STATE OF CALIFORNIA
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL COAST REGION

STAFF TESTIMONY FOR REGULAR MEETING OF JULY 10, 2003
PACIFIC GAS AND ELECTRIC COMPANY'S (PG&E'S) DIABLO CANYON POWER PLANT
RENEWAL OF NPDES PERMIT

Prepared on June 6, 2003

ITEM NUMBER:

SUMMARY

This item proposes to renew PG&E's National Pollutant Discharge Elimination System (NPDES) permit for the Diablo Canyon Nuclear Power Plant (DCPP) in San Luis Obispo County. DCPP continues to operate as it has since 1985, without modification.

A Fact Sheet (Attachment 9) and copy of the proposed Order including a proposed Monitoring and Reporting Program were sent out on May 1, 2003 for public comment.

The proposed Order includes findings regarding thermal effects, impingement, and entrainment issues associated with the once-through cooling water system. The proposed Order also includes a negotiated settlement regarding these issues (hereafter Consent Judgment) approved by the Regional Board on March 21, 2003. The Consent Judgment will provide major benefits to the coastal marine environment. These items are further discussed below in both the Summary and the Discussion sections.

As part of the Consent Judgment, the biological monitoring program for thermal effects is being discontinued, and Discharger will instead contribute funds toward the Regional Board's Central Coast Ambient Monitoring Program pursuant to the Consent Judgment.

The proposed Order includes effluent limitations for physical parameters, metals, and chemical constituents pursuant to the 2001 Ocean Plan and other applicable Plans and regulations. All discharges covered by this proposed Order are to the ocean.

As part of the NPDES permit renewal process, Regional Board staff reviewed the biological impacts associated with the once-through cooling water system at DCPP, and power plant modifications or operational changes that might reduce the biological impacts. This testimony is based on staff's own evaluation and analysis and input from the Regional Board's independent consultants.

Regarding the thermal discharge, there are no reasonable power plant modifications (such as an offshore discharge structure) or operational changes (such as reduced power generation) to address the thermal biological effects. The relevant thermal impacts in this case are the incremental difference between what was predicted and what was actually measured in the receiving water. The costs of options to potentially address the incremental difference between predicted and actual impacts range from hundreds of millions of dollars for an offshore discharge to billions of dollars for reduced power generation. The evidence indicates that these options would not be ecologically effective. Therefore, the alternatives are not reasonable pursuant to the State Thermal Plan and the Porter Cologne Water Quality Control Act.

Regarding impingement of adult fish in the intake structure, the number of fish lost per year is so minor (a few hundred fish per year) that intake structure modifications or operational changes are not necessary. These losses are already minimized pursuant to Clean Water Act Section 316(b).

Regarding entrainment of larvae in the cooling water system, the proportional loss of larvae is significant. However, the costs of power plant modifications or operational changes are wholly disproportionate to the benefit to be gained. Tetra Tech, the Regional Board's independent consultant on alternative cooling systems,

estimates the cost for a closed cooling system at $1.3 billion. Staff considers this a conceptual and minimum estimate due to the many issues and obstacles involved in actually implementing the technology at DCPP.

Intake structure technologies for minimizing entrainment, such as screening devices and filters, are experimental technologies at this time. The only technology that is conceptually possible at DCPP is fine mesh screening. Tetra Tech estimates the cost of installing fine mesh screens at $650 million. This estimate is conceptual because the technology is experimental. Their use at DCPP would require site-specific research. As such, intake technologies are not demonstrated available technologies for DCPP.

Seasonal flow restrictions are not applicable to DCPP because larvae are available and are entrained year round, and there are no threatened, endangered, or otherwise critical species being entrained that would benefit from this alternative. Variable speed pumps would likely offer no increased benefit because DCPP, as a nuclear power plant, is a base load facility (designed to run fairly continuously at full power output).

An offshore intake structure was also evaluated. The conceptual and minimum cost range for this alternative is in the hundreds of millions of dollars. The biological impacts would not be eliminated, but would be moved further offshore and would include major impacts from the construction project. Also, this alternative may not be possible due to the steep bathymetry and rocky substrata offshore of DCPP. Staff knows of no offshore intake structure in an environment similar to that at DCPP.

PG&E submitted an economic analysis report that estimates the Net Present Value of the entrainment losses at $15,786 to $1,905,757. However, the Regional Board's independent scientists agree that this estimate is probably underestimated because it does not include the majority of entrained organisms. The Regional Board's independent scientists believe that the actual value is likely to be in the ten million dollar range. This "value" range can be compared to the cost of saltwater cooling towers. Tetra Tech 2002 estimated the Net Present Value of saltwater cooling towers at $1.3 billion. Using these values, the cost of cooling towers is wholly disproportionate to the benefit to be gained (regardless of whether the entrainment losses have a Net Present Value in the million dollar or ten million dollar range). The same comparison can be made for fine mesh screens ($650 million), although fine mesh screens have not been demonstrated to be effective in settings like DCPP. Assuming for the purpose of this analysis that fine mesh screens are effective, the cost of fine mesh screens is also wholly disproportionate to the assumed benefit to be gained. The costs for closed cooling and fine mesh screens could be significantly higher than the estimates provided.

Considering the major issues with power plant modifications and operational changes, staff and the Attorney General's office negotiated a settlement with PG&E, which is defined in the Consent Judgment attached to the proposed Order. The Consent Judgment provides permanent protection for 5.7 miles of near-shore marine habitat, funding for projects to enhance and protect marine resources, and other benefits.

The following summarizes staff's conclusions:

<u>Thermal Effects</u>

1. There are no reasonable design or operational changes to address the incremental difference between the predicted thermal impacts and the actual thermal impacts.

<u>Impingement and Entrainment</u>

2. Impingement losses are minimized pursuant to Clean Water Act Section 316(b) and no alternative technologies are necessary.
3. Entrainment losses are significant. However, intake structure technologies (such as screens and filters) for reducing entrainment are experimental and therefore are not demonstrated available technologies for the DCPP.
4. Closed cooling systems such as saltwater cooling towers are only conceptually possible at the DCPP, and the conceptual and minimum cost estimate for this alternative is $1.3 billion.
5. The cost of closed cooling systems is wholly disproportionate to their benefit.

<u>Consent Judgment</u>

6. The Consent Judgment provides permanent protection of near-shore marine habitat and other benefits, while the impacts due to DCPP are temporary. Staff previously estimated the value of the Consent

Judgment at $16 to $26 million (not including the ecological "value" of habitat protected in perpetuity). This value range exceeds PG&E's estimate of the Net Present Value of the entrainment losses ($15,786 to $1,905,757), and is similar to the estimated dollar value of the entrainment losses if they are increased by a factor of ten (as suggested by the Regional Board's independent consultants). Although these dollar value comparisons can be made to support the Consent Judgment, staff believes the best valuation is ecological. That is, marine resource benefits from the Consent Judgment will accrue forever, so permanent preservation of resources is invaluable.

DISCUSSION

THERMAL EFFECTS
The temperature of cooling water is raised approximately 20 degrees F during commercial operation of DCPP (the effluent limit is 22 degrees F). Pursuant to the Thermal Plan, existing thermal discharges shall "comply with limitations necessary to assure protection of beneficial uses and Areas of Special Biological Significance." There are no designated Areas of Special Biological Significance near the DCPP. The nearest designated Area of Special Biological Significance is the area surrounding the mouth of Salmon Creek, approximately 60 miles north of Diablo Cove. Therefore, the operative portion of the objective is compliance with limitations necessary to protect beneficial uses. The beneficial uses of the Pacific Ocean, including Diablo Cove, are listed in Finding No. 14 of the proposed Order.

The State Water Resources Control Board's Order No. WQ No. 83-1 (Order WQ 83-1), determined that the Thermal Plan narrative objective requiring protection of beneficial uses meant "reasonable" protection and so accommodated some degradation of beneficial uses by the thermal discharge (hereafter, the term "beneficial uses" refers to the marine habitat use, as effects on other beneficial uses are not in question). Order WQ 83-1 held that the DCPP thermal discharge, subject to an effluent limitation of 20 degrees Fahrenheit over the intake water temperature, provided reasonable protection of beneficial uses based on predicted adverse impacts ("the Predicted Impacts"). The Predicted Impacts versus actual thermal impacts are discussed in previous staff reports to the Regional Board, the staff report for this proposed Order, and staff's testimony for this proposed Order.

PG&E initiated comprehensive biological monitoring of Diablo Cove and the vicinity in 1976. This program is known as the Thermal Effects Monitoring Program (TEMP) or the Ecological Monitoring Program (EMP) in previous Orders. The Regional Board periodically revised the monitoring program, but the program has otherwise continued for 26 years.

TEMP included intertidal, subtidal, and temperature studies at locations in Diablo Cove, Fields Cove and two control stations. Intertidal studies included horizontal and vertical band transects to measure algae and invertebrates and a black abalone census. The subtidal studies included kelp surveys and the measurement of red abalone and fish at various transects. Temperature was measured at various stations within Diablo Cove and the control areas. PG&E submitted annual reports evaluating the TEMP data to the Regional Board from 1985 to the present.

