October 31, 2016

Josie McKinley
Poseidon Water
17011 Beach Boulevard, Suite 900
Carlsbad, CA 92008

Re: **Technical Memorandum: Feasibility of Cylindrical Wedgewire Screens in Agua Hedionda Lagoon**

Dear Josie,

I am pleased to submit HDR's final technical memorandum which is a robust evaluation of the feasibility of installing and operating cylindrical wedgewire screens in Agua Hedionda Lagoon. I look forward to discussing our findings with you at your earliest convenience.

Sincerely,
HDR Engineering, Inc.

Timothy M. Hogan

Tim Hogan
Project Manager

Final Draft Technical Memo: Feasibility of Cylindrical Wedgewire Screens in Agua Hedionda Lagoon

Introduction

Poseidon Resources (Channelside) LP (Poseidon) has developed a conceptual design for the New Screening/Fish-friendly Pumping Structure, that will be implemented when the Carlsbad Desalination Plant (CDP) enters long-term, stand-alone operation following decommissioning of the Encina Power Station (EPS). At that point, the CDP will become subject to the provisions of Chapter III.M of the Water Quality Control Plan, Ocean Waters of California (Desalination Amendment). The long-term, stand-alone CDP will install 1-mm modified (referring to the presence of fish protection features) traveling water screens, designed with a through-screen velocity of 0.5 feet per second (ft/sec) or less, to return collected organisms and debris to Agua Hedionda Lagoon or the Pacific Ocean via the discharge pond.

The feasibility of various intake alternatives was evaluated in a comprehensive CDP Intake/Discharge Feasibility Study Addendum (Addendum) dated August 12, 2016. The Addendum, in conjunction with the original Carlsbad Desalination Plant Intake/Discharge Feasibility Assessment (Feasibility Study) dated August 27, 2015, assessed the feasibility of ten intake/discharge options. Among the options, Poseidon evaluated the feasibility of cylindrical wedgewire screens (WWS) both offshore and in Agua Hedionda Lagoon (Lagoon). Per the definition provided in Chapter III.M. of the California Ocean Plan, "feasible" was defined as "*capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, social, and technological factors.*" WWS in the Lagoon were determined to be infeasible based on this definition.

During the September 27, 2016 meeting with staff from the State Water Resources Control Board and the San Diego Regional Water Quality Control Board (the Boards), additional analysis was requested of the Lagoon-based WWS alternative. The Boards requested that Poseidon conduct a more detailed analysis of WWS in the Lagoon. Therefore, the objective of this technical memorandum (memo) is to evaluate in greater detail the feasibility of WWS in Agua Hedionda Lagoon. The Two wedgewire screening technologies that were considered in this evaluation: 1) airburst-cleaned (hereafter referred to as non-rotating WWS) and 2) brush-cleaned (hereafter referred to as rotating WWS). This evaluation was conducted as a fresh look at this alternative intake concept and is intended to assess in greater detail the technical aspects and potential feasibility of using WWS in the Lagoon.

Literature Review

A search was conducted to identify literature that describes operation and maintenance of WWS, the locations of WWS installations, and other engineering and design details for WWS.

Key literature that addresses the issues of fouling, screen maintenance, and optimal hydrodynamic conditions is summarized in the section below.

McGroddy, Peter M., S. Petrich, and L. Larson. 1981. Fouling and Clogging Evaluation of Fine-Mesh Screens for Offshore Intakes in the Marine Environment. In: Advanced Intake Technology for Power Plant Cooling Water Systems. Proceedings of the Workshop on Advanced Intake Technology. April 22-24, 1981.

Summary: The study was conducted at the Redondo Beach Generating Station (RBGS) to assess fouling and clogging of fine-mesh screens (McGroddy et.al. 1981). This study was comprised of two phases: 1) debris clogging tests in a laboratory setting and 2) screen material coupon fouling testing in the intake flow of the RBGS. The debris study was conducted in a small test tank using an 18-in diameter wedgewire screen. Although not noted, the screen slot size was estimated to be 1.0 mm. Flow for the tank study was drawn from behind the existing traveling screens at the RBGS. To provide a cross current, an air bubbler was used. This bubbler provided a cross current of between 6 and 9 cm/sec (0.2 and 0.3 ft/sec). Debris obtained from the intake flow was added and the head loss measured. The results of this study indicated that the screens are prone to fouling and that multiple air-bursts are needed to completely clean the screens. The cleaning is also most effective when the screen is less than 50% blocked, which could require the screens to be air-burst daily or more frequently during high debris loading periods. Additionally, they note that re-impingement of debris on the screens occurs at low cross-screen velocities.

The second part of the study compared the rate of biofouling of several potential screening materials. Small material coupons were placed on the intakes for several weeks. The percent covered and head loss through the material was measured. The materials tested included carbon steel, epoxy-coated steel, copper, and stainless steel. The mesh size of these materials varied from 0.7 mm to 2 mm. Some of these coupons were also subject to a heat treatment to determine the effectiveness of the heat treatment for controlling biofouling. The results showed that stainless steel was the least prone to biofouling of all the materials. However, the stainless steel coupons all had larger mesh openings than the other screen types. In addition, there appears to be inconsistencies between the percent covered and headloss through identical meshes. The results of the heat treatment tests indicate that the heat treatment kills attached organisms, but does not remove their shells and that the screens are quickly re-colonized.

Conclusions: Since this work was conducted at the RBGS, the results are very useful for assessing what the fouling issues may be for narrow-slot WWS in southern California. Results from the first phase of this study indicate that in the absence of sufficient ambient cross-flow (i.e., sweeping flow), clearing screens of debris and preventing re-impingement of liberated debris could become an issue for a full-scale facility. In addition, for a non-rotating WWS array with a high-pressure air burst system, the air burst may need to be operated quite frequently to maintain screens in a clean condition with low head loss, particularly under high debris loading conditions (e.g., storms). For WWS arrays with multiple screens (as would be required for the CDP flow), a substantial supply of compressed air would be required, resulting in a very large surface disturbance in the Lagoon (see Figure 1). Potential impact to the Carlsbad Aquafarm operations would have to be evaluated as well as potential impacts associated with resuspension of fine sediments that would likely accumulate as a result of the reduced intake velocities at this dead-end in the southern end of the Lagoon.

