Seafloor Infiltration Gallery or Screened Ocean Intake at a Proposed Huntington Beach, CA Desalination Plant:

Is There an Environmentally Superior Option?

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July 31, 2016

● Executive Summary

In response to the pressures of climate change, drought, a growing population, and dwindling water supplies, seawater desalination is poised to become an important source of potable water in California. The state's first large-scale desalination plant recently started commercial production of 50 MGD (Millions of Gallons per Day) in the city of Carlsbad. Poseidon Water, the developer of the Carlsbad facility, has proposed to construct a new 50 MGD desalination plant at Huntington Beach, CA; the permitting of this facility is now pending before the California Coastal Commission. This report is specifically concerned with the minimization of environmental impacts resulting from *water intake* at the proposed Huntington Beach plant.

From an environmental perspective, intake of large volumes of saltwater is potentially problematic because ocean water contains planktonic organisms, including the eggs and larvae of commercially important marine species. The principal environmental impacts of concern for water intakes are broadly categorized as impingement and entrainment (collectively referred to as "I&E"). *Impingement* is the entrapment of larger organisms against the intake screen by the flow of the withdrawn water. *Entrainment* is the passage of smaller organisms through the screen. In addition, intake impacts can include damage to benthic habitat and organisms resulting from intake construction and maintenance.

In regulating desalination seawater intakes, the State Water Resources Control Board (SWRCB) has designated 'subsurface intakes' as the best available technology, unless deemed to be *infeasible* at a specific location, pursuant to California law. However, SWRCB's designation of subsurface intakes as the 'best available intake technology' was based upon the assumption that subsurface intakes reduce or eliminate I&E impacts. This Report has found no scientific evidence supporting this assertion, either in general, or in relationship to the proposed 50 MGD Huntington Beach plant.

Recently, the California Coastal Commission assembled an Independent Scientific & Technical Advisory Panel (ISTAP) of experts to analyze the feasibility of installing and operating a subsurface intake at the proposed Huntington Beach site. ISTAP's reports concluded that, of the various types of subsurface intakes, only a Seafloor Infiltration Gallery (referred to hereafter as SIG) was technically viable at Huntington Beach. However, ISTAP further concluded that a SIG at Huntington Beach would be *infeasible*. Consequently, Poseidon has proposed to use a 1 mm (1/25th inch) screened ocean intake, as an alternative to the use of a SIG at Huntington Beach. Screened ocean intakes are a commonly used, time-tested technology designed to minimize I&E through the use of slow intake speeds (through-screen velocity of 0.5 feet per second or less) and very small screen mesh openings that exclude all but the smallest planktonic organisms.

The salient question for the proposed Huntington Beach desalination plant is whether a SIG is clearly environmentally superior at minimizing the intake and mortality of marine life compared to a 1mm screened ocean intake. In order to answer this question scientifically, this Report systematically examines 1) the overall status of scientific knowledge regarding the environmental impacts of both screened ocean intakes and SIGs in general, 2) the site-specific environmental impacts for both intake types at Huntington Beach, and 3) the impacts of screened ocean intakes relative to large-scale anthropogenic impacts such as climate change and over-fishing.

The findings of this Report can be summarized as follows:

1) Screened ocean intakes in general have well-known, minimal environmental impacts that can be accurately quantified for mitigation purposes. In contrast, there are currently no data available *whatsoever* with which to assess potential environmental impacts resulting from the use of SIGs. As a result, potential SIG environmental impacts may be greatly underestimated.

2) At Huntington Beach, I&E resulting from the use of a screened ocean intake has already been investigated, and shown to have insignificant population-level impacts. In contrast, potential I&E impacts from SIG use at Huntington Beach are unknown.

3) A screened ocean intake will have no benthic impacts at Huntington Beach, whereas the construction and operation of a SIG at this location will have extensive benthic impacts resulting in marine life mortality.

4) Screened ocean intakes are a proven technology, whereas the use of SIGs has never been attempted in an oceanographic setting or on a scale similar to that proposed for the Huntington Beach desalination plant.

5) Several Peer-Reviewers of California's Desalination Amendment expressed concerns about the purported ‘environmental superiority’ of SIGs.

6) Huntington Beach is an ideal location for a screened ocean intake due to low larval fish abundance and diversity in nearshore waters.

7) The magnitude of adverse impacts from desalination plant ocean intake entrainment is inconsequential in comparison to other anthropogenic impacts such as: overfishing, climate change, pollution and acidification.

In conclusion, there is no scientific evidence that a SIG located offshore of Huntington Beach would be environmentally superior to a 1mm screened ocean intake for minimizing the intake and mortality of marine life, and in fact the SIG’s construction and permanent benthic and I&E impacts likely render it the environmentally inferior technology alternative at this site.

Note: Please see Appendix A for an abbreviated version of this report that addresses *only* the issue of SIG environmental impacts. The cover page of Appendix A contains a

list of scientists who have peer-reviewed the report, and *signed in agreement* with its overall conclusion that “Seafloor Infiltration Gallery (SIG) intakes have not been demonstrated to be effective at minimizing intake and mortality of marine life. There is no scientific justification for the assertion that SIGs will eliminate impingement and entrainment of planktonic organisms at the proposed Huntington Beach desalination plant site. In addition, the construction and operation of a SIG at this location may have extensive and deleterious impacts to benthic habitat and organisms.**”**

● Introduction

In response to the pressures of climate change, a growing population, and dwindling water supplies, there has been increasing interest in desalination as an alternative to traditional water sources in California. Seawater desalination in the state is now poised to become an important source of potable water as the current human population of almost 39 million continues to grow, and groundwater and freshwater supplies continue to be depleted. This is particularly important in southern California, which is dependent upon imported water from two environmentally constrained and increasingly less reliable sources: the Sierra Nevada Snowpack and the Colorado River. California's first large scale desalination plant recently started commercial operations in Carlsbad, with an initial capacity to produce up to 50 MGD (millions of gallons per day) of potable water, and several additional plants are proposed to be built along the California coast in coming years.

Because of concerns about the environmental impacts of desalination, a regulatory framework for this industry has rapidly developed. Although these regulations pertain to a variety of environmental issues (including construction impacts, brine discharge, etc.) this report is specifically concerned with the environmental impacts resulting from *water intake*. As part of the desalination process, large volumes of saltwater are removed from the ocean and converted to freshwater primarily through reverse osmosis. From an environmental perspective, this water intake is potentially problematic because ocean water contains planktonic organisms, including the eggs and larvae of commercially important marine species. The principal environmental impacts of concern for water intakes are broadly categorized as impingement and entrainment (collectively referred to as "I&E"). *Impingement* is the entrapment of larger organisms against the intake screen by the flow of the withdrawn water. *Entrainment* is the passage of smaller organisms through the screen (Hogan 2015). In certain cases (as described below), intake impacts can also include damage to benthic habitat and associated benthic organisms.

The State Water Resources Control Board (SWRCB) is the agency primarily responsible for developing environmental regulations applicable to desalination plants along the California coast. In May of 2015, the SWRCB adopted final amendments to the California Water Quality Control Plan for Ocean Waters addressing desalination intakes and brine discharges (the "Desalination Amendment"; SWRCB 2015). The Desalination Amendment provides direction to the state's nine regional boards on the application of California Water Code Section 13142.5(b), which states: "*For each new or expanded coastal power plant or other industrial installation using seawater for cooling, heating, or industrial processing, the best available site, design, technology, and mitigation measures feasible shall be used to minimize the intake and mortality of all forms of marine life*."

With regard to the minimization of intake and mortality of marine life related to desalination seawater intakes, the Desalination Amendment designates 'subsurface intakes' as the best available technology, because they are purported to reduce or eliminate I&E impacts. Subsurface intakes withdraw seawater below the surface of the seabed, and may consist of horizontal or vertical beach wells, or seafloor infiltration galleries (Pankratz 2015).

Poseidon Water, the developer of the 50 MGD desalination facility at Carlsbad, CA, has proposed to construct a new 50 MGD desalination plant at Huntington Beach, CA. The permitting of this facility is now pending before the California Coastal Commission. In line with the Desalination Amendment mandate that subsurface intakes are the best available intake technology, unless *infeasible*, the Commission assembled a panel of experts (Independent Scientific & Technical Advisory Panel, or ISTAP) to analyze the feasibility of installing and operating a subsurface intake at the proposed Huntington Beach site. ISTAP's Phase 1 report (ISTAP 2014) indicated that, of the various subsurface intake technologies available, only 2 types were technically feasible[1] at

[1] *"The technical feasibility of a subsurface intake type depends on a variety of hydrogeological, design, oceanographic, and geochemical constraints. In addition, consideration needs to be given to the historical experiences of the various intake types, and particularly whether precedent exists for the investigated subsurface intake type, meaning that this type has been constructed and successfully operated at a*

Huntington Beach – beach infiltration galleries, and seafloor infiltration galleries (referred to hereafter as SIGs). ISTAP's Phase 2 report (ISTAP 2015) further concluded that the beach infiltration gallery option was technically *infeasible*, leaving a SIG as the only technically viable subsurface intake option at Huntington Beach. However, the same report (ISTAP 2015), also concluded that a SIG at HB is, under California law[2], *infeasible* due to economic and construction-related factors.