As part of amendments to the Monitoring and Reporting Program approved by the Regional Board in February 1995, the Regional Board began a comprehensive review of the monitoring program data in 1995 via a technical workgroup. The technical workgroup included Regional Board staff and the Regional Board's independent scientists, Department of Fish and Game staff, and PG&E. The Regional Board's scientists included both marine biologists and statisticians. Regarding thermal effects, the Regional Board's independent scientists are Dr. Michael Foster, Moss Landing Marine Laboratories, and Dr. David Schiel, University of Canterbury, New Zealand. Dr. Foster is a professor of marine biology (now retired), with expertise in kelp forest ecology and intertidal communities. Both Dr. Foster and Dr. Shiel have extensive experience on designing and implementing near shore marine research and monitoring programs, including monitoring program design, statistical analysis, and data interpretation.

The technical workgroup directed the development of PG&E's *Thermal Effects Monitoring Program Analysis Report, Chapter 1: Changes in the Marine Environment Resulting from the Diablo Canyon Power Plant Discharge,* December 1997 (hereafter Chapter 1). The data was primarily analyzed using the Before-After-Control-Impact and Fisher's Exact Test statistical methods.

Based on Chapter 1, the Regional Board's independent scientists and Regional Board staff concluded that the thermal discharge impacts were greater than the Predicted Impacts, (which the State Water Board had considered reasonable protection of beneficial uses), for the following reasons:

1. The discharge impacts a greater distance of coastline than was predicted. The actual distance is 1.1 miles (all of the intertidal zone in Diablo Cove), with minor changes also observed along an additional 0.7 miles into Field's Cove, for a total distance of 1.8 miles. Field's Cove was intended as a control area, with no biological effects and no thermal plume contact, but the thermal plume was found to extend into this area periodically.

2. The discharge impacts a greater area of the subtidal zone than was predicted. The predicted area of impact was up to 40 acres. The discharge impacts about 56 acres of subtidal kelp occur on a frequent basis and up to 105 acres during major El Nino event years (this has occurred twice since the Power Plant began operation). The effects during El Nino years include early senescence of bull kelp leaves in the extended area outside of Diablo Cove.

3. The magnitude of population and community changes is greater than predicted. The Predicted Impacts in the intertidal zone were limited to one-third of Diablo Cove during a few months out of the year, and few changes were expected. The actual impacts include major reductions in species populations and assemblages in Diablo Cove, including almost complete loss of foliose algae and intertidal fish. These actual impacts are continuous (not seasonal as predicted).

4. The thermal effects include unexpected impacts, such as a major increase in “bare rock” in the intertidal zone in Diablo Cove. This represents a major community shift from foliose algae to predominantly limpets and other grazers with low diversity, and is indicative of a stressed biological community. The thermal discharge also causes detectable effects in the intertidal zone in Field's Cove (an area that was intended to be a biological control area), and exacerbation of withering syndrome disease on black abalone and black abalone population declines in the area.

Regional Board staff concluded that adverse water quality impacts exceeding the Predicted Impacts constituted a violation of various receiving water limitations in PG&E’s 1990 NPDES permit. Discharger vigorously opposed staff’s conclusions as described in Finding No. 34 of the proposed Order. In March 2000, the Regional Board conducted a hearing to determine whether PG&E violated its 1990 NPDES permit and whether to issue a Cease and Desist Order.

The basis for allegations of violation of the permit was a variety of receiving water limitations. PG&E could get a variance from State Water Quality Standards under Clean Water Act Section 316(a). (33 U.S.C. sec. 1326(a).) Section 316(a) provides that if state imposed effluent limitations are more stringent than necessary to assure protection and propagation of a balanced indigenous community of shellfish, fish and wildlife in the receiving water, a Discharger will be subject to less stringent limitations. PG&E has never applied for a variance under 316(a) and so the Regional Board has not made a determination as to whether the discharge would comply with the less stringent standards authorized under Section 316(a).

After hearing testimony and taking evidence in the hearing, the Regional Board continued the hearing for the purpose of closing statements and deliberation. Regional Board staff and PG&E then continued negotiating a tentative resolution and the Cease and Desist Order hearing was never completed.

At the Regional Board’s request, PG&E prepared a comprehensive report on the thermal discharge effects that have occurred since 1995. This report is titled: *Receiving Water Monitoring Program: 1995-2002 Analysis Report,* November 2002. This report analyzes the data collected from 1995-2002 using the same analytical approach as Chapter 1. Regional Board staff and the Regional Board’s independent consultant reviewed the report. The results show that since 1995, there have been minor additional biological changes in Diablo Cove and no additional biological changes in Field’s Cove. The minor additional changes in Diablo Cove are within the areas previously established as being impacted.

Based on State Board Order WQ 83-1, protection of beneficial uses does not require elimination of adverse impacts of the Thermal discharge. The Thermal Plan implementation program requires that existing dischargers determine design and operating changes which would be necessary to achieve compliance with the Thermal Plan. Thus staff evaluated alternatives to improve protection of beneficial uses. For this evaluation, Regional Board staff reviewed PG&E's *Assessment of Alternatives to the Existing Cooling Water System,* 1982, by Tera Corporation. The Tera report provides an overview of site conditions, alternative cooling systems, and estimated costs. Staff also reviewed PG&E's *Diablo Canyon Power Plant 316(b) Demonstration Report,* March 2000. More recently, the Regional Board's independent consultant, Tetra Tech, also provided a report on the feasibility of alternatives, titled: *Evaluation of Cooling System Alternatives, Diablo Canyon Power Plant*, November 2002. Tetra Tech also provided a supplemental memo, dated December 4, 2002, regarding the estimated cost of an offshore discharge. The dispersion of the existing thermal plume is also described in PG&E's *Chapter 1: Thermal Discharge Assessment Report*, December 1997, and several other reports in the record. The conceptually feasible design and operating changes that might be made are construction of an offshore discharge outfall, closed cooling systems, a reduction in cooling water flow, or a reduction in effluent temperature.

Offshore Discharge Outfall: There are several issues of concern regarding an offshore discharge structure at DCPP. The extensive construction effort required for a discharge of this size would result in additional nearshore impacts to the marine environment, including the nearshore area in Diablo Cove, and the subtidal area out to the extent of the outfall, which could be several thousand feet offshore depending on the length of the structure. These construction related impacts would include destruction of intertidal zone, shallow subtidal zone, and kelp forest habitat. In addition, an outfall located one thousand to two thousand feet offshore would shift the source of the thermal plume into the local kelp forest and would likely increase thermal impacts on this habitat forming species and its associated taxa.

Also, additional coastline may be impacted because the thermal plume would no longer be bounded by Diablo Cove. To avoid impacts to kelp and to limit thermal plume contact with the shoreline, the discharge outfall would have to be located several thousand feet offshore, which may not be possible due to the relatively steep bathymetry near DCPP and the rocky substrata (bathymetry is shown on Attachment 1). Finally, the cost of an offshore discharge would be at least $144 to $194 million (Tetra Tech, 2002, Attachment 2). This estimate understates the actual cost because it does not include construction issues associated with rocky substrata. Considering the additional marine impacts, feasibility problems, and costs associated with this option, an offshore discharge structure is not a reasonable alternative at DCPP for protection of beneficial uses.

Closed Cooling Systems: Dry cooling systems and fresh water cooling towers are not feasible at DCPP. The only conceptually feasible closed cooling system for DCPP is a mechanical draft tower system using saltwater. Closed cooling systems are discussed in detail below, and in Attachment 4 of the proposed Order. Mechanical draft towers using saltwater could theoretically reduce cooling water intake volume by approximately 90%. However, the cost of installing saltwater cooling towers is $1.3 billion or more (Tetra Tech, 2002). Also, the site-specific constraints at DCPP (zoning, topography, available space, relocation of existing facilities) makes this option speculative. There are other significant issues associated with cooling towers, such as salt drift, visual impacts, and land use impacts. Considering the high cost and speculative feasibility of mechanical draft cooling towers, this option is not a reasonable design change for protection of beneficial uses associated with the thermal discharge.

Reduced Flow Volume: Reducing cooling water flow at DCPP would require major design changes, such as permanently shutting down one of the two power generation units (a fifty percent flow reduction). Reducing flow volume by fifty percent may not reduce thermal effects in Diablo Cove because the Cove acts as a physical boundary for the plume. Three factors control biological impacts caused by the thermal plume: 1) elevated temperature, 2) frequency of exposure to elevated temperatures, and 3) time. A fifty percent flow reduction may result in less frequent plume contact in some areas, however, less frequent plume contact in some areas only means that biological changes will take longer to occur. Since the discharge will exist for several years, the impacts would continue to occur. Also, reducing flow volume by fifty percent would require decreasing power generation by fifty percent. Decreasing power generation by fifty percent would cost billions of dollars in lost revenue over the life of the facility. This option is not a reasonable design change for protection of beneficial uses.

