CARLSBAD SEAWATER DESALINATION PROJECT
ALTERNATIVES TO THE PROPOSED INTAKE
Poseidon Resources Corporation
March 2, 2004

Alternative Project Intake Source Water Collection Systems – Beach Wells, Infiltration Galleries and Seabed Filtration Systems

Introduction

As described in section 3.0 of this EIR the proposed intake source water collection system includes a connection of the intake pipeline of the desalination plant to the existing cooling water discharge lines of the Encina power plant. The power plant collects cooling water directly from the ocean via the Agua Hedionda Lagoon intake structure, screens the seawater through 3-inch bar rack screens followed by 3/8-inch fine screens, and than pumps it through the power plant condensers for cooling. The cooling water is than conveyed via discharge canal to the power plant discharge structure from where it is directed to the ocean. Since the desalination plant intake is connected to the power plant discharge canal downstream from the condensers, the RO plant intake seawater is pre-screened by the power plant screening facilities. The desalination plant intake facility is equipped with microscreens located immediately downstream of the point of interconnection with the power plant discharge canal, which would effectively remove all particulates and marine organisms larger than 120 microns (0.005 inches) prior to the entrance of the seawater in the seawater desalination plant. This type of intake minimizes entrainment of organisms in the RO plant downstream treatment facilities.

Alternative Subsurface Systems

Since the proposed intake system for the Carlsbad desalination project is essentially an open ocean intake, alternative intake systems considered for the project are three most common subsurface type intake systems: beach wells, infiltration galleries and seabed filtration systems. The subsurface intake facilities provide the key advantage that the source water they collect is pretreated via slow filtration through the subsurface sand/seabed formations in the area of source water extraction. Therefore, source water collected using subsurface intake facilities is usually of better quality in terms of solids, slit, oil & grease, natural organic contamination and aquatic microorganisms, as compared to open surface water intakes.

The key factors that determine if the use of subsurface intake is practical or/and economical are: the transmissivity/productivity of the geological formation/aquifer; the thickness of the production aquifer deposits; and the existence of nearby fresh water source aquifers, which could be negatively impacted by the subsurface intake system operations or have measurable effect on beach well water quality.

Intake Wells. Intake wells are typically vertical or horizontal water collectors drilled in the source water aquifer. The type of horizontal collector wells most widely used for large subsurface intakes is referred to as Ranney wells.

<u>Vertical Intake Wells</u>. This type of wells consist of a non-metallic casting (typically, fiberglass reinforced pipe), well screen, and a stainless steel submersible or vertical turbine pump. The

well casting diameter is between 6 inches and 18 inches, and well depth does not usually exceed 250 feet. The vertical intake wells are usually less costly than the horizontal wells but their yield is relatively small (typically, 0.1 to 1.0 MGD).

Vertical Intake Well Fatal Flaw Analysis. Because the amount of intake source water required for the Carlsbad seawater desalination plant is approximately 106 MGD, under best case scenario (vertical wells of 1.0 MGD capacity) the number of vertical wells needed exceeds 100. The construction and operation of such large number of vertical wells is not practical and feasible due to the significant number of pumps and control equipment associated with the operation of the vertical wells. Because of this fatal flaw, the use of vertical intake well facilities for this project is not further analyzed.

Horizontal (Ranney) intake wells consist of a caisson that extends below the ground surface with water well collector screens (laterals) projected out horizontally from inside the caisson into the surrounding aquifer (see Figure 1).

