Based on Blythe, California, observations for the years 1930 - 1960.

Reference 5.13

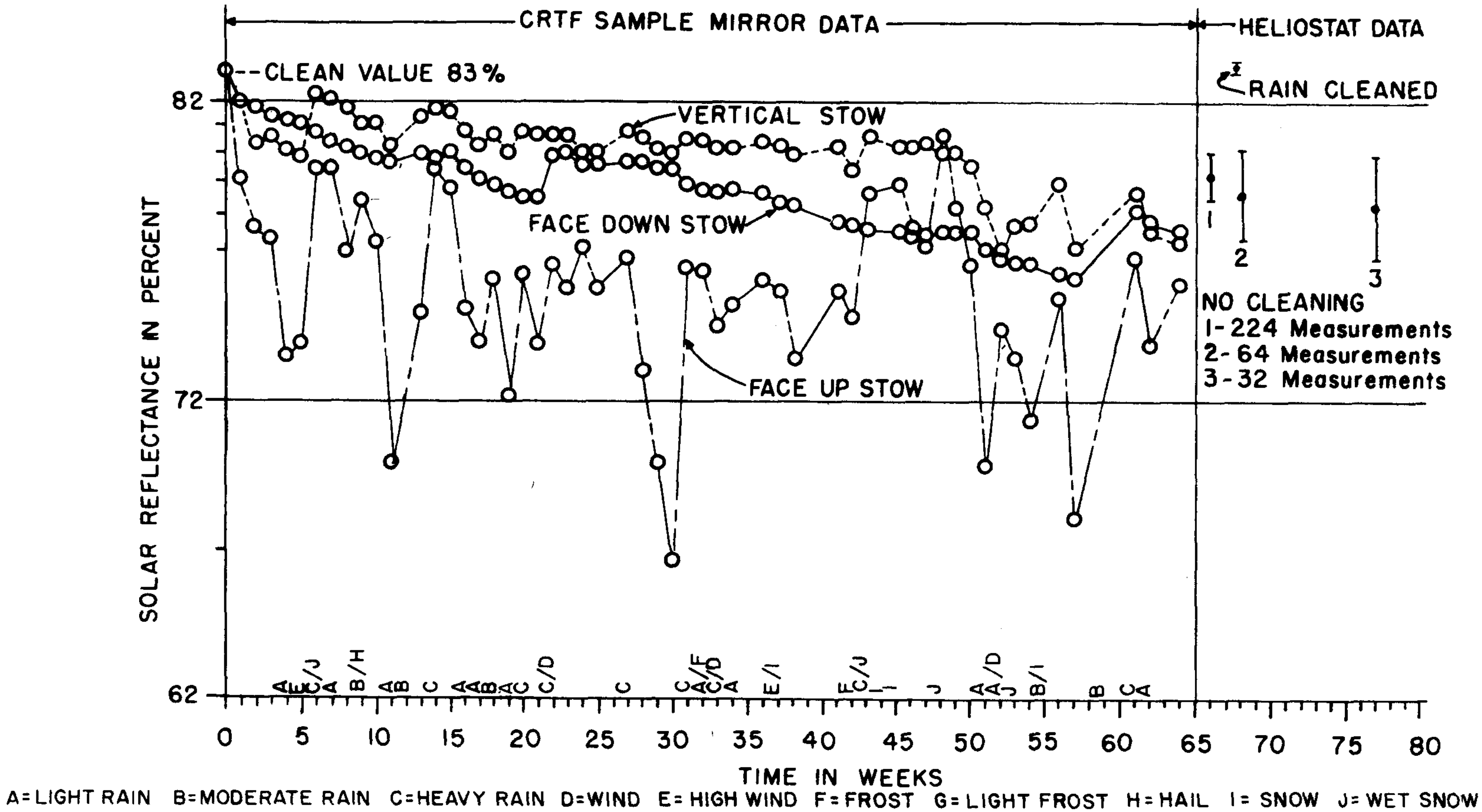


Figure 5-3 Solar Reflectance Measurements for Heliostats at the Central Receiver Test Facility, Alburquerque, New Mexico (Reference 5-15)

rinse with an acidic cleaner. Cleaning appears to enhance existing scratches on a mirror's surface. For planar heliostats the McDonnell Douglas studies recommended routine maintenance cleaning by a high-pressure spray with plain water, although this requires a soft water. After exposure for one to two months at industrial sites and cleaning, glass mirrors showed a loss in specular reflectivity of 0-8% (5.16, 5.17).

Proposed Heliostat Washing Frequency and Water Requirements

Based on the above information it is not believed that each heliostat for the proposed coal/solar hybrid power plant could be cleaned only an average of once a month and still maintain the necessary reflectance even if loss of reflectance is accommodated by heliostat oversizing. A more realistic heliostat washing scheme for the site is outlined below.

Each heliostat would be washed once a month to remove "naturally" deposited materials and prevent buildup of cementing materials. Each heliostat would be washed again each month following that month's dust storm (assuming one to two dust storms per month). The 7,386 heliostats in the eight cells receiving the most coal combustion particulates and fugitive dust emissions would be washed an additional time each month (three times total). This washing scenario would require 6,400 to 93,000 cubic meters or 1.6 to 23 million gallons of water (5.9 - 71 AF) per year. This represents a worst-case analysis because it does not account for natural cleaning by rain. Thunderstorms during the months of July through September occur two to three times per month. If rainfall is about 17 mm (0.5 inches) or more the heliostats would be effectively cleaned. This would probably occur about two or three months out of the year. Light rainfall which is not enough to clean the mirrors would create spotting and possibly reduce reflectance. The amount of wash water required by this scenario represents about 1% of the cooling water makeup required by a wet-cooling tower. The heliostat washing water would probably have to be deionized, however, and therefore the larger volume of water required with this washing scheme would result in use of costly treatment processes.

Environmental Impacts Associated with Heliostat Washing

Aside from the water required for heliostat washing, the effluent from the washing could cause environmental impacts if not properly handled. If clean or deionized water is used for washing, it could fall onto the ground and provide moisture for vegetation. If a detergent is used, it should be biodegradable. Any non-biodegradable detergent or chemical wash water should be collected by the wash trucks (as proposed at Barstow) and either recycled or disposed of in the plant's evaporation basin. Disposal of heliostat wash water is under the jurisdiction of the Colorado River Basin Regional Water Quality Control Board.

5.3.3 Other Water Requirements

An additional 4.1 x 10^6 cubic meters (3,300 AF/yr) would be required for flue gas desulfurization. A significant amount of water would be required for drinking and sanitary uses by construction workers for a period of five years. Construction processes would also require large amounts of water. After construction, the plant would continue to need water for employees' sanitary and drinking purposes.

5.4 Water Treatment Systems

Makeup and sidestream treatment systems are designed to maintain the chemical composition of circulating water so scale formation and corrosion are minimized. A demonstration plant one thousandth the size of the plant necessary for the Sundesert nuclear power plant was built near the site to prove the feasibility of the proposed water treatment system (5.4).

5.4.1 Makeup Water

Makeup water for the cooling system would be conveyed to clarifiers for clarification and partical lime softening. Addition of lime would reduce calcium hardness and alkalinity by precipitation of calcium carbonate. A coagulant, such as ferric chloride, and a coagulant aid (polyelectrolyte) would be added to enhance clarification. An effluent low in calcium and alkalinity yet retaining magnesium and silica would be produced. Sulfuric acid would be added to clarifier effluent to reduce pH (from 10.2 to 7.9) and prevent calcium carbonate scaling. Clarifier underflow would be conveyed to a gravity sludge thickener for sludge concentration and water recovery. This underflow would be discharged to the lined evaporation basin (5.4).

Circulating water would be chlorinated intermittently to prevent biofouling of piping and heat transfer surfaces and thus maintain efficient operation. Circulating water would be chlorinated prior to passage through the condenser about twice a day for 30 minute periods (5.4).

5.4.2 Sidestream Treatment

About one to two percent of the circulating water could be clarified and softend to minimize the blowdown volume. Lime and soda ash would be added to the clarifiers for reduction of calcium, magnesium, alkalinity, and silica. Underflow from the sidestream clarifiers would pass through sludge thickeners before discharge to an evaporation basin.

5.4.3 Cooling Tower Blowdown

The use of makeup and sidestream treatment reduces, but does not eliminate, the need for cooling tower blowdown. To maintain the necessary chemical composition of circulating water, a portion of this water is discharged to the evaporation basin and replaced with makeup water. The quantity of blowdown discharged varies proportionally with variations in the rate of evaporation from the system. Chemical constituents which are neither reduced nor removed in the treatment system will have concentrations approximately 15 times greater than their concentrations in the makeup water.

5.4.4 Boiler Blowdown

In order to maintain the boiler water chemical composition within specifications, water is discharged from the boiler and replaced with demineralized makeup water. Boiler blowdown would be discharged to the evaporation basin.

5.4.5 Demineralization

High quality water (low mineral content) may be required for some plant processes and for heliostat washing. The most commonly used demineralization process is ion exchange. If dissolved solid concentrations are high, reverse osmosis demineralization might be the most economical alternative. If reverse osmosis is used, the effluent would still require final ion-exchange treatment to produce a water sufficiently low in dissolved solids for high quality uses such as high-pressure-boiler makeup water.

5.5 Hydrology

Runoff from rainfall in the local watershed normally occurs during infrequent, but occasionally intense thunderstorms. Numerous small drainage channels show a rapid runoff response to these rainfalls. If strictly sheet flow occurs, the maximum depth of flow across the site area would be approximately 25 cm (10 in). However, due to natural channelization by numerous small dry channels, strict sheet flow is unlikely at the proposed site (5.4).

The site surface topography is fairly level with a gentle rise towards the west of about 37 meters (120 ft). Several seasonal streams which drain from the Mule Mountains cross the site. It would be necessary to change the natural drainage of the site by channelization of flows around the proposed facility to prevent erosion and gully formation in the heliostat field area. The rational method, modified to account for regional characteristics (5.18) can be used to compute surface runoff flows. Surface runoff increases induced by development of a site are based first on the increase of impervious area which follows development. An example change would be from 2% (characteristic of open land) to 9.5% (characteristic of paved surfaces). Channelization can enhance such effects, but results are highly design-specific. If the heliostat field area is paved, the surface runoff from the site is certain to increase substantially.

Destruction of "desert crust" and "desert pavement" by construction operations would result in water erosion of soils and decreased rainwater recharge to groundwater (see discussion under Fugitive Dust, Section 4.4.4).

5.6 Waste Discharges to Land

All cooling tower and other process waste discharges from the proposed plant would be conveyed to a lined evaporation basin for disposal. Design and construction of the basin would be in accordance with the requirements of federal, state, and local regulatory agencies. The State Water Resources Control Board has a policy that permits the use of an unlined evaporation basin only at a salt sink, with approval required by the Regional and State Boards and where the geologic strata underlying the proposed ponds or salt sink would protect usable groundwater (5.19).

Roof and yard runoff within the perimeter of the site would be collected and processed through an oil separator prior to discharge into natural drainage features.

Self-contained portable toilets would be placed throughout the construction area during the initial stages of construction. Wastes from these units would be transported offsite to an approved disposal area. The permanent sewage treatment system would be installed during the early stages of construction and would treat sewage from those areas not served by portable toilets. All sanitary wastes would be conveyed to the plant's sewage treatment facility. Design and construction of the sewage treatment plant would conform to all applicable federal, state, and local guidelines.

5.7 Cooling Subsystem Alternatives

5.7.1 Dry Cooling Tower Alternative

Dry cooling towers use either direct steam condensing or indirect steam condensing. In the direct system, the steam flows directly to the exchangers (finned tubes) and is condensed by cooling air flowing past the tubes. In the indirect system, the steam is first condensed by water flowing around a condenser and the heated water is then run through exchangers where it is cooled by the surrounding air flow. Dry cooling relies on the transfer of sensible heat using convection and some conduction) rather than latent heat (evaporation) for cooling.

Table 5-3 lists advantages and disadvantges of dry cooling systems. The advantages of such a system are mostly environmental. A dry cooling tower would eliminate the need for about 8.6 million cubic meters per year (7,000 AF/yr) of makeup water required for the proposed 430 MWe coal/solar plant. This cooling system would elminate the need for blowdown treatment and discharge costs and would substantially reduce the size of the evaporation basin. Because a dry cooling tower does not produce a moist plume, the impacts for salt deposition on heliostats and vegetation, corrosion, plume visibility, and health impacts from potentially harmful chemicals transported in aerosols would be eliminated. Icing or fogging problems would not occur; however these impacts are considered minimal even with a wet cooling system because of the hot, dry climate at the site. A dry cooling system would reduce the chance of interaction between coal stack emissions and cooling tower plumes.

Cost is the major disadvantage of a dry system. A dry cooling system has a smaller initial temperature difference (hotwell condensate temperature minus ambient dry bulb temperature) as compared to a wet system which can

Table 5-3

Advantages and Disadvantages of Dry-Cooling Tower Systems

Advantages

- Absence of large make-up water requirements
- Absence of treatment and discharge cost from large volumes of blowdown
- Large reduction in size of evaporation basin required
- Reduction of corrosion problems from drift
- No visible or harmful pollution discharge by a moist plume
- No icing and fogging problems from moist plume
- Operation and maintenance costs lower than wet-cooling systems

Disadvantages

- Larger space requirement because of larger heat exchanger surface as compared to wet-cooling tower
- Represents 6-8% of total plant capital cost whereas wet-cooling systems reprsents 3-5% of total plant capital cost
- Cooling efficiency dependent on ambient (dry-bulb) air temperature so not practical in hot climate
- High back pressures (10-15 Hg Abs) reduce plant's annual efficiency by 6-8%
- Thermal plume
- Large size, especially height

cool to the ambient wet bulb temperature. High circulating water temperatures affect the steam condensing temperature and result in high turbine back pressures wich reduce the plant's efficiency. Turbines could be designed for higher back pressures, but such devices are currently not in demand. General Electric has a turbine with high back pressure capabilities that could handle 750 MWe (5.20). Dry cooling systems require a large heat exchange surface and therefore could require more siting space than a wet system. However, Larinoff (5.21) states that a mechanical draft dry tower requires no more total ground acreage than a conventional mechanical-draft wet tower. He also concludes that dry tower low flow rates combined with higher pumping heads results in a circulating pumping power which is no greater, and possibly less, than wet cooling tower systems. Another concern is that corrosion-resistant material such as aluminum would have to be used for the fins or extended parts of the heat exchanger. Emmissions from the coal portion of the plant might be slightly corrosive to the exposed heat exchanger.