Reduced Temperature: Reducing the temperature of the discharge could be achieved by reducing power generation while maintaining cooling water flows. However, even a major reduction in effluent temperature, such as a fifty percent reduction, may provide little or no improvement in thermal effects in Diablo Cove because even relatively small temperature changes over a long period of time will cause biological changes (PG&E, Chapter 1, December 1997). At fifty-percent reduction, the effluent temperature would be a delta of 11^0 F. This degree of elevated temperature is adequate to cause major biological changes, especially over a long period of time. A fifty-percent reduction in power would result in a significant reduction in the available power supply to the state of California (about 1100 MW reduction). Also, a fifty-percent reduction in power generation would cost billions of dollars in lost revenue over the life of the facility. This option is not a reasonable operational change for protection of beneficial uses.

For the reasons noted above, design or operational changes to reduce thermal discharge impacts would either be ineffective or infeasible. Second, the Thermal Plan requires analysis of design or operational alternatives but does not mandate any technology changes. It only requires reasonable protection of beneficial uses. Third, the Regional Board cannot directly mandate use of a particular technology to achieve compliance. (Water Code sec. 13360.) Fourth, PG&E could apply for a variance under Clean Water Act Section 316(a) that could relieve them of a state imposed effluent limitation to eliminate or drastically reduce the volume or temperature of their thermal discharge. Further, the issue with respect to thermal effects is the incremental difference between the Predicted Impacts and the actual impacts that have occurred, not elimination of all impacts (as noted above, Order WQ 83-1 established that some degradation of marine habitat is allowed). Therefore, Regional Board staff sought another means for protecting beneficial uses. The result is an alternative (a negotiated settlement) that requires permanent preservation of coastal habitat, including the same type of intertidal and shallow subtidal habitat affected by the thermal discharge. The settlement is discussed later in this testimony, following the discussion of impingement and entrainment.

ENTRAINMENT AND IMPINGEMENT

Regarding entrainment and impingement, the Regional Board's independent scientists are Dr. Greg Cailliet, Moss Landing Marine Laboratories, and Dr. Pete Raimondi, UC Santa Cruz. Dr. Cailliet is a professor of ichthyology, marine ecology, population biology, and fisheries biology, with main interests in community and population ecology, biological oceanography, marine plankton and nekton, and estuarine ecology. Dr. Raimondi is a professor of ecology and evolutionary biology whose research emphasizes nearshore marine communities. He also has substantial experience on the design, evaluation and analysis of marine monitoring programs, with particular expertise on the evaluation of marine discharges. Dr. Raimondi is currently directing the largest intertidal monitoring program in the world (through the Partnership for Interdisciplinary Studies of Coastal Oceans, or PISCO).

Dr.'s Cailliet and Raimondi participated on the technical workgroup established by Regional Board staff for the DCPP cooling water system. The technical workgroup directed PG&E's entrainment study, including all aspects of the entrainment study design and implementation.

Staff also retained Tetra Tech as an independent consultant on cooling system alternatives (Tetra Tech was not part of the technical workgroup process). Tetra Tech currently assists the U.S. EPA on cooling system analyses with respect to the newly revised Clean Water Act 316(b) regulations.

Impingement

Adult and juvenile fish are impinged on traveling screens in front of the intake structure. The traveling screens are designed to remove debris before it enters the cooling water system. Adult fish can become trapped, or impinged, in the debris and on the screens. PG&E conducted an impingement study during 1985 and 1986. The results of that study show that very few adult fish are actually impinged on the traveling screens. This is due to the low velocity of the water as it passes through the intake structure. The water velocity is slow enough (1 ft/sec) so that fish inhabit the intake structure and swim onto and off of the traveling screens. The study showed that the DCPP intake structure impinged a total of about 400 fish (about 60 pounds) and 1,300 crabs during the sampling period (April 1985 through March 1986).

For comparison, the Huntington Beach Power Plant, with flow volumes about one fourth the flow volumes of DCPP, and with an offshore intake structure, impinges up to 21 tons of fish per year. The El Segundo Power Plant, also with flow values about one fourth DCPP flows and using an offshore intake, impinges about 15 tons of fish per year. Both of the offshore intakes noted above are about 2000 feet offshore in about 35 feet of water. The amount of fish impinged at DCPP (about 60 pounds during the sampling period) is a tiny fraction of the amount impinged at these other power plants. The minor impingement losses at DCPP are so insignificant that they do not justify implementation of alternatives to the cooling water intake structure to further reduce the losses (the losses are already minimized).

Entrainment

Entrainment Studies at DCPP began in October 1996, and continued through June 1999 (about 2 ½ years of sampling in front of the intake structure). In addition to entrainment sampling in front of the intake structure, the study included an offshore sampling program. The offshore sampling area consisted of a grid approximately 17.4 kilometers long and 3 kilometers wide, centered on DCPP. The offshore grid sampling began in June 1997, and continued through June 1999 (approximately two years of sampling).

The study used three methods to analyze the data: 1) Empirical Transport Model, or ETM; 2) Fecundity hindcasting, or FH; and 3) Adult Equivalent Loss, or AEL. Each of these methods has advantages and disadvantages as described in the 316(b) Demonstration report.

The ETM approach estimates the proportion of larvae lost relative to the amount of larvae available in a given source water body. <u>Source water bodies are different for each species.</u> The size of the source water body for a given species is based on the age of entrained larvae and current speed. For <u>nearshore</u> species, the size of the source water body is expressed as length of coastline. For example, if the average age of an entrained larval species is 5 days, and the net current speed of coastal waters is 10 kilometers per day, then the size of the source water body from which the larvae may have come is 5 days x 10 kilometers/day = 50 kilometers of coastline. The size of the source water bodies for nearshore species ranges from tens to hundreds of kilometers.

For <u>offshore</u> species, the source water body is expressed as ocean area, using the same parameters (larval age when entrained and ocean current speed). For offshore species, the sizes of the source water bodies typically range from hundreds to thousands of square kilometers, with larger areas for some species.

The FH and AEL approaches convert larvae to adults using life history information for each species. The major limiting factor with each of these approaches, and most fishery impact assessments, is our lack of knowledge about species life histories (such as larval stage duration, longevity, fecundity, mortality at various larval stages, etc.). The lack of available life history information for most species requires us to make assumptions to fill in the gaps. The results from the FH and AEL approaches have very large statistical errors, so there is a great deal of uncertainty associated with these methods. The assumptions used for the FH, AEL, and ETM approaches were based on the best professional judgment of the technical workgroup members. The consensus of the technical workgroup members was that the ETM approach was the most rigorous, robust, and defensible of the three methods.

The entrainment sampling program identified and enumerated all species collected. The target species (fish and crabs) were selected by the technical workgroup after reviewing the entrainment data. Species were selected based on a list of criteria, such as abundance in samples, threatened or endangered status, etc., as described in the 316(b) Demonstration final report (page 4-1).

The results of the analyses (amounts entrained and equivalent adults lost) are shown in Table 1. The last column lists the size of the source water bodies for each sampling period and species for the ETM method. The ETM method calculates the percentage of larvae taken from these source water bodies for each of the two sampling periods (labeled S1 for year one and S2 for year two). Larval losses are shown for two scenarios, mean larval age and maximum larval age of the species entrained. The age of entrained larvae is critical to the analysis because it determines the duration of exposure and the size of the source water body. Larvae with longer larval duration are at greater risk of entrainment because they are exposed to entrainment for a longer period of time. Longer larval duration also increases the time that larvae are traveling with the ocean current, and thus the size of their source water body. There is debate over whether the mean or maximum larval age should be used in the ETM approach. Both values were used in this evaluation, and results based on mean and maximum larval duration are presented.

The results show that proportional larval losses for offshore (deeper water) species, including sport and commercial species, are relatively low (with the exception of halibut, which had relatively high proportional losses in S1 (year one) and very low proportional losses during S2 (year two). Halibut were included in the analysis because they are an important commercial species, even though the total number of larvae collected was very low relative to other species (378 total larvae collected). Although the ETM approach indicates potentially high proportional entrainment for halibut, the number of larvae entrained only represents 9 and 18 adult fish for the two sampling periods. The FH estimates for halibut were a rough approximation because there is no larval survival data for this species. Nevertheless, since so few larvae were entrained, the FH, AEL, and ETM results for halibut have little or no meaning. The other offshore species include sand dabs, rockfish, white croaker, Pacific sardine, and northern anchovy. The relatively low entrainment numbers for offshore taxa make sense because the intake structure is located at the shoreline.

Larvae from near-shore (relatively shallow water) species are entrained in significantly higher numbers. The nearshore species include smoothhead sculpin, monkeyface prickleback, clinid kelpfishes, snubnose sculpin, and blackeye goby. Again, this makes sense because of the location of the intake structure.

<u>The proportional larval loss values (ETM values) in Table 1 cannot be interpreted without the context provided by the source water body size</u>. For example, the loss of 5% of the larval fish in a source water body that is 1000 km of coastline in size is likely to be a greater loss (in abundance) than a proportional larval loss of 20% from a source water body of that is 50 km of coastline is size. The proportional larval loss estimates below must therefore be considered with the corresponding source water body sizes. In the Table, each value of proportional loss corresponds directly to a specific source water body size. For painted greenling, the proportional larval loss during sampling period 1997-98 was 0.88% based on mean larval duration and 0.91% based on maximum larval duration. These are percent larval losses from source water bodies of 856 km^2 and 2,738 km^2, respectively. The largest proportional larval losses occur with clinid kelpfish, up to 41% from a source water body of 126 kilometers (length of coastline). Note that the values in Table 1 are different than those presented in Attachment 4 of the initial draft Order sent out on May 1, 2003 for public comment. The values below are correct, and will be included in the final permit.