Section 8.4.9 of the Desalination Amendment recommends an option that allows desalination plants to be built and operated in areas where SIGs are not feasible:

> *"Desalination facilities could be sited at locations where subsurface intakes are infeasible as long as the regional water board determines it is otherwise the best available site and in combination with the best available design, technology and mitigation measures results in the least amount of marine life intake and mortality."*

Therefore, as an alternative to the use of a SIG at the Huntington Beach facility, Poseidon proposes to use a 1 mm (1/25th inch) screened ocean intake, with a through-screen velocity of 0.5 feet per second or less. Screened ocean intakes (described in greater detail below) are a commonly used, time-tested technology designed to minimize I&E through the use of slow intake speeds that dramatically reduce impingement, and screen mesh openings that exclude all but the smallest planktonic organisms (Pankratz 2015).

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comparable scale and in a similar setting as the studied Huntington Beach site. In order for a subsurface intake type to be considered technically feasible at the Huntington Beach site, there must not be any fatal flaws, which are defined as conditions that would either not allow a full-scale system to be successfully constructed and operated or would result in a high risk of failure or unacceptable performance of Poseidon's full scale target minimum hydraulic capacity of 100 MGD … Evaluation of the technical feasibility of the considered subsurface intake options involved the collective professional judgment of the Panel as to whether or not the option could be built and reliably operated using currently available methods." ISTAP Phase 1 Report, Page 46

[2] The ISTAP Phase 2 Report, in coming to its conclusion that a Seafloor Infiltration Gallery (SIG) would be *infeasible* at the proposed Huntington Beach (HB) site, relied on California's legal definition of feasibility incorporated in the Coastal Act, the California Environmental Quality Act (CEQA) and the California Ocean Plan Desalination Amendments adopted by the State Water Resources Control Board which requires accomplishing a project within a reasonable period of time and being economically feasible ("*capable of being accomplished in a successful manner within a reasonable period of time and taking into account the economic, environmental, social, and technological factors").*

Given the regulatory framework and seawater intake alternatives (SIGs and screened ocean intakes) described above, the salient question for the proposed Huntington Beach desalination plant is whether a SIG is clearly environmentally superior at minimizing the intake and mortality of marine life compared to a 1mm screened ocean intake. In order to answer this question scientifically, the following report systematically examines 1) the overall status of scientific knowledge regarding the environmental impacts of both screened ocean intakes and SIGs in general, 2) the site-specific environmental impacts for both intake types at the Huntington Beach location, and 3) the impacts of screened ocean intakes relative to large-scale anthropogenic impacts such as climate change and over-fishing.

● Part 1: The I&E impacts from screened open-ocean intakes are quantifiable, well studied, and do not significantly affect source populations.

Pursuant to the requirements of the Desalination Amendment (SWRCB 2015), impingement (the entrapment of larger organisms against the intake screen) will not constitute a significant environmental impact for modern desalination plants. The Amendment requires the reduction of intake flow velocities to speeds of 0.5 feet per second or less. At such speeds, almost all organisms larger than the intake screen mesh are able to avoid becoming permanently impinged. Nevertheless, entrainment of planktonic organisms small enough to fit through intake screens occurs, and constitutes the primary environmental impact of desalination intakes. But what is the overall impact of screened ocean intake entrainment?

Various methods have been developed to accurately quantify entrainment rates. The methodology of these studies typically consists of comprehensive biological surveys coupled with well-established ecological modeling techniques (for example: Adult Equivalent Loss, Fecundity Hindcasting, and Empirical Transport Models) (Ehrler et al. 2002; Hogan 2015). Such studies have shown that entrainment from ocean intakes generally results in low (typically 1% or less) proportional mortality values (that is, the mortality of eggs and larvae killed via entrainment relative to the number of eggs and

larvae produced by the source population of a given species). Given the extremely high natural mortality rates of eggs and larvae (Bailey & Houde 1989), proportional mortality values such as those caused by desalination plant entrainment are not thought to significantly affect the overall sustainability of the source populations (Barnthouse 2013).

Most studies of entrainment have been conducted for power plant intakes, and are reported in industry literature – including environmental impact assessments, technical memos, and the like. However, many peer-reviewed studies of open-ocean intake I&E impacts exist as well. Barnthouse (2013) recently conducted a review of over 50 peer-reviewed scientific journal articles on this subject, and found that the proportional mortality values reported therein were generally in agreement with industry results. Barnthouse summarizes the results of this review, published in the journal "Environmental Science & Policy", with the following statement:

> *"The clear conclusion from the review is that any impacts caused by impingement and entrainment are small compared to other impacts on fish populations and communities, including overfishing, habitat destruction, pollution, and invasive species."*

● I&E impacts from a screened ocean intake at the proposed Huntington Beach desalination plant are minimal, and can be successfully mitigated.

Several studies of I&E impacts have been conducted specifically for the Huntington Beach Generating Station ("HBGS") and the proposed desalination facility at Huntington Beach. Tenera (2011) assessed I&E effects from operation of the proposed Huntington Beach desalination facility in permanent stand-alone mode. This report made the following conclusions:

1) Impingement values would be very low (~ 0.5 lbs. of fish daily), and not significant ecologically or economically.

2) The assemblage of larval fishes and shellfishes in the nearshore ocean environment off of Huntington Beach is less diverse than other nearby coastal areas.
3) No threatened or endangered species were found in entrainment surveys conducted at the desalination plant site, and the potential entrainment of commercially or recreationally valuable species would be very uncommon.
4) The most abundant taxon of larval fish entrained (32%) was gobies - a small, bottom-dwelling type of fish with no commercial value.
5) The proportional mortality of larvae potentially entrained ranged from **0.01-0.23%** of the source water populations.
6) The impacts of entrainment at the Huntington Beach desalination facility in permanent stand-alone mode would *not be significant.*

It is important to note that the above study (Tenera 2011) was conducted assuming the use of the existing ocean intake structure at HBGS, whereas Poseidon proposes the addition of a 1mm (1/25th of an inch) slot size traveling screen to further reduce I&E impacts at this facility. This complies with the Desalination Amendment, which states that, “the effectiveness of [screened intakes] in reducing entrainment is a function of the screen slot size. Mesh screen slot sizes of 0.5 mm to 1.0 mm are required for effective screening for many species at early life stages.” The Desalination Amendment allows for only a 1 percent reduction in the final estimate of mitigation requirements for projects that incorporate a 1 mm screen into the intake design. A 1 mm screen would likely reduce actual entrainment to values substantially lower than those reported by these sources.

Additional factors indicate that Huntington Beach is an ideal location for the use of a screened ocean intake. A review of power plant I&E impacts (SWRCB 2010) indicates that the coastal waters off Huntington Beach have the lowest larval fish concentrations of any of the intake locations that have been studied in southern California (Figure 1). Tenera (2015a) reported that the abundance and species composition of ichthyoplankton (i.e., fish eggs and larvae) offshore of Huntington Beach was consistent in surveys conducted over 10 years apart. Thus, the Huntington Beach location has

consistently low larval abundance and diversity in near-shore waters, further minimizing potential I&E impacts from an open-ocean intake.

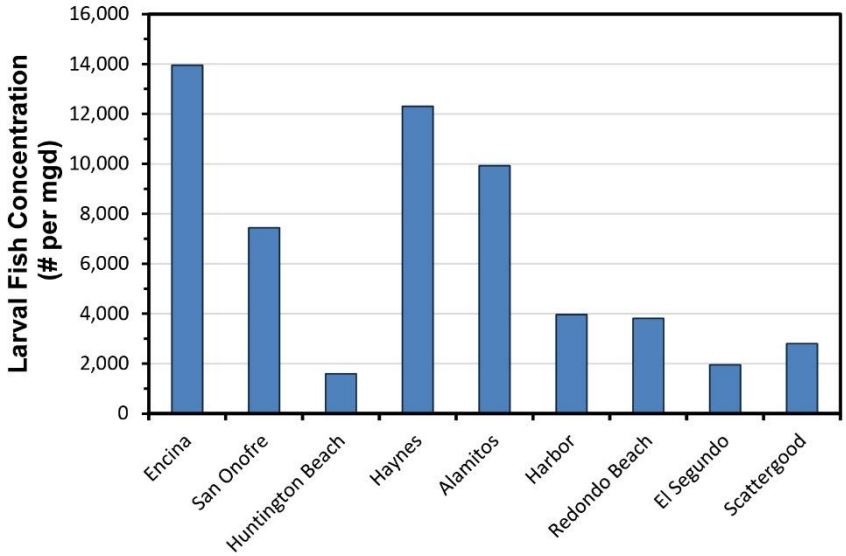

Figure 1. Relative larval fish concentrations at various power plant locations in California (SWRCB 2010)

In summary, the following important points can be made about the proposed ocean intake scenario at Huntington Beach:

1) I&E values (numbers of organisms entrained, and species affected), as well as overall population-level impacts (i.e., proportional mortality) for open-ocean intakes can be quantified with a high degree of accuracy. As will be shown below, this is in stark contrast to the potential impacts of SIGs, which are currently *unquantifiable* due to lack of data.
2) I&E impacts at Huntington Beach have been assessed, and shown to be minimal.
3) Huntington Beach is an ideal location for an ocean intake, due to consistently low larval fish abundance in nearshore waters.
4) At Huntington Beach, the use of a 1 mm screened intake will likely further reduce I&E impacts beyond what has been reported above.

Finally, it should be noted that I&E impacts can be *successfully mitigated*. For example, a desalination plant operator may be tasked with maintaining, restoring or creating new wetland habitat to compensate for lost production by entrained larvae of marine species (Foster et al. 2013). At Huntington Beach, mitigation requirements for the proposed desalination plant in permanent stand-alone mode have been assessed, based upon the guidance for calculating the Area of Production Foregone (APF) found in the Desalination Amendment. The final estimate of required wetland habitat restoration (including the 1% reduction for screened intake) is 16.9 acres (Tenera 2015b).

