6.0 EVALUATION OF ALTERNATIVE INTAKE TECHNOLOGIES

Section 316(b) of the Clean Water Act requires that "the location, design, construction and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact." This requirement applies to both new sources that are seeking NPDES permits for the first time, and to existing sources, such as the Morro Bay Power Plant, that are seeking to renew pre-existing permits. The purpose of this section of the Clean Water Act is to minimize adverse impacts on the aquatic environment caused by cooling water intake structures, particularly the entrainment and impingement of aquatic organisms. This goal is to be achieved through the use of the "best technology available" or "BTA." In this context, the U.S. Environmental Protection Agency has interpreted BTA to mean "the best technology available commercially at an economically practicable cost." In circumstances where the cost of implementing a commercially available technology is "wholly disproportionate" to the environmental benefit to be gained thereby, the technology is considered infeasible and hence not BTA.

The range of alternatives that is considered feasible for an existing source is necessarily narrower than the range of alternatives that might be considered feasible for a new source. For example, alternatives that involve relocation of the intake structure are less likely to be considered BTA for an existing source than for a new source that is evaluating the various locations where an intake structure might be installed in the first instance. Similarly, the cost of retrofitting an existing power plant to employ an entirely different cooling technology (such as closed-cycle cooling) may be so prohibitive or so disproportionate to the benefits to be gained that the retrofitting is not BTA. Thus, while the Clean Water Act does not require a traditional cost/benefit analysis of different alternatives, economic considerations do play an important role in arriving at a determination under Section 316(b). It is also important to note that the Clean Water Act does not require the elimination of all adverse impacts associated with the operation of cooling water intake structures. Rather, dischargers are required to implement BTA to minimize entrainment and impingement effects. The critical question is the magnitude of any adverse environmental impact associated with a given technology. This determination is made on a case-by-case basis by assessing the relative biological value of the source water body and the potential for entrainment/impingement posed by the intake structure.

The evaluation of alternatives presented in this section has been conducted in accordance with EPA's Guidance for Evaluating the Adverse Impact of Cooling Water Intake Structures on the Aquatic Environment: Section 316(b) P.L. 92-500 (EPA Office of Water Enforcement, May 1, 1977). EPA has not published any more recent guidance on 316(b) determinations for existing facilities, and the 1977 guidance, as refined through subsequent case law and EPA administrative decisions, remains the applicable body of law with respect to existing facilities. Although EPA recently published proposed 316(b) regulations for new facilities (65 Fed. Reg. 49060, August 10, 2000), EPA has expressly stated that NPDES permit applicants should not rely on these proposed regulations as guidance, given the numerous uncertainties and outstanding policy issues that are discussed in the proposal and on which comment is being solicited. Among these uncertainties is the role that mitigation or restoration measures should play, if any, in the 316(b) process where a BTA determination cannot otherwise be reached. Moreover, the case has been made in the review of the proposed regulations for new facilities that a facility modernization such as MBPP's would not fall under a "new facility" rule, but rather under an "existing facility" rule.

In compliance with Section 316(b) objectives, the design of the modernized MBPP employs advanced combined-cycle (CC) generation technology and multiple intake cooling water pumps to directly reduce potential intake effects by minimizing cooling water withdrawals. Though the modernized plant design will reduce maximum entrainment rates by nearly 38 percent compared to the existing plant, alternative intake technologies were evaluated for their potential to further reduce biological losses.

This section presents evaluations on whether an intake technology is available, feasible, cost-effective and will minimize impacts via site-specific analyses. The design and operation of the cooling water systems for the new combined-cycle units are described in Section 2.0, along with a discussion of the physical and biological characteristics of the source waterbody. Sections 3.0 through 5.0 present information characterizing entrainment and impingement at the plant. This background information provides the site-specific framework necessary for evaluating the potential biological effectiveness and engineering feasibility of each intake technology considered.

A hierarchical evaluation system is used to assess which alternative intake technologies would reduce biological losses and could be feasible for application to the cooling water system of the MBPP. Alternative intake technologies are evaluated on two levels:

First-Level Evaluation:

Each alternative intake technology is evaluated to determine whether or not it is available and proven (i.e., it has demonstrated operability and reliability) at a cooling water intake similar in size and in environmental setting as MBPP.

Second-Level Evaluation:

Each individual alternative intake technology that passed the First-Level Evaluation is then evaluated with respect to the following biological, technical, environmental and economic criteria:

1. **Potential Biological Benefits**: Implementation of the alternative technology could result in a reduction in the loss of aquatic organisms from the operating conditions described in Section 2.0. Each technology and operational alternative that satisfies the proven and available criterion in the First-Level Evaluation (Table 6-1) is investigated further to determine whether it would reduce the effects of entrainment and impingement reported in Section 5.0. Relevant results of the evaluation are integrated in this section.
2. **Technical Criteria**: Technical criteria focuses on compatibility with the MBPP facility design and site layout, including space availability on land or in the nearby harbor area. Each alternative intake technology is evaluated based on site-specific considerations of engineering feasibility, operations, and reliability.
3. **Other Environmental Impacts**: A key objective of the MBPP Project is to minimize environmental impacts overall. Important elements in meeting this objective include the selection of Project technologies and design configurations that represent a minimal impact on the overall environment and on the community. Consistent with these considerations, each alternative intake technology is evaluated with respect to environmental factors such as visual impact, noise impact, construction impacts, land use requirements, community expectations and support, offsite impacts, safety and waste disposal.
4. **Economic Criteria**: The total economic cost of alternative technologies considered should be proportionate to the environmental benefits anticipated. Selection of least-environmental impact technologies that fall within reasonable cost profiles is an important factor for facility design. Each alternative intake technology is evaluated with respect to cost estimates that reflect total incremental capital costs (including lost capacity capital costs where appropriate), annual operating and maintenance (O&M) costs, and indirect costs such as a reduction of generating capacity. The PV (Present Value) and amortized cost are calculated so the alternatives can be compared on a constant dollar basis. A discount rate of 7% and a project life of 30 years are used in these calculations.

These four criteria were applied to all alternative intake technologies that were considered to be available and proven for application at the plant (First-Level Evaluation). The section ends with a discussion of, and judgment as to, the best intake technology available for the new combined-cycle units.

6.1 First-Level Evaluation – Which Technologies are Proven and Available?

Certain intake technologies and alternate intake locations were determined to be proven and available for consideration for the new CC units (Table 6-1). These include offshore and onshore intake locations and configurations, a once-through cooling water system, and velocity caps. Physical barriers, such as centerflow and dual flow screens, vertical traveling screens, barrier nets, and aquatic filter barriers, are also appropriate for further consideration. Fish diversion systems, such as louvers and angled screens, have been used at cooling water intake structures (CWIS) and can be considered for use by the CC units. Fish collection and return systems, including modified traveling screens and fish pump systems are available considerations.

Although not commonly considered as intake technologies, closed-cycle cooling systems, such as salt water cooling towers and air cooled condensers, have been demonstrated in power plant applications as a mechanism for reducing cooling water intake flow. Operational and maintenance alternatives, such as cooling water pump flow reduction, seasonal energy curtailment resulting in flow reductions, temperature regulation, alternate biofouling control, and maintenance dredging of the intake area are also regarded as proven and available technologies. Other alternative technologies failed to satisfy the first evaluation criterion, and hence are not considered further in the Second-Level Evaluation. Those technologies and operational alternatives are discussed briefly under each alternative intake technology category.

Table 6-1. Availability and Feasibility of Intake Technologies and Operational Alternatives Considered for the Proposed MBPP Combined-Cycle Units.

Intake Technology Category	Demonstrated Proven and Available for Similar Size and Environmental Setting as MBPP	Not Demonstrated Proven and Available for Similar Size and Environmental Setting
Intake Location	Offshore	
	Onshore	
	Adjustable Vertical Barrier	
Behavioral Barriers	Velocity Cap (applicable to offshore intake location only)	Light
		Sound
		Air Bubble Curtain
		Velocity Gradient
		Electrical Barrier
		Chemicals
		Magnetic Field
		Chains and Cables
Physical Barriers	Vertical Traveling screen	Media Filter
	Centerflow and Dual Flow Screens	Porous Dike
	Barrier Net	Radial Well
	Aquatic Filter Barrier	Cylindrical, Wedge-Wire Screens
		Stationary Screen
		Horizontal Traveling Screen
		Drum Screens
Fish Diversion, Collection, and Conveyance Systems	Louvers	
	Angled Screens	
	Modified Traveling Water Screens	
	Fish Return Conveyance Systems	
Closed-Cycle Cooling Systems	Mechanical Draft Cooling Towers	Cooling Pond
	Natural Draft Cooling Tower	
	Hybrid Parallel Condensing (Wet/Dry) Systems	
	Spray Ponds	
	Air-Cooled Condensers	
Operational and Maintenance Alternatives		
	Cooling Water Pump Flow Reduction	
	Seasonal Flow Reduction	
	Through-Plant Temperature Regulation	
	Alternate Biofouling Control	
	Intake Area Dredging	

6.2 Intake Location

Alternative intake locations for the new combined-cycle units at the MBPP include submerged offshore and shoreline intake locations. The new CC units' shoreline intake (which utilizes the existing intake of Units 1 through 4) is the base case against which each alternative is compared.

6.2.1 Offshore Intake Location

Two alternate offshore cooling water intake locations were evaluated for the new combined-cycle units to avoid potential entrainment and impingement of organisms from Morro Bay.

1. The first cooling water intake alternative would consist of abandoning the existing Units 1 through 4 intake structure and constructing a new intake system into Estero Bay, north of Morro Rock.

2. The second alternative location of the cooling water intake would also be in Estero Bay, south of the Morro Bay entrance breakwater and west of the sand spit separating Morro and Estero Bays.

The locations of both alternative cooling water intake lines are shown in Figure 6-1. It is assumed that any installation of a submerged offshore intake structure would also utilize a velocity cap at the inlet (See Section 6.3.2).

6.2.1.1 Potential Biological Benefits

The efficacy of an offshore intake in reducing entrainment depends, to a large degree, on the vertical stratification of entrainable organisms in the water column at the point of withdrawal. In such a system, a reduction in entrainment is achieved by locating the submerged intake at a depth where the concentration of entrainable organisms is less than at other depths. Although the available data are limited, entrainable organisms are expected to be distributed in approximately equal concentrations throughout the water column as a result of strong tidal and wind mixing and the shallow depths in the immediate area of the MBPP (Subsection 2.2.2).

Offshore water depths are typically less than 30 ft within 3,000 ft of the shoreline north and south of the entrance to Morro Bay. Many species that have planktonic larvae which are susceptible to entrainment, such as flatfishes, rockfishes, white croaker, smelts, and northern anchovy, spawn in the nearshore waters of Estero Bay and potentially could be more susceptible to entrainment at an offshore intake than under the present configuration. These offshore areas support a much higher diversity of fish larvae than found at the present intake location in Morro

Bay as shown in Figures 3-2 and 3-7. Not only would an offshore intake dramatically increase the existing facility's impingement rates, the relocation would be expected to increase by several times the relatively low number of species entrained at the intake's Morro Bay location. Because of the large tidal exchange between Morro Bay and Estero Bay, planktonic organisms spawned in the bay, such as gobies and Pacific herring, would be susceptible to entrainment at an offshore cooling water intake sited in the area adjacent to the Morro Bay entrance channel. Furthermore, very little if any vertical stratification in the concentrations of planktonic eggs and fish larvae is expected to occur in these shallow areas, which are subject to turbulent mixing by tidal currents, waves, and wind. Because the waters near the plant are shallow and mixed from surface to bottom by waves and currents, an offshore intake would not be expected to reduce the numbers of organisms entrained.

Offshore intakes located along California's open coast typically terminate as a vertical riser of the inlet conduit in 30 to 50 feet of water. Since the same volume of intake water must pass through an offshore inlet with an opening much smaller (commonly 15 to 20 feet) than the existing shoreline intake, intake velocities will significantly increase to levels far beyond regulatory design standards of 0.5 feet per second (fps). The effectiveness of a submerged offshore intake to reduce the number of impinged organisms depends on locating the intake in an area of low abundance of impingeable organisms. Many of the dominant groups of fishes and invertebrates (e.g., flounder and sole, rockfishes, white croaker, surfperches, crabs, shrimp) are typically found in association with the bottom habitat in the vicinity of the offshore site. Pelagic fish species, such as smelts, northern anchovy, and Pacific herring, are commonly found in large schools moving through the water column. These pelagic schools of fish often concentrate near bottom features during the daytime (EA unpublished). Submerged offshore intakes have higher approach velocities than onshore systems and use conduits within which fishes can become entrapped, resulting in an increase in the number of organisms impinged. Furthermore, there is a distinct possibility that the physical presence and nature of an offshore intake would attract many of the fishes and invertebrates inhabiting Estero Bay (particularly surfperch, rockfishes, and crabs) to the intake location, and so increase the probability of entrapment and subsequent impingement. Thus, use of a submerged offshore intake system will result entrapment and impingement rates significantly higher than those of the existing intake.

6.2.1.2 Technical Criteria

The first cooling water intake alternative would consist of abandoning the existing Units 1 through 4 intake structure and constructing a new intake system in and adjacent to Estero Bay. Additional modifications for this alternative would include the following:

- Installation of two new 10-foot-diameter undersea cooling water intake lines along the route shown in Figure 6-1. These new lines would extend from a point in Estero Bay about 1,000 feet offshore, at a depth of about 30 feet below the water surface, to the shoreline at the base of Morro Rock.

- Construction of a new intake structure immediately onshore in the vicinity of the existing discharge structure. This new structure would contain the new cooling water pumps for the combined-cycle units, a bar rack debris barrier, new traveling screens with screen wash system, and cross-connections to the adjacent discharge line, with slide gates to facilitate periodic heat treating. A fish return system, if justified, could be installed, consisting of a fish collection baskets on the vertical traveling screens and a sluiceway that would return the collected fish and other organisms to the bay.

- Installation of two new, approximately 8-foot-diameter onshore, underground cooling water supply lines (or equivalent cross-sectional area tunnel) extending from the cooling water pumps in the new intake structure to the combined-cycle units, generally following the route of the existing underground cooling water discharge tunnels.

The second alternative location of the cooling water intake would also be in Estero Bay, south of the Morro Bay entrance breakwater and west of the sand spit separating Morro and Estero Bays. This alternative would consist of installing two new 10-foot-diameter intake lines from the existing Units 1 through 4 intake structure in Morro Bay which would extend under the bay to the sand spit, continue underground on the sand spit to point directly east of the southern breakwater, and extend offshore into Estero Bay for a distance of about 1,000 feet to the new intake location. These new intake lines would be tied into the existing Units 1 through 4 intake structure which would contain the new cooling water pumps for the combined-cycle units.

6.2.1.3 Other Environmental Impacts

For the first alternative, relocating the intake structure to the base of Morro Rock would mean adding industrial facilities and taking up valuable land area in a heavily used public park area. Obtaining construction permits and easements would be a formidable task due to the sensitive nature of this park location. Construction of the new onshore underground cooling water supply lines would cause temporary disruption to local tourist traffic at Morro Rock and to public use of the beach.

Construction of the offshore lines would cause additional impacts, and likely require extensive additional marine studies to obtain permits and environmental approvals. These additional permitting requirements would lead to significant project schedule impacts and delay the addition of a much-needed generation resource to the California grid.

Similar difficulties exist for the second location, plus the impacts of underwater construction in the harbor and installation of new large-diameter underground lines on the environmentally sensitive sand spit.

6.2.1.4 Economic Criteria

For the first offshore intake alternative, the estimated total installed cost is about $37 million more than the proposed existing shoreline intake[1]. The estimated incremental Operating and Maintenance costs (O&M) are about $200,000 per year. The PV (Present Value) of these costs is $40 million, and the cost amortized over 30 years is $3 million per year.

For the second offshore intake alternative, the estimated total installed cost is about $42 million more than the proposed existing shoreline intake. The estimated incremental Operating and Maintenance costs (O&M) is $200,000 per year. The PV of these costs is $45 million, and the cost amortized over 30 years is $3 million per year.

6.2.1.5 Conclusion

In summary, an offshore intake appears to offer little or no potential for reducing the losses of fishes and invertebrates entrained at the combined-cycle units' intake, and would certainly increase the numbers entrapped and impinged. The relocation of the intake offshore where mixing effects of tides and wave create homogeneous vertical distributions of plankton would not reduce the susceptibility of planktonic organisms to entrainment. An offshore intake would also entrap large numbers of fishes and invertebrates attracted to the offshore intake, that would be subsequently impinged on the onshore intake screens.

The two offshore intake alternatives that were evaluated would also cause significant schedule impacts to the MBPP project and delay it at least one year. In addition, relocation of the intake offshore would create a navigational hazard near the entrance channel to Morro Bay, and as such, might not be permitted by the responsible regulatory agencies. In the absence of any evidence of a clear potential for reducing entrainment and impingement losses, the alternative offshore intake locations would not constitute an improvement to the new CC units' shoreline intake location.

[1] Incremental capital investment for offshore intake alternatives in lieu of proposed existing shoreline location utilizing existing intake structure of Units 1 through 4.

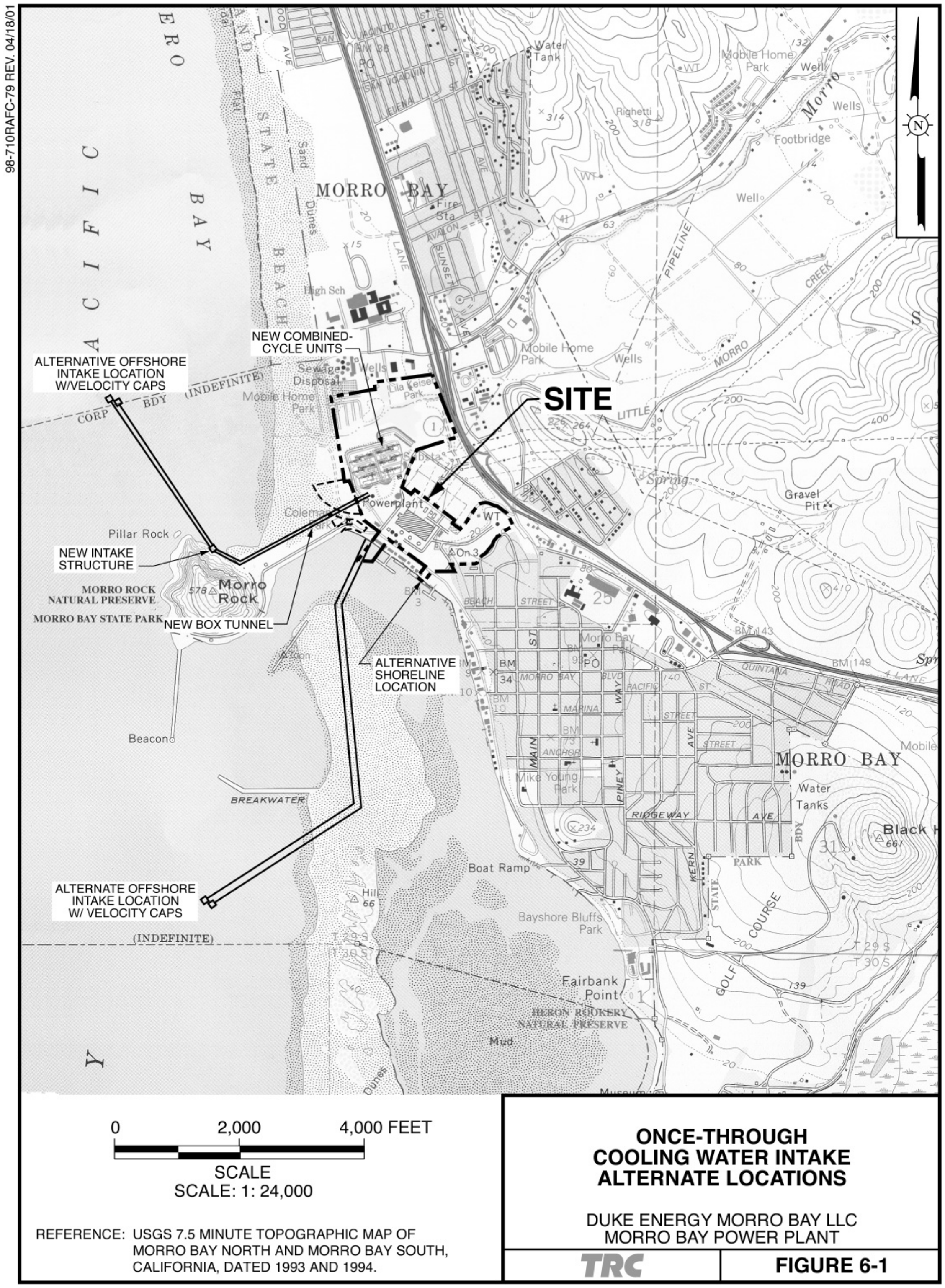

Figure 6-1. Once-through cooling water intake alternate locations.

6.2.2 Alternative Onshore Location

This alternative would involve abandoning the existing shoreline intake facilities and constructing a new shoreline intake with a capacity of 330,000 gpm at a site approximately 250 yards up bay in the waterfront area. Duke Energy owns a parcel contiguous with the power plant at that location (see previous Figure 6-1).

6.2.2.1 Potential Biological Benefits

The similarity of habitat along Morro Bay's outer shoreline does not present any obvious reason to expect a lower potential for entrainment and impingement at any other available shoreline locations. The logical direction, based on present land use and ownership, space and zoning, to rebuild the existing shoreline intake would be further south into Morro Bay's waterfront development and its associated piers, wharves and pilings. If the intake was relocated in this area of the bay, it would be located further into the habitat of *Hypsoblennius spp.*, whose fractional larval entrainment mortality is the highest of Morro Bay's resident species. In this case, a new shoreline location could make entrainment mortality worse for this species of blenny and not improve conditions for any other species.

6.2.2.2 Technical Criteria

The developed nature of the waterfront essentially precludes the consideration of the identified, or any other, alternative bay and harbor shoreline location. Although it could be proposed, it is unlikely to be permitted by relevant agencies, particularly since no benefits are perceived.

6.2.2.3 Other Environmental Impacts

Installation of such a new intake facility would be unnecessarily disruptive to the existing waterfront uses in the area, with no biological benefit. There would be construction-related disturbances for the new facility, as well as demolition-related disturbances for the existing facility. During the operational period, the new facility would interfere with existing navigation activities more than the existing facility does and it would be closer to commercial establishments along the waterfront.

6.2.2.4 Economic Criteria

The estimated total installed cost is about $27 million more than the proposed modifications to the existing shoreline intake structure[2]. The annual Operating and Maintenance (O&M) costs are roughly the same as the existing shoreline intake structure. The PV of this alternative is $27 million. This cost amortized over 30 years is $2 million per year.

6.2.2.5 Conclusion

The additional dredging and installation of the concrete headworks for the new intake would be unnecessarily disruptive to the bay habitat at the site. Due to no clear biological benefits in abandoning the existing shoreline intake facilities, this alternative is eliminated from further consideration for application at MBPP.

6.2.3 Adjustable Vertical Barrier

An adjustable vertical barrier could be used to redirect the present inlet flows of the existing intake from the lower portion of the water column to other depths between the Bay floor and the surface. With such a device it might be possible to reduce entrainment rates by selecting a level of the water column for withdrawal that has relatively lower concentrations of larvae or other organisms than the concentrations at the bottom of the water column.

6.2.3.1 Potential Biological Benefits

No information is available on the stratification of Morro Bay fish or invertebrate larvae. Because of the shallow depth and high tidal current velocities in the area of the intake, it is not expected that water column plankton would be persistently and predictably concentrated at a certain depth. Fish larvae and other forms of plankton in deeper bays, such as San Francisco Bay and the Delta, have exhibited strong patterns of stratification that fluctuated vertically with tidal velocity, directions, and very strongly with daylight and nighttime conditions. It would not seem a practical possibility that the position of a vertical barrier could be adjusted to accommodate all of these varying vertical concentrations of planktonic larvae.

There is a similar likelihood that raising the elevation of the present intake withdrawal higher in the water column would increase the rate of entrainment mortality. Studies by Brothers (1975)[3] found that the larvae of *Clevelandia ios*, the most likely species of the unidentified goby in the

[2] Incremental capital investment for alternate onshore location in lieu of proposed existing shoreline intake utilizing existing intake structure of Units 1 through 4.
[3] Brothers, Edward. 1975. The comparative ecology and behavior of three sympatric California gobies. University of California San Diego. PhD Thesis, 370 pp.

316(b) Morro Bay study, were positively phototactic for the first ten days their larval stage, the stage most susceptible to entrainment. Since these unidentified goby larvae, the most numerous taxa entrained, are found at the surface during their period of risk to entrainment, redirecting the MBPP intake withdrawal from the bottom to the top of the water column could significantly increase entrainment mortality. For a similar reason, adult anchovy that commonly school in the surface water might be more susceptible to impingement if CWIS withdrawal was moved higher in the water column. The presence of a physical barrier surrounding the intake area might reduce the number of crabs that are impinged by directing their bottom movements out and around the intake structure and traveling screens.

The redirected withdrawal of surface water that is commonly warmer in Morro Bay would raise the temperature of the power plant's discharge into Estero Bay (as well as negatively affect the efficiency of power generation). Although the increase in discharge temperature would be relatively small, it would partially negate the new facility's positive reduction in the size of its discharge thermal plume.

6.2.3.2 Technical Criteria

A conceptual adjustable vertical barrier was designed to replace the curtain wall on the existing intake structure of Units 1 though 4 at the MBPP. The adjustable barrier consists of a steel frame and plate assembly that is lifted in place by an overhead 6-ton hoist. Each frame would contain three separate plates, each plate in a separate slotted guide on the vertical sides of the frame. The depth of the water intake opening to the CWIS could then be varied by using the hoist to raise or lower the plates to different relative positions, and providing an appropriate gap between two of the plates at the desired depth. Figure 6-2 shows a conceptual elevation view of this system installed on the intake structure

The work to install such a system would involve coffer damming and dewatering of the intake structure area, modification of the base mat and top deck of the intake structure, installation of columns/beams and a 6-ton hoist support structure system at each of the frame and plate assembly locations. Ten (10) such assemblies would be required at the intake structure. Figure 6-3 shows the major work involved in the installation of the adjustable vertical barrier at the existing intake structure.

6.2.3.3 Other Environmental Impacts

Construction of the adjustable vertical barrier would cause additional temporary impacts from the construction of the coffer damming of the intake structure, with its concomitant disruption to the marine habitat of the harbor area. The project would probably also require additional marine studies to obtain permits and environmental approvals. These additional permitting requirements would lead to significant project schedule impacts.

6.2.3.4 Economic Criteria

The estimated total installed cost for the adjustable vertical intake is about $1.1 million more than the proposed existing shoreline intake structure modifications[4,5]. The annual Operating and Maintenance (O&M) costs would remain roughly the same. The PV of this alternative is $1 million. This cost amortized over 30 years is $89,000 per year.

6.2.3.5 Conclusion

There is no clear evidence that an adjustable vertical barrier could reduce entrainment rates, and no information is available on the stratification of Morro Bay fish or invertebrate larvae to warrant further modification to the existing intake structure barrier wall. It is possible that withdrawal of cooling water closer to the surface could increase entrainment/impingement. This design also has not been demonstrated successfully in sites comparable to Morro Bay. Because of the lack of data on whether adjustable design modifications on the intake barrier will have any effect whatsoever on reducing entrainment and it is not a demonstrated technology, the adjustable vertical barrier alternative is eliminated from additional consideration.

[4] Incremental capital investment for adjustable vertical barrier in lieu of proposed existing intake structure curtain wall utilizing existing intake structure of Units 1 through 4.
[5] Incremental capital investment for alternate onshore location in lieu of proposed existing shoreline intake utilizing existing intake structure of Units 1 through 4.

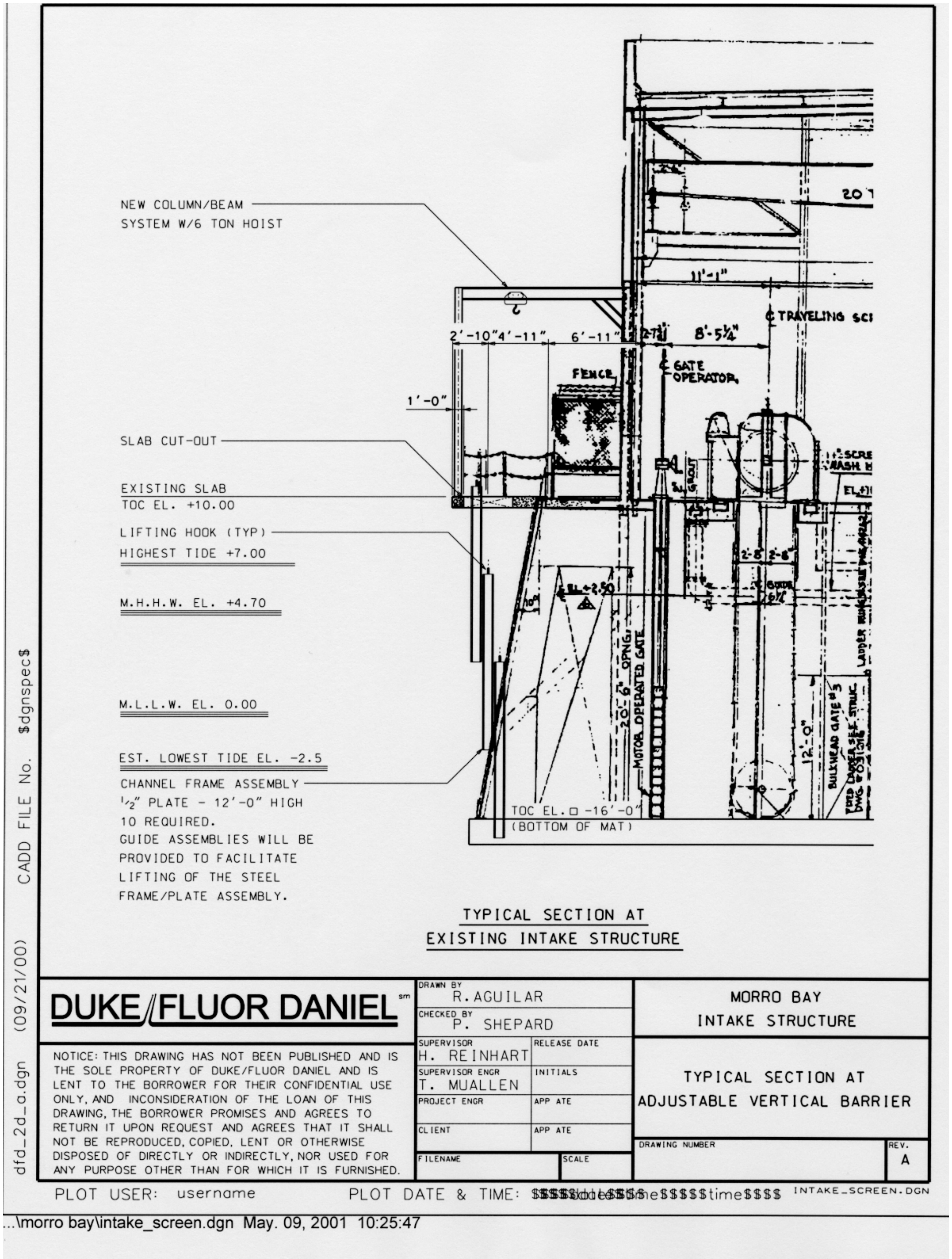

Figure 6-2. Site construction of the vertical barrier steel assembly at the Intake structure area at MBPP.

