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

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 subsurface 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, San Luis Obispo and the West Basin Municipal Water District 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 purported environmental advantages 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, having reviewed all of the available information on this issue, concludes the following: 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.

● **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 1). 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 2). 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.

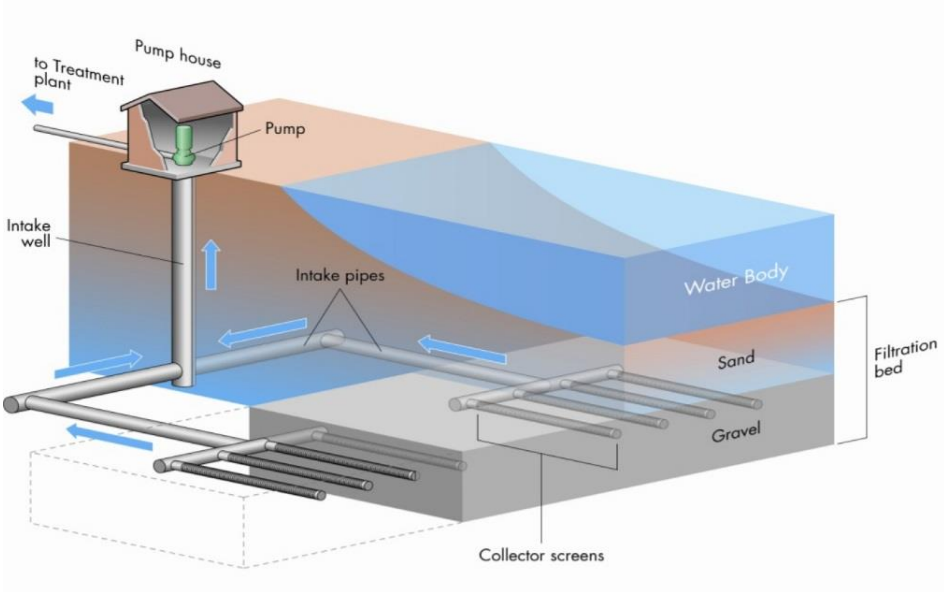

Figure 1 – Overview of a generalized Seafloor Infiltration Gallery (from Voutchkov 2010).

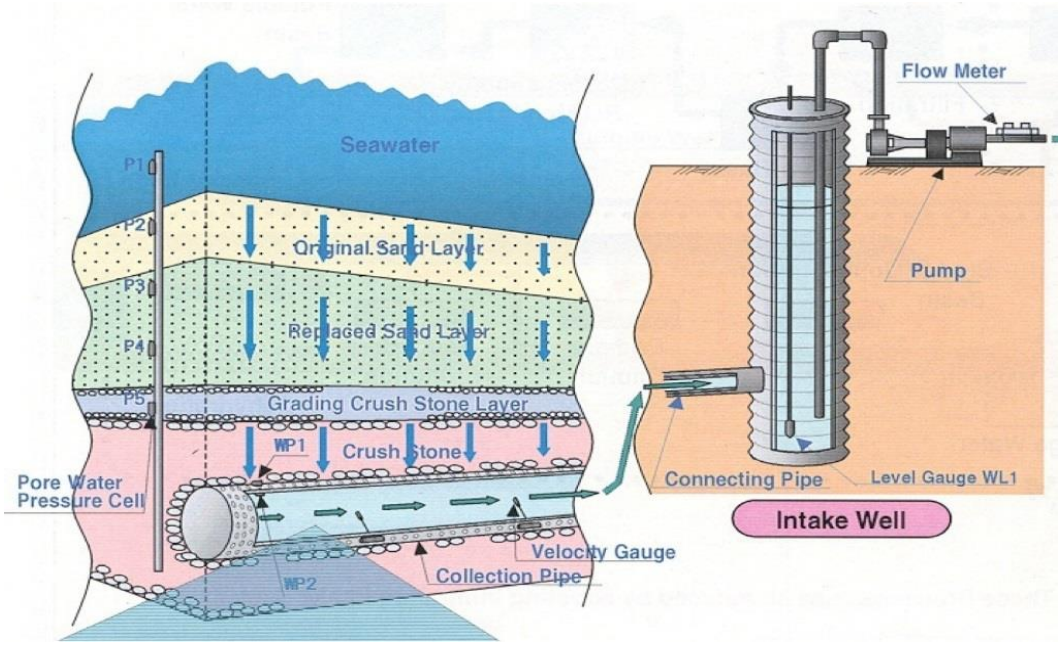

Figure 2 – Cross-section of a generalized Seafloor Infiltration Gallery (from Voutchkov 2010).

● 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 3 and 4). 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 3 and 4). 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.