● **Part 2: Seafloor Infiltration Galleries – What are they and how do they work?**

As described above, environmental impacts resulting from ocean intakes can be accurately quantified, are well studied, and generally shown to have minimal population-level impacts (Barnthouse 2013). How does this compare to the use of a SIG? The following section will introduce the concept and physical design of a SIG, and examine the potential environmental impacts resulting from the use of a SIG at the proposed Huntington Beach desalination plant.

Physical design. A seafloor infiltration gallery is a series of man-made, slow sand media filtration beds located at the bottom of the ocean in a stable offshore location not subject to sediment erosion or deposition. The filtration beds are connected to a series of intake wells located on the shore (Figure 2). Pumps are used to create suction that draws ocean water through the benthos, and subsequently through increasingly larger diameter granular media overlying the intake pipes, effectively filtering the water of much particulate material before it enters the desalination plant (Pankratz 2015) (Figure 3).

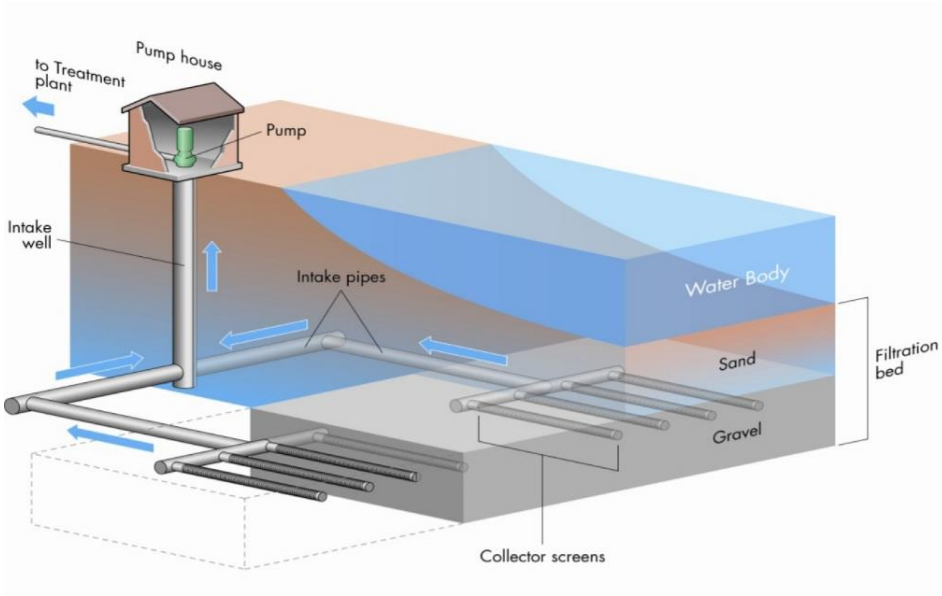

Figure 2 – Overview of a generalized Seafloor Infiltration Gallery (from Voutchkov 2010).

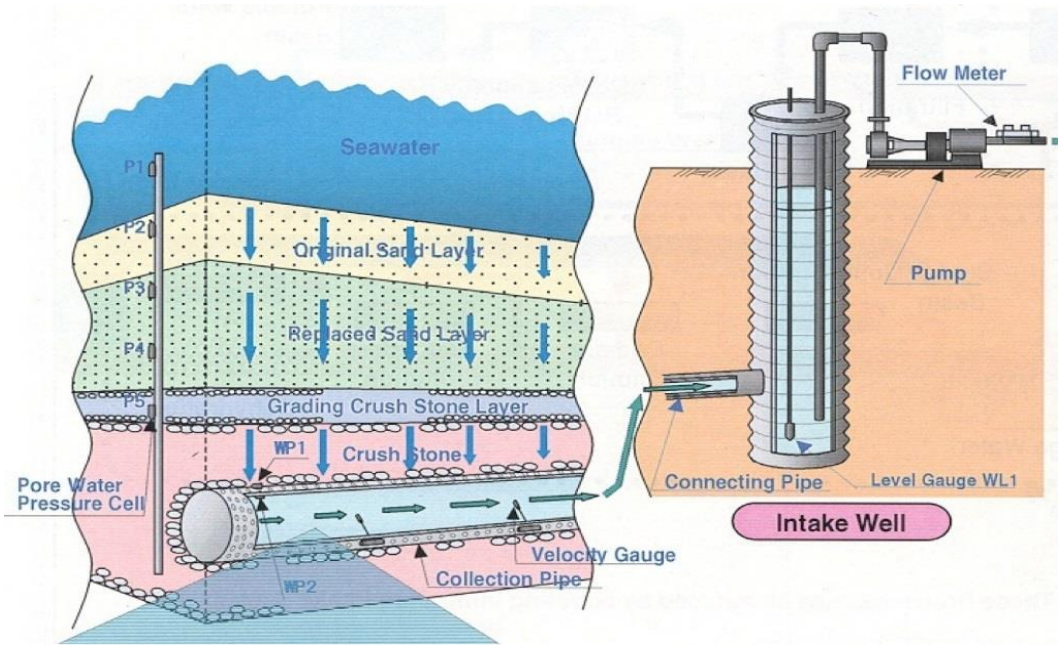

Figure 3 – Cross-section of a generalized Seafloor Infiltration Gallery (from Voutchkov 2010).

The concept of using SIGs as a water intake technology for desalination plants is relatively novel. There are over 6,000 seawater desalination plants presently operating worldwide, and only one (located in Fukuoka, Japan) utilizes a SIG (ISTAP 2014). As discussed below, there are no data on marine life impacts available for this location. The technological appeal of SIG intakes is that they are purported to strain organic matter, suspended sediment, and dissolved organic compounds from the source water before these impurities can enter the desalination plant and reduce the efficiency of reverse osmosis membranes upon which the desalination process depends.

● Proponents of SIGs assert that I&E impacts are 'virtually eliminated'.

Several authors have, without corroborating scientific data, made assertions with regards to reduced environmental impacts of SIGs relative to more commonly used methods such as screened ocean intakes. For example:

"Since the seawater is filtered through granular media [referring to SIG], entrainment of smaller marine organisms is eliminated." (Water Research Foundation 2011)

"Subsurface intakes provide several important advantages. By using sand and sediment as a natural filter, they virtually eliminate impingement and entrainment." (Cooley et al. 2013)

Quite importantly in the context of this report, *the Desalination Amendment specifically cites these uncorroborated references and others on page 64, as evidence that SIGs eliminate I&E impacts:* "Subsurface intakes collect water through sand sediment, which acts as a natural barrier to organisms and thus eliminates impingement and entrainment (MWDOC 2010; Missimer et al. 2013; Hogan 2008; Pankratz 2004; Water Research Foundation 2011)."

●The perception that SIGs eliminate I&E is not supported by science.

This widespread perception that SIGs eliminate I&E is troubling, in view of the fact that the above studies *in no way* attempted to quantify, experimentally or through modeling,

I&E impacts resulting from SIG use. Rather, these articles (of which only one is peer-reviewed) were focused on describing the technological and economic feasibility of SIGs (particularly the Missimer et al. (2013) reference, which is one of the most often cited references with regards to SIG elimination of I&E impacts), or are simply reviews of previous reports. The Hogan (2008) reference is an unpublished conference abstract, and useless as a valid reference. The MWDOC (2010) reference is a memo estimating I&E impacts of *slant wells*, not SIGs, and utilizes in its calculations a vertical infiltration rate approximately 4X weaker than the estimated vertical infiltration rate calculated for a SIG at Huntington Beach; it is also not peer reviewed. The salient point with regards to these references is this: *In no cases are supporting data given, or referenced, with regards to I&E reduction*. These claims are simply assertions made without scientific justification or peer review.

● I&E Impacts from the use of a SIG at Huntington Beach are largely unknown, and potentially larger than previously thought.

The California Coastal Commission is now considering permitting the proposed Huntington Beach desalination plant. In 2013 the Commission staff recommended approval of the project *using a SIG seawater intake system*, because the SIG was thought to be environmentally superior to Poseidon's proposed screened ocean intake. But what is really known about the potential environmental impacts of SIGs at a location such as Huntington Beach? Below, this report reviews the potential mechanisms by which SIGs might reduce I&E, examines the currently available data, and discusses how they relate to environmental impacts.

The rationale behind the concept that SIGs will reduce or eliminate I&E is relatively straight forward: granular media overlying the intake pipes is presumed to act as a barrier to planktonic organisms, and the speed at which water flows into the granular media is thought to be too slow to entrain or impinge these organisms. However, the speed at which water will enter granular media (i.e., vertical infiltration rate) is somewhat variable, depending upon water production rates, suction forces, the size of the infiltration gallery, etc. (The estimated vertical infiltration rate for a SIG at the proposed

desalination plant at Huntington Beach is approximately 1.5 x 10^{-4} ft per second). None of these properties have been studied or verified in relationship to the proposed Huntington Beach 50 MGD facility.

Moreover, there are no studies or models that conclusively demonstrate that SIGs would not impinge or entrain planktonic organisms. At the proposed Huntington Beach desalination plant, production of 50 MGD freshwater would require a daily intake of 106 MGD through a SIG. Considering this large volume of intake water being drawn into the infiltration bed, it is reasonable to hypothesize that planktonic organisms smaller than the size of the interstitial spaces between sand media particles could potentially be entrained. Dehwah & Missimer (2013) note that SIGs would require a periodic cleaning of the uppermost layer of the sand media by raking or sand removal, to remove clogging materials accumulated within the bed. There are no studies that have examined the obvious possibility that at least some percentage of those clogging materials are entrained planktonic organisms. In addition, the ISTAP (2015) Phase 2 Report recognizes the potential for SIG-induced entrainment at Huntington Beach, characterizing entrainment impacts as 'minor' (despite the complete absence of any data at this site that could be analyzed to reach this conclusion or quantify such impacts).