Table 1: Estimated losses due to entrainment at Diablo Canyon.
PG&E's 316(b) Demonstration Report, Pages 7-23 and 7-24, 2000, and Tenera 2003.

				ETM Estimated Percentage Reduction due to Entrainment			
Taxon	**FH Method (annual adult females lost)**	**AEL Method (annual adults lost)**	**Period**	**Mean Larval Duration**	**Maximum Larval Duration**	**Alongshore Distance (km) or Area (km2) Calculated based on Mean Larval Duration**	**Alongshore Distance (km) or Area (km2) Calculated based on Maximum Larval Duration**
Nearshore taxa - source water body calculated using alongshore distance							
smoothead sculpin	no calc	no calc	1997-98	10.50%	15.30%	49.28 km	127.58 km
			1998-99	14.60%	19.80%	51.91 km	142.78 km
monkeyface prickleback	no calc	no calc	1997-98	16.20%	23.20%	51.98 km	120.29 km
			1998-99	10.80%	11.30%	41.53 km	138.58 km

clinid kelpfishes	no calc	no calc	1997-98	31.80%	41.00%	53.57 km	126.12 km
			1998-99	29.40%	39.50%	47.11 km	108.36 km
Subtidal and pelagic taxa - source water body calculated as area							
painted greenling	no calc	no calc	1997-98	0.88%	0.91%	856.24 km^2	2,738.23 km^2
			1998-99	1.14%	0.44%	517.98 km^2	2,642.98 km^2
snubnose sculpin	no calc	no calc	1997-98	3.61%	2.31%	263.00 km^2	1,168.57 km^2
			1998-99	12.06%	2.10%	115.49 km^2	810.28 km^2
cabezon	no calc	no calc	1997-98	0.68%	0.57%	295.42 km^2	614.46 km^2
			1998-99	0.84%	0.92%	141.78 km^2	326.19 km^2
blackeye goby	no calc	no calc	1997-98	13.10%	7.87%	111.14 km^2	359.47 km^2
			1998-99	16.30%	17.90%	63.71 km^2	134.50 km^2
Pacific sardine	3,170 - 8,460	2,600 - 7,000	1997-98	0.03%	0.01%	981.92 km^2	16,562.96 km^2
			1998-99	not calculated			
northern anchovy	16,000 - 45,000	43,000 - 120,000	1997-98	0.06%	0.01%	641.06 km^2	7,174.45 km^2
			1998-99	0.21%	0.02%	360.35 km^2	7,319.59 km^2
white croaker	5,100 - 7,400	14,700 - 64,100	1997-98	0.26%	0.13%	518.87 km^2	2,157.13 km^2
			1998-99	2.11%	0.70%	217.06 km^2	1,468.66 km^2
blue rockfish	18 - 43	160-350	1997-98	0.10%	0.05%	415.20 km^2	998.77 km^2
			1998-99	2.11%	0.36%	199.92 km^2	1,065.08 km^2
KGB rockfish	500 - 620	900 - 1,100	1997-98	1.46%	0.96%	300.38 km^2	1,110.19 km^2
			1998-99	2.18%	0.48%	232.15 km^2	1,493.59 km^2
sanddabs	90 - 430	510 - 1,450	1997-98	0.49%	0.41%	502.77 km^2	805.78 km^2
			1998-99	4.59%	1.06%	158.46 km^2	487.61 km^2
California halibut	no calc	no calc	1997-98	0.08%	0.08%	477.47 km^2	1,858.94 km^2
			1998-99	12.30%	5.25%	199.22 km^2	1,257.20 km^2

brown rock crab	91,000 - 117,000	180,000 - 230,000	1997-98		0.002%		6,318.46 km^2
			1998-99		0.01%		4,423.45 km^2
slender crab	8,950 - 27,300	17,900 - 55,000	1997-98		1.07%		5,065.07 km^2
			1998-99		0.08%		3,991.97 km^2

*Notes:

1. Percent ranges are based on mean larval age and maximum larval age, which determines the duration of exposure to entrainment and source water body size. The older the larvae, the longer their exposure to entrainment, the greater the risk of being entrained, and the larger the source water body.
2. ETM Calculations not possible due to large variation in sampling abundance.
3. FH and AEL calculations not possible for species with little or no life history information.

The conversion of larvae to equivalent adult fish could not be calculated (using the Fecundity Hindcasting and Adult Equivalent Loss methods) for several species due to the lack of life history information (as noted above, results using the FH and AEL methods have large statistical errors). These results show that the number of equivalent adults lost due to entrainment of fish larvae for offshore species is relatively small. Northern anchovies were the highest (up to 120,000 adults lost per year). However, this represents a small fraction of the commercial landing for this species. The number of equivalent anchovy adults lost equates to about two metric tons, with a value of approximately $576/yr. The value of Pacific sardines lost to the commercial fishery is about $700/yr. The commercial loss to the rockfish fishery (blue and KGB rockfish complexes combined) is approximately $21,000/year. The dollar values of the other harvested species in terms of commercial landings are generally small. The dollar values given above do not represent ecological value and are provided for reference only. From an ecological perspective, the workgroup considered these losses to be of minor importance, even considering the large statistical errors associated with the AEL and FH methods.

However, the results also show that the amount of larvae lost for nearshore species is relatively high. The larval losses for nearshore taxa cannot be converted into equivalent adults because very little is known about these species. Also, these non-harvested near shore species have no direct dollar value in terms of commercial fisheries, but do have ecological value. For several nearshore species (sculpins, kelpfish, blackeye goby, monkeyface prickleback), the amount of larvae taken by the power plant is large relative to the amount of larvae available in the source water body (large proportional losses).

As shown in Table 1 above, the source water bodies (measured as length of shoreline) were specific to each species. Data to determine the source water bodies were collected as part of each larval sampling survey. For each sample survey period, larval duration periods were determined for each species. Then, using current data collected prior to the sampling survey period, the range of up coast and down coast movement was calculated. This was done by taking the maximum up coast and down coast current vectors measured during each survey period and adding them together to obtain an estimate of the total along shore movement.

There are no additional data that can be used to determine if this larval loss affects nearshore fish populations or communities. Local population trend data for some species are discussed in the 316(b) Demonstration report, however, there are no data from before the power plant came on-line, and no data from control stations. Therefore, there is no way to determine if any trend is natural or caused by some other factor.

PG&E conducted plankton tows in front of the intake structure from 1990 to 1998 (separately from the required entrainment study work). These data show a potential decline in the amount of snubnose sculpin and clinid kelpfish larvae near the intake structure for the sampling period. The potential trend in larval density could also be due to natural variation. No data are available from before the power plant came on-line, and no control station sampling was done, so the data are inconclusive.

Data from the south control station for the thermal effects monitoring program also indicate a possible decline in clinid kelpfish. The number of adult clinid kelpfish counted at the south control station during fish surveys declined between 1976 and the late 1990's. This sampling method does not provide good estimates of small, cryptic fishes, such as clinid kelpfishes. The data for these species are highly variable and their abundance is commonly recorded as zero even though they are most likely always present. However, there are no controls for this data and therefore no way of knowing if the potential decline is natural. These data are inconclusive.

In conclusion, the available data cannot be used to indicate any population declines due to entrainment. However, the relatively large proportional larval losses for nearshore taxa represent an adverse impact because the larval loss itself, regardless of any resulting population or community level affect, is a loss of resources.

PG&E disagrees with Regional Board staff's position. PG&E concludes that given the low entrainment estimates for offshore species, the conservative nature of the higher nearshore estimates, and the limited nature of the population trend data, the entrainment data do not indicate any adverse environmental impact.

There are uncertainties in this entrainment study (and all other entrainment studies) because several assumptions are made in the data analysis, and the sampling results are highly variable. The major assumptions include:

1. That adequate sampling was done to estimate larval densities in the field.
2. That simple ocean current measurements can be used to estimate the size of source water bodies.
3. That 100% of the entrained larvae are killed.

Although there are uncertainties, and the entrainment results should be considered within the context of the uncertainties, the results are the best estimates of the technical workgroup, and are accepted by Regional Board staff.

