Ocean Plan Amendment
Public Comment
Deadline: 04/18/12 by 12 noon

MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

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April 17, 2012

VIA EMAIL

RECEIVED
04-17-2012
SWRCB Clerk

Jeanine Townsend, Clerk to the Board
State Water Resources Control Board
1001 I Sreet, 24th Floor
Sacramento, CA 95814

Comment Letter – Designating State Water Quality Protected Areas to Protect Marine Protected Areas and the Draft Substitute Environmental Documentation for the Proposed Amendment to the Ocean Plan

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The Municipal Water District of Orange County (MWDOC) appreciates this opportunity to provide comments on the subject "Draft Staff Report and Substitute Environmental Documentation Amendment of the Water Quality Control Plan for Ocean Waters of California Addressing Implementation of State Water Board Resolutions 2010-0057 and 2011-0013 Designating State Water Quality Protection Areas to Protect State Marine Protected Areas". This document was transmitted with the public hearing notice of February 28, 2012. This document contains an Introduction, Overview of the California Ocean Plan, Regulatory Background, Environmental Setting, CEQA Review and Analysis, Water Code Section 13241 and 13242, Proposed Amendments and References.

On March 8, 2012 a lyris email message was received from Mr. Dominic Gregorio, Environmental Program Manager, Ocean, Wetlands and Watershed Section, Division of Water Quality indicating the intent of the email was "…to clarify that the proposed amendments would not result in the designation of new SWQPAs" and would only "...establish a framework and requirements for new SWQPAs designated in the future to protect MPAs…" and "…new SWQPAs would be considered by the Board in a completely different public planning process that would not begin until after the subject amendments are adopted and effective."

Background

Municipal Water District of Orange County (MWDOC). MWDOC is the third largest member agency of the Metropolitan Water District of Southern California and wholesales on average nearly 200,000 acre-feet per year of imported water to 28 retail water providers in Orange County. MWDOC provides regional water supply management planning encompassing water use efficiency programs, water emergency response organization management, water supply reliability planning, and facilitates development of regional and sub-regional water supply projects.

In Orange County, water agencies have long been leaders in water use efficiency programs; groundwater protection, development and management; water reclamation/reuse research and recycling; impaired and brackish groundwater recovery; water resource management and supply reliability planning; and integrated watershed planning; return flow water quality management and treatment; and desalination research including innovative slant well intake technology development.

South Orange Coastal Ocean Desalination Project. Over the past several years, MWDOC has been managing and facilitating the South Orange Coastal Ocean Desalination (SOCOD) Project feasibility investigation and project development work together with five participating agencies – South Coast Water District, Laguna Beach County Water District, Moulton Niguel Water District, City of San Clemente and the City of San Juan Capistrano.

Since 2004, the SOCOD Project (formerly Dana Point Ocean Desalination Project) participants have been investigating the feasibility of a subsurface Test Slant Well to produce feedwater supply for the project. The first of its kind slant well was constructed out under the ocean in spring 2006. The slant well is fully buried under Doheny Beach and extends 350 feet at an angle of 23 degrees from horizontal under the ocean into a marine aquifer. It has a production rate of 3.1 mgd. An 18-month, Phase 3 Extended Pumping and Pilot Plant Test is ongoing and testing work will conclude during the first week of May, 2012. The ocean desalination feasibility investigation will be concluded this fall with submittal of draft/final reports to the grant agencies (CDWR, USEPA and USBR).

Studies were conducted to determine if a slant wellfield would cause any impingement or entrainment of marine organisms along the ocean floor. The findings from those studies showed that a slant wellfield that would draw ocean water from the marine aquifer offshore of Doheny State Beach would not cause impingement or entrainment impacts to marine organisms. The findings from those studies are contained in the attached report that was also previously submitted into the record for the Marine Life Protection Act process and was recently submitted to the State Water Board under the CEQA scoping comment process for desalination facilities and brine disposal.

For brine disposal, the SOCOD Project intends to co-dispose the concentrated ocean water brine with municipal wastewater through the San Juan Creek Ocean Outfall, a facility owned and operated by the South Orange County Wastewater Authority. This facility crosses Doheny State Beach and extends two miles offshore.

The research, demonstration and feasibility investigation into the use of subsurface slant wells for ocean desalination feedwater supply was made possible through grant funding from the California Department of Water Resources, U.S. Environmental Protection Agency and U.S. Bureau of Reclamation as well as local funding from the five aforementioned project participating agencies and MWDOC. This is one type of an environmentally protective technology that can be applied to areas where site conditions can support this approach.

However, the capacity of this type of feedwater system is constrained to the productive capacity of the coastal offshore hydrogeology.

This work has been supported and authorized through regulatory approvals from the California Department of Parks and Recreation, California State Lands Commission, California Coastal Commission, California Department of Fish and Game, California Regional Water Quality Control Board (San Diego Region) and U.S. Army Corps of Engineers. These agencies have continued to support our work in developing this cost-effective and environmentally protective technology for ocean water intakes. Moreover, this project continues to receive widespread environmental and public support because of its environmental protective features, its cost-effective approach, and because of the recognized reliability benefit that can be provided to the South Orange Coastal area of Orange County, an area heavily dependent on imported water.

Comments

The subject Draft Staff Report and SED notes near the top of page 35 that State Water Board Resolution No. 2010-0057 serves as the basis for the proposed amendments described in Section 5.4 (Note: Section 5.4 is Lead Agency; we assume the correct reference is to Section 7 Proposed Amendments). The Draft Staff Report, SED and Proposed Amendments are consistent with this resolution and should be revised accordingly to achieve consistency. We point out a couple of areas that stand out and require clarification.

Clarify Definition in Appendix I for SWQPA–GP for Consistency with MMAIA. The definition under Appendix I for a SWQPA uses the phrase ***"…to maintain natural water quality…".*** The definition for SWQPA in the Marine Managed Areas Improvement Act (MMAIA) PRC Section 36700 (f) defines the intent to be protection from ***"…an undesirable alteration in natural water quality…"***. Accordingly, the definition should be changed to read as follows:

> State Water Quality Protection Areas – General Protection (SWQPA-GP) designated by the State Water Board to protect marine species or biological communities from an undesirable alteration in natural water quality within State Marine Parks and State Marine Conservation Areas.

Revise Proposed Amendment E.1 (a) (2)Description of SWQPA-GP to be Consistent with the SWRCB Resolution No. 2010-0057 and Staff's Intent that this Proposed Amendment is to Protect MPAs. The description includes the expansion of the intent beyond MPAs by inclusion of the phrase ***"… other unique and sensitive areas…"***. This is overly broad, expansive and far-reaching language that goes well beyond the intent of the aforementioned definition of SWQPA, the SWRCB Resolution No. 2010-0057, staff's email clarifying message of March 8, 2012 (D. Gregorio via lyris distribution) and the MMAIA. It needs to be deleted to assure conformity.

Process for Future SWQPA – GP Designations. In SWRCB Resolution 2010-0057, the State Water Board directed staff to work with the Regional Boards to develop recommendations for new SWQPAs to protect water quality in the MPAs that are being developed through the MLPA process. The document should note that the MPAs designations have previously been completed for the southern California region and became effective on January 1, 2012.

The authorizing language in the Marine Managed Areas Improvement Act (MMAIA) defines a Marine Protected Area (MPA) to be consistent with the MLPA process for the following classifications: (1) state marine reserve, (2) state marine park, and (3) state marine conservation area. The MMAIA also clarifies that the State Water Board may designate, delete or modify state water quality protection areas and with the regional boards may take appropriate actions to protect state water quality protection areas. Section 36900 provides general requirements for the designation process. The March 8, 2012 message from the Board indicated that any new SWQPAs would be considered by the Board in a "completely different public planning process" that would not begin until after the subject Ocean Plan amendments are adopted for the SWQPAs and when they become effective.

The proposed procedures for designating SWQPA-GPs are contained and described under "APPENDIX IV PROCEDURES FOR THE NOMINATION AND DESIGNATION OF AREAS OF SPECIAL BIOLOGICAL SIGNIFICANCE (ASBS)". For conformity of intent, this heading should be changed to ***"…DESIGNATION OF STATE WATER QUALITY PROTECTION AREAS".***

These procedures should be made consistent with the intent of designation process for MPAs per our above comments. The designation for SWQPA-GP should clarify that their extent would be limited to no greater of an area than to be overlying and coterminous with the boundaries of established MPAs when proposed.

The approach for designation of new SWQPAs should be consistent with the State Water Board Resolution of 2010-0057 and the MMAIA.

