CHAPTER 118

THERMAL POWER PLANT ENVIRONMENTAL STUDIES

by

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ABSTRACT

Once-through cooling water systems for thermal power plants offer an economical means of dissipating the differential energy of modern-day turbines.

Before the decision to proceed with the design of a once-through cooling water system is made, a considerable study effort must be undertaken in order to determine that no harmful effects will accrue to the environment from the plant's operation.

These studies must include:

1. A comprehensive literature search
2. Field investigations of the air and water
3. Analytical evaluation of the field data

The Pacific Gas and Electric Company has been conducting environmental studies at its operating thermal power plants and at proposed sites since 1958.

This paper describes the approach used by the Company in conducting environmental studies. Meteorological data were obtained from on-site sensors, stored on magnetic tape, and subsequently computer-processed. Oceanographic data in the form of water temperatures, salinity, and dissolved oxygen profiles, as well as current speed and direction, were obtained from surface vessels. Remote sensing systems were used to obtain dispersion and dilution information, sea-surface temperature data, and aerial photographs of flora indigenous to the study area. All remote-sensed data, except for the aerial photographs, were stored on magnetic tape, in flight, and later processed in the computer with graphic off-line printout.

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Introduction

The National Environmental Policy Act, enacted in 1970, the State of California through its local Regional Water Quality Control Boards, the Atomic Energy Commission, and many other regulatory agencies require environmental studies at all operating and proposed power plant sites. Pacific Gas and Electric Company (P G and E) has conducted environmental studies at its operating plants and proposed sites in the marine environment since 1958 (1, 2, 3, 4, 5, 11). The basic philosophy of these studies has remained unchanged from 1958 to the present; however, the methods and techniques have undergone substantial development (6). The primary objective of each study has been to (1) develop an understanding of the physical and biological characteristics of the marine environment, and (2) determine the effects of the plant or potential plant on the marine environment.

Many disciplines are represented in a comprehensive environmental study. In coastal areas, these include oceanography, engineering, biology, meteorology, photogrammetry, and others. Proper interfacing of each is required in order to obtain meaningful results. Each is complementary to the other.

The normal process of most studies in on a "begin-end" basis. Environmental studies for new plant sites seemingly do not fit this pattern at this time. There is a start-point, but, because of the magnitude and variability of the factors involved, there is no end-point. They can be described as "preoperational" and postoperational."

In the preoperational period, the site environs are studied qualitatively and to some extent quantitatively, so that it can be evaluated with respect to physical and biological processes. It is important to study these processes during the different oceanographic seasons. Temperature and salinity distributions, for example, vary seasonally in coastal waters. The basic study program is designed to interface synoptic with on-going studies so that their seasonal changes can be documented for comparison of long-term data. Modeling studies are made, based in part, on field study data.

The postoperational study period differs in length from the preoperational period. Studies at many P G and E plants are continuing to date, even though in some cases the plants have been operational for more than 20 years.

Literature Search

A logical starting point for an environmental study is in the reference library. Marine investigations have been made and reported along the California coastline for over a hundred years. A large compendium of information can be found in the archives of the National Oceanographic Data Center (NODC), Washington, D.C. Information available includes climatology, sea-state conditions, surface and subsurface water temperature, salinity and dissolved oxygen data, and wave height, direction, and period information. Data can be retrieved from the archives in many formats.

The basic selection is made by isolating the smallest geographical area of interest available (Marsden sub-square) and recalling the data.

In addition to NODC, many other data sources are available to the investigator. These include publications of state and federal agencies, privately endowed research organizations, and universities and colleges. The literature search, up to this point, has been confined to descriptions of the environment in or near the power plant site.

The next area of search deals with methodology. The literature is constantly being expanded to include work done in many areas of the world. Although most environmental studies share a common goal, all studies are not conducted in exactly the same manner. For this reason, methodology is constantly being expanded; and one basis for this expansion is motivated by the literature search.

Field Investigations of the Air and Water

The second step in the environmental study is to develop a program which details the organization of the study. At a minimum, this program will include the following main points:

1. On-site recording systems
    - Water temperature
    - Tide stage
    - Meteorological
        - Wind speed and direction
        - Barometric pressure
        - Solar radiation
        - Relative humidity
        - Precipitation
2. Synoptic studies
    - Shipboard
        - Surface and subsurface
            - Salinity
            - Temperature
            - Dissolved oxygen
            - Turbidity
            - Current speed and direction
    - Airborne
        - Sea-surface temperature
        - Dispersion and dilution (dye) studies
        - Photography (i.e., kelp beds)

Figure 1 shows a flow diagram of data acquisition to analysis of an environmental study.