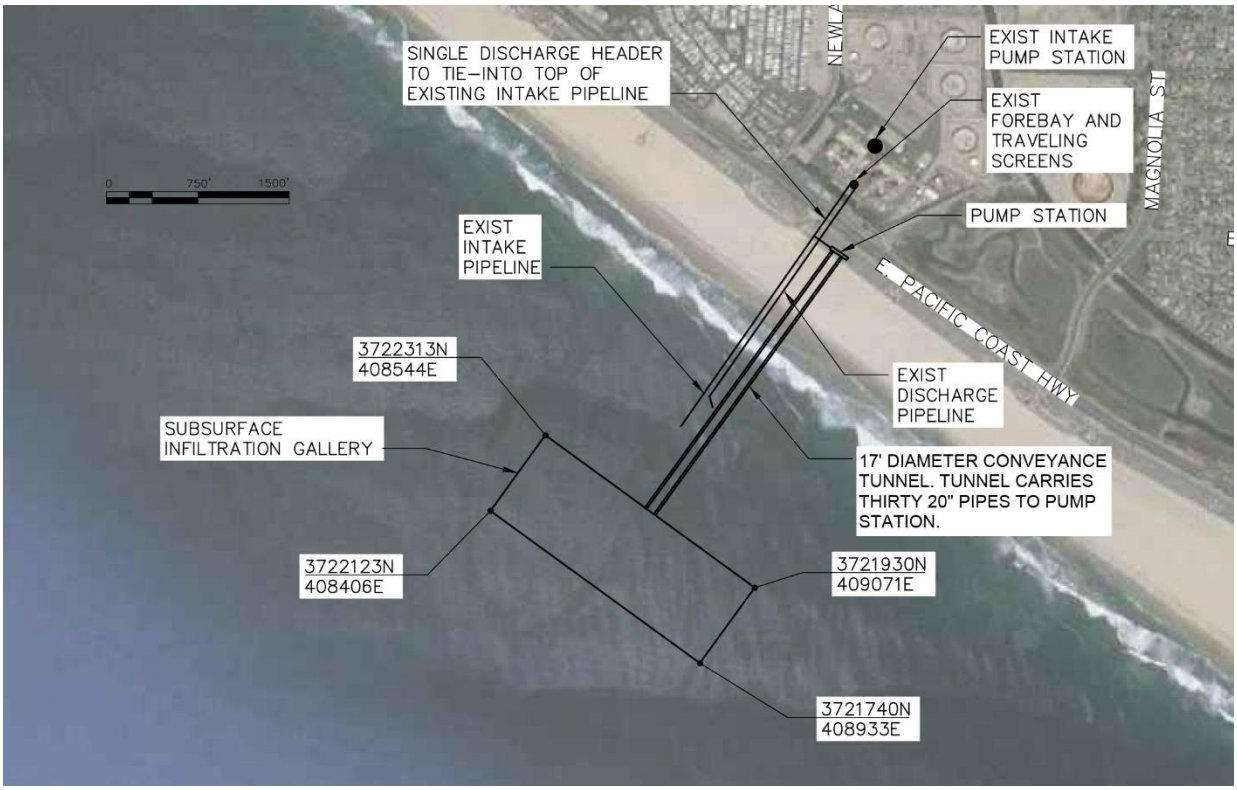

Figure 3. Aerial Map of proposed SIG location offshore of Huntington Beach.

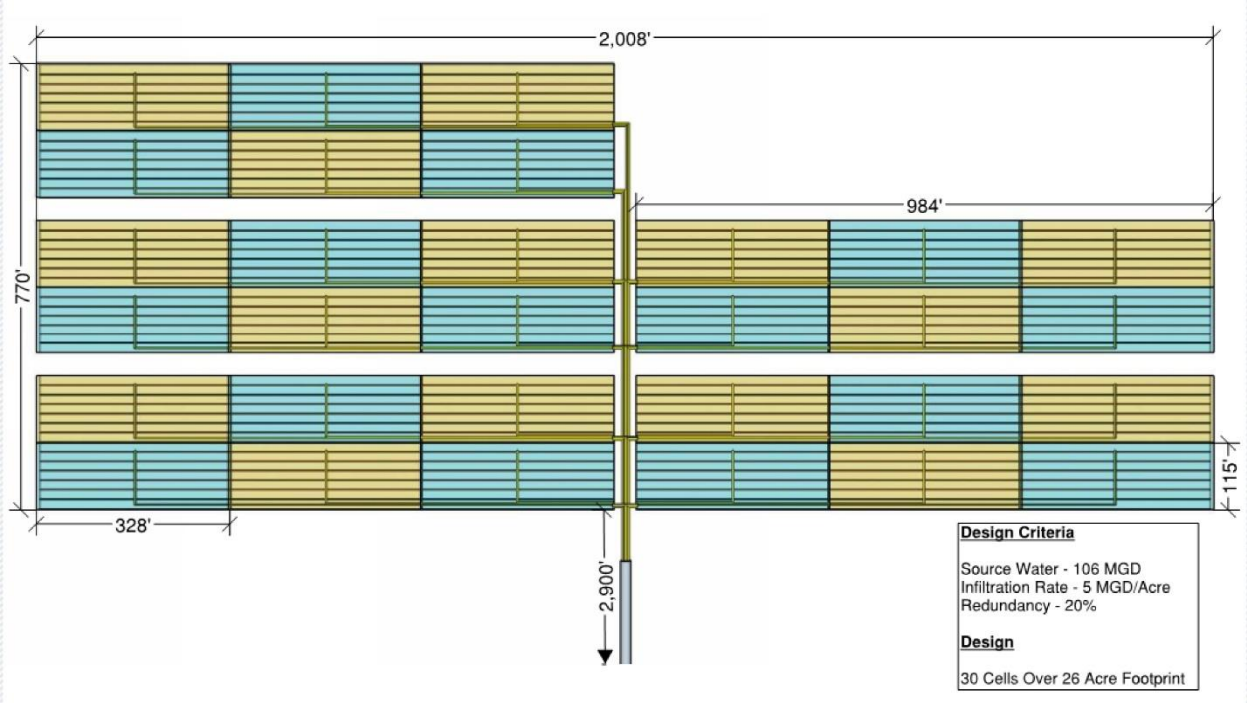

Figure 4. Schematic of proposed SIG design at Huntington Beach.

● 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 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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