Revise the Proposed Amendment to Allow Subsurface Intakes in SWQPAs (Clarify Proposed Prohibition on Seawater Intakes in SWQPAs). The proposed amendment should provide clarification language to the proposed prohibition of seawater intakes found at page 43 (d) (2) to clarify that it does not apply to the use of subsurface intakes, such as slant wells. As written, the prohibition may be construed to apply to all types of seawater intakes. It would be appropriate and protective to the ocean to allow the use of subsurface intakes such as slant beach intake wells or other environmentally protective subsurface or screened intakes in SWQPA – GP areas. We understand that the intent is to prohibit seawater intakes that sit above the seafloor and draw water directly from the ocean (personal communication with D. Gregorio).

We request that Implementation Provisions E. 5 (d) (2) be modified as follows:

Seawater Intakes –No new seawater intakes shall be established within SWQPA-GP, ***with the exception that subsurface slant/horizontal well intakes or other environmentally protective intake technology are allowed.***

<u>Revise the Proposed Amendment to Allow Changes in the Composition of Existing Ocean Discharges).</u> The proposed amendment should provide clarity and flexibility that changes in the composition of discharges from existing outfalls may change over time – e.g., in response to enhanced water conservation measures, or in response to the co-disposal of brines from desalination operations along with treated effluent from POTWs.

Summary

We respectfully request that the State Water Board include the provided information into the record and make the clarifications and conformity changes as noted above in finalizing the Proposed Amendments to the COP for SWQPAs.

Thank you for the opportunity to provide comments. I would be pleased to provide further clarification, provide additional information, or answer any questions. I may be contacted at (714) 593-5003 or by email at rbell@mwdoc.com.

Sincerely,

Richard B. Bell, PE
Principal Engineer/Project Manager

cc: B. Flahive, SOCWA
B. Burnett, SCWD
R. Davis, CalDesal

MEMORANDUM

TO:
Richard Bell, P.E
Principal Engineer
Municipal Water District of Orange County
10500 Ellis Avenue
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FROM:
Noel Davis, Ph.D.
Chambers Group, Inc.
5 Hutton Centre Drive, Suite 750
Santa Ana, CA 92707

SUBJECT: Evaluation of Potential Impacts to Marine Life Due to Operation of Slant Beach Wells

Because of the critical need to bolster the reliability of water supply to south Orange County, the Municipal Water District of Orange County (MWDOC) prepared and adopted the South Orange County Water Reliability Plan in 2002/2003 (Plan). That Plan recommended development of an ocean desalination water supply for the south Orange Coastal area. As part of this planning process, MWDOC conducted a scoping study to identify environmental compliance and permitting issues associated with the construction and operation of a desalination facility (Chambers Group 2002).

During the scoping study, MWDOC held three in-person meetings with permitting and consulting agencies including the Regional Water Quality Control Board San Diego Region (RWQCB), U.S. Army Corps of Engineers (USACE), the National Marine Fisheries Service (NMFS), the U.S. Fish and Wildlife Service (USFWS), the California Department of Fish and Game (CDFG), the California Coastal Commission (CCC) and the City of Dana Point. During those meetings the resource and permitting agencies expressed concerns about the impacts of conventional ocean intakes on marine life. These impacts include impingement of marine organisms against the intake screen and the entrainment of planktonic organisms small enough to pass through the screen. Based on this input, MWDOC made the decision to determine if wells could be used to withdraw ocean water for the desalination facility. Hydrogeologic borings, construction of a test slant well in spring 2006, and subsequent groundwater modeling showed that slant wells were feasible. Slant beach wells avoid impingement and entrainment of marine organisms, provide filtered water, and were found to be cost-effective for the Dana Point site.

The first slant well is now operating and producing 3 mgd. This well is being used to gather process treatment design information over an extended period of pumping and includes use of mobile test facility located at Doheny State Beach. Ongoing activities include hydrogeologic data collection, groundwater and environmental monitoring, groundwater modeling, water quality sampling/analyses, material corrosion testing, and engineering work. The project is in the process of expansion to nine slant wells, with three wells each in three well clusters. The slant wellfield would be constructed and buried along Doheny State Beach. The slant wells are to be drilled approximately 500 feet out under the ocean floor, with the screened intake interval located 50 to 140 feet below the ocean floor. The average distance from the ocean floor to the middle of the screened intake area of the wells is approximately 100 feet.

Benthic organisms live in the top 2 feet of the sediment (most of them in the top 2 inches). Therefore, the distance between the marine life in the sea floor sediments and the intake of the slant wells will be on the average greater than 100 feet. The vertical infiltration rate of ocean water migrating downward through the seafloor during slant wellfield operation is estimated to be quite low, at approximately 0.000051 feet per second (ft/sec) in the immediate vicinity overlying the wellfield and 0.00000078 ft/sec at the outer limits of the ocean water source area (Williams 2010). This intake velocity is four orders of magnitude less than the 0.5 ft/sec through-screen velocity that has been found to be gentle enough to avoid impingement on the screens of conventional ocean intakes (SWRCB 2010). This slow rate of infiltration would be imperceptible to benthic organisms, which routinely experience much greater currents and wave surge in the active wave climate offshore Doheny Beach. This area is subject to significant sand transport and movement from San Juan Creek discharges, wave and tidal forces, and littoral currents. For example, during a March, 1983, storm, there were 20 foot high breakers off Dana Point and 7 to 13 foot high wave runup on Doheny Beach (Jenkins 2010). Such major storms cause as much as 7 foot loss in the thickness of beach sediment cover. Although the March, 1983, storm event is extreme, waves of 4 to 6 feet are common off Doheny Beach and the associated bottom surge from these waves at the shallow water depths of the wellfield produce forces on the sediment and the sediment-dwelling organisms that are much, much greater than the very slight drawdown from the wells.

Dr. Scott Jenkins, an expert in physical oceanography at Scripps InstitutIon of Oceanography analyzed the potential for the ocean water infiltration to affect benthic organisms by inducing scour and erosion of the ocean floor and to affect planktonic organisms by suction induced forces that might pull plankton and floating eggs towards the bottom and thus potentially impinge them on the sea floor (Jenkins 2010). To quantify the potential for ocean floor erosion, the infiltration rates over the wellfield calculated by Williams (2010) were compared to the threshold velocity for transport of the bottom sediments, which have a median grain size of 0.22 millimeters. The maximum increase in wave induced bottom stress was calculated to be 1% directly over the well field and 0.02% at the outer limit of the recharge zone. This value is insignificant because it is nine times smaller than the error implicit in the net shear stress increases to move sand-sized sediment determined under controlled laboratory conditions. Therefore, the net increase in bottom stress calculated for the well field would be negligible and, thus, the slant wellfield will have no discernible effect on the ocean floor. A 1 percent or less increase in bottom stress attributable to the slant well infiltration is trivial compared to the thousands of percent increases in wave induced stresses that occur naturally during major storms and which cause dramatic erosion and seasonal variation in beach profiles (Jenkins 2010).

The very low infiltration rate along the ocean floor that would be caused by the slant wellfield operation may have a very slight potential to trap freely drifting eggs and plankton against the seabed if the suction forces of the slant well are greater than the movement of water that can break the organisms free of the suction and transport them off the seafloor (Jenkins 2010). Organisms potentially impinged would only be those organisms occurring within a few centimeters of the ocean floor that might be affected by these very low infiltration suction forces. Jenkins determined that only minute oscillatory wave velocities are required to prevent these small organisms from becoming trapped or impinged by the seabed. The wave climate off Doheny Beach always produces water movement that exceeds these minimal oscillatory velocities at the depths of the well field and recharge zone. The force balance calculations done by Jenkins show that the ocean would have to become completely quiescent for neutrally buoyant, freely drifting small organisms to become impinged or trapped on the seabed by the vertical pressure gradient induced by the slant well field. Such a quiescent wave climate has never been observed in the vicinity of Doheny Beach.

Based on the analyses performed by Williams and Jenkins, it can be concluded that the intake of ocean water through slant beach wells will have no impact on marine life. This environmentally friendly approach has received wide support from the public, environmental organizations, elected officials, and local, State and Federal resource and regulatory agencies including the California Coastal Commission.

Literature Cited

Chambers Group, Inc.
2002 Scoping of CEQA Compliance and Permitting Issues for an Ocean Desalination Facility in Southern Orange County. Prepared for Municipal Water District of Orange County

Jenkins, S.A.
2010 Potential Impacts on Wave and Current Transport Processes Due to infiltration Rates Induced by the South Orange Coastal Desalination Project. Submitted to R. Bell, P.E., Municipal Water District of Orange County.

State Water Resources Control Board. (SWRCB)
2010 Statewide Water Quality Control Policy for the Use of Coastal and Estuarine Waters for Power Plant Cooling.

Williams, D.E.
2010 South Orange Coastal Ocean Desalination Project – Vertical Infiltration Rate of Ocean Water Migrating through the Seafloor in the Vicinity of the Slant Well Intake System. Technical Memorandum to R. Bell, P.E. Municipal Water District of Orange County.