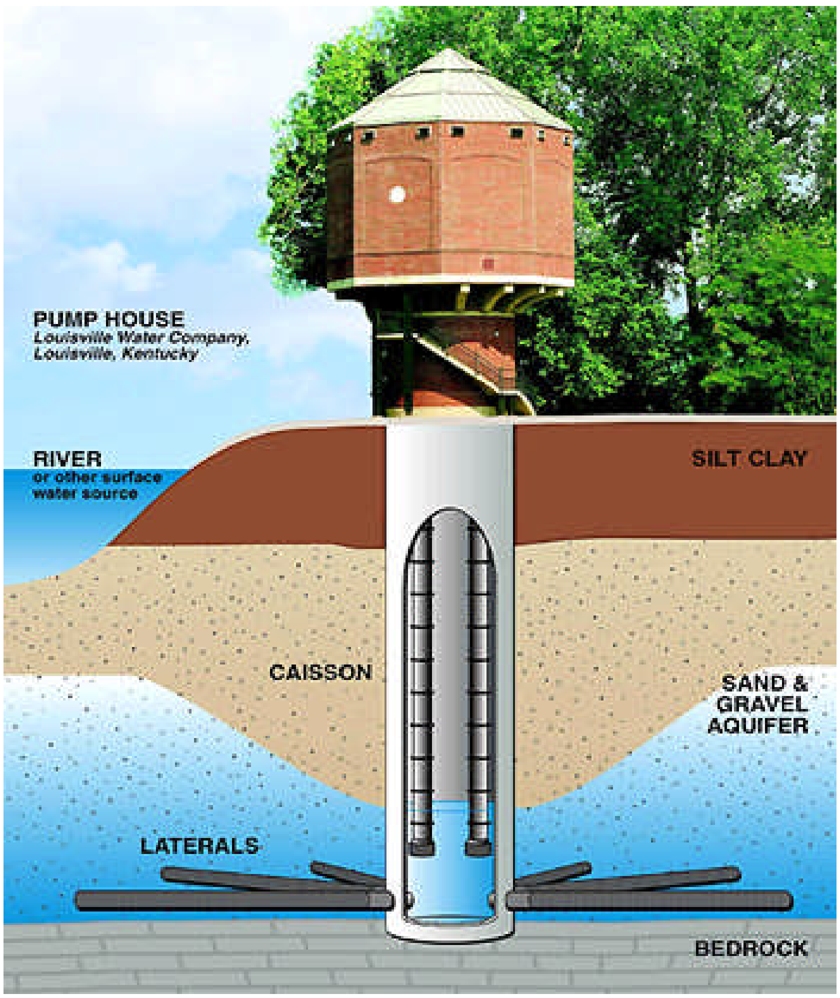

Figure 1 – Horizontal (Ranney) Beach Well

Since the well screens in the collector wells are placed horizontally, higher rate of source water collection is possible than with vertical wells. This allows the same intake water quantity to be collected with fewer wells. Individual horizontal intake wells are typically designed to collect between 0.5 MGD and 5.0 MGD of source water. The caisson is constructed of reinforced concrete that may be between 10 feet to 30 feet inside diameter with a wall thickness from approximately 1.5 to 3 feet. The caisson depth varies according to site-specific geologic conditions, ranging from approximately 30 feet to over 150 feet. The number, length and location of the horizontal laterals are determined based on a detailed hydrogeological investigation. Typically the diameter of the laterals ranges from 8 to 12 inches and their length extends up to 200 feet. The size of the lateral screens is selected to accommodate the grain-size of the underground soil formation. If necessary, an artificial gravel-pack filter is installed around the screen to suit finer-grained deposits.

In large intake applications, such as this shown on Figure 2, the horizontal beach wells are typically coupled with the intake pump station installed above the well caisson. Figure 2 shows one of the three 3.8 MGD horizontal (Ranney) intake beach wells for the largest existing seawater desalination plant located on the Pacific Ocean coast in North America – the 3.8 MGD water supply facility for the Pemex Salina Cruz refinery in Mexico.

Figure 2 – 3.8 MGD Horizontal Seawater Intake Beach Well

For the site specific conditions of the Carlsbad seawater desalination project, the minimum number of individual horizontal beach wells required is 25. This number is determined taking under consideration that the total intake capacity of the desalination plant is 106 MGD; the hydrogeological conditions are very favorable and therefore an individual well can yield 5 MGD of intake water; and that an additional 20 % well standby capacity is incorporated in the intake system design to account for well capacity decrease over the 30-year period of the useful life of the project and for well downtime due to routine maintenance ((106 MGD/5 MGD per well) x 1.2 = 25).

Horizontal Beach Well Fatal Flaw Analysis. The horizontal beach wells have to be located on the seashore, in close vicinity (usually within several hundred feet) of the ocean. Because of the high number of wells needed to supply adequate amount of water for the Carlsbad seawater desalination plant, construction of these facilities would result in disturbance of a significant amount of seashore beach area. Figure 3 shows the approximate size and configuration of a horizontal beach intake well system for a 10 MGD seawater desalination plant with 5 intake wells.