Since impingement losses are insignificant at DCPP, only technologies that may reduce entrainment are relevant to this analysis. There are two potential ways of addressing entrainment losses:

1. <u>Intake Structure Technologies:</u>
   a. Screening or filtering systems
   b. Changing the intake location

2. <u>Reduced Cooling Water Volume Withdrawal:</u>
   a. Variable speed pumps
   b. Seasonal flow limitations
   c. Closed cooling systems (cooling towers, dry cooling)

The Regional Board's DCPP file (and the Administrative Record) includes several references for this evaluation of alternative technologies, including:

a. PG&E's Assessment of Alternatives to the Existing Cooling Water System, 1982, by Tera Corporation.
b. PG&E's *316(b) Demonstration Report,* March 2000 (hereafter 316(b) Demonstration).
c. Tetra Tech's independent report to the Regional Board, *Evaluation of Cooling System Alternatives, Diablo Canyon Power Plant*, November 2002 (hereafter Tetra Tech 2002). **Included here as Attachment 3.**
d. Tetra Tech's memo to the Regional Board regarding an offshore intake structure. **Included here as Attachment 4.**
e. PG&E 's comments on Tetra Tech 2002, dated September 2002.
f. U.S. EPA information for the new and proposed 316(b) regulations, including U.S. EPA's Phase II Technical Development Document and supporting references.
g. *Preliminary Regulatory Development, Section 316(b) of the Clean Water Act, Background Paper Number 3: Cooling Water Intake Technologies,* 1994 (hereafter Background Paper No. 3). **Included here as Attachment 5.**
h. *Fish Protection at Cooling Water System Intakes: Status Report,* EPRI, 1999 (hereafter EPRI 1999).

i. *Feasibility of Retrofitting Cooling Towers at Diablo Canyon Power Plant Units 1 and 2,* Burns Engineering, April 2003 (hereafter Burns 2003). **Included here as Attachment 6.**
j. PG&E's *Estimation Of Potential Economic Benefits Of Cooling Tower Installation At The Diablo Canyon Power Plant,* April 2003, ASA Analysis & Communication, Inc (hereafter ASA 2003). **Included here as Attachment 7.**
k. Review of the ASA 2003 report by Stratus Consulting, an independent Consultant to the Regional Board (hereafter Stratus 2003). **Included here as Attachment 8.**
l. Review of the ASA 2003 report by Dr. Raimondi (hereafter Raimondi 2003).
m. Other power plant case studies and reports in the record.

Intake Structure Technologies (Screens, Filters)
Intake structure technologies are evaluated in detail in Background Paper No. 3 (Attachment 4 to this testimony). This report was prepared by Science Applications International Corporation (SAIC), an <u>independent consultant</u> to the U.S. EPA. The U.S. EPA suggests that agencies use Background Paper No. 3 when implementing Section 316(b) of the Clean Water Act. Background Paper No. 3 describes all potential intake structure technologies, including ten types of intake screens and five types of passive intake systems.

Background Paper No. 3 includes a description of each technology and corresponding Fact Sheets that describe where the technology is being used (if it is being used), advantages and disadvantages, research findings, and design considerations. The conclusions of Background Paper No. 3 are summarized below.

Regarding intake screen systems Background Paper No. 3 states: "The main finding with regard to intake screen systems is that they are limited in their ability to minimize adverse aquatic impacts." The report also states that "there has also been an interest in the use of fine-mesh mounted on traveling screens for the minimization of entrainment. However, the use of fine-mesh mounted on traveling screens has not been demonstrated as an effective technology for reducing mortality of entrainment losses." This is an important issue. Both once-through cooling <u>and screening technologies</u> cause mortality of organisms. The net benefit of a screening technology must be measured as a reduction in overall mortality. If the screening technology prevents entrainment of larvae and eggs, but simply replaces entrainment mortality with screening induced mortality, there is no benefit. Site-specific and species-specific research must be done to determine their potential effectiveness at a particular power plant.

With respect to passive screens, Background Paper No. 3 concludes: "The main findings for passive intake systems are that available technologies that effectively reduce fish eggs and larvae entrainment are extremely limited." Radial wells and wedgewire screens are the only alternatives considered to have potential for reducing entrainment mortality, but they are not used on large scale systems such as DCPP. Radial wells are literally ground water wells, and are used on small-scale applications, not on facilities like DCPP Units 1 and 2, which require a total cooling capacity of 2,500 million gallons per day (mgd). Wedgewire screens are also limited in their application, as discussed later in this report.

A comprehensive review of intake technologies is also provided in EPRI 1999. EPRI is the Electric Power Research Institute, Inc., of Palo Alto, California. Utility companies fund EPRI, which in turn sponsors research on utility industry issues. The conclusions of EPRI 1999 are similar to the conclusions of Background Paper No. 3, that is, more research is needed on the various intake structure technologies before their applicability can be determined.

Tetra Tech 2002 (Attachment 3) illustrates that fine mesh screens have been used at other facilities with varying degrees of success (see also 316(b) Demonstration, EPRI 1999, and Background Paper No. 3). However, fine mesh screens have not been used at a facility similar to DCPP.

Staff concurs with the conclusions of Background Paper No. 3. The data collected on intake technologies to date are limited, highly variable, site-specific, and species-specific. The only technologies that <u>may</u> apply to DCPP for the purpose of reducing entrainment mortality are certain screening technologies, such as fine mesh screens, but they are considered experimental. A major problem with fine mesh screens is biofouling and mortality of larvae that are impinged on the screen. It is also difficult to determine the survivability of larvae that are impinged and then washed off the screens. Tetra Tech reports that survival rates for impinged larvae varies greatly based on studies at other facilities. The 316(b) demonstration report also provides highly variable survivability (or mortality) results from studies done at other facilities. The only way to determine the effectiveness of a screening technology at DCPP is to conduct site-specific research, with independent scientific experts overseeing all aspects of the work. Such research would likely take years to complete, and the total costs are unknown. Therefore, fine mesh screens are not a demonstrated "available" technology for DCPP. Tetra Tech estimates the total cost of installing fine mesh screens at DCPP at $650 million. The major component of this cost is the power plant downtime necessary to install the screens.

Filter Technology: Tetra Tech 2002 concludes that an aquatic filter-barrier is not feasible at DCPP due to the massive size of the filter that would be needed, the ocean conditions at the site, and the experimental nature of the technology. A filter area of approximately 160,000 square feet would be needed, which would be 8,000 feet long by 20 feet deep. Such a system could not be installed in a highly dynamic ocean environment, and has never been used in a setting like that at DCPP or for a facility of this size. The aquatic filter barrier is therefore not available for DCPP.

Screening and filtering technologies are experimental at this time, and there are no known applications of these technologies at facilities similar to DCPP.

Intake Structure Location

Changing the vertical location of the intake structure in the water column is not possible at Diablo Canyon. The intake structure is located in Intake Cove, a relatively shallow (about 35 feet) cove constructed to protect the intake structure from wave and debris. The size of the intake opening takes up most of the vertical depth of the cove.

The potential benefit of moving the location of the intake structure offshore would be to decrease the larval losses for nearshore species. The disadvantage would be greater impingement and entrainment of offshore species, including groundfish species, whose populations are in decline along the west coast. The DCPP intake structure currently impinges an insignificant number of fish per year (a few hundred fish per a year). For comparison, as noted above, the Huntington Beach Power Plant, with flow volumes about one fourth the flow volumes of DCPP, and with an offshore intake structure, impinges up to 21 tons of fish per year. The El Segundo Power Plant, also with flow volumes about one fourth DCPP flows and using an offshore intake, impinges about 15 tons of fish per year. Both of the offshore intakes noted above are about 2000 feet offshore in about 35 feet of water. This information is from documents filed with the Energy Commission by the utility companies. It should be noted that fish return systems are available, such as the system used at the San Onofre Nuclear Generating Station (SONGS). The overall efficiency of the SONGS fish return system is about 68%, making that offshore intake structure more favorable.

However, entrainment of larvae cannot be reduced in an offshore intake system. Some of the offshore taxa that would be impinged and entrained in an offshore intake at DCPP are currently heavily impacted to the point of near collapse. The National Marine Fisheries Service and California Department of Fish and Game recently implemented emergency "no-take" measures for certain species of groundfish, which may apply to an offshore intake structure. Therefore, an offshore intake would simply move the impacts offshore. In addition, the physical construction of an offshore intake system would cause major impacts on a significant amount of marine habitat, including an area of one-hundred feet wide by thousands of feet in length, through the intertidal zone and subtidal kelp beds (Tetra Tech 2002).

Tetra Tech, the Regional Board's independent consultant regarding cooling water alternatives at DCPP, estimates the cost of an offshore intake system at $300 to $455 million, which does not include preparing the ocean floor for construction or other contingencies that could only be determined by a comprehensive assessment of this alternative (Tetra Tech, 2002). Further, an offshore intake structure may not be possible at DCPP due to the steep offshore slope and rocky subtidal habitat. Staff's review of the available information on power plant projects revealed no information that there are any offshore intake structures in an environment such as that found at DCPP. Offshore intakes (or discharges) are typically found where there is a gentle offshore slope in a sandy bottom environment.

In conclusion, an offshore intake structure would not provide an environmental benefit, is not a demonstrated available alternative for a facility like DCPP, and would cost a minimum of $300 to $455 million. Therefore, this alternative cannot be considered available, feasible, or beneficial at DCPP.