12 October 2010

Potential Impacts on Wave and Current Transport Processes Due to Infiltration Rates Induced by the South Orange Coastal Ocean Desalination Project

Submitted by:
Dr Scott A. Jenkins Consulting
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Submitted to:
Richard Bell, PE
Principal Engineer & Project Manager
Municipal Water District of Orange County
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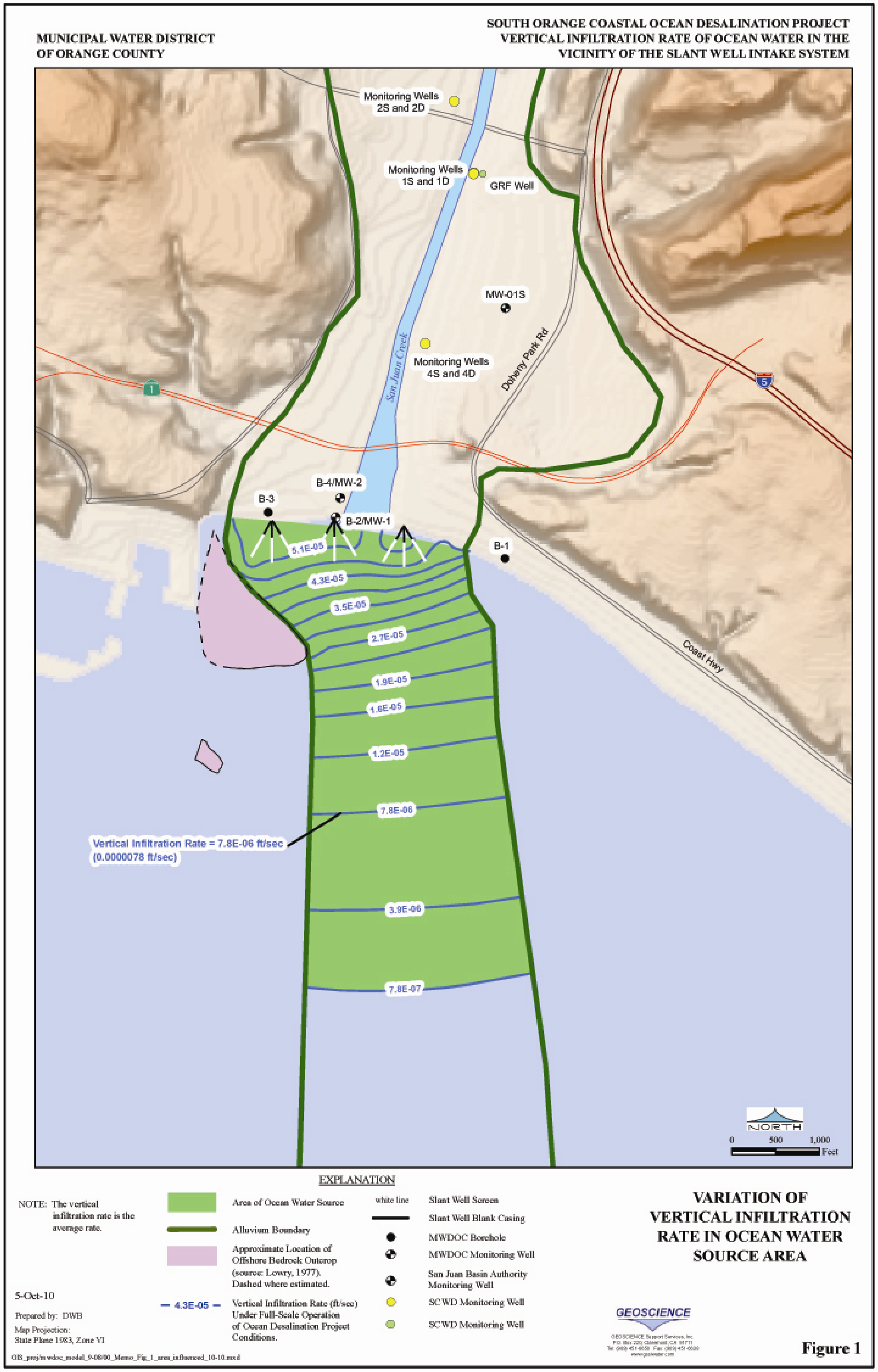
Statement of the Issues: There are two potential marine biology impacts that may arise as a consequence of the infiltration of ocean water through the seafloor in the vicinity of the slant well field of the South Orange Coastal Ocean Desalination Project. **1)** In a technical memorandum by Geoscience dated 1 October 2010, vertical infiltration rates in the immediate vicinity of the slant well field were estimated to be 5.1 X 10^{-5} ft/sec, decaying to 7.8 X 10^{-7} ft/sec at the outer limits of the ocean water source area (see Figure 1). It is well known that vertical suction flows through a sedimentary seabed (also known as ventilated boundary layers) increase the bed shear stresses arising from waves and currents (Conely and Inman, 1994). The decisive determination in assessing this potential impact is whether or not infiltration rates of this magnitude when combined with ambient waves and currents are sufficient to induce scour or erosion of the seabed and thereby disturb resident benthic organisms. **2)** There might be an additional impact on neutrally buoyant, freely drifting micro-organisms (eggs and plankton) if they become impinged on the seabed by the suction forces produced by the vertical pressure gradients of the slant wells that cause the infiltration of ocean water through the seafloor.

Background: Laboratory measurements by Conely and Inman, 1994, show that even very small infiltration rates through a porous seabed result in remarkably large increases in the wave induced shear stress, τ , acting on that bed. The wave induced shear stress in turn causes scour and erosion of the seabed when it exceeds the critical or threshold shear stress, τ_{crit}, that induces sediment motion, or when $\tau \geq \tau_{crit}$. They refer to infiltration rates, w_m , as "ventilation" and quantify it relative to the wave velocity amplitude, u_m, in terms of a ventilation parameter, $\tilde{V} = w_m / u_m$. Figure 2 plots the time variation of the wave induced shear stress on a porous bed for one half cycle of motion, as under a wave crest. The solid curve in Figure 2 plots the bottom stress for no infiltration or ventilation, when $\tilde{V} = 0$. The shear stress curves are normalized by the maximum shear stress with no ventilation, τ_{m0}, and


MUNICIPAL WATER DISTRICT
OF ORANGE COUNTY
SOUTH ORANGE COASTAL OCEAN DESALINATION PROJECT
VERTICAL INFILTRATION RATE OF OCEAN WATER IN THE
VICINITY OF THE SLANT WELL INTAKE SYSTEM
Monitoring Wells
2S and 2D
Monitoring Wells
1S and 1D
GRF Well
MW-01S
Monitoring Wells
4S and 4D
San Juan Creek
Doheny Park Rd
1
5
B-4/MW-2
B-3
B-2/MW-1
B-1
5.1E-05
4.3E-05
3.5E-05
2.7E-05
1.9E-05
1.6E-05
1.2E-05
7.8E-06
3.9E-06
7.8E-07
Vertical Infiltration Rate = 7.8E-06 ft/sec
(0.0000078 ft/sec)
Coast Hwy
NORTH
0
500
1,000
Feet
EXPLANATION
NOTE: The vertical infiltration rate is the average rate.
Area of Ocean Water Source
Alluvium Boundary
Approximate Location of Offshore Bedrock Outcrop (source: Lowry, 1977). Dashed where estimated.
4.3E-05
Vertical Infiltration Rate (ft/sec) Under Full-Scale Operation of Ocean Desalination Project Conditions.
white line
Slant Well Screen
Slant Well Blank Casing
MWDOC Borehole
MWDOC Monitoring Well
San Juan Basin Authority Monitoring Well
SCWD Monitoring Well
SCWD Monitoring Well
5-Oct-10
Prepared by: DWB
Map Projection:
State Plane 1983, Zone VI
VARIATION OF
VERTICAL INFILTRATION
RATE IN OCEAN WATER
SOURCE AREA
GEOSCIENCE
Figure 1