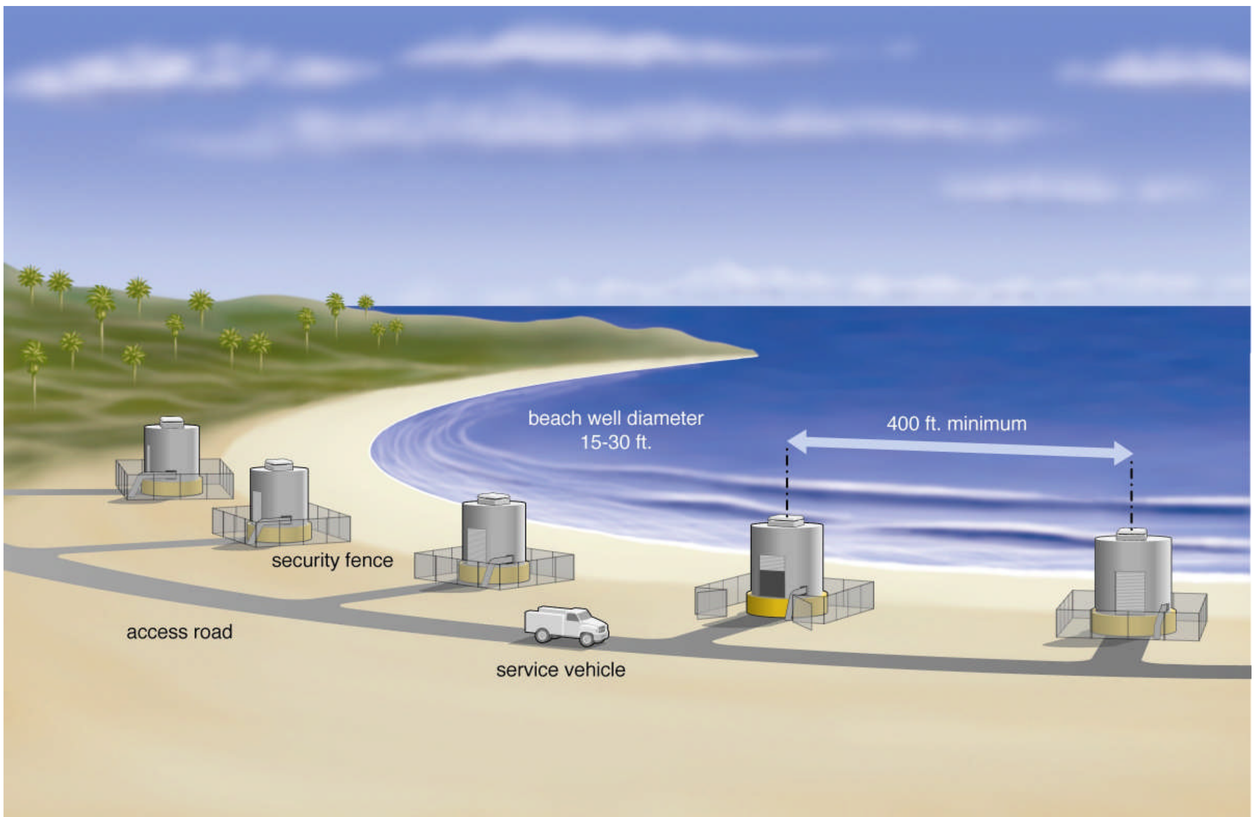

Figure 3 – A Horizontal Beach Well System for 10 MGD Desalination Plant

For 25 horizontal beach wells of individual capacity of 5 MGD, and a minimum distance between the individual wells of 400 ft, the footprint of the beach well impacted seashore area would be at least 100 ft wide by 10,000 feet long (400 ft x 25 wells = 10,000 feet (approx. 2 miles). Therefore, the minimum area of seashore impact as a result of construction of horizontal beach wells for the 50 MGD Carlsbad seawater desalination plant would be (100 ft x 10,000 ft = 1.0 MM sq ft (23 acres)). Figure 4 gives a general representation of the seashore area in front of the Encina power plant which would be impacted by the construction of a beach well intake system for the Carlsbad seawater desalination plant. The portion of the seashore shown on

Figure 4 is only approximately 3,000 feet long. As discussed previously, total length of the impacted seashore area will be 2 miles.