Thus dry-tower system economics are closely tied to the availability of high-exhaust-pressure steam turbines. The present situation in the turbine market restricts the complete exploitation of dry cooling tower system economics. Yet there are dry cooling towers available today which can operate within the complete range of turbine capabilities and restrictions--100 to 1200 MW (5.21).

The 300-MW Wyodak coal-fired power station near Gillette, Wyoming, has been operating with a mechanical draft dry cooling system for 27 months. The plant's water requirement is 200 gpm, and municipal wastewater is used for makeup cooling water.. The plant has operated through a temperature range of -43 to 40°C (-46 to 104°F). Table 5-4 compares building height and space requirements of dry cooling systems in existing power plants. Wyodak's air-cooled condenser requires only 17 square meters per MW; this is an improvement in the space and therefore cost of dry cooling systems. Construction costs for this system were estimated to be $18/kW higher than for a conventional wet-cooling system. The turbine generator is designed for a continuous operation at exhaust pressures up to 15 in. Hg absolute or three times the normal level (5.22).

Forgo (5.23) estimates the total bus-bar power cost for a dry cooling tower at 0.48 mills per kWh higher (7-10%) than the total bus-bar cost for a similar evaporative-type cooling tower. Others estimate power from dry cooled plants to cost 10-15% more than wet towers of current design (5.24). Leung (5.25) estimates that a dry cooling system represents 6-8% of the total plant cost (includes water pumping and piping), whereas a wet cooling system represents 3-5% of total plant cost (includes water pumping and piping, surface condensers, towers and fans, tower basin, water makeup and blowdown systems). United Engineers and Constructors (5.26) state that the cost of dry cooling is three times that of wet cooling. Regardless of these disadvantages, as available cooling water becomes more expensive, the economic cost of dry towers will make their use justifiable for certain areas. Leung (5.25) concludes it is dry cooling tower cost and not their technological validity which currently precludes their use. Numerous installations with outputs of 20-330 MWe use dry cooling systems

Table 5-4

Comparison of Power Plants with Dry-Cooling Systems

Power Station	Net Output MWe	Fuel Coal	Condenser System	Draft	Height ft.	Plot Plan Area ft^2	Power Rating ft^2/MW
Rugeley/GB	120	Coal	Indirect jet	Natural	351	105,460	878.8
Ibbenbueren/FRG	150	Coal	Indirect jet	Natural	328	84,466	563.0
Rasdan/USSR	220	Coal	Indirect jet	Natural	354	125,500	570.5
Schmehausen/FRG	300	Nuclear THTR	Indirect surface condenser	Natural	443	175,250	584.2
Utrillas/Spain	160	Coal	Direct	Mechanical	75	31,700	198.1
Wolfburg/FRG	192	Coal/oil	Direct	Mechanical	75	47,300	246.4
Wyodak/USA	330	Coal	Direct	Mechanical	85	59,000	178.8

Reference 5.22

in the United States, England, Germany, South Africa, and the U.S.S.R. (5.25, 5.27). If both reduced intra-plant and environmental impacts are also considered, dry cooling becomes more attractive, especially for power plants such as solar whose operating efficiency could be reduced by impacts from wet cooling systems.

The assessment team for the proposed Sundesert nuclear plant evaluated the use of a dry cooling tower at the study site. A 20-degree approach, a 5-degree condenser terminal temperature difference, and a 20-degree range to a dry-bulb temperature of 88°F indicate that a five inch mercury back pressure limitation would be exceeded approximately 25% of the year. The plant would be required to shut down or reduce its load for an unacceptable portion of the year (5.28). A completely dry cooling system was not considered viable for the site.

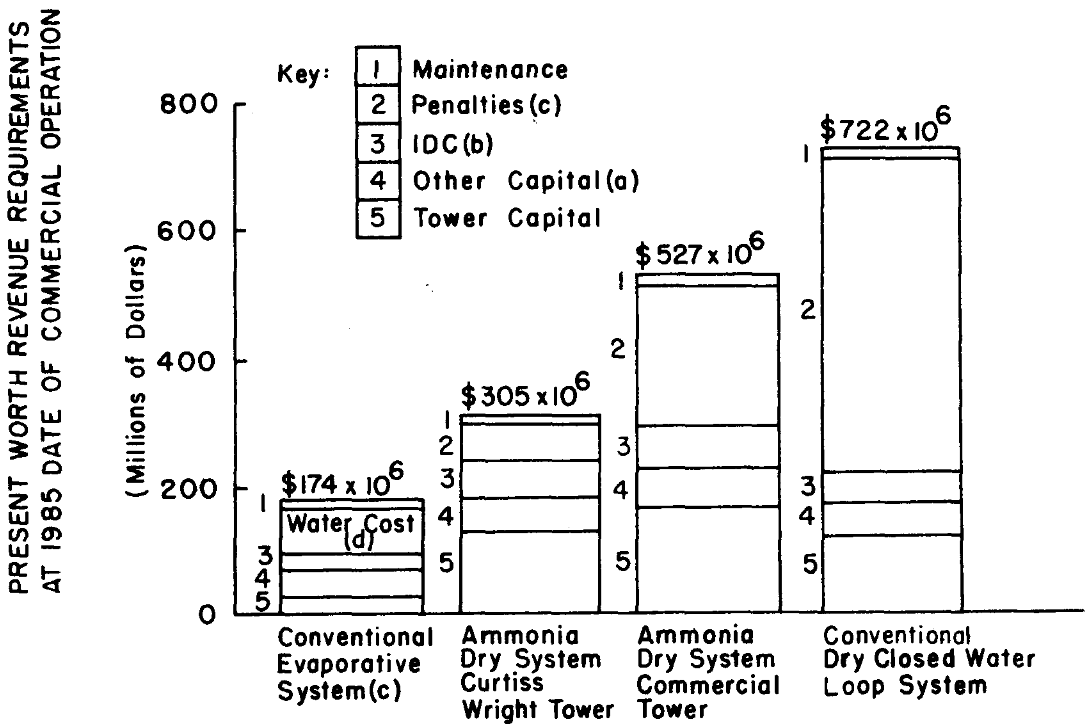
Improved dry cooling using advanced technology could reduce the cost of cooling 15-34% below existing dry cooling cost, an improvement resulting in a savings of 2-4% in overall plant cost. The use of ammonia as an intermediate heat transfer fluid (between turbine and dry tower) appears to be such an advancement in cooling tower technology. Figure 5-4 compares conventional and advanced dry cooling systems to conventional evaporative cooling and shows the cost of ammonia-dry systems approaches an evaporative-system cost (5.29).

5.7.2 Wet/Dry Cooling Tower Alternative

Wet/dry cooling systems can be used as wet towers, dry towers or both. The system can consist of wet/and dry cooling sections combined in a single structure or separate tower structures. Several configurations for wet/dry cooling systems are possible; Figure 5-5 shows schematic representations of a parallel and a series configuration. Figure 5-6 shows a cross-section of a parallel path wet/dry tower. The dry section would be used during cool weather or when power demands are low. The combined tower would be used during operation with higher air temperatures, especially to meet peak energy needs.

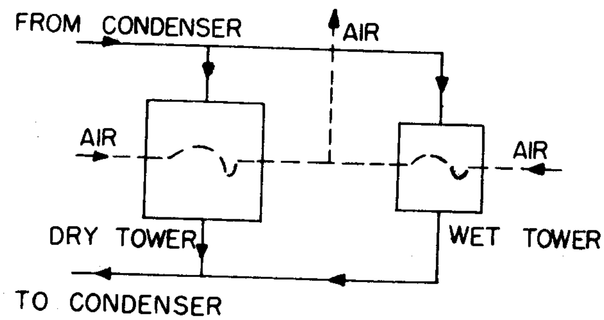
A combination wet/dry cooling system combines the advantages of both a wet and a dry cooling tower while reducing the disadvantages of both systems. Such a cooling system appears especially attractive for a solar power plant located in a hot climate with scarce water, and restricted to available water supplies of low quality. A solar plant also needs to avoid fouling of heliostats by materials transported within a cooling plume. Wet/dry cooling towers have not been used for large power plant (5.32).

Heller (5.33) presents a comparison of annual total costs for a dry cooling systems, a wet cooling system, and a combined wet/dry cooling system based on an 800 MW coal-fired power plant. The plant is to be located in the southwestern part of the United States where dry-bulb temperatures range from 10° to 95°F. The results of this comparison are presented in Figure 5-7. Although the costs are dated, the relative relationship between cooling systems costs for different systems is shown. This figure



Note a - Other Capital Includes Condenser, Piping, Pumps, Pumphouse, Etc.
Note b - IDC = Interest During Construction
Note c - Penalties = Capacity Penalty Plus Replacement Energy Cost, Conventional Evaporative System is Base Case and Hence Does not Have Penalties
Note d - Only Evaporative Systems has Water Costs

Figure 5-4 Comparison of Cooling System Present Worth Revenue Requirements for an 1140-MW Plant



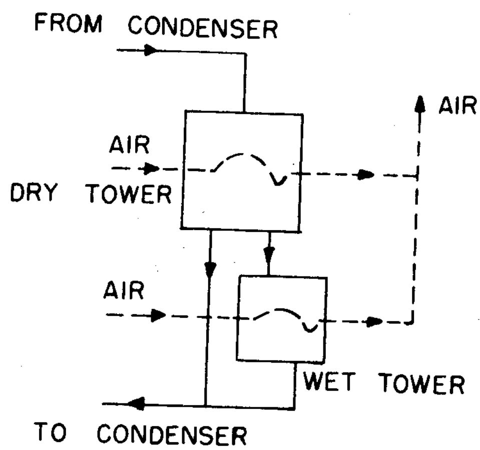


Figure 5-5 Schematic Diagrams of (a) Parallel Path and (b) Series Path Combined Wet/Dry Cooling Systems