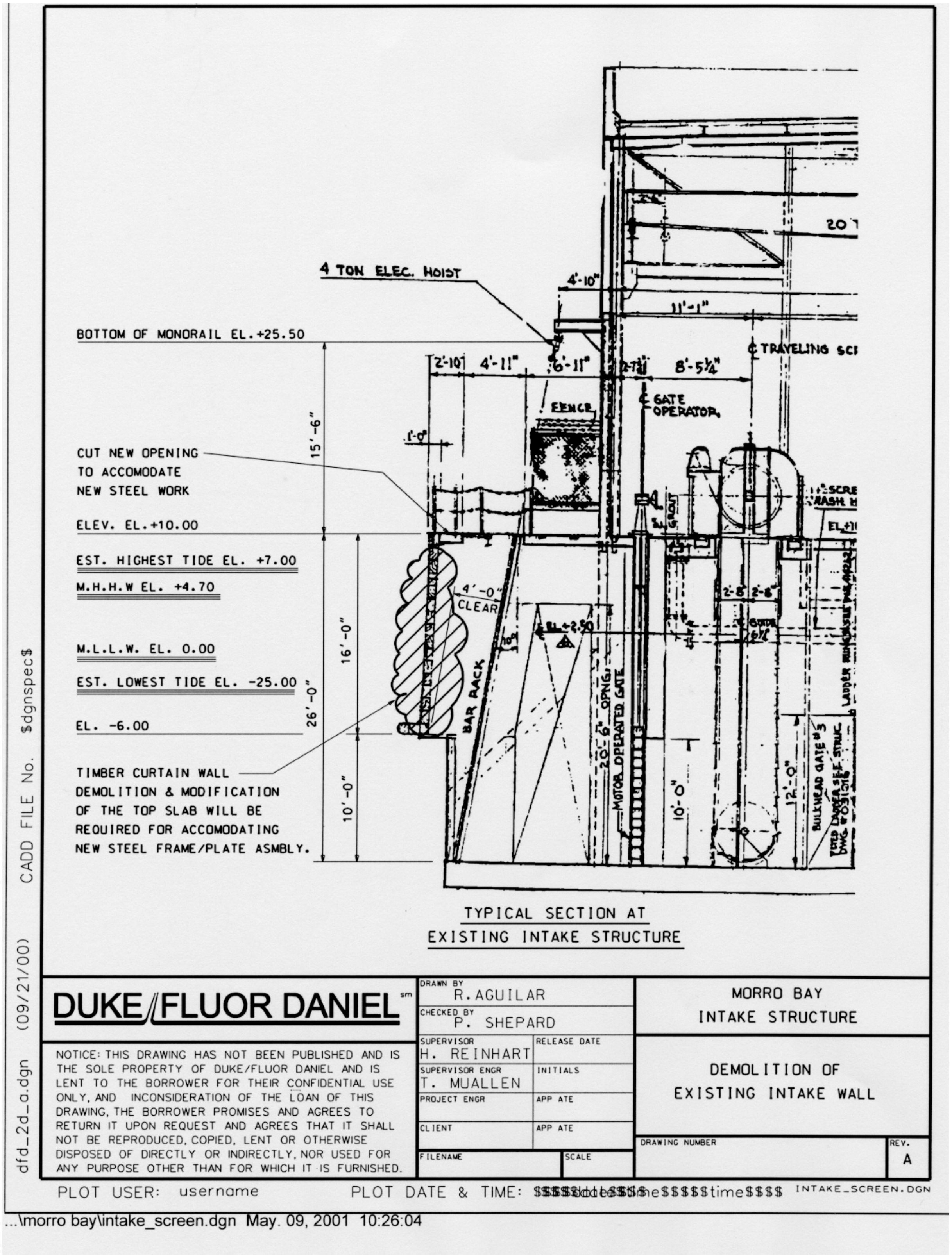

Figure 6-3. Conceptual elevation view for the vertical barrier steel assembly at the Intake structure area at MBPP.

6.3 Behavioral Barriers

Behavioral technologies have received considerable attention, particularly over the past ten years. Where behavioral barriers have any potential application, it is limited to reducing entrapment and impingement of juvenile and adult fishes, and not for macroinvertebrates or for reducing entrainment of any life stages of any organisms.

6.3.1 Non Demonstrated Proven and Available Behavioral Barriers

Despite numerous studies involving existing devices and several new technologies, behavioral technologies are still considered to be experimental by many regulatory and resource management agencies (EPRI 1999). Devices such as velocity gradients, electric barriers, magnetic fields, water jet curtains, hanging chains and cables, and chemicals have been suggested, and in some cases evaluated, as fish protection measures. However, no practical applications of these devices have been developed and they are not considered available technologies for application at cooling water intake structures (Taft 1999). No permanent installation of any of these technologies has been found, nor are there any scientific data currently available to indicate that they are worthy of further evaluation (EPRI 1999). Strobe lights have been used at water intake facilities to effectively repel several fish species in both laboratory and field conditions. Recent studies have demonstrated that various lacustrine, riverine, and anadromous species will avoid strobe light. Conversely, some studies have indicated that certain species from similar environments or with similar life history strategies or phylogeny will not respond to strobe lights in a laboratory setting or under field conditions (Brown 1999). To date, there are no permanent fish protection facilities that include the use of strobe lights. Other forms of light, including overhead and underwater mercury lights and incandescent flood lights, have been tested and installed principally as a fish attractant, as opposed to a fish deterrent, at a number of facilities with mixed results (EPRI 1999). Therefore, careful consideration must be given for any application of lights to avoid increasing impingement of some species.

Air bubble curtains generally have been ineffective in blocking or diverting fishes in a variety of field applications. Air bubble curtains have been evaluated at a number of sites on the Great Lakes with a variety of species. All air bubble curtains at these sites have been removed from service. In no case have air bubbles curtains been shown to effectively and consistently repel any species (EPRI 1999).

The focus of recent fish protection studies involving underwater sound technologies has been on the use of new types of low- and high-frequency acoustic systems that have not previously been available for commercial use. High-frequency (120kHz) sound has shown to effectively and repeatedly repel members of the genus *Alosa* (American shad, alewife, and blueback herring) at sites throughout the U. S. (Ploskey et al. 1995, Dunning 1995, Con Ed 1994). Only one thermal power plant, the James A. Fitzpatrick Nuclear Power Plant in a fresh water environment, has installed a sound system intended to reduce impingement, specifically impingement of alewife (EPRI 1999). Other studies have not shown sound to be consistently effective in repelling species such as largemouth bass, smallmouth bass, yellow perch, walleye, rainbow trout (EPRI 1998), gizzard shad, Atlantic herring, and bay anchovy (Con Ed 1994). Given the species-specific responses to different frequencies that have been evaluated, and the variable results that often have been produced, additional site-, species-, and species lifestage- specific research would be required to evaluate the potential usefulness of applying the technology to an intake system that is perceived to have a significant enough impingement problem to warrant the experimental research at the site.

A response in fish close to a sound source is probably related more to particle motion than acoustic pressure. Particle motion is very pronounced in the near field of a sound source and is major component of what fishes most likely sense from infrasound (frequencies less than 50 Hz). In the first practical application of infrasound for repelling fishes, Knudsen et al. (1992, 1994), found a piston-type particle motion generator operating at 10 Hz to be effective in repelling Atlantic salmon smolts in a tank and in a small diversion channel. Following the success of Knudsen et al. (1992, 1994), there was a general belief in the scientific community that infrasound could represent an effective fish repellent since there was a physiological basis for understanding the response of fishes to particle motion. The potential for currently available infrasound sources to effectively repel fishes has been brought into question by the results of more recent studies. Given these results, infrasound sources need to be further developed and evaluated before they can be considered an available technology for application at CWIS.

Electric barriers have been shown to effectively prevent the upstream passage of fishes. However, a number of attempts to divert or deter the downstream movement of fishes have met with limited success (Bengeyfield 1990, Kynard and O’Leary 1990). Consequently, past evaluations have not lead to permanent applications. Electric barriers have been used with limited success in freshwater, but because of low electrical resistance, no application of electric fish barriers has been made in salt or brackish waters, as exists at Morro Bay. Given their past ineffectiveness and hazard potential, electric screens are not considered a viable technology for application at CWIS.

In general, behavioral barriers have not proven consistently effective in reducing the numbers of fishes impinged at CWIS. In addition, such barriers will not reduce the numbers of entrained organisms or the impingement rates of macroinvertebrates. Behavioral barriers are not considered to represent an effective alternative for reducing entrainment or impingement at MBPP.

6.3.2 Velocity Cap

A velocity cap is a behavioral based technology that is applied only to offshore submerged water intakes. The velocity cap intake minimizes capture of fish by converting the flow of ocean water into the intake pipe from primarily a vertical direction to horizontal, and distributing the flow over a larger area, so that flow velocities are reduced to speeds avoidable by many fish. The general theory is that fish are more sensitive to horizontal rather than vertical flows, and will generally avoid horizontal changes in velocity more readily (U.S. EPA 1977).

6.3.2.1 Potential Biological Benefits

The use of a velocity cap on a submerged offshore vertical riser intake significantly reduces the entrapment and impingement of many forms of pelagic marine life including fish, invertebrates and wildlife such as turtles, seals, sea lions, and birds. The retrofitting of existing offshore vertical intake risers with velocity caps has been proven so effective at reducing intake effects that a new offshore intake riser would not be constructed without a velocity cap. In spite of the effectiveness of velocity caps to reduce the impingement rates of offshore-sited intakes, entrapment and impingement rates of these CWIS remain much higher than at shoreline intake facilities.

6.3.2.2 Technical Criteria

The velocity cap alternative is only applicable if one of the offshore intake alternatives as described in Section 6.2.1 is selected. For the Morro Bay Power Plant offshore intake lines, the velocity cap option would consist of one or more covers securely attached above the entrance of the inlet pipes with adequate open space provided to allow the horizontal entrance of water between the cap and wall of the intake pipe. A typical example is shown in Figure 6-4.

6.3.2.3 Other Environmental Impacts

Other than the construction-related impacts associated with installing an offshore intake system, there are no other significant environmental impacts associated with the velocity cap option.

6.3.2.4 Economic Criteria

The cost of including velocity caps in the offshore intake alternative is negligible compared to the total incremental cost of the offshore intake system.

6.3.2.5 Conclusion

Velocity caps would be included if a submerged offshore intake alternative were to be implemented.

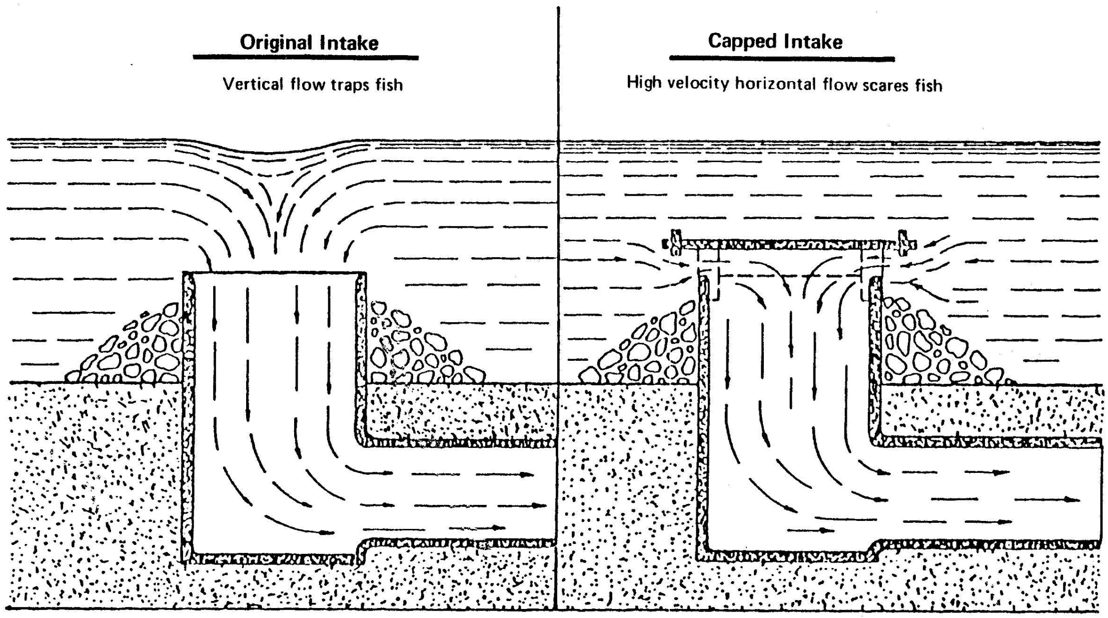

Figure 6-4. Schematic representation of an offshore structure with velocity cap (Weight 1958).

6.4 Physical Barriers

The applicability of physical barrier screen technology to reduce biological losses associated with entrainment and impingement at the new MBPP combined-cycle units is evaluated in the following discussions. The screening technologies that are evaluated include vertical traveling screens, centerflow and dual flow screens, barrier nets, and the new fine mesh floating aquatic filter barrier.

6.4.1 Non Demonstrated Proven and Available Physical Barriers

Media filters, such as rapid sand filters, porous dikes, and radial well intakes, have never been used to provide power plant cooling water from a marine source. Prototype tests have been conducted that have identified debris accumulation, biofouling, and sedimentation as major constraints in the application of media filters in the marine environment. Results of laboratory and small-scale pilot studies have indicated that porous dikes might be effective in preventing passage of juvenile and adult fishes. However, entrainable organisms will generally be trapped in the porous medium or entrained into the pump flow. No recent research has been performed with porous dikes, sand filters, and other forms of media filter intakes. No practical way to apply them to cooling water intake structures has been identified, and the status of these technologies is unlikely to change in the future (EPRI 1999). In the absence of demonstrated performance capabilities and operational reliability in a once-through power plant cooling water system, media filters are not considered to be an available technology for the new combined-cycle units.

To date, large-scale CWIS applications of cylindrical wedge-wire screens have been limited to only a few power plants. These applications employ coarse bar spacings (10 mm, 0.4 in) and have been biologically effective in preventing entrainment and impingement of juvenile and larger fishes. The potential use of 0.5 to 2.0 mm bar spacing to protect early life stages of fish from entrainment (particularly eggs and early larvae) has not been evaluated at a cooling water intake structure (EPRI 1999). In general, consideration of wedge-wire screens with small slot dimensions for CWIS application to reduce entrainment would require *in situ* prototype scale studies to determine the space availability with an ambient parallel current to carry passive organisms and backflushed debris away, the potential biological effectiveness, and identify the ability to control clogging and fouling in a way that does not impact plant operation. Other forms of stationary screens have had little application at CWIS. No information is available on recent advances or installations of flat-panel screens for use as fish barriers. Flat panel screens also require a much larger surface area than do conventional traveling screens for the passage of the same volume of water. Use of these screens for cooling water intakes is precluded except for small volume intakes where the space is available and the screens can be maintained in a clean condition to minimize head loss.

The horizontal traveling screen concept attempted to combine elements of both diversion and collection devices and might have been an effective fish protection system if engineering problems could have been overcome. Unfortunately, years of design, research, and development efforts at two sites did not result in a screen that could operate reliably, even for relatively short periods of time. There has been no additional work on this technology and it is not considered available for application at CWIS (EPRI 1999).

Similarly, while rotary drum screens are often mentioned as technologies for protecting fishes at water intakes in fresh water environments, such screens have never been applied to a steam electric station CWIS in any environment. Drum screens have been used at irrigation and hydroelectric facilities but, even in these applications, the screens are limited by the requirement for maintaining constant water elevations. Drums screens are not considered to be biologically effective, based on the limited data available (Eicher 1974), and are not expected to reduce the numbers of organisms entrained or impinged at the plant's cooling water intake structures. There is no information available to suggest that survival of organisms impinged on drum screens would be significantly different, much less any better, from impingement survival on conventional vertical traveling screens. In the absence of any predicted technical feasibility or biological advantages in the Morro Bay setting, drum screens are not considered to be an acceptable alternative intake technology applicable to the new combined-cycle units.

6.4.2 Vertical Traveling Screen

Vertical traveling screens are physical barriers designed to prevent passage of fish and debris into the water intake system. It is a standard feature at most CWIS intake facilities throughout the U.S. The ability of traveling screens to act as a barrier to fishes without impinging depends on many site-specific factors, such as the size of fish, location of the screens, and presence of escape routes. It is considered advantageous to locate intake screens on the shoreline, as deployed for the new CC units CWIS. The traveling screen system configuration consists of a large vertical meshed screen panels (commonly 3/8 inch opening) mounted on two parallel chains and motor operated from the upper sprocket. Figure 6-5 shows a conventional vertical traveling screen. The screen rotates periodically for cleaning with a direct spray nozzle, the debris/wastes are collected into a trough and carried into a refuse basin.

6.4.2.1 Potential Biological Benefits

Vertical traveling screens, including the type employed at MBPP, represent the industry standard for CWIS. With relatively minor variation and modification, their design and operation varies little with location or facility. Two biologically important features of these active screening systems are proven reliability and their ability to effectively maintain debris-free conditions in the intake area. Both of these operating features serve to lower impingement rates by maintaining consistent intake flows and velocities and reduced amounts of entangling material in the intake forebay.

6.4.2.2 Technical Criteria

The existing MBPP currently utilizes vertical traveling screens at Units 1 through 4 intake structure. Figures 6-6 and 6-7 show the current configuration. The new CC units will continue to utilize the existing vertical traveling screens after the necessary refurbishment.

6.4.2.3 Other Environmental Impacts

There are no other significant environmental impacts associated with the vertical traveling screens.

6.4.2.4 Economic Criteria

The estimated Operating and Maintenance costs (O&M) based on extended use of the existing MBPP vertical traveling screens is $160,000 per year, not including potential major refurbishment costs for the new CC units.

6.4.2.5 Conclusion

The vertical traveling screens, especially at a shoreline location such as exists at Morro Bay, are an industry standard that avoids many of the adverse environmental effects and economic costs of many alternatives, and should continue to be utilized at the MBPP.

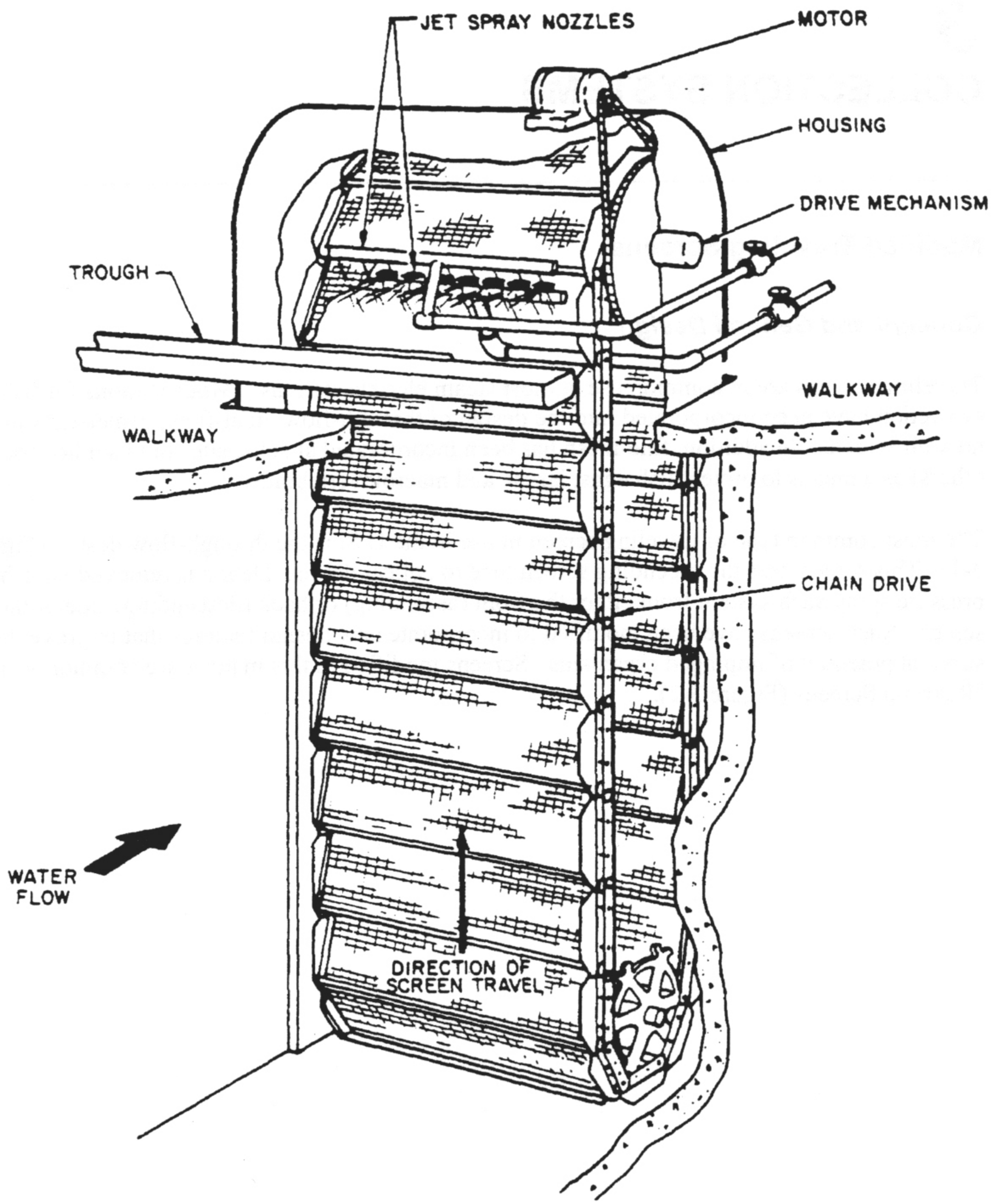

Figure 6-5. Schematic of a conventional traveling water screen (EPRI 1986).

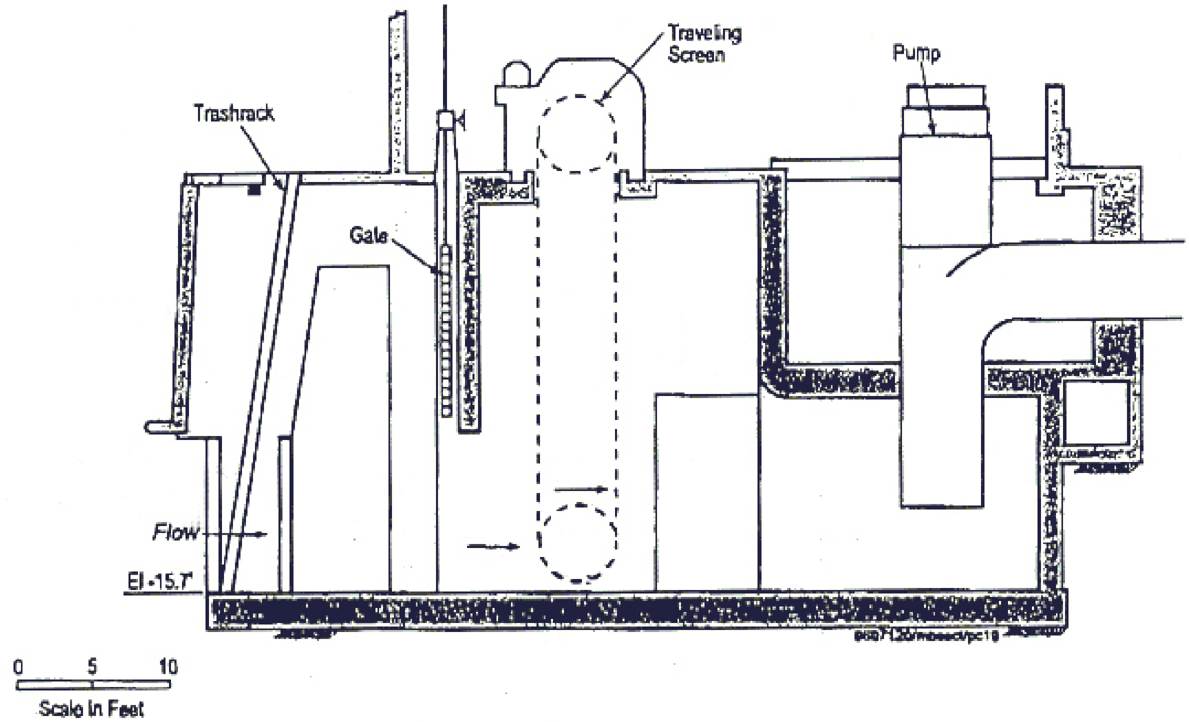

Figure 6-6. Existing Morro Bay Power Plant Units 1 and 2 intake structure, typical section.

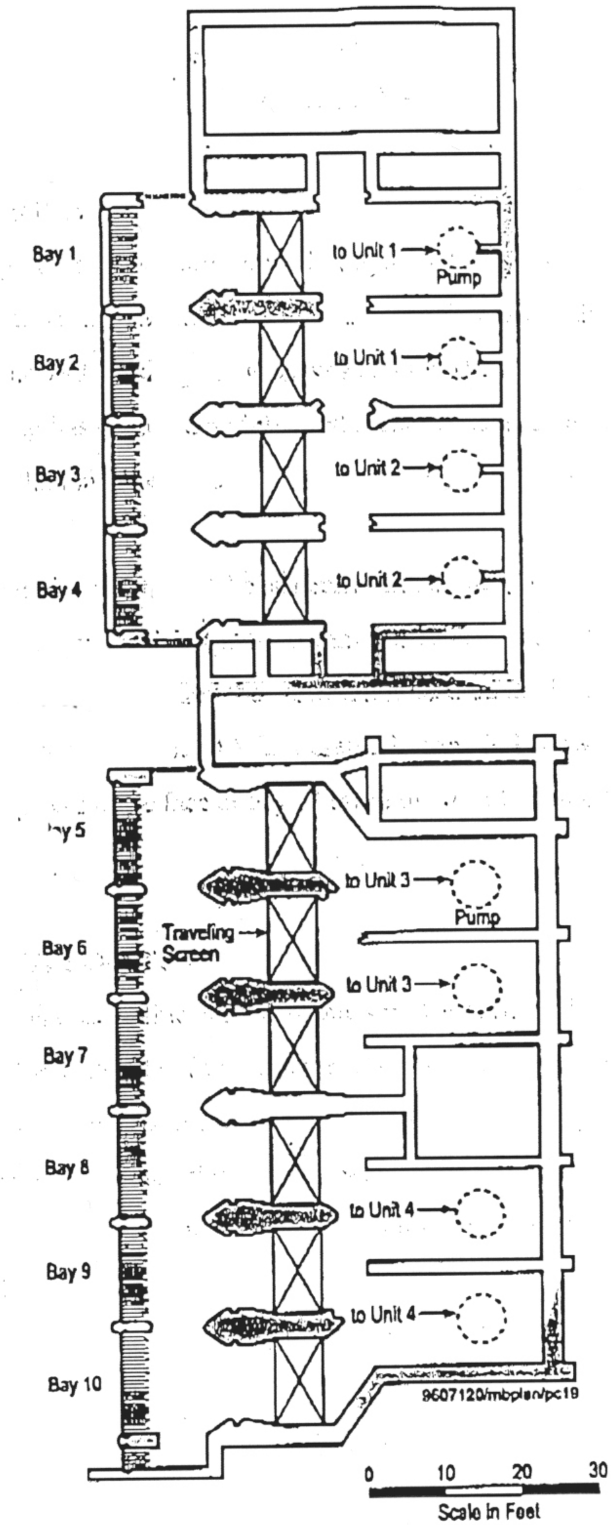

Figure 6-7. Morro Bay Units 1 through 4 intake structure, plan view.

6.4.3 Centerflow / Dual Flow Screen

The centerflow/dual flow traveling screen technology is designed to reduce the biological/ environmental losses to aquatic and marine life resulting principally from impingement. The centerflow screen design concept passes the water through the center and exiting on both sides of the screen conveyor (Figure 6-8). The dual flow screen design concept is the same as a centerflow except that the water entry is from both screens into the center passage (Figure 6-8). These two designs have allowed the use of a finer mesh material without increasing through-screen velocity. Both concepts are used in connection with fish return conveyance systems, as described in Section 6.5.4. The screen is positioned so the fish and debris are trapped in the direction of the flow. There are wall mounted structural components that guide the screen trays and baskets. In the debris/fish removal area, located above the screens are low-pressure spray nozzles to dislodge debris into the removal trays. The fishes and other marine lifeforms are transferred to a fish trough or holding tank to be released back to their natural environment. The application of the system is typical for limited space constraints on the entry channel.