The methodology shown in Figure 1 is the result of many years of effort by the Pacific Gas and Electric Company to improve the quality of each environmental study. Noteworthy of these are the use of magnetic-tape recording systems (computer-compatible) for meteorological data and airborne

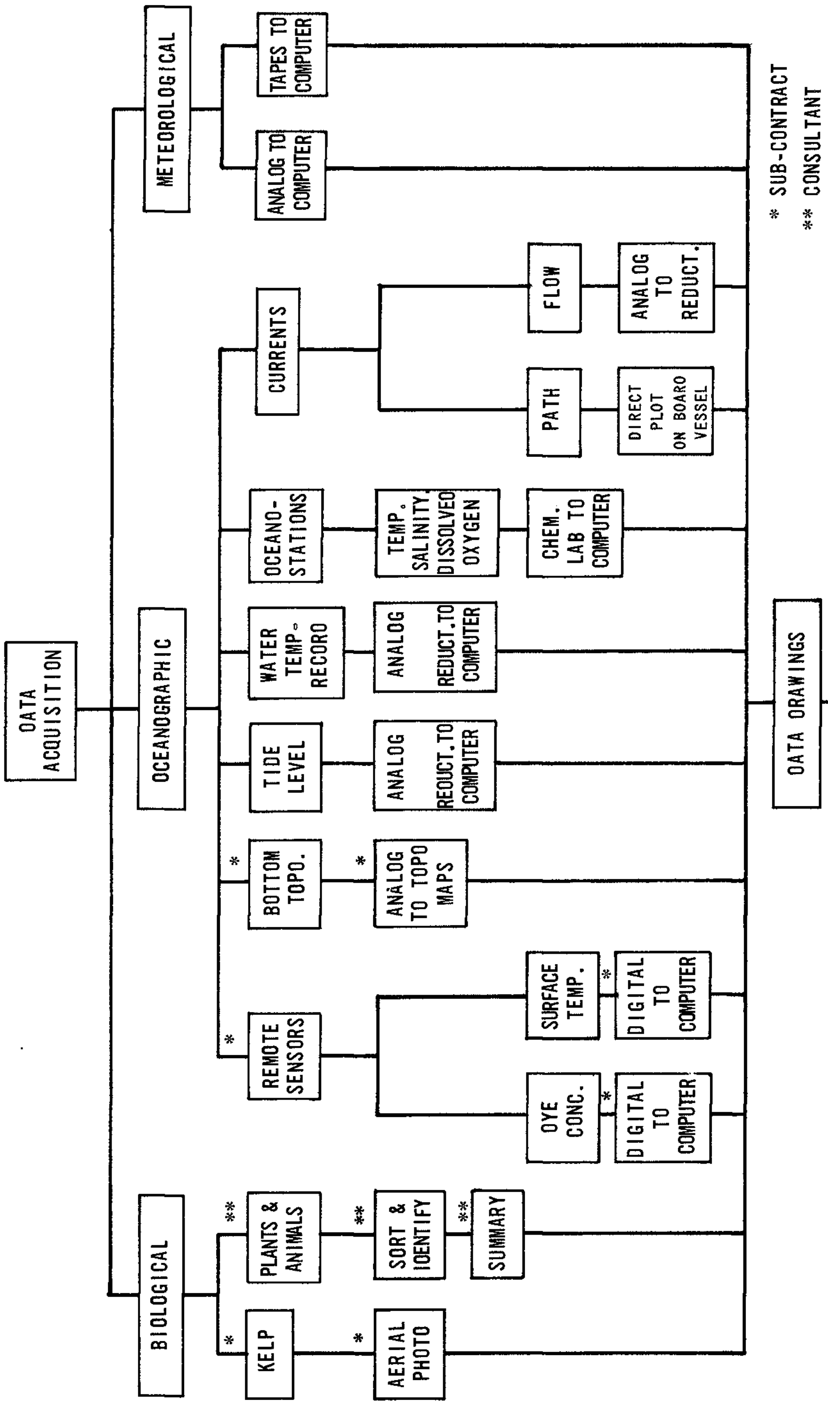


FIG. 1 - ENVIRONMENTAL STUDIES, FIELD STUDIES DATA FLOW

remote-sensing systems (see Figures 2 and 3). There are many advantages in the use of tape systems. Obvious among these are the amount of data that can be obtained, stored, and processed; and the low cost. In addition, with the information in a computer-compatible format, the routining possibilities are expanded.