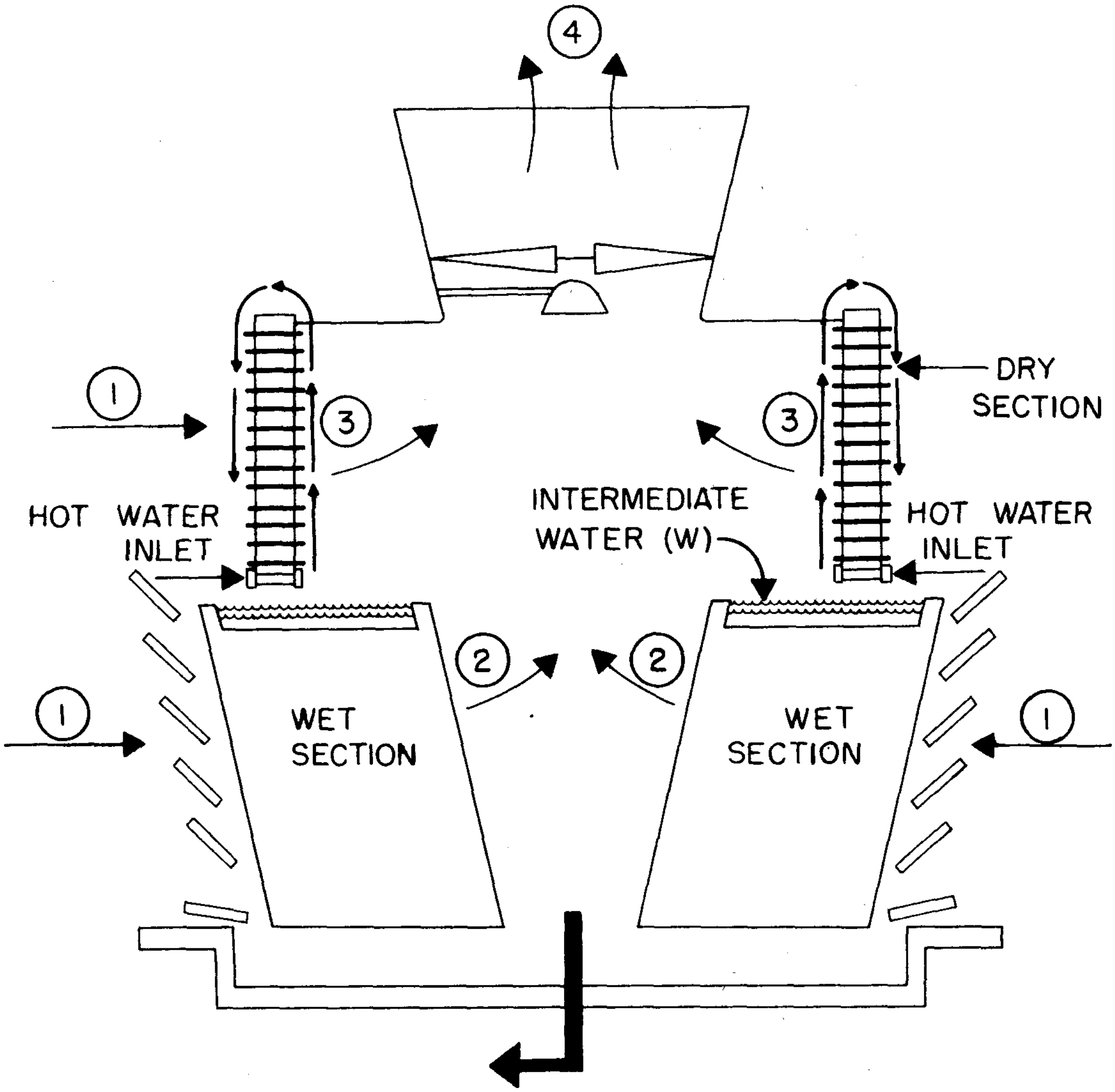


Figure 5-6 Parallel Path Wet/Dry-Cooling Tower

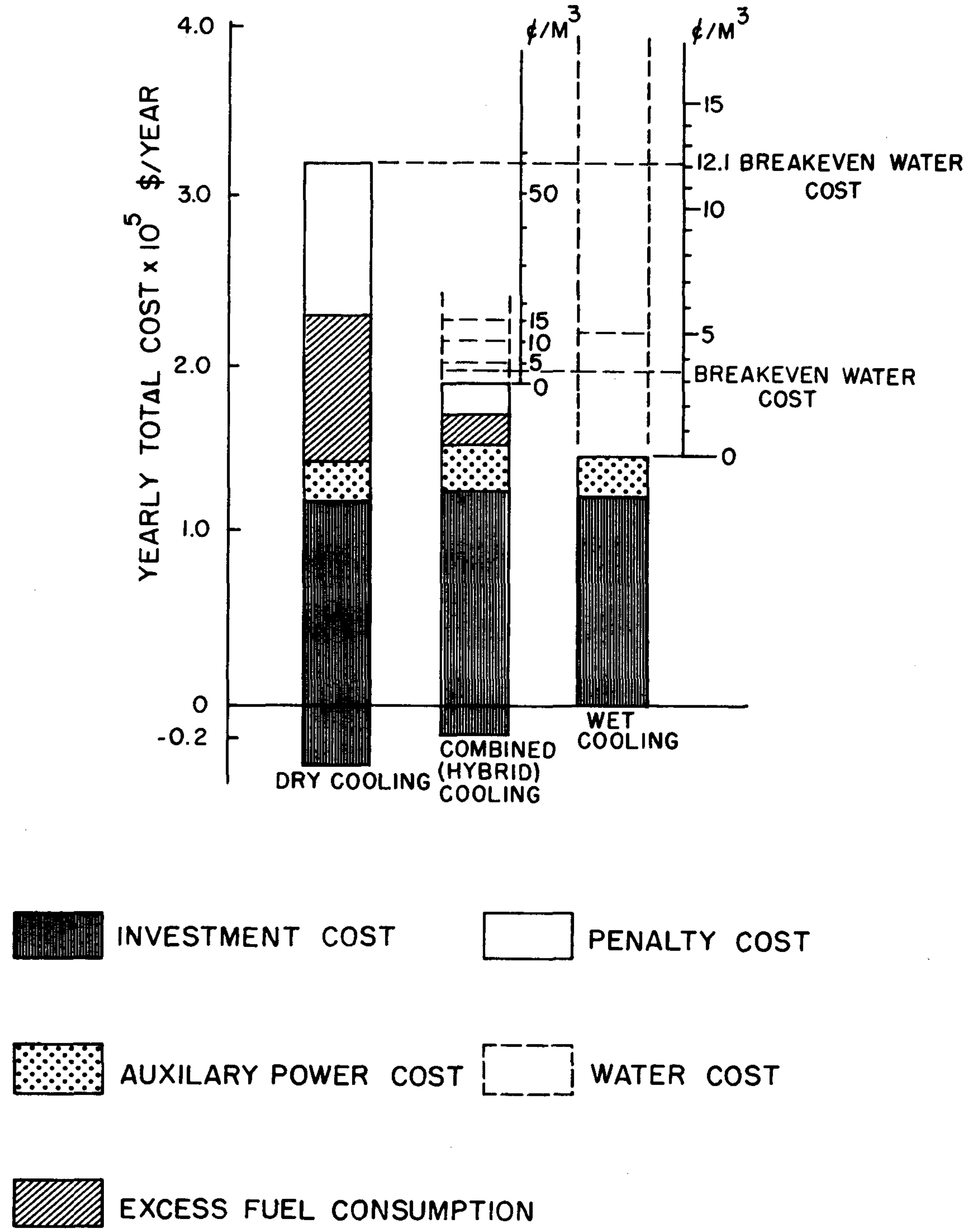


Figure 5-7 Annual Cost Comparisons for a Wet-Cooling, A Combined Wet/Dry Cooling, and a Dry-Cooling System

also introduces the idea of a "breakeven point" - the point where the cost of water makes a dry- or a wet/dry cooling system economically competitive with a wet cooling system. When only considering direct economic and engineering factors, a dry cooling system would impose a cost comparable to a wet cooling system if the price of cooling water is 12.1¢ per cubic meter ($150 per acre foot). A combined wet/dry cooling system would be cost-competitive to a wet system when the price of cooling water is 3.7¢ per cubic meter ($46 per acre foot) or more.

Hendrickson (5.34) estimates the breakeven point where wet/dry cooling would be selected over totally wet cooling at a water cost (1977 dollars) in the range of 45¢ to 68¢ per cubic meter ($389 per AF), depending on geographic location. Various water sources are available which can provide water at less than this cost; conveyance and treatment of agricultural and municipal wastewater costs about 15¢ to 20¢ per cubic meter ($185 to $427 per AF), and purchase of irrigated farms to acquire water rights costs about 6¢ per cubic meter ($74 per AF).

The assessment team for the proposed Sundesert nuclear plant evaluated the use of a 30% dry/70% wet cooling tower and a 65% dry/35% wet cooling tower for the site location. These systems had the dry- and wet cooling towers connected in a series. Circulating cooling water would pass through the condenser and to the dry tower. The dry tower section would provide all cooling until the ambient dry-bulb temperature reached 59°F. Water leaving the dry tower would flow back to the pumphouse forebay. Unused energy in the form of water pressure (created by bypassing the wet cooling towers) would be dissipated in a stilling basin incorporated into the pumphouse forebay design. The circulating-water pumps would then force water through the condenser to close the cycle. The 59°F design point allows the dry tower to operate alone for about 20% (2.4 months) of the year, thus saving about 20% of the cooling water required by a wet system. At ambient temperatures above 59°F, the dry tower could not maintain the required 28°F cooling range below a hot water temperature of 128°F. This constraint is dictated by turbine back pressure limitations (5.5 inches mercury). At ambient temperatures above 59°F, the dry cooling fans would be shut off, but cooling water would still pass through the dry cooling tower where some cooling would occur by natural draft. This procedure would reduce the cooling range of the wet tower another 10% and would result in up to an additional 10% water savings (depending on ambient temperature). Water would pass from the dry tower through the wet cooling tower and on to the circulating-water pumphouse (5.28). Operation of the 65% dry-/35% wet cooling system would be similar to the above described system. A comparison of advantages and disadvantages of these two systems is given in Table 5-5.

San Diego Gas and Electric concluded that a dry tower and condenser would require the use of titanium tubes due to water quality considerations and an ambient dry-bulb temperature of 111°F during 1% of the year. This requirement makes a wet/dry cooling system economically unattractive.

Croley, et al., (5.35) however, present data that indicate a wet/dry tower would be economicallly and environmentally attractive for a site such as

Table 5-5

Advantages and Disadvantages of Wet/Dry-Cooling Systems

30% Dry-/70% Wet-Cooling System	65% Dry-/35% Wet-Cooling System
Advantages	
Makeup cooling water reduced by 30% or 2.3 million cubic meters (1,900 AF/yr)	Makeup cooling water reduced by 65% or 4.9 million cubic meters (4,000 AF/yr)
30% less land required for evaporation basin	65% less land required for evapoaration basin
Wet portion of system emits about 25% less drift due to reduced period of operation	Wet portion emits about 50% less drift due to reduced period of operation
Chemical emissions via plume drift are reduced approximately 25%	Chemical emissions via plume drift are reduced approximately 50%
Salt deposition reduced by about 25%	Salt deposition reduced by about 50%
About 22% less land required for total plant	About 52% less land required for total plant
Disadvantages	
Dry towers visible as main plant structure	Dry towers visible as main plant structure
High capital and operation and maintenance costs	High capital and operation and maintenance costs

Reference 5.28

Blythe Palo Verde. A computer program was developed which determines the total cost (capital cost plus discounted operating cost) for any combination of turbine, type and number of towers, water flow rate, expected power demand and expected meteorological conditions for wet or wet/dry towers. For wet/dry towers, the program determined the optimum mode of operation (dry, wet, or a combinaton of wet/dry) for every set of meteorological conditions and therefore found the lowest total cost for optimum operation of the system over the life of the plant. Based on a 550 MW constant output from a 800 MW plant (5 inch Hg turbine back pressure), Croley, et al. (5.35), concluded that at higher water costs of $0.08 per cubic meter ($98 per acre foot) an optimum dry surface area exists for plants even in a hot climate. Sundesert water costs were estimated to be $0.1 per cubic meter ($135 per acre foot) (5.28). Selection of the basic wet tower size in the combination depends upon prevailing meteorological conditions. The optimum size of the dry tower to be added depends primarily upon water cost. The increased capital cost of the combination towers is compensated for by the lower operating costs resulting from water conservation and from fuel conservation (5.35). The use of separate dry and wet units of conventional design (in series with flow first through dry and then through wet towers) was found to be economically superior to single unit (one-fan) combinations because of larger air flow rates.

It is suggested that further work should utilize the models of Croley, et al. (5.35) with updated input to determine if a wet/dry cooling system would be economical for the proposed power plant site, and if so, to develop the optimum design and mode of operation based on meteorological conditions for the site.

Croley et al. (5.35) discovered that present-day designs of cooling sytems for electric plants appear to place considerable emphasis on capital expenses. So-called "optimum" designs are based upon the consideration of capital costs and one-year operating costs. The operating costs include either a fixed fuel cost or no fuel cost at all whereas experience is likely to include fuel and water cost escalation. These costs are also estimated assuming worst-case meteorological conditions which prevail for a small fraction of the total plant life. Croley, et al. have designed a methodology for synthesizing optimum cooling systems in which capital cost and operation costs are based on the most economical day-to-day operation. Optimization can be over a lifetime operation. Cooling systems optimized in this manner are somewhat larger than those designed conventionally but "they pay for themselves" in operational savings.

Patel, Croley, and Cheng (5.36) state that if economic comparisons include total fuel and water costs, wet/dry cooling towers become optimum even for arid areas. Capital costs amount to no more than 1-3% of the total costs for an operation period of 35 years. In the total economic picture of a power plant cooling system, the operating costs dominate. These costs are composed mainly of fuel and water costs. These authors suggest an operating rule--use dry cooling for air temperatures below 20°F (dry bulb), wet/dry cooling for air temperatures between 20° and 110°F, and wet cooling only for air temperatures above 110°F.

Current research is developing more efficient and less costly wet/dry cooling systems for power plants. The comparable capital cost (sum of the estimated basic capital cost and the capitalized annual operating cost) of an ammonia wet/dry system could be 20% less than current integrated wet/dry systems (5.24). Such a cost reduction would bring the cost of a wet/dry cooling system very close to the cost of a wet cooling system. Pumping costs are less with an ammonia system because natural forces transmit vapor from the reboiler to the cooling tower. Ammonia allows a higher heat transfer temperature difference in the cooling tower. Water treatment costs are less because only the deluge water has to be treated. Consequently, the operating costs of an ammonia wet/dry system are less (5.37, 5.24). Figure 5-8 compares incremental power production costs (in 1976 dollars) from a metal-fin-tube heat exchanger (state-of-the-art) and a plastic-tube heat exchanger and an ammonia-cooled loop (advanced technology). Plastic-tube heat exchangers would have the advantage of less corrosion problems and might reduce water treatment costs. The San Juan Unit 3 (550 MWe) will use an integrated Marlet wet/dry cooling tower. Table 5-6 shows estimated comparable costs of five wet/dry cooling systems for the San Juan Unit 3.

5.7.3 Cooling System Conclusions

A review of cooling tower literature indicate that whereas power companies relied on the once-through-cooling system and the wet cooling tower in the seventies, the constraints of the eighties (decreased water supplies, environmental legislation, plant siting near fuel sources, new technology, etc.) will create a need for dry and wet/dry cooling systems. The power plants at Wyodak and San Juan are examples of this. "...The utilities have so far leaned heavily in favor of cooling systems that involve the least amount of capital expenditure. The cooling-tower manufacturers

Table 5-6

Comparable Costs of Five Wet/Dry Cooling Systems for San Juan Unit 3

TYPE OF SYSTEM	COMPARABLE COST ($ in millions, 1976)
Separate wet/dry	44
Metal fin-tube/deluge	38
Integrated wet/dry	34
Plastic tube/deluge	31
Metal fin-tube/deluge/ammonia	28

Reference: 5.37

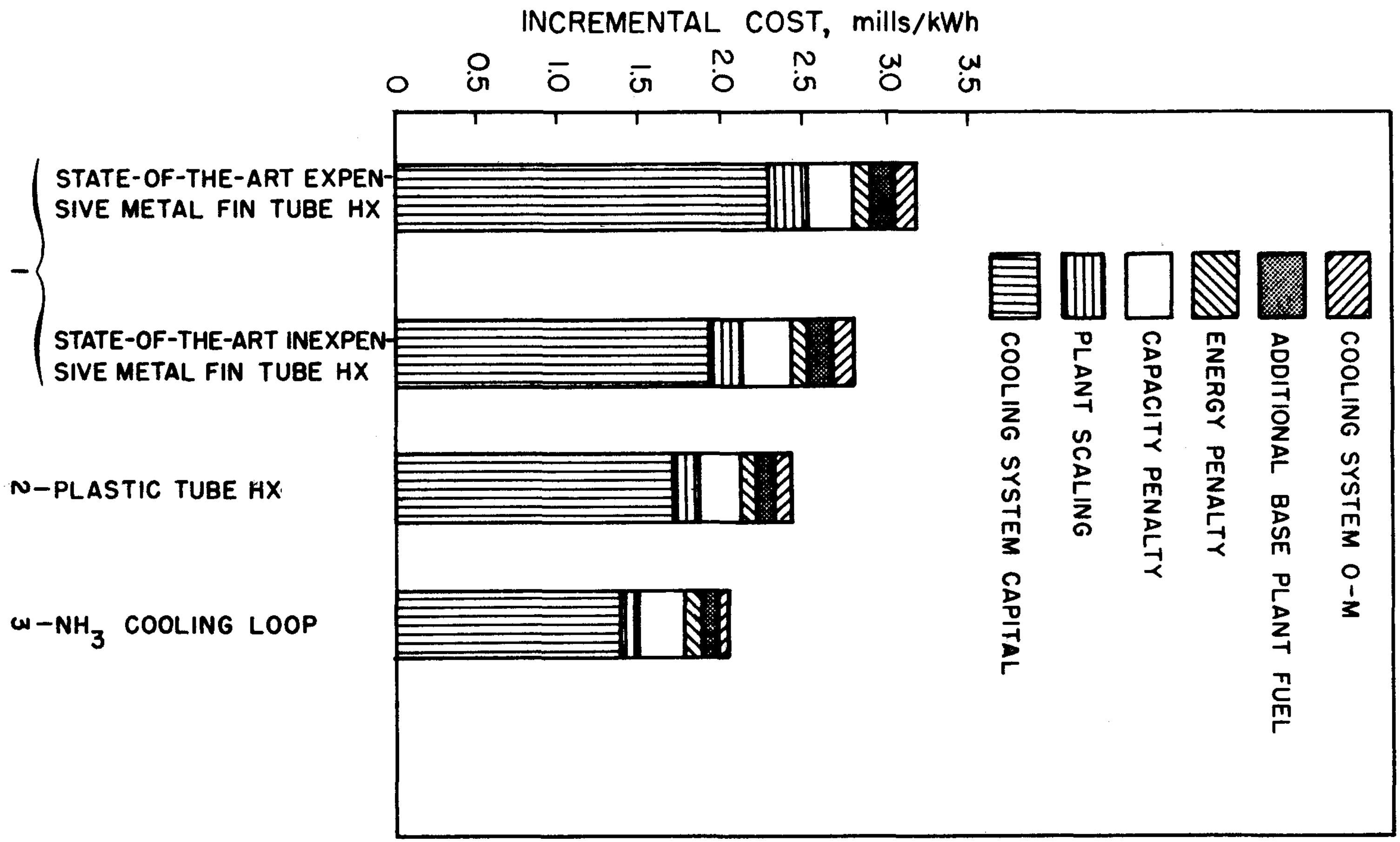


Figure 5-8 Comparison of Incremental Power Production Costs (in 1976 dollars)

also appear to have geared their design philosophy to this end. The present study suggests that some extra investment in the cooling system at the beginning will pay dividends in the form of reduced water consumption and lower fuel consumption" (5.36). The Hanford Engineering Development Laboratory predicted 2-4 GWe using wet/dry or dry cooling for the period 1990-2000 in the Lower Colorado River Basin (5.34).