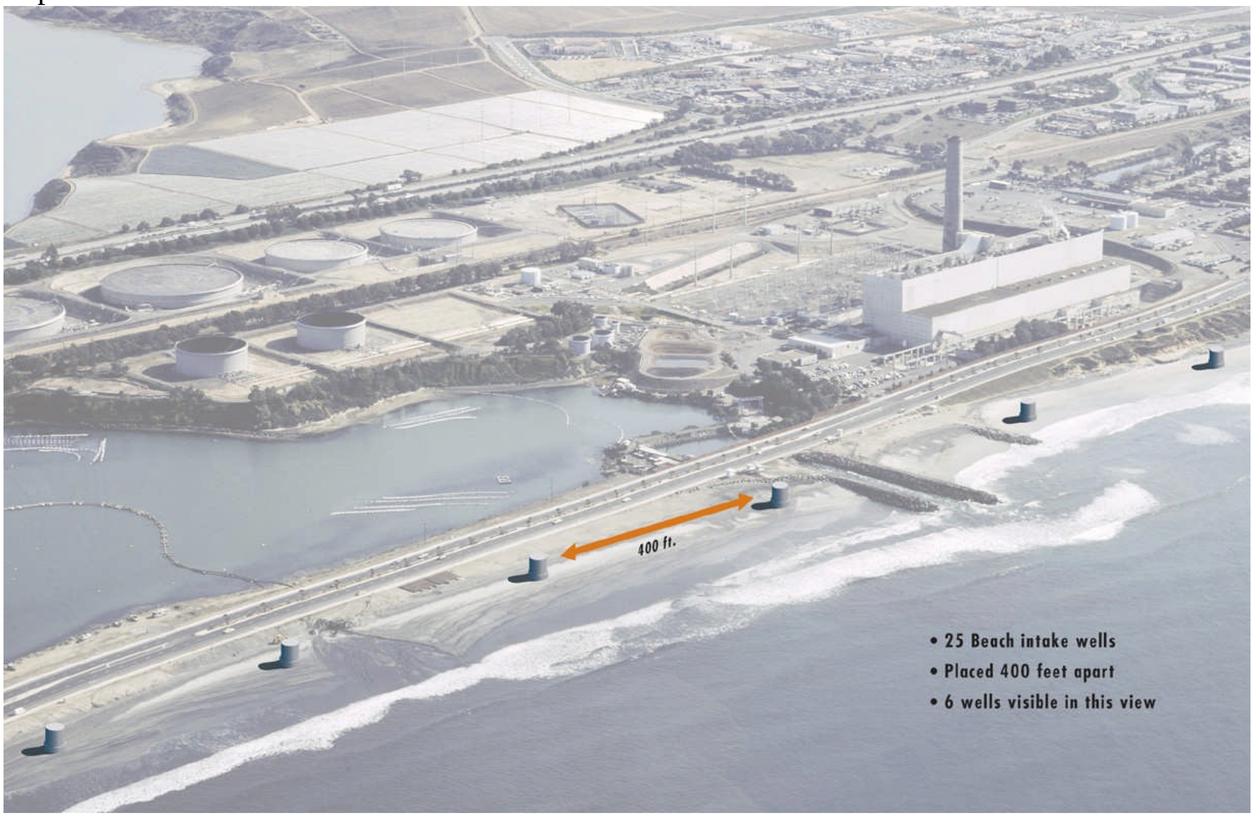

Figure 4 – Beach Well Intake Configuration for the Carlsbad Desalination Plant

Disturbing a two-mile strip of the City of Carlsbad seashore beach to install 25, 20 to 30-feet diameter intake wells for the Carlsbad Desalination Plant will have a measurable negative impact on the biological resources of the beach, which provides a habitat for marine organisms that a key food source for a number of seashore birds.

The intake beach wells for the Carlsbad seawater desalination plant will be constructed as large-diameter caissons and will be tall above-ground concrete structures that would have a visual and aesthetic impact on the shore line (see Figure 3). The pumps and service equipment conveying the water from a large-size beach wells would be located above the wet-well of the caisson. Taking under consideration that the beach wells are located in a close proximity of the ocean, the well intake pumps have to be installed at such an elevation that assures the protection of the well intake pumps and associated auxiliary equipment from flooding. Therefore, the height of the structures of the large plant intake wells with above-grade pump houses would exceed 10 feet above the beach ground level (see Figures 1 through and 3).

For a relatively small-size beach wells the caisson/vertical well collector can be build water-tight and located below grade to minimize visual impact. However, the size and servicing of the well pumps, piping, electrical, instrumentation and other auxiliary equipment of large-capacity wells in this case dictates the location of their pump house to be above grade. Although the above-grade pump house could be designed in virtually any architectural stile, this facility and its service roads and controlled access provisions would change the visual landscape of the seashore (see Figure 3). Taking under consideration that the desalination plant intake equipment and source water has to be protected from acts of vandalism and terrorism, the individual beach wells would have to be fenced-off or otherwise protected from unauthorized access. The large and tall fenced-off beach well concrete structures would have a limited visual and aesthetic appeal. Since the City of Carlsbad public beaches are visually sensitive areas, the installation of large beach wells will affect the recreational and tourism use and value of the City beaches, and will significantly alter beach appearance and character (see Figure 3).

The magnitude of the impact of a beach well intake system on the biological resources of the City beaches and the significant visual and aesthetic alteration of the beach appearance and aesthetic value are considered fatal flows for implementation of intake beach wells for the Carlsbad seawater desalination project.

For comparison, if the desalination plant is co-located with an existing power plant station, as proposed in the base project alternative, the City of Carlsbad coastal beach zone and environment would not be disturbed with the installation of additional structures, equipment and associated service infrastructure (access roads, fences, electrical supply equipment, etc.).

Infiltration Galleries. Infiltration galleries are typically implemented when conventional horizontal or vertical intake wells cannot be used due to unfavorable hydrogeological conditions. For example, they are suitable for intakes where the permeability of the underground soil formation is relatively low, or in the case of river or seashore bank filtration, where the thickness of the beach or the onshore sediments is insufficient to develop conventional intake wells. The infiltration galleries consist of an excavation trench which is filled up with filtration media of size and depth similar to that of the granular media filters used for conventional water treatment plants. Vertical or horizontal collector wells are installed in equidistance (usually 100 to 200 feet) inside the filter media. Typically the capacity of a single collection well is 0.2 to 2.0 MGD. The most common type of infiltration gallery is a horizontal well collection system with a single trench (Figure 5).

