HDR

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Re: Technical Memorandum: Comparison between Onshore Traveling Water Screens and Offshore Cylindrical Wedgewire Screens for the Huntington Beach Desalination Plant

Introduction

Poseidon's proposed Huntington Beach Desalination Plant (HBDP) has undergone an intake and discharge feasibility analysis. The study evaluated the schedule (timing), technical, economic, environmental, and social aspects of the project to determine the best available intake and discharge technologies for minimizing the intake and mortality of all forms of marine life consistent with the requirements of CWC Section 13142.5(b). Relative to the intake technologies available for the HBDP, since the previous Independent Scientific Technical Advisory Panel (ISTAP) review deemed subsurface intakes infeasible for the site, the feasibility study focused only on surface intake technologies. The two principal intake technologies available for the HBDP are offshore cylindrical wedgewire screens (WWS) to replace the existing velocity cap or onshore modified traveling water screens (TWS) with the existing velocity cap left in place.

The State Water Resources Control Board (SWRCB) issued a final staff report addressing seawater desalination referred to as the Substitute Environmental Documentation (SED). The SED was prepared in support of an amendment to the Water Quality Control Plan for Ocean Waters of California (Ocean Plan) to address desalination facility intakes, brine discharges, and incorporate other non-substantive changes. The SED was intended to present the Desalination Amendment (hereafter referred to as the Ocean Plan Amendment, OPA) as well as the basis for and rationale applied in the development and analysis of the amendment, and other alternatives considered in accordance with the California Water Code (Water Code) and California Environmental Quality Act (CEQA).

Section 8.3 of the SED presents the information considered by SWRCB staff members relative to the seawater intake technologies and designs that are available for minimizing the intake and mortality of all forms of marine life. This technical memorandum (memo) is provided to evaluate, in the context of the information provided in the SED, the advantages and disadvantages of each of the surface intake technologies under consideration for the HBDP. The memo is structured on the framework provided in Section 8.3 (regarding the preferred method of seawater intake) of the SED and makes use of the definition of "feasible" provided in the Coastal Act and the Desalination Amendment: "*capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, social, and technological factors*".

Comparisons are made between offshore WWS and onshore TWS in the section below and in Table 1 and Table 2

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Comparison

Section 8.3.1.1.1 – Construction-related Mortality

There are greater construction-related impacts to the marine environment associated with the installation of the offshore WWS design. During construction a barge would be moored offshore at the worksite, limiting access to the site for other purposes. Installation of the WWS supports would disrupt the seafloor sediments. Conversely, the TWS design would require only minimal offshore work to modify the velocity cap and to install the fish return system.

The presence of the existing intake pipeline presents an opportunity to avoid construction-related impacts since it already exists as a component of the AES Huntington Beach Generating Station (HBGS) cooling water intake system.

Section 8.3.1.1.2 – Operational Impacts

As stated in this section of the SED, operational impacts are divided into impingement and entrainment:

> *In addition to construction-related mortality, intake and mortality of marine life occurs through two primary mechanisms. Organisms may become trapped against surface water intake screens by the suction power of the surface water intakes, referred to as impingement. Smaller organisms in the water column such as algae, plankton, fish larvae, and eggs, that pass through surface water intake screens are drawn into the facility and will perish when exposed to the high pressure and heat of a cooling water or desalination system. This process is referred to as entrainment.*

The 1-mm TWS and 1-mm WWS designs would both have through-screen velocities of 0.5 ft/sec or less meeting the goals of the Ocean Plan. The two designs would have comparable entrainment impacts. However, since there is a possibility that the organisms may be entrapped (caught in the intake system between the velocity cap and the onshore TWS) in the TWS design, and not returned to the ocean through the fish return system, the impingement impacts of the TWS may be greater.

Section 8.3.1.2.1 – Reducing Intake Flow Volume

The SED identifies three uses for withdrawn seawater:

> *to serve as source water, backwash water for the pretreatment system, and to dilute brine wastes and other effluent generated*

The withdrawn flow at the HBDP will be used as source water (feedwater) for the reverse osmosis process and as backwash water; no additional flow will be withdrawn for diluting the brine (flow augmentation).

Of the two intake technologies under consideration, the WWS design requires slightly less intake flow and would therefore have less of an entrainment footprint; the WWS design requires 16.9 acres of APF and the TWS design requires at least 17.1 acres. The slightly higher intake flow for the onshore TWS is required for the screen spraywash system and to provide flow in the fish return system.

Section 8.3.1.2.2 – Reducing Through-Screen Intake Flow Velocity

Each intake technology is designed to meet the OPA's through-screen velocity requirement of 0.5 ft/sec at 15% blocked. However, the through-screen velocity present offshore with the WWS design would be challenged by the ambient currents (e.g., waves, tidal currents) while the through-screen velocity present at the onshore TWS would be the single dominant vector. The offshore WWS location potentially provides a hydrodynamic benefit since the likelihood of all flow vectors being normal to the screen face is low (i.e., ambient hydrodynamics may aid exclusion).