Larger planktonic organisms could be immune from SIG-induced entrainment into the sand media, simply on the basis of size exclusion. However, this does not eliminate the possibility of *impingement upon* the sand media. To date, there are no studies that have experimentally examined sand media impingement of planktonic organisms at flow rates similar to those that would occur for seawater desalination at Huntington Beach, or even estimate the potential for impingement in any meaningful way. For certain types of subsurface infiltration galleries, such as beach galleries, it has been suggested (but not verified) that turbulent forces would be large enough to overcome suction forces, thus scouring planktonic organisms off the benthos and preventing permanent impingement (Jenkins 2010). However, the center of a SIG array at the Huntington Beach location would be located at least 2900 ft from shore (Figures 4 and 5). The bathymetry at

Huntington Beach is such that, at this distance from shore, the SIG would be approximately 40 ft. below the ocean surface – it is unlikely that turbulence at this depth would be strong enough to scrub impinged biota off the seabed.

Even presupposing that typical turbulent forces over the seabed are strong enough to dislodge impinged planktonic organisms, this does not eliminate the possibility of multiple, temporary impingements as a planktonic organism drifts across the inflow field, which would be over 2000 ft in length in the case of the proposed Huntington Beach SIG (Figures 4 and 5). Survival rates of impinged organisms vary among species, but are largely a function of body size (Hogan 2015) and exposure to turbulence (e.g. Jessopp 2007; Rehmann et al. 2003). These factors suggest the possibility of multiple impingement-induced injury and mortality resulting from SIG use at Huntington Beach.

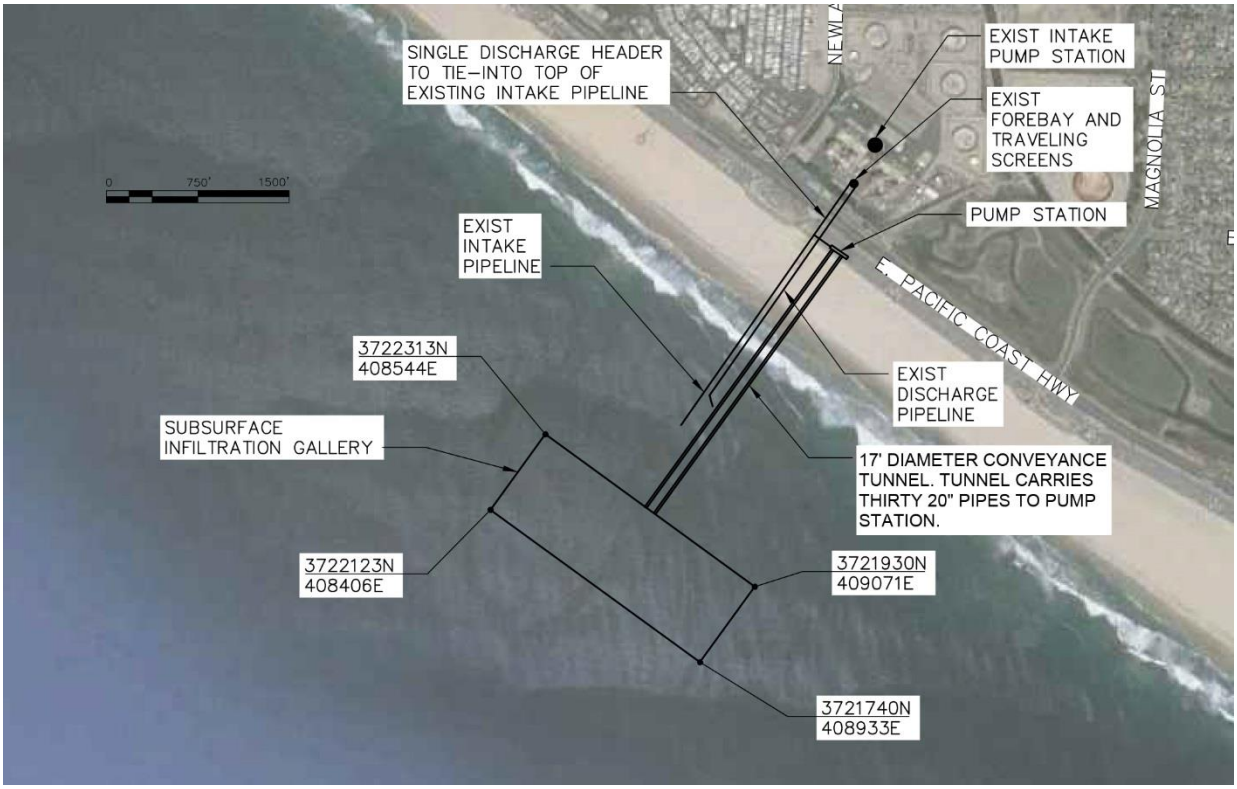

Figure 4. Aerial Map of proposed SIG location offshore of Huntington Beach.

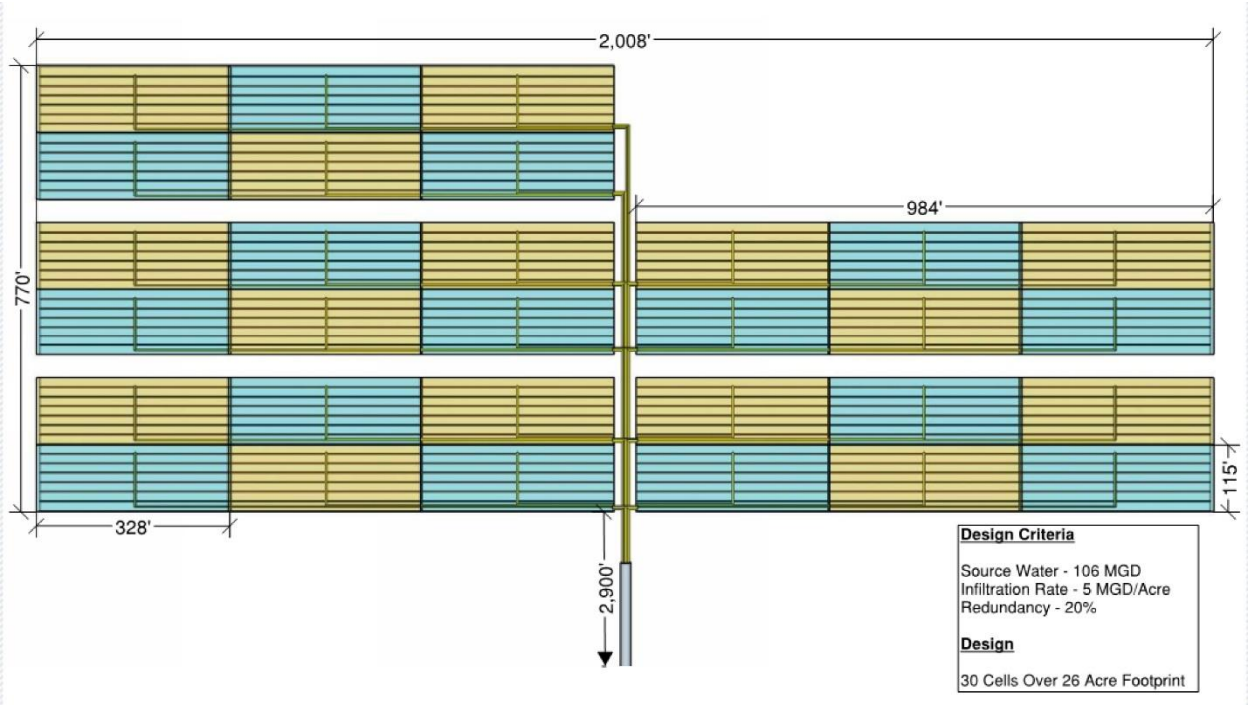

Figure 5. Schematic of proposed SIG design at Huntington Beach.

● A SIG array at Huntington Beach would negatively impact benthic habitat.

Prevailing state environmental regulations for seawater desalination plants require that the technologies employed *"minimize the intake and mortality of all forms of marine life."* With this in mind, it is important to note that SIGs have the potential to introduce large-scale, negative impacts to near-shore benthic habitat at Huntington Beach, resulting in significant mortality of marine life. To begin with, the construction of a SIG at Huntington Beach would require extensive seafloor excavation (ISTAP 2015). SIG construction would require the removal of approximately 400,000 cubic yards of seafloor over an area of 25.4 acres of benthos (at minimum), in order to install an intake bed with dimensions of 2,008 ft length, 770 ft width, and to a depth of 6 ft. The subtidal sandy bottom found offshore of Huntington Beach provides important habitat for infaunal invertebrates and fishes (Tenera 2015c), as well as critical nurseries for commercially valuable fish species such as California halibut (Fodrie & Mendoza 2006; Fodrie & Levin 2007). SIG construction would necessarily entail the destruction of all benthic habitat

and associated organisms in the work zone, and likely disrupt neighboring habitat through turbidity plumes generated by construction.