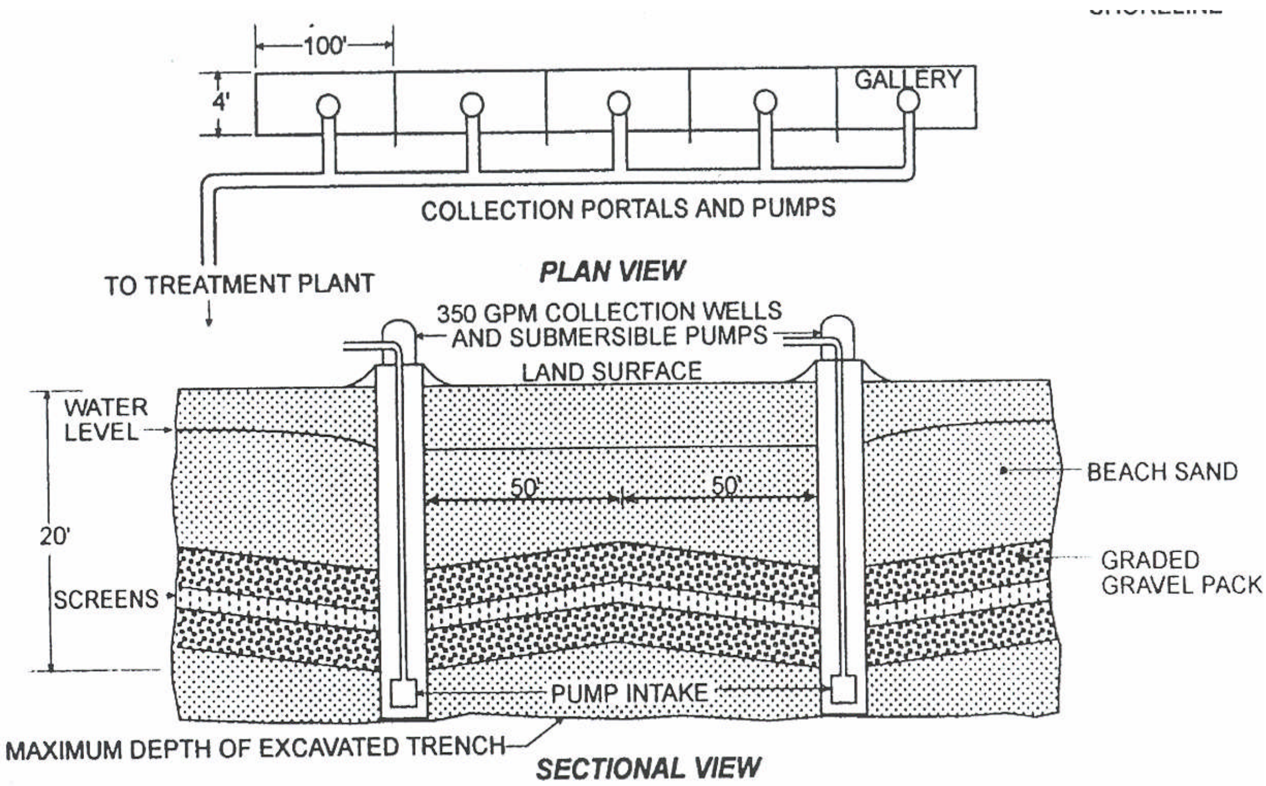

Figure 5 – Infiltration Gallery

The media in the infiltration gallery is configured in three distinctive layers: a bottom layer of sand media of approximately 3 to 6 feet, followed by a 4 to 6 feet layer of graded gravel pack surrounding the horizontal well collector screens; topped by a 20-foot to 30-foot layer of sand. The horizontal well collector screens are typically designed for inflow velocity of 0.1 ft/sec or less.

The infiltration galleries could be designed either similar to conventional rapid sand filters (if the natural ocean water wave motion can provide adequate backflushing of the infiltration gallery media) or could be constructed as slow sand filtration systems, which have at least a 30-feet layer of sand overlying the collection well screens. Infiltration galleries are usually 15 to 20 % more costly to construct than conventional intake wells and therefore, their use is warranted only when the hyrogeological conditions of the intake site are not suitable for intake wells.

The infiltration gallery shown on Figure 5 is 500 feet long, 4 feet wide and can deliver intake flow of 2.5 MGD, which is adequate to provide source water for 1 MGD seawater desalination plant. This system consists of four 0.5 MGD duty intake wells and one 0.5 MGD standby intake well. The infiltration gallery needed for the 50 MGD Carlsbad seawater desalination plant will be 50 times longer than that shown on Figure 5 and will have a total length of 25,000 feet (4.7 miles). In order to install this infiltration gallery on the City of Carlsbad shore, a beach strip 4-foot wide and 4.7-foot long has to be excavated at a depth of approximately 30 feet. This massive excavation work will yield 3 million cubic feet (approximately 14,000 cubic yards) of beach sand excavation debris, a portion (10 to 20 %) of which have to be transported and disposed off site.

Due to the large beach strip area that needs to be disturbed (4.7 miles) and excavated (at 30 feet depth), the impact of the installation of the infiltration gallery on the City beaches will be very significant. Disposal of over 0.3 to 0.6 million cubic feet of beach sand will also be a challenging task. In addition, the construction of this intake beach gallery will require the construction of 50 intake wells along the 4.7-mile long beach strip, which will cause measurable visual and aesthetic impact on the City beach. The significant environmental and other impacts of the construction of intake infiltration gallery for the Carlsbad desalination project render the use of infiltration galleries for this project fatally flawed.