6.4.3.1 Potential Biological Benefits

Centerflow screens fitted with fine mesh screens have demonstrated relatively high survival of impinged organisms when coupled with an appropriate return conveyance system. Although impingement survival at the MBPP might be increased by the use of centerflow screens, it would depend upon the installation of an effective fish return that would also improve impingement survival of the existing MBPP CWIS. The installation of centerflow screens would not be expected to reduce MBPP entrainment losses, and depending upon the species entrained could theoretically reduce existing survival rates associated with the plant passage.

The biological effectiveness of both systems have been evaluated. An experiment has been conducted for the centerflow screen system at the Barney M. Davis Power Station (Murray and Jinnette 1978). The study was done also on the influence of debris loading on survival of the target species.

The location of the Barney M. Davis Power Station is on the shoreline of the upper Laguna Madre near Corpus Christi, Texas. The flow velocities going through the fine-mesh screens range from 1.7 ft/s to 3.1 ft/s. The samples were collected on a month to month basis from January to December of 1977. The study collected a total of 12,060 individual marine organisms, it represented 15 species of invertebrates and 37 species of vertebrates. The overall survival rate for the individual was 86 percent. The most abundant fish with the lowest mortality rate was the menhaden in the month of February. They made up of 33 percent of the caught fish but has exhibited only 5 percent mortality.

The effect of the debris being caught by the centerflow screen was studied on how debris affected the survival of impinged organisms. The effect of debris and survival is related. During the months of January, February, and March, the debris weight fluctuated, and the mortality rate followed the same pattern.

A study has been done on the Roseton Generating Station's dual flow screen system at Central Hudson Gas and Electric Corporation (CHGE). The dual flow screens were designed to improve fish survival through implementation of water retaining lifting buckets, dual-pressure spray cleaning system, flattened woven wire mesh and faster operational speeds. The flow velocity approaching the screens was 0.75 ft/s. The system used both the low (organism removal) and the high-pressure (debris removal) overhead sprays to clean the screens.

The Roseton post-impingement survival program was conducted during the seasonal periods of May 9 through August 30, and September 30 through November 29 of 1990. The study collected 48,729 fish representing 30 species and a total of 12,668 fish were evaluated for extended survival test. The post-impingement survival for the dual screen flow was found to be higher than the conventional traveling screens that was simultaneously studied.

6.4.3.2 Technical Criteria

Due to their orientation to the current in an intake structure, centerflow and dual flow screens would require a structure that projects further out into the harbor than do the existing shoreline vertical traveling screens.

6.4.3.3 Other Environmental Impacts

Other environmental impacts from centerflow and dual flow screens are the additional space requirements constrained by available landward space at the site and the impacts associated with the necessary construction activities and filling in of Morro Bay to construct the new facility seaward of the existing intake structure into the harbor, reducing bay bottom habitat.

6.4.3.4 Economic Criteria

The estimated total installed cost for dual flow screens is about $4 million more than the proposed existing vertical screens[6]. The Operating and Maintenance costs (O&M) are estimated to be the same as the existing vertical traveling screens. The estimated total installed cost for centerflow screens is approximately the same as dual flow screens. The PV for either screen type is $4 million. This cost amortized over 30 years is $314,000 per year.

6.4.3.5 Conclusion

In the absence of a demonstrated potential for long-term survival for impinged ichthyoplankton, such as northern anchovy, Pacific herring, surfperch, rockfishes, white croaker and flatfishes, centerflow and dual flow screens do not offer alternative intake technology to reduce the combined entrainment and impingement losses at the new MBPP combined-cycle units. Insufficient data preclude a detailed comparison of the potential survival of early life stages of fish impinged on centerflow and dual flow screens (which would require fine-mesh screen material, continuous rotation). To date, no studies have been conducted of long-term survival of fishes impinged on centerflow screens operated in a power plant cooling water intake, and it is unlikely that survival would be any higher than for vertical traveling screens.

The alternative is not cost effective since it only addresses impingement impacts, which are not a significant issue with the present CWIS. Even if they were more effective, the cost-benefit of installing and operating centerflow or dual flow screens would be wholly disproportionate to the economic loss of impinged organisms, which is valued in the few thousands of dollars per year.

[6] Incremental capital investment for centerflow or dual flow screens in lieu of proposed existing vertical traveling screens at the existing intake structure of Units 1 through 4.

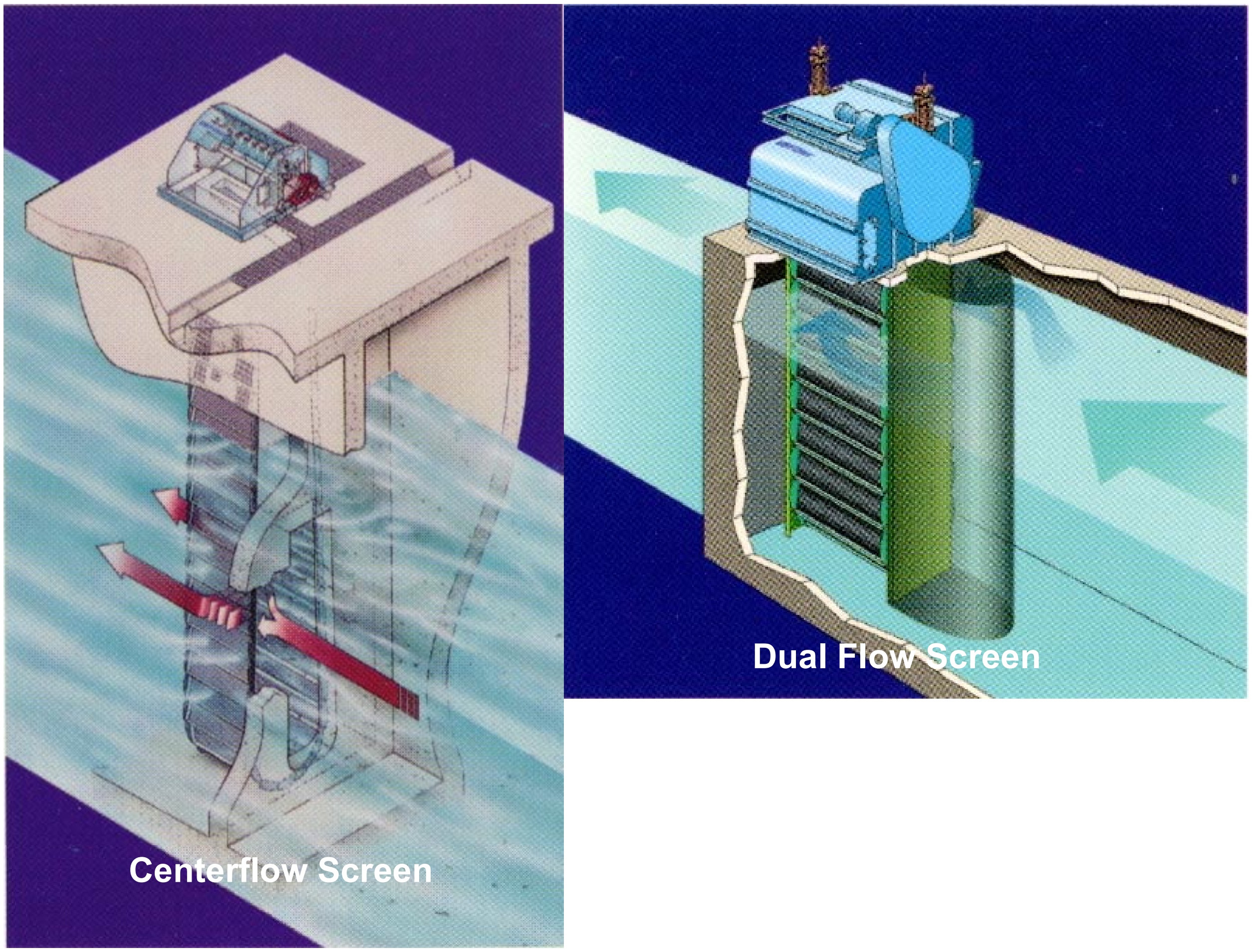

Figure 6-8. Centerflow screen and dual flow screen (Courtesy of US Filter).

6.4.4 Barrier Net

A barrier net is a physical barrier technology designed to reduce biological losses associated with marine lifeform entrapment and impingement. Barrier netting is composed of large fish nets and anchors which are strategically located in the aquatic or marine habitat. The netting design is dependent on local fish populations and debris concentrations. The effectiveness of the barrier nets to prohibit fishes from entering the water intake depends on the fish species and size to be protected, near-field hydraulic conditions (low velocity), and debris present, including vegetation in the waterbody (low concentration). The mesh size of the nets must be selected to prevent fish passage but not cause entrapment of the fish. This method has been effectively applied to several power plants cooling water systems and has reduced impingement dramatically. Barrier nets have generally been employed where there is an intake canal leading to the pumps, rather than where the intake structure is located along a shoreline.

6.4.4.1 Potential Biological Benefits

Under the proper hydraulic conditions (primarily low velocity) and without heavy debris loading, barrier nets have been effective in blocking fish passage into water intakes. Several recent applications in the midwest United States have been presented (Michaud and Taft 1999). At the Ludington Pumped Storage Plant on Lake Michigan, a 2.5-mile long barrier net, set in open water around the intake jetties, has been successful in reducing entrainment of all fish species that occur in the vicinity of the intake (Reider et al. 1997). The net was first deployed in 1989. Modifications to the design in subsequent years led to a net effectiveness for target species (five salmonid species, yellow perch, rainbow smelt, alewife, and chub) of over 80 percent since 1991, with an effectiveness of 96 percent in 1995 and 1996.

Another application was applied at the Chalk Point Station on the Patuxent River (Loos 1986). The barrier system is composed of two barrier nets, the purpose of the outside net is to trap most of the debris and jellyfish while the finer mesh net is used inside to prevent the smaller marine organisms. The nets were placed in the mouth of the intake canal; outer barrier is made of a series of sewn panels (1.25-inch stretch mesh), inner barrier is of finer mesh 0.75-inch stretch mesh (Figure 6-9). The nets were originally deployed in July 1981. Further modification to the net system was done in 1985, which increased the effectiveness of the system. Impingement of crabs was reduced by 84 percent.

Barrier nets can be considered a viable option for protecting fishes provided that relatively low velocities (generally less than 1 ft/sec) can be achieved and debris loading is light.

6.4.4.2 Technical Criteria

Barrier nets can be considered a viable option for protecting some fish from entrapment and impingement provided that they satisfy the initial requirements: 1) Near-field hydraulic conditions, relatively low velocities (generally less than 1 ft/sec), 2) Light debris concentration. The nets tend to fail due to heavy debris load, 3) Small variety of species present. Net sizing has to be specific to certain sizes and species of fish.

Regardless of the non-ideal conditions at the Morro Bay location, a conceptual barrier net design was developed incorporating 25 feet by 100 feet net panels with ¼ in mesh, float lines, and lead lines for the purpose of this analysis.

6.4.4.3 Other Environmental Impacts

The installation of a barrier net at the MBPP CWIS could potentially exclude shoreline habitat and interfere with other uses such as navigation and other water related activities. In addition, barrier nets have reported significant problems with biofouling buildup. It could also potentially entangle and possibly kill certain species of fish, crabs, marine birds, and marine mammals. Maintaining clean surfaces have been so difficult in freshwater that one of the common problems with barrier nets is that they sink from biofouling and have to be removed for cleaning, typically at the end of the year during the winter. Biofouling is so much harder to control in the marine environment that barrier nets could conceivably fail within a very short period of time, a few months.

6.4.4.4 Economic Criteria

The range of potential costs of a barrier net for the MBPP is somewhat uncertain do to the nature of a functional and environmental acceptable design. Based on recent installations at other similar sites, costs could range up to $2 million. This base cost does not include the cost of multi-purpose design elements to mitigate overall MBPP project impacts or any design features unique to Morro Bay's environmental setting. Annual Operations and Maintenance (O&M) costs would depend to a large extent on the final barrier net design. A portion of these O&M costs would be offset by reduced costs of the existing intake facilities and operation of the cooling water system with cleaner conduits than at present.

6.4.4.5 Conclusion

The low potential biological benefits (due to no entrapment and low impingement with the existing intake configuration and operation) relative to other environmental, logistical, and costs for installation and operation at MBPP, preclude barrier nets from being considered a viable alternative for MBPP.

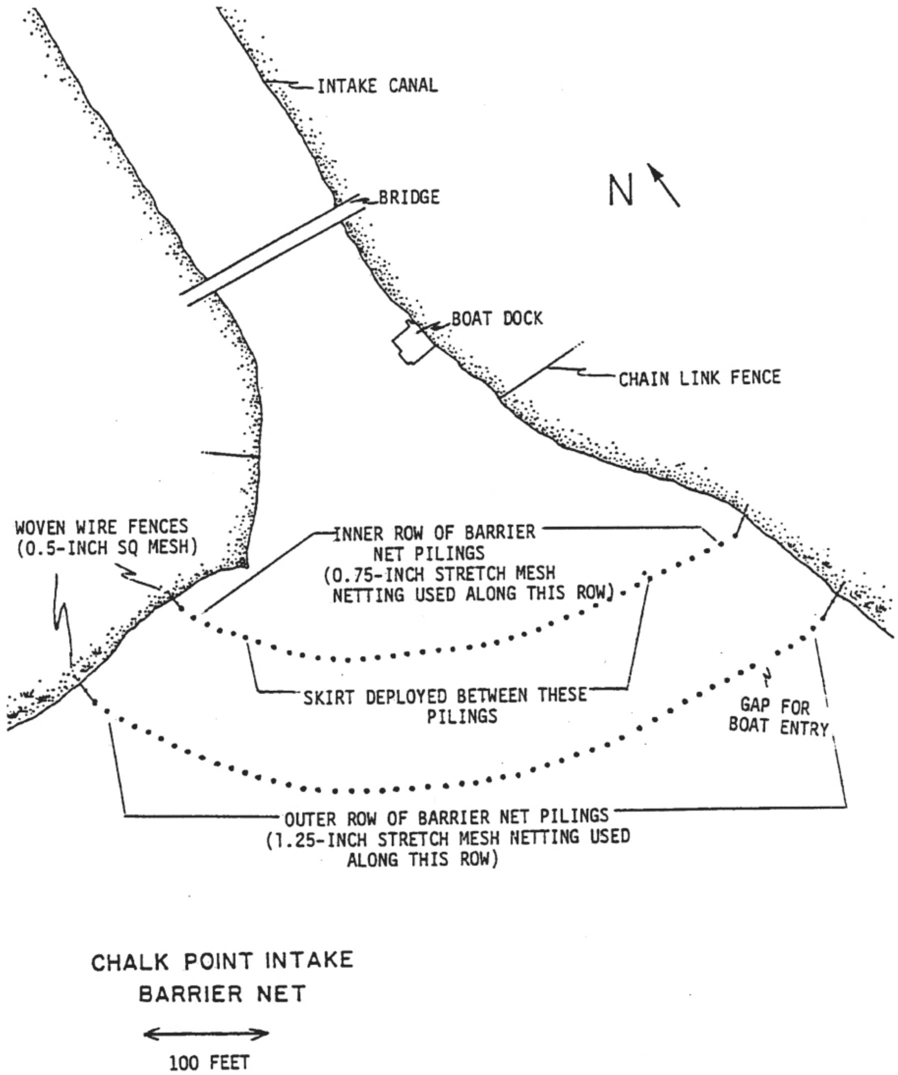

Figure 6-9. Visual example of Chalk Point Barrier Net Configuration (EPRI 1999).

6.4.5 Aquatic Filter Barrier

An Aquatic Filter Barrier (AFB) is another physical barrier technology designed to reduce biological losses associated with marine lifeform entrainment and impingement. A newer version of a very fine mesh barrier net, currently manufactured by Gunderboom, consists of polyester fiber strands that are pressed into a water-permeable fabric mat. The net is deployed ahead of an intake with a large screening surface area such that velocities through it are extremely low. The net requires some sweeping flow along its surface, and an air burst system to keep it clean.

6.4.5.1 Potential Biological Benefits

In 1993 and 1994, Orange and Rockland Utilities, Inc. sponsored a study of a 3.0-mm, fine mesh net at its Bowline Point Generating Station on the Hudson River (LMS 1996a). In 1993, fine suspended silt caused the net to clog and sink. In 1994, spraying was not effective in cleaning the net when it became fouled by the alga *Ectocarpus spp*. Excessive fouling caused two of the support piles to snap, ending the evaluation (LMS 1996a). In both years, abundance of the target ichthyoplankton species, bay anchovy, was too low to determine the biological effectiveness of the net. On the basis of studies to date, the researchers conclude that a fine mesh net may be a potentially effective method for preventing entrainment at Bowline Point. However, pending further evaluation, this concept is considered to be experimental.

A newer version of barrier net, currently manufactured by Gunderboom, consists of polyester fiber strands that are pressed into a water-permeable fabric mat. Beginning in 1995, Orange & Rockland Utilities, Inc. has sponsored an evaluation of the Gunderboom to determine its ability to minimize ichthyoplankton entrainment at the Lovett Generating Station on the Hudson River (LMS 1996b, 1997, and 1998; ASA 1999). Despite difficulties in keeping the boom deployed and providing adequate cleaning reported in 1995-1997 studies, 1998 study results show a large reduction in entrainment and reliable operation following a number of improvements to the net. By adding a computer-controlled air sparging system to continuously remove the build-up of silt in the fabric's mesh, cleaning and reliability problems may have been resolved at this site. At this time, the Gunderboom systems have been ordered or installed at a number of power plant CWIS and continue to be successful at Lovett.

6.4.5.2 Technical Criteria

A successful aquatic filter barrier design (AFB) must meld biological considerations of the targeted exclusion organisms with engineering parameters and constraints of the site and power plant operating characteristics. Functional design consideration of an MBPP AFB include the exclusion of larvae in the size range of 1 to 3 mm from maximum intake flows of 330,000 gpm. The semi-porous barrier material is manufactured with appropriate diameter perforations to meet particle size filter specification and in lengths and widths of sufficient surface area for plant intake flows. AFB materials are typically designed to allow filter flows of 10 gpm per square foot. An AFB design for MBPP based on the size range of entrained larvae and intake flows would require approximately 33,000 square feet of barrier. Bottom depths in the installation area generally determine the AFB's dimensions. The MBPP AFB might have a length of approximately 2,000 feet assuming an average depth of 15 feet in an installation area in front of the intake. The barrier's final design would require information from a number of studies and field tests of the site's design characteristics such as:

- Detailed plant site mapping to include shoreline structures, intakes, discharges and general layout.
- Nearshore Bathymetry
- Bay floor and area geotechnical data for anchoring and piling considerations.
- Current data including speed, direction, fluctuation, local considerations and anomalies, if applicable.
- Suspended solids levels, fluctuations, events, physical characteristics and composition.
- Debris transport relevant to type and degree of materials to be anticipated, including logs, trash, microalgae, seagrasses, etc.
- Wind and wave considerations, including fetch.
- Tidal current and elevation changes.
- Benthic infauna, epifauna and nearshore fisheries usage of area.
- Target organisms for exclusion, life stages, location in water column, size, seasonality.
- Permitting, navigational and local planing issues.

The existing data and knowledge on the physical site characteristics for inclusion in the design and planning process would be reviewed in a preliminary investigation of the site. This includes inspection of shoreline features, deployment considerations, plant operations and available resources. At the MBPP site, installation space in front the intake would appear to potentially be the single most limiting site characteristic. Tidal flows in the channel in front of the project's CWIS appear to provide appropriate flushing flows required to sweep particles along the surface of the AFB, and sediment loads are normal for bays similar to Morro Bay.

6.4.5.3 Other Environmental Impacts

The installation of an AFB at the MBPP CWIS could potentially exclude shoreline habitat and interfere with other uses such as navigation and other water related activities. However there are several AFB design concepts that might avoid or significantly reduce AFB effects in these environmental areas. Two conceptual designs that maintain open shoreline habitat and could expand the area's water-related facilities are illustrated in Figures 6-10 and 6-11 (Courtesy of Gunderboom). These examples of a modified AFB design concept illustrate a potential range of solutions to the site's environmental considerations The Figure 6-10 example would satisfy most environmental benefit criteria, whereas the Figure 6-11 example would be more complex and provide additional marina facilities to the community. The examples indicate that some additional design effort might identify and refine, through appropriate regulatory and planning processes, a design that meets environmental and community criteria at the MBPP site.

6.4.5.4 Economic Criteria

The range of costs of an AFB project for the MBPP is somewhat uncertain due to the nature of a functional and environmental acceptable design. Recent installations at other sites, have required capital investments in the range of $4-6 million. This base cost does not include the cost of multi-purpose design elements (wharves, piers, boat ramps, boardwalks, etc) to mitigate overall MBPP project impacts or any design features unique to Morro Bay's environmental setting. Annual Operations and Maintenance (O&M) costs, which would depend to a large extent on the final AFB design, are estimated at around $300,000 to $500,000 and include operation of an air burst cleaning system, repair, and replacement of the AFB materials over their estimated 10 year life span. A portion of these O&M costs would be offset by reduced costs of the existing intake facilities and operation of the cooling water system with cleaner conduits than at present. The PV for this alternative is $8-12 million and this cost amortized over 30 years is $0.6 million to $1 million per year.

6.4.5.5 Conclusion

The installation of an aquatic filter barrier for the combined-cycle plant would reduce the entrainment and impingement effects of the project's CWIS. However, the cost effectiveness of installation of an AFB at the MBPP would need further evaluation of its efficacy and cost effectiveness through detailed engineering feasibility and biological evaluations.

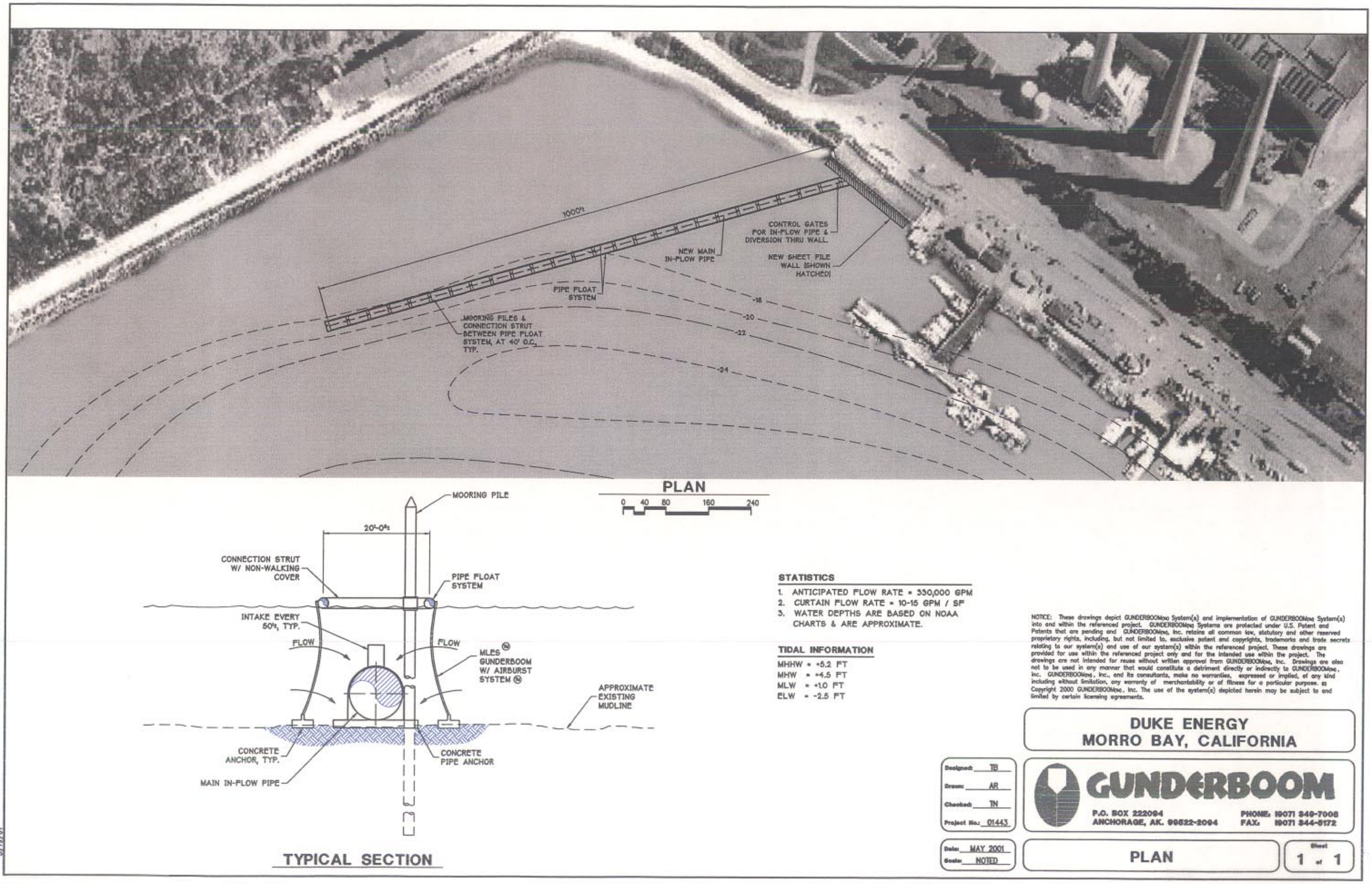

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Figure 6-10. Example Conceptual Design of an AFB at the MBPP (courtesy of Gunderboom).

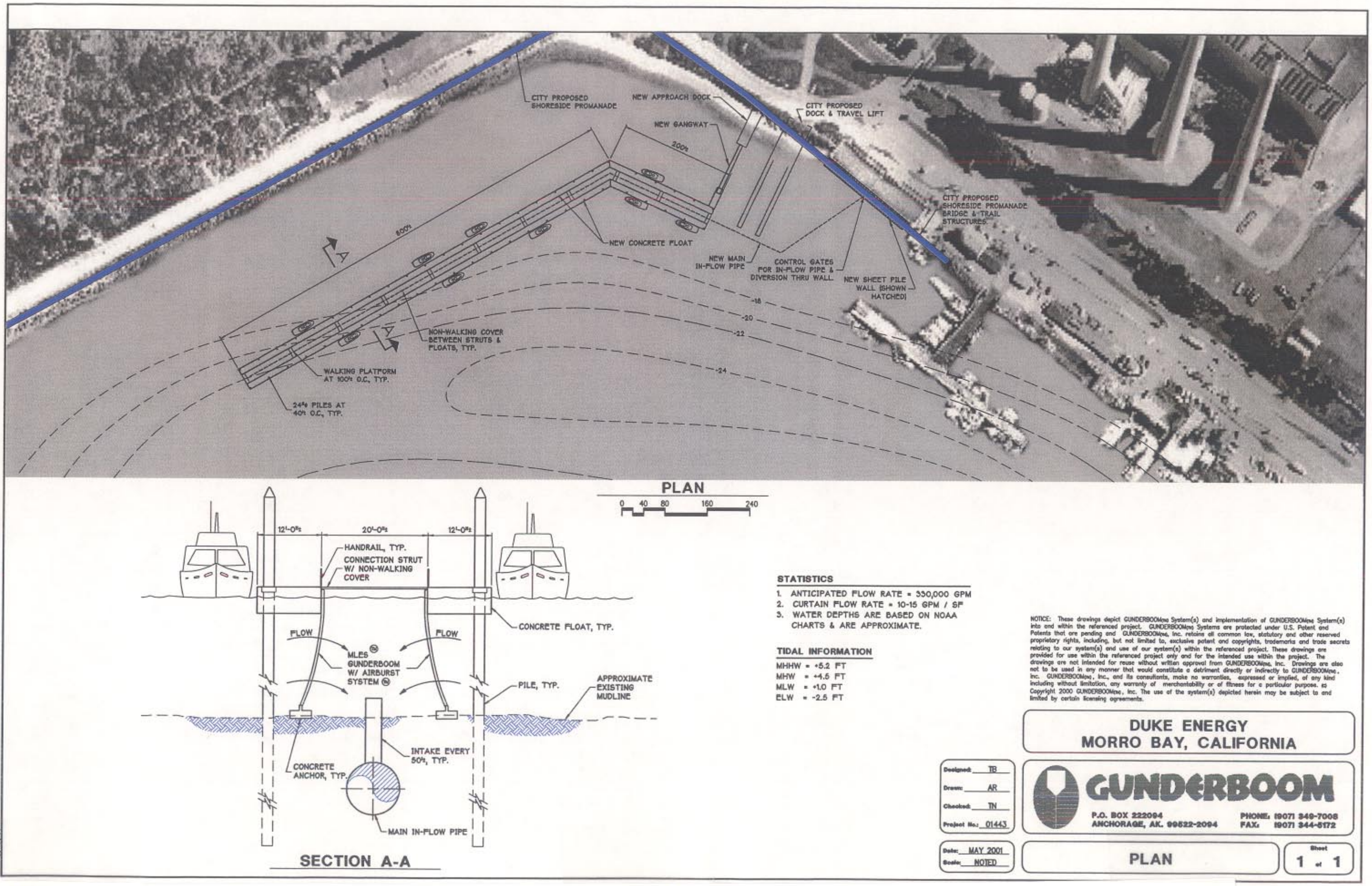

Figure 6-11. Alternative Example Conceptual Design of an AFB at the MBPP (courtesy of Gunderboom).

6.5 Fish Diversion, Collection, and Conveyance Systems

The uses of fish diversion, collection, and conveyance systems are limited to reducing entrapment and impingement of juvenile and adult fishes, and have no effect on entrainment of eggs, larvae, and other early life stages of fish. Fish diversion and collection systems such as louvers, angled screens, and modified traveling screens are only of benefit when they are installed and operated in concert with an effective fish return conveyance system.

6.5.1 Louvers

A louver diversion system consists of an array of evenly spaced, vertical slats (venetian blind concept) aligned across an entry channel at a specified angle leading to a fish bypass. The design of the diversion system is based on the approach flow velocity and swimming speed of fish (Figure 6-12). The concept behind the system is that it will create a stimulus in the water to divert the fish to a safer area. The effectiveness of the system is based on species characteristics, life-stage, and site specifics. Louvers generally are not considered acceptable by most environmental regulatory agencies in the country because they have been less effective compared to other fish protection systems. The louver system has been applied though to riverine environments with migratory species. There are studies that demonstrated the louvers to have 80-95 percent effective in diverting a wide variety of species over a wide range of condition (EPRI 1986, 1994a). Since louver arrays are necessarily set at an angle to the flow, they require a length of an intake channel or canal to work effectively. They are not applied to shoreline intake locations, but have been applied to onshore intake screen well used in conjunction with offshore submerged intakes which entrap fish.