SIG disruption of benthic habitat at Huntington Beach would not be a one-time only occurrence. Once the SIG is in operation, greatly altered conditions would characterize the new benthic habitat overlying the intake pipes, including unnatural vertical suction forces and possibly artificial granular media. It is unknown whether benthic organisms would be able to recolonize this habitat following the initial excavation, or how the altered habitat would affect basic biological processes such as feeding and reproduction. Even assuming successful recolonization, routine SIG maintenance would involve periodic removal of the filter bed surface, disrupting if not destroying any newly established populations of benthic organisms (ISTAP 2015).

Tenera (2015c) quantified the potential environmental impacts of a SIG at Huntington Beach. These authors estimated significant mortality of benthic organisms due to SIG construction impacts: "construction of the SIG would result in the initial loss of 977 million infaunal invertebrates, 277 epifaunal invertebrates, 7,891 demersal invertebrates, and 59,221 demersal fishes." They also noted that long-term (i.e., post-construction) impacts are difficult to quantify because there are currently no data available to assess the probability that impacted benthic communities will recover and function properly following initial destruction of benthic habitat for SIG construction. In comparing the impacts of SIGs versus entrainment impacts from the use of an ocean intake at Huntington Beach, they conclude: *"…entrainment losses do not result in any impacts on habitat and are not likely to ever affect the adult populations of the entrained taxa. In contrast, the construction, maintenance, and operation of a SIG will result in actual destruction of habitat, organisms, and all of the associated ecological services."*

● SIGs are not environmentally superior at Huntington Beach, and have never been used at flow rates comparable to those proposed for the Huntington Beach desalination plant.

There is no comparable scientific basis for the conclusion that a SIG would be environmentally superior at Huntington Beach, since they have never been operated at a scale comparable to the water intake rates (>100 MGD) required for the proposed desalination plant at Huntington Beach. Currently, there is only one relatively large-scale desalination plant in the world that utilizes SIG intakes. This is the Fukuoka desalination plant in Japan, which has a total intake flow of only 27 MGD. There have been no studies (published or otherwise), or even industry literature, that attempt to quantify I&E or benthic impacts resulting from SIG use at this facility. On a considerably smaller scale (but more locally relevant), a 0.3 MGD experimental desalination plant utilizing SIG technology has been operating in Long Beach, CA for almost 10 years. Again, no studies have been conducted to examine its environmental impacts (Yan Zhang, Long Beach Water Department, Personal Communication).

● **Several Peer-Reviewers of the Desalination Amendment text expressed concerns about the purported 'environmental superiority' of SIGs.**

Appendix I of the Desalination Amendment (Responses to External Scientific Peer Review Comments) contains the comments of several scientists who critically reviewed the document. Of the six reviewers who addressed the use of SIGs in their comments, three expressed concerns that mirror the subject matter of this report, calling into question the lack of data to conclude the environmental superiority of SIGS as compared to ocean intakes:

1) Ben Hodges, PhD (University of Texas at Austin):

"the statement in Conclusion 2 that "subsurface seawater intakes will minimize impingement and entrainment of marine life," is not precisely correct. It would be better to state that such methods will reduce impingement and entrainment…"

2) Nathan Knott, PhD (NSW Department of Primary Industries, Australia):

[SIGs are] “unlikely to draw large animals into the sediments or the system itself (e.g., adult and juvenile fish). Nevertheless, I would like to see more information provided on whether this is the case – presumably no field studies on associated impacts exist.” “Missimer et al. (2013) suggests that far less plankton (e.g., bacteria, algae and larvae) are drawn into the desalination system when using subsurface intake systems. This may be the case, but it is likely that many micro-organisms (e.g., plankton) are still drawn into the sediments and trapped there.”

“Overall this system [SIGs] seems promising, though I feel more targeted research on the ecological implications needs to be carried out. For example, I would suspect that the drawing of water through sandy sediments would change the infaunal community substantially.”

3) Lisa Levin, PhD (Scripps Institution of Oceanography):

“Subsurface seawater intake construction and operation will have ecological impacts but there appear to be no studies of these. How will water overlying the intake bottom be affected and will intake drawdown rates be slower than swim speeds of larvae?”

“Often the assumption is made that shallow, nearshore, sand-covered seabed is more or less expendable, but it does serve important ecological functions. For example, subtidal sands provided habitat for infaunal invertebrates fed on by demersal fishes, or as nursery grounds (e.g., for CA halibut – Fodrie and Levin, 2007).”

“Water sucked downward through sediments will involve some loss of invertebrates and fishes – as larvae and adults – and thus loss of ecosystem services. Although they will be localized, these should be quantified and compared to losses from other sources.”

● Part 3: The magnitude of environmental impacts related to a desalination plant screened ocean intake is inconsequential relative to other anthropogenic impacts.

As stated above, a review of the industry and peer-reviewed journal literature indicates that entrainment of eggs and larvae into the open-ocean intakes of desalination plants does not significantly impact source populations of fish and invertebrates in coastal California waters, with typical proportional mortality values of 1% or less. By contrast, these organisms are subject to a wide range of other anthropogenic threats whose magnitude is far greater than any population-level threat posed by ocean intake entrainment, including over-fishing, ocean acidification, climate change, pollution, and habitat degradation (to name but a few). A comprehensive review of these anthropogenic threats is beyond the limited scope of this report. Below, this report provides examples of just some of these threats, specific impacts that have been identified for each, and when possible, a quantification of the mortality incurred by a particular species due to the threat.

Coastal habitat destruction: The ISTAP (2015) Phase 2 Report indicates that coastal wetlands would be negatively impacted by the prolonged (up to 7 years) construction of a SIG at Huntington Beach. Wetlands function as nursery areas for many commercially important fish and invertebrate species. Southern California has already lost close to 90 percent of its original coastal wetland habitat as a result of filling or dredging during the last century. This in turn greatly decreases the populations of marine species that use these areas as nurseries, as well as the amount of eggs and larvae released into the ocean by such species. For example, for the common sole *Solea solea* – (a flatfish), loss of wetlands nursery habitat is estimated to have led to an (up to) 36% loss in local population size (Rochette et al 2010).

Climate change: Increases in the temperature of the ocean are expected to have several major oceanographic consequences that directly impact zooplankton (i.e., eggs and larvae) in CA waters. For example, ocean warming will lead to increased stratification of the water column, which in turn will decrease upwelling of nutrient-rich

cold water that normally is transported into coastal waters. This is expected to decrease coastal productivity (i.e., phytoplankton, the major food source of zooplankton, will decrease). Although the net effects are difficult to quantify at present, it is likely that this process will decrease the survivorship of zooplankton, and therefore negatively impact adult fish and invertebrate populations, as well as the coastal fisheries dependent upon them. In addition, increased stratification will keep oxygen from the atmosphere from mixing into deeper waters – this oxygen limiting effect has already been linked to an over 60% decrease in some deepwater fish populations (Koslow et al. 2011).

Over-fishing: The impacts of overfishing have been devastating around the world. In California waters, there are numerous examples of precipitous declines in population sizes of various species as a result of over-exploitation. Some examples include:

- Pink abalone, *Haliotis corrugata* (a species of concern to desalination regulatory agencies) is currently only 0.1% of its historical population size in CA waters due to overfishing (Coates et al. 2013).
- Giant sea bass, *Stereolepis gigas*, are critically endangered, with population levels less than 10% of normal levels due to over-fishing (Chabot et al. 2015).
- The collapse of sardine and anchovy populations in CA waters has been linked to over-fishing; these effects are likely exacerbated by human-induced climate change (Lindgren et al. 2013).

Ocean acidification: As a result of increased carbon emissions by human industrial activity, the world's oceans are becoming measurably more acidic. Ocean acidification is of grave concern because it will decrease the ability of shell-building organisms to incorporate calcium carbonate into their bodies. For example, zooplankton like foraminifera (a key food species for many organisms that form the basis of the food chain) could decrease in abundance by over 40% in coming decades (Roy et al. 2015). This is also likely to be the most important change in benthic habitats over the coming century, as many benthos inhabitants, such as clams, are shell-builders. For example, shellfish hatcheries in the Pacific Northwest are reporting losses of up to 25% yield attributable to measurable decreases in seawater pH (Barton et al. 2015).

Hofman et al. (2014) review the potential effects of acidification on CA zooplankton species such as the bay mussel, *Mytilus trossulus,* and the purple sea urchin *Strongylocentrotus purpuratus*, and concluded that these species will be negatively impacted in terms of growth rate, development, reproduction, or other biological parameters critical to survival.

Because of the large number of co-occurring anthropogenic impacts, it is difficult to estimate with precision the magnitude of population level decrease that is attributable to any one source. However, it is quite clear that these changes will be *orders of magnitude greater* than any small impacts due to ocean intake entrainment from discrete desalination operations.

● CONCLUSION: A seafloor infiltration gallery is not environmentally superior to a screened ocean intake for minimizing the intake and mortality of marine life at the proposed Huntington Beach desalination plant.

This report has examined the overall body of scientific knowledge regarding the environmental impacts of both SIGs and screened ocean intakes in general, as well as the potential environmental impacts for both intake types that are specific to the Huntington Beach location. The findings of this report can be summarized as follows:

1) Screened ocean intakes in general have well-known, minimal environmental impacts that can be accurately quantified for mitigation purposes. In contrast, there are currently no data available *whatsoever* with which to assess potential environmental impacts resulting from the use of SIGs. As a result, potential SIG environmental impacts may be greatly underestimated.

2) At Huntington Beach, I&E resulting from the use of a screened ocean intake has already been investigated, and shown to have insignificant population-level impacts. In contrast, potential I&E impacts from SIG use at Huntington Beach are unknown.