The best cooling tower system is plant and site specific. Although the Sundesert economic evaluation indicated wet/dry cooling was not an acceptable system the needs of a coal/solar hybrid power plant are different. High costs of water treatment, environmental effects of salt drift, potential fouling of heliostat surfaces, and competition for water resources all argue for adoption of a water conservation strategy. This study concludes that a wet/dry cooling tower system would reduce water consumption and is a viable alternative. However, modeling such as that developed by Croley, et al. (5.35) should be done to verify the conclusion.

In addition, the steam Rankine cycle is usually considered when proposing plans for power plants. The use of other energy conversion cycles such as Brayton or Stirling may be more efficient and could reduce cooling water requirements (5.38, 5.39).

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6.0 LAND USE IMPACTS

6.1 Present Land Status

The Blythe site as identified in the Sundesert EIS is designated as an "approved power plant site" on the Energy Production and Utility Corridors Element maps for the California Desert Plan, Bureau of Land Management (6.1). Four alternative management plans for the land adjacent to the site are discussed in the California Desert Conservation Area Plan Draft. These are (1) No Action, (2) Protection, (3) Balanced, and (4) the Use Alternative. In both the No Action and Balanced alternatives, the lands surrounding the plan site have been specified as Class M: moderate use-resource use according to the principles of conservation; planning to provide for trade-offs between uses where conflicts occur, and mitigation of damage caused by permitted use. Under the Protection alternative, lands adjacent to the plant site are designated Class L: limited use oriented towards giving priority protection to sensitive natural, scenic, ecological and cultural resources while placing limitations on other uses that may conflict or degrade these values. The Use alternative designates lands in vicinity of the site as Class L and Class I: intensive use, permits development with reasonable mitigation and protection of sensitive resource values through rehabilitation when necessary. This represents the most consumptive use-oriented class. The proposed solar thermal hybrid plant will require more land than originally considered for Sundesert. Thus a new land-use plan may be required by BLM (6.2).

The entire 7,040 acres (11 mi^2) of the site is owned by San Diego Gas and Electric and was acquired through a land exchange with the Bureau of Land Management (6.3). It is assumed that the entire acreage would be required for solar hybrid installation (half for the plant, half for the exclusion area). The present status of the parcel is "plant site held for future use" by San Diego Gas and Electric.

To assure adequate cooling water for the Sundesert plant, the applicant purchased an additional 7,700 gross acres of farmland within the Palo Verde Irrigation District. This acreage could be retired from irrigation with corresponding water savings. The maximum amount of water required to maintain irrigation of these lands has been estimated to be approximately 33,300 AF/Y.

The major crops have been alfalfa, wheat, barley, cotton, lettuce, onions, and garlic. Table 6-1 summarizes the total acreage under cultivation and the value of the major crops previously described (6.4). If required, retirement of 2,500 acres of farmland is estimated to result in approximately $1,425,000 loss in income (average crop value of $570 per acre). Water requirements for the solar hybrid installation (430 MWe), however, are considerably less than for the proposed Sundesert installation (1900 MWe). If a similar strategy to use water from the Palo Verde Outfall Drain is adopted for the proposed Solar-hybrid facility it is unlikely that farmland would need to be retired (see Chapter 5).

6.2 Potential Site Problems

Lands on which the site is located restrict use to residential and light agricultural purposes. Therefore a change of zoning wil be necessary for the construction of the plant. Listings of federal, state, regional and local regulatory requirements are presented in Tables 6-2, 6-3, and 6-4.

Table 6-1

Palo Verde Acreage and Crop Report

	1978		1979	
Crop	Acres	Value	Acres	Value ($)
Alfalfa	23,800	8,163,400	24,388	12,803,700
Wheat	14,400	3,420,000	13,677	4,325,400
Barley	112	21,300	44	7,100
Cotton	26,000	13,104,000	27,000	20,088,000
Lettuce	4,400	7,260,000	4,500	7,115,600
Onions	3,000	2,604,000	5,200	4,513,600
Garlic	52	38,900	220	231,000
Total	71,764	34,611,600	75,029	49,084,400

Average number of acres - 73,400
Average value - $41,848,000
Average crop value per acre - $570 Reference 6.4

6.2.1 Construction

The ground surface at the site ranges from approximately elevation 350 feet on the east side to elevation 400 feet in the west side. The mesa, upon which the proposed plant site is situated, slopes eastward at about 40 ft/mi toward the Colorado River Floodplain. Therefore if a uniform flat field is required huge amounts of earth will have to be graded and/or moved. Even if the present grade is acceptable excavation for heliostat and building foundations, trenching for control cables, flood control structures, and vehicular traffic will produce soil and vegetation disturbance, potential shuffling of rare artifacts, habitat loss and subsequent displacement of animals. Adequate mitigation provisions must be developed to prevant the temporary soil disruption from becoming permanent damage through wind and water erosion. The compaction of the soil from construction will alter assimilation and percolation of water into the soil and may effect the local biota. The desert is a very sensitive

Table 6-2

Federal Licenses, Permits, and Approvals

Agency	Authorization	Code or Status	Environmental Concern
Federal Aviation Administration	Notice of Intent to construct and approval of an obstacle and its marking pursuant to an airport airway analysis study	49 USC Sec. 1301 et seq.	Public Safety
U.S. Forest Service	Special Use Permit or Easement	16 USC Sec. 471	Aesthetics
Federal Communications Commission	License to construct and operate electronic transmitting equipment	47 USC Sec. 151	
Bureau of Land Management	Special Land Use Permits Special Material Sale Easements	43 USC Sec. 1 et seq.	
Bureau of Indian Affairs	Rights-of-way through Indian Lands	25 USC Sec. 311 et seq.	All Environmental Impacts
National Park Service	Land Use Permit	National Forest Provisions 16 USC Sec. 1 et seq.	Land
Bureau of Reclamation	Land Use Permit	43 USC Sec. 371 et seq.	Land
Bureau of Outdoor Recreation	Land Use Permit	16 USC Sec. 460 L et seq.	Land

Table 6-2, (Continued)

Agency	Authorization	Code or Statute	Environmental Concern
Bureau of Mines	Land Use Permit	30 USC Sec. 1 et seq.	Impact to Mineral Resources
Department of Labor Occupational Safety and Health Administration	Adherence to OSHA Requirements	Occupational Safety and Health Act of 1970, 29 USC Sec. 651 et seq.	Occupational Safety
Army Corps of Engineers	Permit to construct in navigable waters Permit for discharge of dredge or fill material	Rivers and Harbors Act 33 USC 401, 403 et seq. 33 USC 1344 and 33 CFR 209, 120	Water
Advisory Council on Historic Preservation	Negative determination Memorandum of Agreement	Historic Sites 16 USC Sec. 470 et seq.	Protection and preservation of historic and cultural properties
Environmental Protection Agency	Adherence to air quality requirements	Clean Air Act as Amended, 42 USC Sec. 1857 et seq.	Air
Secretary of Interior	Approval of Water Supply Contracts	Boulder Canyon Proj. Act, 43 USC Seq. 617 et seq.	Water

Table 6-3

State Licenses, Permits and Approvals

Agency	Authorization	Code or Statute	Environmental Concern
California Water Resources Control Board	Certification of Compliance	Porter-Cologne Water Quality Control Act, Water Code, Se. 13000 et seq. as amended	Water Quality
State Department of Transportation	Encroachment Permit Crossing Permit	Streets & Highways Code, Sec. 670 et seq. Sec. 117 et seq.	Land (Transmission, Transportation)
State Department of Parks & Recreation	Encroachment Permit	Public Resources Code, Parks & Monuments Div., Sec. 5001 et seq.	Land (Transmission)
State Public Utilities Commission	Certificate of Convenience & Necessity	Public Utilities Code, Sec. 1001 et seq.	Need for Facility
State Department of Fish and Game	Approval	Fish & Game Code, Sec. 5650 et seq.	Impacts to Fish & Game
Colorado River Board	Land Use Permits Approval of Water Contract	Calif. Water Code, Colorado River Bd. Provisions, Sec. 12500 et seq.	Water & Land Use
State Department of Industrial Relations	Permit to Operate Equipment	Calif. Occupational Safety & Health Act of 1973	Safety
	Cal-OSHA Permit & requirements Safety Permits	Calif. Labor Code, Sec. 6300 et seq. as amended	

Table 6-3, (Continued)

Agency	Authorization	Code or Statute	Environmental Concern
California Energy Resource Conservation & Development Commission	Notice of Intention Site & Facility Certification	Warren-Alquist Act Public Resources Code, Sec. 25000 et seq.	All Environmental Impacts
State/County Pollution Control Financing	Review of region, basin or state plan for environmental protection	Calif. Pollution Control Financing Authority Act	Air, Water
American Society for Mechanical Engineers	Owner's Certificate of Authorization	ASME Boiler & Pressure Vessel Codes, Sec. III	Safety
State Department of Motor Vehicles	Vehicle Registration	Vehicle Code, Sec. 4000 et seq.	Safety
Air Resources Board	Review	Mulford-Carrel Air Resources Act, Health & Safety Code, Sec. 39000	Air

Table 6-4

Regional and Local Licenses, Permit and Approvals

Agency	Authorization	Code or Statute	Environmental Concern
Regional and Local Planning Organizations	Review	Govt. Code, Sec. 65000 et seq.	Air, Water, Transportation
Regional Water Quality Control Board	Industrial Waste Discharges permit (NPDES)	Porter-Cologne Water Act, Sec. 13000 et seq., as amended	Water
South Coast Air Quality Management District	Authority to construct Permit to operate	Mulford-Carrel Air Resources Act, Lewis Act Formed AQMD Health & Safety Code Sec. 39000	Air
		State Implementation Act & AQMD Rules	Public Safety
County Flood Control District	Crossing Permits Crossing Easements Discharge Permit	Cobley-Alquist Flood Plain Management Act, Water Code, Sec. 8400 et seq.	Water
Sanitation District-County Department of Health	Sanitation Approval	County Ordinances	Public Health
County Department of Health	Well Permit	County Ordinances	Water
County Water Pollution Department	Waste Discharge Review	Porter-Cologne Water Quality Control Act, Water Code Sec. 13000 et seq.	Water

Table 6-4, (Continued)

Agency	Authorization	Code or Statute	Environmental Concern
County Department of Building & Safety	Grading Permit Building Permits	State Bldg. Standards Law, Health & Safety, Sec. 18900 et seq.	Public Health
County Planning Commission	Zoning/General Plan compliance	Govt. Code, Zoning Regulations Provisions, Sec. 65850, et seq.	Land
	Conditional Use Permits Variances, zone changes		
	Preliminary Environ-mental Assessment questionnaire	Calif. Environmental Quality Act, Public Resources Code, Sec. 21000	
County Board of Supervisors	Zone changes & appeals	Govt. Code, Sec. 55300 et seq.	Land
Court of Appeals	Appeals	No specified Code	Land
County Fire Department	Fire Protection Review & Approval	As applicable	Public Safety
County Road Department	Overload approvals construction permit Excavation permit	Streets & Highways Code, City Streets Provisions, Sec. 1800	Transportation
County	Easemant Franchise for pipelines & transmission lines	Franchise Act of 1937 Public Utilities Code, Sec. 6201 et seq.	Land, transmission
	Position Statement	CPUC General Order 131	

ecological community and while a slight disturbance might enhance colonization of opportunistic vegetation, most studies have shown a negative response to construction (6.5).

6.3 Potential Away-from-Site Problems

6.3.1 Aesthetics

Once the heliostats are installed, the reflective surface will be visible from great distances. For the many people who visit the desert area to enjoy the scenery, the facility may be either an interesting curiosity or a visual eyesore. The plant cannot be easily concealed because of the size of the field, the high reflectivity of the mirror surfaces and the height of the receiver tower.

6.3.2 Transmission Line Corridors

Additional strips of land will need to be cleared for the construction of transmission lines, roadways, and other support structures for the plant. This will amplify water and wind erosion, and the re-vegetation problems. The transmission lines may also become attractive nuisances to birds while transmission line service roads will provide ready access to remote locations by recreational vehicle. The controlled use of service roads by the public is currently under study by BLM but will require agreement by the utility owners.

6.3.3 Recreational Activities

The area attracts recreationists to the desert area as well as to the water activity areas of the Colorado River. Accompanying the anticipated growth of the area will be a rise in the recreation industry. Principal activities of the recreationists include rock-hounding and exploring the region in desert vehicles. In the past, there have been a few illegal point-to-point motorcycle races. These uncontrolled activities may impact the field of heliostats by generating fugitive dust which would reduce heliostat reflectivity and increase the frequency of mirror cleaning (see Chapter 4 section 4.4). The solar-hybrid installation may become a significant attraction for off-road visitors. Vast amounts of land surrounding the site may thus be impacted by sightseers.

Hunting and target practice are also common recreational activities in the desert and the heliostat field may be subject to both intentional and unintentional damage from firearms.

6.3.4 Exclusion Areas

The problems discussed above reinforce the need for either an exclusion area, or an area of closely controlled access. The size of the exclusion area required is difficult to determine because of the open terrain. Fugitive dust as well as bullets travels great distances.

A one-mile exclusion area around the plant site, or 13 square kilometers (5 mi^2), would increase the plant's total land requirements to 41 square kilometers (16 mi^2). A two-mile exclusion area would increase the land requirement to 84 square kilometers (33 mi^2). An exclusion area wider than two miles was not considered feasible because of the large land requirement, but an exclusion area is considered necessary for the effective operation and safety of a coal/solar hybrid power plant.