The second phase of the study indicates that careful selection of materials is needed to ensure that biofouling rates are minimized (a common design practice). Alternatively, rotating WWS offer the potential for minimizing the growth of biofouling organisms, though no data are currently available on the performance of such systems utilizing narrow-slot wedgewire in a fully marine system.

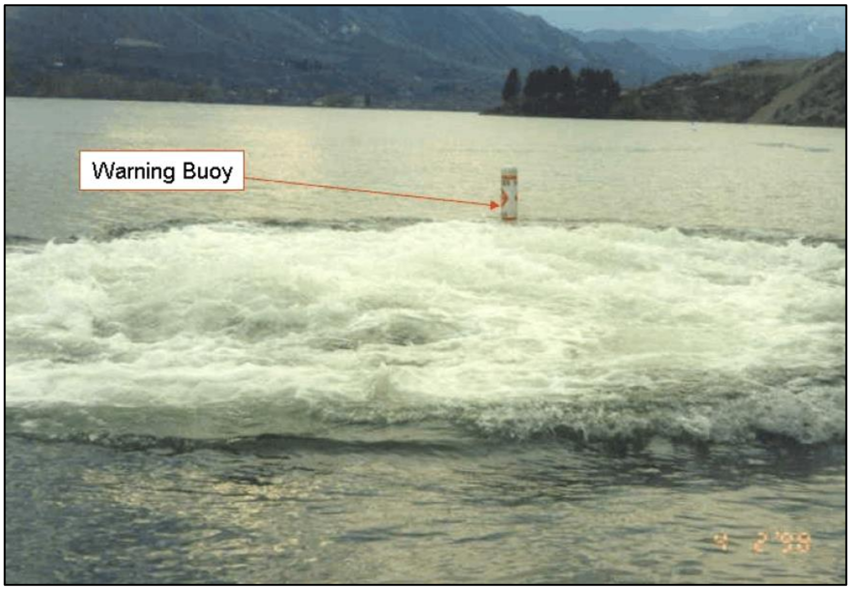

Figure 1. Surface boil resulting from high-pressure air burst cleaning of cylindrical wedgewire screens (from USBR 2006).

Wiersema, James M., D. Hogg, and L.J. Eck. 1979. Biofouling Studies in Galveston Bay-Biological Aspects. In: Passive Intake Screen Workshop. December 4-5, 1979. Chicago, IL.

Summary: This study compared the rates of fouling for several small, non-rotating WWS in Galveston Bay, Texas. The screens were not equipped with airbursting capabilities. All the test screens were 9.5 inches in diameter with 2.0-mm slot openings. The only difference between the screens was their construction materials; one was stainless steel, two were copper-nickel alloys (CDA 706 and CDA 715), and one was a silicon-bronze-manganese alloy (CDA 655). These screens were mounted to a test apparatus that contained pumps and flow meters to measure the flow through each screen during the test period. The total duration of the test was 145 days. The results indicate that the copper alloys significantly reduce bio-fouling of the screens. At the conclusion of the test period, the copper alloy screens remained at least 50% open. The stainless steel screen fouled very quickly and was completely clogged after 2 weeks. In general, the progression of bio-fouling agents was similar for all the screens. First, a slime layer formed over the screens which trapped sediments and provided a base for further colonization. After about 4 weeks, hydroids began to colonize the screens. The hydroids were the dominant bio-fouling organism until tube-building amphipods appeared. The amphipods were only able to establish themselves on the portions of the screen with significant hydroid cover. This is assumed to be a result of the hydroids providing a buffer between the screens and the amphipods. Throughout the test period there was a small amount of colonization by bryozoans and loosely attached barnacles. While this study did not include an air backwash, the researchers postulated that an airburst could be used to break up the slime layer thus retarding the growth of other biofouling agents. To date, there have been no studies to determine if an air backwash effectively removes a slime layer.

Conclusions: As above, this study reinforces that careful selection of materials is needed to ensure that biofouling rates are minimized. Although this study evaluated the performance of non-rotating screens without an airburst, the authors thought airbursting could potentially help in controlling biofouling. Rotating (i.e., brush-cleaned) WWS offer the potential for minimizing the growth of biofouling organisms; however, without data on the performance of such full-scale systems utilizing narrow-slot wedgewire in a fully marine system, installation of such WWS assumes a good deal of operational risk.

U.S. Bureau of Reclamation. 2006. Fish Protection at Water Diversions: A Guide for Planning and Designing Fish Exclusion Facilities. Water Resources technical Publication. 480 pp.

Summary: This reference manual was published by the U.S. Bureau of Reclamation (USBR) to provide design guidance for fish protection facilities at water diversions and dams in freshwater. However, the basic design principles described are applicable to any sourcewater – freshwater or marine. The USBR makes the following recommendation about cylindrical WWS:

"*Cylinder screen installations should be avoided in backwater areas, dead ends, and the ends of canals because debris tends to accumulate in these areas and there are no means of removing debris from screen surfaces.*"

Conclusions: Per the excerpted section above and other research that describes the preferred hydraulic/hydrodynamic characteristics for cylindrical WWS (EPRI 2003), a WWS array in the Lagoon presents an operational challenge since there is no ambient current to sweep debris away from the screens.

Electric Power Research Institute (EPRI). 2003. Laboratory Evaluation of Wedgewire Screens for Protecting Early Life Stages of Fish at Cooling Water Intakes. Palo Alto, CA: EPRI 1005339.