Seabed Filtration Systems. These subsurface intake systems consist of a submerged slow sand media filtration system located at the bottom of the ocean in the near-shore surf zone, which is connected to a series of intake wells located on the shore (see Figure 6).

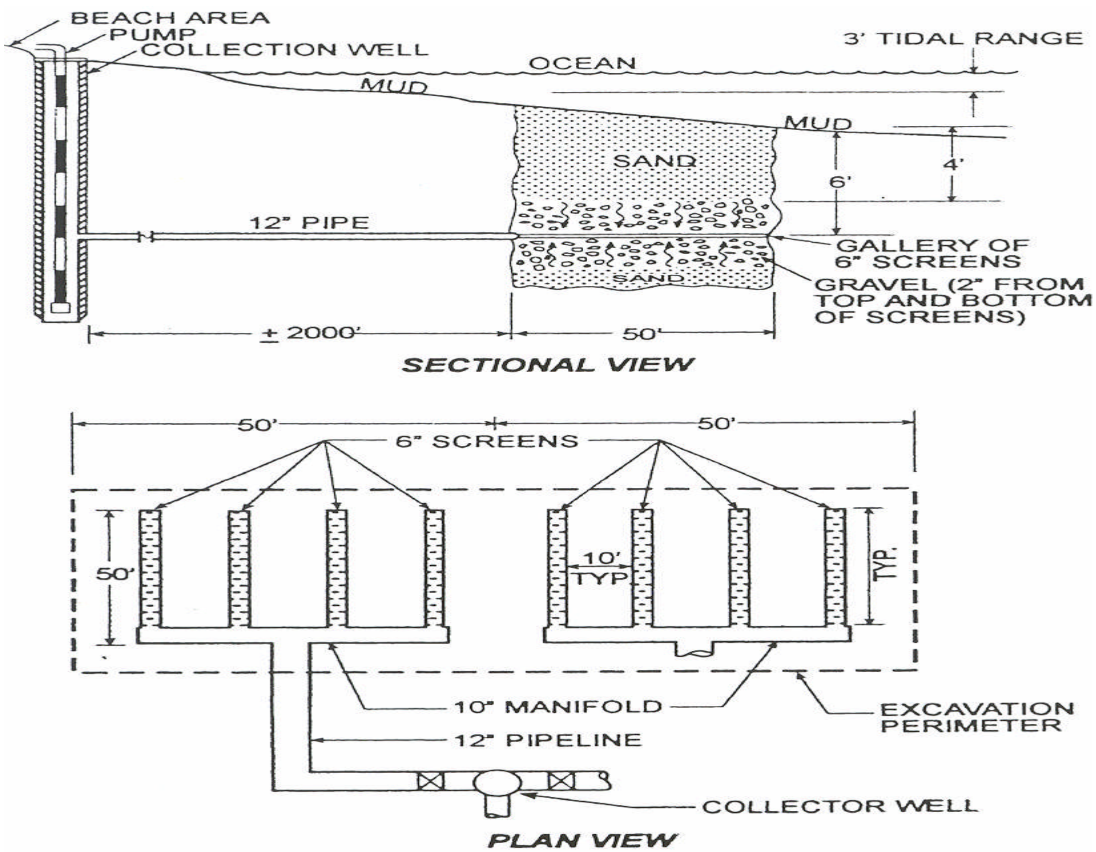

Figure 6 – Seabed Filtration System

As such, seabed filter beds are sized and configured using the same design criteria as slow sand filters. The design surface loading rate of the filter media is typically between 0.05 to 0.10 gpm/sq ft. Approximately 1 inch of sand is removed form the surface of the filter bed every 6 to 12 months for a period of three years, after which the removed sand is replaced with new sand to its original depth. Typically, seabed filtration systems are the costliest subsurface intake systems. Their construction costs are approximately 1.2 to 2.3 times higher than these of the conventional intake wells. In terms of overall cost of water (including both the capital and O&M components) the seabed filtration systems are usually more costly than any of the other type of subsurface intakes. As seen on figure 6, the ocean floor has to be excavated to install the intake piping of the wells. These pipes are buried at the bottom of the ocean floor excavation pit (see Figure 7).