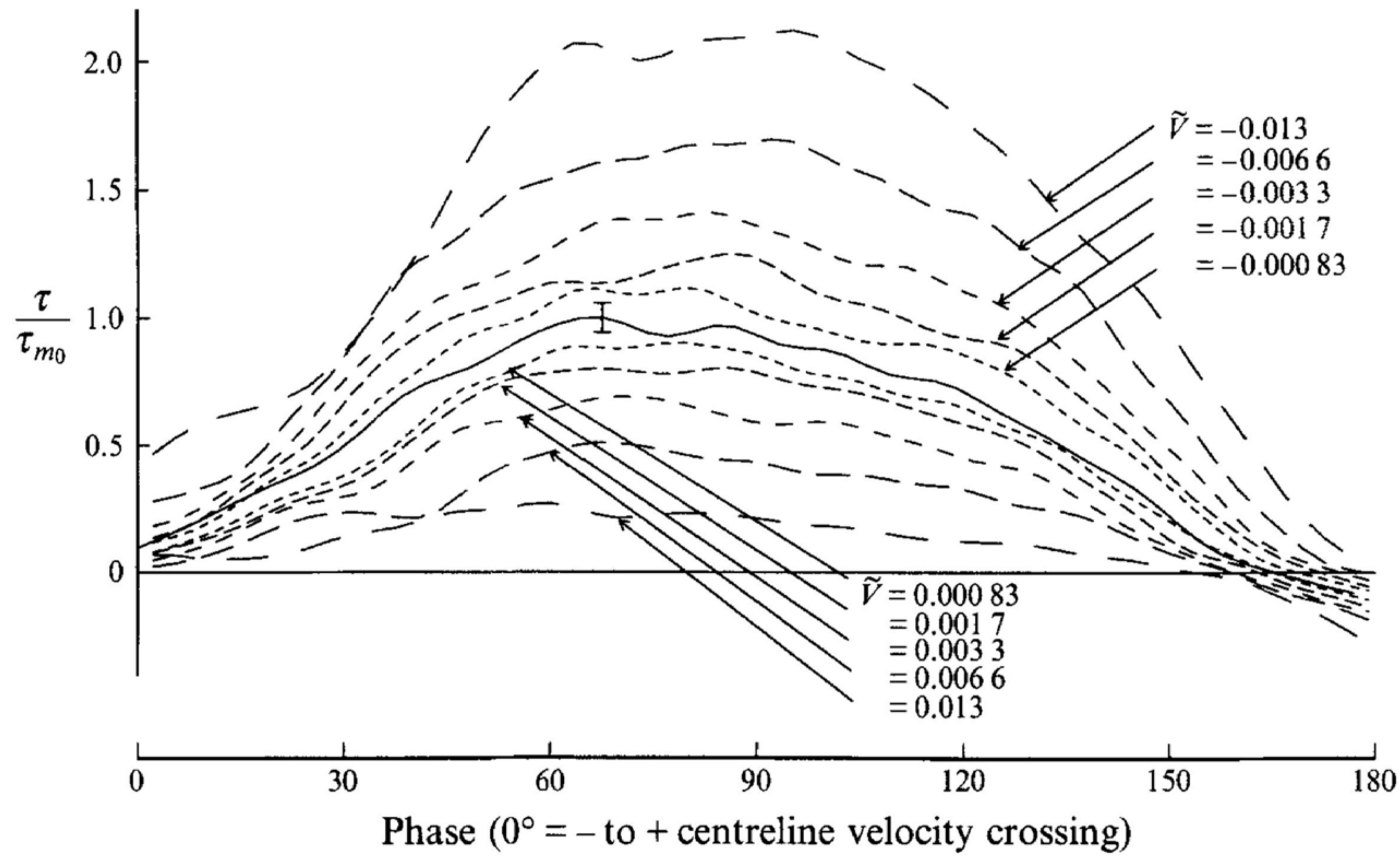


FIGURE 2. Ensemble-averaged bed stress for various values of $\tilde{V}$. Values are normalized by the maximum unventilated bed stress. Solid line is bed stress for unventilated case. The error bar represents 95% confidence level of peak stress [from Conley and Inman, 1994].

we find that the curve for no ventilation reaches a maximum of $\tau / \tau_{m0} = 1.0$. Above this curve are other bottom shear stress curves for negative ventilation, $\tilde{V} < 0$, when water is being drawn or sucked into the bed, as would occur with infiltration into the seabed above buried slant wells. Figure 2 shows that the maximum bottom stress doubles when the infiltration rate or ventilation is only 1.3% as large as the wave velocity amplitude, when $\tilde{V} = -0.013$. On the other hand, the wave induced bottom stress is diminished when water is forced out of the bed, a condition referred to as injection, when $\tilde{V} > 0$. The injection examples in Figure 2 (when $\tilde{V} > 0$) show that $\tau / \tau_{m0} < 1.0$

The wave induced bottom stress in Figure 2 can be integrated over time to give the average bottom stress over a wave length with no ventilation, $\langle |\tau_0| \rangle$, and with ventilation, $\langle \tau_v \rangle$. The ratio of these two time-averaged shear stresses give the percentage increase in bottom stress due to ventilation, as plotted in Figure 3. Conely and Inman, 1994, show that this ratio follows a simple linear relationship,

$$\frac{\langle \tau_v \rangle}{\langle |\tau_0| \rangle} = \frac{b\tilde{V}}{2 f_w} \qquad (1)$$

Where $b = 0.9$ for ideal granular sedimentary seabeds and $f_w = 2\tau_{m0} / \rho u_m^2$ is the wave friction factor after Jonsson, 1963, and ρ is the density of the ocean water.

Analysis of Potential for Seabed Erosion: Figure 3 and equation (1) indicate that the percentage increase in wave induced bottom stress grows linearly with the ventilation parameter, $\tilde{V} = w_m / u_m$. To quantify the potential for seabed erosion we calculate this parameter in terms of the size of the reported infiltration rates w_m over the slant well field relative to the threshold velocity for transport, $u_m = u_{crit}$, of the native beach sediment. Figure 4 plots the grain size distribution of the native beach sand taken from the surf zone at Doheney Beach by Reed, et al, 1975. The median grain size is shown to be 0.22 mm (220 microns). Figure 5 gives the threshold velocity for transport (black curve) as a function of median grain size. Inspection of Figure 5 indicates that the threshold velocity for transport for 0.22 mm sized sand is $u_m = u_{crit}$ = 0.6 ft/sec. Therefore the ventilation parameter directly over the well field when the wave oscillatory velocity is at the threshold of beach scour is:

$$\tilde{V} = w_m / u_m = \frac{5.1 \times 10^{-5}}{6 \times 10^{-1}} = 8.5 \times 10^{-5} \qquad (2)$$

With this value of ventilation parameter inserted into equation (1) or plotted in Figure 3, the infiltration rate over the well field will cause a net increase in wave induced bottom stress of $\langle \tau_v \rangle / \langle |\tau_0| \rangle = 1\%$. Figure 6 gives contours of net bottom stress increases over a near shore region from the slant well field extending offshore to the outer limits of the recharge zone based on the infiltration rates calculated by Geoscience, 2010, in Figure 1. While the

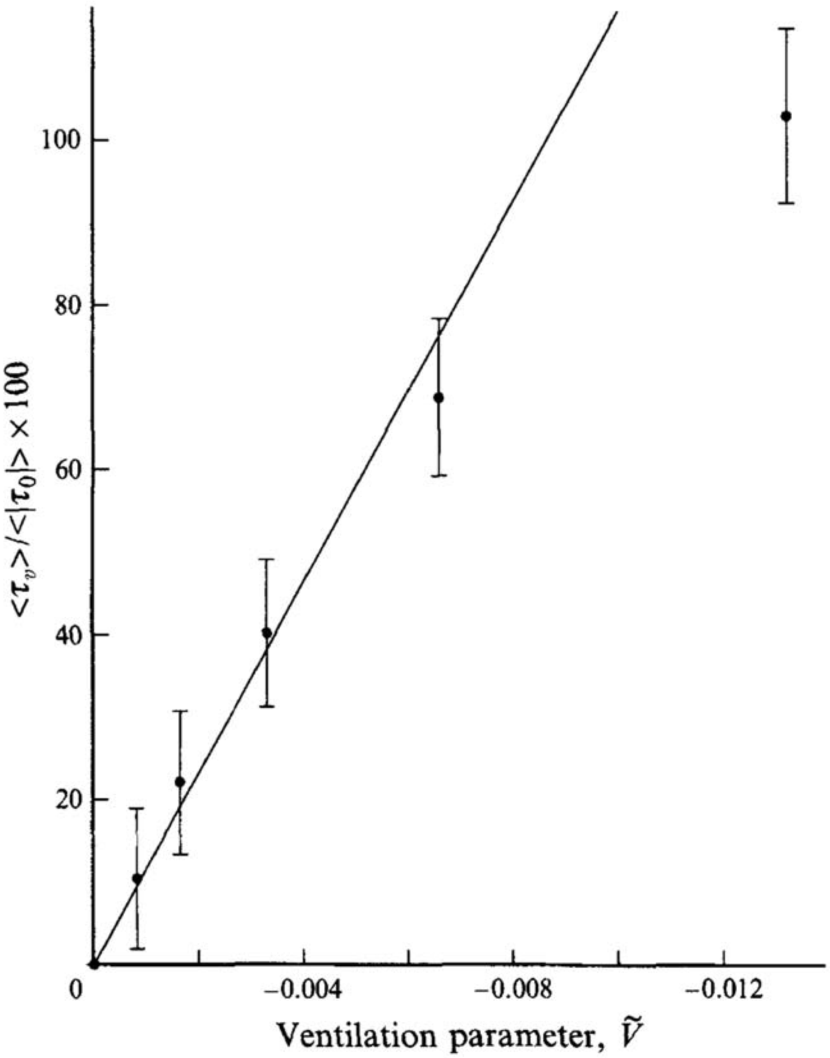


FIGURE 3. Average net ventilated bed stress as a percentage of average gross unventilated bed stress *vs.* $\tilde{V}$. Solid line is computed from (1) with $b = 0.9$. Error bars are 95% confidence interval [from Conley and Inman, 1994].