<u>Reduced Cooling Water Volume Withdrawal</u>

Variable Speed Pumps: In theory**,** variable speed pumps may reduce entrainment rates in some cases by decreasing cooling water flows relative to fixed speed pumps. DCPP is a nuclear power plant and is designed to operate as a base load facility with minimal changes in power output over long periods of time (316(b) Demonstration). Accordingly, variable speed pumps are not applicable to DCPP, and independent cost estimates are not available. PG&E's 316(b) Demonstration report estimates that the maximum possible benefit of variable speed pumps would be to reduce cooling water flows by 2 to 10%, and estimates the cost of installing variable speed pumps at $6.7 million. However, this cost estimate does not include the cost of power plant shut down time, which would be in the hundreds of millions of dollars. The existing pumps are embedded in the concrete of the intake structure, so replacement of the pumps would be a major construction project (as with fine mesh screen installation). This alternative would offer little or no benefit, and the costs due to power plant down time are very high. Therefore this alternative is not reasonable at DCPP.

Seasonal Flow Limitations: Seasonal flow limitations are applicable in cases where one or more particularly important species (such as endangered or threatened species) are being entrained during specific times of the year. This is not the case at DCPP, where no threatened or endangered species were identified in the entrainment sampling program (316(b) Demonstration). At DCPP, larvae are available and entrained throughout different seasons, and seasonal flow limits would require choosing some species over others for protection. This alternative is not recommended at DCPP as there is no practical way to choose certain taxa as being more important than others unless there are threatened or endangered species present. The cost (lost revenue) of seasonal flow restrictions depends on the duration and magnitude of the seasonal limitation and energy prices. The costs could range into the hundreds of millions per year depending on these factors.

Tetra Tech 2002 included total revenue estimates for DCPP. Based on estimated revenue of $900,000 per Unit per day, annual revenue is estimated at $657 million at DCPP. Therefore, any significant reduction in cooling water flows (such as 20% annual reduction) will result in a cost in the hundred million-dollar per year range. As noted above, there is no biological argument for seasonal flow limitations based on the species entrained. Therefore, this alternative is not reasonable at DCPP.

Closed Cooling Systems

Closed cooling systems are of two main types: wet and dry. Wet cooling systems recirculate fresh or saltwater through towers. Make-up water is needed to replace losses due to evaporation. Dry cooling systems recirculate fresh water in a truly closed system (like the radiator in an automobile); no evaporation occurs and therefore no makeup water is needed. These systems follow the general hierarchy below:

<u>Closed Cooling Systems</u>

- I. Wet Cooling (saltwater or freshwater)
    - a. Mechanical Draft Cooling Towers
    - b. Natural Draft Cooling Towers
- II. Dry Cooling
    - a. Air Condensers
- III. Hybrid Cooling (saltwater or freshwater)
    - a. Mechanical Draft Towers and Air Condensers Combined

Availability of Wet Cooling Systems

In a mechanical draft system, heated water from the power plant is pumped to the top of cooling towers where it is then sprayed downward inside the tower. Air is forced upward through the tower by large fans (this makes them "mechanical draft"). The forced air transmits heat from the water to the atmosphere. The cooled water collects at the bottom of the tower where it is recirculated back to the power plant. Some water is lost to evaporation, and "make-up" water is needed to keep the volume constant. Mechanical draft cooling towers can be designed to handle all or part of the cooling load. Mechanical draft towers using <u>freshwater</u> are the most common cooling systems, and are being installed on the majority of new non-nuclear power plants in California (California Energy Commission 2002). All of the newly constructed and planned power plants in California use natural gas to generate electricity. No nuclear power plants are planned.

Mechanical draft towers using freshwater could theoretically reduce cooling water withdrawal from the Pacific Ocean to zero. However, fresh water cooling towers at DCPP would require approximately 50,000 gallons per minute, or 72 million gallons per day of fresh water to replace the water evaporated in the cooling towers (make-up water). This quantity of fresh water is not available at DCPP or anywhere in the vicinity. Conceptually, a desalination system could be constructed to provide the necessary fresh water supply. However, sufficient ocean water or brackish ground water would have to be withdrawn in a volume sufficient to provide 72 million gallons per day of fresh water after desalinization (on the order of 150 MGD). A desal system using ocean water would have it's own entrainment issues. Additionally, the cost of cooling towers alone, without a massive desalination system, is in the billion dollar range (see estimate below for saltwater cooling towers). Finally, it is unlikely that there is enough space available at DCPP to build both a very large desalination facility and the very large mechanical draft cooling system (Tetra Tech 2002). The surrounding land is in the Coastal Zone and is zoned for agricultural use. Burns 2003 maintains that there is not enough available space around DCPP to build the mechanical draft cooling towers alone, without the desalination facility.

Mechanical draft towers that use saltwater could reduce cooling water withdrawals by up to about 95%. Tetra Tech estimates 132 towers would be required @ 60 ft wide x 60 ft long x 65 ft high. Tetra Tech estimates the total net present value of costs for this system to be $1.3 billion. This cost includes revenue losses for a shut down period of six months (which could be significantly longer). Burns 2003 states that the minimum downtime for DCPP would be one year, which would result in significantly higher costs than estimated by Tetra Tech 2002. There are significant issues associated with retrofitting DCPP with cooling towers, including available space, relocation of existing structures and utilities to another location (which may not be possible), rezoning, and permitting by other agencies. The cooling towers would have to be located where the parking lot, service road, and large warehouse (475 ft x 207 ft) are currently located. There does not appear to be adequate space within the industrial zoned area to relocate these facilities, thus requiring rezoning of nearby land and approval by various permitting agencies. In addition, no facility of this size has ever been retrofitted with a closed cooling system. The cost estimate of $1.3 billion should be considered within the context of the project, which is conceptual, unprecedented, and highly complex. The costs could therefore be significantly higher than the estimate presented by Tetra Tech, and the retrofit may not be physically possible. Accordingly, retrofitting DCPP with salt water cooling towers is a conceptual option only, with unknown actual costs.

Tetra Tech also considered natural draft cooling towers. This system would require 10 towers, 200 feet in diameter by 450 feet in height. The total cost would be over $2 billion when lost revenue due to down time is considered. Further, the performance of a natural-draft cooling tower is dependent on relative humidity. In the vicinity of the DCPP, the relative humidity falls below 68 percent about 10 percent of the time (when the wet bulb temperature is 61°F). When this occurs, tower performance will be reduced and plant efficiency will be further impacted. The visual impacts of ten 450-foot high towers would also be significant. Further, the seismic zoning at DCPP precludes the construction of such tall structures (Tetra Tech, 2002). Accordingly, natural draft cooling towers are not available at DCPP.

Availability of Dry Cooling Systems

Dry cooling technology is similar to the cooling system in an automobile. Heated water is pumped from the power plant to a large external "'radiator" or condenser. Large fans force air over the condensers and heat is thereby transferred from the condenser to the atmosphere. Dry cooling systems can be totally closed, requiring no make-up water. U.S. EPA has found that dry cooling is not "best technology available" for new power plants on a national basis but might be feasible in limited cases based on site-specific circumstances (66 Fed. Reg. p. 65305, col. 3; U.S. EPA has tentatively made the same determination for existing power plants 67 Fed. Reg. p. 17168). In California and elsewhere, dry cooling is used where fresh water supplies are very limited. No nuclear power plants have been retrofitted with dry cooling systems.

Tetra Tech concluded that dry cooling is not an available alternative at DCPP. Tetra Tech determined that eight air-cooled condensing systems would be required, each occupying an area of 316 feet by 197 feet with an overall height of 119 feet. Each condenser would use forty, 150 hp fans; and the resulting turbine back pressure would be in the range of 3.5 to 4 inches HgA, considerably higher than DCPP's design value of 1.5 inches HgA. GEA Energy Technology Division, a leading designer of dry cooling systems, maintains that the length of duct from a power plant to an air-cooled condenser should be limited to a distance less than or equal to 200 feet. It is not physically possible to place eight very large dry cooling units within 200 feet of DCPP. At DCPP, duct lengths of 500 to 1000 feet would be required. Since these specifications for dry cooling cannot be met at DCPP, Tetra Tech did not provide costs estimates for this system. However, the U.S. EPA estimates that dry cooling systems cost approximately three times more than wet cooling systems, which would result in a cost of several billion dollars at DCPP. Therefore, dry cooling is not an available alternative at DCPP.

Availability of Hybrid Systems
Hybrid systems are simply a combination of dry and wet cooling technologies. The proportion of cooling assigned to each technology depends on site-specific conditions, such as the amount of make-up water available. A hybrid system that uses both dry cooling and fresh water mechanical draft towers would reduce cooling water withdrawals to zero. A hybrid system that uses dry cooling and saltwater mechanical draft towers could reduce cooling water flows by 95% or greater. However, hybrid systems use the same technologies discussed above (wet and dry systems), and therefore are not currently available at DCPP for the reasons noted above. The same issues apply to a hybrid system: lack of available space, unproven applicability at a site like DCPP, lack of fresh water, and extreme costs.

Other Cooling Technology

Cooling Ponds: There are two types of cooling ponds: "passive" and "spray." These systems are not available at DCPP because of the massive size needed. The ponds would have to be thousands of acres in size to provide the cooling capacity needed at DCPP (PG&E's 316(b) Demonstration Report, 2000).