Whether the exclusion area would be enclosed with a material such as cyclone fencing or alternatively posted and patrolled is uncertain. Fencing would not allow larger predators inside the exclusion area and would protect vegetation and small animals (e.g., rodents and reptiles) from some predators and off-road vehicles. An exclusion area would be minimally disturbed by construction and operation so a natural habitat should remain and might be useful as a wildlife refuge. The impact of the large reflective heliostat array on local wildlife behavior, however, is not known.

6.4 References

6.1 U.S. Dept. Interior, Bureau of Land Management. "The California Desert Conservation Area: Final Environmental Impact Statement and Proposed Plan." (September 1980).

6.2 Flint, B. U.S. Department of Interior, Bureau of Land Management. California Desert Plan Program. Personal communication.

6.3 Vaughn, F. San Diego Gas and Electric, Public Relations. Personal communication.

6.4 Riverside County Acreage and Crop Report, Palo Verde Valley District. Riverside County Agricultural Commission.

6.5 Lathrop, E.W. and E.F. Archbold. "Plant response to Los Angeles Aqueduct construction in the Mojave Desert". Environmental Management 4(2):137-148 (1980).

7.0 BIOLOGY

The Southern California Desert is the home for a wide variety of animal species, and the Blythe site is no exception. Much of the ecological data presented in this report are based on the Sundesert environmental assesment documents. The greatest variety and concentrations of small mammals (Merriam's kangaroo rat, the desert kangaroo rat, the desert pocket mouse) may be found in the arroyos. These small mammals avoid the intense desert heat by going underground and/or becoming nocturnal. This incidentally contributes to the illusion that the desert is a wasteland. This subgroup is a portion of the 53 species of mammals identified as having ranges that encompass or potentially encompass the Blythe site (7.1). During the Sundesert inventory, reptiles were found to be an important sector of the fauna (17 species of snakes and 14 species of lizards). Also included in the inventory were 6 amphibian species (4 species of toads). Birds are also present. The listed rare, threatened, and/or endangered species having ranges that encompass the area include the California Brown Pelican (Pelecanus occidentalis californicus), Southern Bald Eagle (Haliaeetus l. leucocephalus), Peregrine Falcon (Falco peregrinus anatus), California Black Rail (Laterallus jamaicensis coturniculus), Yuma Clapper Rail (Rallus longirostris yumanensis), and the California Yellow-billed Cuckoo (Coccyzus americanus occidentalis), (7.2). No species of significant commercial or recreational value have been identified at the site.

7.1 Threatened or Endangered Species

Two avian species (California Black Rail and California Yellow Billed Cuckoo - listed as rare by the State of California; and the Yuma Clapper - listed as endangered by both U.S. Department of Interior and State of California, have been seen on the site. It is unlikely that any of the three species will breed or settle exclusively in the area and therefore the status of these species would not be significantly impacted by the proposed facility. The other three species (California Brown Pelican, Southern Bald Eagle, Peregrine Falcon) are winter visitants.

It is reasonable also to expect some endangered plant species may occur at the proposed site. This possibility represents a significant uncertainty which this study does not address. For our purposes it was assumed that endangered plant species do not represent a significant constraint to siting.

Another major uncertainty is our imperfect knowledge of the total resource required to support any particular endangered species. Thus a predatory bird such as the Peregrine Falcon may require several square miles of foraging range in the desert where animal populations are diffuse, while the survival of an endangered plant species may depend upon a water supply derived from rainfall in mountains many miles away.

This concern is further amplified by uncertainties as to the structure and function of desert ecosystems. The numbers of species present in the desert is low and consequently the food-webs somewhat simplified compared to more mesic ecosystems. Even so, it seems unlikely that one particular species is critical to both the structure and function of the desert ecology. Not all ecologists agree, however. An opposing interpretation is that in arid lands "food-webs" are simplified to the point of being considered "food-chains" in which every link is critical. If this view is correct, every species present is likely to be equally important to the integrity of the system. "Disruption of the plant community will cause a shift in species dominance which requires an extremely long period for ecosystem recovery - fromo decades to centuries. The clear, warm, dry climate of the Southwest makes the deserts fragile and slows down any biotic recovery following disturbance." (7.3). This argument suggests that it is not necessary that a project (solar/coal hybrid plant) equally effect all species present. Only one or a few species need be significantly effected to result in alteration of the entire ecology of the area.

The spirit of the Endangered Species Act includes not only protection of rare and endangered species but also prevention of those actions which result in new species being added to the list. The removal of large tracts of land, such as are required for large solar energy installations, increase the probability that species not now considered endangered will eventually become so.

7.2 Potential Biological Effects of Facility Construction

The dominant vegetative cover type within the plant site boundary is the creosote bush, growing along the mesa (Figure 3-2). Specific to the northeastern border are orache and creosote bush in the low arroyo, and creosote bush and honey mesquite in the valley. Patches of barren mesa and mountain areas may be found in the central, northern, and eastern areas. Barren mesa and mountains form an impressive border to the west of the site. Strips of Palo Verde ironwood growing in the arroyos traverse the plant site in an east to west formation. There is also a patch of creosote bush and burro bush along the mesa, slightly off-centered to the southeast. Similar vegetation cover may be found to the north and south of the site to accommodate displaced animals.

During the construction phase, there will be removal of vegetation, excavation, earth moving, vehicular traffic, and increased human activity. The major impacts associated with such activities are habitat loss and soil erosion. The large amount (5 mi^2) of vegetation (habitat) removal and/or alteration may affect species distribution and abundance, patterns of migration, nesting, and feeding habits (loss of temporary and/or permanent refuges). The small mammals exhibit a high reproductive rate and extraordinary abilities to rapidly recolonize uninhabited areas so a prolonged population decline is not expected. The reproductive capacities of animal populations are able to withstand losses of a few individuals without drastic changes in overall population numbers. However, if losses exceed reproductive capabilities, shifts in the community structure may occur. It is not certain however, how noise from the construction will affect these animals or any of the other species. Of more immediate concern is the actual killing of the ground-burrowing animals so common in the desert environment. It is likely to be impossible to remove all the ground animals prior to breaking up the land and to also keep them away during construction.

A significant amount of fugitive dust generation is expected, especially during the construction stages (see chapter 4). It is likely that fugitive dust impacts would continue even after the construction phase is over. This activity may trigger abnormal wind erosion and thereby result in off-site degradation of vegetation (habitat) making those areas partially unacceptable to animals. Precipitation runoff may even carry the sediment to the Colorado River and subsequent silting may alter the aquatic environment.

Because of their mobility, most of the species will generally move to surrounding areas, thereby causing displacement problems. The sudden and overwhelming flow of different species onto adjacent land areas may cause increased population stresses (reduction or loss in total available habitat, destruction or modifications of food webs, and changes in populations). Aggravating this condition may be increased compaction of the soil and overgrazing of the thriving vegetation resulting from the concentration of feeding activities.

7.3 Potential Biological Effects and Facility Operation

Once completed, the solar/coal hybrid plant will be a permanent resident of the desert for at least 30 years (expected operating life of the plant). The amount of land area designated for the proposed plant is small relative to the available land in the desert. The apparent uniformity of the ecology and the absence of large concentrations of animal pollutions lessens the impact to wildlife. Because the Sundesert assessment was done several years ago and focused on a smaller site area, more current data should be collected regarding the presence of rare, threatened, and/or endangered plant and animal species at the proposed site before solar development is undertaken.

An exclusion area (if needed) would increase the amount of total land required but should represent a relatively undisturbed environment which could serve as a wildlife reserve. Feral burros have been observed to move from the mountains to the agricultural areas in the evening to feed and then return to the mountains again (their daytime resting area). Therefore, the facility may disrupt their movement permanently and force the use of new routes. Feral burrows are viewed by some as undesirable because of their impact on natural ecosystems. The consequence of rerouting their foraging pattern is a likely increase in their impact at other desert locations.

Although destruction of vegetation is expected during construction, a more mesic environment will be provided during operation within the heliostat array through shading, wind deflection, and possibly infiltration of heliostat washwater. These should combine to aid the re-vegetation process. Plants more tolerant to shade may replace former vegetation types. If food sources are available, animals displaced by construction are expected to re-populate, except those large enough to be excluded by the fencing.

If wet cooling towers are used, vegetation on and near the site could be impacted by salt deposition from cooling tower drift. This study did not evaluate this impact in detail but salt damage from drift to vegetation has been documented (7.4). Because many desert plants are somewhat salt-tolerant, this impact may not be significant.

It is not known what kind of biological effect the mirror field per se will have on birds and nearby wildlife. The field of mirrors may function as an attractant or, on the other hand, birds may avoid the vicinity. Beneath the canopy of heliostats is a very cool environment that may become a favorite place for birds and small animals. The heliostat support structures may provide a suitable nesting place for both birds and insects, creating additional heliostat cleaning problems. The central receiver tower may also become an attractive nuisance. It is not anticipated that emissions from the coal portion of the hybrid plant will affect any animal species.

A stand-by cooling water strategy provides for intake water directly from the Colorado River in emergencies or when regular agricultural runoff is not available. Impingement of fish on water intake screens, and entrainment of larvae in the condenser cooling water, therefore, is not expected to be significant.

7.4 References

7.1 San Diego Gas and Electric Company. "Environmental Report Construction Permit Stage," Volume 1. August 1977.

7.2 San Diego Gas and Electric Company. "Environmental Report Construction Permit Stage," Volume 2. August 1977.

7.3 Patten, D.C. "Solar Energy Conversion: An Analysis of Impacts on Desert Ecosystems," Final Report. Arizona State University, Tempe. 1978, p.1.

7.4 Power Plant Siting Program, Maryland Department of Natural Resources and Water Resources Research Center, University of Maryland. "A Symposium on Environmental Effects of Cooling Tower Emissions," WRCC Special Report No. 9, 1979.

8.0 SOCIOECONOMIC CONSIDERATIONS

The Desert Valley Impact Comittee, Inc. did an extensive socioeconomic analysis of the Sundesert Nuclear facility, and pertinent information appearing in that document has been adopted in this report (8.1).

Many of the socioeconomic impacts resulting from the construction and operation of the proposed project are due to the sudden large influx of people into the area. It is very difficult to ascertain the manpower requirements (construction, operation, indirect) of the coal/solar hybrid power plant. To simplify the task, we can first examine the labor figures expected for the 430 MWe coal portion of the hybrid plant. During the period of peak demand, the coal plant project may require 626 workers, of which 209 will be new residents (8.2). The combined population of Blythe and Palo Verde is about 7,550 people. The result would be a 3% increase in the population of the two towns. The solar portion of the hybrid plant would probably attract at least that same number of employees. Therefore, a 6 percent increase in the town populations resulting from the hybrid plant is a reasonable minimum estimate. In all likelihood, the percentage increase would be higher because family members (spouse and children) have not been included in the estimates. Simply assuming all workers are married with no children increases the estimate to 12%. Surveys have shown that 5% is generally as much growth a small community can comfortably absorb (8.3). Activities relating to construction of the proposed coal/solar hybrid plant should exceed that limit. It is reasonable to assume that some strain will be placed upon the existing services and utilities serving the townships during a five year construction period. Only 150 workers are anticipated to be required for normal plant operations.

8.1 Demography

Data collected by the Census Bureau show three major trends affecting cities today: (1) a movement of the population out of the central cities and into the suburbs or exurbs, (2) fastest growth in non-metropolitan areas (farm areas) and (3) movement of large numbers of people from the northeastern and north-central regions of the country to the south-west and western regions (8.4). The Blythe area in itself is an attractive recreational area. In addition, the large solar hybrid investment will surely be protected from floods, and flood protection structures may function to promote more rapid floodplain development. It is conceivable that the town of Palo Verde (3-4 miles ESE of the site, population 216) and Blythe (16 miles NE of the site, 1979 population 7,250) may experience substantial growth.

During construction it is not unusual for the population of small remote towns to double within a span of 3-5 years (8.5, 8.6). The solar/coal hybrid plant will create new job opportunities for the residents already living in the region as well as the newcomers to the area. Both the construction and operation phases will require specially trained personnel which would have to be brought to the site. It is not known what percentage of the work force could be filled by the local residents. A great number of the farms are taking advantage of mechanization and many area residents (farm laborers) might welcome new employment opportunities. Although this growth would add vitality to the regional economy, it could also produce a strain on the public services provided by the towns. Table 8-1 lists a few of the facilities now existing in Blythe. It is obvious that an increase in the number of available services will be necessary to accommodate the increase in population. As a consequence, more land must be dedicated to urban development in the way of housing, schools, wastewater treatment and other municipal services, recreation, and to some of the facilities listed in Table 8-1.

Table 8-1

Community Facilities, Blythe, California

Markets	5
Electrical Stores	2
Department Stores	8
Hardware Stores (applicances, lumber)	3
Motels	11
Restaurants	12
Mobile Parks	5
Banks	4
General Hospital	1

Reference: Herlis Denton
State Employment Development Department
Blythe, California

8.2 Business and Tourism

The city of Blythe does not boast a very strong economy. The civilian labor force unemployment rate for male and female were 2.3% and 3.3% respectively during 1979. Although most of the residents were employed, 9.6% of all families had income less than the poverty level (8.7). It therefore appears that most of the materials, equipment and labor force will have to be imported for this project. Even on a regional basis, the area would have difficulty supplying even "common" services during the 5 year construction period.

The operating personnel for the plant (150 plus families) may comprise a more permanent population and together with the anticipated long term growth of the valley stimulate new businesses. It is important that undesirable project planners work closely with the local businessmen to mitigate impacts.

Tourism is a principal industry, but somewhat seasonal, and it should not be jeopardized by activities pertaining to this project. Precautions should be taken to prevent construction worker and tourist housing requirements from coming into conflict. The motel/restaurant industry functioning primarily as a tourist facility, should not be allowed to become over-crowded by the plant workers. The mobile parks frequently visited by vacationers in their recreation vehicles must not be displaced from those parks. There will be instances when the dormant tourist industry would welcome such business. However, a "space crisis" may develop during the peak visitor season.

Accompanying the growth of the area a rise in the recreation industry may occur. This industry may in turn magnify the effect of the coal/solar plant, through demand for more leisure home development. Principal activities of the recreationists include rock-hounding and exploring the region in off-road vehicles, water sports on the Colorado River, and hunting and fishing.