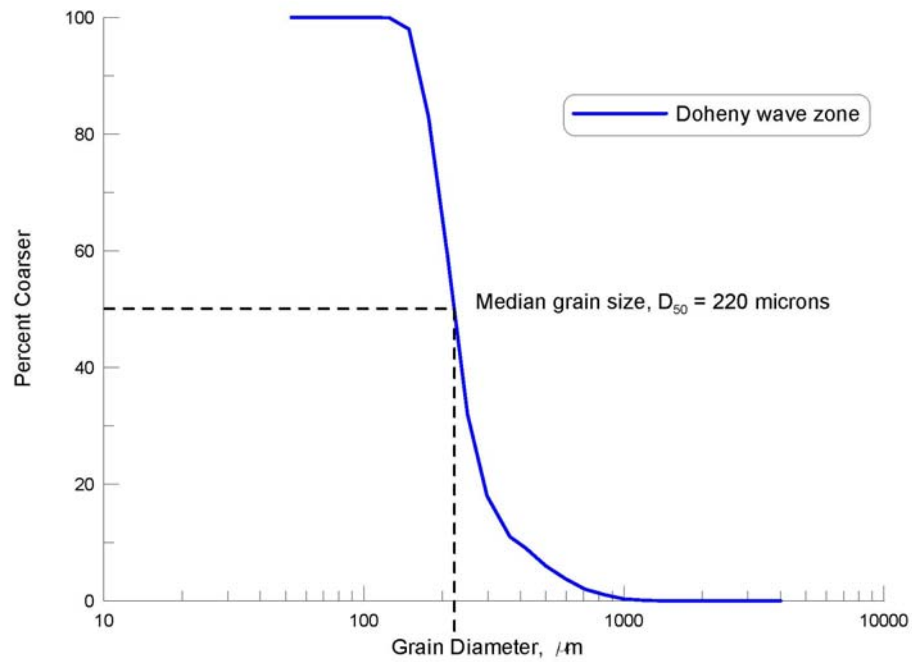


Figure 4 . Grain size distribution at Doheny Beach, from surfzone measurements after Reed et al., 1975.

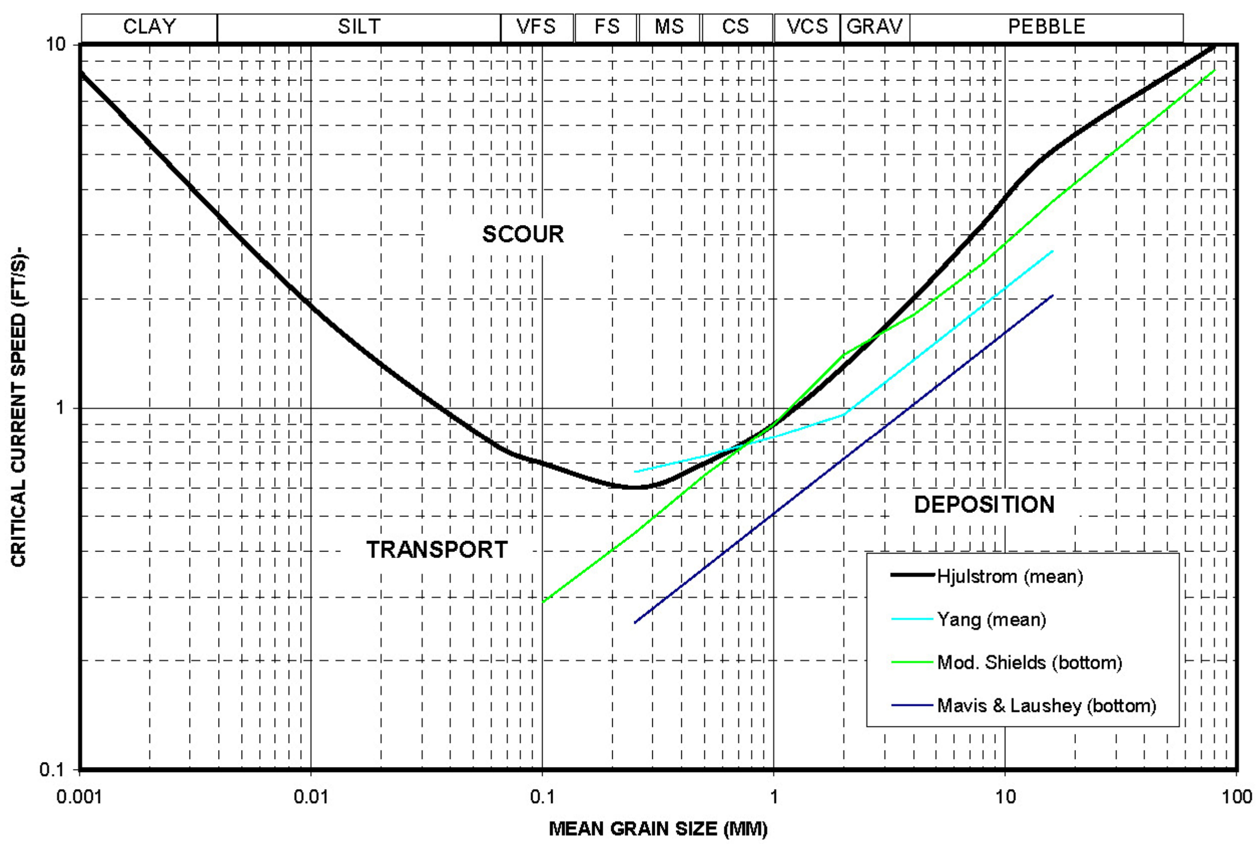


Figure 5: Threshold velocity of transport for quartz sediment as a function of mean grain size, (from Everest, 2007).

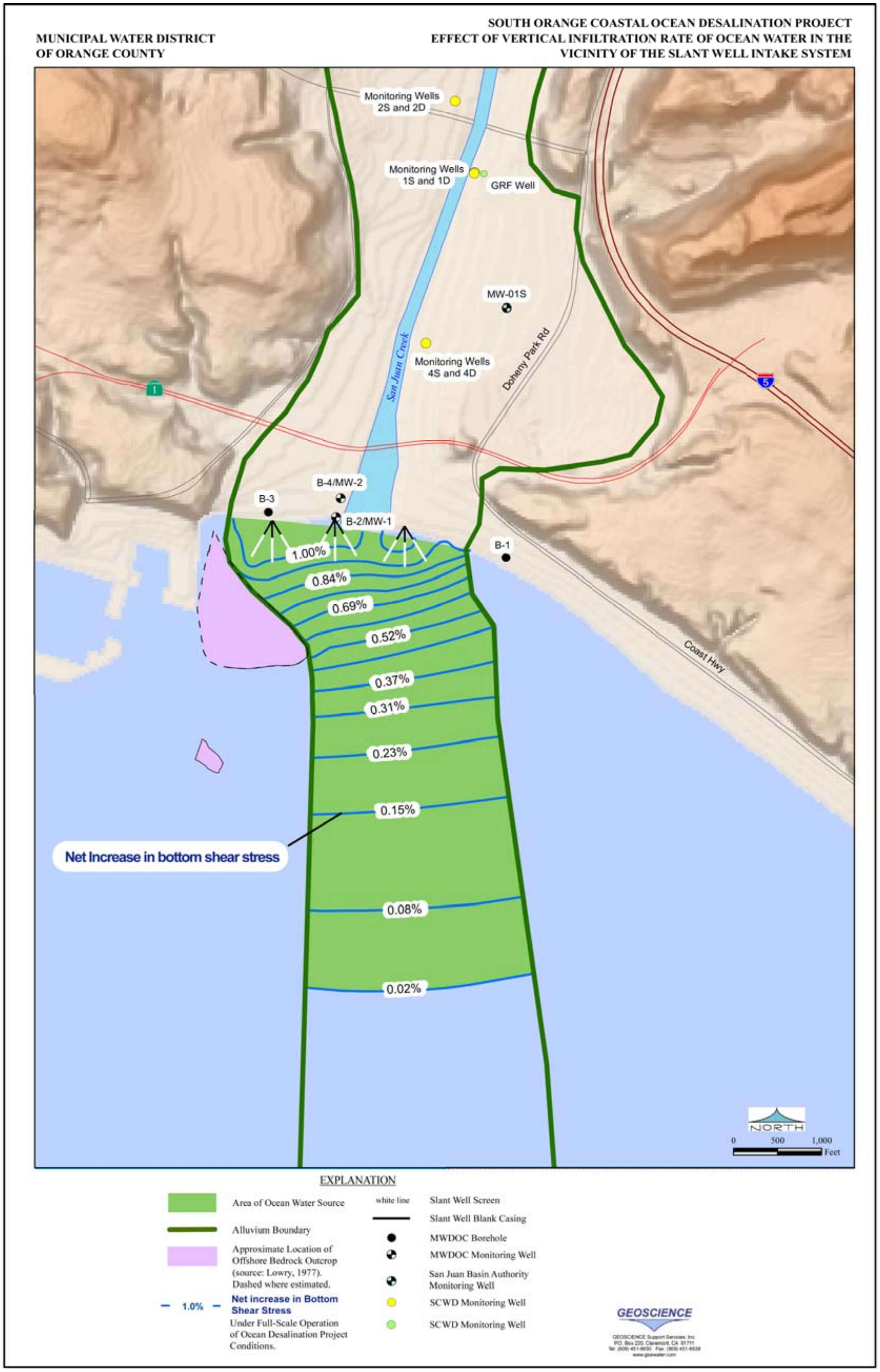


Figure 6. Net increase in wave-induced bottom stress at scour onset due to infiltration rates plotted in Figure 1 [after GEOSCIENCE, 2010].