Instrumentation. Instrumentation used by the company ranges from rather simple water temperature recorders to sophisticated infrared line scanners. Some of these instruments and related support equipment are shown in Figure 4. These items are utilized from a chartered 65-foot steel-hulled commercial fishing vessel, which serves not only as a platform but also provides the quarters for test personnel. Typical field synoptic study periods last from seven to ten days and are conducted on a 24-hour per day basis. Airborne systems, including an infrared scanner and a high altitude reconnaissance camera, are shown in Figures 5 and 6.

Methodology. The shore-based systems are operated for the duration of the study. The airborne systems are operated at selected intervals of current and tidal stage periods. One of the advantages of infrared line scanners is their ability to operate during any portion of the lunar day (for sea-surface temperature data-gathering). On board the primary research vessel, temperature, salinity, and dissolved oxygen data are obtained from surface to near bottom at each oceanographic station. These data are reduced on board and organized for subsequent onshore computer processing. Temperature and salinity data are processed for density and stability determinations.

Current speed and direction are determined by three methods:

1. Current meter (flow)
2. Radar-tracked drogue (path)
3. Dye-path drift

Remote-sensing systems, excluding aerial photography, combine the operation of the instruments in the aircraft with related or supporting systems aboard the research vessel. These surface vessel systems are commonly referred to as "ground truth systems." For sea-surface temperature, the airborne infrared scanner is determining the water temperature ($\pm$ 1°F) to a depth of approximately 20 microns (7). A precise inflight calibration of the scanner can only be made by comparing the scanner values (voltage/temperature) with surface temperature values obtained by a system operating in the same bandwidth (8-14 microns) as the scanner. This is accomplished by the use of an infrared radiometer on board the surface vessel. Ground-truth data are obtained for the scanner, when it is operating in the tracer dye mode, by the use of water sample data obtained through the use of a fluorometer operating on board the surface vessel. Dye concentrations can be determined by the scanner to 0.1 PPB (8).

Analysis

Most environmental studies are designed to cover annual cycles. In some coastal areas, such as California, the annual cycle consists of three

