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REEXAMINATION OF ALTERNATIVES TO REDUCE LOSSES OF STRIPED BASS AT THE CONTRA COSTA AND PITTSBURG POWER PLANTS

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SUMMARY

This report presents results of a reexamination undertaken by Pacific Gas and Electric Company (PGandE) in response to discussions with the staffs of the Central Valley and San Francisco Bay Regional Water Quality Control Boards. The purpose of the reexamination was the evaluation of the current feasibility, costs, and potential effectiveness of alternative methods and technologies for further reducing the losses of larval and juvenile striped bass at PGandE's Contra Costa and Pittsburg power plants. This report summarizes and documents results of the technical evaluation of alternatives as an update and extension of the "Assessment of Alternatives to Reduce the Losses of Striped Bass, Contra Costa and Pittsburg Power Plants" (TERA, 1982).

This reevaluation identified alternatives that may be feasible and could be effective in further contributing to the reduction in striped bass losses at the two power plants. Alternatives include modified traveling water screens, various methods to reduce cooling water volumes at Contra Costa Units 1-3, Contra Costa Units 4 and 5 and Pittsburg Units 1-4, various methods to reduce cooling water volumes required when Contra Costa house units are in service, hydrogen cooling improvements at Contra Costa 6 and 7, and two resource management alternatives.

Information on operation performance, reliability, capital and operating costs, and the estimated effectiveness of the various alternatives in reducing striped bass losses are discussed. Cost estimates have been based in large part on operating conditions at the two power plants in 1984 and 1985. The effectiveness of each alternative to reduce striped bass losses was based on assumed operating conditions and actual cooling water system operations, unit loading, and striped bass densities observed in 1984 and 1985. Estimates of incremental percentage reduction in striped bass losses are based on actual and assumed operation in 1984 and/or 1985, and therefore should be used only as a relative guide in evaluating various alternatives because of the difficulty in determining if these two years are representative. The actual cost and effectiveness of each alternative will vary between years based on future operating and environmental conditions influencing the losses of striped bass at the Pittsburg and Contra Costa power plants.

1.0 INTRODUCTION

1.1 PURPOSE

This investigation was undertaken by Pacific Gas and Electric Company (PGandE) in response to discussions with the staffs of the Central Valley and San Francisco Bay Regional Water Quality Control Boards, to review the current feasibility, costs, and potential effectiveness of alternative technologies for further reducing the losses of larval and juvenile striped bass at PGandE's Contra Costa and Pittsburg power plants. This report summarizes the results of the more recent technical review of alternatives in the "Assessment of Alternatives to Reduce the Losses of Striped Bass, Contra Costa and Pittsburg Power Plants" (TERA, 1982) and evaluates additional technologies.

This section of the assessment provides a summary description of the Contra Costa and Pittsburg power plants and describes the measures implemented to comply with the BTA requirements of the NPDES permit provisions for the facilities. Section 2.0 provides a brief description of alternatives now under more detailed consideration by PGandE to assist in reducing the losses of striped bass at the power plants and reviews the cost of implementation and the potential effectiveness of the alternatives.

1.2 DESCRIPTION OF FACILITIES

The physical configurations and major characteristics of the cooling water systems at the Contra Costa and Pittsburg power plants are shown in Figures 1-1 and 1-2, and in Tables 1-1 and 1-2. Extensive descriptions of the designs and operations of the facilities are presented in the original assessment document completed in 1982. Copies of that document are available from PGandE.

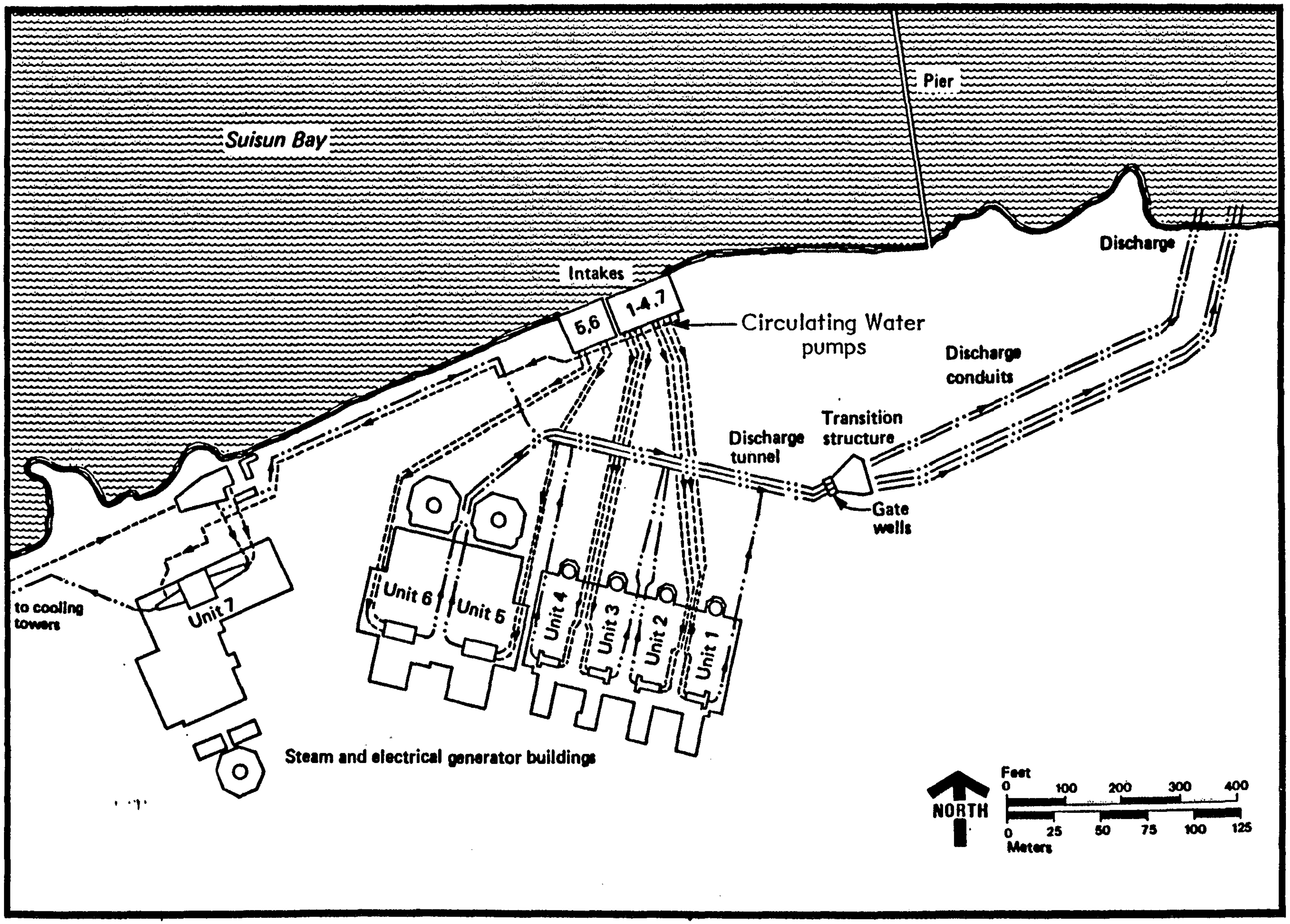

FIGURE I-1

GENERAL CONFIGURATION OF THE PITTSBURG POWER PLANT
UNITS I-7 COOLING WATER SYSTEMS

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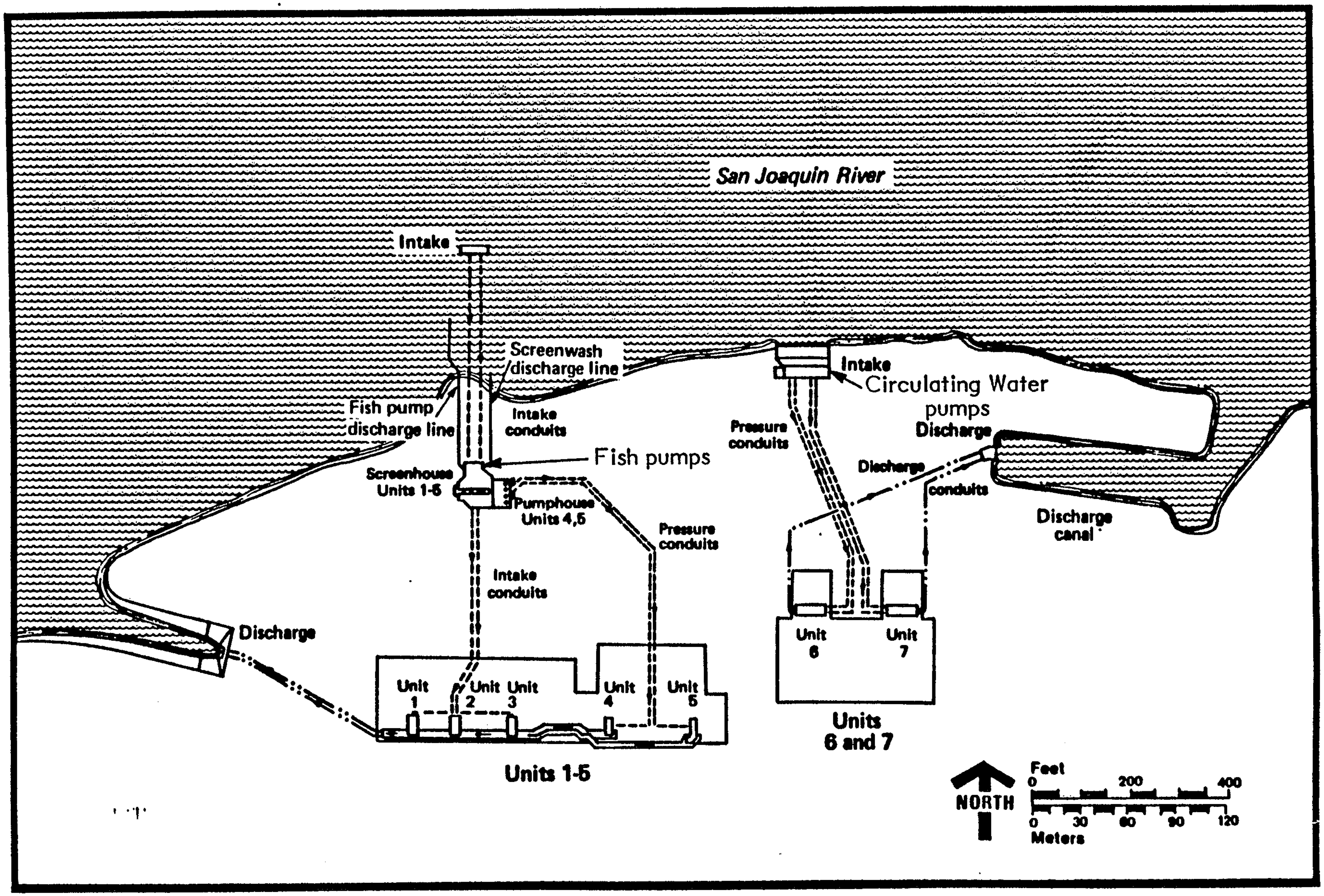

FIGURE I-2

GENERAL CONFIGURATION OF THE CONTRA COSTA POWER PLANT
UNITS I-5 AND UNITS 6 AND 7 COOLING WATER SYSTEMS

TABLE I-I

SUMMARY OF CHARACTERISTICS
PITTSBURG POWER PLANT

Unit	Gross Unit Output (MWe)	Net Unit Output (MWe)	Design Cooling Water Flow (gpm)	Design Condenser Temperature[a] Rise (oF)
1	160	153	98,600	15
2	170	163	98,600	15
3	160	153	98,600	15
4	170	163	98,600	15
5	330	325	160,500[c]	18
6	330	325	160,500[c]	18
7	740	720	20,000	(b)
TOTALS	2,060	2,002	735,400	

(a) At design power output.

(b) Unit 7 uses a closed cycle cooling tower system to dissipate heat.

(c) The circulating water pump motors on these units are equipped with VSDs. All other units have constant speed pump motors.

TABLE 1-2

SUMMARY OF CHARACTERISTICS
CONTRA COSTA POWER PLANT

Unit	Gross Unit Output (MWe)	Net Unit Output (MWe)	Design Cooling Water Flow (gpm)	Design Condenser Temperature Rise (°F)
1	122	116	89,800[a]	16
2	122	116	89,800[a]	16
3	122	116	89,800[a]	16
4	122	117	55,200	24
5	120	115	55,200	24
6	345	340	152,700[b]	19
7	345	340	152,700[b]	19
TOTALS	1,298	1,260	685,200	
Auxiliary Cooling			11,800	
			697,000	

[a] Cooling water flows include both the main and auxiliary (house) units.

[b] The circulating water pump motors on these units are equipped with VSDs. All other units have constant speed pump motors.

1.3 CURRENT BTA PROVISIONS

A number of changes to operations at the Contra Costa and Pittsburg power plants were required as a condition of the NPDES permits for the facilities issued in 1983, and were supplemented by certain voluntary measures undertaken by PGandE to aid in the reduction of striped bass losses at the facilities. The operational changes required as conditions of the NPDES permits and those undertaken voluntarily by PGandE are listed below.

<u>Measures Required in the NPDES Permits</u>

1. Circulating water pumps were removed from service as soon as practicable after a unit was removed from service, in order to reduce cooling water volumes.

2. Variable speed circulating water pump controls with discharge temperature feedback were installed at Pittsburg Units 5 and 6 and at Contra Costa Units 6 and 7.

3. A resource management plan was implemented to preferentially operate Pittsburg Unit 7 whenever possible during the striped bass entrainment period based on the unit's availability for commitment and dispatching.

4. The area in the vicinity of the Pittsburg Power Plant and Contra Costa Power Plant Units 6 and 7 cooling water intake structures was dredged to reduce intake approach velocities by modifying the area's bathymetry.