maximum net increase in bottom stress is 1% directly over the well field, the net stress increase drops to only 0.02% at the outer limit of the recharge zone where infiltration rates are only w_m = 7.8 X 10^{-7} ft/sec. Regardless, the net increase in bottom stress calculated for the well field at the onset of scour from equation (1) is every where substantially smaller than the error bars of the net shear stress increase in Figure 3, even under carefully controlled laboratory conditions. At these very small values of ventilation parameter, the error in the net shear stress increase calculated from equation (1) is about +/- 9%, nine times greater than the theoretical maximum effect of the slant wells. Therefore the net increase in bottom stress calculated for the well field may be regarded as negligible in a statistical sense. In a physical sense, it is equally negligible in comparison to naturally occurring broad-scale seasonal beach profile variation and erosion at Doheny Beach and the surrounding Dana Point headland. Figure 7 gives a refraction/diffraction plot for the 1 March 1983 storm, indicating 6m high breakers off Dana Point and 2m – 4m high wave runup at Doheny Beach. Such storms can cause as much as 2m loss in the thickness of the beach sediment cover, as evidenced by the envelope of variability in beach profiles shown in Figure 8. A 1% increase in bottom stress as attributable to the maximum effect of the slant well infiltration rates is trivial by comparison to the thousands of percent increases in wave induced stresses that occur naturally during such storms and which cause such dramatic erosion and seasonal variation in beach profiles shown in Figure 8.

Analysis of Potential for Seabed Impingement of Micro-organisms: The vertical pressure gradients in the seabed sediments produced by of the slant wells have the potential to trap or cause neutrally buoyant, freely drifting micro-organisms (eggs and plankton) to impact on the seabed by the action of suction forces, F_s . Figure 9 gives a force and moment balance of a micro-organism that has hypothetically been impacted on the seabed by the action of these suction forces forming an impact crater on a seabed sloping at angle β. The vertical pressure gradients causing such an impact are assumed to be isotropic through the seabed sediments and arise from the hydraulic head difference, Δh , acting across the average vertical distance, Δx between the seafloor and the middle of the intake well screen sections. If we assume these pressure gradients act on small spherical micro organisms whose equivalent diameter is D , then the suction force holding these organisms against the seabed is

$$F_s = \frac{1}{8} \rho g \pi D^3 \frac{\Delta h}{\Delta x} \qquad (3)$$

Here g is the acceleration of gravity and from Geoscience (2010) the vertical gradient of hydraulic head through the seabed is $\Delta h / \Delta x$ = 65 ft/120 ft = 0.54. Nanoplankton have an equivalent spherical diameter of 5 microns, and net plankton have an equivalent spherical diameter of 20 -30 microns (Langdon, 1988). The impacted or impinged plankton will remain trapped on the sea bed until the suction moment restraining its motion $F_s \times r_1$ is exceeded by the sum of hydrodynamic moments acting to move it out of its impact crater, as shown by the moment balance in Figure 9. This moment balance reduces to:

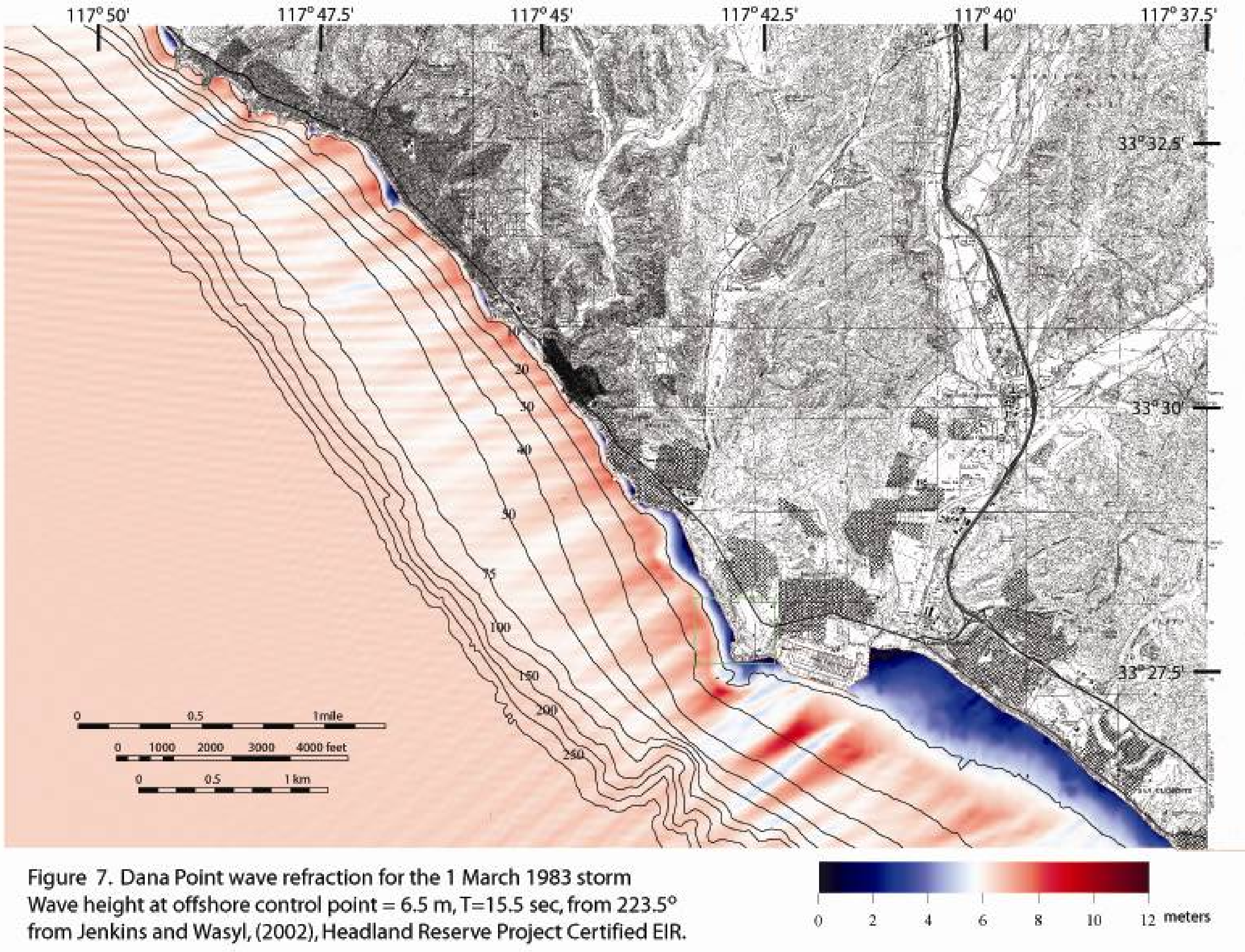


Figure 7. Dana Point wave refraction for the 1 March 1983 storm
Wave height at offshore control point = 6.5 m, T=15.5 sec, from 223.5°
from Jenkins and Wasyl, (2002), Headland Reserve Project Certified EIR.