3) A screened ocean intake will have no benthic impacts at Huntington Beach, whereas the construction and operation of a SIG at this location will have extensive benthic impacts resulting in marine life mortality.

4) Screened ocean intakes are a proven technology, whereas the use of SIGs has never been attempted in an oceanographic setting or on a scale similar to that proposed for the Huntington Beach desalination plant.

5) Several Peer-Reviewers of California's Desalination Amendment expressed concerns about the purported ‘environmental superiority’ of SIGs.

6) Huntington Beach is an ideal location for an ocean intake due to low larval fish abundance and diversity in nearshore waters. Additionally, Poseidon’s proposed use of a 1 mm screened intake would further reduce I&E impacts.

7) The magnitude of adverse impacts from desalination plant ocean intake entrainment is inconsequential in comparison to other anthropogenic impacts.

In conclusion, there is no scientific evidence that a SIG located offshore of Huntington Beach would be environmentally superior to a 1mm screened ocean intake, and in fact the SIG’s construction and permanent benthic and I&E effects likely render it the environmentally inferior technology alternative at this site.

Note: Please see Appendix A for an abbreviated version of this report that addresses *only* the issue of SIG environmental impacts. The cover page of Appendix A contains a list of scientists who have peer-reviewed the report, and *signed in agreement* with its overall conclusion that “Seafloor Infiltration Gallery (SIG) intakes have not been demonstrated to be effective at minimizing intake and mortality of marine life. There is no scientific justification for the assertion that SIGs will eliminate impingement and

entrainment of planktonic organisms at the proposed Huntington Beach desalination plant site. In addition, the construction and operation of a SIG at this location may have extensive and deleterious impacts to benthic habitat and organisms.**"**

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Appendix A

Supplementary Report: "No Evidence that a Seafloor Infiltration Gallery (SIG) Intake Will Minimize Intake and Mortality of Marine Life at a Proposed Desalination Plant in Huntington Beach, CA."

Appendix A (following pages) is an abbreviated version of the preceding report, that addresses *only* the issue of potential SIG environmental impacts at a proposed Huntington Beach desalination plant.

This supplementary report was peer-reviewed by a number of scientists, who have ***signed in agreement*** with its overall conclusion, which states:

"Seafloor Infiltration Gallery (SIG) intakes have not been demonstrated to be effective at minimizing intake and mortality of marine life. There is no scientific justification for the assertion that SIGs will eliminate impingement and entrainment of planktonic organisms at the proposed Huntington Beach desalination plant site. In addition, the construction and operation of a SIG at this location may have extensive and deleterious impacts to benthic habitat and organisms."

Scientist	**Affiliation**
Ngai Lai, PhD	University of California, San Diego
Dovi Kacev, PhD	National Marine Fisheries Service
Helena Arayfar, MS	National Marine Fisheries Service
Michael Kinney, PhD	National Marine Fisheries Service
Mary Blasius, MS	California State University, Long Beach
Kristy Forsgren, PhD	California State University, Fullerton
Robert Rubin, PhD	Santa Rosa Junior College
Marcus Drymon, PhD	University of South Alabama
Darin Topping, PhD	Texas Parks and Wildlife Department
Justin Krebs, Ph.D.	AKRF Consulting
Omar Santana, MS	ECOCIMATI Conservation Group
William Watson, PhD	N/A
Greg Hoisington, MS	URS Corp. Biological Consultants
Jeremy Vaudo, PhD	Florida International University

No Evidence that a Seafloor Infiltration Gallery (SIG) Intake Will Minimize Intake and Mortality of Marine Life at a Proposed Desalination Plant in Huntington Beach, CA

Daniel Cartamil, PhD

Scripps Institution of Oceanography,
Cartamil Environmental Consulting

Prepared for: Orange County Water Independence Sustainability & Efficiency (OC WISE)

OC WISE is a diverse coalition of associations, labor, community groups, young people organizations, business and non-profit organizations united to support and advocate for all forms of new local water for Orange County. The coalition was formed as a direct response to both the unpredictability of the County's water supply and the need to develop new local supplies of water capable of ensuring sustainable water for the County.

In supporting development of the proposed Huntington Beach desalination facility, OC WISE is mindful of the debate over the viability of a seafloor infiltration gallery (SIG) intake at the site, and whether there is scientific data supporting the assertion that a SIG is the environmentally superior intake for the facility. Accordingly, OC WISE commissioned this report.

OC WISE members include: Association of California Cities-Orange County; Huntington Beach Chamber of Commerce; LA-OC Building and Construction Trades Council; League of United Latin American Citizens (LULAC), Millennials for New Water UCI; Orange County Young Democrats (OCYD); Orange County Association of Realtors; Poseidon Water; South Orange County Economic Coalition.

● Introduction

In response to the pressures of climate change, drought, a growing population, and dwindling water supplies, seawater desalination is poised to become an important source of potable water in California. The state's first large-scale desalination plant recently started commercial production of 50 MGD (Millions of Gallons per Day) in the city of Carlsbad. In addition, the city of Santa Barbara is expected to re-commission its desalination facility in 2016, while Oxnard and San Luis Obispo also plan to develop facilities on the southern California Coast. Poseidon Water, the developer of the Carlsbad facility, has proposed to construct a new 50 MGD desalination plant at Huntington Beach, CA; the permitting of this facility is now pending before the California Coastal Commission. This report is specifically concerned with the environmental impacts resulting from *water intake* at the proposed Huntington Beach plant.

From an environmental perspective, intake of large volumes of saltwater is potentially problematic because ocean water contains planktonic organisms, including the eggs and larvae of commercially important marine species. The principal environmental impacts of concern for water intakes are broadly categorized as impingement and entrainment (collectively referred to as "I&E"). *Impingement* is the entrapment of larger organisms against the intake's screening surface by the flow of the withdrawn water. *Entrainment* is the passage of smaller organisms through the screen. In addition, environmental impacts can include damage to benthic habitat and organisms resulting from intake construction and maintenance.

California environmental regulations (specifically, the recently adopted "Desalination Amendment"; SWRCB 2015) stipulate that new desalination plants should utilize *"the best available site, design, technology, and mitigation measures… to minimize the intake and mortality of all forms of marine life."* In addition, the Desalination Amendment designates 'subsurface intakes' (those that withdraw seawater from below the surface of the seabed) as the best available intake technology, primarily because they are assumed to reduce or eliminate I&E impacts.

The California Coastal Commission recently assembled a panel of experts (Independent Scientific & Technical Advisory Panel, or ISTAP) to analyze the feasibility of installing and operating a subsurface intake at the proposed Huntington Beach site. ISTAP's investigations (ISTAP 2014, 2015) indicated that, of the various subsurface intake technologies available, only one, a 'Seafloor Infiltration Gallery' (hereafter referred to as SIG), was technically viable at this location. However, due to the lack of scientific data supporting the environmental superiority of SIG intakes, there are legitimate concerns over the potential environmental impacts of a SIG at Huntington Beach. Therefore, this report seeks to lend scientific input to the SIG debate which can be used by regulators in understanding and addressing California's policy on preferred seawater intakes for desalination facilities.

Given the regulatory and environmental framework described above, the salient question this report addresses is the following: Is there scientific evidence to justify the use of a SIG intake as the 'best available technology' at Huntington Beach? In other words, have SIGs been demonstrated to perform the function of minimizing the intake and mortality of marine life, as mandated by CA law?

This report reviews all of the available information, and concludes the following: Seafloor Infiltration Gallery (SIG) intakes have not been demonstrated to be effective at minimizing intake and mortality of marine life. Currently, there is no scientific justification for the assertion that SIGs will eliminate impingement and entrainment of planktonic organisms at the proposed Huntington Beach desalination plant site. In addition, the construction and operation of a SIG at this location may have extensive and deleterious impacts to benthic habitat and organisms.

● **Part 1: Seafloor Infiltration Galleries – What are they and how do they work?**

Physical design. A seafloor infiltration gallery is a series of man-made, slow sand media filtration beds located at the bottom of the ocean in a stable offshore location not subject to sediment erosion or deposition. The filtration beds are connected to a series of intake wells located on the shore (Figure 2). Pumps are used to create suction that draws ocean water through the benthos, and subsequently through increasingly larger diameter granular media overlying the intake pipes, effectively filtering the water of much particulate material before it enters the desalination plant (Pankratz 2015) (Figure 3). The technological appeal of SIG intakes is that they are purported to strain organic matter, suspended sediment, and dissolved organic compounds from the source water before these impurities can enter the desalination plant and reduce the efficiency of reverse osmosis membranes upon which the desalination process depends.

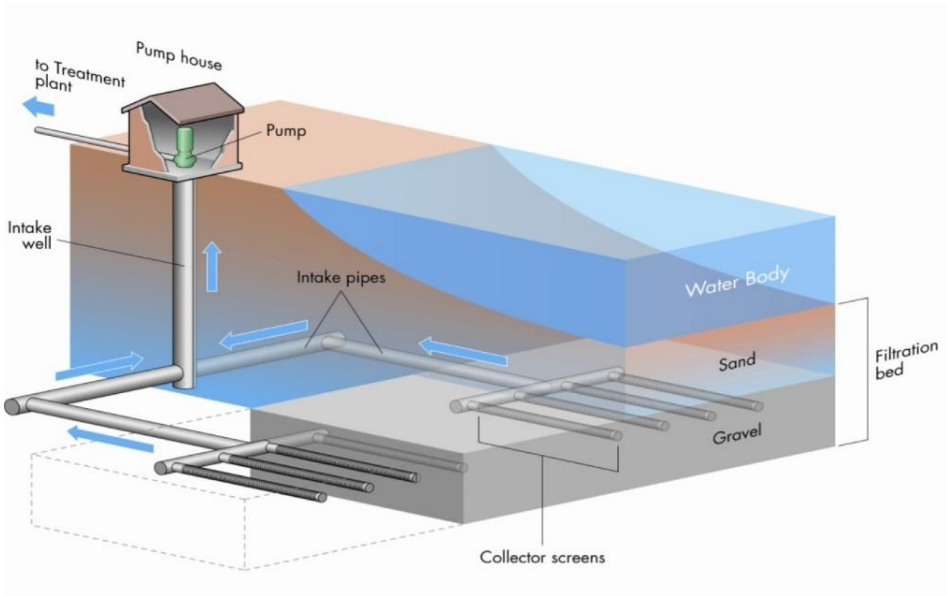

Figure 2 – Overview of a generalized Seafloor Infiltration Gallery (from Voutchkov 2010).