5. The use of Pittsburg Units 1-6 and Contra Costa Units 1-7 was reduced to the extent possible during the entrainment period.

6. An entrainment monitoring program was conducted at both the Pittsburg and Contra Costa power plants (required beginning in 1985). Results of this program provided weekly information on the size-specific densities and normalized (150 mm equivalent) densities of striped bass entrained. These data provided input for the preferential dispatching of units between Pittsburg and Contra Costa in a voluntary effort to further reduce actual striped bass losses.

Voluntary Measures Implemented During the 1984 and/or 1985 Entrainment Periods

1. Units at Pittsburg and Contra Costa were dispatched to maintain discharge temperatures below the 86°F (30°C) threshold for entrainment thermal mortality whenever possible during the entrainment period.

2. An independent daily inspection and report was made on the operation of individual circulating water pumps at all units, operation of the fish pump return system at Contra Costa Units 1-5, and discharge temperatures for all units throughout the entrainment period to help ensure rigorous adherence to operational practices designed to reduce cooling water flows/discharge temperatures at the two power plants.

3. Pittsburg and Contra Costa units were preferentially dispatched based on the geographic distribution of larval and juvenile striped bass.

1.4 EFFECTIVENESS OF CURRENT CHANGES

The relative effectiveness of operational changes instituted at the two plants during 1984 (March 1, 1984 to February 28, 1985) was estimated using the SIMBAS Hindcast model. The relative estimate of striped bass loss reduction was based on 1984 striped bass densities and actual cooling water system operation in 1984. These were compared with average base operations in 1976, 1978, and 1979. An estimated 63 percent reduction in striped bass losses was achieved in 1984, representing a saving of 55,600 equivalent striped bass.

2.0 IDENTIFICATION OF ALTERNATIVES

2.1 GENERAL

This section provides a brief description of the method of identification and evaluation of alternatives and describes the engineering and environmental characteristics of those alternatives reexamined by PGandE.

2.2 EVALUATION METHOD

The assessment of alternatives conducted in this study was based on a reevaluation of the alternatives determined to be potentially feasible in the 1982 investigation and additional alternatives that may aid in reducing the losses of striped bass. The 1982 Assessment of Alternatives completed by PGandE considered a total of 43 alternatives to reduce losses of striped bass at the Contra Costa and Pittsburg power plants. Twenty-two of these alternatives were determined to be potentially feasible based on evaluations completed during the assessment (Table 2-1). The determination was based on two primary considerations. The first was whether the alternative would be effective in reducing the losses of larval and juvenile striped bass at either of the power plants. The second was the compatibility of the alternative with the existing plants from an engineering and operations perspective. Table 2-2 lists alternatives which were screened from further analysis in this reevaluation and provides the basis for their exclusion. Table 2-3 lists those previously considered alternatives which warranted further detailed consideration in this update as well as several new alternatives.

2.3 DESCRIPTION OF ALTERNATIVES NOW UNDER CONSIDERATION BY PGandE

As shown in Table 2-3, the reevaluation of alternatives to reduce the losses of striped bass at the Contra Costa and Pittsburg power plants identified 14 possible alternatives that may be feasible and could be effective in further contributing to the reduction in losses of striped bass at the power plants. The

TABLE 2-1

ALTERNATIVES DETERMINED IN 1982 TO BE POTENTIALLY FEASIBLE FOR REDUCING THE LOSSES OF STRIPED BASS

CONTRA COSTA AND PITTSBURG POWER PLANTS*

Shoreline Intake Structure at Contra Costa 1-5
Offshore Intake for Contra Costa 1-5
Addition of Porous Dike in Front of Intake Structures
Modify Cross Sectional Area of Intake Systems
Provide Lateral Escapeways at Contra Costa 1-5
Angled Traveling Water Screens at Contra Costa 1-5
Maintenance Dredging
Bar Rack Maintenance
Removal of Predatory Fish at Contra Costa 1-5
Modify Existing Traveling Water Screens
Addition of Physical Barriers

- Cylindrical Wedge Wire Screens

Fish Pump Removal Systems
Mechanical Draft Cooling Towers
Reductions to Circulating Water Pump Operations

- Selective Operation of Pumps
- Install Two-Speed Motors
- Install Variable Speed Motor Controls
- Install Magnetic Couplings

Alternative Cooling Water Sources
Reduce Thermal Stresses on Entrained Striped Bass
Reduce Recirculation Using Physical Barriers at Contra Costa 6 and 7
Resource Management

- Operation of Selected Units
- Dispatch Units to Operate with Discharge Temperature of 86°F or Less Whenever Possible.
- Dispatch Units Based on Location of Striped Bass

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* Source: Assessment of Alternatives to Reduce the Losses of Striped Bass, Contra Costa and Pittsburg Power Plants (TERA, 1982).

TABLE 2-2

ALTERNATIVES ELIMINATED FROM DETAILED ANALYSIS IN THE 1985 REEVALUATION

ALTERNATIVE	BASIS FOR EXCLUSION FROM DETAILED ANALYSIS
Addition of Porous Dike	The operational reliability of a porous dike intake structure in the Delta environment is uncertain. No new information is available to suggest that sedimentation and debris loading would not result in unacceptable operational reliability of porous dike intake structures at the two plants.
Modify Cross Sectional Area of Intake Systems Shoreline Intake Structure at Contra Costa 1-5 Offshore Intake for Contra Costa 1-5 Angled Traveling Water Screens at Contra Costa 1-5	It was concluded in the 1982 assessment that these alternatives would not significantly reduce losses of striped bass. No new biological information is available to suggest that these alternatives would contribute to a significant reduction in striped bass impingement losses. The number of striped bass currently being impinged at Contra Costa 1-5 is very low (approximately 10 fish per day). These alternatives would not reduce entrainment losses substantially.
Provide Lateral Escapeways at Contra Costa 1-5	It was concluded in the 1982 assessment that lateral escapeways would not significantly reduce entrainment or impingement losses. No new information is available to suggest that striped bass losses would be reduced substantially by this alternative.
Maintenance Dredging	This alternative was implemented in 1983.
Bar Rack Maintenance	This alternative was implemented in 1983.
Removal of Predatory Fish at Contra Costa 1-5	No new information is available to suggest that this alternative would contribute to a significant reduction in striped bass losses. Predatory fish, including striped bass and catfish, were removed from the Contra Costa 1-5 intake structure in 1983 when the intake was dewatered for maintenance and repair. Observations made in the Contra Costa 1-5 intake forebay over the past two years suggest that predation losses are not significant at the present time.
Addition of Physical Barriers - Cylindrical Wedge Wire Screens	As discussed in the 1982 assessment report, designs for this type of system have not been tested for power plant cooling water systems as large as those of Contra Costa or Pittsburg. No additional data is available on the operations or reliability of wedge wire screens at power plants with cooling water flows and environmental conditions similar to those at Pittsburg or Contra Costa.
Fish Pump Removal Systems	A fish pump removal system is in operation at Contra Costa 1-5 but was determined in the 1982 assessment to be ineffective at Pittsburg as well as the remaining units at Contra Costa. No new information is available to suggest that fish pumps would be effective in reducing striped bass losses at the shoreline intake structures for either the Pittsburg Power Plant or Contra Costa Units 6 and 7.
Mechanical Draft Cooling Towers	Based on information presented in the 1982 assessment, it was concluded that the cost of mechanical draft cooling towers was disproportionate to the expected reduction in striped bass losses. No new information is available to suggest that the cost of mechanical draft cooling towers would be substantially less than that estimated in the 1982 assessment.
Alternative Cooling Water Sources	The only potentially feasible alternative source of cooling water identified in the 1982 assessment for the Contra Costa and Pittsburg power plants would be unavailable until after 1994. No additional information is available to suggest that alternative water sources would be potentially available earlier than predicted in the 1982 assessment.

TABLE 2-3

ALTERNATIVES EVALUATED IN DETAIL IN THE 1985 REEVALUATION

ALTERNATIVE	COMMENTS
1 **Modify Existing Traveling Water Screens**	See Section 2.4
Reduce Circulating Water Pump Operation	See Section 2.5
Contra Costa 1-5 and Pittsburg 1-4	
2 - VSD motor controls	See Section 2.5.1
3 - Two-speed motors	See Section 2.5.2
4 - Magnetic couplings	See Section 2.5.3
5 - Cross overs at Contra Costa 1-3	See Section 2.5.4
6 - Cross overs at Pittsburg 1-4	See Section 2.5.5
Contra Costa 1-3 house units only	
7 - Combined VSDs and two-speed motors	See Section 2.6
8 - House unit supply from Units 6 and 7	
9 - New pump(s) for house units	
10 - Modification to existing supply conduits	
11 - Recirculation water flow	
Contra Costa Units 6 and 7 only	
12 - Hydrogen cooling improvements	See Section 2.7
Resource Management	See Section 2.8
13 - Dispatch units based on location of striped bass	See Section 2.8.1
14 - Dispatch units to operate with discharge temperatures of 86 degrees F or less when possible.	See Section 2.8.2

following sections provide summary descriptions of the engineering and economic characteristics of each alternative and discuss the potential effectiveness of each alternative in reducing striped bass losses.

The effectiveness of the various alternatives in reducing striped bass losses was estimated using biological and operational data from 1984 and 1985 which reflects the resource management program and other operational changes utilized during the entrainment periods of these two years to reduce striped bass losses. The method used in 1984 and 1985 to determine the entrainment start date and end date relied on a threshold density of 9-10mm striped bass entrained at the Pittsburg Power Plant and on the use of CDFG summer tow net survey data each year (as specified in the NPDES permits), respectively. Considering the recent changes in the geographic distribution and relative densities of striped bass susceptible to entrainment, a more sensitive approach to determining when striped bass are entrained at the two plants each year is appropriate. Results of the entrainment monitoring studies required at both plants provide the data necessary to establish the entrainment period start and end dates based on a density threshold of striped bass actually entrained at both power plants as discussed in Section 2.8.

The incremental reduction in striped bass losses estimated for each alternative should be considered as only a relative tool in evaluating alternatives, since the actual effectiveness of each alternative would vary in future years with variation in both operational and biological factors affecting striped bass losses. The incremental percentage reduction in striped bass losses achieved by various alternatives in this assessment, primarily operational alternatives such as dispatch of units based on the geographic distribution of striped bass and maintaining discharge temperatures below 86°F when possible, would vary in the future years depending on plant operations, the spatial distribution of larval and juvenile striped bass, and the timing and duration of the entrainment period.

2.4 MODIFIED VERTICAL TRAVELING WATER SCREENS

Modifications to the existing traveling water screens (TWS) and fish handling systems may be feasible at the Pittsburg and Contra Costa power plants. These modifications could include use of such features as finer mesh screens, fish buckets, increased screen rotation frequency, dual sprays, and gravity sluiceway fish return systems. While these devices have the potential to be effective means for reducing either entrainment or impingement impacts, their use must include consideration of a balance between biological performance and reliable operation of the intake system. It would not be prudent to install such devices for these intake systems without first testing both the physical and biological effectiveness of such devices. Field studies were conducted at the Pittsburg Power Plant in 1983 to evaluate both the operational and biological effectiveness of modified intake screens. Because of the low number of striped bass collected in the study, results from the impingement survival study were inconclusive. The extremely low numbers of striped bass collected at the Pittsburg Power Plant during 1984 and 1985 would not have provided sufficient numbers of striped bass to support another attempt to quantitatively study the biological effectiveness of the modified screen.

The discussion which follows presents the conceptual design and environmental assessment associated with implementing modified vertical traveling screens, on a full-scale basis, on each of the existing intake structures at the Pittsburg and Contra Costa power plants.

Conceptual Design

This alternative involves the use of modified vertical traveling screens as a possible means of reducing impingement and entrainment losses at the Pittsburg and Contra Costa power plants. This retrofit program could involve modifying the existing vertical traveling screens such that they would have fine mesh screens, fish buckets along the base of each screen panel, a low-pressure spray to wash the fish from the screen, high-pressure sprays for debris removal, continuous screen rotation, and a gravity sluiceway to return the fish to the river.

Design Configuration

The modifications which could be made to each vertical traveling water screen include the following:

- o Replace existing baskets with free-style fish-handling baskets fitted with fish troughs along trailing edge (Figure 2-1)
- o Replace existing screens with fine-mesh woven wire screens (e.g., 1/8" x 1/2" mesh)
- o Install roller bearings on head shaft
- o Install stoody bushing on foot shaft
- o Replace basket chains
- o Change high-pressure (95 psig) upper spray to low-pressure (10-15 psig) back spray of same flow rate
- o Modify splash housing to accommodate fish return sluiceway.