6.5.1.1 Potential Biological Benefits

There have been various studies to evaluate the effectiveness of louver diversion system. Southern California Edison's Redondo Beach station conducted experiments on 18 species of fish including northern anchovy, queenfish, white croaker, walleye, surfperch, and shiner perch in a test flume (Schuler 1973). They tested in velocities ranging 0.5 to 4 fps. The louvers were placed in angles ranging 20 degrees to 90 degrees to the direction of the flow. The maximum guidance of 96 to 100 percent happened with the louvers spaced at 1-inch apart, set at a 20 degree orientation to the flow with flow vanes normal (90 degrees) to the frame, and an approach flow velocity of 2 fps. V. Schuler determined that the configuration of the bypass channel was as important to the effectiveness as the louver and the velocity settings. Additionally, it was determined that the system worked equally well in light or in darkness (Schuler 1973; Schuler and Larson 1975).

Based on the results from the Redondo Beach experiment, California Edison's San Onofre Nuclear Generating Station (SONGS) developed and installed a traveling louver system. The plant's once-through cooling system includes intake structures situated approximately 0.62 miles (1 km) from the shore at depths of 29.5 ft. The intake has a wide lower lip and velocity cap and the facility depends on a fish return system to mitigate fish entrapment. The diversion system utilizes the guiding vanes and louvers to direct the fish away from the banks of traveling screens into a safe collection area (Figure 6-13). Velocity through the screens is between 2 to 3 fps. The data for biological effectiveness could not be found for this facility.

Northeast Utilities Service Company has conducted a research to evaluate the use of louvers for diverting juvenile and adult clupeids and Atlantic salmon smelts in the Holyoke Canal on the Connecticut River (Harza and RMC 1992; Harza and RMC 1993; Stira and Robinson 1997). The effectiveness of the louver was evaluated on the juvenile clupeids (American shad and blueback herring) tests at various canal flows. The experiment found that 76 percent of marked and recaptured test fishes were guided, and 86 percent of the naturally migrating fishes were guided to a bypass channel that safely returned the fish to the river (Harza and RMC 1993). A separate experiment was performed with Atlantic salmon smelts indicated a guidance effectiveness of 85 to 90 percent (Harza and RMC 1992). Refer to Figure 6-14 for this system configuration.

6.5.1.2 Technical Criteria

Louvers have been used effectively at several large agricultural water diversions and hydroelectric installations. Most of the louver applications to date have been with migratory species in riverine environments. Therefore, the ability of this alternative to protect species commonly impinged at CWIS is largely unknown. Further, due to the large openings between louver slats, louver systems do not provide a positive barrier either to early life stages of fishes or to debris that could block the condenser tube system and lead to reduced operating reliability and increased maintenance. Therefore, traveling water screens are required downstream of louvers for CWIS applications, and since louver arrays are necessarily set at an angle to the flow, they require a length of an intake channel or canal to work effectively. Therefore the arial extent of the total system is much larger than for shoreline intakes, and the facilities would have to be built out into the Morro Bay harbor.

6.5.1.3 Other Environmental Impacts

As noted above, a louver system requires a channel leading up to the screen in which the louvers are installed at an angle to the flow. Due to constraints on the availability of landward space at the MBPP, such a channel would have to be built seaward out into the harbor area. This would cause unacceptable contaminant effects associated with the necessary construction activities and filling in of Morro Bay, reducing bay bottom habitat.

6.5.1.4 Economic Criteria

Further consideration of louver systems for diverting and aiding in the collection of fish at the MBPP cooling water intake, with total installed costs, would require extensive engineering feasibility and biological evaluations. The alternative is not cost effective at the MBPP site since it only addresses impingement impacts, which are not a significant issue with the present CWIS. The cost-benefit of the modification would be wholly disproportionate to the economic loss of impinged organisms that is valued in the few thousands of dollars per year.

6.5.1.5 Conclusion

The low potential biological benefits (due to no entrapment and low impingement with the existing intake configuration and operation) relative to other environmental, logistical, and costs for installation and operation at MBPP, preclude louvers from being considered a viable alternative for MBPP. There would be no reason to install such a fish diversion system at a shoreline intake such as exists at MBPP.

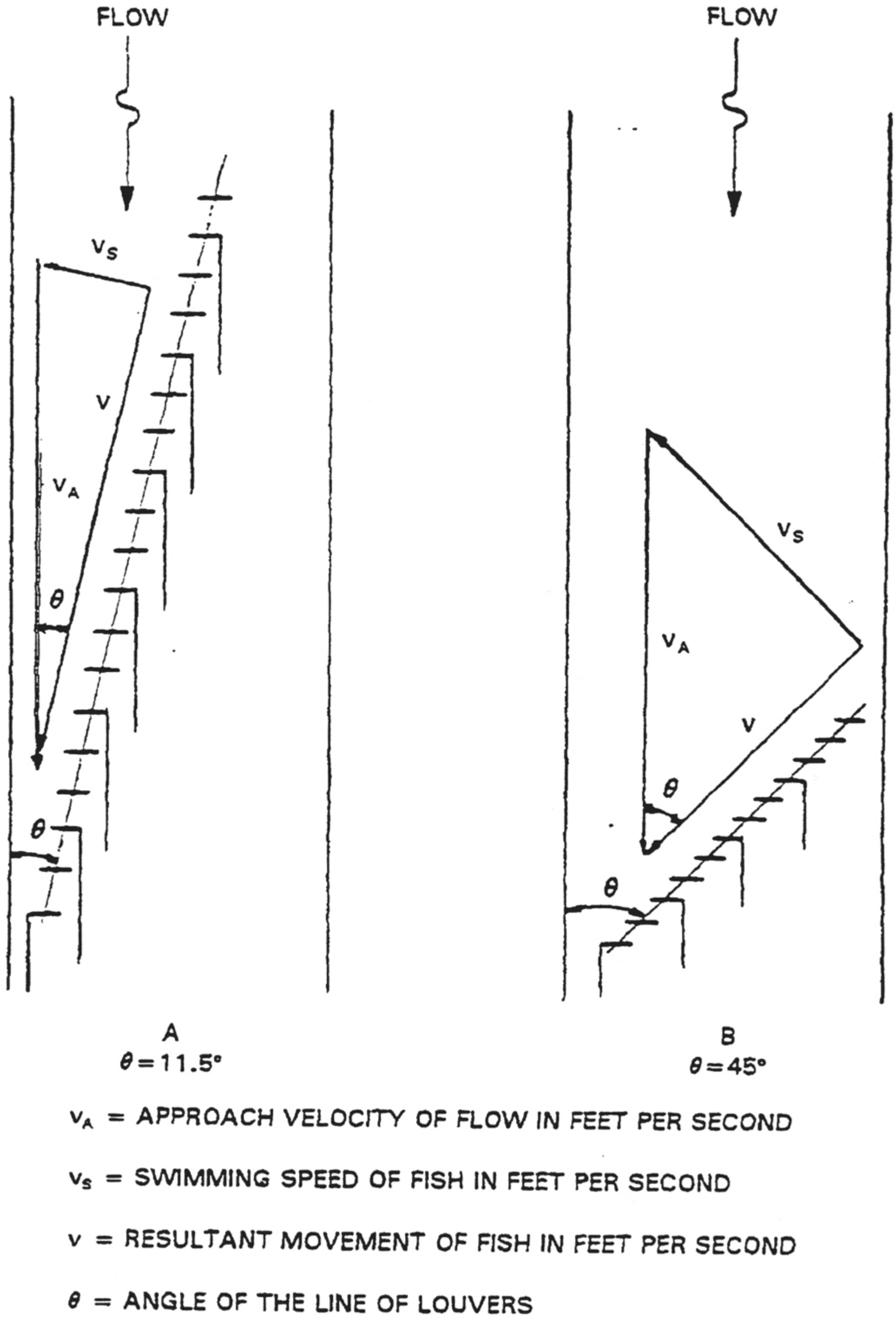

Figure 6-12. Louver array (EPRI 1999).

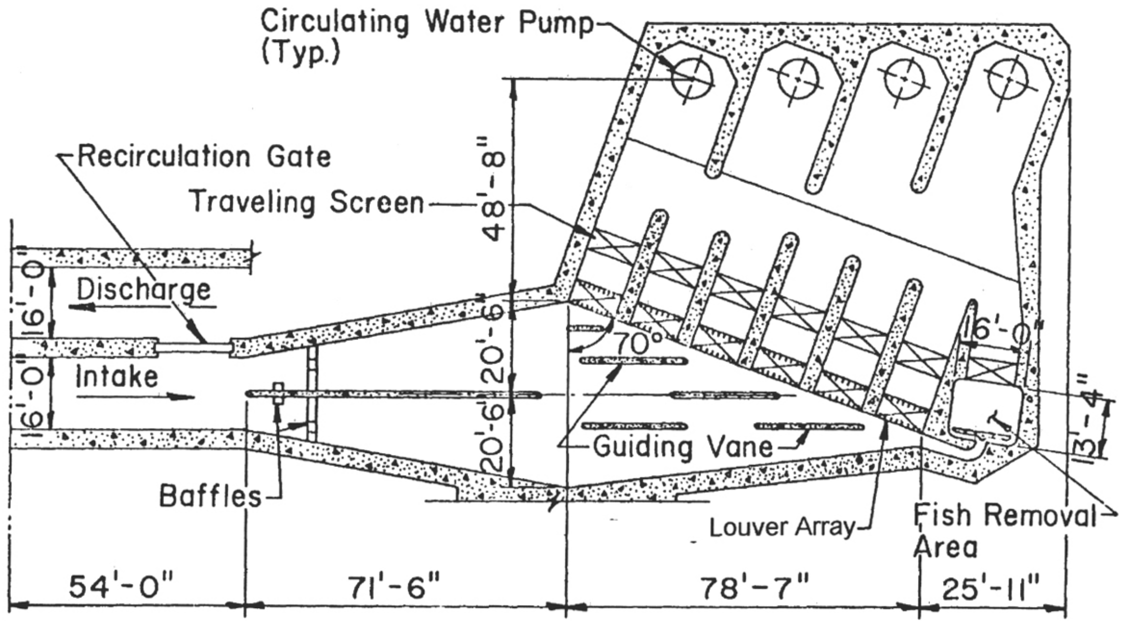

Figure 6-13. Louver System at SONGS (EPRI 1987).

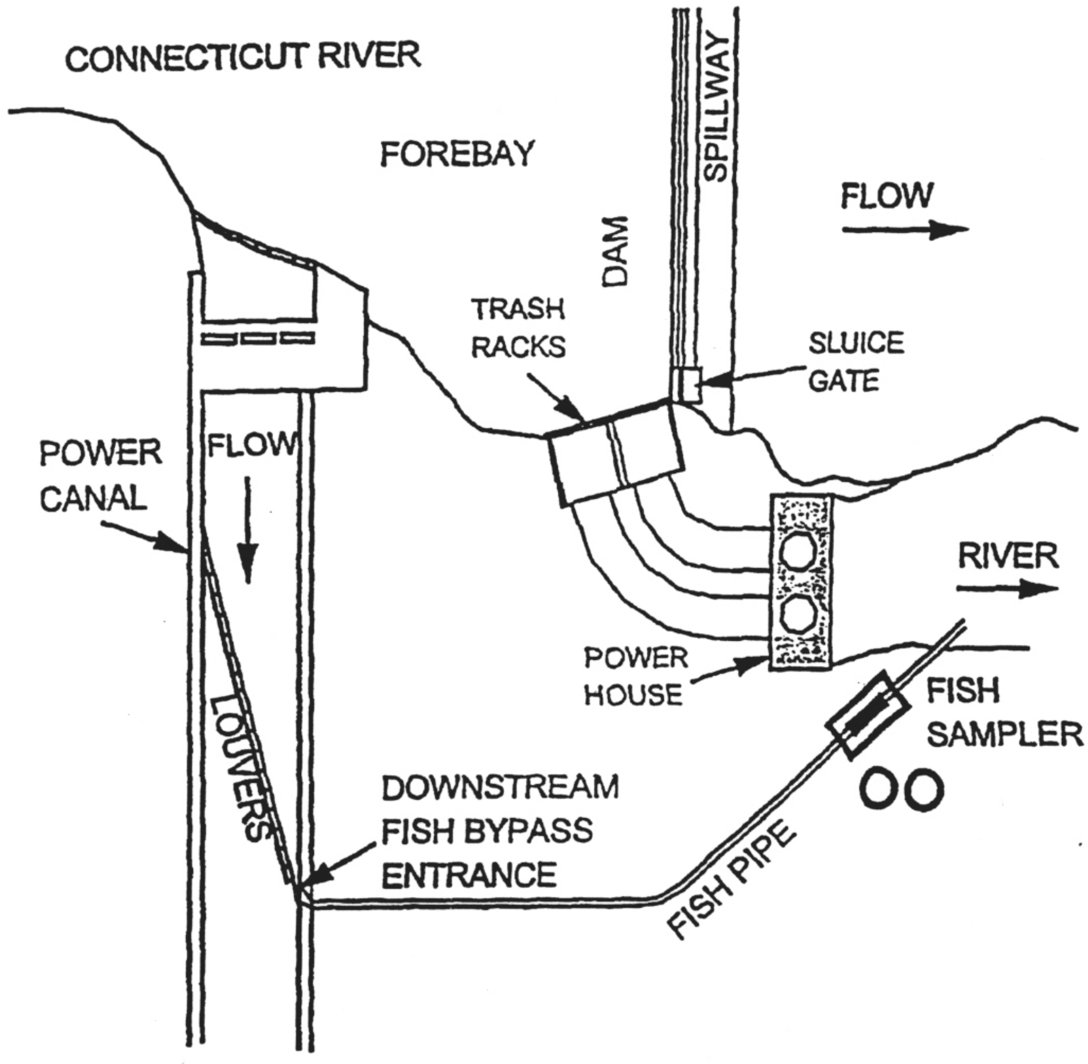

Figure 6-14. Holyoke Louver System (Stira and Robinson 1997).

6.5.2 Angled Screens

The angled screen design is composed of a series of vertical traveling screens arranged strategically to a certain angle to maximize fish/marine animal diversion leading to a primary bypass line. The organisms captured in the primary bypass line will typically be led to a secondary bypass line, holding tank, or released back to the natural habitat. Most of these screen installations or applications have been to protect young salmonids. Angled screens have been studied for possible use at CWIS to protect a variety of fish in freshwater, riverine, estuarine, and marine environments (EPRI 1999). It also has been used in hydroelectric and irrigation intake facilities. Through the combined studies gained from those experiences, the angled screen system can be very effective in diverting fish to the bypass line if given the proper physical and hydraulic conditions.

6.5.2.1 Potential Biological Benefits

Installations of angled screens in combination with diversion and fish return systems are effective at removing entrapped and/or impinged organisms with varying degrees of return survival. There have been various studies on angled screen application to different plants/facilities around the United States. In Brayton Point Station Unit 4 at Mt. Hope Bay, MA., an 18-month biological effectiveness evaluation was conducted. The study was to determine the species, number and initial/extended survival life of fishes diverted in the bypass line (Davis et al. 1988). The system configuration is that the intake structure has eight openings that extend to the bottom of the skimmer wall. There are trash racks and behind it is a screenwell. A center wall divides the structure into two halves and each half is equipped with three flush mounted vertical traveling screens. The screens are set 25 degrees normal to the flow. The fish are lead to a rectangular opening then the fish are sluiced back to Lee River (Figure 6-15).

The diversion efficiency of the angled screen was determined by the comparison of the proportion of fish entering the bypass to the number of fish entering the screenwell. The number of fish that entered the screenwell was calculated by adding the fish impinged on the angled screens to the estimated number of fish diverted during the impingement period. The survival rates at the Brayton facility varied from 25 percent for fragile species to 65 percent for hardy species. The overall diversion efficiency of all species was 76.3 percent (Davis et al. 1988). The study noted that the diversion efficiency increased to 89.7 percent when young-of-the-year bay anchovy were excluded. There were a total of 79,206 fish collected from the angled screens and diversion flow during the experimental period. The system was not very effective for young bay anchovy but was sufficient to protect the other species.

A full-scale experiment was conducted in the Danskammer Point Generating Station on the Hudson River in 1981 (EPRI 1999). The angled screen system was installed in the cooling water intake canal (Figure 6-16). The configuration of the system consisted of two vertical traveling screens set at 25-degree angle to the flow. The angled channel led to a 0.5-ft wide bypass. The bypass line then was headed to the fish collection and larval collection tanks.

The diversion effectiveness study was conducted over a three-year period, and divided into two sections: a study of young/older fish and a study of ichthyoplankton (EPRI 1999). The young and older fish were collected on a seasonal basis from the fish pump discharge using nets and from the collection tanks for which the fish has a 96 hour mortality expectancy. A total of 59,309 fishes representing 38 species were collected during February 18, 1981 through October 27, 1983. The diversion efficiency range was from 95.4 to 100 percent, and a mean of 99.4 percent. The species affected on the river were the bay anchovy, blueback herring, white perch, spottail shiner, alewife, atlantic tomcod, pumpkinseed and american shad. The study determined that the overall efficiency (diversion efficiency times initial survival times latent [96 hr] survival) ranged from 67.9 percent for alewife to 98.7 percent for spottail shiner, and a mean percentage of 84.4 (EPRI 1999). The angle screen system has proven that it can protect the young-of-the-year and older fish, and it is an effective device for preventing impingement.

6.5.2.2 Technical Criteria

The primary application for an angled screen diversion system is if the traveling screen system is impinging a significant amount of fishes/marine organisms. The scenario happens mostly in conjunction with long offshore type intake conduits and other configurations where organisms are entrapped and can’t escape contacting the intake. In the MBPP project, the shoreline intake system was implemented. Since angled screens are angled to the current, the overall intake structures required to house them must project out in front of the pumps. At Morro Bay, such an installation would have to be built out into the harbor area in front of the existing intake structure, or the entire pump bay array and intake structure building would have to be moved further inshore.

6.5.2.3 Other Environmental Impacts

As noted above, an angled screen system requires an area leading up to the pumps in which the screens are installed at an angle to the flow. This would take up additional area from the harbor or from land inshore of the existing intake structure building. Building into the harbor would result in effects related to the necessary construction activities and filling in of Morro Bay, reducing bay bottom habitat.

6.5.2.4 Economic Criteria

Further consideration of angled screen systems for diverting and aiding in the collection of fish at the MBPP cooling water intake, with total installed costs, would require extensive engineering feasibility and biological evaluations. The alternative is not cost effective at the MBPP site since it only addresses impingement impacts, which are not a significant issue with the present CWIS. The cost-benefit of the modification would be wholly disproportionate to the economic loss of impinged organisms that is valued in the few thousands of dollars per year.

6.5.2.5 Conclusion

The low potential biological benefits (due to no entrapment and low impingement with the existing intake configuration and operation) relative to other environmental, logistical, and costs for installation and operation at MBPP, preclude angled screens from being considered a viable alternative for MBPP. There would be no reason to install such a fish collection and diversion system at a shoreline intake such as exists at MBPP.

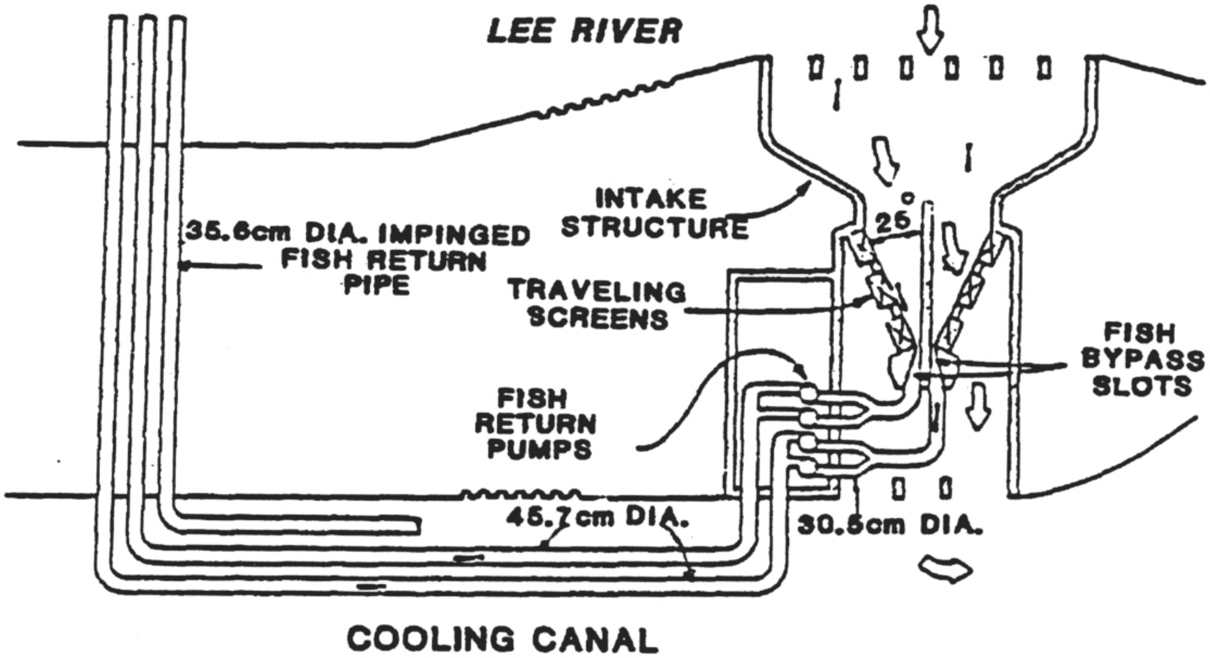

Figure 6-15. Brayton Point Station Unit 4 angled screen intake structure fish return systems (Davis et al. 1988).

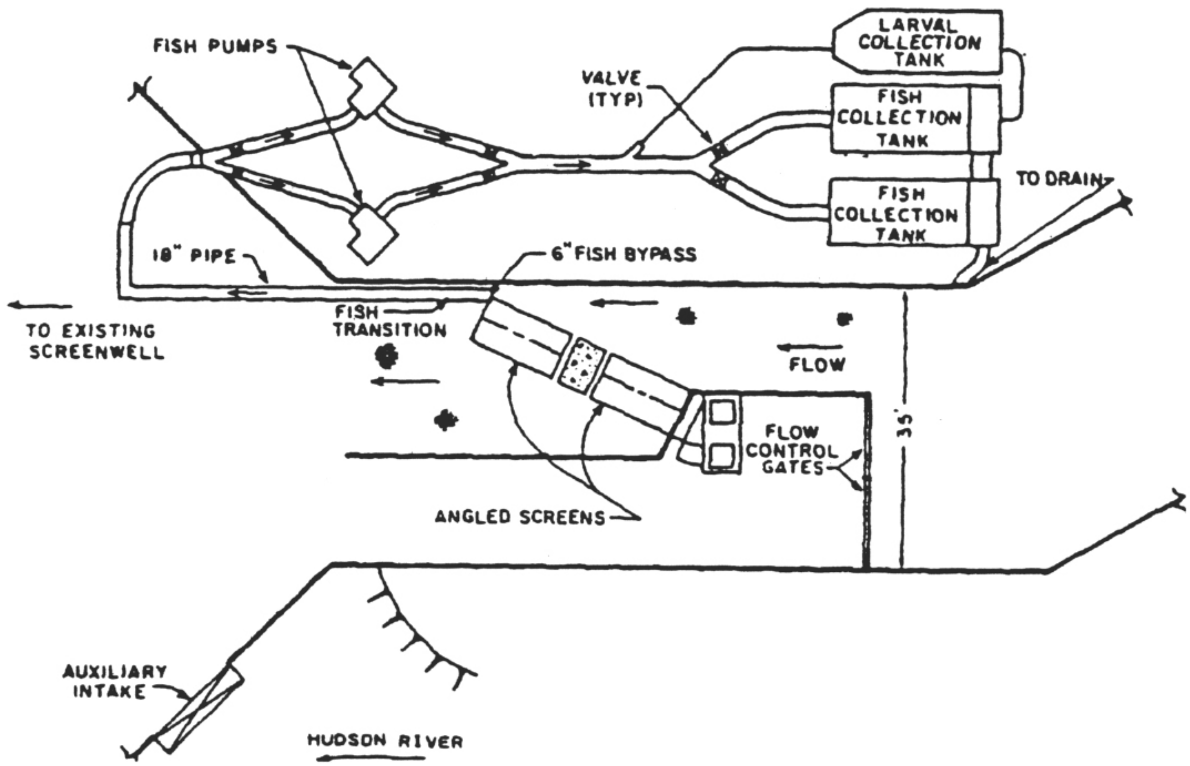

Figure 6-16. Danskammer angled screen system layout (EPRI 1999).

6.5.3 Modified Traveling Water Screens

As described in Section 2, the existing Units 1 through 4 intake structures will be retained to serve as a shoreline intake structure for the new CC units. The intake structures and screen configurations will result in screen approach velocities of only 0.23 – 0.25 fps at full base load, and 0.30 – 0.33 fps at full peak load. These maximum approach velocities are well below U.S. EPA guidelines of 0.5 fps for the design of new cooling water intake structures.

Traveling screens of various types are standard features at CWIS. Without the addition of various fish handling design (e.g., fish lifting buckets) and operating features (e.g., continuous screen operation), traveling screens generally result in high mortality to all but the hardiest species that become impinged on them. They have no capacity for protecting entrainable sized organisms. If these screens are placed relatively flush with the face of the CWIS, as exists and proposed for use by the CC units, traveling screens can be considered to offer protection to juvenile and adult fishes that have the swimming capability to avoid impingement.

This alternative evaluates the use of a vertical traveling screen with fish handling features. For some species of fishes, impingement mortality can be reduced through structural modifications to conventional vertical traveling screens and a change in intake screen operation from intermittent to continuous rotation. The structural differences to the current intake proposed for use by the new CC units for this alternative would include installation of watertight fish collection baskets along the screen, both low-pressure and high-pressure wash systems, and a fish return sluiceway. A differential control and two-speed motor are also included, so that when the screen is operated continuously it rotates at slow speed, and as the of number fishes and/or debris loads increase, the screen rotation rate can be automatically increased. In general, the same 3/8-inch screen mesh would be used on modified vertical traveling screens.

Screens modified to reduce impingement mortality need to be accompanied by a fish pumps and/or sluiceway designed to return impinged organisms to the receiving waterbody. Most installations of modified traveling screens use a dual sluiceway return system, a gravity sluiceway return system for impinged organisms removed from the screens by the low-pressure spraywash and another sluiceway for debris removed by the high-pressure spraywash.

The alternative modified screen system evaluated for the CC units' intake structure is shown in Figure 6-17. This system would consist of new vertical screens installed in the existing Units 1 through 4 intake structures behind the existing bar racks. The screens would be smooth top mesh and furnished with fiberglass fish baskets and differential speed controls. Low and high-pressure spray wash systems are provided to wash recovered fish and other organisms into a fish trough on the top of the intake structure. Impinged debris would be washed into a separate debris trough, also on top of the structure. A dual-directional water-filled fish sluiceway would extend from the fish trough to Morro Bay Harbor to return recovered organisms to the harbor at the shoreline approximately 800 feet northwest of the intake structure or 800 feet south depending upon the direction of the prevailing tidal currents.

6.5.3.1 Potential Biological Benefits

Modifications of vertical traveling screens that include fish buckets, a low-pressure wash system, provisions for continuous rotation, and a fish return system represent an alternative technology with the potential for reducing impingement losses of several of the species of fish and invertebrates impinged at the intake structures.

Several modifications to increase the biological effectiveness of conventional vertical traveling screens have been attempted in recent years. Tests on the biological effectiveness of varying the frequency of traveling screen rotation were conducted at the Moss Landing Power Plant (MLPP) (see PG&E 1983; Section 4.2). Information is also available for impingement survival of chinook salmon from the Columbia River (Page et al. 1976, and Page et al. 1978) and of striped bass from the Hudson River (EA 1979, Texas Instruments 1977). Data from these and other studies are used to examine the potential effectiveness of modified vertical screens at the new combined-cycle units.

In addition, consideration has recently been given to the potential effectiveness of a screen mesh smaller than the standard 3/8 in. (9.5 mm) but larger than 0.04-in. (1.0-mm) fine-mesh screen material for reducing the combined losses of entrainment and impingement.

Modifications to the design and operation of vertical traveling screens, such as the use of continuous screen rotation, low-pressure spray washes, and fish lifting buckets, are alternatives that have been used to increase the biological effectiveness of conventional vertical traveling screens. In many cases, continuous screen rotation has resulted in substantial increases in fish and invertebrate survival. Increasing screen rotation frequency at the Moss Landing Power Plant (MLPP) Units 6 and 7 intake contributed to a substantial increase in impingement survival for both surfperch and rockfishes (see PG&E 1983; Table 4-7). However, together these species constituted only 15 percent of the fishes impinged at MLPP. The use of these modifications would have no benefit without a fish return system. However, these studies also suggest that impingement survival of species such as northern anchovy, Pacific herring, smelt, and silversides, which together constituted approximately 75 percent of the impinged fishes, would probably not be improved substantially by increased screen rotation frequency. Based the 1999-

2000 MBPP impingement study finding that northern anchovy represented 74 percent of the impinged fish, a fish collection and return system at the new MBPP combined-cycle units would be similarly ineffective in reducing the majority of predicted impingement losses.

Limited information is available to assess the potential of this modification for improving impingement survival for other impinged species such as plainfin midshipman, and crabs with higher survival potential than fragile species such as northern anchovy, Pacific herring, smelt, and silversides. Although available data are incomplete, it is expected that the addition of fish buckets, low-pressure spraywashes, and continuous rotation of screening surfaces could increase survival of fragile species. In particular, impingement survival of surfperch and rockfishes could be increased, assuming the fish could be safely returned to the bay. The safe return of impinged organisms has proven to be a difficult and generally unsolved problem at most fish return locations.