8.3 Education and Employment

It is not certain what job classifications created may be filled by the local residents. Uncertainties also exist as to the attractiveness of the "new" jobs to the already employed townspeople. Manpower requirements and local availability must be carefully studied to resolve the employment problems. Non-manual jobs (clerical and maintenance) could be filled almost entirely from the Valley's labor market. However, the people's willingness to do so is not known. There may be a shift of the farm workers to the plant because of higher wages and the increasing trend of farm mechanization. As a result, the demand for farm workers may rise and be met by immigrants from Mexico followed by development of a stable Mexican community. Preferential hiring of Palo Verde Valley residents for specific manual jobs may be hindered because of laws, regulations and labor contracts which give preference to current union members. The unorthodox nature of the proposed plant may generate complex union jurisdiction issues and involvement not previously discusses (new occupational specialties may evolve). Should a shortage of trained personnel occur, training of interested local residents should be encouraged. The local work force resides a convenient distance from the plant site in the neighboring towns (Palo Verde, population less than 300 is 3 miles away; the city of Blythe, population 7,250 is 16 miles away). Adequate plans must be developed to ease the potential traffic congestion from plant personnel, coal deliveries, and agricultural transportation.

If the incoming group of construction and operational plant personnel is comprised of primarily single workers, the impact on the educational facilities (elementary, junior high, and high school) may be low. On the other hand, if a large number of workers with families are recruited, additional office space, portable class rooms and teachers will have to be acquired.

The Palo Verde Community College may take an active role in the training programs for the local residents interested in the new jobs at the plant. Specialties having a shortage of union workers could gain support of apprenticeship programs administered by the appropriate union.

8.4 Housing and Utilities

At present, there is a shortage of all types of permanent housing in the valley. The vacancy rate is about 1% and the local motels report an average occupancy rate of 95%. Additional housing will require the counties to process zone changes (conversion of adjacent farmland to residential use) to allow for orderly community growth. Even if the land areas do become available, an investigation will be needed to determine if there is adequate local financing to support the housing developments.

It is assumed that the jobs offered at the new plant will pay higher wages than that presently earned by many of the local residents. The shortage of housing will cause prices to rise unless some control is placed on it. Persons on low wages may not be able to afford these higher prices for housing. A substantial amount of low income housing and/or rental subsidization may be necessary. Considering the five year construction plan, a population of 1,000 to 1,500 workers and families may be the maximum present during any given phase.

A possible solution to the housing problem may be an expansion of mobile home parks. This could benefit both the project personnel and the tourist industry. While this may relieve the shortage, there is an inherent money problem associated with it. Recreational mobile homes are taxed as vehicles and not real property and therefore the income received does not pay the full cost of providing adequate public services. This shortfall is usually offset by a parking/utility fee.

Another alternative would be to have the developer provide temporary housing for about 1,000 workers at the site. In addition to housing, some recreation and cafeteria style dining should also be considered. The location of the temporary housing should be such as to permit easy conversion into other valuable community uses following plant construction.

Presently natural gas, electric, and telephone services in the Palo Verde Valley are provided by Southern California Gas Company, Southern California Edison, and the Continental Telephone Company, respectively. If the new housing projects occur in areas where facilities exist, the impact to service should not be severe. In a rural and undeveloped area such as Palo Verde or Blythe, additional lead time may be required for the utilities to satisfactorily meet the demand for service by developers. Depending upon the expenses to the utilities, the builder may need to advance money for the extensions to the new developments. If a temporary housing scenario is adopted, the sponsor probably will be required to advance a non-refundable fee covering the cost of installation and removal of the service. Given adequate lead times together with construction dates and the required dates for service, the utilities should be able to meet these impacts.

8.5 Local Services

The Blythe Airport, owned by the Riverside County Department of Airports, has recently been improved with additions for airplane parking as well as more lighting. Therefore, the facility should accommodate increases in traffic by private or commercial airplanes. However, if there is a considerable increase in air traffic, additional emergency ground support may be needed.

The city of Blythe has a number of lighted baseball fields with additional fields near the Colorado River. There is already overcrowding of these county park facilities. Along the Colorado River, there are only a few beach areas, access points and boat ramps. Additional accesses to the River as well as other types of recreational facilities may have to be increased but might be paid for by the plant developer. At the present time, there are adult recreation programs, dance instruction, Christmas crafts, and other special events. Youth activities are primarily limited to Boy Scouts and church organizatons. An expansion of the various recreational programs may be useful but may not match the recreational interests of the transient work force. Simple enlargement of existing facilities may not ease the over-crowding problems. It may be better to develop new areas to lessen congestion. The City of Blythe police force would need additional staff and equipment.

Parallel to the development of new recreational facilities is the improvement of roads and highways (widening or extension). Already existing structures and locales may need better or more access roads. More lighting may be needed for highways. An increase of traffic at certain intersections may require installation of traffic lights to ease congestion. There may also be instances when project traffic conflicts with agricultural traffic especially during peak harvest seasons.

If the population were to increase by 5,000-7,000, which may be possible if the plant were actually built, it is probable that from 5-7 additional physicians will be needed (average of one physician per 1,000 population). In addition, usually from 4-6 hospital beds are recommended per 1,000 people therefore, 25-35 beds would be needed at the hospital. Also during certain construction phases, it may be necessary to have additional emergency services. There may also be a need for crisis, alcohol, drug, and emergency services which are not presently essential.

8.6 Taxes

Of primary concern is money to finance the socioeconomic impact mitigation program. Income generated from all taxable sales amounted to $54,300 in 1979 (8.9). This is not a substantial income and even with an increase in anticipated sales is not likely to be an adequate source of funds to pay for the expenses of development.

8.7 References

8.1 Desert Valley Impact Committee, Inc. "Socioeconomic Impacts on the Palo Verde Valley of the Proposed Sundesert Nuclear Plant - an Interim Report." (June 29, 1978).

8.2 Environmental Science and Engineering/Institute of Geophysics and Planetary Physics. "Study of Alternative Locations of Coal-Fired Electric Generating Plants to Supply Energy from Western Coal to the Department of Water Resources." University of California, Los Angeles, p. 83 (February 10, 1976).

8.3 Gilmore, J.S. and M.K. Duff. "Boom Town Growth Management: A Case Study of Rock Springs - Green River, Wyoming." Westview Press, Inc. p. 2 (1975).

8.4 Sternlieb, G. and J.W. Hughes. "The Changing Demography of the Central City". Scientific American. 243(2):48-53 , (1980).

8.5 Champion, D. and A. Ford. "Boom-town Effects". Environment 22(5):25-31, (1980).

8.6 Cortese, C.F. and B. Jones. "The Sociological Analysis of Boom Towns". In Boom Towns and Human Services. J.A. Davenport and J. Davenport III, (eds.) University of Wyoming, Department of Social Work. Laramie, Wyoming, pp.4-18, (1979).

8.7 United States Bureau of the Census. "Census of Population 1970." General Social and Economic Characteristics - California. p. 6-1012.

8.8 U.S. Department of the Interior, Bureau of Land Management. "Proposal to BLM to Facilitate the Planning Process for the Proposed Cadiz Race, Revision 1." (1979).

8.9 Riverside County Department of Development. "Community Economic Profile for Blythe Riverside County, California". (January, 1980).

9.0 OCCUPATIONAL AND PUBLIC HEALTH AND SAFETY

9.1 Occupational Health and Safety On-Site

The coal fired portion of the hybrid plant presents occupational hazards generic to any coal fired power plant in operation today. The combustion of coal can produce air pollutants that are harmful to health (9.1). Both sulfur dioxide and nitrogen oxides are known respiratory irritants. The combustion of coal also generates trace elements such as mercury, lead, cadmium, selenium, nickel, arsenic, and such organic compounds as benzo(a) pyrene, which can be poisonous or carcinogenic. Although these combustion emissions are potentially hazardous, their emission will be controlled to comply with stringent air quality standards and should therefore pose no greater threat than emissions from conventional coal plants. One benefit derived from the solar-coal hybrid design is the ability to reduce the amount of coal burned and thereby reduce emissions and solid wastes. The annual frequency of occupational injuries and accidental deaths associated with coal combustion energy systems per 1,000 MWe power plant is 1.2 and 0.01, respectively (9.2). Using these figures, an estimate of the worker injuries and accident deaths for the 430 MWe hybrid plant would be 0.5 and 0.004, respectively. These figures indicate a low risk of worker accidents related to electric power production from combustion of coal.

With regard to the solar portion of the proposed plant, the principal hazards arise from heat transfer and storage fluids. Sodium is proposed for both heat transfer and storage purposes. Sodium burns in air at ambient temperature, hydrolyzes on contact with moisture in air or flesh and has an explosive potential. During loading and unloading (handling), accidental releases may cause burns and fires. Leaks of the piping system carrying the sodium could also result in burns and fires.

There are presently no solar thermal central receiver systems in commercial use. Therefore, unlike coal-fired power plants, historical data on worker health and safety in solar thermal plants is not available. Estimates can be made indirectly by determining the probability of system component failure and the assumed hazards involved in repairing the failure. As many as 0.4 leaks per year per kilometer of piping may be expected in a single (100 MWe) solar thermal central receiver system (Table 9-1). For the proposed 430 MWe plant rated at 0.9 availability, about 3 leaks per year per kilometer of piping may occur. Collection of the fluid from undetected leaks over time can increase fire and other hazards in some cases. Although the number of leaks expected is large, a significant number of major accidents or injuries is not expected. Using a selection of 105 Standard Industrial Classifications (SIC) with worker functions similar to those anticipated in a solar thermal power system, a range from 25 injuries per 100 worker-years to about 5 injuries per 100 worker-years was derived (9.3). Some low to intermediate value of 6-10 injuries per 100 worker-years may be a reasonable estimate for the proposed hybrid coal/solar plant. Of primary concern within the routine hazards are the events which would necessitate disassembly of components containing the coolant, sodium.

Table 9-1

Leak Rates in 100 MWEe Central Tower Systems
Single Tower

Component	Number	Leaks Per Year*
Valves	88	0.003
Connectors	240	0.03
Welds	15,400	0.2
Piping (km)	108	0.4
Pressure Vessels	41	0.04

*1 year = 3500 hours at 0.4 availability

Reference: Worker Health and Safety in Solar Thermal Power System - IV. Routine Failure Hazards, A.Z. Ullman et al, UC 12/1214, October p.67, (October 1979).

There are many safety features built into the plant to monitor the sodium. The plant will be equipped with closed-loop television and sodium-sensitive aerosol detectors to detect leaks. In addition, catch pans placed under major components will confine leaked sodium to a local controlled drainage area. As a backup, nitrogen gas will flood the catch pans in the event of sodium combustion. As a precautionary measure, approved fire suppressant extinguishers will be placed in easily accessible areas. An appropriate repair strategy to cope with routine maintenance would be to have a specialized operation and maintenance crew to exclusively attend to the solar portion of the hybrid plant. Other problems associated with sodium release may be encountered during mismatches in energy flows (interruption of coolant flow, or a loss of an energy sink in the coolant loop). In case of these emergencies, the safety design of the plant will re-direct the heliostat off the receiver (boiler) in less than 15 seconds to prevent overheating. In the event of a turbine rupture, missile generation and injuries such as burns and blinding may be a problem, but these hazards are common to other power systems as well. An even more complicated chain of reactions is triggered by a steam generator rupture. The event shares the problems already mentioned for the turbine rupture, and in addition includes the potential of starting sodium fires which could cause more burns. These potential failures are expected to be mitigated in the final design and operating procedures of the commercial plant. Ullman et al (9.3) concluded that despite the complexity of solar thermal systems, accident rates should be in the lower 10 percentile compared to accident rates in industries with similar worker assignments.

Another component of the solar unit that may create potential problems is the heliostat. Hazards range from temporary blinding, to increased incidence of skin cancer, to lacerations from broken mirrors. Of great concern is the misdirection of heliostats caused by electronic failure or an inadvertant control room order (one way signal, no acknowledgement). Experience at the 5MWt test facility at Sandia Laboratories, Albuquerque indicates that these kinds of potential problems are easily avoided by intelligent operation and maintenance procedures.

Common to any work area there are given worker hazards such as falls, transportation, electric shock, fires, etc. There is also the possibility of a catastrophic event such as an aircraft running into the 300 M (1083 ft) tower, or a flood, or an earthquake. In our judgement, however, occupational hazards in the proposed solar-coal hybrid facility may be somewhat different than in a conventional power plant but no greater.

9.2 Public Health and Safety

Potential hazards to the general public include injuries that could result from transportation of coal and materials to and from the facility, possible effects from coal-burning emissions, escape of sodium from the facility boundaries, and the nuisance of glare from the heliostat field.

The remoteness of the site located in an area of good air quality suggests that the primary problem may be associated with the glare from the heliostat field and/or receiver. This is not viewed as a direct hazard. However, depending on the visibility of the plant from highways it may distract drivers and contribute to traffic accidents.

Barring a catastrophic event such as an aircraft colliding with the tower, or rupture of the sodium-cooled receiver, sodium is not likely to escape from the facility. If an exclusion area is enforced around the periphery of the site, the risk of public exposure to sodium is even more remote.

We would anticipate that coal would be delivered by rail. Since a new railroad spur would be required it should be located to avoid populated areas and construction of underpasses or overpasses should reduce automobile/train incidents.

9.3 References

9.1 Ferris Jr., B.G. "Health effects of exposure to low levels of regulated air pollutants: a critical review". Air Pollution Control Association Journal 28:428-497 (1978).

9.2 National Research Council. "Implications of Environmental Regulations for Energy Production and Consumption," Vol. VI, Washington, D.C. p.31 (1977).

9.3 Ullman, A.Z. et al. "Worker Health and Safety in Solar Thermal Power Systems. II. Data Base and Methodology for the Estimation of Worker Injury Rates." Laboratory of Nuclear Medicine and Radiation Biology, UCLA, UC 12/1212, (1979).

10.0 SUMMARY OF ENVIRONMENTAL IMPACTS

A conceptual design of a Solar Control Receiver-Coal Hybrid Power System, developed by Rockwell International (10.1), was used as a "strawman" to search for environmental constraints to siting such a facility in the southwest. For purposes of this study an "approved" power plant site was chosen near Blythe, California, located in the eastern Mojave Desert near the Colorado River. The Environmental Reports prepared for the proposed Sundesert Nuclear Plant (10.2) are specific to this site and were used extensively for site characterization.