Summary: This was a study comprised of two phases. The first phase was conducted in a laboratory flume and was an evaluation of the effectiveness of WWS for reducing impingement and entrainment of early life stages of organisms. The second phase of the study used numerical modeling tools to evaluate the characteristics of flow passing through the screen. The results indicate that higher ambient sweeping velocities generally result in lower impingement and entrainment; therefore, increasing the ambient velocity to slot velocity ratio will increase biological effectiveness (i.e., greater ambient velocities increase exclusion of passive early life stages)

Conclusions: Inasmuch as early life stages of aquatic organisms are similar to free-floating debris in that both are passive, designing WWS installations with hydraulics that are optimized for biological effectiveness should also result in optimized performance in terms of debris exclusion. To design a WWS array for optimal biological performance requires the presence of an ambient sweeping flow; to optimize debris shedding performance, the same is true. The absence of sweeping flow in the southern end of the Lagoon makes this location very challenging from a debris and sediment removal perspective.

Missimer, T., T. Hogan, and T. Pankratz. 2014. Passive Screen Intakes: Design, Construction, Operation, and Environmental Impacts. In: Missimer, T., B. Jones, and R. Maliva (eds). Intake and Outfalls for Seawater Reverse-Osmosis Desalination Facilities: Innovations and Environmental Impacts, Springer, 544 pp.

Summary: This is a chapter from a book focused on intakes and outfalls at seawater reverse osmosis desalination facilities. The chapter is focused solely on cylindrical WWS. It notes that cylindrical WWS are not well-suited for installation at the end of dead-end canals or along seawalls where the ambient velocity is low. Regardless of air burst systems or rotating screen technologies, debris is likely to accumulate under these conditions since there is insufficient ambient velocity to carry it away. Therefore, in addition to the WWS array, the intake structure must include equipment and a procedure to remove the accumulation of debris.

Conclusions: As noted in other literature, there is potential for debris and sediment to accumulate near the screens when the ambient velocity is insufficient. Such is the case in the Lagoon; therefore, the intake structure must include a means to collect and remove debris that may accumulate. It is particularly important to have this capability during storm conditions, when the probability for high debris loads increases.

Vendor Feedback

HDR contacted two large WWS vendors to determine the extent of their installations in marine conditions and to solicit feedback on the feasibility of WWS in the Lagoon. Their responses are summarized below.

Intake Screens Incorporated (ISI)

ISI manufactures rotating cylindrical wedgewire screens that are designed to rotate the screening cylinders past fixed internal and external brushes to keep the screen clean. This mechanical system provides a good means for combating biofouling growth on the screens' internal and external faces. ISI screens have been installed at many freshwater intakes as well as some smaller marine intakes, but not yet to a scale as would be required for the CDP.

ISI's concerns over a potential installation in the Lagoon were centered more on how to manage debris (e.g., macroalgae, sediment) than biofouling. If screens are rotated frequently enough, it's likely that biofouling could be adequately managed. Keeping free-floating debris from accumulating and potentially occluding portions of the screen would be a key design goal. In order to provide the operational reliability required for the CDP, the screens would have to be mounted on a retractable system, so that they could be removed from service and cleaned in the event of a large debris influx. Management of sediment near the screen array would be accomplished by periodic dredging of the areas where it accumulates or by jetting it to area where it can be more easily removed/dredged.

HDR developed the conceptual design presented below which ISI concurs would be appropriate for managing the risk posed by debris at this site.

Bilfinger Water Technologies (BWT, formerly Johnson Screens)

BWT is a top vendor of non-rotating, air burst-equipped cylindrical wedgewire screens. BWT has a comprehensive list of installations worldwide, some of which are in fully marine waters, though none of which are in a semi-enclosed wasterbody similar to the Lagoon.

BWT noted that although it could likely be engineered, installing an array of WWS in Agua Hedionda Lagoon would be a "*first of a kind intake of this type in the world*". Given the location of the water withdrawal point at the end of an enclosed waterbody, BWT expressed concerns that free-floating debris would enter the Lagoon from the Pacific Ocean and potentially accumulate near the screens. Therefore, they noted that a bar rack and trash raking system be required near the Carlsbad Boulevard bridge if WWS were being considered. Without such a debris management structure, BWT had concerns about large strands of kelp potentially occluding the screen surfaces (regardless of whether they were stationary or rotating screens). BWT also noted concerns over sediment accumulation and suggested that a concrete pump basin with desilting provisions may be required. Noting the potential for high corrosion rates, BWT suggested that duplex stainless steel would be required. BWT stated "*Even with these precautions there is little certainty that a reliable system could be attained.*"

To illustrate their concern about heavy debris loads in marine intake applications, BWT provided some figures (Figure 2)

HDR developed the conceptual design presented below which BWT stated would be the minimum required for managing debris and sediment at this site in the Lagoon.

Figure 2. Photographs of seawater intake debris collected by BWT intake screening equipment.

Intake Design – General Description

SITE

A new structure would be constructed in the Lagoon to support the coarse screening of debris, the array of WWS, and provide a debris settlement area nears the screens that can be cleared with a horizontal mechanical raking system . The trash rack structure would be a U-shaped pier supported by H-piles embedded to a depth of approximately 60 ft. The screens would be mounted on two new intake pipes that connect to the existing EPS intake tunnels. The intake pipes would convey water from the screening point in the Lagoon to an onshore wet well from which the existing SWRO Pump Station would draw feedwater and flow augmentation water flow. The wet well would be sufficiently sized to also house the Flow Augmentation Pump Station ("Fish-friendly Pumping Structure"). Both feedwater and flow augmentation water for the CDP would be withdrawn through the new WWS array from the existing source waterbody (Agua Hedionda Lagoon). The new WWS array would require significant in-water construction activity. Construction would be done from a derrick barge moored in the Lagoon. A general schematic of the layout is provided in Figure 3.

An amendment to the lease agreement would be required from NRG for the Lagoon installation site. Based on the dimensions of the design (and allowing 5 feet on each side of installed equipment), a lease of approximately 0.35~~6~~ acres would be required for the Lagoon-based WWS array and trash rack structure.