Facility Requirements

No modifications to the concrete structure would be necessary for the intake at Contra Costa 1-5. A single fish sluiceway could be built to run the length of the intake structure of Pittsburg 1-6. This sluiceway would collect fish from all 13 screens and carry them to the west end of the intake structure of Pittsburg 5 and

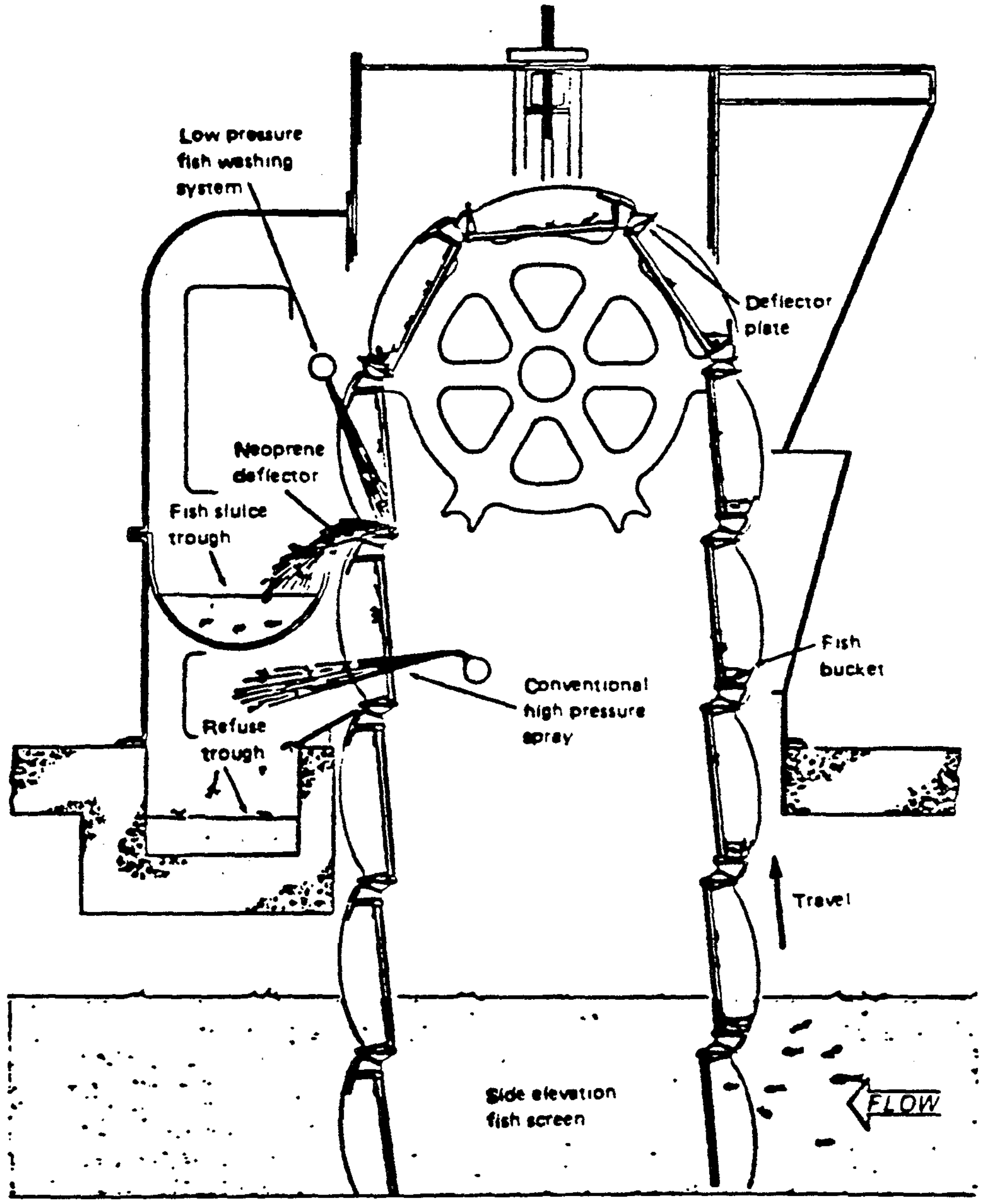

FIGURE 2-1

RISTROPH MODIFIED TRAVELING SCREEN WITH FISH BUCKETS, A MODIFIED SPRAY AND WATER SYSTEM, AND A SLUICEWAY FOR FISH (COURTESY OF ENVIREX)

6. Similarly, a sluiceway could be built to run the length of the intake headworks at Contra Costa 6 and 7. It would collect fish from the six screens and carry them to the east end of the structure. The sluiceways would be limited to an average slope of approximately 0.7 percent except at the discharge, which would angle steeply downward to lower the fish quickly into the river. The main wash water distribution header would have to be relocated if the fish sluiceway is to be located adjacent to the existing debris trough on the back side of the screens. Possible alternative locations are the curb of the service road or on the deck in front of the screens.

From the fish sluiceway located on the intake structure, the fish would enter a sluiceway conduit which would ultimately carry them back to the river. The pipe for Pittsburg 1-6 would be approximately 22 in. in diameter, and the pipes for Contra Costa 1-5 and 6 and 7 would be about 16 in. in diameter, both made of fiberglass.

To ensure flow velocities greater than the sustained cruise speed of the fish, a slope greater than 0.5 percent would be required. However, if subsequent analyses show that it is desirable to keep the flow subcritical (where deep flow becomes a thin, high velocity film) in order to preclude shock impacts, the slope would be maintained at less than 1 percent. Assuming the need for subcritical flow, an average slope of 0.7 percent was used as the design point.

In the design concept, the fish return conduit would run 300 ft along the shore. The conduit would be maintained at a 0.7 percent grade, to ensure deep rapid flow, until near the point where the fish would be released where the conduit would slant downward at a 45 degree angle to lower the fish rapidly into the water. Finally, the conduit would discharge to the river at least 20 ft offshore.

Performance

Because of the uncertainties associated with the operation and biological effectiveness of modified intake screens installed at the Pittsburg and Contra Costa power plants, PGandE installed and tested a fine-mesh Ristroph modified traveling water screen at the intake structure of Pittsburg Power Plant

Units 1-4. The tests were conducted between November 1982 and January 1984. The principal objectives of these tests were to:

- o Determine if the modified screen is operationally acceptable
- o Determine if the modified screen would significantly reduce striped bass losses.

Operational Tests

The operational performance of the modified screen was evaluated using the following three criteria:

1. The modified screen must be capable of passing sufficient water flow to the circulating water pumps under various seasonal Suisun Bay water conditions
2. The amount of carryover or leakage of debris into the circulating water system must not impair plant availability or reliability
3. The maintenance requirements of the modified screen must not impair plant availability or reliability.

In order to characterize the environmental and operational conditions under which the modified screen was being tested, the following data were collected: sediment levels behind Units 1-7 intake screens; a series of measurements to index the bathymetric contours in front of the intake structures; drive motor operations on the modified screen; differential hydraulic gradients across the modified screen; and tide elevations at the plant.

In conjunction with this supplementary data, the water velocities were continuously measured behind seven traveling water screens serving Units 1-4. This included the modified screen to determine if the fine-mesh screen can pass sufficient water flow to the circulating water pumps (criterion 1). This was done between November 1982 and November 1983. Based on a comparison of these velocity measurements, the conclusion was reached that the fine-mesh modified screen can pass sufficient water to the circulating water pumps to maintain unit operation. Operation of the modified screen was acceptable during the test based on criterion 1.

From November 1982 to January 1984, visual inspections of the modified screen baskets were made periodically and documented to determine if the amount of carryover or leakage of debris associated with the modified screen would impair plant availability or reliability (criterion 2). Also, a log was kept noting the frequency of cleaning and volume of debris removed from each condenser water box inlet. In summary, the modified screen appeared to satisfactorily exclude most of the typical debris (e.g., peat) from the circulating water system; however, the spraywash system of the modified screen did not adequately remove filamentous algae that became entwined in the modified screen and subsequently carried over into the circulating water system where it then fouled the condenser water box inlet and had to be removed manually. Based on observations by PGandE personnel, carryover of this algae has not been a problem on the conventional screens in the past or during the test period. The likelihood of the algae recurring in abundance in the vicinity of Pittsburg and Contra Costa power plants in future years is unknown. Therefore, no conclusion can be made as to whether or not this would be a chronic operational maintenance problem for the modified screen. Another concern is the ability of the modified screen to exclude the large (heavy) amounts of debris from the cooling water system which have been a problem in previous years with the conventional screens. During this test, large quantities of debris did not come into contact with the modified screen. Therefore, no conclusion was made on how well the modified screen would perform in excluding large amounts of debris from the circulating water system. Results of the testing program were inconclusive regarding criterion 2.

From November 1982 to January 1984, maintenance records were kept for work performed on the modified screen as well as on the adjacent conventional screens to determine if maintenance requirements of the modified screen would impair plant availability or reliability (criterion 3). The modified screen had more maintenance requirements than the conventional screens; however, PGandE staff considered the increased maintenance level acceptable. Although PGandE followed routine maintenance requirements for the modified screen and these requirements did not impair plant availability or reliability, there were two outages of the modified screen attributable to failure of screen components during the test period. Both outages were related to continuous operation of the modified screen. The first outage was due to a worn motor bearing which occurred 13 weeks after beginning continuous operation. The second outage, which occurred after 14 months of operation, was due to failure of the basket chains. During the examination of the screen, PGandE personnel observed that the basket chain had fractured in two locations and that some of the baskets had become bent. In addition, excessive wear of the basket end plates, the drive sprockets, and the boot plate was noted. This indicated that the modified screen failure may have been due to the basket chain stretching. The mechanical failure of the screen was evaluated; however, additional information on screen maintenance requirements needs to be compiled before a conclusion can be drawn regarding the impact of increased screen maintenance (routine preventive maintenance, screen overhaul, and repair frequency following mechanical failure) on plant operations.

Biological Tests

The biological evaluation of the modified screen tested at the Pittsburg Power Plant was developed within the framework provided by the striped bass simulation model (SIMBAS). This model has established a basis for estimating incremental benefits for reducing striped bass losses associated with installation of modified intake screens at the Pittsburg and Contra Costa power plants. However, several basic assumptions included in SIMBAS have been founded on a synthesis of data compiled primarily from laboratory studies on size-specific screen retention, low-pressure spraywash efficiency, and impingement survival of larval and juvenile striped bass. The Pittsburg field study was developed to provide quantitative information about impingement of striped bass on the modified screen for use in evaluating the screen's biological effectiveness.

The biological field studies were conducted from June to September 1983. These studies were intended to provide data useful in determining: (1) the efficiency of the low-pressure spraywash system in removing different size classes of striped bass from the test screen; (2) the specific size classes of striped bass retained on the small-mesh screen; and (3) the proportion of striped bass in each size class surviving impingement on the modified intake screen. A total of 217 impingement samples were collected in 35 days of sampling which resulted in the collection of only 287 striped bass (only 61 of 217 samples contained striped bass). Because so few striped bass were collected during the test period, the results of the biological field studies are statistically inconclusive.

Available data indicate that the low-pressure spraywash system was effective (greater than 80 percent removal efficiency) in removing impinged striped bass greater than 30 mm long from the modified screen, but substantially less effective for smaller striped bass. However, no definite conclusions could be drawn because of the small number of striped bass collected in the impingement samples. Size-specific screen retention could not be quantified with confidence by normalizing densities to 150 mm equivalent bass because a statistically insignificant number of striped bass were collected in the impingement samples. General trends in the length frequency distributions of striped bass collected, however, suggest that retention of striped bass less than 20 mm in length is low and that most striped bass greater than approximately 25 mm long appear to be retained by the modified screen. An insufficient number of striped bass were collected to statistically characterize the 96-hour impingement survival. General trends in impingement survival observed for the juvenile striped bass collected in this study were, however, considerably lower than those expected based on laboratory findings.

A biological evaluation of modified vertical traveling screens conducted at the Danskammer Point Generating Station (Hudson River, New York) provided results similar to results of the impingement survival study conducted on the modified screen at the Pittsburg Power Plant. Intake screen modifications tested in the Danskammer impingement survival study consisted of fish buckets on the screen panels, a neoprene splash plate, and a low-pressure spraywash header. This study directly compared impingement survival rates at the

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modified screen with those at a standard vertical traveling intake screen during continuous and intermittent wash modes. White perch were the most common species collected during the tests. Long-term (84-hour) impingement survival was found to be significantly lower on the modified screen than on the conventional screen during continuous operation for young-of-the-year white perch impinged during the fall and for yearlings and adults impinged during the spring. Survival of yearlings (only 54 collected) during the winter was not significantly different between the modified and conventional screens. The study concluded that "under the conditions observed at the Danskammer plant, there seems to be no particular advantage in using the modified screen system" (A Biological Evaluation of Modified Vertical Traveling Screens. Prepared for Central Hudson Gas and Electric Corporation by Ecological Analysts, Inc. 1982.).

Field studies conducted at the Pittsburg Power Plant and the studies at the Danskammer plant both suggest that modified intake screens are not effective in consistently improving survival of impinged striped bass and white perch.

The extremely low numbers of striped bass collected in impingement monitoring studies during 1984 and 1985 to date at the Pittsburg Power Plant would not have provided sufficient numbers of striped bass to support a quantitative study (with statistically significant results) of the biological effectiveness of the modified screen.

Costs

The estimated capital costs and economic evaluation for modified screen designs at the Contra Costa and Pittsburg power plants are shown in Tables 2-4 and 2-5.

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3/8" or fine mesh?
-either one, same cost

TABLE 2-4

ECONOMIC EVALUATION OF
MODIFIED SCREEN DESIGNS
CONTRA COSTA UNITS 1 - 7 (a)

COST COMPONENT	CONTRA COSTA UNIT 1	UNIT 2	UNIT 3	UNIT 4	UNIT 5	UNIT 6	UNIT 7	TOTALS
Capital cost (1983 dollars)	127,700	127,700	127,700	127,700	127,700	400,500	400,500	1,439,500
Labor Cost (1983 dollars)	10,200	10,200	10,200	10,200	10,200	32,500	32,500	116,000
Total Capital plus Labor (1983 dollars)	137,900	137,900	137,900	137,900	137,900	433,000	433,000	1,555,500
Total Capital plus Labor (1985 dollars)	154,365	154,365	154,365	154,365	154,365	484,700	484,700	1,741,227
Contingency	23,155	23,155	23,155	23,155	23,155	72,705	72,705	261,184
Total Direct Costs	177,520	177,520	177,520	177,520	177,520	557,405	557,405	2,002,411
Capital Indirects	52,670	52,670	52,670	52,670	52,670	165,382	165,382	594,115
Overhead Costs	37,705	37,705	37,705	37,705	37,705	118,393	118,393	425,311
Total Cost	267,895	267,895	267,895	267,895	267,895	841,180	841,180	3,021,837 ←
Annual Cost (@ 10 yr life)	68,554	68,554	68,554	68,554	68,554	215,258	215,258	773,288
Annual Cost (@ 15 yr life)	56,231	56,231	56,231	56,231	56,231	176,564	176,564	634,284
Annual Cost (@ 20 yr life)	50,847	50,847	50,847	50,847	50,847	159,656	159,656	573,545
Power to Pumps (energy and capacity)	12,820	12,820	12,820	12,820	12,820	38,450	38,450	141,000
Pump Maintenance	3,480	3,480	3,480	3,480	3,480	10,400	10,400	38,200
Power to Traveling Water Screens	440	440	440	440	440	1,300	1,300	4,800
Maintenance	15,340	15,340	15,340	15,340	15,340	46,000	46,000	168,700
Total Annual Cost @ 10 yr life	100,634	100,634	100,634	100,634	100,634	311,408	311,408	1,125,988
Total Annual Cost @ 15 yr life	88,311	88,311	88,311	88,311	88,311	272,714	272,714	986,984
Total Annual Cost @ 20 yr life	82,927	82,927	82,927	82,927	82,927	255,806	255,806	926,245

NOTES: (a) Cost calculations by TERA 9-30-85 based on data from the 1982 study.