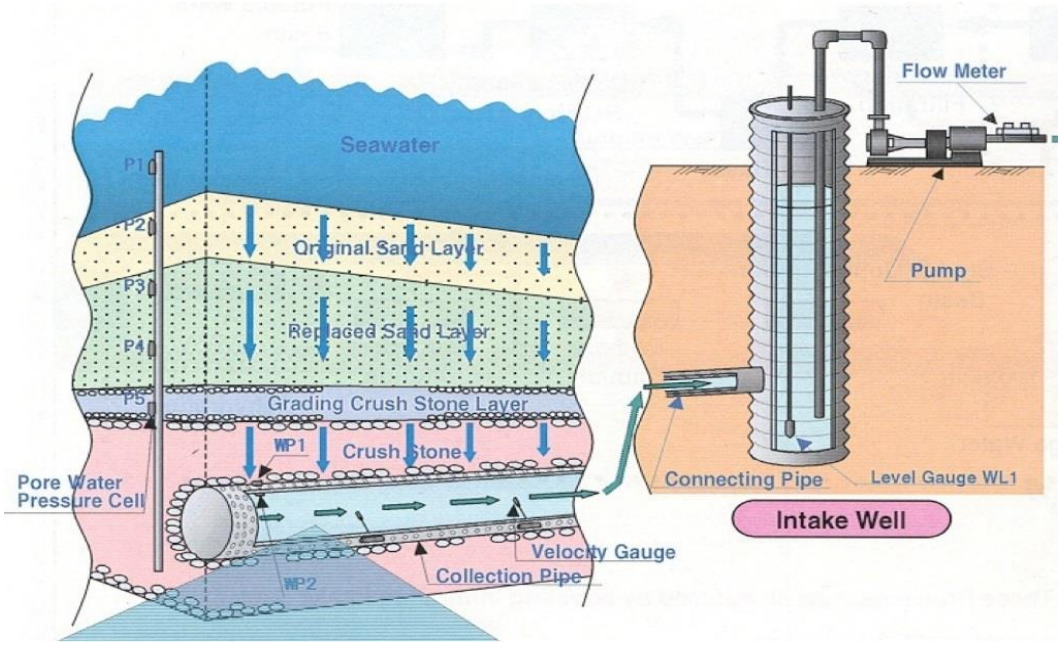

Figure 3 – Cross-section of a generalized Seafloor Infiltration Gallery (from Voutchkov 2010).

● Proponents of SIGs assert that I&E impacts are 'virtually eliminated'.

Several authors have made assertions with regards to reduced environmental impacts of SIGs relative to more commonly used methods such as screened ocean intakes. For example:

"Since the seawater is filtered through granular media [referring to SIG], entrainment of smaller marine organisms is eliminated." (Water Research Foundation 2011)

"Subsurface intakes provide several important advantages. By using sand and sediment as a natural filter, they virtually eliminate impingement and entrainment." (Cooley et al. 2013)

Quite importantly in the context of this report, *the Desalination Amendment specifically cites these references and others on page 64, as evidence that SIGs eliminate I&E impacts:* "Subsurface intakes collect water through sand sediment, which acts as a natural barrier to organisms and thus eliminates impingement and entrainment

(MWDOC 2010; Missimer et al. 2013; Hogan 2008; Pankratz 2004; Water Research Foundation 2011)."

●The assertion that SIGs eliminate I&E is not supported by science.

This widespread perception that SIGs eliminate I&E is troubling, in view of the fact that the above studies *in no way* attempted to quantify, experimentally or through modeling, I&E impacts resulting from SIG use. Rather, these articles (of which only one is peer-reviewed) were focused on describing the potential technological and economic feasibility of SIGs (particularly the Missimer et al. (2013) reference, which is one of the most often cited references with regards to SIG elimination of I&E impacts), or are simply grey-literature reviews. The Hogan (2008) reference is an unpublished conference abstract, and useless as a valid reference. The MWDOC (2010) reference is a memo estimating I&E impacts of *slant wells* (another type of subsurface intake), not SIGs, and utilizes in its calculations a vertical infiltration rate approximately 4X less than the estimated vertical infiltration rate calculated for a SIG at Huntington Beach; it is also not peer reviewed. The salient point with regards to these references is this: *In no cases are supporting data given, or referenced, with regards to I&E reduction*. These claims are simply assertions made without scientific justification.

● I&E Impacts from the use of a SIG at Huntington Beach are largely unknown, and potentially larger than previously thought.

What is known about the potential environmental impacts of SIGs at a location such as Huntington Beach? Below, this report reviews the mechanisms by which SIGs might reduce I&E, examines the currently available data, and discusses how they relate to environmental impacts.

The rationale behind the concept that SIGs will reduce or eliminate I&E is relatively straight forward: granular media overlying the intake pipes is presumed to act as a barrier to planktonic organisms, and the speed at which water flows into the granular media is thought to be too slow to entrain or impinge these organisms. However, the

speed at which water will enter granular media (i.e., vertical infiltration rate) is somewhat variable, depending upon water production rates, suction forces, the size of the infiltration gallery, etc. (The estimated vertical infiltration rate for a SIG at the proposed desalination plant at Huntington Beach is approximately 1.5×10^{-4} ft per second).

There are no studies or models that conclusively demonstrate that SIGs would not impinge or entrain planktonic organisms. At the proposed Huntington Beach desalination plant, production of 50 MGD freshwater would require a daily intake of 106 MGD through a SIG. Considering the enormous volume of intake water being drawn into the infiltration bed, it is reasonable to hypothesize that planktonic organisms smaller than the size of the interstitial spaces between sand media particles could potentially be entrained. Dehwah & Missimer (2013) note that SIGs would require a periodic cleaning of the uppermost layer of the sand media by raking or sand removal, to remove clogging materials accumulated within the bed. There are no studies that have examined the obvious possibility that at least some percentage of those clogging materials are entrained planktonic organisms.

Larger planktonic organisms could be immune from SIG-induced entrainment into the sand media, simply on the basis of size exclusion. However, this does not eliminate the possibility of *impingement upon* the sand media. To date, there are no peer-reviewed studies that have experimentally examined sand media impingement of planktonic organisms at flow rates similar to those that would occur for seawater desalination at Huntington Beach, or even estimated the potential for impingement in any meaningful way. For certain types of subsurface infiltration galleries, such as beach galleries, it has been suggested (but not verified) that turbulent forces would be large enough to overcome suction forces, thus scouring planktonic organisms off the benthos and preventing permanent impingement (Jenkins 2010). However, the center of a SIG array at the Huntington Beach location would be located at least 2900 ft from shore (Figures 4 and 5). The bathymetry at Huntington Beach is such that, at this distance from shore, the SIG would be approximately 40 ft. below the ocean surface – it is unlikely that turbulence at this depth would be strong enough to scrub impinged biota off the seabed.

Even presupposing that typical turbulent forces over the seabed are strong enough to dislodge impinged planktonic organisms, this does not eliminate the possibility of multiple, temporary impingements as a planktonic organism drifts across the inflow field, which would be over 2000 ft in length in the case of the proposed Huntington Beach SIG (Figures 4 and 5). Survival rates of impinged organisms vary among species, but are largely a function of body size (Hogan 2015) and exposure to turbulence (e.g. Jessopp 2007; Rehmann et al. 2003). These factors suggest the possibility of multiple impingement-induced injury and mortality resulting from SIG use at Huntington Beach.