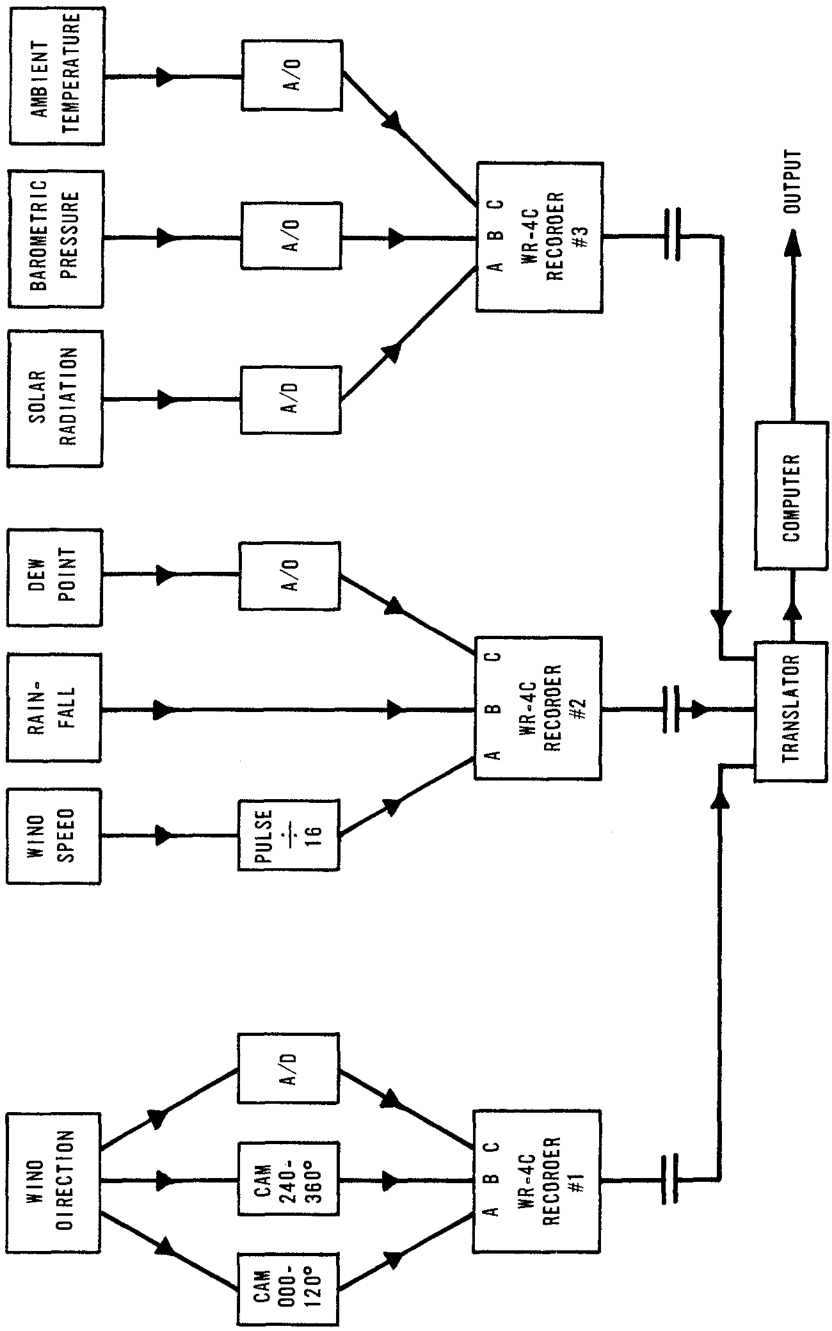


FIG. 2 ENVIRONMENTAL DATA ACQUISITION SYSTEM

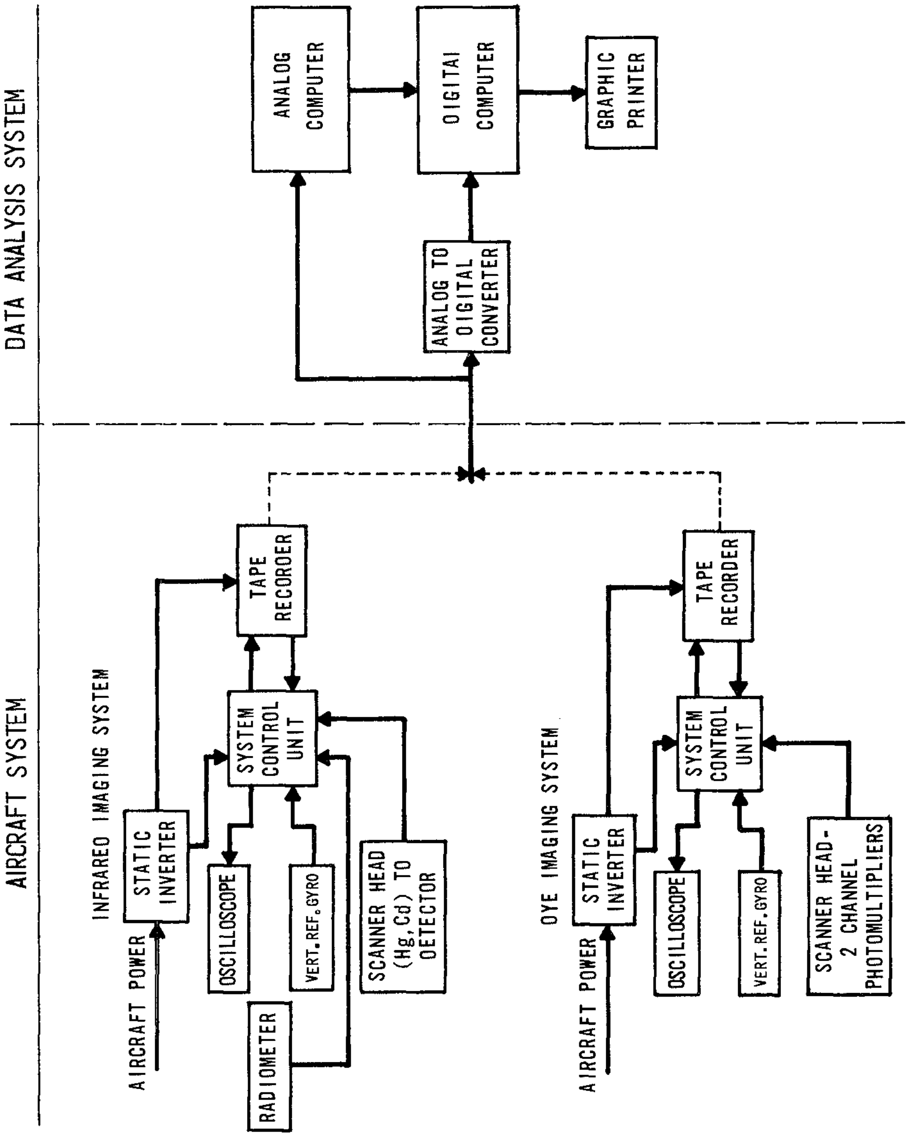


FIG. 3 - BLOCK DIAGRAM OF DATA FLOW FROM ACQUISITION TO GRAPHIC PRINTER

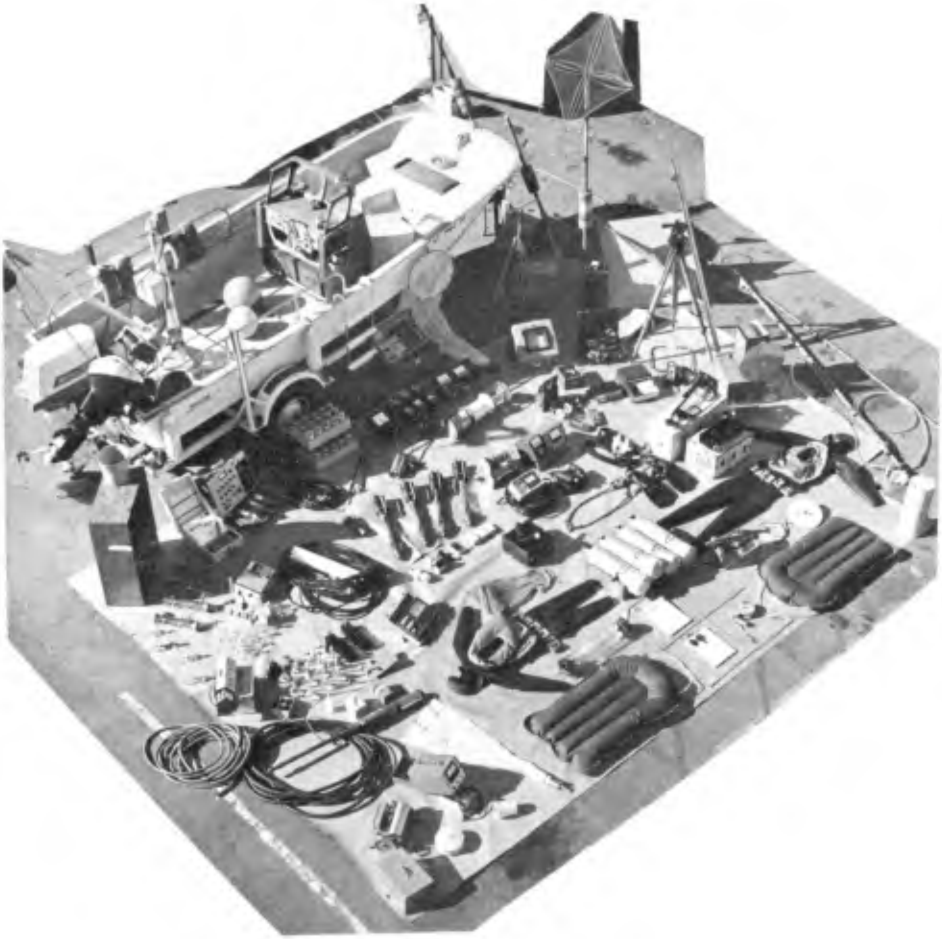


Figure 4 - Equipment Used in Environmental Field Studies

Figure 5 - Airborne Infrared Scanner-Control Systems, Reference Units and Magnetic Tape Recorder Located Inside Aircraft

Figure 6 - High Altitude Recon Camera - Infrared Type 2443 Aero Neg Film used for Kelp Mapping Flights

seasons, while in inland or estuarine areas there are four seasons. Summary data analysis is therefore made of the full year's cycle.