~~1980, '81 dollars?~~

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TABLE 2-5

ECONOMIC EVALUATION OF
MODIFIED SCREEN DESIGNS
PITTSBURG UNITS 1 - 6 (a)

COST COMPONENT	PITTSBURG UNIT 1	UNIT 2	UNIT 3	UNIT 4	UNIT 5	UNIT 6	TOTALS
Capital cost (1982 dollars)	220,750	220,750	220,750	220,750	411,500	411,500	1,706,000 ←
Labor Cost (1982 dollars)	17,750	17,750	17,750	17,750	33,000	33,000	137,000
Total Capital plus Labor (1982 dollars)	238,500	238,500	238,500	238,500	444,500	444,500	1,843,000
Total Capital plus Labor (1985 dollars)	266,977	266,977	266,977	266,977	497,573	497,573	2,063,054
Contingency	40,047	40,047	40,047	40,047	74,636	74,636	309,458
Total Direct Costs	307,023	307,023	307,023	307,023	572,209	572,209	2,372,512
Capital Indirects	85,230	85,230	85,230	85,230	158,845	158,845	658,609
Overhead Costs	64,369	64,369	64,369	64,369	119,966	119,966	497,407
Total Cost	456,622	456,622	456,622	456,622	851,021	851,021	3,528,529 ←
Annual Cost (@ 10 yr life)	116,850	116,850	116,850	116,850	217,776	217,776	902,951
Annual Cost (@ 15 yr life)	95,845	95,845	95,845	95,845	178,629	178,629	740,638
Annual Cost (@ 20 yr life)	86,667	86,667	86,667	86,667	161,524	161,524	669,715
Power to Pumps (energy and capacity)	20,150	20,150	20,150	20,150	63,750	63,750	208,100
Pump Maintenance	5,400	5,400	5,400	5,400	16,900	16,900	55,400
Power to Traveling Water Screens	475	475	475	475	7,250	7,250	16,400
Maintenance	22,050	22,050	22,050	22,050	59,000	59,000	206,200
Total Annual Cost @ 10 yr life	164,925	164,925	164,925	164,925	364,676	364,676	1,389,051
Total Annual Cost @ 15 yr life	143,920	143,920	143,920	143,920	325,529	325,529	1,226,738
Total Annual Cost @ 20 yr life	134,742	134,742	134,742	134,742	308,424	308,424	1,155,815

NOTES: (a) Cost calculations by TERA 9-30-85 based on data from the 1982 study.

1,226,738
986,984
2,213,722

3,528,529
3,021,837
6,550,366 - total for all units

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Effects On Striped Bass

The potential reduction in striped bass losses attributable to installation of modified traveling screens at the Pittsburg and Contra Costa power plants was estimated using results from the hindcast version of the striped bass simulation model (SIMBAS). Assumptions regarding size-specific impingement survival used in the analyses were those based primarily on laboratory studies (referred to as literature-based impingement survival results, where survival varies from 0.62 to 0.75). Biological data collected in the modified screen test conducted at the Pittsburg Power Plant in 1983 suggest that actual survival of striped bass impinged on modified screens is substantially lower than impingement survival rates derived from laboratory studies (where survival varies from 0 to 0.59). Incremental percentage reduction estimates were also calculated using results of the 1983 impingement study. The 1984 striped bass density distribution and plant operation data were used in the analysis. Operational conditions for 1976, 1978, and 1979 were used as the basis for comparison.

The incremental percentage reduction in relative striped bass losses associated with installation of modified intake screens is shown below:

	Incremental Percentage Reduction		
	Contra Costa 1-5	Pittsburg 1-4, 7	Contra Costa 6 and 7, and Pittsburg 5 and 6
Impingement Survival Results Based On Literature			
Modified screens with 3/8 in. mesh	0.3	0.6	1.3
Modified screens with fine screen mesh (1/8 x 1/2 in.)	-3.8*	1.0	0.5
1983 Pittsburg Impingement Survival Results			
Modified screens with 3/8 in. mesh	0.1	0.2	0.3
Modified screens with fine screen mesh (1/8 x 1/2 in.)	-3.8*	-11.4	-16.5*

* Increase in losses.

A reduction in losses on a fine-mesh screen compared with losses on a conventional 3/8 in. mesh screen would occur if the impingement survival rate of those fish retained on the fine-mesh screen but not on the 3/8 in. mesh screen is higher than the entrainment survival rate. In years when the intake water temperatures and plant operation are greater, the entrainment survival rate would be less.

During 1984 (March 1, 1984 to February 28, 1985) an estimated 32,650 equivalent striped bass were ~~cropped~~ killed at the Pittsburg and Contra Costa power plants combined. It was estimated that modified screens installed at the two plants would have reduced (increased) the number of equivalent striped bass ~~cropped~~ killed in 1984 as shown below:

	Reduction in Equivalent Striped Bass ~~Cropped~~ killed in 1984		
	Contra Costa 1-5	Pittsburg 1-4, 7	Contra Costa 6 and 7, and Pittsburg 5 and 6
Impingement Survival Results Based On Literature			
Modified screens with 3/8 in. mesh	250	550	1150
Modified screens with fine screen mesh (1/8 x 1/2 in.)	-3400*	900	400
1983 Pittsburg Impingement Survival Results			
Modified screens with 3/8 in. mesh	100	150	300
Modified screens with fine screen mesh (1/8 x 1/2 in.)	-3400*	-10000	-14550*

* Increase in losses.

Because of uncertainties regarding their potential effectiveness in reducing striped bass losses, it was concluded that modified intake screens with 3/8 in. ~~screen mesh or finer mesh~~ are not a demonstrated technology for use at the Pittsburg and Contra Costa power plants.

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2.5 ALTERNATIVES TO REDUCE CIRCULATING WATER PUMP OPERATION AT CONTRA COSTA 1-5 AND PITTSBURG 1-4

The 1982 assessment completed by PGandE identified four major alternatives available for reducing the operation (and thus the cooling water flows) of the circulating water pumps at both the Contra Costa and Pittsburg power plants. These alternatives included new equipment or modifications to the pumps serving the main units at each plant and consisted of 1) VSD motor controls; 2) two-speed motors; 3) magnetic couplings; and 4) cross-over systems to permit single pump operation at certain units. Each of these four alternatives has been reevaluated in this assessment for those units at the plants which do not now employ VSDs. In addition to these alternatives, PGandE has identified options for reducing cooling water flows associated with operation of Contra Costa house units.

2.5.1 VSD MOTOR CONTROLS

The installation of new motors with variable speed (frequency) controls on the circulating water pumps at the Pittsburg 1-4 and Contra Costa 1-5 units would allow flexibility in matching circulating water flow rates to unit load.

Conceptual Design

Variable speed controls modify the frequency of the electricity used to run motors and thereby allow normal single-speed motors to operate at variable speeds. At present the only variable frequency controls available for loads below 800 hp operate at 480 volts. These controls could be installed at Pittsburg 1-4 to control the existing circulating water pump motors, which currently run off 480-volt busses. Because the motors for the Contra Costa units draw current from 4160-V busses, stepdown transformers would be required. The controls would require construction of air conditioned motor control buildings, step-down transformers for the new motors and condenser air evacuation pumps.

Based on monitoring and operating data acquired since installation of VSD units at Contra Costa 6 and 7 and Pittsburg 5 and 6, VSD installations at the smaller units of the plants could reduce total annual circulating water volumes by approximately 40 percent.

Costs

The estimated costs and economic evaluations for installation and operation of variable speed pump controls at Contra Costa Units 1-5 and Pittsburg Units 1-4 are shown in Tables 2-6 and 2-7.

Effects On Striped Bass

The potential incremental reduction in striped bass losses at Pittsburg Units 1-4 and Contra Costa Units 1-5 was estimated using the forecast version of the striped bass simulation model (SIMBAS). The forecast version uses estimates of intake temperature and plant load to estimate discharge temperatures and cooling water volumes. While this approach makes it difficult to accurately reproduce actual 1984 discharge temperatures and flow conditions, it does allow for consideration of variations in cooling water flow where VSD operation depends on load and temperature. The 1984 striped bass density distribution and plant operation data was used in the analysis, and operational conditions for 1976, 1978, and 1979 were used as the basis for comparison. During the period from March 1, 1984 to February 28, 1985 an estimated 32,650 equivalent striped bass (from a hindcast model simulation) were ~~cropped~~ killed at the two plants. The estimated reduction in the number of equivalent striped bass ~~cropped~~ killed in 1984 and the corresponding incremental percentage reductions in losses associated with the simulated operations of variable speed pump control are shown below:

	Contra Costa 1-3	Contra Costa 4 and 5	Pittsburg 1-4
Estimated reduction in equivalent striped bass ~~cropped~~ killed in 1984	600	350	1,750
Estimated incremental percentage reduction	0.7	0.4	1.9

TABLE 2-6

ECONOMIC EVALUATION OF
VSD INSTALLATIONS AT
CONTRA COSTA UNITS 1 - 5 (a)

COST COMPONENT	CONTRA COSTA UNIT 1	UNIT 2	UNIT 3	UNIT 4	UNIT 5	TOTALS
Material Cost	301,000	301,000	301,000	301,000	301,000	1,505,000
Labor Cost	235,000	235,000	235,000	235,000	235,000	1,175,000
Total Direct Cost	536,000	536,000	536,000	536,000	536,000	2,680,000
Capital Indirects	159,031	159,031	159,031	159,031	159,031	795,156
Overhead Costs	113,846	113,846	113,846	113,846	113,846	569,231
Total Cost	808,877	808,877	808,877	808,877	808,877	4,044,387
Annual Cost (@10 yr life) (b)	206,992	206,992	206,992	206,992	206,992	1,034,959
Annual Cost (@15 yr life) (b)	169,783	169,783	169,783	169,783	169,783	848,917
Annual Cost (@20 yr life) (b)	153,525	153,525	153,525	153,525	153,525	767,625
Annual Auxiliary Power Savings (@10 yr life) (c)	27,000	27,000	27,000	115,000	115,000	311,000
Annual Auxiliary Power Savings (@15 yr life) (c)	33,000	33,000	33,000	137,000	137,000	373,000
Annual Auxiliary Power Savings (@20 yr life) (c)	38,000	38,000	38,000	160,000	160,000	434,000
Annual Heat Rate Penalty (@ 10 yr life)	4,000	4,000	4,000	43,000	43,000	98,000
Annual Heat Rate Penalty (@ 15 yr life)	5,000	5,000	5,000	51,000	51,000	117,000
Annual Heat Rate Penalty (@ 20 yr life)	6,000	6,000	6,000	60,000	60,000	138,000
Net Savings (cost) @ 10 yr life	(183,992)	(183,992)	(183,992)	(134,992)	(134,992)	(821,959)
Net Savings (cost) @ 15 yr life	(141,783)	(141,783)	(141,783)	(83,783)	(83,783)	(592,917)
Net Savings (cost) @ 20 yr life	(121,525)	(121,525)	(121,525)	(53,525)	(53,525)	(471,625)

NOTES: (a) Cost calculations and assumptions by PGandE 9-25-85.

(b) Based on levelized fixed charge rates of: 25.59% for 10-year life, 20.99% for 15-year life, and 18.98% for 20-year life.

(c) Based on levelized system power values of: $0.070/kwh for 10-year life, $0.083/kwh for 15-year life, and $0.097/kwh for 20-year life.

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TABLE 2-7

ECONOMIC EVALUATION OF
VSD INSTALLATIONS AT
PITTSBURG UNITS 1-4 (a)

COST COMPONENT	PITTSBURG UNIT 1	UNIT 2	UNIT 3	UNIT 4	TOTALS
Material Cost	256,000	256,000	256,000	256,000	1,024,000
Labor Cost	220,000	220,000	220,000	220,000	880,000
Total Direct Cost	476,000	476,000	476,000	476,000	1,904,000
Capital Indirects	132,138	132,138	132,138	132,138	528,550
Overhead Costs	99,795	99,795	99,795	99,795	399,182
Total Cost	707,933	707,933	707,933	707,933	2,831,732
Annual Cost (@10 yr life) (b)	181,160	181,160	181,160	181,160	724,640
Annual Cost (@15 yr life) (b)	148,595	148,595	148,595	148,595	594,381
Annual Cost (@20 yr life) (b)	134,366	134,366	134,366	134,366	537,463
Annual Auxiliary Power Savings (@10 yr life) (c)	109,000	109,000	109,000	109,000	436,000
Annual Auxiliary Power Savings (@15 yr life) (c)	129,000	129,000	129,000	129,000	516,000
Annual Auxiliary Power Savings (@20 yr life) (c)	151,000	151,000	151,000	151,000	604,000
Annual Heat Rate Penalty (@ 10 yr life)	80,000	80,000	80,000	80,000	320,000
Annual Heat Rate Penalty (@ 15 yr life)	95,000	95,000	95,000	95,000	380,000
Annual Heat Rate Penalty (@ 20 yr life)	111,000	111,000	111,000	111,000	444,000
Net Savings (cost) @ 10 yr life	(152,160)	(152,160)	(152,160)	(152,160)	(608,640)
Net Savings (cost) @ 15 yr life	(114,595)	(114,595)	(114,595)	(114,595)	(458,381)
Net Savings (cost) @ 20 yr life	(94,366)	(94,366)	(94,366)	(94,366)	(377,463)

NOTES: (a) Cost calculations and assumptions by PGandE 9-25-85.