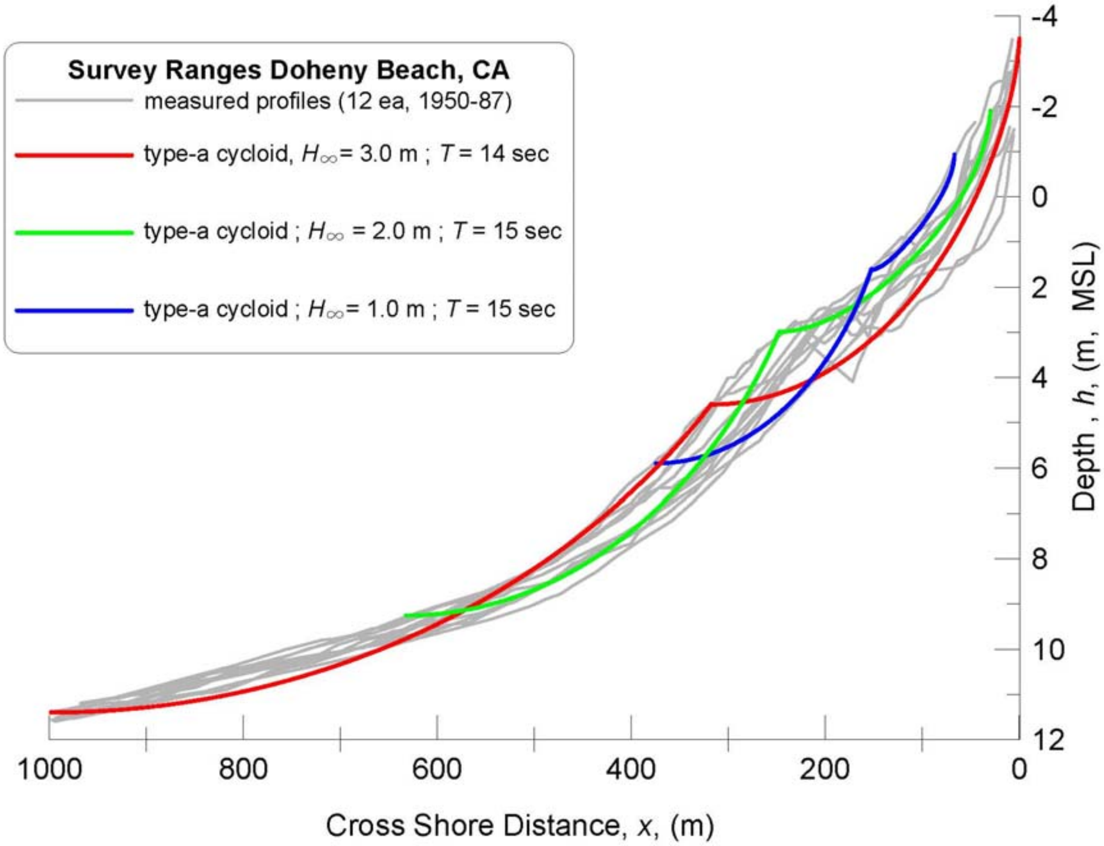


Figure 8. Envelope of variability of measured beach profiles (1950-87) at Doheny Beach, CA (grey) compared to the ensemble of elliptic cycloid solutions (colored) for selected incident wave heights and periods with D = 220 μm, N = 10, γ = 0.8, and Λ = 0.81. (after Jenkins and Inman, 2006).

$$F_s \sin(\phi - \beta) = \rho C_d A_0 u_m^2 (1 + \cos\phi) + \rho c_m V_0 \frac{du}{dt}(1 + \cos\phi) \qquad (4)$$

where ϕ is the angle of repose; the first term on the right hand side of equation (4) is due to hydrodynamic drag; and the second term is due to the wave pressure (virtual mass force) acting on the impinged organism. Since the organism is very small in relation to the wave height or oscillatory amplitude, the virtual mass force is negligible compared to the drag force (Jenkins and Inman, 1985, Batchelor, 1970). The hydrodynamic drag due to the wave oscillations acting to scrub these tiny organisms free of the suction forces can be represented as

$$F_d = \frac{1}{4} \rho\, C_d \pi D^2 u_m^2 \qquad (5)$$

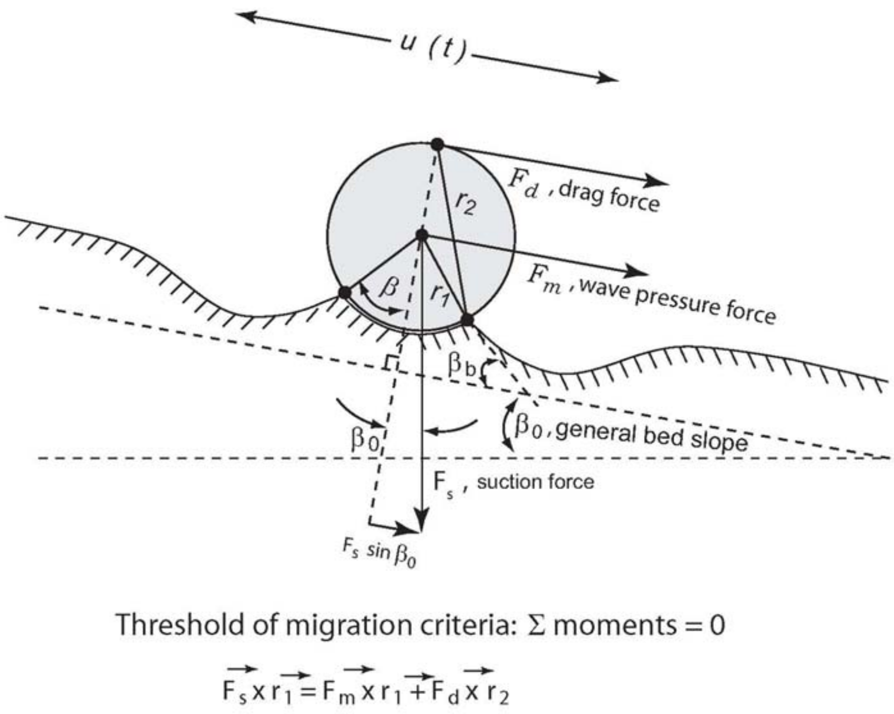


Figure 9. Criteria for incipient motion of neutrally buoyant micro-organism impacted on the seabed by well infiltration rates. Organism moves when the sum of moments due to hydrodynamic forces (right side of equation) exceed the moment due to suction forces arising from vertical pressure gradient induced by the buried slant wells (left side of equation).

Where $C_d = 24/R_e$ is the drag coefficient on a tiny sphere (Stokes approximation); $R_e = u_m D/\upsilon$ is the Reynolds number and $\upsilon = 10^{-2}$ cm^2/sec is the kinematic viscosity (Batchelor, 1970, Jenkins and Inman, 1985). In a worst case scenario, we take $\sin(\phi - \beta) \cong 1$ and $(1 + \cos\phi) \cong 1$, whence the organism will break free of the pressure gradient holding it on the sea bed when the oscillatory wave velocity exceeds the following:

$$u_m \geq \frac{gD^2}{48\upsilon}\frac{\Delta h}{\Delta x} \cong 0.01 \text{ cm/sec} \qquad \text{(netplankton)}$$

$$\cong 0.003 \text{ cm/sec} \qquad \text{(nanoplankton)} \qquad (6)$$

In either case, only minute oscillatory wave velocities are required to prevent these micro-organisms from becoming trapped or impinged by the seabed. The wave climate at Doheny Beach and the Dana Point region *always* produces waves that exceed these minimal oscillatory velocities in the depth regime of the well field and recharge zone shown in Figure 1, (USACOE, 1987, 1991).

Conclusions: Analytic calculations were made to determine the potential for seabed erosion and micro-organism impingement on the seabed due to infiltration rates and pressure gradients induced by the slant well field of the South Orange Coastal Ocean Desalination Project. The calculations were based on infiltration rates and seabed pressure gradients modeled by Geoscience, (2010). While the modeled infiltration rates were found to increase net bottom shear stress by no more than 1% at the onset of erosion, this value is considered statistically insignificant as it is nine times smaller than the error implicit in the net shear stress increases determined under controlled laboratory conditions. Even then, whatever sediment transport is attributable to this 1% increase in bottom stress is both limited to the immediate vicinity of the slant well intake and is insignificant in comparison to naturally occurring seasonal beach profile variation and storm induced erosion. Force balance calculations show that the ocean would have to become perfectly quiescent in order for nano- and netplankton and other neutrally buoyant, freely drifting micro-organisms to become impinged or trapped on the seabed by the vertical pressure gradient induced by the slant well field. Such a quiescent wave climate has never been measured or observed at this site.

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GEOSCIENCE

Technical Memorandum

To:	Mr. Richard Bell, P.E. Principal Engineer Municipal Water District of Orange County 10500 Ellis Avenue Fountain Valley, California 92728
From:	Dennis E. Williams, Ph.D. President GEOSCIENCE Support Services, Inc.
Date:	October 5, 2010
Subject:	**South Orange Coastal Ocean Desalination Project – Vertical Infiltration Rate of Ocean Water Migrating Through the Seafloor in the Vicinity of the Slant Well Intake System**

Background

The South Orange Coastal Ocean Desalination Project will be located near the mouth of San Juan Creek in Dana Point, Southern California. The 15 mgd desalination plant will include a subsurface feedwater supply system consisting of seven slant wells[1] producing a total of 30 mgd. Based on results from ground water modeling, 95% of the recharge to the 30 mgd slant well supply is derived from ocean water sources migrating through the alluvium beneath the ocean. Figure 1 shows the area of the ocean water source for the slant well feedwater supply system along with the alluvial boundary in the vicinity of the wellfield. The area of the ocean water source was delineated based on groundwater model drawdowns greater than one foot in the alluvial aquifer beneath the ocean. This area is the area of recharge to the main aquifer tapped by the well screens. The purpose of this technical memorandum is to quantify the vertical

[1] A total of nine slant wells will be constructed, with seven wells operating continuously at any given time to produce the 30 mgd feedwater supply. Operation of the wellfield will include periodic rotation of slant well pumping in order to provide for routine maintenance.