From the literature search, it has been determined what data exists for the area under study. An example of this is shown in Figure 7. Data from two shore stations and from NODC (Marsden Sub-square 83) are compared. In this case, sea-surface water temperature data (mean, maximum, and minimum - monthly), covering a time period 1847-1970, have been plotted. Data obtained during our studies are then compared against the long-term data to determine if significant variations existed during our study period.

Similar comparisons can also be made with meteorological, wave height, wave period, salinity, and temperature with depth data.

With these data in this format, it is then possible to analyze both the old and the new data with respect to the following:

1. Basic ranges - minimums and maximums
2. Short-term vs. long-term mean variations
3. Seasonal variations

Sea-surface temperature and dispersion and dilution data obtained by the airborne remote-sensing system are graphically displayed for analytical purposes.

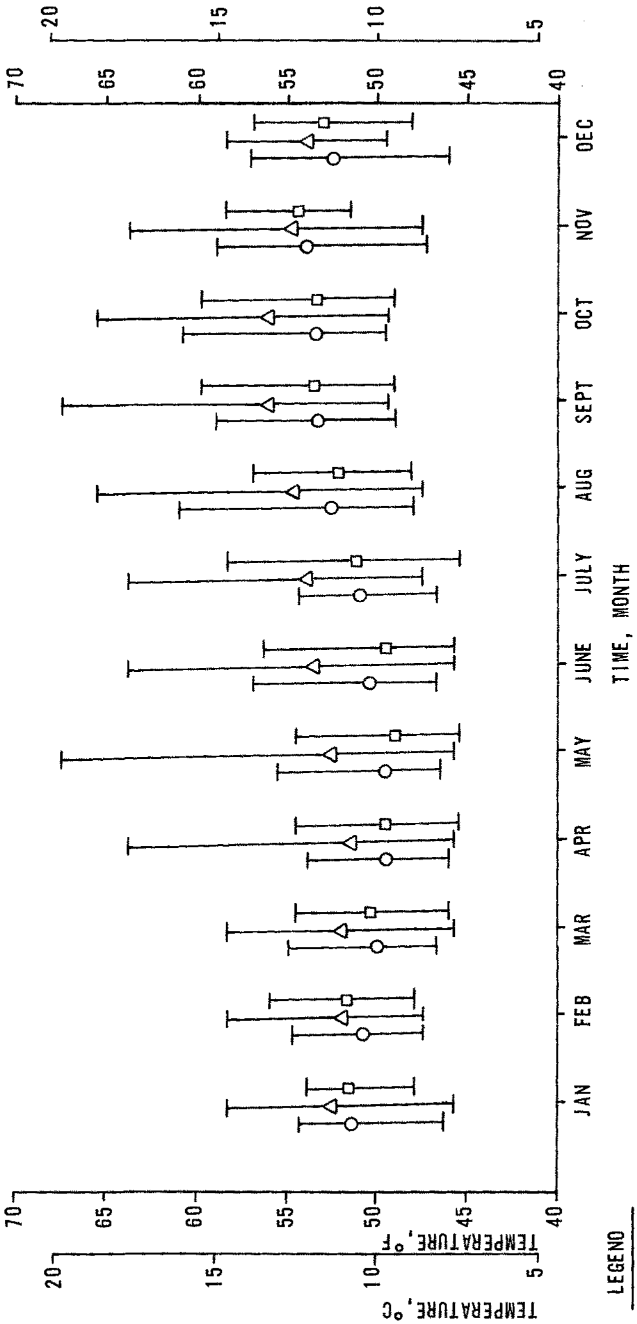
Figure 8 shows examples of both black-and-white imagery and computer output (5). Both show a view of the thermal effluent from a power plant operating at a load of 1500 MWe, a flow of 1350 CFS, and a temperature difference (intake-discharge) of 22°F. The difference in the two figures is that the black-and-white imagery is qualitative, while the computer output shows the actual areas in square feet contained within each isotherm. The task of analyzing the plant thermal output has thus been quantified.