(b) Based on levelized fixed charge rates of: 25.59% for 10-year life, 20.99% for 15-year life, and 18.98% for 20-year life.

(c) Based on levelized system power values of: $0.070/kwh for 10-year life, $0.083/kwh for 15- and $0.097/kwh for 20-year life.

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2.5.2 TWO-SPEED MOTORS

The installation of two-speed motors on the circulating water pumps at the Pittsburg 1-4 and Contra Costa 1-5 units would allow some flexibility in matching circulating water flow rates to unit load.

Conceptual Design

This alternative, without the retrofitting described for the cross-over system in Section 2.5.4, would require new two-speed motors, an upgraded motor control center, and condenser air evacuation pumps.

Performance

This system would limit the choice of circulating water flow rates. Contra Costa 1-5 could be operated with circulating water flow rates equal to approximately 50, 75, and 100 percent of those which currently occur when two circulating water pumps are operated per unit. It would also be possible to operate Pittsburg 1-4 at rates equal to approximately 50, 75, and 100 percent of the present rates of flow through these units. A 50 percent flow rate would be achieved by operation of the two circulating water pumps at a unit at the lower of the two pump speeds. Operation of the two circulating water pumps at a unit in the higher of the two pump speeds would result in a cooling water flow of 100 percent of that which currently occurs. A 75 percent cooling water flow rate would be achieved by operating one circulating water pump at the lower speed and one pump at the higher speed. The actual achievable flow rates would be dependent upon the speed ratio selected for the motors, which in turn would depend upon the system head characteristics.

Although installation of two-speed motors would allow some flexibility in matching circulating water flow rates to unit load, two-speed motors offer less operational flexibility than variable speed pump controls (Section 2.5.1).

Costs

The estimated costs and economic evaluations for the installation and operation of two-speed motors at Contra Costa Units 1-5 and Pittsburg Units 1-4 are shown in Tables 2-8 and 2-9.

Effects On Striped Bass

The effectiveness of two-speed motors in reducing striped bass losses at Contra Costa 1-5 and Pittsburg 1-4 was estimated based on the assumption that the pumps would operate at 50 percent flow when unit load was at or below 50 percent. Circulating water flow was assumed to be 75 percent of design at unit loads from 51 to 75 percent and that cooling water flows would be 100 percent of design when unit load was above 75 percent. Pump operation was assigned to the lowest level possible within eight-hour or longer time periods based on an inspection of hourly unit load records. The eight-hour time period assumed in this analysis was based on an operational constraint in which motor speed would be changed no more than once in eight hours. After determining the cooling water flows for each time period for each unit, normalized striped bass losses were calculated using 1984 biological monitoring data. The incremental striped bass loss reduction was then calculated for each unit using the estimated equivalent loss based on actual operations in 1984.

During the period from March 1, 1984 to February 28, 1985 an estimated 32,650 equivalent striped bass were ~~cropped~~ killed at the two plants. The estimated reduction in the number of equivalent striped bass ~~cropped~~ killed in 1984 and the incremental percentage reductions in losses resulting from the simulated operation of two-speed motors are shown below:

	Contra Costa 1-3	Contra Costa 4 and 5	Pittsburg 1-4
Estimated reduction in equivalent striped bass ~~cropped~~ killed in 1984	600	300	1,650
Estimated incremental percentage reduction	0.7	0.3	1.8

TABLE 2-8

ECONOMIC EVALUATION OF
TWO SPEED MOTOR INSTALLATIONS AT
CONTRA COSTA UNITS 1 - 5 (a)

COST COMPONENT			CONTRA COSTA			
	UNIT 1	UNIT 2	UNIT 3	UNIT 4	UNIT 5	TOTALS
Material Cost	242,000	242,000	242,000	242,000	242,000	1,210,000
Labor Cost	158,000	158,000	158,000	158,000	158,000	790,000
Total Direct Cost	400,000	400,000	400,000	400,000	400,000	2,000,000
Capital Indirects	118,680	118,680	118,680	118,680	118,680	593,400
Overhead Costs	84,960	84,960	84,960	84,960	84,960	424,799
Total Cost	603,640	603,640	603,640	603,640	603,640	3,018,199
Annual Cost (@10 yr life) (b)	154,471	154,471	154,471	154,471	154,471	772,357
Annual Cost (@15 yr life) (b)	126,704	126,704	126,704	126,704	126,704	633,520
Annual Cost (@20 yr life) (b)	114,571	114,571	114,571	114,571	114,571	572,854
Annual Auxiliary Power Savings (@10 yr life) (c)	28,000	28,000	28,000	116,000	116,000	316,000
Annual Auxiliary Power Savings (@15 yr life) (c)	33,000	33,000	33,000	138,000	138,000	375,000
Annual Auxiliary Power Savings (@20 yr life) (c)	38,000	38,000	38,000	161,000	161,000	436,000
Annual Heat Rate Penalty (@ 10 yr life)	4,000	4,000	4,000	43,000	43,000	98,000
Annual Heat Rate Penalty (@ 15 yr life)	5,000	5,000	5,000	51,000	51,000	117,000
Annual Heat Rate Penalty (@ 20 yr life)	6,000	6,000	6,000	60,000	60,000	138,000
Net Savings (cost) @ 10 yr life	(130,471)	(130,471)	(130,471)	(81,471)	(81,471)	(554,357)
Net Savings (cost) @ 15 yr life	(98,704)	(98,704)	(98,704)	(39,704)	(39,704)	(375,520)
Net Savings (cost) @ 20 yr life	(82,571)	(82,571)	(82,571)	(13,571)	(13,571)	(274,854)

NOTES: (a) Cost calculations and assumptions by PGandE 9-25-85.

(b) Based on levelized fixed charge rates of: 25.59% for 10-year life, 20.99% for 15-year life, and 18.98% for 20-year life.

(c) Based on levelized system power values of: \$0.070/kwh for 10-year life, \$0.083/kwh for 15-year life, and \$0.097/kwh for 20-year life.

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TABLE 2-9

ECONOMIC EVALUATION OF
TWO SPEED PUMP INSTALLATIONS AT
PITTSBURG UNITS 1-4 (a)

COST COMPONENT	PITTSBURG				
	UNIT 1	UNIT 2	UNIT 3	UNIT 4	TOTALS
Material Cost	249,000	249,000	249,000	249,000	996,000
Labor Cost	169,000	169,000	169,000	169,000	676,000
Total Direct Cost	418,000	418,000	418,000	418,000	1,672,000
Capital Indirects	116,037	116,037	116,037	116,037	464,147
Overhead Costs	87,635	87,635	87,635	87,635	350,542
Total Cost	621,672	621,672	621,672	621,672	2,486,689
Annual Cost (@10 yr life) (b)	159,086	159,086	159,086	159,086	636,344
Annual Cost (@15 yr life) (b)	130,489	130,489	130,489	130,489	521,956
Annual Cost (@20 yr life) (b)	117,993	117,993	117,993	117,993	471,974
Annual Auxiliary Power Savings (@10 yr life) (c)	110,000	110,000	110,000	110,000	440,000
Annual Auxiliary Power Savings (@15 yr life) (c)	130,000	130,000	130,000	130,000	520,000
Annual Auxiliary Power Savings (@20 yr life) (c)	152,000	152,000	152,000	152,000	608,000
Annual Heat Rate Penalty (@ 10 yr life)	80,000	80,000	80,000	80,000	320,000
Annual Heat Rate Penalty (@ 15 yr life)	95,000	95,000	95,000	95,000	380,000
Annual Heat Rate Penalty (@ 20 yr life)	111,000	111,000	111,000	111,000	444,000
Net Savings (cost) @ 10 yr life	(129,086)	(129,086)	(129,086)	(129,086)	(516,344)
Net Savings (cost) @ 15 yr life	(95,489)	(95,489)	(95,489)	(95,489)	(381,956)
Net Savings (cost) @ 20 yr life	(76,993)	(76,993)	(76,993)	(76,993)	(307,974)

NOTES: (a) Cost calculations and assumptions by PGandE 9-25-85.

(b) Based on levelized fixed charge rates of: 25.59% for 10-year life, 20.99% for 15-year life, and 18.98% for 20-year life.

(c) Based on levelized system power values of: $0.070/kwh for 10-year life, $0.083/kwh for 15- and $0.097/kwh for 20-year life.

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Corresponding estimates of the effectiveness of two-speed motors in reducing striped bass losses based on the operations and striped bass densities observed during the period between March 1 and September 1, 1985 are presented below:

	Contra Costa 1-3	Contra Costa 4 and 5	Pittsburg 1-4
Estimated reduction in equivalent striped bass ~~cropped~~ in 1985	450	300	650
Estimated incremental percentage reduction	1.2	0.8	1.8

Although the overall incremental percentage reduction in losses was similar in 1984 (2.8 percent reduction) and 1985 (3.8 percent reduction), the distribution between unit groups varied for the two years. Variation in the incremental reduction attributable to two-speed motors (and other alternatives) is expected to vary between years in response to variations in operations and in the striped bass density distribution at the two power plants.

2.5.3 MAGNETIC COUPLINGS BETWEEN EXISTING MOTORS AND PUMPS

The installation of magnetic couplings between existing motors and pumps at Pittsburg 1-4 and Contra Costa 1-5 would allow flexibility in matching circulating water flow rates to unit load.

Conceptual Design

Magnetic couplings could be installed between the existing circulating water pumps and motors to allow circulating water flow rates to be varied continuously to match unit power levels. The controls needed to operate the couplings would require new motor control center buildings and a new 115-or 220-volt system.

Performance

The reduction in circulating water flows with this alternative would be comparable to those expected for VSDs and could amount to an annual average reduction of approximately 40 percent below the values associated with constant speed pump operations. However, reliability and performance of the existing cooling water pumps with magnetic couplings is uncertain. There is a potential for excessive pump and mounting vibration because of the extended pump shaft that would be needed for these installations. Because of concern over reliability and operational problems resulting from excessive motor shaft vibration, it was concluded that magnetic couplings do not represent an acceptable alternative for reducing striped bass losses at the Pittsburg and Contra Costa power plants.

Costs

The estimated costs and economic evaluations for the installation of magnetic couplings between the circulating water pumps and motors for Contra Costa 1-5 and Pittsburg 1-4 are shown in Tables 2-10 and 2-11.

Effects On Striped Bass

Installation of magnetic couplings between the circulating water pumps and motors would allow flexibility in matching circulating water flow rates to unit load. The response time and operational flexibility of magnetic couplings for matching cooling water volumes to unit load is expected to be the same as that achieved by variable speed pump controls. However, because magnetic couplings are not considered to be an operationally acceptable alternative, the effectiveness of magnetic couplings in reducing striped bass losses at Pittsburg 1-4 and Contra Costa 1-5 was not quantified.

so this isn't an alternative

2.5.4 CROSS-OVERS AT CONTRA COSTA 1-3 AND PITTSBURG 1-4

CONTRA COSTA 1-3

A cross-over system of piping and valves permits single circulating water pump operation when unit loads are low. Operation of a cross-over system is feasible at Contra Costa Units 1-3. Contra Costa Units 4 and 5 have double-pass condensers which result in a higher ΔT (Table 1-2) than that for single-pass condensers. A cross-over system was concluded to be an impractical approach

TABLE 2-10

ECONOMIC EVALUATION OF
MAGNETIC COUPLINGS INSTALLATIONS AT
CONTRA COSTA UNITS 1 - 5 (a)

COST COMPONENT	CONTRA COSTA UNIT 1	UNIT 2	UNIT 3	UNIT 4	UNIT 5	TOTALS
Material Cost	232,000	232,000	232,000	232,000	232,000	1,160,000
Labor Cost	178,000	178,000	178,000	178,000	178,000	890,000
Total Direct Cost	410,000	410,000	410,000	410,000	410,000	2,050,000
Capital Indirects	121,647	121,647	121,647	121,647	121,647	608,235
Overhead Costs	87,084	87,084	87,084	87,084	87,084	435,419
Total Cost	618,731	618,731	618,731	618,731	618,731	3,093,654
Annual Cost (@10 yr life) (b)	158,333	158,333	158,333	158,333	158,333	791,666
Annual Cost (@15 yr life) (b)	129,872	129,872	129,872	129,872	129,872	649,358
Annual Cost (@20 yr life) (b)	117,435	117,435	117,435	117,435	117,435	587,176
Annual Auxiliary Power Savings (@10 yr life) (c)	23,000	23,000	23,000	96,000	96,000	261,000
Annual Auxiliary Power Savings (@15 yr life) (c)	27,000	27,000	27,000	114,000	114,000	309,000
Annual Auxiliary Power Savings (@20 yr life) (c)	32,000	32,000	32,000	133,000	133,000	362,000
Annual Heat Rate Penalty (@ 10 yr life)	4,000	4,000	4,000	43,000	43,000	98,000
Annual Heat Rate Penalty (@ 15 yr life)	5,000	5,000	5,000	51,000	51,000	117,000
Annual Heat Rate Penalty (@ 20 yr life)	6,000	6,000	6,000	60,000	60,000	138,000
Net Savings (cost) @ 10 yr life	(139,333)	(139,333)	(139,333)	(105,333)	(105,333)	(628,666)
Net Savings (cost) @ 15 yr life	(107,872)	(107,872)	(107,872)	(66,872)	(66,872)	(457,358)
Net Savings (cost) @ 20 yr life	(91,435)	(91,435)	(91,435)	(44,435)	(44,435)	(363,176)

NOTES: (a) Cost calculations and assumptions by PGandE 9-25-85.