Wholly Disproportionate Cost Test

Legal Background
U.S. EPA interpretations of Section 316(b) have consistently implemented a "wholly disproportionate" cost test as established in a 1977 Decision of the Administrator. (*Public Service Company of New Hampshire, et al. Seabrook Station, Units 1 and 2*, (June 10, 1977 Decision of the Administrator) Case No. 76-7, 1977 WL 22370 (E.P.A.) "*Seabrook I*.") In *Seabrook I*, the U.S. EPA Administrator ruled that U.S. EPA was not required to perform a cost/benefit analyses when applying Section 316(b) on a case-by-case basis. However, the Administrator reasoned that cost must be considered otherwise "the effect would be to require cooling towers at every plant that could afford to install them, regardless of whether or not any significant degree of entrainment or entrapment was anticipated." (*Id*. pp. 6-7.) The Administrator ruled "I do not believe it is reasonable to interpret Section 316(b) as requiring use of technology whose cost is wholly disproportionate to the environmental benefit to be gained." The "wholly disproportionate" test was affirmed by the Federal First Circuit Court of Appeals in *Seacoast Anti-Pollution League v. Costle* (1st Cir. 1979) 597 F.2d 306.)1

The First Circuit Court clarified the "wholly disproportionate test" was one of incremental cost. The Court stated: "[t]he Administrator decided that moving the intake further offshore might further minimize the entrainment of some plankton, but only slightly, and that the costs would be 'wholly disproportionate to any environmental benefit'." (*Id*. at 311.) The wholly disproportionate test has continued to be used by U.S. EPA when applying Section 316(b) since the *Seabrook I* decision. It does not appear in the 1977 Draft Guidance because that document was issued in May 1977 before the *Seabrook I* ruling.

While U.S. EPA has continued to use the wholly disproportionate test, there does not seem to be any consistency in how the test is used. In *Seabrook I*, the Administrator considered various construction/design

1. *Seabrook I* was appealed and remanded based on some procedural issues. (*Seacoast Anti-Polution League* v. *Costle*, 572 F.2d 872.) On remand, the Administrator cured the procedural flaws and readopted all the findings in *Seabrook I*. (*Public Service Co. of New Hampshire, et al.* v. *Seabrook Station Units 1 and 2* (August 4, 1978 Decision of Administrator.) The Court of Appeal in *Seacoast Anti-Pollution League* v. *Costle,* 597 F.2d 306, cited in text above, affirmed the Administrator's decision on remand.

alternatives and the alternative to locate the intake offshore. Concluding that these alternatives would provide minimal environmental benefit, the Administrator rejected them. The First Circuit Court of Appeals affirmed that the cost of the offshore outfall location was wholly disproportionate to this minor additional minimization of entrainment.

When U.S. EPA drafted the New Plant Final Rule, it determined that closed-cycle cooling was best technology available for all new facilities but provided for site-based alternatives justified by use of alternative technologies and restoration projects. (66 Fed. Reg. 65314, cols. 2-3; 65315 cols. 1-2.). Nonetheless, the New Plant Final Rule preserves a form of the wholly disproportionate test. It provides that if the discharger demonstrates that facility-specific data shows the cost of compliance would be wholly disproportionate with costs considered by U.S. EPA when establishing a compliance requirement, a less costly alternative may be permitted. (40 C.F.R. § 125.85(a).)

Application of the Wholly Disproportionate Test to DCPP

A wholly disproportionate cost test compares the cost of technology alternatives to the benefit to be gained by implementing alternatives. The U.S. EPA provides information on entrainment valuation methods in their supporting documentation for the proposed 316(b) rule for existing facilities. The valuation methods basically attempt to put a dollar value on entrainment losses. U.S. EPA acknowledges that this is a difficult process because there are few actual values, such as commercial fishing values, associated with entrained larvae. Assumptions must therefore be made about larval losses with no associated economic value.

PG&E submitted a report titled *Estimation Of Potential Economic Benefits Of Cooling Tower Installation At The Diablo Canyon Power Plant,* April 2003, ASA Analysis & Communication, Inc (hereafter ASA 2003). The report discusses four categories of benefits: market benefits, nonmarket direct use benefits, indirect use benefits, and nonuse benefits. Benefits were estimated according to methods used by the EPA in its benefits case studies for the proposed Phase II rulemaking under § 316(b) of the Clean Water Act (see Chapters A5, A9, and A10 of Part A of the Case Study Document available at: http://www.epa.gov/waterscience/316b/casestudy/).

ASA 2003 estimates that the total annual benefit expected due to implementing cooling towers at DCPP would range from $1,755 to $110,647 per year. To estimate the Net Present Value of the series of annual benefits ASA 2003 assumed that the cooling towers would not be in operation until 2008 (due to design, permitting, construction, and tie-in). ASA 2003 assumed the use of cooling towers would end in 2023, the mean year of license expiration for the two DCPP units. For purposes of bounding the expected benefits, discount rates of 2 percent (applied to upper bound values) and 7 percent (applied to lower bound values) were used.

Under these assumptions, ASA 2003 estimated the Net Present Value of expected benefits to the target species from implementing closed cycle cooling at DCPP would range from $11,045 to $1,334,030. Since the target species represent approximately 70 percent of the total entrainment of fish larvae, ASA 2003 assumed that the overall economic benefits could be estimated by dividing by 0.7 and, thus, range from $15,786 to $1,905,757.

The Regional Board's independent consultant regarding entrainment valuation, Stratus Consulting Inc., reviewed the ASA 2003 report and concluded that in general, ASA 2003 may significantly underestimate the actual value of entrainment losses because most of the entrained taxa are not accounted for in the analysis (Stratus 2003). The Regional Board's independent scientists agree. Dr. Raimondi's review of ASA 2003 indicates that the larval losses could be valued in the ten million dollar range, depending on the assumptions made. Stratus 2003 also states that the Habitat Recovery Cost (HRC) method could also be used to estimate the entrainment value losses, which would result in a much higher valuation for the losses. The HRC method estimates the cost of creating or restoring habitat that would produce the losses caused by entrainment. Stratus notes the HRC approach is not true benefit "valuation" method, and therefore cannot be taken as a measure of economic benefits. However, Stratus states that the HRC method can be used in a policy context or in permit negotiations as a point of reference for evaluating technology costs. Staff acknowledges this potential approach, but notes that no habitat restoration work appears to be viable for the DCPP area. However, the Department of Fish and Game is currently implementing a process to establish marine reserves throughout California, which, based on empirical evidence, would provide major benefits to marine life, including substantial increases in larval productivity. The Regional Board could direct funds from the approved Consent Judgment to support this effort, which would help offset entrainment losses.

This Net Present Value of entrainment losses as estimated by ASA 2003 ($15,786 to $1,905,757) or the higher estimate by Raimondi 2003 (ten million dollar range) can be compared to the cost of salt water cooling towers. Tetra Tech 2002 estimated the Net Present Value of saltwater cooling towers at $1.3 billion. Using these values, the cost of cooling towers is wholly disproportionate to benefit to be gained.

The only other potential technology for reducing entrainment at DCPP is fine mesh screening. If for the purpose of analysis fine mesh screens are assumed to be as effective as cooling towers at reducing entrainment, which is highly unlikely based on the limited data available from the references noted above, then the same economic benefit as above can assumed. That is, a Net Present Value of $15,786 to $1,905,757, or up to the ten million dollar range, for the resulting benefits of fine mesh screens can be compared to the Net Present Value of the cost of the screens, which is $650 million based on Tetra Tech 2002. Using these values, the minimum cost of this experimental technology is wholly disproportionate to the benefit to be gained.

Staff realizes that the estimated value of reduced entrainment (the benefit) is subject to qualitative evaluation and there are uncertainties involved in the methodology. However, even if the higher Net Present Value of the benefits is used (the ten million dollar range) the costs of technologies would still be wholly disproportionate to the benefits to be gained.

OTHER INFORMATION

The proposed Order differs from the existing Order in the following ways:

1. The proposed Order only includes discharges to the Ocean. Non-ocean discharges will be covered by the General Stormwater permit or other discharge permits as appropriate to better assure protection of beneficial uses.
2. The proposed Order has new effluent limits as required by the current Ocean Plan, including effluent limits for several additional constituents.
3. The proposed Order has revised narrative limitations pursuant to the current Ocean Plan.
4. The narrative requirement for toxicity testing has been revised to require sampling when toxicity is most likely to be present per plant operating conditions chemical uses.
5. PG&E must perform toxicity testing on any new chemicals added to the discharge to assure compliance with the effluent toxicity limitations.

CONCLUSION

Considering the major issues with power plant modifications and operational changes, staff and the Attorney General's office negotiated a settlement with PG&E, which is defined in the approved Consent Judgment attached to the proposed Order. The Consent Judgment provides permanent protection for 5.7 miles of near shore marine habitat, funding for projects to enhance and protect marine resources, and other benefits as stated in the Consent Judgment and the proposed Order, if the Regional Board adopts the permit. If the Board does not approve the permit, the Consent Judgment is invalidated. Based on economic or ecological valuation, and Clean Water Act Section 316(b), staff believes the Consent Judgment is a reasonable settlement for the impacts caused by the once-through cooling water system at the Diablo Canyon Power Plant. There are other issues with respect to the proposed Order, such as applicable laws, regulations, and policies. These are addressed in staff's Fact Sheet for this agenda item (Attachment 9).