Approximately 298 MGD of seawater would be withdrawn directly from the Lagoon -- 127 MGD for processing by the CDP and 171 MGD for brine dilution. Approximately 60 MGD of the diverted seawater would be converted to fresh water which would be piped to the Water Authority's delivery system in the City of San Marcos. The remaining flow (67 MGD) would be returned to the EPS discharge tunnel for blending with seawater prior to discharge to the Pacific Ocean. The discharge would consist of brine produced by the reverse osmosis process (60 MGD) and treated backwash water from the pretreatment filters (7 MGD). The salinity of the discharge prior to dilution would be approximately 65 ppt (67 ppt with no backwash water included), whereas the average salinity of the seawater in the vicinity of the discharge channel is 33.5 ppt. Poseidon is proposing an initial dilution of the brine to 42 ppt prior to discharge. This would be accomplished by mixing the CDP discharge with 171 MGD of the seawater withdrawn from Pacific Ocean along with the RO feedwater. The combined CDP discharge and dilution water flow rate would be 238 MGD. As compared to the existing project operations, the CDP operations described above would achieve a 10% average annual increase in fresh drinking water production while reducing total quantity of seawater required for processing and flow augmentation purposes.

Agua Hedionda Lagoon is characterized as seasonal estuary whose mouth remains permanently open to the Pacific Ocean as a result of sustained intake flows from the EPS (Tenera 2008). As such, there is free movement of mobilized sediment between the Ocean and the Lagoon. Tetra Tech (2007) notes that sediments in the outer Lagoon (where the CDP intake will be located) are nearly all sand (95.1-96.2%). Jenkins (2013) describes the grain size in the Lagoon thusly, noting that the range in grain size is lower than the median beach grain size: "*The median grain size of the newly deposited sediments varies between 130 and 204 microns among the cores taken on the outer portion of the flood tide bar and between 120 and 210 microns on the inner portion. The spread in the distributions is nearly identical on inner and outer bar sections and the median grain sizes in both the upper and lower limits of that spread is well below the median beach grain size of 290 microns*." Jenkins (2016) also notes that due to the withdrawal of the power plant, the ability of the Lagoon to flush sand back out, even during spring tides, is reduced. Therefore, periodic dredging of the Lagoon is conducted to maintain free-flowing tidal exchange with the Pacific Ocean.

Figure 3. General schematic of the CDP with Lagoon-based 1-mm wedgewire screens and flow augmentation.

DESIGN

The WWS would be mounted on two new intake pipes that connect to the existing EPS intake tunnels (Figure 5 and Figure 6). The intake pipes and screens would be oriented perpendicular to the shoreline. The screens would be retractable via a vertical track system. Individual screens could be raised above the water surface to deck level via an electric winch and wire cable. Since WWS (neither rotating nor non-rotating) are not equipped with means to manage large water-born debris, the screens would be protected by an upstream coarse trash rack structure. The trash rack would be comprised of sections of vertical bars to prevent the ingress of large water-borne debris (e.g., kelp). The trash rack sections would be supported by H-piles embedded in the Lagoon substrate. The piles would also serve as structural support for the deck above. The trash rack would be cleared of accumulated debris by a traveling rake. The rake would collect debris and transfer it to a conveyer that discharges to a debris loading bin on the shoreline. The debris loading bin would connect to a buried conveyer that would deliver collected debris to the discharge pond. The deck would be large enough to provide vehicle access. This vehicle access lane would be at deck level (approximately El 10 ft). The vehicle access lane would provide means to maintain the retracted screens and the trash raking equipment. The trash raking equipment will extend above the deck level, as will the tracks that allow retraction of the WWS above the water surface. Below the water surface along the bottom of the concrete base, a horizontal debris rake would provide means to remove the finer debris (e.g., eel grass) that passes the trash rack. The horizontal rake would move collected debris shoreward, where it would be added to the debris conveyer system

The WWS array would be comprised of ten 84-inch diameter WWS (8 plus 2 redundant) with 1.0-mm slot widths (Figure 4). The length of each screen would be approximately 27 feet. Screens would be spaced one radius (i.e., 3.5 ft) from each other end-to-end. The screens would likely be the rotating type in order to minimize biofouling growth, though an airburst cleaning system could be considered as well. Regardless of the cleaning technology, keeping the screens clean will be a challenge in this location since there is no natural sweeping current to carry away liberated debris (i.e., not biofouling, but free-floating debris occurring throughout the water column). To minimize the risk posed by biofouling in the marine water, the screens would be constructed of a material known to minimize the growth of biofouling organisms (e.g., stainless, super duplex, or copper-nickel). Screens could be retracted periodically for inspection and/or manual cleaning if required.

The screens are designed to maintain a through-slot velocity of 0.5 ft/sec or less under all expected operating conditions. The concept design includes a fouling factor of 30~~15~~%, meaning that under a clean condition, the design through-slot velocity is 0.43 ft/sec. For typical operations, all ten screens would be operable when the CDP enters long-term standalone operational mode, meaning the through-slot velocity would be well below 0.5 ft/sec. In the event a screen is taken out of service, the intake system is designed to maintain a through-slot velocity below 0.5 ft/sec.