Section 8.3.1.2.3 – Installing Intake Screens

This section of the SED has a broad focus and includes consideration of mesh/slot size, screen cleaning approaches, and biological performance of the two intake technologies.

Traveling Screens (rotating vertical, modified vertical, inclined)

Relative to TWS, the SED provides references supporting the conclusion that TWS modified with fish-friendly features can substantially reduce impingement mortality:

> *The screen operates continuously to keep impingement time relatively short consequently modified traveling screens have been shown to substantially reduce impingement mortality. (U.S. EPA 2009; U.S. EPA 2011) The Dominion Power's Surry Station uses Ristroph screens with a fish wash and return system. Data from the facility showed increased fish survival rates following impingement through use of the wash system and that the impinged fish had a 93.8 percent survival rate, although mortality varied by species. (EPRI 1999) Other generating stations (e.g. Coarse bar screens, floating booms, and angled coarse screens.) have employed the use of Ristroph screens with similar reports of reductions in fish losses due to impingement. (Taft 2000)*

In addition, the SED provides support for the use of fine-mesh TWS for reducing entrainment:

> *US EPA Region IV and the Florida Department of Environmental Regulation required that the Tampa Bay Electric Company's newly constructed once-through cooling system Big Bend Unit 4 utilize traveling screens with a 0.5 mm mesh size, in addition to Unit 3. Each unit had an intake capacity of 540 cubic feet per second (cfs; 349 MGD) once the screens were installed. In some cases, the traveling screens were able to reduce entrainment by more than 80 percent. (Brueggemeyer et al. 1987)*
>
> *Other studies have investigated the efficacy and use of fine-mesh traveling screens to reduce entrainment in conjunction with the functionality of the screens in terms of plant reliability. (Thompson 2000; Hogarth and Nichols 1981) The US EPA required that the Brunswick Steam Electric Plant in North Carolina install and use 1.0 mm mesh size with a fish return system on two of the four traveling screens in addition to implementing flow-minimization requirements and a 9.5 mm mesh size fish diversion device at the facility. There was an 82 percent decrease in the average density of entrained fish after the requirements were implemented. Hogarth and Nichols (1981) investigated the reliability of fine mesh intakes and reported that the fine mesh traveling screens significantly reduced entrainment without jeopardizing the plant reliability. After the flow minimization requirements were implemented, the intake volumes dropped from 1105 - 1205 cfs (714-778 MGD) intake volume varies seasonally at the plant) to 605 to 915 cfs (390- 591 MGD). (Hogarth and Nichols 1981)*

The SED notes that although fine-mesh screens can reduce entrainment of some life stages of some taxa, they cannot prevent entrainment of very small organisms (e.g., phytoplankton). This is true of any intake technology and relates only to the smallest mesh size that is feasible from an engineering perspective.

Wedgewire Screens

Relative to WWS, the SED concludes that when properly designed and when environmental conditions are appropriate, WWS are effective at reducing impingement and entrainment:

> *Cylindrical wedgewire screens can reduce impingement and entrainment if the screen slot size is sufficiently small (0.5 to 1.0 mm) to physically block passage of an organism (EPRI 1999) additionally, hydraulic factors can contribute to the reduction in impingement and entrainment at wedgewire screens. (EPRI 2003; Tomljanovich 1978; Weisburg 1987) The cylindrical shape of the wedgewire screen, combined with a very low through-slot velocity, is also necessary to allow juvenile and adult fish to escape the flow field. A relatively high ambient current cross-flow helps move organisms around and away from the screen. Additionally, high velocity cross-flow provided by ambient currents prevents buildup of debris on the screens. (Taft 2000; Weisberg et al. 1987) When these conditions are present, wedgewire screens are effective at reducing entrainment and impingement. (Taft 2000) In some cases, hydrodynamic forces can prevent impingement entirely by sweeping organisms past the screen, thus preventing contact with the screen. (Enercon 2010b)*
>
> *Numerous studies have evaluated the effectiveness of wedgewire screens at reducing impingement and entrainment (Heuer and Tomljanovich 1978; Taft 2000; Weisberg et al. 1987; EPRI 2003; EPRI 1999; EPRI 2005) and some of those studies have shown wedgewire screens can significantly reduce entrainment of fish eggs and larvae at intake pipes. (Weisberg et al. 1987; EPRI 2003; EPRI 2005)*

The SED provided a number of references illustrating the concern regarding fouling and corrosion of WWS in the marine environment and offered the following recommendation:

> *The screen composition is a factor that should be investigated in the design process of a facility. It is imperative that the wedgewire screens are maintained so slot-size integrity is maintained, through-screen velocity does not exceed 0.5 ft/s (0.15 m/s), and the facility still has adequate intake flow. The 0.5 ft/s intake velocity standard is consistent with the CWA 316(b) rule, which further requires the assumption that the screen is under a 15 percent blocked condition. Consequently, an owner or operator would target a through-screen velocity of 0.43 ft/s to meet the 316 (b) requirements. This requirement helps to ensure that even if the screen is partially blocked or clogged, that the intake velocity is maintained at a safe rate in order to prevent impingement and reduce entrainment.*

<u>Importance of Screen Slot or Mesh Size</u>

The OPA requires 1-mm slot/mesh for reducing entrainment impacts. Both designs (WWS and TWS) utilize 1-mm slots/mesh.

Section 8.3.1.2.4 – Velocity Caps

The SED provides a number of references supporting the conclusion that velocity caps are effective at reducing the number of organisms impinged at onshore screening structures:

> *Velocity caps have shown to be an effective way of reducing impingement at offshore facilities. (U.S. EPA 2000) Based on a U.S. EPA technology efficacy assessment, velocity caps can reduce impingement by more than 50 percent, and minimize entrainment and entrapment of larger marine species between inlet structures and screens onshore. (WateReuse 2011a)*

> *The Los Angeles Department of Water and Power (2007) released a detailed report that assessed the velocity cap effectiveness at reducing fish impingement at the Scattergood Generating Station (SGS) cooling water intake structure. The velocity cap reduced the abundance of impinged fishes by 97.6 and the biomass of impinged fished by 95.3 percent. (LADWP 2007)*
>
> *The study (at San Onofre Nuclear generating Station) compared impingement prior to installing velocity cap to impingement following velocity cap installation. Total impingement was reduced 95 percent from 272.2 tons to 14.95 tons following installation of a velocity cap. (Tenera 2006)*

Modifications to decrease the open area of the existing HBGS velocity cap would be effective in reducing the number of organisms impinged at the onshore TWS. However, the WWS design would replace the existing velocity cap, having a similar (likely better) effect on reducing impingement.

Conclusion

Based on the analysis provided in the SED, and based strictly on relative potential biological performance, the WWS design will likely provide the greatest protection to impingeable organisms near the HBDP seawater withdrawal point although the use of the fish return system should help minimize the difference. Lack of data on the operation and maintenance needs of narrow-slot WWS in the open ocean, however, puts into question the technical feasibility (i.e., reliable operation) of WWS. By comparison, modified TWS are very common and have been shown to operate predictably in the open ocean. Having the TWS onshore makes servicing them faster and less risky than having to do so offshore if WWS are implemented.

Table 1. Comparison of Offshore Wedgewire Screens and Onshore Traveling Water Screens.

SED Section	**Surface Offshore Wedgewire Screens (WWS)**		**Surface Onshore Modified Traveling Water Screens (TWS)**	
	Advantages	**Disadvantages**	**Advantages**	**Disadvantages**
8.3.1.1.1 – Construction-related Mortality	NA	• Requires offshore, barge-based construction work for the installation of the WWS and removal of the velocity cap • Likely disruption of the seafloor sediments during construction • Underwater noise during construction • Restricted access to offshore area during construction • Small loss of benthic habitat associated with screen supports	• Requires minimal offshore, diver-based construction work for the modification of the velocity cap and the installation of the fish return discharge pipe • Less restricted access than WWS to offshore area during modification of the velocity cap and installation of the fish return discharge pipe	• Likely disruption of the seafloor sediments associated with installation of fish return discharge pipe • Underwater noise during construction • Small loss of benthic habitat associated with the fish return system
8.3.1.1.2 – Operational Impacts (Impingement and Entrainment)	• WWS provides passive exclusion at the point of water withdrawal in the source waterbody • Physical exclusion occurs for organisms with a limiting dimension greater than 1 mm[i] • Hydrodynamics and fish behavior have potential to increase exclusion potential[ii] • WWS eliminate onshore impingement[i] • Passive exclusion of debris offshore precludes the need to handle it onshore	NA	• Modification of cap to maintain withdrawal velocity preserves cap's function as a behavioral deterrent (minimizing impingement at onshore TWS)[iii] • Physical exclusion occurs for organisms with a limiting dimension greater than 1 mm	• Long distance between point of water withdrawal and screening location • TWS actively handle organisms to collect, rinse, and return them to the source waterbody • Impingement survival varies by species and life stage[iv]