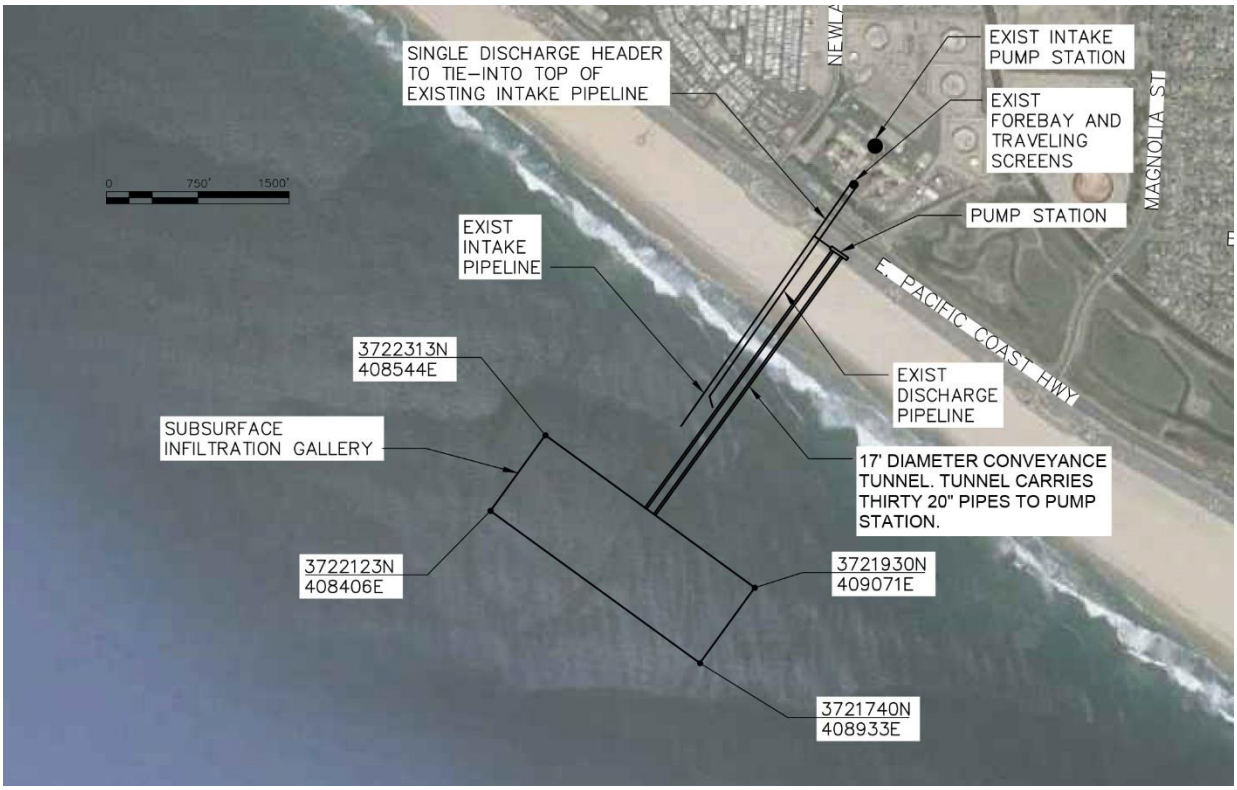

Figure 4. Aerial Map of proposed SIG location offshore of Huntington Beach.

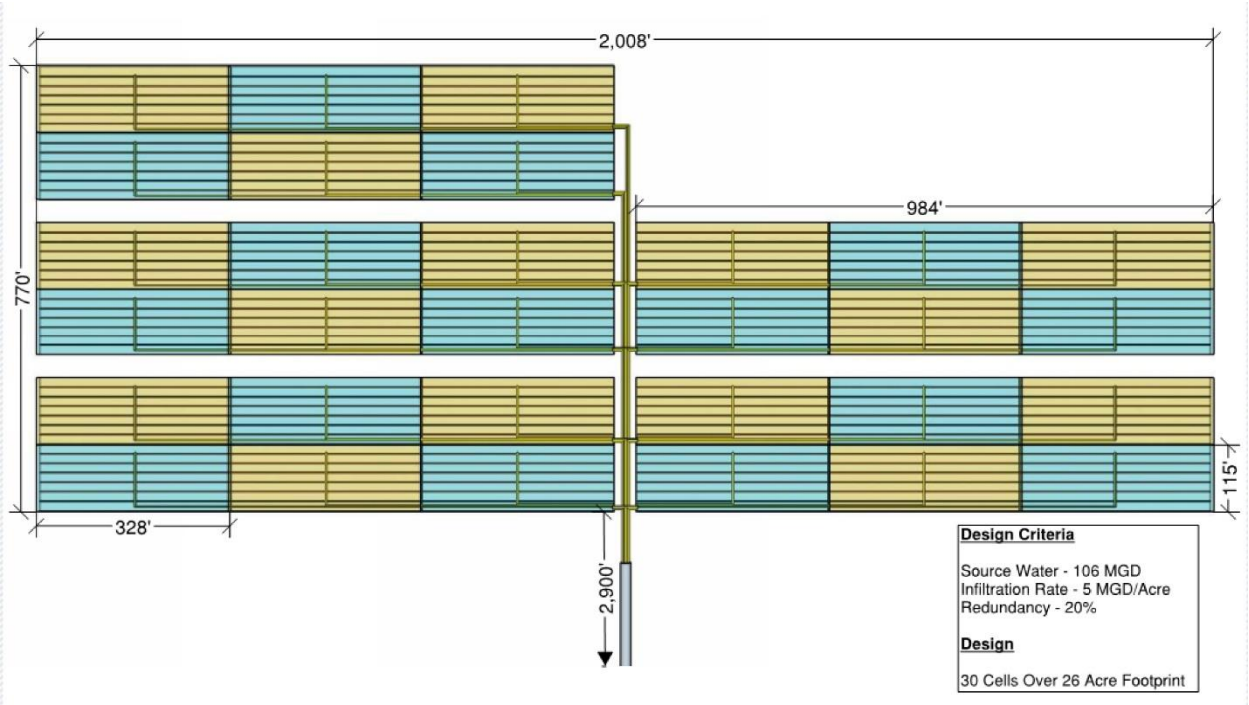

Figure 5. Schematic of proposed SIG design at Huntington Beach.

● A SIG array at Huntington Beach would negatively impact benthic habitat.

Prevailing state environmental regulations for seawater desalination plants require that the technologies employed *"minimize the intake and mortality of all forms of marine life."* With this in mind, it is important to note that SIGs have the potential to introduce large-scale, negative impacts to benthic habitat offshore of Huntington Beach, resulting in significant mortality of marine life. To begin with, the construction of a SIG at Huntington Beach would require extensive seafloor excavation (ISTAP 2015). SIG construction would require the removal of approximately 400,000 cubic yards of seafloor over an area of 25.4 acres of benthos (at minimum), in order to install an intake bed with dimensions of 2,008ft length, 770 ft width, and to a depth of 6 ft. The subtidal sandy bottom found offshore of Huntington Beach provides important habitat for infaunal invertebrates and fishes (Tenera 2015c), as well as critical nurseries for commercially valuable fish species such as California halibut (Fodrie & Mendoza 2006; Fodrie & Levin 2007). SIG construction would necessarily entail the destruction of all benthic habitat

and associated organisms in the work zone, and likely disrupt neighboring habitat through turbidity plumes generated by construction.

SIG disruption of benthic habitat at Huntington Beach would not be a one-time only occurrence. Once the SIG is in operation, greatly altered conditions would characterize the new benthic habitat overlying the intake pipes, including unnatural vertical suction forces and artificial granular media. It is unknown whether benthic organisms would be able to recolonize this habitat following the initial excavation, or how the altered habitat would affect basic biological processes such as feeding and reproduction. Even assuming successful recolonization, routine SIG maintenance would involve periodic removal of the filter bed surface, disrupting if not destroying any newly established populations of benthic organisms (ISTAP 2015).

Tenera (2015c) quantified the potential environmental impacts of a SIG at Huntington Beach. These authors estimated significant mortality of benthic organisms due to SIG construction impacts: "construction of the SIG would result in the initial loss of 977 million infaunal invertebrates, 277 epifaunal invertebrates, 7,891 demersal invertebrates, and 59,221 demersal fishes." They also noted that long-term (i.e., post-construction) impacts are difficult to quantify because there are currently no data available to assess the probability that impacted benthic communities will recover and function properly following initial destruction of benthic habitat for SIG construction. their report concludes that *"… the construction, maintenance, and operation of a SIG will result in actual destruction of habitat, organisms, and all of the associated ecological services."*

● SIGs have never been used at flow rates comparable to those proposed for the Huntington Beach desalination plant.

SIGs have never been operated at a scale comparable to the water intake rates (>100 MGD) required for the proposed desalination plant at Huntington Beach. Currently, there is only one relatively large-scale desalination plant in the world that utilizes a SIG intake. This is the Fukuoka desalination plant in Japan, which has a total intake flow of

only 27 MGD. There have been no studies (published or otherwise), that attempt to quantify I&E or benthic impacts resulting from SIG use at this facility. On a considerably smaller scale (but more locally relevant), a 0.3 MGD experimental desalination plant utilizing SIG technology has been operating in Long Beach, CA for almost 10 years. Again, no studies have been conducted to examine its environmental impacts (Yan Zhang, Long Beach Water Department, Personal Communication).

● CONCLUSION: A Seafloor Infiltration Gallery (SIG) has not been demonstrated to perform the function of minimizing the intake and mortality of marine life at the proposed Huntington Beach desalination plant.

This report has examined the overall body of scientific knowledge regarding the environmental impacts of SIGs in general, as well as the potential environmental impacts for SIGs that are specific to the Huntington Beach location. The findings of this report can be summarized as follows:

1) Although SIG intakes are purported to reduce or eliminate I&E impacts, there is no scientific evidence whatsoever to support this assertion. In fact, SIGs do have potential I&E impacts that have not yet been investigated. There are currently no data available with which to assess potential I&E impacts resulting from the use of a SIG at Huntington Beach.

2) The construction and operation of a SIG at Huntington Beach will likely have extensive benthic impacts resulting in significant marine life mortality.

3) The use of a SIG has never been attempted in an oceanographic setting or on a scale similar to that proposed for the Huntington Beach desalination plant.

In conclusion: “Seafloor Infiltration Gallery (SIG) intakes have not been demonstrated to be effective at minimizing intake and mortality of marine life. There is no scientific justification for the assertion that SIGs will eliminate impingement and entrainment of

planktonic organisms at the proposed Huntington Beach desalination plant site. In addition, the construction and operation of a SIG at this location may have extensive and deleterious impacts to benthic habitat and organisms.**”**

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