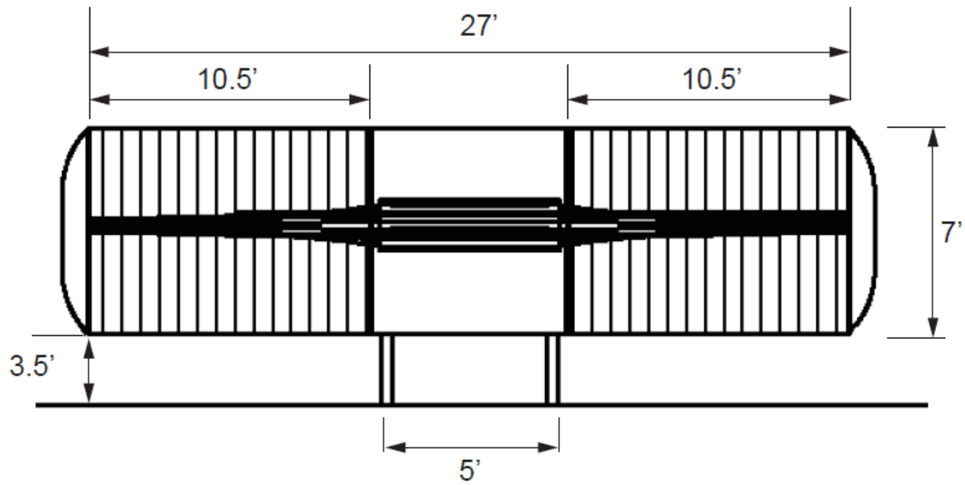

Figure 4. 84-in diameter cylindrical wedgewire screen.

The WWS array and trash rack structure would be attached to the existing EPS inlet structure. The structure would extend out into the lagoon approximately 181 ft and would be approximately 71 ft wide with the screens at a depth of approximately 7 feet below MLLW. This location was selected to minimize impacts to the existing undeveloped shoreline, to minimize use conflicts with the Carlsbad Aquafarm, and to make efficient use of the existing EPS intake infrastructure. Two 6.5-ft diameter intake pipelines would convey the withdrawn water from the two separate WWS arrays to a new wet well west of the SWRO Pump Station. The two pipelines would be mounted on the submerged concrete slab floor. The new wet well would function as a common plenum from which SWRO process water flow would be drawn by the existing pumps at the Intake Pump Station and from which augmentation flow would be drawn by fish-friendly axial flow pumps. A total flow of 298 MGD would be withdrawn: 127 MGD for process water side and 171 MGD for flow augmentation. Figure 5 and Figure 6 provide plan and section views, respectively, of the new WWS intake structure with trash rack in the Lagoon.

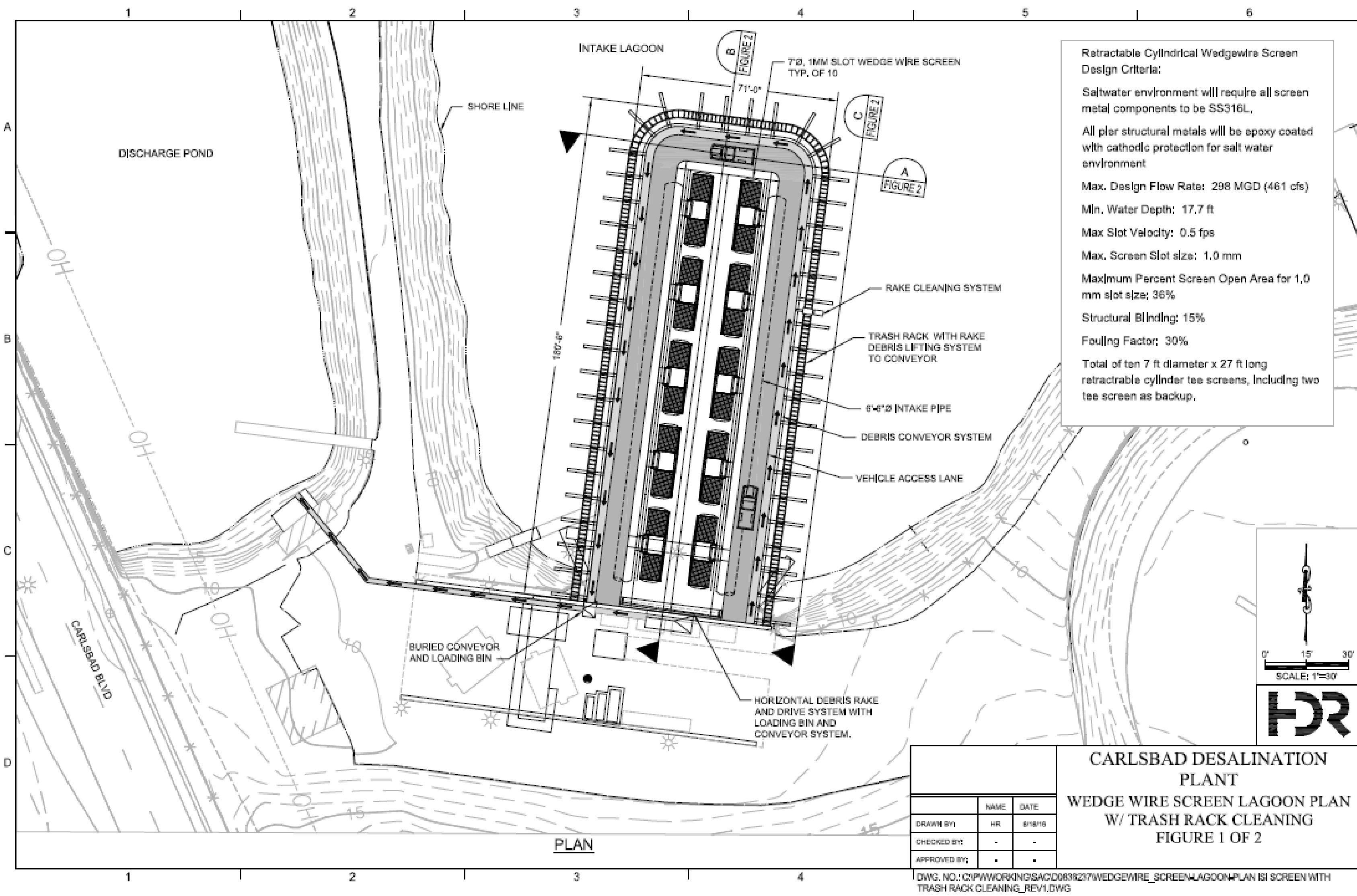

Figure 5. Lagoon-based 1-mm wedgewire screens with flow augmentation for long-term stand-alone operation, plan view.