In addition to the fish handling provisions noted above, traveling screens have been further modified to incorporate screen mesh with openings as small as 0.5 mm to collect fish eggs and larvae and return them to the source water body. For many species and early life stages, mesh sizes of 0.5 to 1.0 mm are required for effective screening. Various types of traveling screens, such as through-flow, dual-flow, and center-flow screens, can be fitted with small mesh screen material.

The absence of data on the impingement survival of the fish eggs and larvae present in the vicinity of the MBPP, and the uncertainties regarding operational reliability of small mesh screens in a marine environment, eliminate the consideration of small mesh as an alternative intake technology for use at the MBPP intake.

6.5.3.2 Technical Criteria

Modifications within the intake structure building would be required to install the new screening system and its appurtenant low- and high-pressure wash systems with their respective troughs. Outside of the building, fish return conduits would have to be installed along the shoreline approximately 800 feet up bay and 800 feet down bay from the intake structure.

6.5.3.3 Other Environmental Impacts

Other than consideration of the space requirements and construction related effects of installing the two fish return conduits along the shoreline, no other significant environmental effects associated with installing and operating modified traveling water screens are anticipated.

6.5.3.4 Economic Criteria

For the new CC units, the incremental capital costs of a modified screen are those associated with the difference in cost for the fish handling modifications and fish conveyance system as compared to the existing screen system. Modification of the existing vertical intake screens with the additional features described for fish handling (fish baskets, deflectors, dual spraywash system, differential controls, fish return system, etc.) would have an incremental capital cost of approximately $14 million more than utilizing the existing screen system.

6.5.3.5 Conclusion

The low potential biological benefits (due to no entrapment and low impingement with the existing intake configuration and operation) relative to other logistical and costs for installation and operation at the MBPP, preclude modified traveling screens from being considered a viable alternative for MBPP.

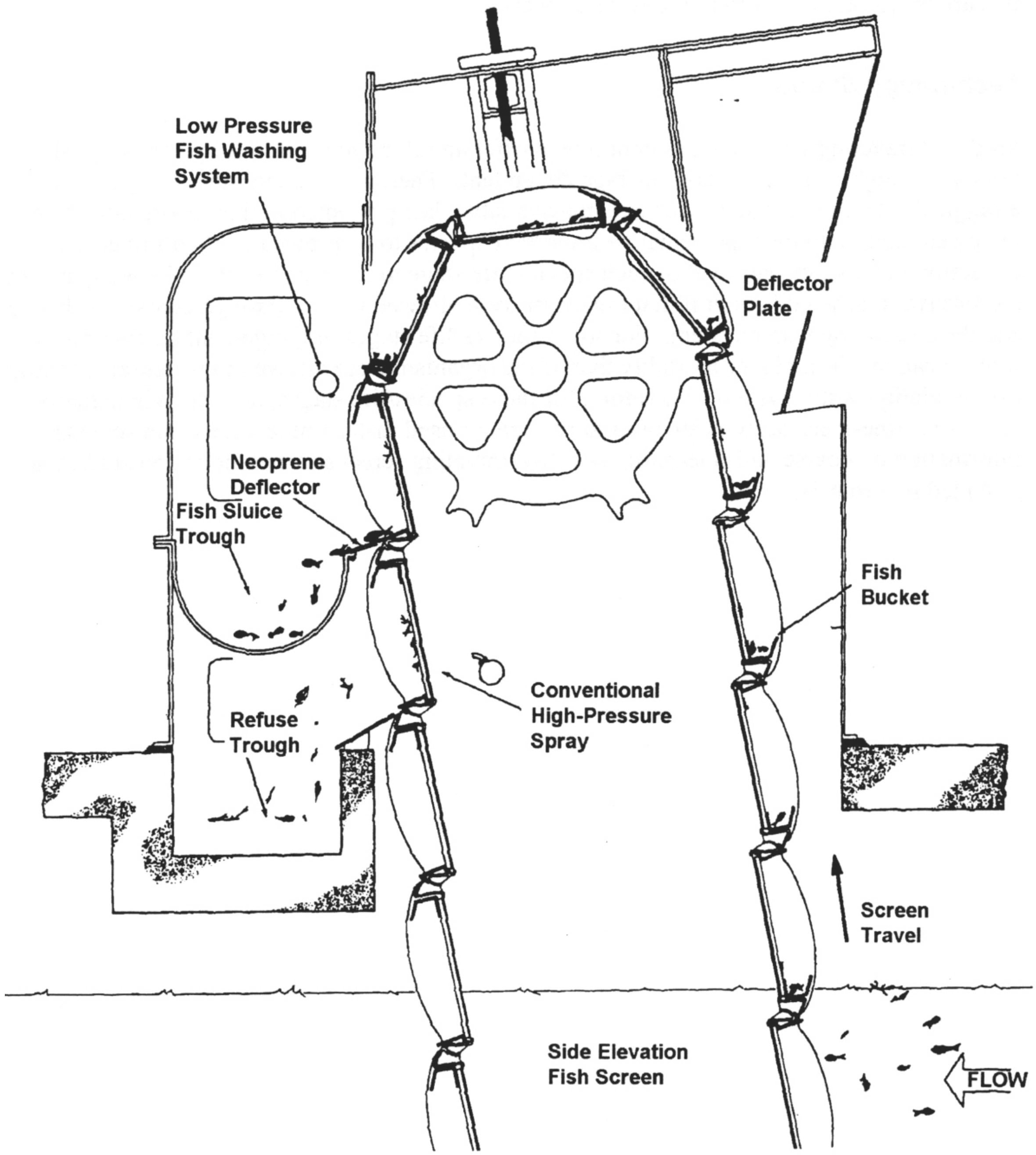

Figure 6-17. Section of a traveling water screen modified for fish protection (EPRI 1986).

6.5.4 Fish Return Conveyance Systems

A fish return conveyance system would be required with any of the previously discussed fish diversion and collection systems. There are two basic types of conveyance systems for the return of entrapped or impinged organisms and debris to the waterbody, one using a trash pump to transport material away from the intake and one using gravity flow.

6.5.4.1 Potential Biological Benefits

Both pump-augmented return systems and gravity flow return systems have the advantage of minimizing recirculation and re-impingement of debris and organisms on intake screens due to the relatively large transport distance capability, but pump augmented systems often result in mechanical abrasion and high mortality of organisms. The gravity sluiceway return system reduces mechanical abrasion, but may result in a higher rate of re-impingement due to relatively limited transport distances. It is concluded that no further consideration should be given to a fish pump return system for the MBPP intake because of the uncertainty that such a system successfully return the majority of impinged fish, northern anchovy, alive to Morro Bay. Fishes that were returned alive to the bay would be susceptible to disease and predation at the fish return discharge point due the stress of passage through the pumped fish return system. Impinged material from all the units will be returned to Estero Bay by a large-diameter pump that empties into the discharge conduit of Units 1 and 2.

Previous studies have concluded that the potential magnitude of reduction in impingement losses attributable to a gravity fish conveyance system is uncertain (PG&E 1983). However, the combination of a modification to the screens and their operation and the installation of a modified screenwash gravity sluiceway return system for an intake may have potential for improving impingement survival at locations where impingement losses are a problem.

6.5.4.2 Technical Criteria

Modifications within the intake structure building would be required to install the new fish collection troughs. Outside of the building, fish return conduits would have to be installed along the shoreline approximately 800 feet up bay and 800 feet down bay from the intake structure. See Figure 6-18 for a plan view of the approximate alignment of the two conduits.

6.5.4.3 Other Environmental Impacts

Other than consideration of the space requirements and construction related effects of installing the two fish return conduits along the shoreline, no other significant environmental effects associated with installing and operating modified traveling water screens are anticipated.

6.5.4.4 Economic Criteria

In addition to the costs of installing and operating the fish diversion and collection system to which the fish return conveyance system is attached, the principal costs would be those related to the easements required, and the capital installation costs of the two approximately 800 foot long conduits leading away from the intake structure along the shoreline. These costs are included in the total installed cost of the modified water traveling screens in the previous section.

6.5.4.5 Conclusion

The low potential biological benefits (due to no entrapment and low impingement with the existing intake configuration and operation) relative to other logistical and costs for installation and operation at MBPP, preclude fish diversion, collection, and conveyance systems from being considered viable alternatives for application at MBPP.

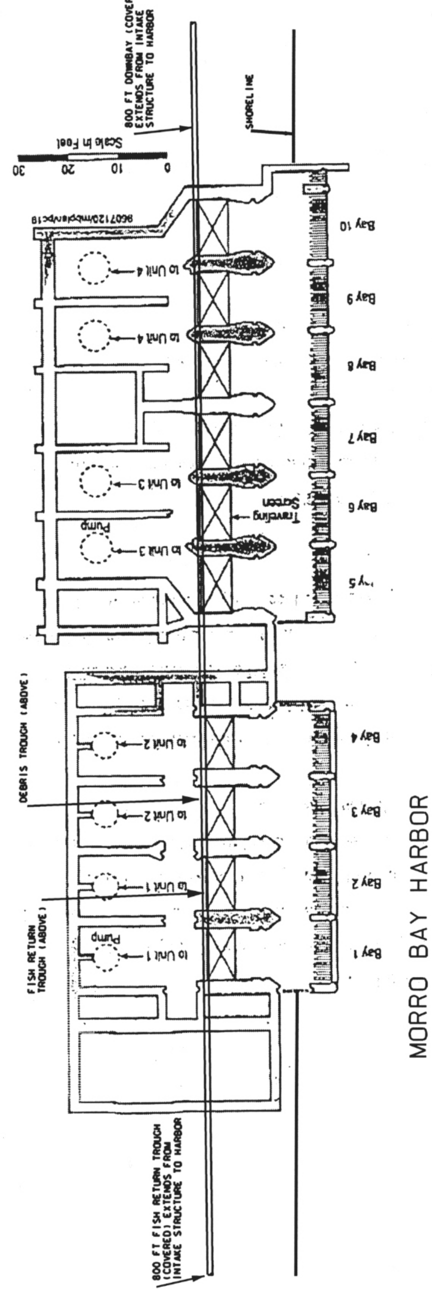

Figure 6-18. Plan view of the approximate alignment of the two conduits.

6.6 Closed-Cycle Cooling Systems

These alternatives would replace the existing once-through ocean cooling water system proposed for use for the new CC units. With a once-through system, the circulating seawater serves as a medium for absorbing the latent heat in condensing the exhaust steam. The heated circulating seawater from the condensers and closed-cooling exchangers is discharged to the ocean. The alternative closed-loop cooling water systems, except for the air-cooled condenser, employ a recirculating cooling water system instead of the once-through system. With the recirculating system, the same water constantly re-circulates. Water losses through evaporation due to rejecting heat to the atmosphere occur in cooling equipment and must be replenished. Potentially applicable recirculating systems at the MBPP could utilize one of the following for heat rejection:

1. Mechanical draft cooling tower,

2. Natural draft, hyperbolic cooling tower,

3. Hybrid parallel condensing (wet/dry) system,

4. A spray pond with a network of piping serving banks of spray nozzles, and

5. A very large, man made cooling pond or a managed wetted marsh which takes advantage of natural evaporative cooling.

A closed-cooling system, dry-cooling alternative using a direct air-cooled condenser could also be utilized at the MBPP. Closed-cycle cooling water system alternatives at MBPP could reduce intake effects by reducing the use of seawater for cooling.

6.6.1 Non Demonstrated Proven and Available Closed-Cycle Cooling – Cooling Pond

This closed-cycle cooling water alternative would replace the once-through seawater cooling water system at the plant with a recirculating cooling water system and man-made evaporation cooling pond. A cooling pond is a shallow reservoir having a large surface area for dissipating heat from the water. This option would consist of constructing a lined, large earthen water pond. The most important factor to dissipate heat effectively is to have a large surface area. Cooling ponds require the least amount of water make-up, but require a large amount of land. In this cycle, the warm water from the steam turbine condensers and other cooling water users in the plant will be discharged to the cooling pond. The cooling of the water occurs by radiation and convection to the surrounding air. The cooled water then is pumped back to the condenser to repeat the cycle.

Because of the site limitations on land at the MBPP, the closed-cycle cooling pond or a managed marsh alternative did not pass the First-Level Evaluation of being an available technology to utilize at the MBPP site. A cooling pond is not technically feasible in the MBPP project because of its large land space requirement. It is estimated that a cooling pond system for the new MBPP combined-cycle units would require more than 300 acres of plot space to adequately cool the circulating water and a necessarily greater area for a managed marsh version of the cooling pond. This requirement will not work on a site that contains only 140 acres (including PG&E switchyard). The use of this system is normally limited to plant sites with significant amount of excess space. Therefore, this option is eliminated from further review.

6.6.2 Mechanical Draft Cooling Tower

This closed-cycle cooling water alternative would replace the once-through seawater cooling water system plant with a recirculating cooling water system and mechanical draft cooling towers. Figure 6-19 presents a schematic flow sketch of a mechanical draft cooling tower system. With this scheme, warm water from the steam turbine condensers and other cooling water users in the plant would flow to the mechanical draft cooling towers consisting of air-to-water contact surfaces (fills) and electric motor-driven fans. The recirculating water to be cooled falls from the top through the tower where it contacts a high airflow drawn through the tower by the fans. Cooling occurs primarily through partial evaporation of the falling water (similar to the operation of a "swamp" cooler) and contact cooling of the water by the cooler air. Cooled water collects in large collecting basins beneath the towers where cooling water circulation pumps return the water to the condensers and other equipment users to repeat the cycle.

Recirculating water is lost from the process principally in two ways: through evaporation from the towers and "blowdown" (purge) streams. The blowdown stream is to prevent the buildup of dissolved solids in the recirculating water since the solids do not evaporate in the tower. A third minor loss consists of liquid water droplets (drift) entrained with the air and water vapor leaving the top of the cooling tower. The evaporation, blowdown, and drift losses must be replenished by adding replacement ("makeup") water to the system.

6.6.2.1 Potential Biological Benefits

For a seawater recirculating cooling water system and mechanical draft cooling towers, the estimated ocean water required for makeup is about 3 percent of the proposed once-through cooling water intake. Consequently the entrainment of organisms could be reduced by up to 97 percent. However, entrainment survival studies at a wide variety of locations and species have demonstrated once-through system survival rates as high as 80 percent. The survival rate for a seawater recirculating cooling system serving the new CC units would be zero. Therefore, the reduction in the mortality of entrained organisms for mechanical draft cooling towers compared to the once through cooling water system would be about 85 percent.[7].

The number of fishes impinged would also be reduced, though not as directly, by reducing the seawater intake rate.

6.6.2.2 Technical Criteria

Three hypothetical sources of circulating water potentially exist at the Morro Bay site: ground water (freshwater), reclaimed water from municipal sewage treatment, or seawater. Although freshwater systems have the advantage of smaller makeup water requirements due to lower dissolved solids, a continuous freshwater makeup supply of about 6,000 gpm would be required for a freshwater mechanical draft cooling tower system to serve the new CC units at the MBPP. However, the freshwater supply is limited in the area of the MBPP.[8] Possible sources of freshwater at the MBPP include groundwater from wells or distilled water produced from an existing, but mothballed desalination plant in Morro Bay.

The existing MBPP has utilized ground water from onsite wells primarily for uses such as firewater and equipment washdown and potable water. However, well capacity is not sufficient to support additional cooling water makeup requirements. Also, an existing desalination plant at Morro Bay is reported to have a 576,000-gallons per day (gpd) or 400-gpm capacity. The plant is currently mothballed and not in operation. It has also been reported that capacity could be expanded to approximately 1,200,000 gpd or 830 gpm. Recent discussion with the local publicly owned treatment works (POTW) located near MBPP indicated that, on average, the total effluent from their municipal sewage treatment plant is about 1,400 gallons per minute (gpm) of reclaimed water.

[7] $(0.20 - 0.03)/0.20 = 0.85$

[8] Freshwater supplies are so limited in the area that demineralized water for feedwater is currently provided (and will continue to be provided) by a seawater evaporation system, instead of ground water.

Using a possible freshwater mixture of reclaimed water and desalination plant distillate, makeup water requirements to a freshwater cooling tower at summer design conditions would be approximately 6,000 gpm for the combined-cycle facility. The available 2,230 gpm makeup (reclaimed water + distillate from the desalination plant at double the current capacity) would not even be adequate to supply the make-up water requirements of one of the two proposed combined-cycle power plant units. As a result, the combined-cycle unit would not be able to perform as designed from an availability and efficiency point of view, which significantly affects the economic justification.

Additional operational costs would also arise from the desalination plant for processing the desalinated distillate to the combined-cycle unit. Availability and schedule costs are also a high concern due to low historical availability and reliability of the existing desalination plant. Availability and reliability are vital to support combined-cycle units that are designed for over 95% availability throughout the year.

Another concern is raised from the use of reclaimed municipal wastewater as cooling tower makeup water. Environmental hazardous risks are possible from bacterial releases (or other contaminants) mixing in the cooling tower exhaust streams (as drift and blowdown) if the wastewater treatment plant were to experience a leak or operational upset. Mitigation measures to guard against such an accidental release could include maintaining a higher than usual residual chlorine level in the circulating water and continuous chlorine monitoring leading to higher operation and maintenance (and insurance) costs.

Due to the current and expected future limitations of freshwater supply in the area as well as possible operational issues, it was decided that a freshwater system was not feasible or realistic and that this evaluation would further consider only seawater cooling towers or seawater as the source of recirculating cooling water.

Seawater mechanical draft cooling towers for the MBPP CC units would consist of two structures, one for each unit, each approximately 500 feet x 50 feet x 50 feet high. Figure 6-20 presents a conceptual plot plan location for the MBPP utilizing seawater mechanical draft cooling towers sized for the new combined-cycle units. Considering the necessary separation that must be maintained between the towers and other structures to prevent recirculation of saturated air, this system would occupy a total plot area of at least 100,000 ft^2. Ocean water or seawater makeup for this system would be supplied from the existing Units 1through 4 intake location. The circulating water and blowdown stream would contain salinity (dissolved solids) approximately 50 percent greater than local seawater. The estimated combined full capacity flow rates for both towers are:

Recirculating water	330,000 gpm
Blowdown (returned to ocean)	9,600 gpm
Makeup (withdrawn from ocean)	10,000 gpm

The blowdown stream will contain residual concentrations of biocides, dispersants, and other conditioning chemicals, in higher concentrations than the existing once-through cooling water discharge.

Absence of expensive anti-plume devices, visible fog plumes could be expected (probably frequently during the winter) due to condensation in the atmosphere of the considerable amount of water vapor emitted from the top of towers. These plumes would constitute a visual impact in addition to increased size and cost of the tower structure itself. Plumes could also affect visibility on surrounding streets and highways during certain wind conditions. Figure 6-21 presents actual cooling towers that would be similar in size to this alternative at the MBPP.

6.6.2.3 Other Environmental Impacts

The most important environmental impacts or concerns of mechanical draft cooling towers are air quality, ambient noise, and aesthetics. Due to the height and length of cooling tower structures and their visible vapor, cooling towers have a visual and aesthetic impact on the surrounding area. Drift would also lead to increased fine particulate salt emissions from the facility in the form of dissolved solids emitted with the drift droplets. Cooling tower drift "raining" out of the plume could cause a nuisance salt water deposition on the surrounding area which could result in increased equipment maintenance requirements in the plant and adverse effects on nearby agriculture, and at times on local businesses and residences (Note Figure 6-21). Assuming drift is 0.00025 percent of circulating water (a very conservatively low assumption which may not be achievable), the estimated additional particulate emissions to the atmosphere associated with drift would be about 495 pounds per day (lb/day).[9] This quantity would represent a substantial increase in particulate PM_{10} emissions from the project and could cause adverse air quality impacts.

Additional fossil fuel must be burned to generate power for the additional auxiliary load due to the cooling tower fans and pumps further impacting air quality.

Further, due to the large fans required and associated very high air flows, mechanical cooling towers are a significant potential source of overall power plant noise impacts on surrounding

[9] Based on about 5 percent dissolved solids in the circulating water.

areas due to the significant quantity of elevated equipment such as fans, motors, and gears. Environmental concerns are also raised by possible entrained residual chemicals in the cooling tower blowdown and their impact on aquatic life.

6.6.2.4 Economic Criteria

The estimated total capital cost associated with the two forced draft mechanical cooling towers for the new CC units including towers, basins, chemical additive systems, and supporting systems is about $55 million more than the proposed once-through cooling water system modifications.[10] The estimated incremental Operating and Maintenance costs (O&M) are $600,000 per year.

Mechanical draft cooling towers would significantly diminish the net power output and operating efficiency of the modernized plant. The combination of the higher steam turbine condenser temperatures caused by the recirculating cooling system and the higher plant electrical load compared to the once-through cooling water case would decrease the net power output available from the new CC units by approximately 50 MW (for the same fuel consumption). This reduction in capacity will have to be made up either with increased emissions due to increased duct firing to obtain the same plant output, or by other, probably less efficient and more polluting power sources located elsewhere. With the recent increase in natural gas prices, this will have an adverse affect on the cost of electrical power to the California consumer. The incremental energy cost resulting from the reduced plant output for this alternative is estimated to be $8 million per year.[11]

The Present Value of the total capital cost, O&M cost, and incremental energy cost is $165 million. This amount amortized over 30 years is approximately $13 million per year.

[10] Additional capital investment of $15 million required to substitute mechanical draft cooling towers for the proposed once-through cooling water system plus a capital investment of $40 million required to build additional plants to replace the decrease in net plant output as a result of the mechanical draft cooling towers. The net output of the proposed plant will be reduced by up to 50 MW (for the same fuel consumption). Additional power plants will have to be built to replace the lost capacity and meet the needs of California consumers. Additional environmental impacts would result from the new plant sites. A capacity capital cost of $800/kW is assumed for the additional plants.

[11] The net output of the plant will be reduced by up to 50 MW (for the same fuel consumption) as a result of using mechanical draft cooling towers. Additional power plants would have to be built to replace the lost capacity and meet the needs of California consumers. Incremental Energy Cost is the additional annual fuel expense borne by California consumers to fuel the additional plants. A typical plant heat rate of 10,000 MMBtu/kWh, average natural gas price of $5/MMBtu, and capacity factor of 90% are assumed.

6.6.2.5 Conclusion

In summary, although there may be a reduction in overall entrainment mortality of around 85 percent, the mechanical draft recirculating cooling system would result in the following adverse impacts as compared to the once-through cooling system:

- Visual impacts of the cooling tower structure and condensed exhaust plumes.
- Drift deposition within the plant and nearby properties plus increased emissions of particulate matter due to dissolved salts in the drift.
- Occasional reduced visibility on nearby streets and highways with associated safety concerns.
- Reduced electricity generation efficiency and high maintenance chemical costs.
- Significant land use.
- Potential noise impacts.
- Significant economic costs over the life of the project.

For these reasons, the proposed once-through cooling water system is preferred to a recirculating cooling water system and a mechanical draft cooling tower.

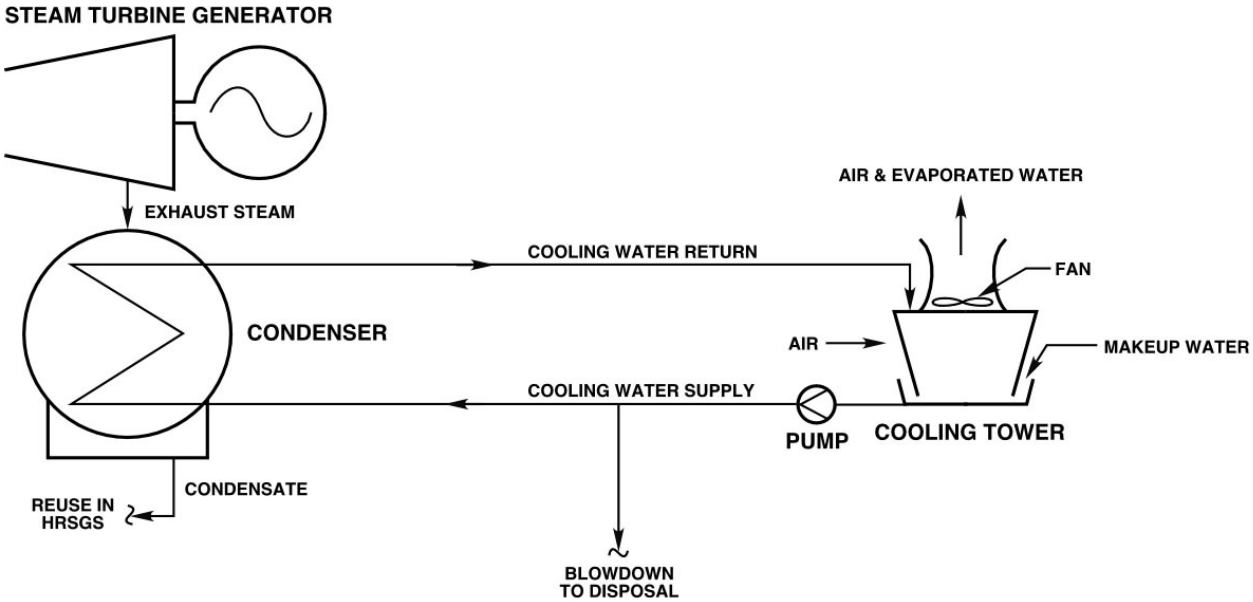

Figure 6-19. Schematic flow sketch of a mechanical draft cooling tower system.

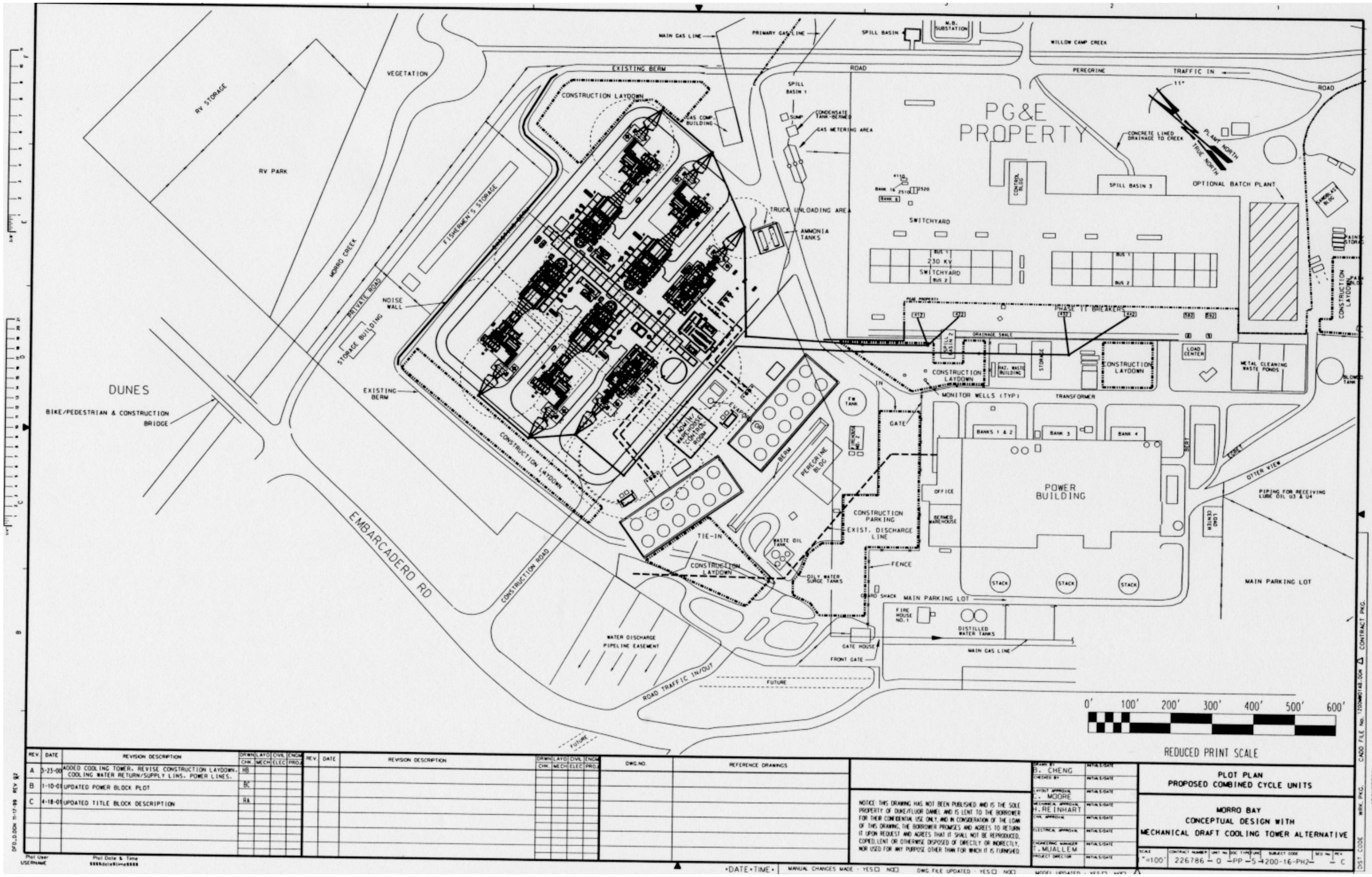

Figure 6-20. Morro Bay Power Plant alternative closed-cycle cooling mechanical draft cooling towers conceptual plot plan location.