(b) Based on levelized fixed charge rates of: 25.59% for 10-year life, 20.99% for 15-year life, and 18.98% for 20-year life.

(c) Based on levelized system power values of: $0.070/kwh for 10-year life, $0.083/kwh for 15-year life, and $0.097/kwh for 20-year life.

TABLE 2-11

ECONOMIC EVALUATION OF
MAGNETIC COUPLING INSTALLATIONS AT
PITTSBURG UNITS 1-4 (a)

COST COMPONENT	PITTSBURG UNIT 1	UNIT 2	UNIT 3	UNIT 4	TOTALS
Material Cost	238,000	238,000	238,000	238,000	952,000
Labor Cost	190,000	190,000	190,000	190,000	760,000
Total Direct Cost	428,000	428,000	428,000	428,000	1,712,000
Capital Indirects	118,813	118,813	118,813	118,813	475,251
Overhead Costs	89,732	89,732	89,732	89,732	358,928
Total Cost	636,545	636,545	636,545	636,545	2,546,179
Annual Cost (@10 yr life) (b)	162,892	162,892	162,892	162,892	651,567
Annual Cost (@15 yr life) (b)	133,611	133,611	133,611	133,611	534,443
Annual Cost (@20 yr life) (b)	120,816	120,816	120,816	120,816	483,265
Annual Auxiliary Power Savings (@10 yr life) (c)	91,000	91,000	91,000	91,000	364,000
Annual Auxiliary Power Savings (@15 yr life) (c)	108,000	108,000	108,000	108,000	432,000
Annual Auxiliary Power Savings (@20 yr life) (c)	126,000	126,000	126,000	126,000	504,000
Annual Heat Rate Penalty (@ 10 yr life)	80,000	80,000	80,000	80,000	320,000
Annual Heat Rate Penalty (@ 15 yr life)	95,000	95,000	95,000	95,000	380,000
Annual Heat Rate Penalty (@ 20 yr life)	111,000	111,000	111,000	111,000	444,000
Net Savings (cost) @ 10 yr life	(151,892)	(151,892)	(151,892)	(151,892)	(607,567)
Net Savings (cost) @ 15 yr life	(120,611)	(120,611)	(120,611)	(120,611)	(482,443)
Net Savings (cost) @ 20 yr life	(105,816)	(105,816)	(105,816)	(105,816)	(423,265)

NOTES: (a) Cost calculations and assumptions by PGandE 9-25-85.

(b) Based on levelized fixed charge rates of: 25.59% for 10-year life, 20.99% for 15-year life, and 18.98% for 20-year life.

(c) Based on levelized system power values of: \$0.070/kwh for 10-year life, \$0.083/kwh for 15- and \$0.097/kwh for 20-year life.

for reducing striped bass losses at Contra Costa Units 4 and 5 primarily because of operational constraints associated with the double pass condenser design at these units.

Conceptual Design

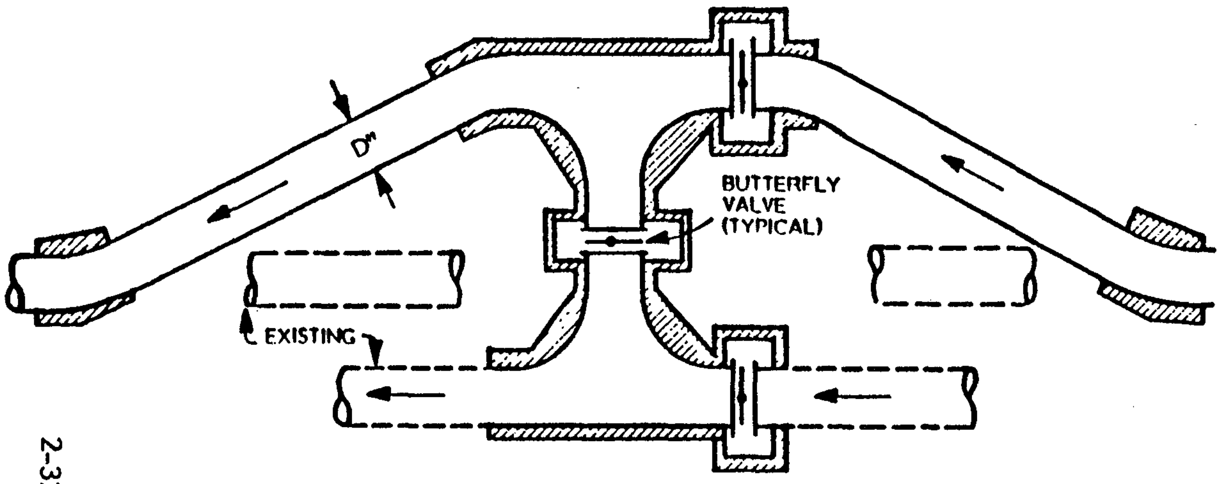
The piping and valves now installed on the cooling water systems at Units 1-3 of the Contra Costa Power Plant would allow cross-over operations with some modifications to the condensers. As now configured, it is possible to supply each condenser with one circulating water pump at reduced load, but additional equipment would be required to maintain circulating water pressures within acceptable limits. This alternative would thus require the installation of vacuum priming systems and motor controls. Allowance was also made for replacing circulating water pump motors and switch gear.

PITTSBURG 1-4

With the existing circulating water systems for Pittsburg 1-4, two circulating water pumps must be operated for each unit to assure proper flow distribution through the condensers whenever the units are operating. A cross-over system of pipes and valves with condenser evacuation pumps (vacuum priming systems) would allow these units to be operated with one circulating water pump when under partial loads.

Conceptual Design

The major design and operating features of a single-unit cross-over system are presented in Figure 2-2 (a total of four cross-over systems would be required to retrofit Pittsburg 1-4). Replacing circulating water pump motors and switch gear may also be required for this alternative at both Pittsburg and Contra Costa units. During normal full load operation, the cross-over butterfly valves would be closed, all circulating pump discharge butterfly valves would be open, and all circulating water pumps would be operating. Whenever a unit was operated at less than about half load for at least 6 hours during the night or on weekends, one pump would be shut down, the associated discharge valve would be closed, and



PLANT	UNITS	D"
PITTSBURG	1-4	54

NOTE: ONE CROSS-OVER PER UNIT

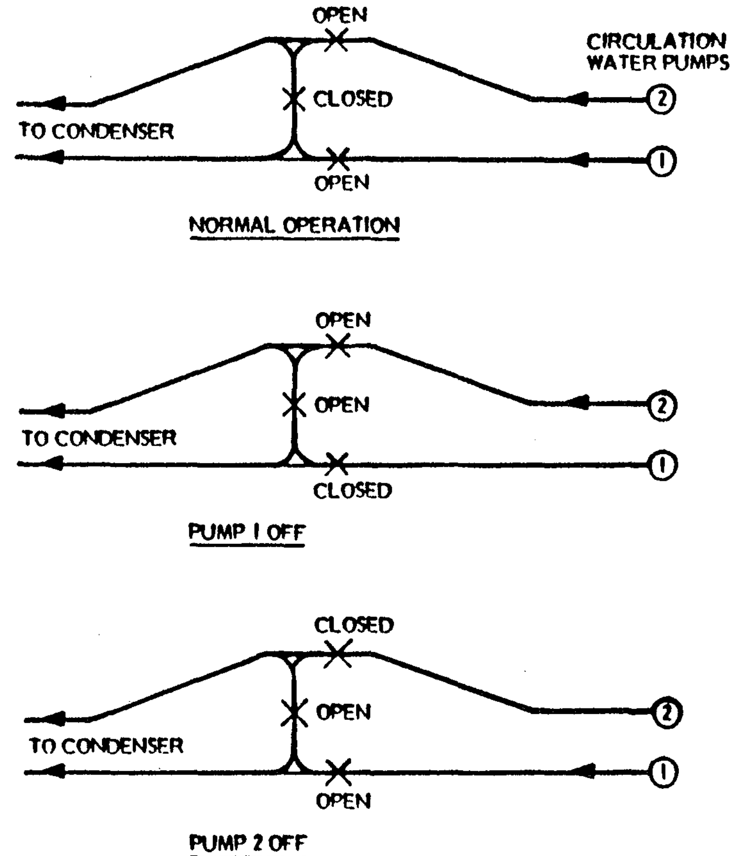


FIGURE 2-2

CROSS-OVER SYSTEM TO ALLOW
SINGLE CIRCULATING PUMP OPERATION
AT REDUCED LOADS

the cross-over valve would be opened. The circulating water pump still in operation would therefore supply water to both halves of the condenser. When going from two-pump to one-pump operation, a complicated dynamic change in pressures will occur within the circulating water system of the unit. When the cross-over valve reaches the fully opened position, the flow rate from the remaining pump would increase (runout) until a new lower circulating water system pressure head is established. The reduction in pressure head which would occur at this time could result in air accumulating in the condenser-water boxes. If this air were not removed, a restriction of flow through the upper condenser tube rows would result, reducing condenser effective cooling surface and baking dirt onto the condenser tube surfaces. To avoid this phenomenon, the condensers of each unit retrofitted with a cross-over system would have an air evacuation system.

Costs

The estimated costs and economic evaluations for the installation and operation of cross-over systems at Contra Costa Units 1-3 and Pittsburg Units 1-4 are shown in Tables 2-12 and 2-13. Cost summaries presented in Tables 2-12 and 2-13 include cross-over systems which utilize the existing circulating water pump motors at Pittsburg 1-4 and Contra Costa 1-3. Cost estimates are also presented which include the installation of new circulating water pump motors at each unit because of concern over the reliability of the existing motors.

Effects On Striped Bass

The potential effectiveness of cross-over systems in reducing striped bass losses at Pittsburg 1-4 and Contra Costa 1-3 was estimated based on an assumption that the cross-over system would be operated whenever a unit was operated at or below 50 percent load for 6 hours or longer at night (defined as 2100 to 0600 hours) and on weekends. Hourly unit loads for 1984 and 1985 were reviewed for each unit and the number of consecutive hours of operation at or below 50 percent load during each specified time period were compiled. For those periods when operation remained at or below 50 percent load, it was assumed that operation of the cross-over system would result in a reduction in cooling water

why only at night & on wke

TABLE 2-12

ECONOMIC EVALUATION OF
CIRCULATING WATER SYSTEM CROSS-OVER INSTALLATION AT
CONTRA COSTA UNITS 1 - 3 (a) (b)

A. CROSS OVER COSTS WITH THE INSTALLATION OF NEW CIRCULATING WATER PUMP MOTORS

COST COMPONENT	CONTRA COSTA UNIT 1	UNIT 2	UNIT 3	TOTALS
Total Direct Cost	161,000	161,000	161,000	483,000
Capital Indirects	47,769	47,769	47,769	143,306
Overhead Costs	34,196	34,196	34,196	102,589
Total Cost	242,965	242,965	242,965	728,895
Annual Cost (@ 10 yr life)	62,175	62,175	62,175	186,524
Annual Cost (@ 15 yr life)	50,998	50,998	50,998	152,995
Annual Cost (@ 20 yr life)	46,115	46,115	46,115	138,344
Cost of Constant Speed Operations (c)	31,332	31,332	31,332	93,996
Annual Operations Costs with Cross Overs	15,666	15,666	15,666	46,998
Auxiliary Power Savings (d)	15,666	15,666	15,666	46,998
Heat Rate Penalty	8,600	8,600	8,600	25,800
Net Savings (cost) @ 10 yr life	(55,109)	(55,109)	(55,109)	(165,326)
Net Savings (cost) @ 15 yr life	(43,932)	(43,932)	(43,932)	(131,797)
Net Savings (cost) @ 20 yr life	(39,049)	(39,049)	(39,049)	(117,146)

B. CROSS OVER COSTS WITHOUT INSTALLATION OF NEW CIRCULATING WATER PUMP MOTORS

COST COMPONENT	CONTRA COSTA UNIT 1	UNIT 2	UNIT 3	TOTALS
Total Direct Cost	67,500	67,500	67,500	202,500
Capital Indirects	20,027	20,027	20,027	60,082
Overhead Costs	14,337	14,337	14,337	43,011
Total Cost	101,864	101,864	101,864	305,593
Annual Cost (@ 10 yr life)	26,067	26,067	26,067	78,201
Annual Cost (@ 15 yr life)	21,381	21,381	21,381	64,144
Annual Cost (@ 20 yr life)	19,334	19,334	19,334	58,001
Cost of Constant Speed Operations (c)	31,332	31,332	31,332	93,996
Annual Operations Costs with Cross Overs	15,666	15,666	15,666	46,998
Auxiliary Power Savings (d)	15,666	15,666	15,666	46,998
Heat Rate Penalty	8,600	8,600	8,600	25,800
Net Savings (cost) @ 10 yr life	(19,001)	(19,001)	(19,001)	(57,003)
Net Savings (cost) @ 15 yr life	(14,315)	(14,315)	(14,315)	(42,946)
Net Savings (cost) @ 20 yr life	(12,268)	(12,268)	(12,268)	(36,803)

NOTES: (a) Cost calculations by TERA based on discussions with PGandE 10-24-85.

(b) No cost penalties for this alternative have been assumed for replacement power for unit downtime during construction.

(c) Based on levelized system power value of $0.06/kwh.