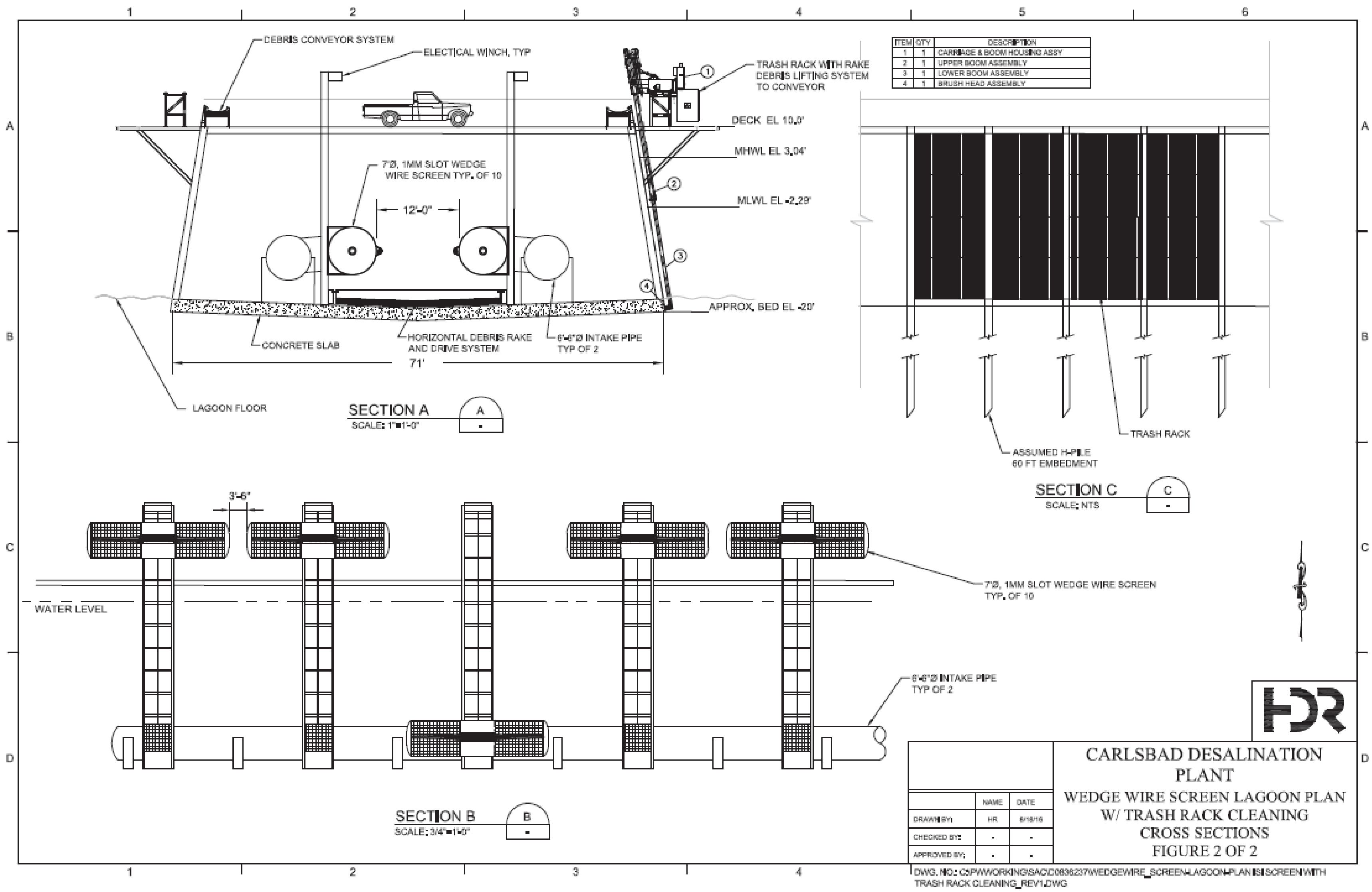

Figure 6. Lagoon-based 1-mm wedgewire screens with flow augmentation for long-term stand-alone operation, section views.

TECHNOLOGY

Previous research has shown that WWS can be effective for reducing impingement and entrainment (Gulvas and Zeitoun 1979; Zeitoun et al. 1981; Tenera 2010). However, biological performance in locations like the southern end of the Lagoon where ambient currents are low or absent are expected to be less than optimal. EPRI (2003) noted that the capacity to sweep organisms past the screens most likely contributes to the reduction in impingement and entrainment of early lifestages with this technology. Hanson et al. (1978) and Huer and Tomljanovich (1978) concluded similarly that impingement and entrainment rates were inversely related to ambient sweeping velocity. The biological and engineering performance of cylindrical WWS is optimized when there is sufficient ambient velocity to carry organisms and debris away from the screens (EPRI 2006). Such ambient currents are not present at the southern end of the Lagoon.

Cylindrical WWS utilize wire that is V- or wedge-shaped in cross-section. The wire is welded to a framing system to form a slotted screening element (Figure 7).