Environmental impacts were considered in a somewhat broader context than normal. Thus, Tables 10-1, 10-2, and 10-3 identify impacts of the plant on the environment, impacts of the environment on the plant, and intra-plant impacts (impacts of one plant subsystem on another subsystem). Impact categories evaluated include air quality, water use, water quality, hydrology, geology, occupational health and safety, public health, meteorology, socioeconomics, vegetation and wildlife, aesthetics, solid waste disposal, and seismicity. Time did not allow equal evaluation of all impact categories. Some concerns which are considered important and necessary for a complete environmental assessment were not addressed. For example, noise, energy efficiency (waste heat use), transmission corridors, transportation corridors, traffic, legal and institutional factors (sun rights and restricted access), economics, materials requirements and manufacturing and facility air emissions impacts on the environment.

10.1 Environmental Impacts--Facility on Environment

10.1.1 Land Use

Availability of land at the Blythe site does not appear to be a problem for the construction of the proposed hybrid plant. However, changes in zoning will be required. Disturbance of the land area for construction is certain (grading and clearing) and the effects on the assimilation and percolation of water are only speculative. The extent of alteration of the present desert region is largely unknown. An increase on the human population is anticipated but the impact on land use remains uncertain. Nearby lands to the east support a very intensive agriculture. Property value increases could either force farmers to sell land because of increased property taxes, or entice farmers to sell for profit. More open space would be used for urban development as the demand for public services and housing in the area increases. The impact of building the plant on local land uses is uncertain, but as a minimum urban development would increase primarily to accommodate workers during the five year construction phase.

The major land use impact from a solar plant is the large land requirement (five square miles for a 430 MWe plant without an exclusion area) compared to other types of power plants (Sundesert required one square mile for two 950 MWe nuclear plants). An exclusion area would significantly increase the land area required by a solar facility, but the exclusion area could serve a secondary use as a wildlife reserve. The land area requirement

Table 10-1

Environmental Impacts of a Solar-Coal Hybrid Power Plant
Sited in the Blythe-Palo Verde Area

Type of Impact	Source of Impact	Significant	Unique to Solar-Thermal
AIR QUALITY			
• Facility Emissions	0	NA	
• Fugitive Dust	C	X	X[1]
METEOROLOGY			
• Climate Modification			X
Cooling Tower	0		
Heliostat Field	0		
LAND USE			
• Area required	C+0	X	
• Zoning changes	I	X	
• Exclusion of alternate uses	0	X	X[2]
• Solid waste disposal	0+I		
GEOLOGY			
• Grading and Construction	C	X	X[1]
WATER QUALITY	C+0	X[3]	
HYDROLOGY			X[1]
• Surface Water Runoff	C+0	X	
• Erosion	C+0	X	
• Lower Water Table	C+0	X[3]	
VEGETATION AND WILDLIFE			X[1]
• Endangered Species	C+0		
• Species Diversity and Abundance	C+0	X	
• Habitat Destruction	C	X	
• Death and Displacement	C	C	
• Migration Barrier	C+0	X	
• Facility Emissions	0	NA	
• Fugitive Dust	C	X	
• Cooling Water Intake	0		

Table 10-1, (Continued)

Type of Impact	Source of Impact	Significant	Unique Solar-Thermal
HEALTH AND SAFETY	C+O		X[4]
SOCIOECONOMICS			
• Public Services	C	X	
• Housing	C	X	
• Transportation	C	X	
• Commercial facilities	C	X	
• Recreation	C	X	
LEGAL-INSTITUTIONAL CONSTRAINTS	C+O	NA	X[5]
AESTHETICS	C+O	X	X[1]
NOISE	C	NA	
TRANSPORTATION CORRIDORS	C+O	NA	
TRANSMISSION LINE CORRIDORS	C+O	NA	
TRAFFIC	C+O	NA	
ECONOMICS	I	NA	
MATERIALS REQUIREMENTS AND MANUFACTURING	I	NA	
ENERGY ANALYSIS	I	NA	

C - Construction
O - Operations
I - Institutional
NA - Not Assessed

X[1] - Function of solar large land requirement
X[2] - Assumes nearby activity would compromise heliostats
X[3] - If groundwater used
X[4] - Injuries from heliostats or working fluids
X[5] - Sun rights

Table 10-2

Environmental Impacts of the Blythe-Palo Verde Site on a Solar-Coal Hybrid Power Plant

Type of Impact	Source of Impact	Significant	Unique to Solar-Thermal
AIR QUALITY			
• Phytogenic Emissions	0	X[1]	X
• Crop Dusting	0	NA	X
• Fugitive Dust	0	X[1]	X[2]
WATER QUALITY AND SUPPLY			
• Treatment Requirements	C+0	X	
• Availability	C+0		
SEISMICITY			
• Earthquake Safety	0		

Table 10-3

Air Quality Impacts Arising from Interaction of Subsystems In a Solar-Coal Hybrid Power Plant

Type of Impact	Source of Impact	Significant	Unique to Solar-Thermal
FACILITY EMISSIONS			
• Coal Particulate Deposition	0	X[1]	X
• Cooling Power Particulate Deposition	0	X[1]	X
• Plume Attenuation of Insolation	0	X	X
FUGITIVE DUST	0		X

C - Construction
0 - Operations
NA - Not Assessed

X[1] - Function of impaired heliostat efficiency (unknown)
X[2] - Function of solar large land requirement

for a solar plant is considered a significant impact unique to a solar facility. The construction of this plant would exclude or constrain other land uses as well as limit present uses of open space. However, this impact is not considered disqualifying for the chosen site because of the large amount of similar open desert in the region.

10.1.2 Hydrology

Construction of the plant would alter surface water runoff patterns over a large area (five square miles), and surface runoff would be significantly increased if the site is paved. Because of this, it is recommended that the heliostat field not be paved. Conceivably the soil surface could be stabilized with vegetation to increase rainwater infiltration, decrease erosion, and reduce fugitive dust emissions. Sediment basins should be constructed to retain eroded sediments and thus reduce discharges of suspended solids to streams and the Colorado River. The alteration of hydrological patterns for such a large area is considered significant and unique to a solar plant.

Sufficient groundwater for the proposed plant is available in the Palo Verde Mesa Basin and the Arroyo Seco Valley Basin, but groundwater pumping in either basin would result in a lowering of the groundwater level. A lowered groundwater table could impact vegetation patterns in the entire basin. The quality of groundwater is such that it would require extensive treatment for plant use. Since the groundwater is subject to the same regulatory constraints as Colorado River water it is recommended that the proposed plant use agricultural runoff from the Palo Verde Outfall Drain as proposed in the Sundesert Environmental Reports. Agricultural runoff would require extensive treatment for plant use. The use of agricultural runoff water would not significantly impact other water needs, but the use of groundwater probably would.

10.1.3 Water Quality

Water quality in the Colorado River would be marginally improved (positive impact) if agricultural runoff water is used for the proposed plant since the water allocated to the project from the Colorado River would remain in the river and contaminated agricultural runoff water would be consumed at the facility. If groundwater is used to supply the plant's total water needs, water would be removed faster than the aquifer could be recharged. This would result in a significant impact--degradation of groundwater quality and therefore the possible exclusion of groundwater supplies for other uses. All liquid wastes (cooling water blowdown, boiler blowdown, heliostat wash water) would be disposed of in the plant's lined evaporation basin. Heliostat wash water, if it does not contain chemicals, could fall on the ground and provide moisture for vegetation. Sanitary wastes would be treated on site.

10.1.4 Occupational Health and Safety, Public Health

Most of the occupational hazards identified for the hybrid coal/solar plant are generic to any coal fired power plant currently in operation.

It is therefore assumed that adequate precautions and safety procedures can be adopted for use at the new plant. Potential problem areas specific to the solar-thermal portion of the plant will be from the coolant (sodium) and the heliostats. Release of sodium through leaks, if immediately recognized and properly repaired, does not appear to be a serious problem. However, if the sodium is not efficiently contained, the explosive potential is a serious threat. Use of an alternate thermal storage fluid such as eutectic salt mixtures rather than sodium could reduce hazards to workers.

Heliostat accidents could result in blinding, burns and lacerations. The geometry of the heliostat array suggests that workers within the array are not likely to be exposed accidentally to more than a single sun intensity. Safety goggles should reduce this potential hazard. Standards and procedures for operation and maintenance should be developed to protect worker health and safety at the time of facility design. An exclusion area would protect the public from plant accidents, but this is not the primary rationale for an exclusion area. The subsystems of the proposed plant that are the same or similar to other power plants would have the same projected injury and death rates. The hybrid solar-coal power plant is not anticipated to have occupational health and safety or public health impacts greater than other power plants. However, any new technology would be expected to experience a few more injuries or accidents until operating experience has been gained.

10.1.5 Meteorology

Impacts from the heliostat field and cooling towers on meteorology were evaluated. The proposed facility may have minor effects on microscale meteorology. Changes such as additional cloud formation if a wet cooling tower is used and the production of dust devils are the most significant local weather modifications anticipated. Such modifications could result in slight intra-plant impacts, such as reduced heliostat efficiency from dust deposition on mirrors and reduced solar insolation from clouds. The facility is not expected to produce climate changes on a regional or global scale. A cooler, more moist environment would probably be created within the heliostat field as compared to the surrounding open desert. More measurements within and near heliostats are needed for confirmation, but a solar plant in the 100 to 1000 MWe range should not significantly impact climate.

10.1.6 Air Quality

It was assumed the plant would meet existing air quality standards. The impact of coal combustion and cooling tower emissions on the local environment was not evaluated. The literature documents salt damage from cooling tower drift to nearby sensitive vegetation (10.3). Many desert plants are somewhat salt tolerant; further research is needed to quantify air emission impacts on organisms. Fugitive dust created by construction and clearing of such a large area of land could significantly impact nearby vegetation (including crops) and create a public nuisance. Under dry desert conditions, fugitive dust problems could continue beyond the construction phase. This possibility also needs further evaluation.

10.1.7 Geology

The large land area requirements unique to solar plants would result in a significant impact to the site terrain. Details concerning design requirements for the heliostat field were not available. The Rockwell report gives only one height specification for the heliostat pedestals, implying the need for a flat field (10.4). We assumed, therefore, that the heliostat field would require grading. Additionally, trenches would need to be dug for the underground control and power cables connecting the heliostats and the central control. Finally, a certain amount of inadvertent soil disturbance would occur during construction due to the movements of heavy equipment and materials, and the grading of temporary service roads.

Grading and leveling of the site would remove vegetation and destroy the "desert pavement and crust." Hydrological patterns would be altered significantly and wind erosion of soils could result in significant impacts to neighboring land uses. It is recommended that as little grading as possible occur on the site.

Grading requirements could be greatly reduced by adopting heliostats with variable pedestal heights, calibrated for different positions on the field. Careful planning and execution might greatly reduce the number of temporary service roads and vehicular and materials movements.

10.1.8 Vegetation and Wildlife

Grading, plant construction, and heliostat installation would essentially remove or disturb all existing vegetation on the site, thus resulting in habitat destruction. Burrowing animals would be crushed during construction. Mobile animals would be displaced and probably would die because surrounding areas could not support them. The facility would act as a migration barrier for animals large enough to be excluded by fences. Large amounts of fugitive dust would be generated by plant construction. The above stated impacts would be significant if any rare, endangered, or threatened species are dependent on the site. However, none have been identified. These impacts would not be significant to other species because the plant area is small compared to the amount of similar habitat in the region. Modification of local climate by the facility should not signficantly impact vegetation and wildlife. Vegetation and small animals and insects would probably repopulate the heliostat field although the species composition may be different from adjacent land because of a cooler and more moist environment. Cooling water intake directly from the Colorado River would only be used in emergencies. Therefore the biological impact of water intake should not be signficant. Impacts on vegetation and wildlife from coal combustion emissions and cooling tower drift were not assessed. If an exclusion area exists, it could function as a refuge for plants and animals.

10.1.9 Aesthetics

The plant would be visible for many miles during daylight hours. Many people visit or live in the desert because it is removed from major development. Reflections from the plant may have a significant visual impact on nearby residents in Palo Verde, visitors, and travelers on local roads. This impact is unique to a solar facility but whether it will represent an attraction or detraction is uncertain.

10.1.10 Solid Waste Disposal

Solid waste generated during construction and operation activities would be disposed of in accordance with State Solid Waste Management Board, State Water Resources Control Board, and other state and federal regulations. Sludge from the plant's sewage treatment system would be discharged to lined evaporation basins. It is likely that a solid waste disposal site will need to be developed, thereby contributing to land requirements.

10.1.11 Socioeconomics

Backed by a moderately weak economy, it is unlikely that the town of Blythe will be able to provide much in the way of support services. This would mean that construction and operation personnel would not enjoy the full privileges of having a community nearby. As a consequence, additional costs may have to be incurred by the sponsor of the project. A "boom town phenomenon" could result from construction of the plant. The willingness of the local residents to find work at the plant is unknown. If a percentage of the work force comprised of the townspeople can be determined, the potential socioeconomic problem areas may be better defined. From that, a strategy for recruiting out-of-community personnel can be devised to lessen the severity of the socioeconomic impacts. Adequate precautions must be taken to protect the much depended upon tourist industry. Inadequate income generated from taxation appears to be a problem confronting economic growth, should growth be desired. Once decided, the choice for economic growth is still dependent on the willingness of financial institutions to make the necessary loans to pay for developments. Good communication between project officials and local town representatives is essential to mitigate the unavoidable socioeconomic impacts.

During construction the workforce would significantly impact public services (schools, sewage, water, police, and fire), housing, transportation, commercial facilities, and recreation. The impact of resident operating personnel and families is not anticipated to be significant.

10.2 Environmental Impacts - Environment on Facility

10.2.1 Air Quality

Phytogenic emissions appear to be insignificant compared to other emissions impacting mirror efficiency, but their chemical composition might still be important. Fugutive dust mass loadings from off-road vehicles and other sources such as dust storms are considered to be large enough to be a significant effect on heliostat efficiency. Crop dusting impacts were not assessed, but should be evaluated to determine significance to heliostat efficiency. These air quality environmental impacts on the power plant are unique to a solar facility.

A key piece of data needed to assess these effects is the relationship between mass of pollutant deposited on heliostat surfaces and change in heliostat efficiency. Conversations with scientists at Sandia Laboratories in Albuquerque indicate that these data are currently being collected.

10.2.2 Seismicity

The site meets normal siting criteria and was considered acceptable for the proposed Sundesert Nuclear Power Plant.

10.2.3 Water Quality and Supply

Water rights play an important part in the procurement of water for power plants. Water availability for the scenario studied is not a problem because of prior negotiations assigning water to the proposed Sundesert facility. Adequate water supplies for solar power plants at other locations could be a siting constraint. This point is underscored by the following statement extracted from the "Summary of Environmental Data Statement of the Water Supply Phase for the Sundesert Nuclear Project."