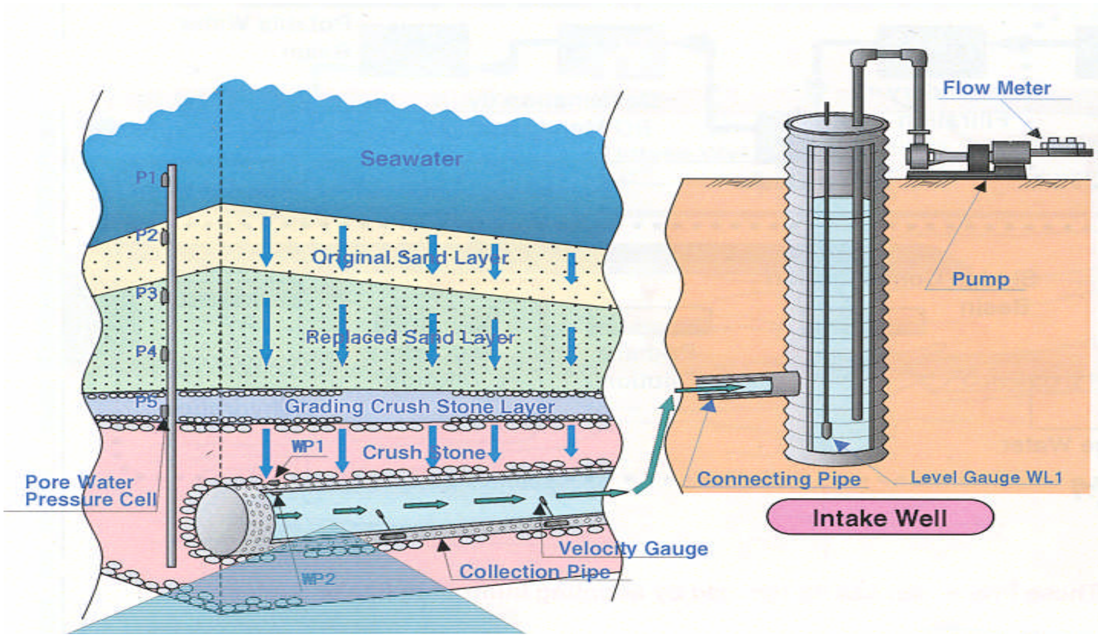

Figure 7 – A Cross-Section of a Seabed Intake System

For the source water intake feed rate of 106 MGD (74,000 gpm) needed for the Carlsbad seawater desalination project and a typical seabed design surface loading rate of 0.07 gpm/sqft, the total area of the ocean floor needed to be excavated to build a seabed intake system of adequate size is 24.3 acres (74,000 gpm/0.07 gpm.sq ft = 1,057,000 sq ft = 24.3 acres). Assuming that the seabed is 200 feet wide, this translates to impact of on the ocean floor of over one mile (1,057,000 sq ft /200 ft = 5,285 ft). The excavation of 24.3 acre/1-mile long strip of the ocean floor in the surf zone to install a seabed filter system of adequate size to supply the Carlsbad Desalination project, will result in a very significant impact on the benthic marine organisms in this location (see Figure 8). In addition, the use of this system will have a similar effect on the City beach, because the implementation of this intake system would also require installation of beach wells that collect the intake water prior to transferring it to the seawater desalination plant for further treatment.

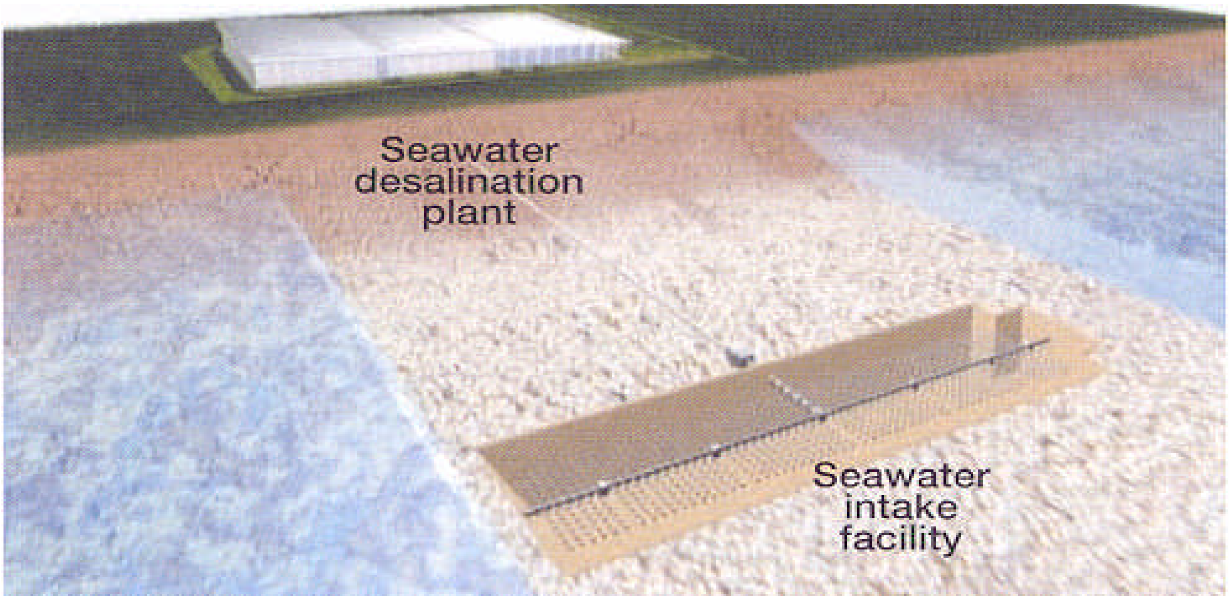

Figure 8 – Zone of Impact of the Seabed Intake System of the Ocean Floor

Currently, there are no existing large seawater desalination plants (with capacity over 5 MGD) using seabed intake systems. The largest seawater desalination plant with a seabed intake system currently under construction is the 13.2 MGD Fukuoka District RO facility in Japan. This plant is planned to be operational in late 2005. The Fukuoka seawater desalination plant seabed intake area is 312,000 sq ft. Taking under consideration that the Carlsbad seawater desalination plant is approximately 3.8 times larger in capacity, the corresponding surface are for this intake would be 1,185,600 sq ft. This comparison indicates that the estimated area of seafloor impact could actually be even higher than that presented in the estimates given above.