8.3.1.1.2 – Operational Impacts (Intake Pipeline)	With 1-mm slots at the offshore withdrawal point, organisms with a limiting dimension greater than 1 mm will be physically excluded from entering the intake pipeline	• Despite 1-mm slots, early life stages of certain macrofouling organisms (e.g., barnacle nauplii, mussel veligers) will still likely pass • Macrofoulers may crop other planktonic organisms in the intake flow (e.g., ichthyoplankton)	Organisms that enter the intake pipeline via the offshore velocity cap are provided a means of egress through the fish return system	Macrofoulers may crop other planktonic organisms in the intake flow (e.g., ichthyoplankton)
8.3.1.2.1 – Reducing Intake Flow Volume	Total flow of 106 MGD is 1 MGD less than TWS option	Results in 16.9 acres of APF	NA	• Total flow of 107 MGD is 1 MGD greater than the WWS option for auxiliary flow needed for screen wash and return conveyance • Results in 17.1 acres of APF
8.3.1.2.2 – Reducing Through-screen Intake Flow Velocity	• 0.5 ft/sec or less • Complies with OPA for minimizing impingement	NA	• 0.5 ft/sec or less • Complies with OPA for minimizing impingement	NA
8.3.1.2.3 – Installing Intake Screens				
Screen Mesh Size/Slot Width	• 1-mm slot has been selected • Complies with OPA for minimizing entrainment	NA	• 1-mm mesh has been selected • Complies with OPA for minimizing entrainment	NA
Screen Cleaning	• WWS are available in various materials that have suppressed biofouling potential (e.g., copper-nickel)	• No information on maintenance requirements for narrow-slot cylindrical wedgewire screens in marine environment • Air burst cleaning has been successful in some	• Sufficient information on maintenance requirements to be comfortable about operational performance • Screen type with fine-mesh is in use at many seawater intakes	NA

		situations[i] but not feasible for long offshore distance • Brush-cleaned WWS are available, but lacking information on maintenance requirements of narrow-slot WWS in seawater and not feasible for long offshore distance May require frequent diver cleaning • May require frequent offshore inspections • Offshore location repairs may require barges and may be time consuming • Due to the offshore location, WWS are exposed to storms with potential risk of damage	globally • Cleaning of screen does not require divers • Continuous screen rotation provides good debris removal capacity • Onshore location simplifies inspection effort • Onshore location repairs are greatly simplified and less time consuming	
Coarse Bar Screens, Trash Racks, and Angled Coarse Screens	WWS precludes the need for any of these coarse screening structures, unless they are provided as part of an emergency bypass system	NA	NA	NA
Traveling Screens (fish-friendly modifications)	NA	NA	• Modified TWS operate continuously to minimize impingement duration which reduces impingement mortality[v] • Survival in fish returns can be high[vi]	• Modified TWS actively handle organisms to collect, rinse, and return them to the source waterbody • Impingement survival varies by species and life stage[iv] • Though survival in fish return systems can be high, impingement on TWS can result in

				potentially stressed organisms being returned to the source waterbody • Fish return requires additional intake flow for screen wash and return conveyance
Traveling Screens (fine mesh)	NA	NA	• Smaller mesh reduces entrainment of earlier life stages[vii] • Smaller mesh intercepts more debris • 1-mm mesh has been selected • Complies with OPA for minimizing entrainment	• Smaller mesh could have smaller percent open area, increasing the screening area required • Fine-mesh does not reduce entrainment of phytoplankton, zooplankton, and some of the eggs and larvae of fish and invertebrates that are smaller than 1 mm.
Wedgewire Screens (biological performance)	See content above for section 8.3.1.1.2	NA	NA	NA
Wedgewire Screens (fouling and corrosion)	See content above for section 8.3.1.2.3	See content above for section 8.3.1.2.3	NA	NA
Importance of Screen Slot or Mesh Size	• Narrow-slot WWS reduce entrainment of early life stages • If WWS is designed properly, impingement is potentially eliminated • Modeling can be done to estimate exclusion potential for various slot sizes	• Species-specific characteristics (e.g. head capsule depth relative to length) can impact exclusion potential • Potential for fouling • Uncertainty about cleaning method/frequency	• Fine-mesh modified TWS reduce entrainment of early life stages • Modeling can be done to estimate exclusion potential for various mesh sizes	• Species-specific characteristics (e.g. head capsule depth relative to length) can impact exclusion potential
8.3.1.2.4 – Velocity Caps	NA	NA	See content above for section 8.3.1.1.2	See content above for section 8.3.1.1.2

Table 2. Feasibility Comparison of Offshore Wedgewire Screens and Onshore Traveling Water Screens

Feasibility Prong	**Surface Offshore Wedgewire Screens (WWS)**	**Surface Onshore Modified Traveling Water Screens (TWS)**
• Environmental	√+	√-
• Social	√-	√+
• Technical	√-	√+
• Reasonable Period of Time	3 months	8 months
• Economic	$20,880,897	$15,310,800

i Cylindrical wedgewire screen references:
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[iv] Impingement survival references:

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[v] Continuous rotation of modified TWS references:

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