> "The preparation of an early-phase Environmental Impact Report covering the water supply aspects of the Sundesert Nuclear Project will enable the Company to secure from each of the California Colorado River water contractors their final approvals of the water supply agreements for the project. Conditional approval of these contracts has been given by each of the California contractors. However, these agencies have made their final approval and execution of the contracts subject to the review and consideration of a final Environmental Impact Report on the water supply phase of the project. Without these agreements, San Diego Gas & Electric Company cannot be assured at the outset that a water supply will be available for its proposed power plant. Lacking this assurance, the Company's entire project would be jeopardized in that the planning, design and development of the electric generating facilities could not go forward. The assurance of a cooling water supply is therefore a fundamental cornerstone of the project."

Use of agricultural runoff water would be a better alternative water source for the plant than groundwater for reasons discussed in Sections 5.2. Solar power plants do not require significantly more water than other types of power plants. The cooling system and stack desulfurization system require the most water. Water required for heliostat washing is much less, although the cost of deionizing even this amount of water would be significant. Construction water requirements would be signficant if used for dust control and compaction but represent a short-term impact.

Both groundwater and agricultural runoff water is of poor quality (high in total dissolved solids) and would require extensive treatment for plant use. Heliostat wash water and boiler makeup water would require deionization. The poor quality of water supplies at the site would impact the plant significantly with respect to economics (treatment of cooling water, process water, and heliostat water; materials used in water systems; etc.).

10.3 Intra-Plant Impacts

The most significant intra-plant impacts appear to be from impaction of particulate matter from coal burning and the deposition of salt particles from cooling tower operation on heliostat surfaces. As an upper limit, worst-case estimate, approximately 2-4 kg of coal particulates and salt particles will accumulate on a heliostat in a 30-day period; fugitive dust can increase this by another 1-2 kg, and coal handling and intra-plant vehicle travel may also have significant (but as yet unquantified) contributions to this total. The plume from the coal stack could significantly reduce available insolation at certain wavelengths, thereby adversely affecting operation of the solar subsystem. Additional research needs to be done in this area. These intra-plant air quality impacts are unique to solar facilities.

Another significant finding is that not all the heliostats are expected to need the same washing schedule. Mass deposition, and therefore cleaning frequency, are expected to depend highly upon the location of the heliostat in the field in relation to the emission sources.

10.4 Mitigation of Environmental Effects Through Selection of Alternative Sub-Systems

Large-scale commercial solar thermal-fossil fuel hybrid power plants are still in early stages of conceptual design. Their economics are unproven, subsystem choices are many, and potential sites poorly identified. Our choice of the Rockwell International design was an arbitrary selection made on the basis of its rated capacity (430 MWe) and the thoroughness of its design. The following discussions including subsystem alternatives do not necessarily represent "better" or "more acceptable" ways of achieving the same ends, but are suggested as options that we feel may mitigate some environmental concerns and demonstrate the adaptability of hybrid systems to different environmental settings. In every case, no detailed analysis has been performed to determine whether the Rockwell or the suggested alternative subsystems are inherently more or less environmentally benign, economically attractive, or otherwise "better."

10.4.1 The Three-Quadrant Heliostat Array

Given certain assumptions and a theoretical approach the Rockwell heliostat "field design and layout criteria" was to "minimize cost of annual energy" (10.4). In reality, site-specific considerations render invalid many assumptions, and practicalities do not always conform to theories.

For example, using the Rockwell criteria, assumptions, and approach, a nearly circular heliostat array presents itself as the optimal field layout. But such a design requires placement of the cooling towers far from the main plant area, a distance ranging from 1568 m (5140 ft) to 2398 m (7867 ft), depending upon direction of the predominant wind. Further, the Rockwell design places the coal combustion chimney coaxial with the receiver subsystem. Several comments are relevant.

Site-specific factors are important in determining the shape of the heliostat field. Depending upon latitude and terrain, power densities may be better optimized by an elliptical field. One consequence is that the distance to the cooling towers can be greatly increased or decreased. At an estimated cost of $1000 per linear foot, increases in the distance from the main plant area to the cooling towers can be a significant consideration (10.5). The Rockwell design would require a capital outlay of $5.14 million to $7.87 million just for the equipment and materials to connect the cooling towers to the main plant; a more ellipitically-shaped field could increase or decrease the upper limit of that cost range.

With the combustion chimney in the center of the heliostat field, the plume will inevitably affect the reflective power of at least some of the heliostats all of the time. With a more elliptical field, the power degradation could be greater if the plume overlays the long axis. Further, the frequency of heliostat cleaning and the environmental impacts of cleaning would be increased.

One option to reduce the undesirable effects of plume fallout projected at the Blythe site is the use of a three-quadrant heliostat array. With a site-specific predominant wind direction, one quadrant of the heliostat field could be eliminated. This would be the quadrant that would be most often affected by the combustion plume. The cooling towers and the combustion chimney would be placed in this non-reflective quadrant. Use of this alternative would decrease the distance from the main plant to the cooling towers and so decrease the cost of that aspect of the facility. It would elimate the heliostats that formerly were the most impacted and thereby reduce heliostat cleaning costs and potential impacts on the environment. It may be possible to use a receiver that would require cooling on only three sides, a possible cost reduction. Use of this alternative, though, has its costs.

The heliostat field would require redesigning to maintain design power ratings. Increased heliostat packing densities and/or numbers of heliostats and/or enlarged field area and/or more sophisticated heliostat designs might be required to maintain power levels. The reciever would require redesigning, and resultant thermal stress or heliostat aiming inaccuracies may prohibit the use of a receiver that is not cooled on all sides.

10.4.2 Coal Combustion Alternatives

There are a number of ways of burning coal which reduce emissions. The following paragraphs present simple, brief descriptions of five alternative techniques and technologies as they exist in the first year of the 1980's. By the time-frame of the solar-coal hybrid facility, the 1990's, there may be advancements which will make one or more of these suggested alternatives to the Rockwell pulverized-coal combustion subsystem the optimal approach.

Solvent-Refined Coal (SRC)

Manufacturing SRC involves dissolving pulverized coal in a solvent at moderately high pressure and temperature, treating the solution with hydrogen to remove an appreciable part of the sulfur, filtering the hot solution to remove insoluble coal-ash minerals, and then driving off the solvent and recovering the demineralized, low-sulfur product. Two pilot plants have been operating since 1973. Commercial-scale burning tests have shown that SRC is a premium fuel in regard to heat value, ash, and sulfur content. Commercial-size SRC plants have been proposed (10.6). Use of SRC in the solar-coal hybrid plant can reduce its emissions-abatement load and environmental impacts, and increases the facility's availability.

Coal Gasification

Coal can also be gasified to produce a low- to medium-Btu gas. Low-Btu gas is not economically stored or shipped more than a short distance before combustion and must therefore be considered a form of direct combustion of coal. The gas is cleaned before burning so that minimal emission controls are required at the combustion facility. Again, as with SRC, use of coal-derived gas in the solar-coal hybrid can reduce its emissions and environmental impacts, and increase the facility's availability by decreasing heliostat cleaning requirements.

Synfuel

There are several methods of converting coal to a low-sulfur, low ash synthetic fuel oil. The technologies currently under serious development include one indirect approach, two direct pyrolytic methods, and four direct solvent extraction processes. The technologies differ in conversion efficiencies. No commerical direct liquefaction plants are in operation in the U.S. Combustion of this kind of low-polluting fuel in the solar-coal hybrid facility can decrease the plant's environmental impacts. Liquid fuel from oil shale represents a similar alternative.

Supercritical Boilers

The solar-coal hybrid facility need not use a conventional pulverized coal-fired boiler. One alternative is the supercritical boiler. In this design, the critical pressure of water is surpassed and water behaves throughout the cycle as a single-phase fluid. The primary advantage of this design lies in having most of the energy of the system embodied as thus extreme temperature and not pressure. The hazards of pressurized steam are avoided. The system requires water of extreme purity since, lacking need for a steam drum, there is no place for accumulated impurities to be occasionally "blown down." The system has the additional requirement of sophisticated materials and procedures to maintain reliability in operation. The additional safety resultant from use of this alternative subsystem should be considered, remembering that by the timeframe of the solar-coal hybrid facility, the materials and procedures may be sufficiently developed to make this a workable option.

Cyclone Furnaces

Pulverized coal is not an essential requirement. The coal need only be crushed, resulting in cost savings and reduced coal dust generation. Cyclone furnaces can utilize crushed coal, and provide other advantages as well. Being more efficient than conventional furnaces, cyclone types are smaller for a given power rating. Secondary heat recovery systems can also be smaller. With cyclone furances, 70 to 80 percent of the ash is converted to slag, thereby greatly decreasing the fly ash in the secondary furnace, compared with 20 percent ash recovery in dry-bottom, conventional pulverized-coal-fired furnaces. Low-sulfur Western coal quickly fouls dry-bottom furnaces, but cyclone furnaces can use this coal without such fouling problems. The one major disadvantage of this furnace is the controls. This type of furnace was developed in the late 1930's. The potential growth of use of low-sulfur Western coal and the increased restrictions on fly-ash emissions can bring the cyclone furnace back into the market. It deserves consideration for use in a solar-coal hybrid facility expected to use Western coal.

Fluidized-Bed Combustion (FBC)

FBC is another method of using coal in the solar-coal hybrid facility. There are several advantages with this option. A wide range of rank and quality of coals can be burned via FBC. Reduced requirements for boiler tube surface and furnace size result from a higher heat transfer rate than in conventional boilers; lowered capital costs also result. A scrubber is not required, so there is an increased energy conversion efficiency. SO_x and NO_x emissions are reduced. FBC produces a solid waste more readily amenable and acceptable to disposal than that from a wet-scrubber applied to conventional boilers. FBC can operate at an elevated pressure sufficient to use a combined gas-turbine/steam-turbine cycle for generating electricity at higher efficiency. Two major problems exist with FBC. A relatively large amount of fine particulate matter is generated during operation of the FBC furnace. Removal of these particulates is essential to long-term, reliable performance. The other major problem concerns corrosion and erosion of turbine blades, boiler tubes, and general furnace interior surfaces. FBC has many attractions in its current, immature state. By the time of the solar-coal hybrid, FBC technology may have matured to make it a viable subsystem (10.7).

10.4.3 Receiver Coolant and Energy Storage Fluid Alternative

The Rockwell design uses liquid sodium as the receiver coolant and energy storage medium. Water and eutectic salt mixtures are viable coolant alternatives, and other sensible and latent heat storage media are available. Thermochemical energy storage systems are still under development.

Water is a fluid with a relatively high heat capacity and can be used as the sole fluid in a steam Rankine system. Using water alone greatly reduces the hazards to workers and the environment resultant from a release of the coolant material, relative to other materials. The greatest hazard to workers arises from the fact that the bulk of the energy carried in the water is stored as pressure, arising from the phase change, and not just temperature; missile generation as well as burns and other injuries can result with accidental releases of the fluid. Additives to the water to control corrosion or microbial action can mean additional hazards to the workers and the environment. Use of a steam Rankine system usually means a lower over-all system efficiency. Cooling requirements are usually increased with less efficient systems, and water resources generally are taxed to a greater degree as the result. The steam Rankine cycle has the advantage of years of operational experience. Molten salt receivers are still under development but have potential advantages over water, having a greater heat capacity and easy interface with eutectic salt thermal energy storage systems.

Other candidate fluids for energy storage include LiH, $Ge_{0.4}S_{0.6}$, and KNO_2-$NaNO_2$. All accrue the same general advantages, including relatively stable thermal behavior and high energy storage densities. But whereas elemental sodium can burn in air at ambient temperatures, be hydrolyzed upon contact with moisture in the air or by flesh, and can generate heat sufficient to ignite various flammable materials, the alternative energy storage materials may represent improvements in worker and environmental health and safety. Currently seemingly prohibitive cost considerations are the major disadvantages of the lithium and germanium materials, while corrosion problems plague the potassium medium.

Energy can alternatively be stored thermochemically, via reversible chemical reactions. Generic examples of this method rely on inorganic hydroxides, methane, and metal hydroxides. All share three general advantageous characteristics: the amount of energy stored per unit mass and volume is much greater than in other systems; energy may be exchanged at constant temperature; and energy can be stored for long time periods at ambient temperature. All are generally complex and currently undeveloped.

Further research is necessary to better determine the efficacy of these alternatives in enhancing the safety, reliability, and benignity of the receiver coolant and energy storage subsystem (10.8).

10.5 Conclusions

Environmental impacts unique to the solar coal hybrid power plant sited near Blythe, California were determined to be in the categories of land use, air quality, geology, hydrology, vegetation and wildlife, health and safety, legal and institutional constraints and aesthetics. A number of conventional environmental concerns such as economics, noise, transmission line corridors, and materials requirements were not assessed.

With regard to the effect of the facility on the environment, all but health and safety and legal and institutional constraints were functions of the large land requirement. The 430 MWe solar hybrid facility was estimated to require about 5 mi^2 of land with no provision for an exclusion area. This compares to an estimate of 1 mi^2 of land required to accommodate two 950 MWe nuclear power plants as proposed by San Diego Gas and Electric Company. The diffuse nature of solar insolation precludes definition of a strategy to mitigate the large land requirement for the defined technology.

With regard to the effect of the environment on the facility, air quality was the most significant concern. At issue was the question of degradation in heliostat performance resulting from fugitive dust and crop dusting. Paradoxically, a significant source of fugitive dust was determined to be residual material produced during construction that had blown off-site but remained close enough to be blown back onto the site. A second fugtive dust source was associated with off-road recreational vehicles. This concern could be mitigated by an exclusion or controlled access area surrounding the facility, but at a significant increase in land use.

With regard to the interactions of subsystems within the facility proper, the greatest concern was for air quality. Both degradation of solar insolation from coal combustion emissions, and particulate deposition on heliostat surfaces were viewed as significant problems which could compromise the efficiency of the facility. Both problems could be mitigated by use of cleaner burning fossil fuels. Analysis of potential degradation of heliostat surfaces was constrained by limited information on heliostat mass loading characteristics. Compared to the estimates made by Rockwell International, an increase was projected in amount and cost of improving quality of water used for both power generation and heliostat washing.

Because environmental impacts are site specific, some siting criteria that were not considered limiting for this study might be limiting for a solar power plant being sited elsewhere. This study's conclusions about impacts differ somewhat from other evaluations (10.9). Climate modification was not considered a significant impact. Vegetation and wildlife impacts were also not considered significant for the specified study site. Aesthetics was considered a significant impact.

10.6 References

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