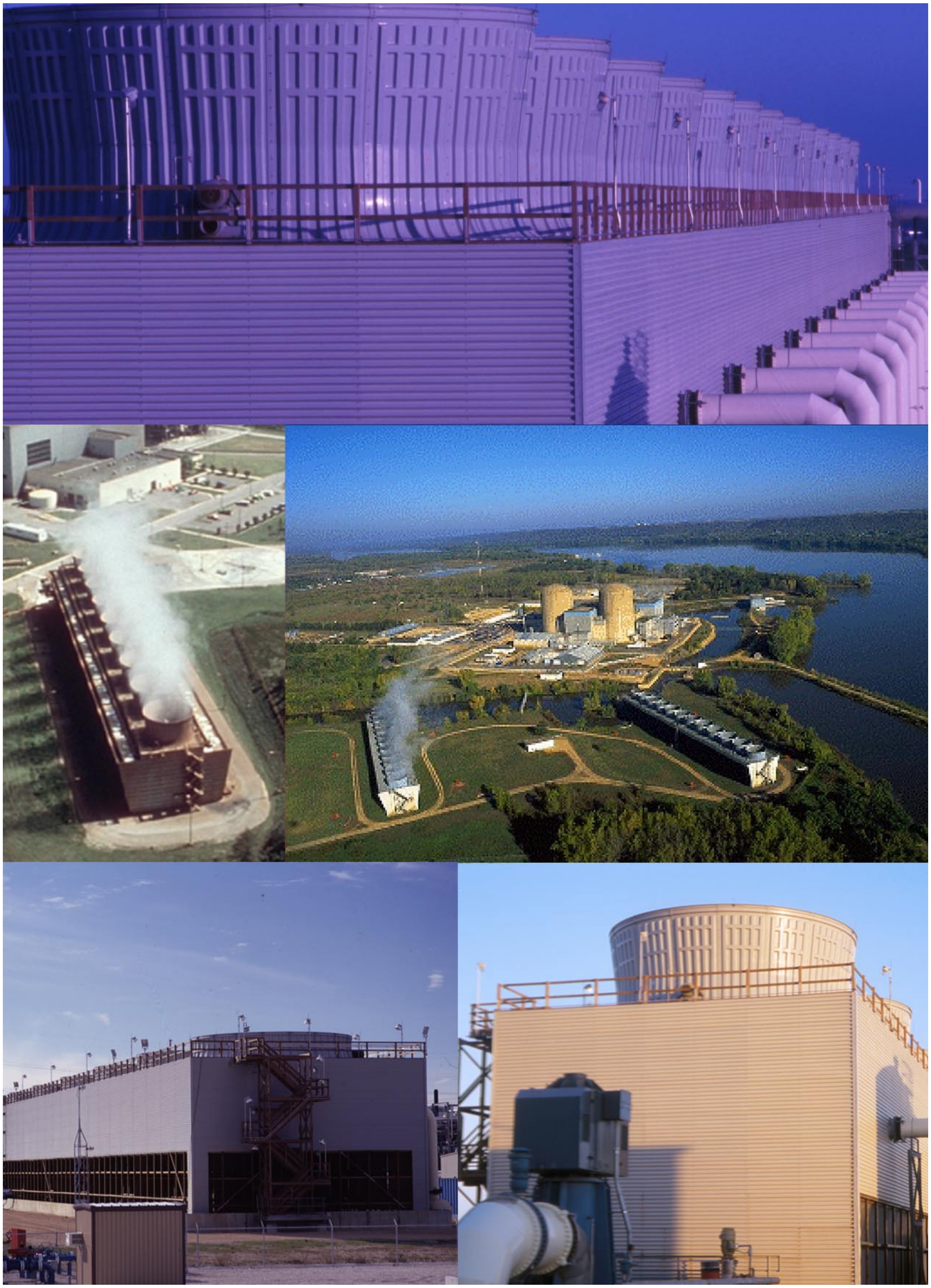

Figure 6-21. Visual example of mechanical draft cooling towers that would be similar size to those proposed for MBPP.

6.6.3 Natural Draft Cooling Tower

This closed-cycle cooling water alternative would replace the once-through seawater cooling water system plant with a recirculating cooling water system and natural draft cooling tower. A natural draft cooling tower system is similar in principal to the mechanical draft system. The primary difference is that the mechanical fans to move the cooling air are replaced by what is essentially a very large chimney. Figure 6-22 presents a schematic flow sketch for this type of cooling system. Air is drawn in at the base of the tower due to the less dense (more buoyant), warmer air exiting the top of the tower. This natural air circulation contacts the returned cooling water inside the tower and cools the water, mainly by evaporation. As a result, the cooling water re-circulation, blowdown, and makeup rates and quality would be similar to the mechanical (forced draft) system.

6.6.3.1 Potential Biological Benefits

For a seawater recirculating cooling water system and a natural draft cooling tower, the estimated ocean water required for makeup is about 3 percent of the proposed once-through cooling water intake rate. Consequently the entrainment of organisms could be reduced up to 97 percent, assuming 100 percent mortality of larvae through the once-through system. Entrainment survival studies at a wide variety of locations and species have demonstrated once-through system survival rates as high as 80 percent. The survival rate for a natural draft cooling tower recirculating cooling system serving the new CC units would be zero.

The number of fishes impinged would also be reduced, though not as directly, by reducing cooling water pump operation.

6.6.3.2 Technical Criteria

A natural draft cooling tower to serve the Morro Bay combined-cycle units would be at least approximately 250 feet in diameter at the base and about 400 feet in height. Figure 6-23 presents a conceptual plot plan location for the MBPP utilizing a natural draft cooling tower sized for the new combined-cycle units.

6.6.3.3 Other Environmental Impacts

Most of the potential negative impacts described for the mechanical draft cooling towers would also be associated with a new natural draft cooling tower for the MBPP. The blowdown discharge to the ocean would be the same. Drift losses and the resulting particulate PM_{10}

emissions would also occur, although at somewhat reduced rates. Noise impacts would be less. Visible condensate plumes would also periodically occur at the top of the tower.

The overall visual impact due to the size of the tower is most significant environmental impact on the surrounding area. Figure 6-24 presents an example of the visual impact from a natural draft cooling tower on the surrounding area.

6.6.3.4 Economic Criteria

The estimated total capital cost for a natural draft tower is about $64 million more than the proposed once through cooling water system[12]. The estimated incremental Operating and Maintenance cost (O&M) is about $400,000 per year. The plant electrical load would be reduced, due to the lack of mechanical fans, but the net power output available from the new CC units would still be decreased by about 48 MW. The incremental energy cost resulting from this decrease in efficiency is approximately $8 million per year.[13]

The Present Value of the total capital cost, O&M cost, and incremental energy cost is $173 million. This amount amortized over 30 years is approximately $14 million per year.

6.6.3.5 Conclusion

This alternative is eliminated from further consideration for most of the same reasons as the mechanical draft cooling tower, primarily because of the very adverse visual impacts of such a massive structure and space constraints at the site, in addition to the significant economic and other costs relative to any benefits achieved.

[12] Additional capital investment of $26 million required to substitute a natural draft cooling tower for the proposed once-through cooling water system plus a capital investment of $38 million required to build additional plants to replace the decrease in net plant output as a result of the natural draft cooling tower. The net output of the proposed plant will be reduced by up to 48 MW (for the same fuel consumption). Additional power plants will have to be built to replace the lost capacity and meet the needs of California consumers. Additional environmental impacts would result from the new plant sites. A capacity capital cost of $800/kW is assumed for the additional plants.

[13] The net output of the plant will be reduced by up to 48 MW (same fuel consumption) as a result of using a natural draft cooling tower. Additional power plants would have to be built to replace the lost capacity and meet the needs of California consumers. Incremental energy cost is the additional annual fuel expense borne by California consumers to fuel the additional plants. A typical plant heat rate of 10,000 MMBtu/kWh, average natural gas price of $5/MMBtu, and capacity factor of 90% are assumed.

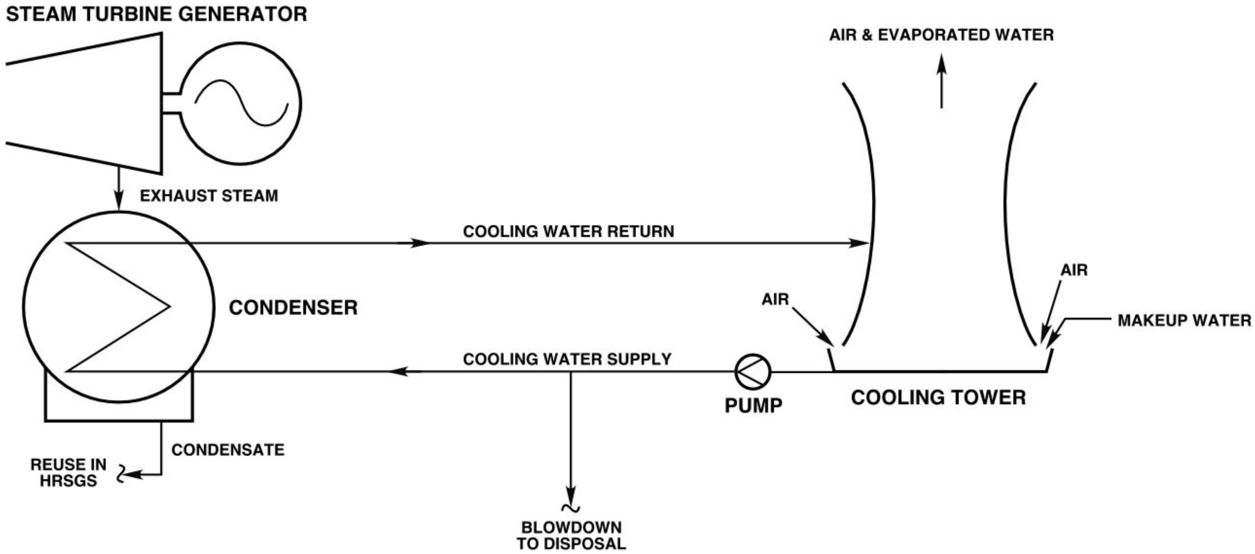

Figure 6-22. Schematic flow sketch of a natural draft cooling tower system.

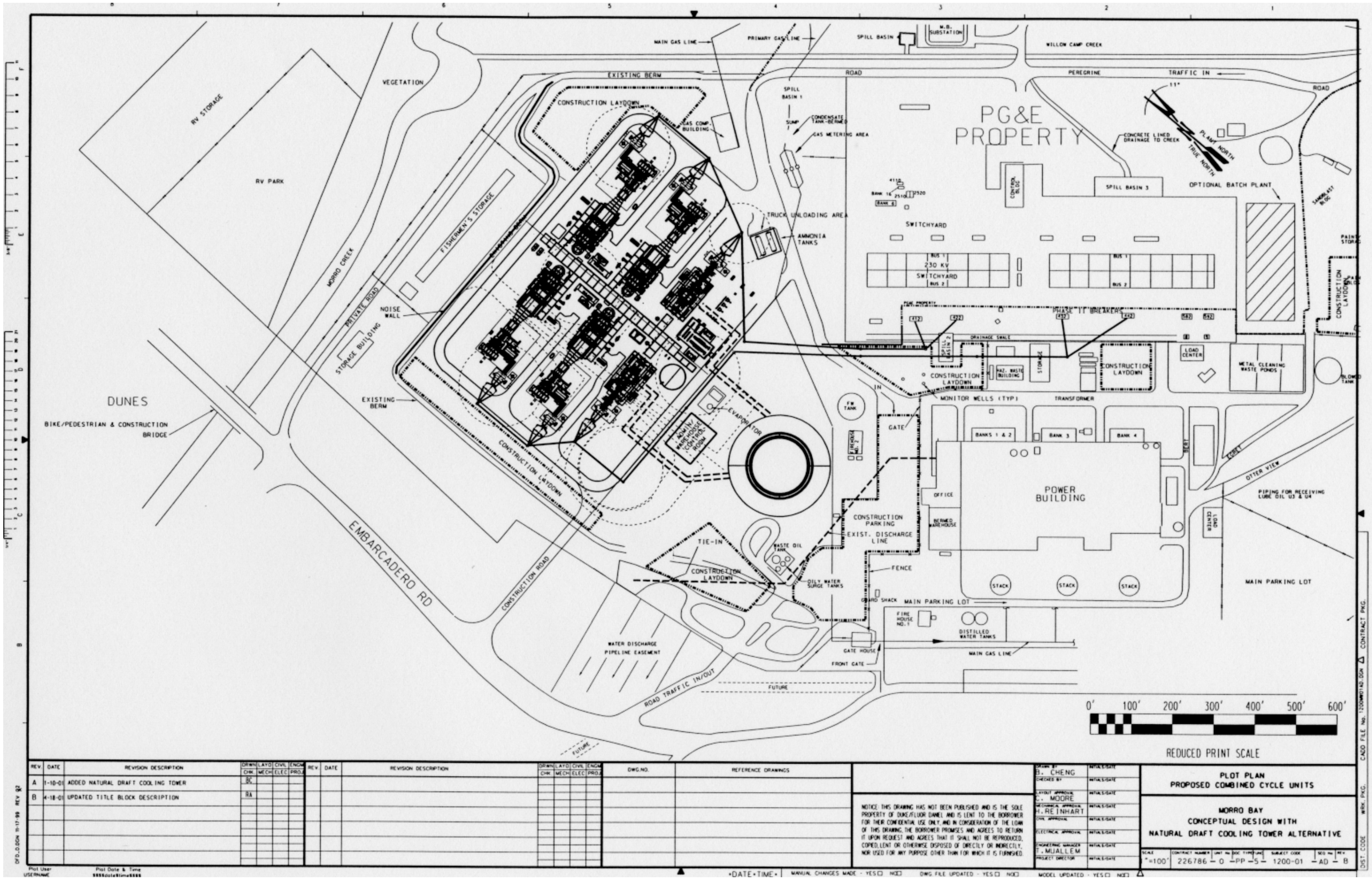

Figure 6-23. Morro Bay Power Plant alternative closed-cycle cooling natural draft cooling tower conceptual plot plant location.

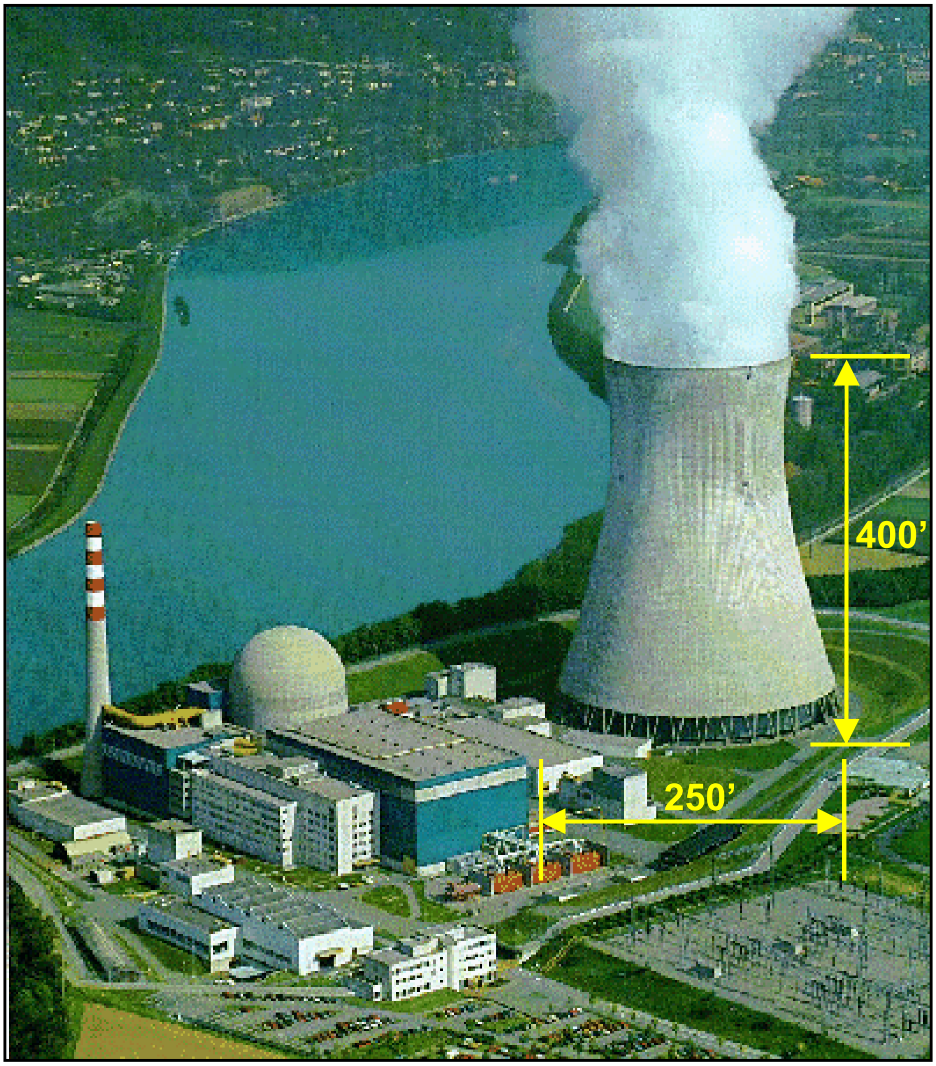

Figure 6-24. Visual example of a natural draft, hyperbolic cooling tower at a power plant facility.

6.6.4 Hybrid Parallel Condensing (Wet/Dry) System

This closed-cycle cooling water alternative would replace the once-through seawater cooling water system plant with a parallel condensing wet/dry system. This system utilizes a parallel condensing cooling system where the steam turbine exhaust steam is condensed simultaneously in both a standard steam surface condenser (SSC) and in an air cooled direct condenser (ACC). This parallel cooling system is sometimes called a hybrid system. Figure 6-25 presents a schematic flow sketch for this type of cooling system.

The amount of steam condensed in each device depends on the overall heat rejection load, availability of makeup water and ambient conditions. During operation, the condensing pressures in both the SSC and ACC constantly equilibrate due to self-adjustment of steam flows entering each device. For example, if the water temperature in the surface condenser were to be incrementally raised, steam flow to the surface condenser would decrease. Steam flow to the direct condenser would increase and turbine backpressure would increase slightly. As ambient conditions, load conditions and heat rejection capability of each device vary over time, the steam flow to each automatically adjusts without any active components being required on the steam side.

6.6.4.1 Potential Biological Benefits

For a hybrid parallel condensing system serving the new CC units, the estimated ocean water required for makeup is about 1.5 percent of the proposed once-through cooling water intake rate. Consequently the entrainment of organisms could be reduced up to 98.5 percent, assuming 100 percent mortality of larvae through the once-through system. Entrainment survival studies at a wide variety of locations and species have demonstrated once-through system survival rates as high as 80 percent. The survival rate for a hybrid parallel condensing system serving the new CC units would be zero. Therefore, the reduction in the mortality of entrained organisms for hybrid parallel condensing system compared to the once through cooling water system would be about 93 percent.[14] The number of fishes impinged would also be reduced, though not as directly, by reducing cooling water pump operation.

6.6.4.2 Technical Criteria

Figure 6-26 presents a conceptual plot plan location for the MBPP utilizing hybrid parallel condensing systems sized for the new combined-cycle units.

[14] (0.20 – 0.015)/0.20 = 0.925

The hybrid parallel condensing system consists of proven standard equipment and systems including: a standard air cooled condenser, a standard surface condenser, a standard mechanical draft cooling tower with a standard circulating water system for the tower/surface condenser.

Steam flowing to the SSC is taken off the main steam duct in a manner that best suits the specific steam turbine exhaust configuration and steam duct routing to the ACC. A conventional circulating water system interconnects the SSC with a conventional mechanical draft cooling tower (CT) system. Steam condensed in the SSC returned to the main condensate tank via a condensate forwarding pump. The air ejection system is appropriately connected to both the SSC and the ACC.

The control philosophy of the system is to minimize turbine backpressure for optimizing cycle efficiency and to minimize the makeup water flow, which reduces the impact to the fish. In order to properly accommodate this, the cooling tower is designed for the heat load duty when the HRSGs are unfired at the average summer ambient temperature.

In order to achieve more power output, especially at higher ambient temperatures, the HRSG duct burners are fired. When the HRSGs are fired however, the heat load to the cooling tower exceeds the design capacity of the cooling tower and the ACC must be turned on. The ACC fans are operated at full speed during the warmer periods of the year when the HRSGs are duct fired and the electrical demand is higher.

6.6.4.3 Other Environmental Impacts

The most important environmental impacts or concerns with the hybrid parallel system are the combined affects from both the standard CT system and a standard ACC system. This includes the air quality due to drift from the CT, increase in ambient noise from the fans of both systems, and the visual aesthetic impact from both large structures as described previously in those sections.

For the same fuel input, the plant will generate less power due to the higher backpressure and the higher auxiliary loads of the additional pump and fan motors, making the plant less efficient. Alternately, more fuel must be burned in order to generate the same power as from the once through system. Burning more fuel increases the air emission discharges further worsening the environmental impact.

Further, due to the large fans required and associated very high air flows, mechanical cooling towers are a significant potential source of overall power plant noise impacts on surrounding areas due to the significant quantity of elevated equipment such as fans, motors, and gears.

Environmental concerns are also raised by possible entrained residual chemicals in the cooling tower blowdown and their impact on aquatic life.

6.6.4.4 Economic Criteria

The estimated total capital cost for a hybrid parallel system lies between the previously described CT system and a standard ACC at approximately $116 million more than the proposed once through cooling water system[15]. The estimated incremental Operating and Maintenance (O&M) costs are about $500,000 per year. The plant electrical power requirement would be increased over the once through system, due to the addition of mechanical fans for both the CT and the ACC systems. The net power output available from the new CC units would be decreased by about 100 MW. The incremental energy cost resulting from this decrease is approximately $12 million per year.[17]

The Present Value of the capital costs, O&M costs, and incremental energy cost is $273 million. This amount amortized over 30 years is approximately $22 million per year.

6.6.4.5 Conclusion

In summary, although there may be a reduction in overall entrainment mortality of around 93 percent, the hybrid parallel condensing system serving the new CC units would result in the following adverse impacts as compared to the once-through cooling system:

- Visual impacts of the ACC, CT structure and condensed exhaust plumes.
- Drift deposition within the plant and nearby properties plus increased emissions of particulate matter due to dissolved salts in the drift.
- Occasional reduced visibility on nearby streets and highways with associated safety concerns.

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[15] Additional capital investment of $36 million required to substitute a hybrid parallel condensing system for the proposed once-through cooling water system plus a capital investment of $80 million required to build additional plants to replace the decrease in net plant output as a result of the hybrid parallel condensing system. The net output of the proposed plant will be reduced by up to 100 MW (for the same fuel consumption). Additional power plants will have to be built to replace the lost capacity and meet the needs of California consumers. Additional environmental impacts would result from the new plant sites. A capacity capital cost of $800/kW is assumed for the additional plants.

[16] Based on a net margin of $15/MW-hr and a 90 percent capacity factor.

[17] The net output of the plant will be reduced by up to 100 MW (for the same fuel consumption) as a result of using a Hybrid Parallel Condensing System. Additional power plants would have to be built to replace the lost capacity and meet the needs of California consumers. Incremental Energy Cost is the additional annual fuel expense borne by California consumers to fuel the additional plants. A typical plant heat rate of 10,000 MMBtu/kWh, average natural gas price of $5/MMBtu, and capacity factor of 90% are assumed.

- Reduced electricity generation efficiency and high maintenance chemical costs.
- Significant land use.
- Potential noise impacts.
- Significant economic costs over the life of the project.

The air-cooled condenser portion of this alternative results in a substantial loss in net power output. The significant adverse visual and noise impacts of both these systems would encroach upon the community-promised land near the MBPP. For these reasons, the proposed once-through cooling water system is preferred to a hybrid parallel condensing system.

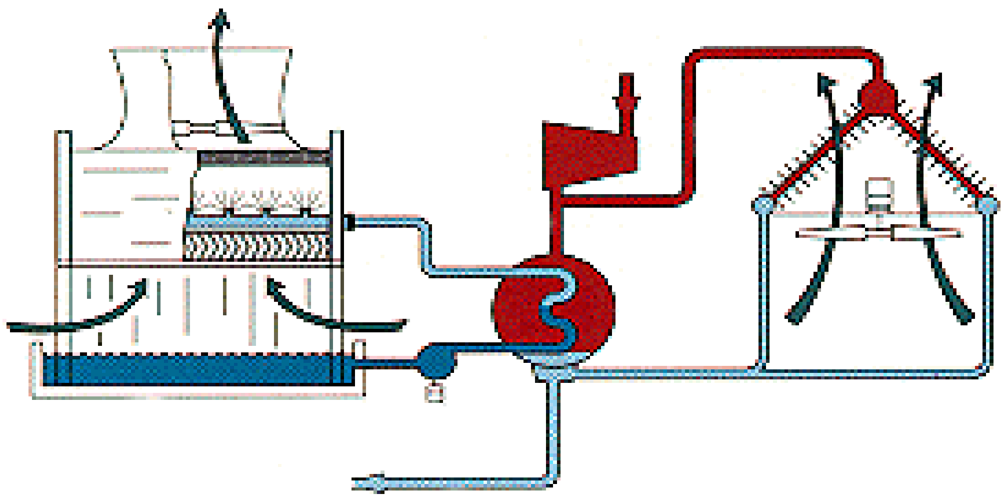


Figure 6-25. Schematic flow sketch of a parallel condensing system (courtesy of GEA).

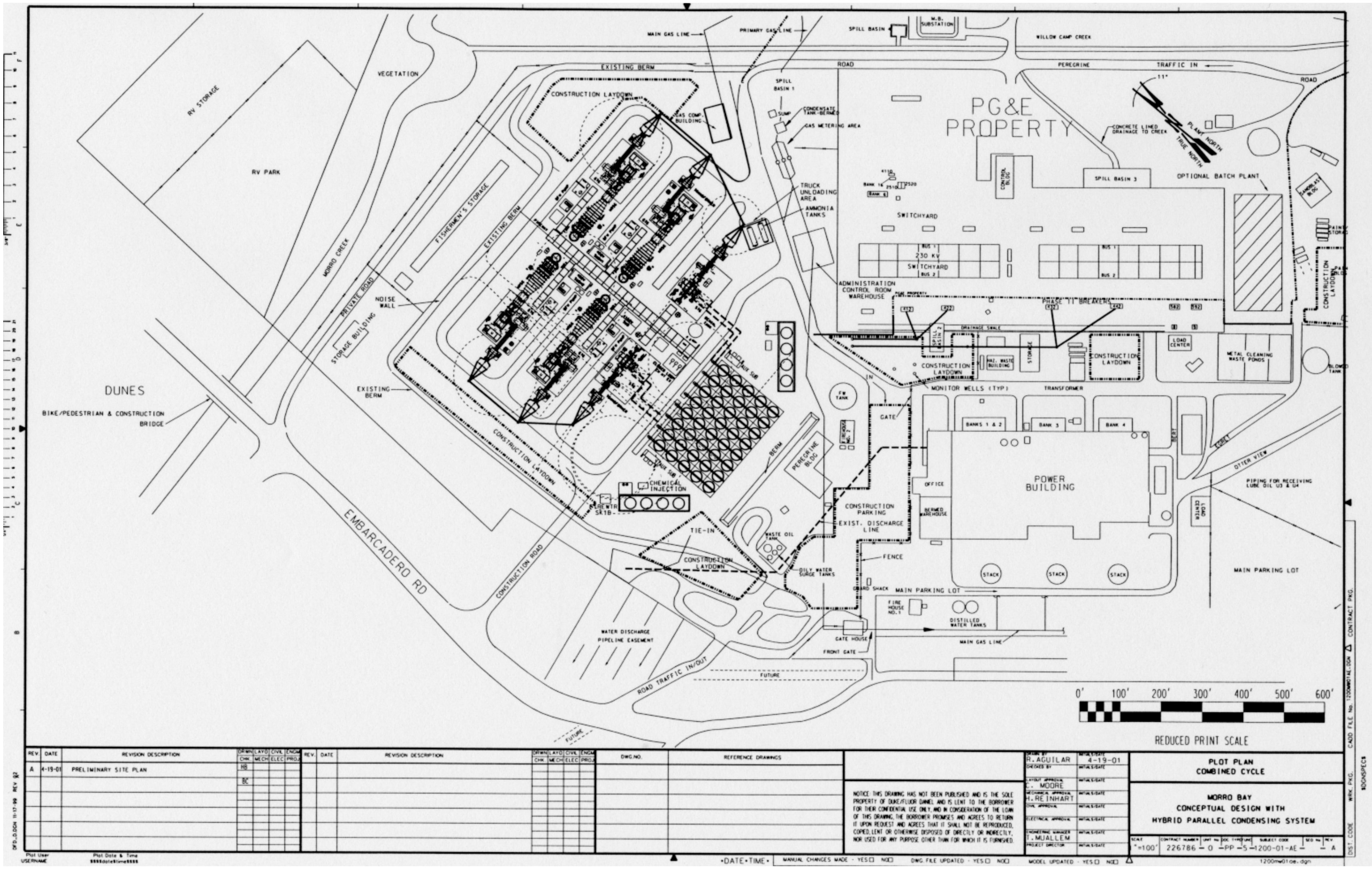


Figure 6-26. Morro Bay Power Plant alternative closed-cycle cooling hybrid parallel condensing system conceptual plot plan location.

6.6.5 Spray Cooling Pond

This closed-cycle cooling water alternative would replace the once-through seawater cooling water system plant with a recirculating cooling water system and spray ponds. Spray ponds provide an another method for lowering the temperature of cooling water by evaporative cooling. Because the water-air interface is significantly enhanced, spray ponds greatly reduce the cooling area required in comparison with cooling ponds, though substantial space is still needed. A spray pond uses a number of nozzles that spray water into contact with the surrounding air, similar to a sprinkler irrigation system.

6.6.5.1 Potential Biological Benefits

For a spray-pond heat rejection system serving the new CC units, the estimated ocean water required for makeup is about the same as for the mechanical and natural draft cooling tower alternatives. Consequently the entrainment of organisms could be reduced up to 97 percent, assuming 100 percent mortality of larvae through the once-through system. Entrainment survival studies at a wide variety of locations and species have demonstrated once-through system survival rates as high as 80 percent. The survival rate for a spray-pond parallel condensing system serving the new CC units would be zero. Therefore, the reduction in the mortality of entrained organisms for spray ponds compared to the once through cooling water system would be about 85 percent.[18]

The number of fishes impinged would also be reduced, though not as directly, by reducing cooling water pump operation.

6.6.5.2 Technical Criteria

The water usage rates (i.e., makeup water rates) are about the same for the spray pond as for the cooling tower options, since the amount of heat to be removed through cooling water evaporation is the same. Therefore, as previously explained, seawater is the only water resource available in sufficient quantity to meet this requirement. Similarly the blowdown discharge to the ocean would also be about the same as for the cooling towers.