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infiltration rate of ocean water migrating through the seafloor in the vicinity of the slant well intake system under full-scale project conditions (i.e., 30 mgd).

<u>Calculation of Vertical Infiltration Rate of Ocean Water Migrating Through the Seafloor</u>

The vertical infiltration rate of ocean water migrating through the seafloor in the vicinity of the slant well intake system under full-scale project conditions (30 mgd) can be calculated using the following equation:

$$w = \frac{Kv}{\theta} \bullet \frac{\Delta h}{\Delta x}$$

Where:

- w = Vertical infiltration rate of ocean water migrating through the seafloor (ft/sec),
- Kv = Vertical hydraulic conductivity of seafloor sediments (0.000014 ft/sec),
- θ = Effective porosity of seafloor sediments (0.15),
- Δh = Hydraulic head difference between the ocean surface and ground water levels in the vicinity of feedwater supply wellfield (65 ft),
- Δx = Average vertical distance from the seafloor to the middle of the intake well screen[2] sections (120 ft)

The vertical hydraulic conductivity value of 0.000014 ft/sec and the effective porosity value of 0.15 were based on field data (on-shore and test slant well lithologic logging and lab permeameter measurements) and verified by the calibrated ground water model. The maximum hydraulic head difference between the ocean surface and the slant well pumping levels was estimated to be 65 ft under the full-scale project conditions.[3] The average distance from the seafloor to the middle of the screened portions of the slant well feedwater supply is

[2] Assuming 1,000 ft slant wells drilled at 9 degrees below horizontal with 500 ft of screen in the lower portion of the wells

[3] GEOSCIENCE Support Services, Inc., 2007. Subsurface System Intake Feasibility Assessment. Task 4 Report. Prepared for the Municipal Water District of Orange County.

approximately 120 ft. Therefore, the maximum vertical infiltration rate of ocean water migrating vertically downward through the seafloor to the slant well intake screens is estimated to be 0.000051 ft/sec. That is the maximum vertical infiltration rate of ocean water migrating through the seafloor over the zone of ocean water recharge is in the vicinity of the maximum drawdowns (i.e., near the slant well intakes).

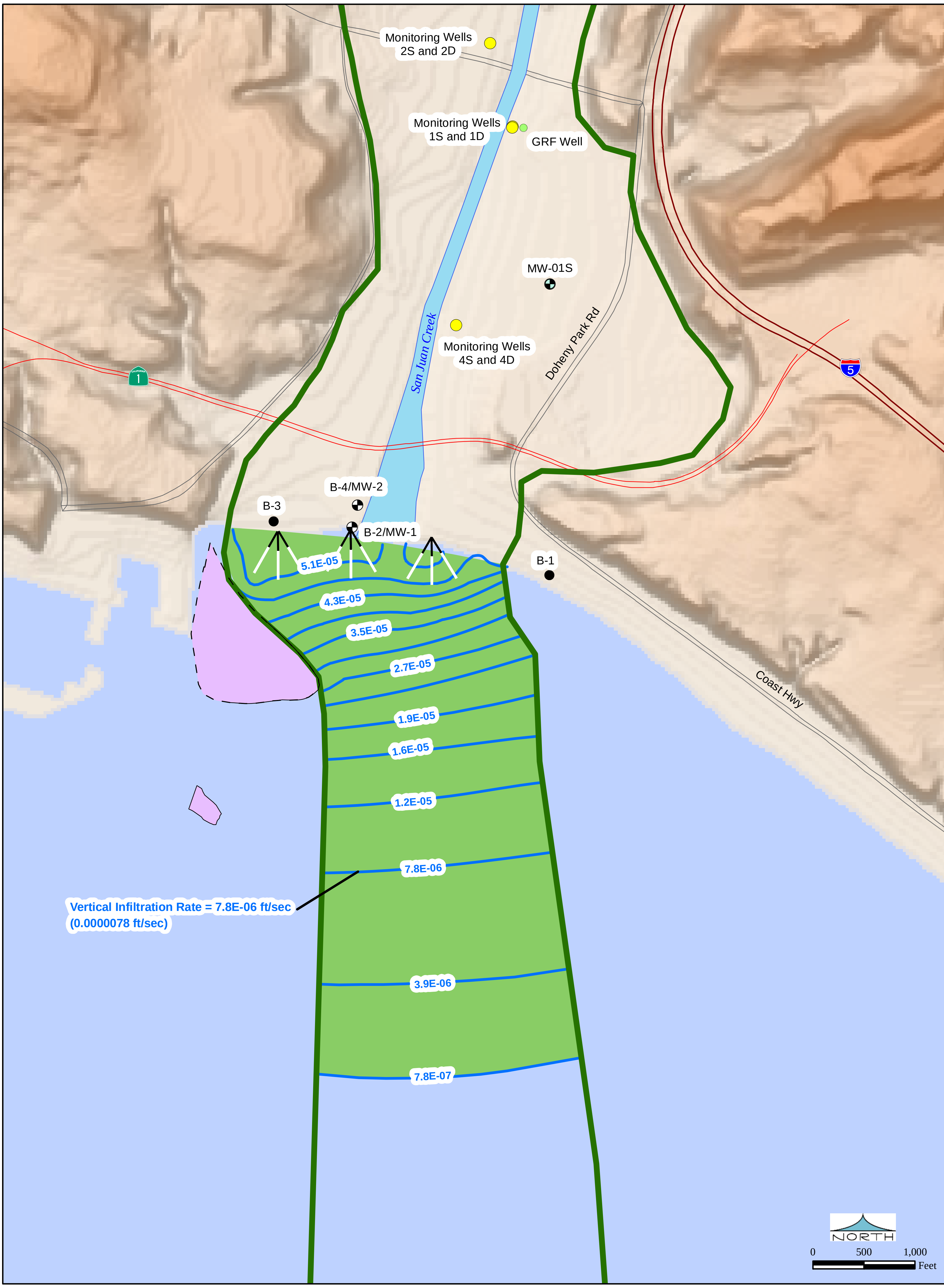
Variation of Vertical Infiltration Rate within the Ocean Water Source Area

The variation of vertical infiltration rate of ocean water migrating through the seafloor for the area within the ocean water source area (to the wellfiled) was calculated using the same equation as used above. However, the hydraulic head difference was varied over the area of the ocean water source area, specifically 65 ft in the immediate vicinity of the wellfield to one foot at the boundary of the ocean water source area. The same vertical hydraulic conductivity value of 0.000014 ft/sec and effective porosity value of 0.15 were used. It was also assumed that infiltration from the ocean travels vertically downward to a depth representing the middle point of the slant well intake screens (i.e., 120 ft). In other words, in areas away from the slant well intakes, vertically migrating ocean water was assumed to travel vertically 120 ft under a varying hydraulic head difference before turning horizontal and migrating to the wellfield area.

Based on these assumptions, the vertical infiltration rate varies (under full-scale operating conditions) from 0.00000078 ft/sec at the outer limits of the ocean water source area to 0.000051 ft/sec in the immediate vicinity of the wellfield (see Figure 1).

MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

SOUTH ORANGE COASTAL OCEAN DESALINATION PROJECT VERTICAL INFILTRATION RATE OF OCEAN WATER IN THE VICINITY OF THE SLANT WELL INTAKE SYSTEM



EXPLANATION

NOTE: The vertical infiltration rate is the average rate.

Area of Ocean Water Source

Alluvium Boundary

Approximate Location of Offshore Bedrock Outcrop (source: Lowry, 1977). Dashed where estimated.

4.3E-05 — Vertical Infiltration Rate (ft/sec) Under Full-Scale Operation of Ocean Desalination Project Conditions.

white line — Slant Well Screen

Slant Well Blank Casing

MWDOC Borehole

MWDOC Monitoring Well

San Juan Basin Authority Monitoring Well

SCWD Monitoring Well

SCWD Monitoring Well

VARIATION OF VERTICAL INFILTRATION RATE IN OCEAN WATER SOURCE AREA

5-Oct-10

Prepared by: DWB

Map Projection:
State Plane 1983, Zone VI

GIS_proj/mwdoc_model_9-08/00_Memo_Fig_1_area_influenced_10-10.mxd

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Figure 1