The data obtained during environmental studies, whether it be physical, biological, or related disciplines, are complementary. For example, physical data are directly related to model studies. The suitability of a physical or analytical model can be verified by studies at operating power plants (10). This paper has covered the physical studies needed as input to biological assessment which must be pursued in a parallel mode of investigation.

Summary

Thermal power plant environmental studies are designed to document the characteristics of the impact area of the plant. They should include a thorough literature search of previous studies in the area. A comprehensive study plan must be developed. It should be designed to include all seasons of the year. Whenever possible, acquired data should be stored in a computer-compatible format. The analysis should include the interfacing of all disciplines within the study.

Note: For NODC data only, temperatures recorded 5 times or more were shown.



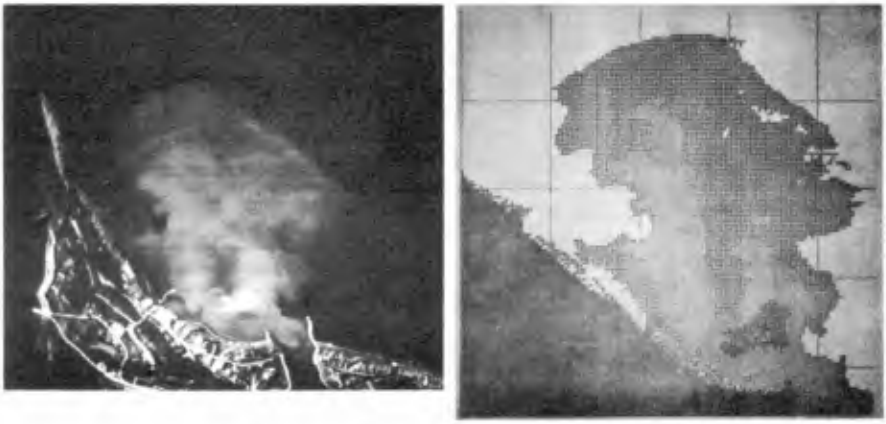
LEGEND

○ 1961-1969 (SCRIPPS INSTITUTION OF OCEANOGRAPHY, MENDOCINO SHORE STATION (39°18.2'N, 123°48.2'W) DATA, MEAN FOR MONTH)

△ 1847-1970 (NODC MARSDEN SQUARE 121 SUBSQUARE 83, MEAN FOR MONTH)

□ 1961-1969 (SCRIPPS INSTITUTION OF OCEANOGRAPHY, FT. ROSS SHORE STATION (38°30 7'N, 123°14.5 W) DATA, MEAN FOR MONTH)

FIG. 7 - MEAN, MAXIMUM AND MINIMUM MONTHLY SEA SURFACE WATER TEMPERATURES RECORDED NEAR PT. ARENA, CALIFORNIA



LEVELS 1 2 3 4 5 6 7 8 9 10 11 12 13

LEVEL	TEMP. (DEG. F)	NUMBER OF AREA ELEMENTS	AREA (SQ.FT.)
1	56.99 - 58.00	4917	6053900
2	58.00 - 60.00	2302	2834300
3	60.00 - 62.00	147	180991
4	62.00 - 64.00	43	52942
5	64.00 - 66.00	18	22161
6	66.00 - 68.01	11	13542
7	68.01 - 69.99	7	8617
8	69.99 - 72.00	1	1230
9	72.00 - 74.00	1	1230
10	74.00 - 76.00	1	1230
11	76.00 - 78.00	2	2461
12	78.00 - 80.00	0	0
13	80.00 - 82.00	0	0

AREA OF ONE ELEMENT (SQ. FT.) = 1231.74
TIME OF PASS = 1345
ALTITUDE (FEET) [illegible]
HEADING (DEG. FROM NORTH) 30
SPEED (MPH) 100
GRID SIZE IN FEET = 1000
MOSS LANDING IR TEST 12/6/70

FIGURE 8 - Thermal scan (left) and computer constructed surface isotherms (right) for the Moss Landing Power Plant Units 6 and 7 at a load of 1500 MWe, a cooling water flow of 1350 cfs, and a temperature difference of 22^{o}F, December 6, 1970.

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