A spray pond cooling system for the new CC units would consist of three circular ponds, each pond about 620 feet in diameter, and with many vertical spray nozzles per pond. Large cooling water pumps, similar to those needed for the cooling towers, would circulate the cooled water

[18] (0.20 – 0.03)/0.20 = 0.85

from the pond to the steam condensers and back. Figure 6-27 presents a conceptual plot plan location for the MBPP utilizing spray ponds sized for the new combined-cycle units.

6.6.5.3 Other Environmental Impacts

Most of the potential negative impacts described for the mechanical draft towers would also be associated with spray ponds for the MBPP. The land area requirements would be greater. The blowdown discharge to the ocean would be the similar, with the quantity of blowdown depending on the amount of drift that additionally removes water from the pond. Noise is not expected to extend beyond the immediate area, except for the circulation pumps. A visual plume would not be forced up into the air, rather evaporated water would occasionally condense to form a fog in surrounding cold outside air. Because the pond is not contained within a structure, there is more wind drift loss of water droplets than with cooling towers, which might be objectionable to nearby structures or highways. This could have the potential for keeping equipment near the pond frequently wet, and also would have the potential for leaving "scum" marks on equipment, windows, and cars in the surrounding area as the drift evaporates after settling. Figure 6-28 presents an example of the visual impact from a spray pond on the surrounding area.

Two significant differences between the mechanical cooling tower and spray ponds are physical appearance and land use. Rather than the large rectangular, building-like structure for a cooling tower, passersby viewing the spray ponds would observe a relatively low berm to contain the ponds and the multiple fountain-like water sprays, extending perhaps at least 15 feet into the air. Considerable land is required for the spray ponds, significantly more space is needed than for the cooling tower or other closed cycle cooling options. Based on the preliminary design for this analysis, virtually all the land occupied by the existing power plant building and stacks and more would be needed to accommodate the spray ponds, thus eliminating the proposed non-industrial future uses under consideration for this portion of the property

6.6.5.4 Economic Criteria

The estimated total capital cost for spray ponds is about $70 million more than the proposed once-through cooling water system modifications[19]. The estimated incremental total Operating and Maintenance costs are slightly less than those for the mechanical draft cooling tower. The

[19] Additional capital investment of $30 million required to substitute spray ponds for the proposed once-through cooling water system plus a capital investment of $40 million required to build additional plants to replace the decrease in net plant output as a result of the spray ponds. The net output of the proposed plant will be reduced by up to 50 MW (for the same fuel consumption). Additional power plants will have to be built to replace the lost capacity and meet the needs of California consumers. Additional environmental impacts would result from the new plant sites. A capacity capital cost of $800/kW is assumed for the additional plants.

[20] Based on a net margin approximately $15/MW-hr and a 90 percent capacity factor.

spray ponds would reduce net power generation by about 50 MW. It is not possible to estimate the incremental energy cost of reduced plant output without further engineering work to characterize the plant output relationship to ambient temperature.

The existing MBPP facility would have to be demolished to make room for the spray ponds. Since the spray ponds are required for cooling the new CC units, this would significantly delay completion of the project and exacerbate the tight electricity supply situation since the existing plant would have to be taken offline before the new plant's cooling system could be built.

6.6.5.5 Conclusion

Uncontrolled drift from a spray pond could create unsightly nuisance drift deposits. Land requirements for this option would consume portions of the property presently considered to be dedicated for future non-industrial uses. The spray pond option would significantly increase the capital and operating costs of the project, while decreasing plant efficiency and the net power generated for the state, and would require that the existing plant be taken off line and removed before the new plant's cooling system could be built. For these reasons, the proposed once-through cooling water system is preferred to spray ponds.

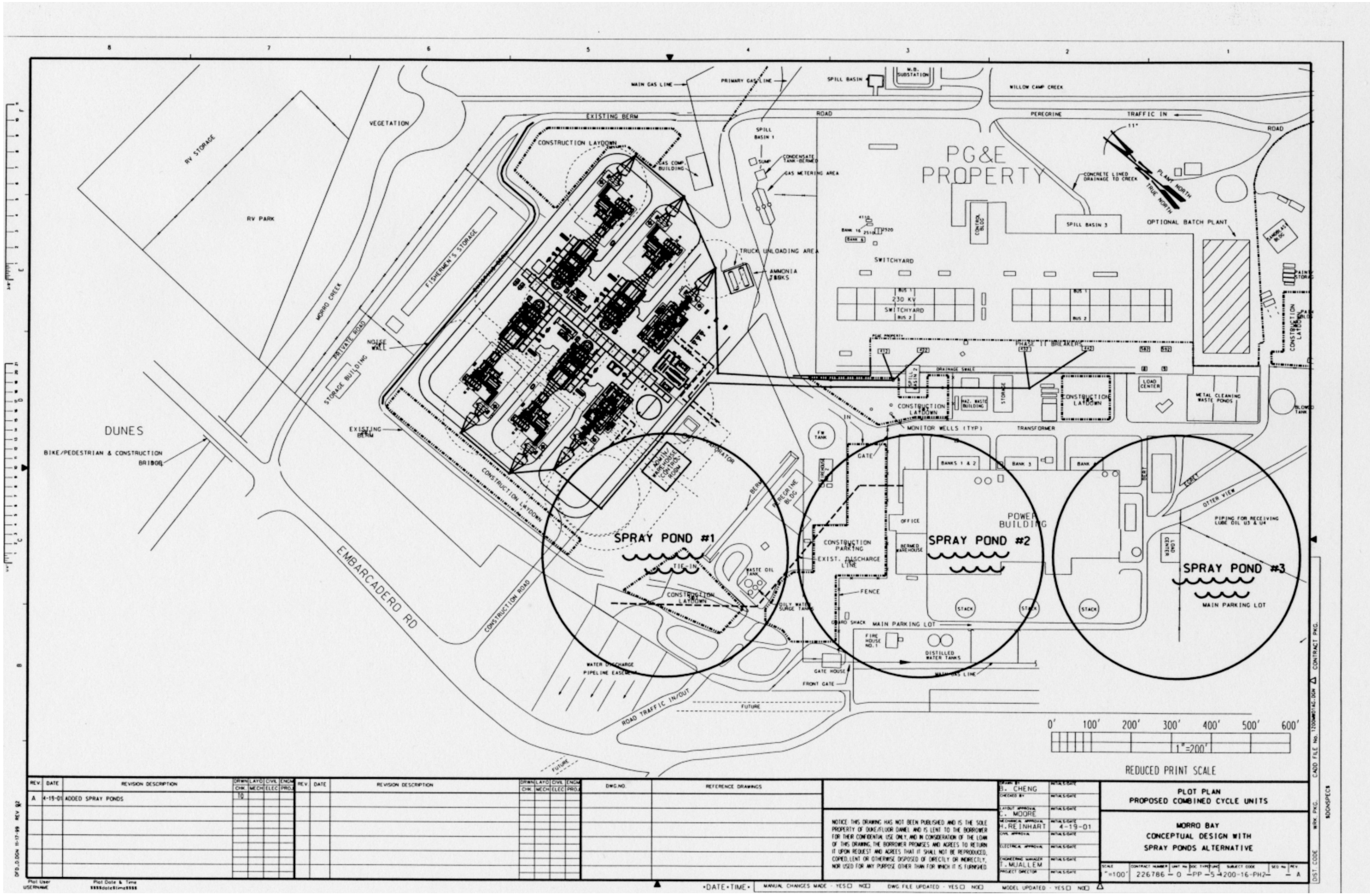


Figure 6-27. Morro Bay Power Plant alternative closed-cycle cooling spray ponds conceptual plot plan location.

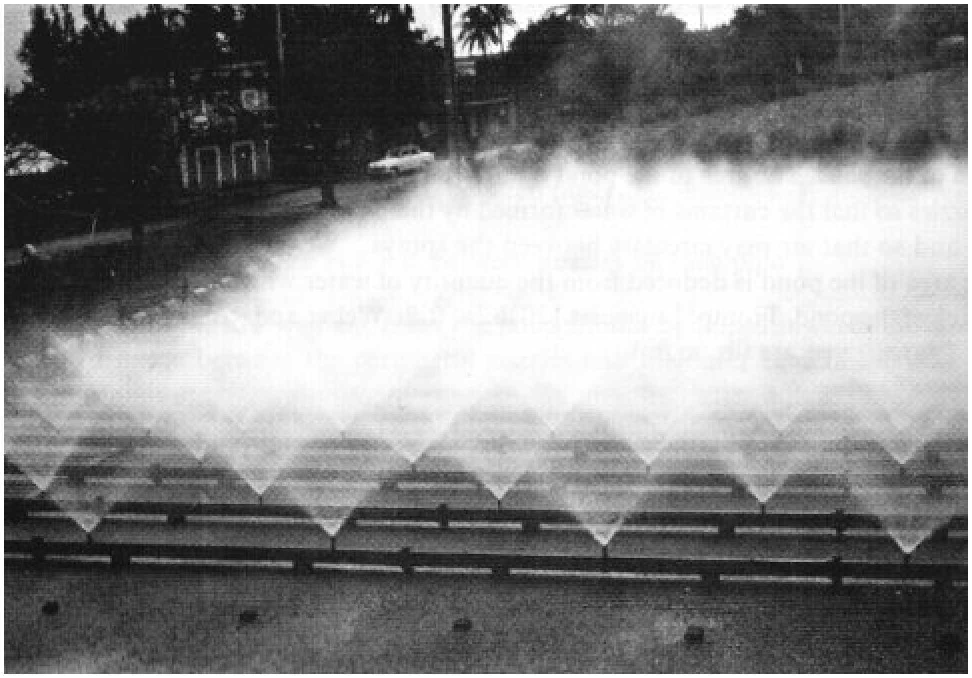


Figure 6-28. Visual example of a spray pond.

6.6.6 Air-Cooled Condenser

This closed-cycle cooling water alternative would replace the once-through seawater cooling water system with a direct air-cooled condenser(s) (ACC) system. In an ACC system, exhaust steam from the steam turbine generator is cooled and condensed in a large external heat exchanger using atmospheric air as the cooling medium. Figure 6-29 presents a schematic flow sketch for this type of cooling system. Large, electric motor-driven fans move large quantities of air across finned tubes (similar in principle to an automobile radiator) through which the exhaust steam is flowing. Heat transfer from the hot steam to the air cools the steam, which condenses and is returned to the steam cycle. The now warmer air is exhausted to the atmosphere. In this case, there would be no seawater required for condenser cooling.

Air-cooled condensers for power plants are very large structures and consume significant amounts of power for operation of the fans. The higher condensing temperature of these ACC systems significantly lowers steam turbine power output and electrical generation compared to electrical efficiency of once-through or recirculating water-cooled condensers.

6.6.6.1 Potential Biological Benefits

The main potential biological benefits of the air-cooled condenser compared to any other closed-cooling (wet-cooling) alternatives or the once-through system is that no seawater is required as circulating cooling water. The only seawater usage would be for the existing desalination system for boiler feedwater makeup. Thus, for an air-cooled condensing system serving the new CC units, the estimated ocean water required for makeup is about zero percent of the proposed once-through cooling water intake rate. Consequently the entrainment and impingement of organisms is essentially eliminated.

6.6.6.2 Technical Criteria

It is estimated that the air-cooled condensers for the new MBPP combined-cycle units, one for each unit, would each occupy about 0.8 acre, extend to a height of 90 feet. Figure 6-30 shows the plot space that would be consumed.

6.6.6.3 Other Environmental Impacts

Air-cooled condensers for power plants are very large structures and require a large land area. Noise impacts are substantial and require extensive abatement. Figure 6-31 presents an example of the visual impact from an air-cooled condenser on the surrounding area.

6.6.6.4 Economic Criteria

The estimated total capital cost associated with the two direct air cooled condensers for the new CC units including supporting systems is about $120 million more than the proposed once-through cooling water system.[21] The estimated incremental Operating and Maintenance costs (O&M) are about $300,000 per year.

Air-cooled condensers for power plants are very large structures and consume significant amounts of power for operation of the fans. Noise impacts are substantial and require extensive abatement. Air-cooled condensers would significantly diminish the net power output and operating efficiency of the modernized plant. The combination of the higher steam turbine condenser temperatures caused by the recirculating cooling system and the higher plant electrical load compared to the once-through cooling water case would decrease the net power output available from the new CC units by approximately 102 MW for the same fuel consumption. The incremental energy cost of the lost power resulting from this decrease in net plant output is approximately $14 million per year.[22]

The Present Value of the total capital cost, O&M cost, and incremental energy cost is $301 million. This amount amortized over 30 years is approximately $24 million per year.

6.6.6.5 Conclusion

While the air-cooled condenser alternative has the greatest biological potential to reduce entrainment and impingement of biological organisms, it also has a substantial loss in net power output. The significant adverse visual and noise impacts of this system would encroach upon the community-promised land near the MBPP. Coupled with the very large associated costs, the proposed once-through cooling water system is preferred to the air-cooled condenser alternative.

[21] Additional capital investment of $39 million required to substitute an air-cooled condenser for the proposed once-through cooling water system plus a capital investment of $81million required to build additional plants to make up for a decrease in net plant output as a direct result of the air-cooled condenser. The net output of the proposed plant will be reduced by up to 102 MW (for the same fuel consumption). Additional power plants will have to be built to replace the lost capacity and meet the needs of California consumers. Additional environmental impacts would result from the new plant sites. A capacity capital cost of $800/kW is assumed for the additional plants.

[22] The net output of the plant will be reduced by up to 102 MW (for the same fuel consumption) as a result of using an air-cooled condenser. Additional power plants would have to be built to replace the lost capacity and meet the needs of California consumers. Incremental Energy Cost is the additional annual fuel expense borne by California consumers to fuel the additional plants. A typical plant heat rate of 10,000 MMBtu/kWh, average natural gas price of $5/MMBtu, and capacity factor of 90% are assumed.

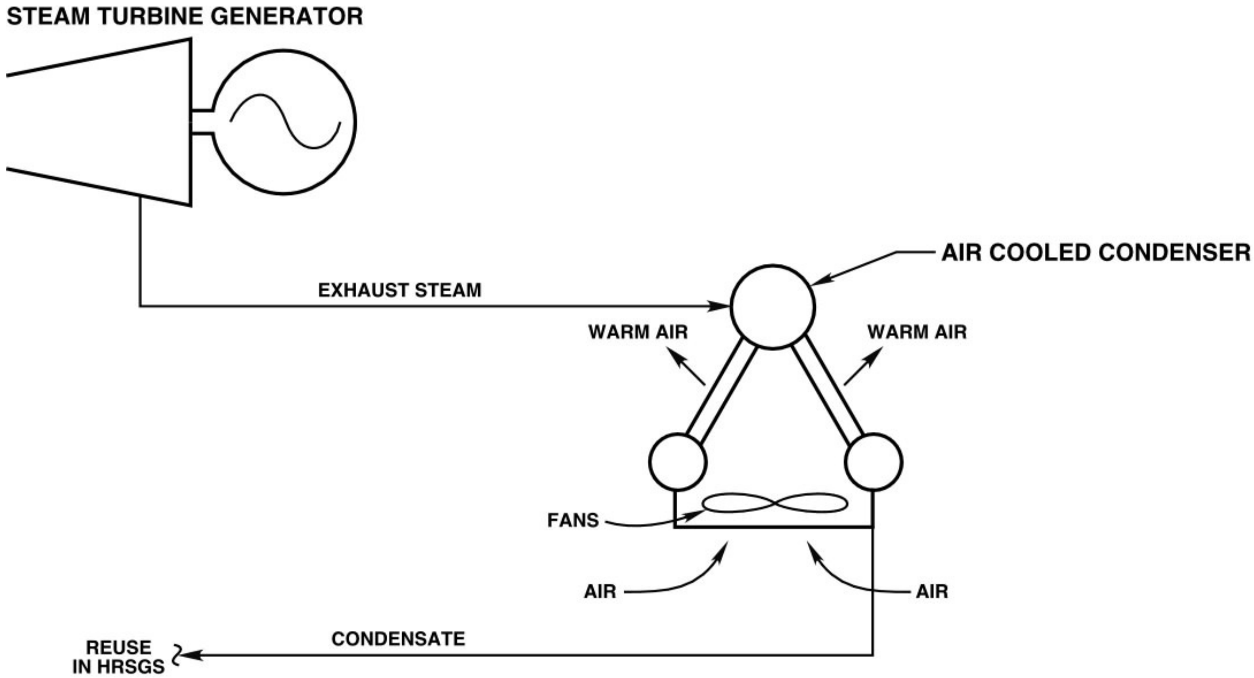


Figure 6-29. Schematic flow sketch of a direct air-cooled condenser system.

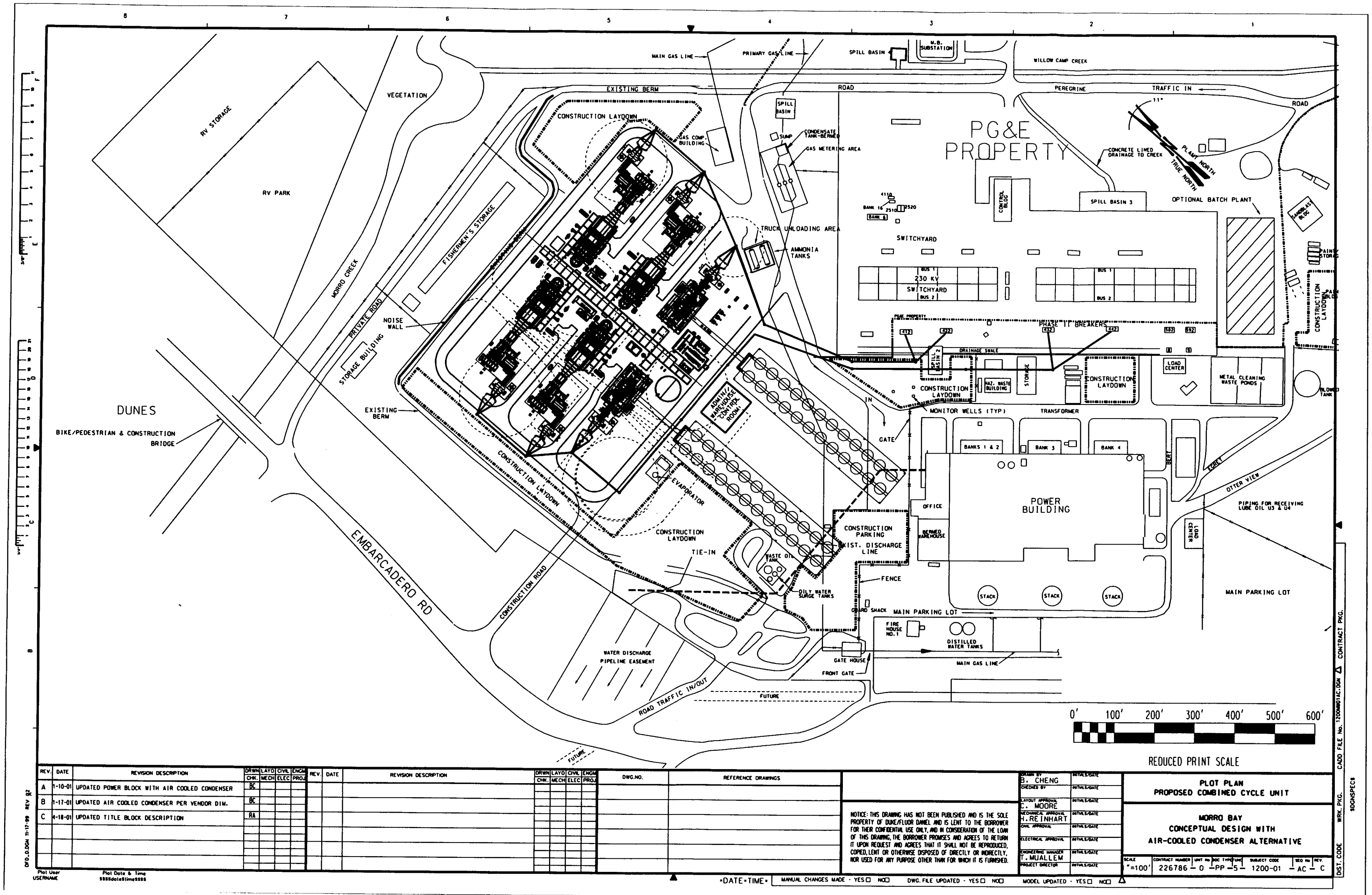


Figure 6-30. Morro Bay Power Plant alternative closed-cycle cooling air-cooled condensers conceptual plot plan location.

Figure 6-31. Visual example of an air-cooled condenser (courtesy of GEA).

6.7 Operational and Maintenance Alternatives

Maintenance activities and operational modifications which may reduce entrainment and impingement losses include reductions in cooling water pump flows, seasonal curtailment of cooling system operation, use of alternative biofouling schemes, through-plant temperature regulation, and maintenance dredging in front of the cooling water intake.

6.7.1 Cooling Water Pump Flow Reduction

A reduction in the number of cooling water pumps in operation and/or installation of variable-speed cooling water pumps represents alternative operational strategies for reducing cooling water volumes and intake approach velocities, and hence reducing the number of organisms entrained and possibly those impinged.

6.7.1.1 Potential Biological Benefits

Reducing the operation of the cooling water pumps during periods when generation is low or is not occurring would reduce the numbers of organisms entrained and possibly those impinged. Entrainment losses would be reduced in approximately the same proportion as the reduction in cooling water flow rates.

The number of fishes impinged would also be reduced, though not as directly, by reducing cooling water pump operation. It is therefore concluded that short-term (hourly or daily) reductions in the volume of cooling water that coincide with reduced generation have a high probability of reducing entrainment and impingement losses.

6.7.1.2 Technical Criteria

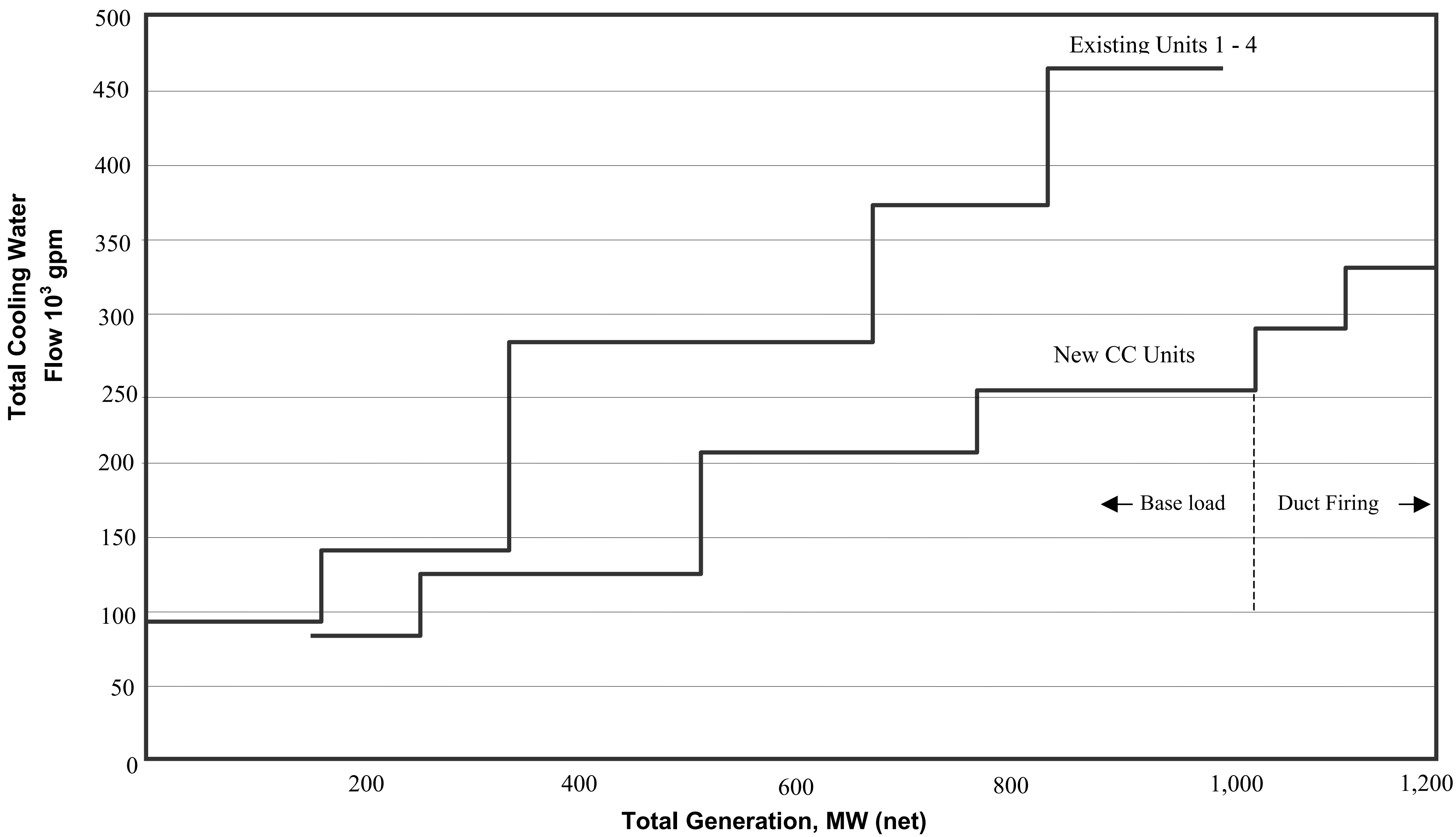
A reduction in the number of cooling water pumps in operation is an operational strategy for reducing cooling water volume use and intake approach velocities, and hence the rates of entrainment and impingement. The use of multiple cooling water pumps for the new MBPP combined-cycle units (four pumps per unit) will provide flexibility to reduce cooling water flows during certain operating conditions, unlike Units 1 through 4 which must run both cooling water pumps per operating unit, even at significantly reduced generating levels. It is expected that each of the new combined-cycle units will operate with only three of the four cooling water pumps in operation at base load (non-duct fired), which should be the most common operating mode.

The currently proposed configuration of the new combined-cycle units will allow reduced cooling water pump operation during certain reduced load operating scenarios. As described in Section 2, the presently proposed new facilities consist of two essentially independent 600 MW units. Each unit is provided with two CTG/HRSG trains, which supply steam to one steam turbine generator (STG)/condenser set. Only the STG condensers require the use of significant amounts of cooling water. The STGs are provided for the sole purpose of recovering (in essence recycling) excess heat from the combustion turbines to create additional energy, and thereby are a significant reason for the very high thermal efficiency of the combined-cycle process.

Four cooling water pumps per 600 MW unit will supply cooling water to the condenser in the unit they serve (a total of eight new cooling water pumps for the entire 1,200 MW addition). If only one of the two new units is operating in base (non duct-firing) load, only three of the eight new cooling water pumps would run to serve it. Each unit will run its fourth pump only during peak (duct-firing) load operations, which will be limited to no more than 4,000 hours per year. In certain other operating conditions it will be possible to also reduce cooling water flow rates. For example, if one unit is operating at significantly reduced capacity such as only one of the two CTG/HRSG trains on line, it may possible to satisfactorily operate that unit with only two of its four cooling water pumps operating. Figure 6-32 for a depicts how cooling water flows will change with generating load with the new units compared to the existing plant cooling water pump operations.

Another alternative for cooling water pump flow reduction is to install variable-speed cooling water pumps. This would consist of replacing the fixed speed motors on the eight cooling water pumps with variable speed motors and purchasing variable speed pumps. Variable speed motors could be used to reduce cooling water flow by adjusting the motor load, thus affecting the pump's capacity. The reduced flow capability is necessary to accommodate the peak/off-peak power consumption changes. The potential benefits of the variable speed pumps are comparable to the multiple cooling water pump option.

Figure 6-32. Comparison of existing MBPP cooling water flows and the future reduced cooling water flows.



Another approach to reduce cooling water flows to the minimum level necessary to maintain efficient operation of the unit at a specific generating load would be to install variable-flow pumps or modify the existing pumps to incorporate variable features. Since the combined-cycle units are expected to run near full base load or limited peak load for most of the year, which dramatically reduces the potential benefits of variable flow devices, this alternative will not be evaluated for the new units. As discussed above, it will be possible to reduce the number of CC unit cooling water pumps in operation from eight to as few as two during part load conditions which, in effect is a variable flow capability.

6.7.1.3 Other Environmental Impacts

Changes in condenser backpressure resulting in reduced turbine cycle thermal efficiency, along with increased temperature differentials through the condenser system (delta-T), are to be expected when cooling water flow rates are reduced during generation. Although a reduction in cooling water volume is expected to result in a decrease in the number of entrained organisms, the associated increase in delta-T would increase the discharge temperature and may increase thermal plume size.

6.7.1.4 Economic Criteria

The incremental total installed cost of replacing the fixed speed motors on the eight cooling water pumps with variable speed motors is about $3 million.

6.7.1.5 Conclusion

Since the new combined-cycle units will be provided with four cooling water pumps each, the reduced cooling water usage benefits of variable speed motors can be accommodated simply by taking one or more of the multiple fixed speed pumps off line at reduced loads. This approach eliminates the unnecessary extra investments and complexity of installing variable speed pumps while obtaining similar environmental benefits. As previously discussed, it is expected that each CC unit will operate with three pumps during base load operation, which is the most common operating mode. There is no significant advantage to using the variable speed pumps over the multiple cooling water pumps.

6.7.2 Seasonal Flow Reduction

Seasonal curtailment of cooling system operations would result in a reduction in the numbers of organisms entrained and impinged.

6.7.2.1 Potential Biological Benefits

Seasonal curtailment of cooling system operation could reduce the numbers of organisms lost by entrainment and impingement. The amount of the reduction depends on the length of time the cooling system is out of operation and the concentration of organisms during the period of curtailment. Based on the seasonal distribution of entrainment and impingement, February through April and July were selected as possible periods for curtailment. Seasonal curtailment of cooling system operation would result in a reduction in the numbers of organisms entrained and impinged, and is therefore considered to be an alternative technology for further consideration for the new CC units. Various strategies for curtailment of cooling system operation would result in a reduction of both entrainment and impingement losses in an amount that would depend on the abundance of organisms present during the period of curtailment and the duration of the outage.