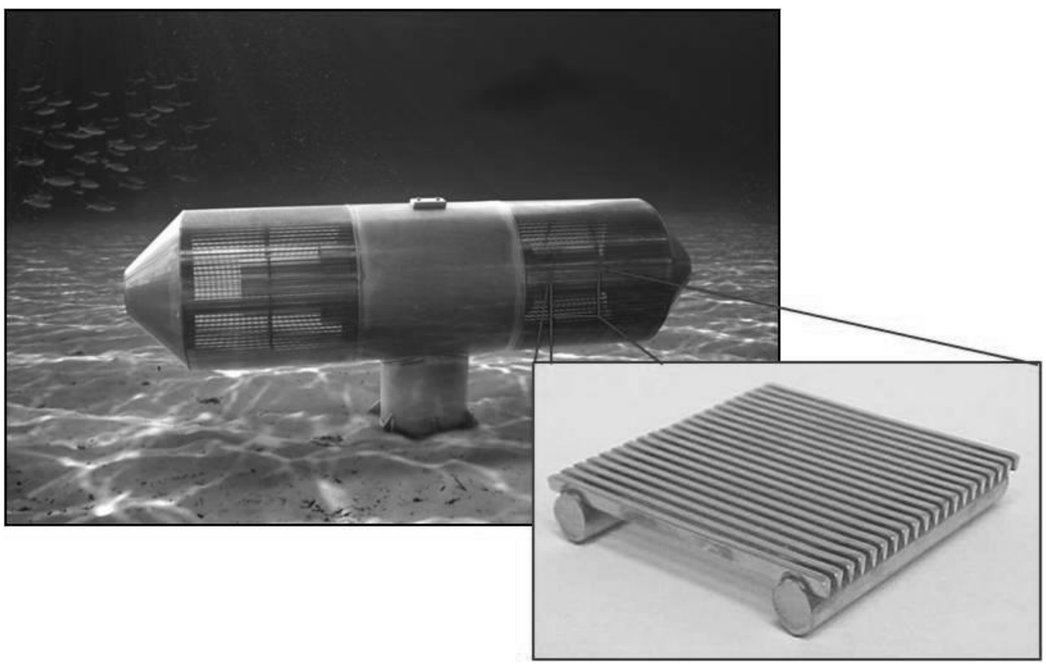

Figure 7. Cylindrical wedgewire screen, showing detail of v-shaped wedgewire (Image courtesy of Bilfinger Water Technologies, formerly Johnson Screens).

These screens have been biologically effective in preventing entrainment and impingement of fish and have not caused unusual maintenance problems in freshwater applications. However, the potential for clogging and biofouling remains a major concern in a marine environment with narrow-slot and few data are available on the performance in marine waters. Since WWS are intended to be installed in areas where sufficient ambient current is available to sweep debris and organisms away from the screen face, they are not equipped with any coarse screening structure. Therefore, in areas where ambient currents are expected to be low or absent, an additional coarse screening structure (e.g., trash rack) would be required to intercept, collect, and remove large debris; and a separate system would be required to intercept, collect and remove sediment and small debris that will accumulate in the area around the screens inside the trash racks.

Technical Feasibility

Site Constraints

The installation of a WWS array in the Lagoon presents construction-related site constraints. The existing EPS intake structure at the Lagoon interface would have to be modified to create a new sealed bulkhead to accept the new intake pipelines. Additionally, installation of a WWS/trash rack structure poses a potential use conflict with the existing Carlsbad Aquafarm. The Aquafarm has a substantial footprint in the Lagoon and would have to be displaced if the intake design were to extend too far north into the Lagoon. Therefore, the WWS array and associated trash rack were designed to stay as close to the existing EPS inlet as possible.

Embedment of the piles and placement of the screens and associated piping would be accomplished with a derrick barge moored over the intake location. Therefore, the schedule and duration of the installation effort is contingent upon the availability of an adequately sized derrick barge local to the area.

In order to construct this Lagoon-based WWS array with associated trash rack, an NRG lease of approximately 0..35~~36~~ acres would be required. This area represents the footprint of the Lagoon-based WWS array and trash rack structure plus 5 feet on all sides of the installed equipment.

Equipment

Cylindrical WWS with wide slot widths (3 to 9.5-mm) are a proven technology used widely throughout the world for screening large seawater flows; however, there are no data readily available on the performance of narrow-slot screens in fully marine environments. ISI has installed a few rotating WWS in marine water: however, these are substantially smaller than the 298 MGD flow rate for the CDP. As a result, there are major technical concerns regarding the use of WWS in a dead-end Lagoon that does not have adequate sweeping currents to sweep dislodged debris from the screens.

Without a substantial coarse screening structure and second-stage debris collection and removal device (horizontal mechanical rake) for finer debris that passes the trash rack (i.e., trash rack as shown in Figure 5 and Figure 6), the screens would be at risk of fouling with water-born debris. In addition, means (e.g., dredged or jetted) to remove accumulated sediment would be required.

Marine Life Feasibility

The screened surface intake under consideration would be located within the Lagoon. Feedwater and flow augmentation for the Expanded CDP would be withdrawn through a new 1-mm WWS array with trash rack. The organisms that could potentially be impacted by the surface water intake include those occurring near the water withdrawal point. Previous entrainment sampling indicates that gobies and blennies are the dominant taxa. There is also a benthic impact associated with the construction of this WWS intake alternative.

Impingement

Impingement is the pinning of larger organisms against the screen mesh by the flow of the withdrawn water. The magnitude of impingement losses for any species from intake operation is a function of the involvement of the species with the intake (number or proportion impinged) and the subsequent mortality of those organisms (referred to as impingement mortality or IM).

Intake velocity is commonly accepted to be the strongest predictor of impingement. Furthermore, a through-screen velocity of 0.5 ft/sec or less has been identified for being protective of impingeable sized fish. Per the Desalination Amendment language at 2.d.(1)(c)iv., the SWRCB has prescribed a through-screen velocity no greater than 0.5 ft/sec in order to minimize impingement at surface water desalination intakes.

The screens in the array for the long-term stand-alone CDP intake/discharge structure are designed to passively exclude organisms by utilizing a through-screen velocity that is 0.5 ft/sec or less with a 30% fouling factor. As passive screens, no active handling of fish is required. Based on the passive design and the low through-slot velocity, the WWS would meet the Desalination Amendment requirement for minimizing impingement at the New Screening/Fish-friendly Pumping Structure for the CDP.

Entrainment

Entrainment is the passage of smaller organisms through the screening mesh. The magnitude of entrainment losses for any species from intake operation is a function of the involvement of the species with the intake (number or proportion entrained) and the subsequent mortality of those organisms as they pass through the process equipment (referred to as entrainment mortality).