(d) Auxiliary power savings based on 1000 hrs/yr for Units 1-3.

TABLE 2-13

ECONOMIC EVALUATION OF
CIRCULATING WATER SYSTEM CROSS-OVER INSTALLATION AT
PITTSBURG UNITS 1-4 (a)

A. COSTS OF CROSS OVERS WITH THE INSTALLATION OF NEW CIRCULATING WATER PUMP MOTORS

COST COMPONENT	PITTSBURG UNIT 1	UNIT 2	UNIT 3	UNIT 4	TOTALS
Total Direct Cost	327,000	327,000	327,000	327,000	1,308,000
Capital Indirects	90,775	90,775	90,775	90,775	363,101
Overhead Costs	68,557	68,557	68,557	68,557	274,228
Total Cost	486,332	486,332	486,332	486,332	1,945,328
Annual Cost (@10 yr life) (b)	124,452	124,452	124,452	124,452	497,810
Annual Cost (@15 yr life) (b)	102,081	102,081	102,081	102,081	408,324
Annual Cost (@20 yr life) (b)	92,306	92,306	92,306	92,306	369,223
Annual Auxiliary Power Savings (@10 yr life) (c)	62,500	62,500	62,500	62,500	250,000
Annual Auxiliary Power Savings (@15 yr life) (c)	74,250	74,250	74,250	74,250	297,000
Annual Auxiliary Power Savings (@20 yr life) (c)	86,750	86,750	86,750	86,750	347,000
Annual Heat Rate Penalty (@ 10 yr life)	80,000	80,000	80,000	80,000	320,000
Annual Heat Rate Penalty (@ 15 yr life)	95,000	95,000	95,000	95,000	380,000
Annual Heat Rate Penalty (@ 20 yr life)	111,000	111,000	111,000	111,000	444,000
Net Savings (cost) @ 10 yr life	(141,952)	(141,952)	(141,952)	(141,952)	(567,810)
Net Savings (cost) @ 15 yr life	(122,831)	(122,831)	(122,831)	(122,831)	(491,324)
Net Savings (cost) @ 20 yr life	(116,556)	(116,556)	(116,556)	(116,556)	(466,223)

B. COSTS OF CROSS OVERS WITHOUT INSTALLATION OF NEW CIRCULATING WATER PUMP MOTORS

COST COMPONENT	PITTSBURG UNIT 1	UNIT 2	UNIT 3	UNIT 4	TOTALS
Total Direct Cost	243,750	243,750	243,750	243,750	975,000
Capital Indirects	67,665	67,665	67,665	67,665	270,660
Overhead Costs	51,103	51,103	51,103	51,103	204,413
Total Cost	362,518	362,518	362,518	362,518	1,450,073
Annual Cost (@10 yr life) (b)	92,768	92,768	92,768	92,768	371,074
Annual Cost (@15 yr life) (b)	76,093	76,093	76,093	76,093	304,370
Annual Cost (@20 yr life) (b)	68,806	68,806	68,806	68,806	275,224
Annual Auxiliary Power Savings (@10 yr life) (c)	62,500	62,500	62,500	62,500	250,000
Annual Auxiliary Power Savings (@15 yr life) (c)	74,250	74,250	74,250	74,250	297,000
Annual Auxiliary Power Savings (@20 yr life) (c)	86,750	86,750	86,750	86,750	347,000
Annual Heat Rate Penalty (@ 10 yr life)	80,000	80,000	80,000	80,000	320,000
Annual Heat Rate Penalty (@ 15 yr life)	95,000	95,000	95,000	95,000	380,000
Annual Heat Rate Penalty (@ 20 yr life)	111,000	111,000	111,000	111,000	444,000
Net Savings (cost) @ 10 yr life	(110,268)	(110,268)	(110,268)	(110,268)	(441,074)
Net Savings (cost) @ 15 yr life	(96,843)	(96,843)	(96,843)	(96,843)	(387,370)
Net Savings (cost) @ 20 yr life	(93,056)	(93,056)	(93,056)	(93,056)	(372,224)

NOTES: (a) Cost calculations and assumptions by PGandE 10-24-85.

(b) Based on levelized fixed charge rates of: 25.59% for 10-year life, 20.99% for 15-year life, and 18.98% for 20-year life.

(c) Based on levelized system power values of: $0.070/kwh for 10-year life, $0.083/kwh for 15-year life, and $0.097/kwh for 20-year life.

flows of 50 percent. The corresponding reduction in equivalent striped bass losses was estimated for each time period for each unit.

During the period from March 1, 1984 to February 28, 1985 an estimated 32,650 equivalent striped bass were ~~cropped~~ killed at the two plants. The estimated reduction in the number of equivalent striped bass ~~cropped~~ killed in 1984 and the incremental percentage reductions in losses resulting from the simulated operation of cross-overs are shown below:

	Contra Costa 1-3	Pittsburg 1-4
Estimated reduction in equivalent striped bass ~~cropped~~ killed in 1984	350	950
Estimated incremental percentage reduction	0.4	1.0

Corresponding estimates of the effectiveness of cross-over systems in reducing striped bass losses based on the operations and striped bass densities observed during the period between March 1 and September 1, 1985 are presented below:

	Contra Costa 1-3	Pittsburg 1-4
Estimated reduction in equivalent striped bass cropped in 1985	350	500
Estimated incremental percentage reduction	1.0	1.3

The relative effectiveness of cross-over systems in reducing striped bass losses was estimated to be greater in 1985 than in 1984. The difference in estimated incremental percentage reductions between the two years is due in large part to greater relative reductions in striped bass losses at Contra Costa 1-3 in 1985. The increase in incremental percentage reduction estimates for Contra Costa 1-3 between 1984 (0.4 percent) and 1985 (1.0 percent) resulted from differences in both unit operations and the density distribution of striped bass susceptible to entrainment between the two years used in this analysis.

2.6 ALTERNATIVES APPLICABLE TO CONTRA COSTA 1-3 HOUSE UNITS

The Contra Costa Power Plant employs three house units that are used to provide transmission system stability, spinning reserve, and start-up capability for Contra Costa 1-3 during a system outage. These house units are currently supplied individually with cooling water from a main circulating water pump. Two circulating water pumps for a main unit operate when both the main generator unit and house unit are in service. However, only one circulating water pump need be operated when only the house unit is in service.

The three house units at Contra Costa are each 9 MW electric generating units. House unit operation varies between single unit, two unit, and three unit operation, although two units are in service most frequently. Given the mode of operation of the units at Contra Costa, there are periods throughout the year where only one house unit is in operation and is supplied by one operating circulating water pump. A review of pump operations data for 1985 showed that operation of a house unit alone occurred approximately 12 percent of the time. In view of this operational feature and the existing installations, an alternative means of supplying the house units at Contra Costa may be available.

Five alternatives were evaluated for reducing cooling water volumes associated with Contra Costa house unit operation. Alternatives included a combination of variable speed pump drives and two-speed motors, supplying house unit cooling water from Contra Costa Units 6 and 7, installation of new pumps dedicated to providing house unit cooling water, modifications to the existing house unit supply conduits, and an operational option of recirculating water flow within the Units 1-3 cooling water system. Each of these alternatives was evaluated based on operational feasibility and cost of implementation. All of the alternatives considered are equally effective in reducing cooling water volume required for operation of the house units. After the alternatives had been evaluated, recirculating water flow within the Contra Costa 1-3 cooling water system was selected as the preferred option.

Recirculating cooling water is currently possible with the existing piping configuration of the house unit cooling water supply system, and would involve the use of existing condenser bypass piping to recirculate that portion of the cooling water volume withdrawn by the circulating water pumps not required by the house unit for unit operation. Indeed, this operational procedure can be used during periods of house unit operation only.

As described in Table 1-2, the circulating water pumps for Units 1-3 of the Contra Costa plant are designed for a cooling water flow rate of 44,900 gpm per pump and can only be operated at this flow rate with the existing constant speed pumps. Since the cooling water flow requirement of one house unit is approximately 9,000 gpm, a substantial excess volume of cooling water would be pumped and discharged during periods of house unit operation only, without the bypass piping. Through the realignment of valves and controls during house unit operation only, it is possible to reject that portion of the design flow not required by the house unit and to return this recirculation flow to the pump intake of the circulating water system for Units 1-3. Thus the total volume of cooling water withdrawn from the river during this mode is only 9,000 gpm (for one house unit), resulting in a significant reduction in the volume of cooling water used by Contra Costa Units 1-3.

Cost

Because the circulating water system at Contra Costa 1-3 currently has the necessary piping and control valves to permit recirculation flow during house unit operation, no significant capital expenditures are expected for this alternative. Incremental costs associated with operation and maintenance of the recirculation system and initiation of a data recording procedure to document the frequency and duration of recirculation flow are anticipated to be minimal.

Effects On Striped Bass

Inspection of 1985 operating records indicated that specific house units were in operation approximately 12 percent of the time when the corresponding main unit was not in service. No records are available, however, on either the frequency or duration of water recirculation. The mortality of entrained striped bass during periods of recirculation flow is also unknown. Mortality of entrained striped bass attributable to mechanical stresses during repeated passage through the house unit cooling system when recirculation flow occurs may be as high as 100 percent, although this is offset by a reduction in the number of new fish entrained.

The potential effectiveness of recirculating cooling water flow in support of house unit operation was estimated based on the assumption that recirculation would occur when a specific house unit was in operation more than 24 hours after the corresponding main unit was removed from service. Operating records were reviewed to compile information on the frequency and duration of house unit operation. Based on these operating records it was assumed that cooling water volumes could be reduced to 9,000 gpm when house unit operation exceeds main unit operation by more than 24 hours. Mortality of striped bass entrained during periods of recirculation was assumed to be 20 percent. Using unit-specific equivalent striped bass losses for 1984 as a basis, it was estimated that recirculation of cooling water flow would have reduced the number of equivalent striped bass ~~cropped~~ killed in 1984 by less than 250 fish, an incremental reduction of 0.3 percent. Recirculation flow at Contra Costa 1-3 during house unit only operation was estimated to reduce the equivalent number of striped bass ~~cropped~~ killed between March 1 and September 1, 1985 by approximately 150 fish, an incremental percentage reduction of 0.4 percent.

2.7 HYDROGEN COOLING IMPROVEMENTS: CONTRA COSTA UNITS 6 AND 7

Currently the Contra Costa Units 6 and 7 are occassionally curtailed due to high hydrogen gas temperatures. The combined curtailments for Contra Costa Units 6 and 7 due to high cold gas temperature have averaged 4200 MWh/yr between 1978 and 1984. PGandE is currently evaluating the alternative approaches for hydrogen cooling improvements at Contra Costa Units 6 and 7. Resolving the hydrogen temperature problem will provide some benefits in reducing the losses of striped bass at the Contra Costa Power Plant by reducing the need for committing additional generating units.

Effects On Striped Bass

The incremental reduction in striped bass losses resulting from hydrogen cooling improvements on Contra Costa Units 6 and 7 was estimated by assuming the elimination of curtailments at Units 6 and 7 and thereby reducing the commitment of other units at the Contra Costa Power Plant. Hourly unit curtailment and unit-specific operating records were examined to determine the occurrence, frequency, and duration of Contra Costa Units 6 and 7 curtailments and operating conditions when commitment of other units at the Contra Costa Power Plant might have occurred in anticipation of potential unit curtailments. It was assumed that under such conditions, operation of one unit at Contra Costa Units 1-5 could have been eliminated.

Based on the levels of operation assumed, it was estimated that an incremental reduction in striped bass losses of approximately 0.7 percent could be achieved by eliminating the hydrogen temperature problem. During 1984, it is estimated that the number of equivalent striped bass ~~cropped~~ killed would have been reduced by 650 fish. Based on levels of operation and the striped bass density distribution observed between March 1 and September 1, 1985, it was estimated that the number of equivalent striped bass ~~cropped~~ killed would have been reduced by approximately 500 fish; an incremental percentage reduction in 1985 of 1.4 percent.

The effectiveness of hydrogen cooling improvements at Contra Costa Units 6 and 7 will vary in future years in response to factors such as electrical demand, the operational characteristics of the hydrogen cooling system, intake water

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temperatures, and the densities of striped bass susceptible to entrainment and impingement. No costs are associated with this alternative as PGandE will need to resolve the hydrogen temperature problem for its own purposes.

2.8 RESOURCE MANAGEMENT

Consideration of resource management alternatives focused on two options:

- o Dispatch of units at the Pittsburg and Contra Costa power plants based on the geographic distribution of striped bass susceptible to entrainment.
- o Dispatch of like units at Pittsburg and Contra Costa power plants to maintain discharge temperatures below 86° F whenever possible.

Estimates of the incremental reduction in striped bass losses associated with the resource management alternatives discussed below will vary depending on the timing and duration of the entrainment period. The effectiveness of the resource management alternatives in reducing striped bass losses was estimated using biological and operational data from 1984 and 1985 which reflect the resource management program and other operational changes utilized to reduce striped bass losses during the entrainment periods of these two years. The approach used to determine the entrainment start date relied on a threshold density of 9-10mm striped bass entrained at the Pittsburg Power Plant. The entrainment period end date was established using CDFG summer tow net survey data each year (as specified in the NPDES permits). Considering the recent changes observed in the geographic distributional patterns and relative densities of striped bass susceptible to entrainment, among other factors, a more sensitive approach to determining when striped bass are entrained at the two plants each year is appropriate. Results of the entrainment monitoring studies required at both plants provide the data necessary to establish the entrainment period start and end dates based on actual occurrence of striped bass in all size classes entrained at both power plants.