6.7.2.2 Technical Criteria

Seasonal curtailment of energy production will be strongly influenced by uncertainties associated with generation requirements of the deregulated energy market. The ability to curtail or de-rate the new MBPP combined-cycle units will be under the control of the California Independent System Operator (ISO) that can issue “must operate” orders as conditions of demand and supply warrant.

6.7.2.3 Other Environmental Impacts

The principal environmental impact of applying seasonal curtailment is that MBPP’s generating capacity would have to be replaced from other sources available to the electrical transmission grid. In addition to requiring that more power generation facilities be built and available on a net basis, most available sources will generate electricity less efficiently than would the new MBPP combined cycle units, and they would pollute more per MW-hour of electricity produced than would the MBPP units.

6.7.2.4 Economic Criteria

The economic consequences of seasonal curtailment are such that Duke Energy would not construct a CC plant that could not operate for four months of the year. In this scenario, existing Units 1 through 4 would continue to operate at high capacity levels in the absence of new, more efficient generation at MBPP. Continued use of Units 1 through 4 in the absence of new generation would result in greater impingement and entrainment since the impacts of Units 1 through 4 are greater than the proposed CC plant.

Once the CC plant is constructed, seasonal curtailment of the new CC units will likely be infeasible because of increasing demand for electrical energy in the central and northern California load centers and the uncertain availability of surplus energy from other sources to replace it. The estimated costs of replacement energy alone that would result from curtailment of operation of the new CC units from February through April and July to reduce entrainment and impingement losses are summarized in Table 6-2. The estimated costs are based on expected operation of the new CC units and recent system power price projections. The estimated net loss of future power sales revenue corresponding to the curtailment of new CC units operation during February through April plus July is about $48.5 million per year. These projections are subject to a number of market variables in addition to the questions of alternative energy sources to reliably serve customers and the demand for electricity. Fluctuating fuel costs, which are a major factor in the cost of replacement energy, make accurate projections of net future energy revenue difficult. This curtailment strategy is particularly inappropriate since it would severely reduce electrical generating capacity during the critical summer period when electrical demand is highest.

An alternative approach to using curtailment to reduce biological losses is to schedule maintenance outages to coincide with periods of greatest biological loss. However, it is inappropriate to schedule maintenance during the critical summer period. It may be possible to schedule maintenance during February and March when electrical loads are not as high and when other resources such as hydropower are more readily available. However, scheduled maintenance outages for fossil-fueled plants are generally of much shorter duration than at nuclear-fueled plants, where this option has sometimes been considered.

Table 6-2. Estimated Cost of Replacement Energy during two Periods of Operation Curtailment for the Morro Bay Combined-cycle Units.

Period of Curtailment	Energy Payment ($/MW-hr)*	Fuel Cost ($/$10^6$ Btu)*	Operating Time (hrs/month)**	Output When Operating (MW)***	Lost Revenue ($)****
February	35.57	4.17	605	1,200	$4,934,622
March	36.16	3.87	670	1,200	$7,603,428
April	26.35	3.71	670	1,200	$603,804
July	71.94	3.86	650	1,200	$35,338,680
Total					$48,480,534

*Duke Energy projected energy and natural gas prices for central California coast for 2005.

**Estimated operating time assuming about 90 percent capacity factor.

***Lost energy payments less avoided costs of fuel (based on nominal heat rate for new CC units of 6,900 Btu/kW-hr.

****Revenue contributions must cover all operating costs and a return on capital.

It is not expected that frequent significant scheduled outages for the new CC units will occur. Minor maintenance outages for cleaning of the new units will be scheduled for short periods, about four hours of downtime, approximately once per combustion turbine generator (CTG) unit per month. Annual inspections will also be scheduled for each unit that will require about one day off line per CTG. More thorough inspections, requiring about two days, will take place every three to five years. Major overhauls, requiring an outage of about two weeks, typically occur about every eight years. Therefore, no significant biological benefits could be achieved by attempting to schedule maintenance outages during predicted sensitive periods.

Daily curtailment of cooling system operation (e.g., at night or when load is low) is another alternative approach for reducing biological loss. It is likely that generation levels of the new CC units will be reduced or one or both units taken off line during periods of decreased demand, such as late evening and early morning. However, these units will be among the most efficient fossil fuel units available in the state system and are expected to be used frequently to meet base load demand day and night. Therefore, although it is expected that the new units will sometimes operate at reduced load with corresponding benefits to marine organisms, a commitment to regular curtailment of cooling system operation is considered to be impractical for the new CC units, based on the projected need for highly efficient sources of base load generation and the additional need for rapid response to electrical demands within the system.

Curtailment of operation of the CC units beyond what would occur from normal scheduling is not acceptable, because it removes the generating capacity of the plant from reliable service when it is needed to serve system loads. The availability of replacement power is uncertain.

6.7.2.5 Conclusion

For the cost, operational reliability, and flexibility reasons discussed above relative to the potential improvements in biological effects, curtailment of power generation as a method of reducing entrainment and impingement losses for the new CC units is not considered to be a viable alternative.

6.7.3 Through-Plant Temperature Regulation

Through-plant temperatures are relatively low at the MBPP throughout the year. In 2000, the annual average discharge temperature was 73°F[23]. Exposure to discharge temperatures above 86°F (30°C) during cooling system transit are lethal to entrained striped bass larvae. Therefore,

[23] 2000 NPDES Discharger Self-Monitoring Report for MBPP

thermal stresses are not expected to be a significant cause of mortality to entrained fishes or invertebrates.

6.7.3.1 Potential Biological Benefits

Existing through-plant temperature rises of 20°F and less, combined with an average annual discharge temperature of 73°F, are normally below most known lethal temperature thresholds of larvae fish and invertebrates. Fluctuations in daily generating loads and the temperature of ambient incoming water combined to produce short-term and varying thermal dose. Morro Bay organisms entrained subjected to the thermal dose of plant passage during generation periods are accustomed to the bay’s temperature fluctuations and are able to tolerate the thermal exposures of plant passage. Lowering through plant temperatures would not significantly benefit entrainment survival. Therefore, through-plant temperature regulation is not expected to result in a significant reduction in entrainment losses. Discharge temperature regulation through pumping of additional cooling water would result in overall higher total rates of entrainment, proportional to the increased flows. The additional entrainment would result in higher total entrainment mortalities due to mechanical and other non-temperature mechanisms of entrainment mortality.

6.7.3.2 Technical Criteria

In order for the new plant to maintain its generating capacity, a necessity if it is to be built, through-plant temperature regulation would be accomplished through the installation and operation of larger or additional cooling water pumps at the intake. If the pumps required additional screen surface area to meet screen approach velocity requirements, than additional intake facilities would need to be constructed along the Morro Bay harbor shoreline.

6.7.3.3 Other Environmental Impacts

Other than increased entrainment and impingement impacts, the other environmental impacts would be principally from the additional electrical demand required to meet the requirements of the pumps, and from the additional space requirements for additional pumps, if they are required.

6.7.3.4 Economic Criteria

Assuming a 50 percent increase in cooling water pumping capability, the additional capital costs would be approximately $4 million. Assuming a 100 percent increase in cooling water pumping capability, the additional capital costs would be approximately $11 million, and the additional incremental annual O&M (mainly power costs) costs would be approximately $15-30 million. In the latter case, additional intake facilities would be necessary along the harbor shoreline.

6.7.3.5 Conclusion

Notwithstanding the economic and other environmental costs, there are no potential biological benefits that wouldn't be more than offset by adverse biological effects from the adoption of through-plant temperature regulation above the 20°F design maximum temperature differential for the MBPP CC units. Therefore this alternative is not considered further for adoption at MBPP.

6.7.4 Alternate Biofouling Control

The biofouling control procedure currently used at MBPP consists of intermittent chlorination (Subsection 2.1.2) for slime control and infrequent heat treatment for biofouling control. These control schemes have been adequate to control marine growth and are planned for application to the new CC units as well.

Alternative biofouling control schemes, which can be considered for application at the new combined-cycle units, include the following:

1. increased chlorine dosage,
2. increased frequency of chlorination from intermittent dosage to continuous application,
3. use of alternative chemical toxins, including bromine, chlorine dioxide, chlorine bromide, and ozone,
4. application of toxic coatings on cooling system conduit walls,
5. oxygen depletion (stagnation),
6. mechanical cleaning,
7. increased heat treatment, and
8. increased water velocities within cooling system conduits.

6.7.4.1 Potential Biological Benefits

All of these alternatives, with the exception of increasing chlorination frequency to continuous application and increased water velocities within the cooling water conduits, are expected to have the potential of reducing entrainment cropping by controlling the colonization of cooling water system conduits by marine fouling organisms. Because the chlorine is also toxic to entrained fish eggs, larvae, and juveniles and invertebrates, continuous chlorination would potentially result in 100 percent entrainment mortality. Increasing the velocity of cooling water through the conduits to levels above 10 fps (300 cm/sec) has the potential of reducing colonization by marine organisms. Increasing cooling water velocities would, however, substantially increase mechanical damage to entrained ichthyoplankton and macroinvertebrates and increase impingement losses. Increasing velocities within the cooling water conduits is therefore not considered to be an effective method of reducing the combined losses resulting from entrainment and impingement at the new combined-cycle units.

6.7.4.2 Technical Criteria

Chlorination and heat treatment are currently used at the MBPP in an effort to control slime accumulation on condenser surfaces and colonization of the cooling water systems by macroinvertebrates such as barnacles, mussels, and hydroids. Although entrainment impacts were assessed with an assumption that 100 percent of entrained organisms would be cropped during transit by biofouling organisms, this conservative assumption probably overestimates actual losses that could be minimized by rigorous control of biofouling growth in new MBPP combined-cycle units' CWS. Heat treatment of the Units 1 through 4 cooling water systems, accomplished by recirculation of warm condenser outlet water, is used to control macroinvertebrates between the condenser outlet gates and the intake inlet gates. Equipment included in the heat treatment involves the inlet tunnel from the inlet gates to the condenser outlet gates, cooling water pumps and traveling screens.

The current NPDES Permit requires the following heat treatment biofouling effluent limitation: "During heat treatment to remove biofouling organisms from conduits, the maximum temperature of the discharge (measured at the end of the discharge canal) shall not exceed the natural temperature of the intake water by more than 35 degrees F (19.4 degrees C)."

In addition to heat treatment, sodium hypochlorite (bleach) solution is injected periodically into the circulating water tunnels just after the traveling screens for control of micro-fouling (microscopic algae and bacteria growth) on condenser surfaces. Residual chlorine levels at the discharge are limited to less than 0.20 mg/l as required by the NPDES permit.

6.7.4.3 Other Environmental Impacts

Since biofouling treatments are conducted following standard procedures within NPDES permit limits, no environmental effects are anticipated.

6.7.4.4 Economic Criteria

Since biofouling treatment periods and frequencies for the new combined-cycle units are proposed to be similar to those used for Units 1 through 4, no significant changes in costs are anticipated compared to those of the existing plant, except those related to reduced flows.

6.7.4.5 Conclusion

Biofouling treatment periods and frequencies for the new combined-cycle units are necessary and beneficial, and will be similar to those used for Units 1 through 4 with the possibility of some dosage adjustments as necessary when the units come on line. It is expected that the heat treatment procedures and schedules for the new CC units will be similar to those currently used for Units 1 through 4. It is currently planned to inject hypochlorite solution at the inlet to the new CC condensers rather than at the suction of the cooling water pumps as currently practiced for Units 1 through 4.

6.7.5 Intake Area Dredging

6.7.5.1 Potential Biological Benefits

Sediment accumulation at or within a cooling water intake structure may reduce the effective size of the cooling water intake. The cooling water demand remains the same but the water is now drawn through an opening increasingly restricted by sediment build-up, resulting in higher cooling water intake approach velocities. Increased approach velocities at the intake structure may result in increased rates of impingement. The MBPP regularly takes action (dredging and other maintenance activities) to ensure that approach velocities are at or below the design velocities (see discussion in the Technical Criteria). Although the reduction in the number of organisms impinged is difficult to quantify or predict, it is clear that lower intake approach velocities decrease the likelihood of organisms being impinged.

6.7.5.2 Technical Criteria

Sediment (sand and silt) transported by littoral drift continually deposits within Morro Bay Harbor, which is the source of cooling water for the Morro Bay Power Plant. This natural deposition also occurs in front of, and within, the power plant cooling water intake structure. MBPP's NPDES permit requires measurement of bar rack approach velocity and sediment deposition at the intake structures annually. The permit also requires dredging as necessary to eliminate sand and silt build-up and to clean bar racks as necessary to maintain bar rack approach velocities as close as practicable to design velocities. Bar rack cleaning takes place year-round with specific frequencies dictated by seasonal debris loading patterns. Dredging activities are much less frequent since significant, multi-agency permitting is required for both the dredging and disposal of the spoils. Due to the high cost of permitting and dredging (currently estimated to be $200,000 per event), dredging events are designed to remove as much sand as possible as to increase the length of time between events.

6.7.5.3 Other Environmental Impacts

For intake area dredging, no significant other environmental impacts are expected to occur. Such activities are carried out under permits with established environmentally protective requirements and procedures.

6.7.5.4 Economic Criteria

As mentioned in the Technical Criteria, the cost of permitting and dredging is currently estimated at $200,000 per event.

6.7.5.5 Conclusion

The annual bathymetric surveys are used to monitor sediment so dredging can be permitted and completed before the sediment build-up results in higher-than-design intake approach velocities. Since this monitoring is currently required – and is expected to be required in the future – no further consideration of additional dredging is warranted. Intake area dredging will continue on an as-needed basis.

6.8 Summary and Conclusions

The potential biological benefits, engineering constraints, environmental impacts, and economic costs of the alternative intake technologies considered in Sections 6.2-6.6 are summarized below. On the basis of this information, a recommendation is made as to the best technology available (BTA) for the intake system of the new combined-cycle units at the MBPP.

6.8.1 Summary of Potential Biological Benefits

An examination was made of the relative effect of operation of the plant's cooling water system on fish and macroinvertebrate populations. As evaluation of the field studies of intake effects conclude in Section 5.0, evidence has been found to indicate that cooling water system operations of the new combined-cycle generating units will not result in a significant adverse impact on the populations of fish and invertebrates inhabiting Morro Bay and Estero Bay. There is no empirical evidence that the populations of gobies and other bay/estuarine species in Morro Bay are not at a level limited by their habitat carrying capacity. Most of the organisms entrained and impinged are species that are distributed widely by ocean currents along the Pacific coast, and by the large tidal exchange in Morro Bay. The broad extent and movement of these species along the coast reduces the risk of localized population effects. In addition, the species whose larvae are entrained typically have very high natural mortality rates. The overwhelming majority of the numbers of fish larvae entrained is represented by species of no commercial or recreational value. None of the entrained or impinged species are protected or of special concern.

For these reasons, it was concluded that the impact of the proposed modernized Morro Bay Power Plant's operation on populations of local marine life has been and will continue to be undetectable at the population levels of the species involved. More importantly, there is no certainty that implementation of alternative intake technologies designed to further reduce entrainment or impingement mortality would result in a detectable increase in population abundance for fish and invertebrate species inhabiting the Morro Bay region and the adjacent coastal waters. The recommendations and discussion of alternative intake technologies presented here are based in part on this conclusion.

Based on results of the Second-Level Evaluation on potential biological benefits of the alternative intake technologies, the following was concluded regarding alternative technologies that were deemed to have no biological benefit if applied to MBPP:

1. There are no reasonable alternative intake locations that would reduce entrainment and impingement losses, nor would installing an adjustable vertical barrier;

2. No behavioral barriers that could reduce numbers of organisms exposed to either entrainment or impingement could be applied to the shoreline intake at MBPP;

3. Entrainment and impingement losses would not be substantially reduced by use of alternate designs of traveling screens or barrier nets;

4. Fish diversion, collection and conveyance systems are unnecessary at MBPP since there is no entrapment, and low impingement, with the existing configuration and operation of the shoreline intake system at the plant;

5. A screen mesh size of 3/8 in. (0.9 cm) is acceptable. There is insufficient data available to determine whether the survival of early life stages of fish impinged on smaller mesh screens would exceed the survival of organisms entrained through the MBPP cooling systems; and

6. Through-plant temperature regulation is likely to increase the overall mortality of entrained and impinged organisms.

The following alternative intake technologies may reduce entrainment and/or impingement losses for the new CC units:

1. Aquatic filter barrier,

2. Replacement of the proposed once-through cooling system with a closed-cycle system (e.g. either seawater mechanical or natural draft cooling towers, a hybrid system, a spray pond, or air cooled condensers),

3. Cooling water pump flow reduction,

4. Seasonal curtailment of cooling water flows,

5. Alternate biofouling control, and

6. Intake area dredging.

Each of these alternatives is expected to offer some potential for reducing the losses of organisms by entrainment and/or impingement.

6.8.2 Summary of Economic Criteria

The economic cost was estimated for each of the alternative intake technologies. The costs considered include total incremental capital cost (including lost capacity capital costs where appropriate), annual O&M cost, and the incremental energy cost resulting from reductions in plant net output.

Economiccost data were normalized by presenting all costs as incremental to a base case utilizing once-through cooling. PV (Present Value) and amortized cost metrics are calculated so the alternatives can be compared on a time-adjusted cost basis. A 7% discount rate and project life of 30 years were used for the calculation of time-adjusted cost metrics.

Figures 6-33, and 6-34 graphically show the relative magnitude of the time-adjusted cost metrics for the selected alternatives (aquatic filter barrier and technically feasible closed-cycle cooling system alternatives). As can be seen, intake technologies other than once-through cooling would significantly increase the economic cost of the proposed plant.

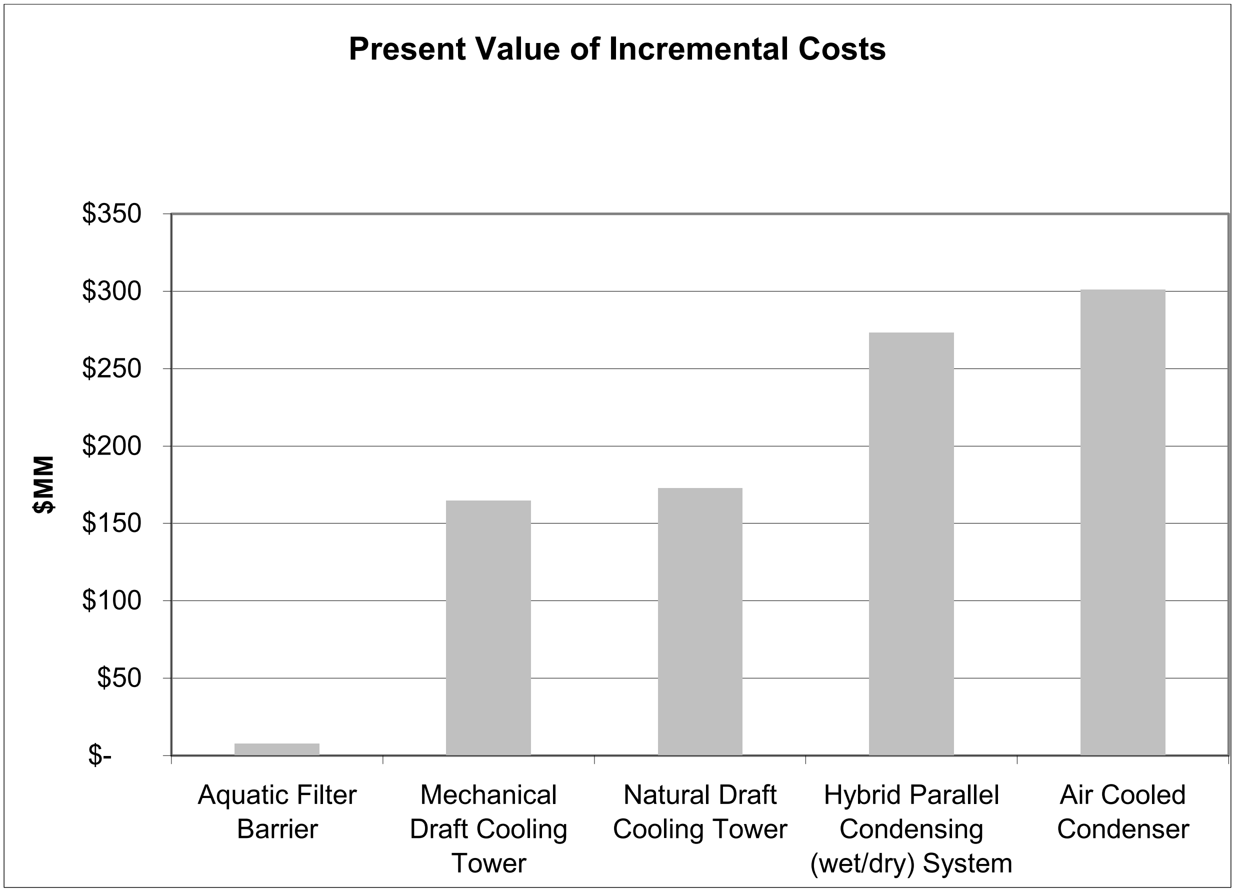


Figure 6-33. Present Value of incremental costs of selected alternatives.

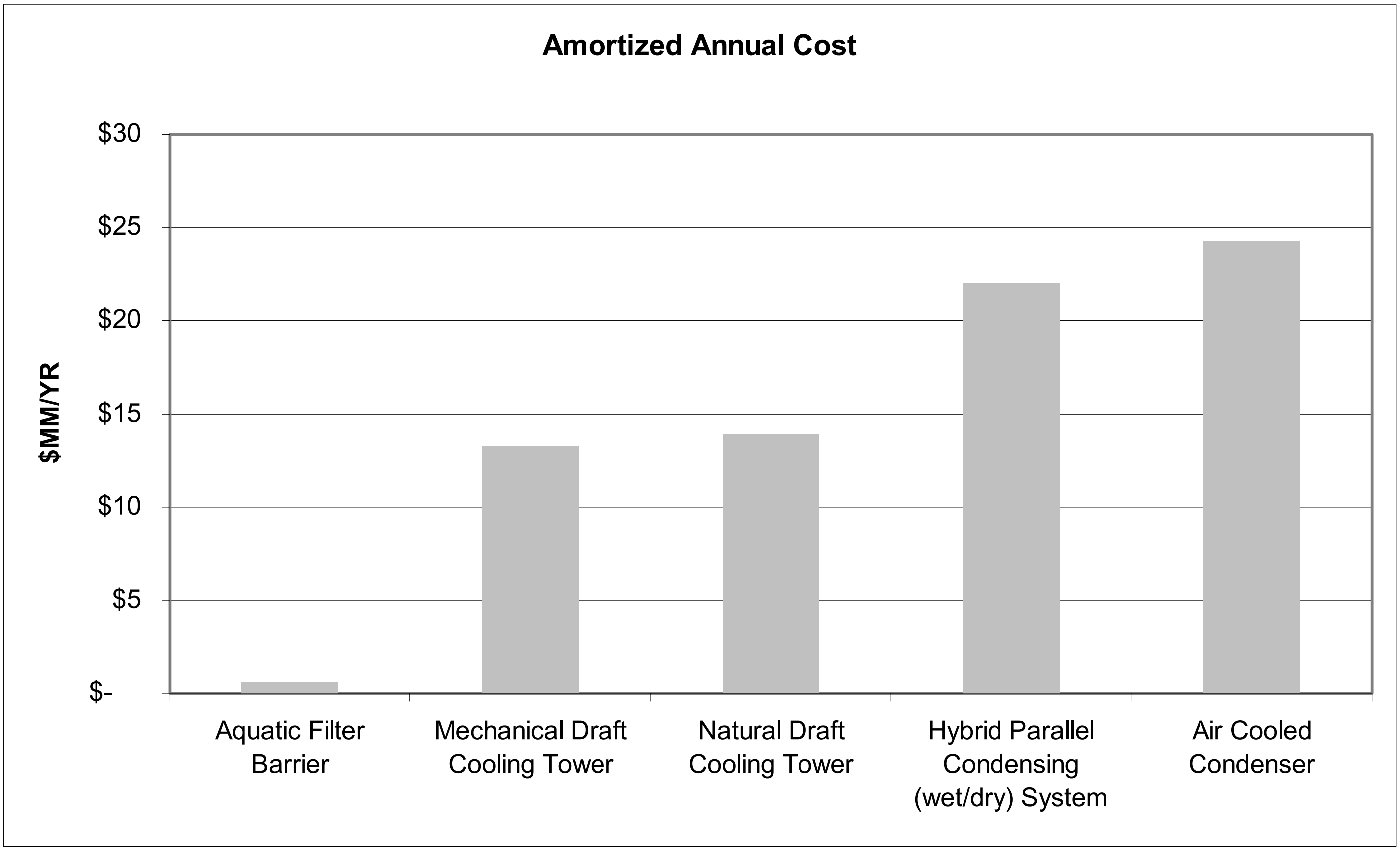


Figure 6-34. Amortized annual costs of selected alternatives.

6.8.3 Discussion

The installation of an aquatic filter barrier (AFB) for the combined-cycle plant would reduce the entrainment and impingement effects of the project's CWIS. However, the cost effectiveness of installation of an AFB at the MBPP would need further evaluation of its efficacy and cost effectiveness through detailed engineering feasibility and biological evaluations. The existing data and knowledge on the physical site characteristics for inclusion in the design and planning process would need to be reviewed in a preliminary investigation of the site. This includes inspection of shoreline features, deployment considerations, plant operations and available resources. At the MBPP site, installation space in front the intake would appear to potentially be the single most limiting site characteristic. Tidal flows in the channel in front of the project's CWIS provide appropriate flushing flows required to sweep particles along the AFB and sediment loads are normal for bays similar to Morro Bay. The installation of an AFB at the

MBPP CWIS could potentially exclude shoreline habitat and interfere with other uses such as navigation and other water related activities. However there are several AFB design concepts that might avoid or significantly reduce the AFB effect in these environmental areas.

Closed-cycle cooling options (mechanical draft cooling towers, natural draft cooling tower, a hybrid parallel condensing (wet/dry) system, spray ponds, and air cooled condensers) were eliminated on the basis of unacceptable environmental impacts and construction and operating costs. Drift droplets and solids "raining" out of the cooling tower plumes and a spray pond could cause a nuisance liquid deposition on the surrounding area and significant additional particulate emissions. Potential impacts to local agriculture and equipment would occur from deposition of these drift salts. Mechanical draft cooling towers and direct air-cooled condensers are a significant potential source of overall power plant noise impacts on surrounding areas. All closed-cycle alternatives significantly reduce plant output due, primarily, to reduced steam turbine generator efficiency, and, secondarily, to increased internal plant loads. Likewise, all options would result in significant visual impacts, particularly the natural draft tower and dry-cooling tower, and take up significant land areas. For all the above reasons, the proposed once-through cooling water system is preferred to a closed-cycled cooling system.

Reduction in cooling water pump operations to coincide with periods of reduced electrical generation or when a unit is out of service has also been identified as a biologically effective method of reducing the losses of organisms through entrainment and impingement. The Morro Bay Power Plant can be operated at reduced loads with less than full circulating water flow, either through removing pumps from service or through installation of variable-speed motor controls. Reducing cooling water flow except when needed based on generation load will be practiced for the new CC units. Operating in this manner, with the flexibility of four pumps per unit, provides the functional equivalent of variable speed pump motor controls.

Seasonal curtailment of cooling system operations would result in reductions of both entrainment and impingement losses. The level of reduction would depend on the abundance of organisms present during the period of curtailment and the duration of the curtailment. The economic consequences of this alternative are so severe that Duke Energy would abandon the modernization project. This scenario would result in the associated impacts of higher cost and less reliable electricity for California consumers and increased operation of Units 1 through 4, which require significantly more cooling water per MW-hr generated, and have greater marine impacts, than the proposed CC units. Therefore, curtailment of power plant operation as a method of reducing entrainment and impingement is not a viable alternative.

Alternative chemical biocides, application of toxic coatings, and routine mechanical cleaning are not considered to be effective alternative biofouling control techniques. However, the biofouling control procedures currently used at MBPP consists of intermittent chlorination for slime control and infrequent heat treatment for biofouling control. Continued periodic heat treatment when needed will reduce the numbers of biofouling organisms lining the conduits and therefore reduce the number of entrained fish and crab larvae preyed upon by these fouling organisms. These control schemes have been adequate to control marine growth and are planned for application to the new CC units as well.

Periodic dredging of the intake area to reduce approach velocity is believed to indirectly reduce the impingement rate for fishes. No reduction in entrainment or impingement of macroinvertebrates is expected from dredging. Because sediment accumulates in the vicinity of the intakes, the area is periodically dredged as part of the standard operation of the plant, and this practice will be continued after installation of the new CC units.

6.8.4 Conclusions

The proposed new combined-cycle units' CWIS shoreline vertical traveling screen design represents the best technology available. This conclusion is based on the finding of relatively insignificant entrainment and impingement effects (including no population level effects) and consideration of various demonstrated alternative technologies, including potential biological effectiveness for further reducing entrainment and impingement losses, engineering feasibility, and cost-effectiveness, as outlined in the guidance manual (USEPA 1977).

Recommended operating practices for the new CC units include (1) reducing the operation of the cooling water pumps except as needed for the level of power generation be followed, (2) continuation of intermittent chlorination and periodic heat treatment for biofouling control, and (3) monitoring and dredging the intake area when necessary to reduce intake velocities by removing accumulated sediment impeding intake flows.

Future entrainment rates will be reduced proportionally to the new facility's 38 percent reduction in cooling water intake. Future impingement rates will also be reduced because of reductions in intake velocities corresponding to reduced intake volume. On an annual average, comparing year 2000 actual operations to conservatively high projected combined-cycle unit operations, future entrainment rates will be reduced by 35 percent compared to the present. Since it is reasonable to assume that the existing MBPP will continue to operate into the foreseeable future if it is not modernized as proposed, the reduced flows (and therefore entrainment and impingement) resulting from the modernized project represent the best technology available.

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