Per the Desalination Amendment language at 2.d.(1)(c)ii., the SWRCB has prescribed screens with 1.0-mm mesh in order to reduce entrainment at surface water desalination intakes. In accordance with the Desalination Amendment, Poseidon has selected a 1.0-mm slot width for the Lagoon-based WWS.

Based on intake-related entrainment through the process water screens (127 MGD) and the flow augmentation system (171 MGD), the calculated APF is 84.0 acres when assuming 100% entrainment mortality. The total APF of 84.3 acres uses the methodology set forth in Appendix E of the Staff Report for the Desalination Amendment. The factors that could potentially contribute to entrainment mortality in the flow augmentation system include pump passage (shear and blade strike) and exposure to elevated salinity (osmotic stress).

Brine Mixing Zone

The BMZ, for the CDP is a 200-meter (656-foot) semi-circle originating from the terminus of the discharge channel in the Pacific Ocean. Outside of the BMZ, salinity cannot exceed 2 ppt over ambient background salinity. Within the BMZ, entrained organisms will experience elevated salinity. The benthic area encompassed by the BMZ would be approximately 15.5 acres.

Lagoon Habitat

Construction of the WWS array with associated trash rack structure would permanently impact Lagoon habitat. The footprint of the new structure, approximately 0.35~~6~~ acres directly upstream of the existing EPS inlet structure, would be permanently lost. Construction of this intake would create temporary physical and noise impacts to the benthos and shoreline associated with mooring of construction equipment and pile driving/vibration to construct the deck support structure.

Since approach velocities would be quite low, operation of this intake will likely require that accumulated sediment near the screen array be periodically dredged or, alternatively, that the sediment be jetted from the intake area. The design of the trash rack and the system to remove the accumulated debris around the screens should be adequate to manage all anticipated debris and sedimentation. The cost of the operation and maintenace of the debris removal systems has not been evaluated in this assessment, but it would have a material impact on the life-cycle cost of this alternative.

Conclusion

The feasibility of using WWS in the Lagoon was evaluated in the Addendum dated August 12, 2016. Poseidon has prepared this memo to further evaluate the use of WWS in the Lagoon at the request of the Boards. This evaluation was conducted as a fresh look at this alternative intake concept and is intended to assess in greater detail only certain feasibility criteria that have the greatest impact on the feasibility determination.

As with the Addendum, this memo evaluated design and operation-related issues of Lagoon-based WWS with flow augmentation. Additionally, the potential marine life impacts are evaluated. One of the goals of the Desalination Amendment is "*determining whether a proposed technology is the best available technology feasible to minimize intake and mortality of all forms of marine life.*" Further, the Desalination Amendment defines "feasible" as: "*capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, social, and technological factors*." In this context, the evaluation provided in this memo addresses only a portion of what would be considered in determining the feasibility of WWS in the Lagoon. This memo provides information that addresses whether we expect WWS in the Lagoon can be "*accomplished in a successful manner*". The memo also provides information that addresses the "*technological factors*" that must be taken into account and provides estimates of the comparative marine life impact (a part of what would be considered in "*environmental factors*")

The Lagoon-based WWS alternative poses real technical concerns about the location being appropriate for the selected technology and raises doubt about whether it represents an intake technology that could be "*accomplished in a successful manner*". WWS have been shown to provide good protection to aquatic organisms, though their application has historically targeted riverine sites where there is consistent uni-directional sweeping flow. Only recently have researchers begun considering full-scale marine installations of WWS. Most of the marine installations considered have been in areas where there is greater exposure to ambient sweeping currents. The hydrodynamic characteristics of the Lagoon, particularly in the southern part near the existing EPS inlet structure, create an inherently risky and, to date, untested operating environment.

The literature review provides a summary of the research conducted to date that is germane to the use of WWS in a marine environment and also the importance of considering the hydrodynamic characteristics of the source waterbody when selecting WWS. The literature available indicates that:

- in the absence of sufficient ambient cross-flow (i.e., sweeping flow), clearing screens of debris and preventing re-impingement of liberated debris could become an issue for a full-scale facility,
- installation of WWS in hydraulic dead-ends risks the accumulation of debris
- controlling biofouling on WWS is critical to ensuring proper hydraulic function; though, without data on the performance of a full-scale system of narrow-slot wedgewire in a fully marine system, such a system at the CDP would be the first of its kind. Such an intake would result in a good deal of operational risk.

Feedback from two of the top WWS vendors (ISI and Bilfinger) indicated that there were reservations about the operational reliability of WWS in the Lagoon. ISI noted that although their rotating screen should be adequate for managing the growth of biofouling on the screen face, they would require the system design to allow the screens to be retractable. In addition, having a means for collecting large and small water-born debris and a means for managing sediment must be design goals as well. Bilfinger echoed these concerns adding that free-floating strands of kelp could be very difficult to manage in the dead-end Lagoon location.

The design is presented in this memo represents the minimum required for managing debris, though there remains substantial risk associated with such an unproven application of the wedgewire screen technology at a site like the southern end of the Lagoon. At the southern end of the Lagoon, the biological performance of the screens is likely to be less than optimal since ambient sweeping currents near the screen faces would be very low. Without sufficient sweeping current~~)~~, the predominant flow vectors will be toward the screen faces. As was discussed in this memo, optimizing biological performance of WWS relies in large part on siting screens where there is sufficient ambient velocity to carry passive or poorly swimming organisms past the screen; the Lagoon is sub-optimal in this regard.

When compared to the other alternative technologies, the Lagoon-based WWS with flow augmentation would require 99.9 acres of mitigation - 0.1 acre more than the surface screened intake with flow augmentation (99.8 acres). Therefore, the surface screened intake with flow augmentation is the best alternative (relative to mitigation acreage) after considering the feasibility of the intake/discharge options for the CDP when it begins long term stand-alone operation.

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