Seabed Intake Fatal Flaw Analysis. The significant environmental impacts on the benthic organisms of the 24.3 acre/1-mile long strip of the ocean floor in the surf zone along with the beach seashore impacts of installing intake collection wells that service the seabed intake are fatal flows for the practical implementation of this intake system for the Huntington Desalination Project. Additional issue that makes this system not viable is the fact that the seabed intake will be collecting seawater from the surf zone, which based on a number of third party studies (such as the Komex study) and the sanitary survey completed for this project, indicate that the level of coli bacteria in the surf zone is several orders of magnitude higher than that in the area of the power plant intake, which is approximately 1,400 feet away from the surf zone, i.e. co-location of the desalination plant intake with the power plant discharge under the proposed base scenario will likely yield much better quality source seawater in terms of bacterial content than the source water collected via the seabed intake.

Summary Comparison Between Base and Beach Well Intake Alternatives

The detailed analysis of common alternative subsurface intake systems (beach wells, infiltration galleries and seabed intakes) presented above clearly indicates that these systems are not viable for the site-specific conditions and size of the Carlsbad seawater desalination plant. Although beach wells have proven to be quite economic for desalination plants of capacity smaller than 1 MGD, open surface ocean intakes have found significantly wider application for large seawater reverse osmosis (SWRO) desalination plants. At present, worldwide there are only four operational SWRO facilities with capacity larger than 5.3 MGD using beach well intakes. The largest SWRO facility with beach wells is the 14.3 MGD Pembroke plant in Malta. This plant has been in operation since 1991. The 11 MGD Bay of Palma plant in Mallorca, Spain has beach wells with capacity of 1.5 MGD each. The third largest plant is the 6.3 MGD Ghar Lapsi SWRO in Malta. Source water for this facility is supplied by 15 vertical beach wells with unit capacity of 1.0 MGD.

As mentioned previously, the largest SWRO plant in North America which obtains source water from beach wells is the 3.8 MGD water supply facility for the Pemex Salina Cruz refinery in Mexico. This plant also has the largest existing seawater intake wells – three Raney-type radial collectors with capacity of 3.8 MGD, each. In addition, currently there are no operational large-scale (with capacity of 5 MGD or above) seawater desalination plants worldwide, which use infiltration galleries or seabed systems for collecting source water for seawater desalination plants.

In summary, the key factors that render the use of beach wells, infiltration galleries and seabed systems unfeasible for the Carlsbad desalination project are:

- Significant site impact of a large portion of the City beaches caused by the need for large excavation works.

- Measurable impact on the shore or benthic marine organisms in the area of the intake.

- Visual and aesthetic impacts that will change the character, appearance and recreational value of the City beaches.

- Lack of full-scale experience with seawater desalination plants of similar size to the Carlsbad desalination project, which use beach wells, infiltration galleries and seabed systems.

Additional factor which contribute to rendering these alternatives not feasible for this application is the oxygen concentration of the desalination plant discharge. Based on our previous experience, beach well water typically has a very low dissolved oxygen (DO) concentration. The DO concentration of this water is usually less than 2 mg/l, often it varies between 0.2 and 1.5 mg/L. The RO treatment process does not add appreciable amount of DO to the intake water. Therefore, the RO system product water and concentrate have the same or lower DO concentration. Low DO concentration of the product water will require either product water reaeration or will result in significant use of chlorine.

Since the low DO concentrate from the well intake desalination plant is to be discharged to the ocean, this discharge will not be in compliance with the United States Environmental Protection Agency's daily average and minimum DO concentration discharge requirements of 4 mg/L and 5 mg/L, respectively. Because this large desalination plant using intake wells would discharge a significant volume of low-DO concentrate, this discharge could cause oxygen depletion and significant stress to aquatic life. Therefore, this beach well desalination plant concentrate has to be re-aerated before surface water discharge. For this large desalination plant, the amount of air and energy to increase the DO concentration of the discharge from 1 mg/L to 4 mg/L is significant and would have a measurable effect on the potable water production costs. Discharge of this low DO concentrate to a wastewater treatment plant would also result in a significant additional power use to aerate this concentrate prior to discharge. For comparison the concentrate from RO plant with co-located intake (base EIR alternative) will have DO concentration of 5 to 8 mg/L, which is adequate for disposal to the ocean, without re-aeration.