Inspection of normalized striped bass density distributions for 1978, 1979, 1984, and 1985 for each plant has led to the development of a proposal in which a normalized striped bass density threshold of 5×10^{-4} equivalent bass/m^3 would be used to initiate and end the entrainment period. Based on the density of bass collected, the resource management program would be in effect whenever the density of entrained striped bass at either power plant exceeded 5×10^{-4} equivalents/m^3. Information provided to PGandE Power Control on the geographic distribution would simply reflect the power plant at which normalized densities are highest during the entrainment period.

2.8.1 DISPATCH OF THE PITTSBURG AND CONTRA COSTA POWER PLANT UNITS BASED ON THE GEOGRAPHIC DISTRIBUTION OF STRIPED BASS SUSCEPTIBLE TO ENTRAINMENT

This alternative is based on the dispatch of units at the two power plants in accordance with the geographic distribution of larval and juvenile striped bass. If, for example, the relative density of striped bass susceptible to entrainment is higher at the Pittsburg Power Plant than Contra Costa, then favoring the dispatch of Contra Costa units could result in fewer striped bass being entrained.

Conceptual Approach

The approach to this alternative would be to dispatch units, to the extent feasible given other operating constraints, as indicated by economic dispatching unless contradicted by the geographical distribution of striped bass (with the exception of preferential operation of Pittsburg Unit 7). Using data collected from the entrainment monitoring program, actual entrainment densities are available weekly for use in establishing dispatching priorities. Entrainment samples are collected from the discharge of Pittsburg Units 5 or 6 and Contra Costa Units 6 or 7 weekly during the striped bass entrainment period (sampling is scheduled for the period from May 1 to August 1). Based on the size-specific density of striped bass collected in each sample, a normalized density (number of equivalent bass/m^3) is calculated for each power plant and reported to PGandE's

Power Control Department on a weekly basis as one input to scheduling unit dispatch at both plants during the following week.

Performance

Entrainment sampling data (normalized densities) were used as one input in unit dispatch at Pittsburg and Contra Costa during the entrainment period in 1984 and 1985. Comparative entrainment samples were collected on Monday and Tuesday at the two power plants, the samples were processed, and larval and juvenile striped bass were identified and measured each week. Normalized densities from the Monday and Tuesday samples were documented, and results for both power plants were reported to PGandE Power Control by Friday. These weekly density comparisons were used in establishing unit dispatching priorities for the following week.

Costs

The cost of this alternative is associated with the differential cost of preferential operation of Pittsburg Unit 7 and the dispatch of other units at the two power plants in a mode other than that dictated by economic dispatching criteria. The estimation of incremental cost associated with dispatch of units based on the geographic distribution of striped bass is complex and has not been estimated for use in this report. The overall estimated cost for differential fuel use associated with the resource management plan during the 1984 entrainment period was $4.6 million. The cost of the current entrainment monitoring and reporting effort as a determinant of the geographic distribution of larval and juvenile striped bass is approximately $100,000 per year based on the current weekly turnaround of monitoring data.

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Effects On Striped Bass

The incremental reduction in striped bass losses attributable to use of the geographic distribution in striped bass entrainment at the two plants was estimated using operating and biological data collected in 1984 and 1985. Because PGandE voluntarily implemented a scenario of dispatching units at the Pittsburg and Contra Costa plants based on the striped bass density difference between the two locations in 1984 and 1985, the actual operating data reflect the contribution of this alternative within limits imposed by other operating constraints. Several methods were used to evaluate the potential effectiveness of this alternative. In general, the analyses involved altering the plant-specific striped bass density for each entrainment collection to reflect a geographic distribution which was completely opposite to the actual distributions observed in 1984 and 1985. Using this approach, the assumed incremental reduction in striped bass losses in 1985 was estimated to be 4 percent, representing a reduction in 1985 equivalent striped bass losses of 1,400 fish. No incremental reduction was detected in striped bass losses for 1984. The effectiveness of unit dispatch based on the geographic distribution of entrained striped bass is expected to vary considerably between years in response to variation in the distribution of striped bass and variation in operational flexibility between units at the two plants.

2.8.2 DISPATCH OF LIKE UNITS AT PITTSBURG AND CONTRA COSTA TO MAINTAIN DISCHARGE TEMPERATURES BELOW 86°F WHENEVER POSSIBLE

The mortality of larval and juvenile striped bass entrained at the Pittsburg and Contra Costa power plants is dependent on exposure to both mechanical and thermal stresses. Results of entrainment survival studies conducted at both power plants show that entrainment mortality is less than 20 percent when discharge temperatures are less than 86°F. Entrainment mortality increases significantly when discharge temperatures exceed 86°F and entrainment mortality is 100 percent at temperatures of 93.2°F and above. Because of the sensitivity of entrained striped bass to discharge temperatures above 86°F, one alternative for potentially reducing striped bass losses involves minimizing the occurrence of discharge temperatures above 86°F during the entrainment period.

Conceptual Approach

This alternative would consist of dispatching like units to all reach 86°F discharge temperatures before any unit exceeds 86°F. The power levels at which any unit is able to operate without exceeding a discharge temperature of 86°F would depend on the temperature of the intake water and the condition of numerous unit components.

Performance

PGandE implemented a program during the 1984 and 1985 entrainment periods to dispatch like units to maintain discharge temperatures below 86°F when practical. Inspection of the hourly discharge temperature records for the period from May through July, 1985 showed that discharge temperatures exceeded 86°F less than 15 percent of the time:

	Percent of Hourly Temperatures Above 86°F
Contra Costa 1-5	6
Contra Costa 6	13
Contra Costa 7	10
Pittsburg 1-4	7
Pittsburg 5	1
Pittsburg 6	11

Cost

The cost of this alternative, although not calculated for this report, would include differential fuel use costs for dispatching less efficient units to maintain discharge temperatures below 86°F whenever possible.

Effects On Striped Bass

The effectiveness of maintaining discharge temperatures below 86° F whenever possible was evaluated by reviewing unit-specific curtailment records for the

1984 entrainment period. The curtailment records designate, by day and occurrence, the duration of curtailments for each unit attributable to maintaining discharge temperatures below 86° F. Since the actual hourly unit-specific operating records for 1984 (and 1985) reflect voluntary like unit dispatch to minimize discharge temperatures above 86°F, it was necessary to estimate what striped bass losses might have been in the absence of such dispatch. The analysis assumed that discharge temperatures would have been 91° F on average (based on an analysis of actual discharge temperatures), resulting in entrainment mortality of 80 percent during that time period when a curtailment occurred. Operation of variable speed pumps was assumed to be 100 percent for the entire duration of each curtailment. Based on this assumed operating scenario and the corresponding striped bass density data for 1984, a potential striped bass entrainment loss was calculated. The difference between the potential loss and the actual loss, summed over the 1984 entrainment period for all units, was assumed to reflect the incremental reduction in striped bass losses resulting from maintaining discharge temperatures below 86° F when possible. Based on these assumptions, the incremental reduction in striped bass losses was estimated to be 5 percent, representing a reduction in equivalent striped bass losses during 1984 of approximately 4,600 fish. The estimated incremental reduction in striped bass losses during the period from March 1 to September 1, 1985 was also estimated to be approximately 5 percent, representing a reduction in the number of equivalent striped bass ~~cropped~~ killed of approximately 1,800 fish.

APPENDIX A

COMPARISON OF ECONOMIC EVALUATIONS OF ALTERNATIVES WITH COST DATA PROVIDED IN THE 1982 ASSESSMENT

This appendix is provided in response to an inquiry of the Regional Water Quality Control Boards staffs on August 29, 1985 regarding the comparison of cost and economic information in this report with that provided in the 1982 Assessment of Alternatives.

COST AND ECONOMIC DATA INCLUDED IN THE 1982 ASSESSMENT

The Assessment of Alternatives to Reduce the Losses of Striped Bass at the Contra Costa and Pittsburg Power Plants (TERA, 1982) included detailed information, data, and calculations regarding the capital and operating costs of alternatives considered in that study along with estimates of the dollar benefits associated with each alternative. Such cost and economic information was provided in various sections of the 1982 report, and was presented in several tabular formats. The methodologies for calculating major economic and cost factors were also discussed in Appendix E of the document.

Provided below is a brief description of the method of presentation of data in the 1982 report using an example alternative (variable speed motor controls) from that study. The next section of this appendix describes the cost methods used in this 1985 study for the alternative, and is presented to facilitate the review and comparison of cost data in the two reports.

Cost information concerning the use of new pump motors with variable frequency motor controls (VSDs) was presented in the following tables of the 1982 assessment:

Table 1-5	Summary Assessment of Alternatives
Table 3.5-8	Estimated Costs for VSDs
Table 3.5-9	Levelized Power Costs and Savings
Page 4-21	Summary of Levelized Annual Costs (Savings)
Appendix E.4	Example Calculation of Annual Costs

A. Table 1-5

The cost information presented in Table 1-5, page 1-40 of the 1982 report, expressed the costs of the VSD alternative in terms of both ANNUAL COSTS (SAVINGS) and TOTAL LIFETIME COSTS (SAVINGS). The values shown for ANNUAL COSTS (SAVINGS) were taken directly from Table 3.5-9 and express the "costs" (as a negative number if the dollar cost of the alternative is greater than its economic benefit) or the "savings" (as a positive number if the dollar benefit is greater than its cost). The TOTAL LIFETIME COSTS (SAVINGS) VALUE expressed the cost of the alternative as a total amount by multiplying the annual cost by the life of the alternative. In the case of VSDs at Pittsburg 1-4, the ANNUAL COST was shown as $172,000 per year. The TOTAL LIFETIME COST was shown as $2.8 million ($172,000 x 16 yr. life).

B. Tables 3.5-8 and 3.5-9

Table 3.5-8, page 3.5-24, presented the capital and labor costs for installing VSDs on each of the four unit groups at the Contra Costa and Pittsburg power plants. The Capital Costs line of that table was derived from actual engineering estimates made at the time of the study. All other lines (or components of cost) were calculated using factors specific to the plants and to economic calculations using 1982 values. The final line of the table titled LEVELIZED ANNUAL REVENUE REQUIREMENTS converted TOTAL COST for a unit group into an ANNUAL COST using factors presented in Appendix Table E-3.

Table 3.5-9 showed the details of this annual cost calculation along with the estimated SAVINGS that would result from use of the alternative. The difference between LEVELIZED ANNUAL COST and ANNUAL OPERATING SAVINGS yielded the NET ANNUAL SAVINGS (COST) of the alternative.

B. Page 4-21

The summary information on page 4-21 of the 1982 assessment simply restated the ANNUAL COST (SAVINGS) value taken from Table 3.5-9. The cost value shown on this page is the same as NET ANNUAL SAVINGS (COST) as noted above under the description of Table 3.5-9.

C. Appendix E.4

The example calculations presented in Appendix E.4 of the 1982 assessment were intended to illustrate the method used to determine the ANNUAL OPERATING SAVINGS value shown in Table 3.5-9. In the example shown, the ANNUAL OPERATING SAVINGS was calculated by determining the difference between the energy costs of operating constant speed pumps versus pumps with VSDs. The calculations of ANNUAL OPERATING SAVINGS were used to calculate NET ANNUAL SAVINGS (COST) of the alternatives.

COST AND OPERATING DATA INCLUDED IN THE 1985 RE-EXAMINATION

The major components of cost and net benefit (or loss) included in this report can be directly compared to the costs shown in the 1982 assessment. The only changes in cost values between the two reports are:

- o Engineering estimates of the equipment required for the alternatives and the cost of such equipment have been done using 1985 cost factors and current conditions of existing systems at the power plants.
- o The cost factors for labor, contingency, level annual fixed charge rates, etc. are 1985 values and differ from those factors used in 1982.
- o The current PGandE methodology (i.e., step-by-step procedure) for calculating total annual costs differs slightly from that used in 1982. These calculation

methodologies, however, yield comparable values for TOTAL ANNUAL COST.

- The ANNUAL COST of each alternative, and thus the NET ANNUAL COST (SAVINGS) has been calculated for a range of economic lives (viz. 10, 15 and 20-yrs) in this report. Such information provides additional details to aid in decision making.

- Cost and economic information for the Contra Costa and Pittsburg power plants has been presented in separate tables during this study rather than in single tables organized by unit group.

This comparison of 1982 versus 1985 economic and cost data can be illustrated as follows:

The economic evaluation of VSD installations at the Contra Costa Power Plant is shown in Table 2-6 of this report. The line entitled MATERIAL COST is comparable to the line entitled CAPITAL COST in Table 3.5-8 of the 1982 study. The line entitled TOTAL COST is directly comparable on both tables although calculated using a slightly different calculation procedure.

The lines entitled ANNUAL COST (@ ___ yr life) in Table 2-6 are comparable to the line entitled LEVELIZED ANNUAL REVENUE REQUIREMENT in Table 3.5-8. The only difference between these tables is that an ANNUAL COST (or REVENUE REQUIREMENT) has been calculated in the 1985 study for three economic lives. Only one life (viz. the remaining life of the unit) was calculated in the 1982 study.

The lines entitled NET SAVINGS (COST) $ ____ yr life in Table 2-6 are directly comparable to the column entitled NET ANNUAL SAVINGS OR COST in Table 3.5-9, and show the net cost associated with an alternative. This value is a measure of the economic merits of an alternative considering the expenditures required to install it and the resultant increase or decrease in operating costs.

The value termed TOTAL LIFETIME COST in the 1982 study (see A. above) has not been calculated or presented in the 1985 assessment; however, the TOTAL

LIFETIME VALUE of an alternative can be easily determined by multiplying the NET SAVINGS (COST) line by the appropriate life shown. This calculation would yield the following results if done with the data in Table 2-6:

		TOTAL LIFETIME COST
Net Savings (cost) @ 10 yr life	($821,959)	($8,219,590)
Net Savings (cost) @ 15 yr life	($592,917)	($8,893,755)
Net Savings (cost) @ 20 yr life	($471,625)	($9,432,500)