RECOMMENDATION

Adoption of proposed Order No. R3-2003-0009, and Monitoring and Reporting Program No. R3-2003-0009

ATTACHMENTS

1. Bathymetry map of DCPP vicinity.
2. Memo from Tetra Tech to the Regional Board regarding an offshore discharge structure, dated December 4, 2002.

3. Tetra Tech's independent report to the Regional Board, *Evaluation of Cooling System Alternatives, Diablo Canyon Power Plant*, November 2002.
4. Memo from Tetra Tech to the Regional Board regarding an offshore intake structure, dated November 25, 2002.
5. *Preliminary Regulatory Development, Section 316(b) of the Clean Water Act, Background Paper Number 3: Cooling Water Intake Technologies,* 1994.
6. *Feasibility of Retrofitting Cooling Towers at Diablo Canyon Power Plant Units 1 and 2,* Burns Engineering, April 2003.
7. *Estimation Of Potential Economic Benefits Of Cooling Tower Installation At The Diablo Canyon Power Plant,* April 2003, ASA Analysis & Communication, Inc.
8. Review of the ASA 2003 report by Stratus Consulting, an independent Consultant to the Regional Board (hereafter Stratus 2003).
9. Fact Sheet for proposed Order No. R3-2003-0009

References used by staff during the permit process for DCPP, which are part of the record (some references are listed in the text above):

1. U.S. EPA 316(b) Phase II Technical Development Document for New Facilities, including all Chapters, Appendices, and supporting documentation, 2001.

2. U.S. EPA 316(b) Phase II Technical Development Document for Existing Facilities, including all Chapters, Appendices, and supporting documentation, 2003.

3. PG&E's *Thermal Effects Monitoring Program Analysis Report, Chapter 1: Changes in the Marine Environment Resulting from the Diablo Canyon Power Plant Discharge,* December 1997.

4. PG&E's *Receiving Water Monitoring Program: 1995-2002 Analysis Report,* November 2002.

5. *Moss Landing Power Plant Modernization Project 316b Resource Assessment,* Duke Energy, April 2000.

6. *Evaluation of Cooling System Alternatives, Proposed Morro Bay Power Plant*, Tetra Tech, May 2002.

7. *Morro Bay Modernization Project 316(b) Resource Assessment*, Duke Energy, 2001.

8. *Application for Certification, Moss Landing Power Plant Modernization Project. Application to the Energy Commission*.

9. U.S. EPA *Guidance for Evaluating the Adverse impact of Cooling Water Intake Structures on the Aquatic Environment*, 1977. Discusses Section 316b requirements, study design, the degree of impact, etc.

10. U.S. EPA *Guidance for Determining Best Technology Available for the Location, Design, Construction, and Capacity of Cooling Water Intake Structures for Minimizing Adverse Environmental Impact*, April 1976.

11. *Impact on the Steam Electric Power Industry of Deleting Section 316a of the Clean Water Act: Capital Costs;* Veil, J.A.; Argonne National Laboratory, 1993.

12. PG&E's *Moss Landing Power Plant Cooling Water Intake Structures 316b Demonstration*; Ecological Analysts, Inc; 1983. The original 316b report for Moss Landing Power Plant.

13. PG&E's *Assessment of Alternatives to the Existing Cooling Water System,* 1982, by Tera Corporation, for the Diablo Canyon Power Plant. Analyzes cooling system alternatives and cost estimates.

14. California Coastal Commission's *Adopted Coastal Commission Resolution to Further Condition Permit No. 183-73, San Onofre Nuclear Generating Station Units 2 and 3*, June 28, 1991. Discusses cooling system impacts, costs of alternatives, and why mitigation was chosen over closed cooling.

15. California Coastal Commission's *Staff Recommendation: Permit Application and Condition Compliance,* regarding SONGS. Discusses power plant impacts and mitigation costs.

16. *Fish Protection at Cooling Water Intakes,* Status Report; EPRI, 1999. Discusses the status of many fish protection systems.

17. Proceedings from EPRI's *Power Generation Impacts on Aquatic Resources Conference*. 1999. Many papers on all aspects of the CWA 316b process. Technology, biological studies, mitigation, etc.

18. *The Quick and the Dead: Fish Entrainment, Entrapment, and the Implementation and Application of Section 316b of the Clean Water Act*; May, James, R; Vermont Law Review, 1995. Discusses history of CWA 316b, application and results at several facilities, with some discussion of costs. Illustrates the many wide ranging solutions agreed to by agencies and utilities.

19. State of New Jersey's NJPDES/DSW Permit No. NJ0005622, PSE&G Salem Nuclear Generating Station. Discussion of legal basis for considering costs of cooling alternatives, recommended mitigation, responses to comments.

20. Section 8 of a report by the Marine Review Committee to the Coastal Commission regarding SONGS: *Potential Corrective Measures.* Considers closed cooling, moving the discharge, costs, mitigation. Recommends rejection of closed cooling and adoption of mitigation measures. Note that approved mitigation at SONGS does not "mitigate" entrainment impacts.

21. U.S. EPA hired SAIC to produce three documents: *Preliminary Regulatory Development, Section 316b of the Clean Water Act*, 1994:

    Background Paper Number 1: *Legislative, Regulatory, and Legal History of Section 316b and Information on Federal and State Implementation of Cooling Water Intake Structure Technology Requirements.*

    Background Paper Number 2: *Cooling Water Use for Selected United States Industries.*

    Background paper Number 3: *Cooling Water Intake Technologies.*

22. U.S. EPA Record of Decision on Tampa Electric Company Big Bend Unit 4, NPDES Permit No. FL0037044. 1982. Discusses impacts, and alternatives.

23. U.S. EPA NPDES Permit Nos. FL000680 and FL001473, Indian River Power Plant and Cape Canaveral Power Plant. 1983. Discusses impacts and alternatives. Allows significant entrainment and impingement impacts because other alternatives would present different impacts, and the Florida manatee benefits from the thermal discharge.

24. U.S. EPA Advanced Permit Writer's Course, Presentation Materials. June 1995. Discusses 316b, policy, intent, implementation, permitting procedures, alternatives, etc.

25. U.S. EPA NPDES Permit No. FL000817, Tampa Electric Company. Discusses entrainment impacts and solutions. 1981.

26. U.S. EPA Determination Regarding Issuance of Proposed NPDES Permit No. MA0025135 for Boston Edison Company's Pilgrim Power Plant. Discusses 316b process, impacts, alternatives, resolution. 1977.

27. Hudson River Settlement Agreement: Technical Rational and Cost Considerations; Barnthouse, Lawrence, et al.; American Fisheries Society Monograph, 1988. Discusses entrainment impacts, interpretations, alternatives, resolution.

28. State of New Jersey, Department of Environmental Protection and Energy, letter dated January 31, 1994, regarding PSE&G Salem Nuclear Generation Station, NPDES Draft Permit No. NJ0005622. Several attachments. Discusses alternatives analysis, costs, and "wholly disproportionate" test.

29. State of New Jersey, Department of Environmental Protection and Energy, Fact Sheet for NPDES Permit No. NJ0005622, 1993. As above.

30. State of New Jersey, Department of Environmental Protection and Energy, final NPDES Permit No. NJ0005622. 1994. As above.

<u>Biology:</u>

31. *Improvement of Environmental Impact Analysis by Application of Principles Derived from Manipulative Ecology: Lessons from Coastal Marine Histories*; Peterson, C.H.; Australian Journal of Ecology; 1992. Discusses studies of marine impacts, resolutions, regulatory process, with emphasis on how to do better. Excellent paper

32. *Detecting Ecological Impacts: Concepts and Applications in Coastal Habitats.* Schmitt and Osenberg, ed; 1996. Discusses monitoring, studies, ability to detect impacts, mitigation, biological impact predictions versus actual impacts.

33. *Relative Contributions of Hudson River and Chesapeake Bay Striped Bass Stocks to the Atlantic Coastal Population*; Van Winkle, W.; American Fisheries Society Monograph, 1988.

34. *Science in the Courtroom*; Yost, Thomas; American Fisheries Society Monograph, 1988. Discusses scientific arguments about entrainment impacts that occurred in the courtroom regarding Hudson River, including compensation. Suggests ways to improve the overall process.

35. *Comparison of Trends in the Finfish Assemblage of Mount Hope Bay and Narragansett in Relation to Operations at the New England Power Brayton Point Station;* Gibson, Mark; Rhode Island Division of Fish and Wildlife, 1996. Several comment letters also included.

36. California Coastal Commission, *Procedural Guidance for Evaluation of Wetland Mitigation Projects in California's Coastal Zone*, 1995.

<u>Additional Documents in the Record:</u>

37. Curriculum Vitae, Greg Cailliet, Ph.D., Moss Landing Marine Laboratories.

38. Curriculum Vitae, Pete Raimondi, Ph.D., UC Santa Cruz.

39. Curriculum Vitae, Michael Foster, Ph.D., Moss Landing Marine Labs.

40. Curriculum Vitae, David Schiel, Ph.D., University of Canterbury.

41. All correspondence, monitoring reports, engineering reports, and miscellaneous documents in the Regional Board file for DCPP.