APPENDIX AB

Feasibility of Alternative Seawater intakes for the Huntington Beach Seawater Desalination Project – Technical Memorandum

Prepared by Psomas, May 2007

FEASIBILITY OF ALTERNATIVE SEAWATER INTAKES FOR THE HUNTINGTON BEACH SEAWATER DESALINATION PROJECT - TECHNICAL MEMORANDUM
Huntington Beach, California

May 2007

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Executive Summary

The purpose of this technical memorandum is to evaluate the feasibility of the use of subsurface intakes (vertical beach wells and slant/horizontal wells) for the site-specific hydrogeologic and environmental conditions of the Huntington Beach Seawater Desalination Project (HBSDP). This memorandum also provides a comparison of the suitability of subsurface intakes for the Huntington Beach and Dana Point desalination projects. A comprehensive analysis of the available information on the subsurface conditions, geological formations, transmissivity and water quality characteristics of the coastal and inland aquifers in the vicinity of the proposed desalination project site allows one to conclude the following:

1. Use of both vertical beach wells and slant/horizontal wells is not feasible for the Huntington Beach seawater desalination project because of site-specific hydrogeological, source water quality and environmental constraints inherent to the project site.

2. Reduction of the Huntington Beach project size below its proposed capacity of 50 million gallons per day (MGD) is not expected to improve subsurface intake viability because most of the source water quality and environmental constraints which render the project unfeasible would not be eliminated or diminished significantly with the reduction of the project size.

3. The viability of subsurface intakes for source water supply to seawater desalination plants is very site specific. While a recently completed preliminary study finds the use of this type of intakes suitable for the 15 MGD Dana Point seawater desalination project, located in Southern Orange County, the application of the same type of intakes for the Huntington Beach project was found infeasible because of the poorer aquifer water quality and the potential detrimental environmental and soil subsidence impacts of the operation of this intake on the nearby coastal wetlands (Brookhurst, Magnolia, Newland, & Talbert Marshes), the Ascon landfill, the Pacific Coast Highway (PCH), and the Talbert seawater intrusion barrier, which are mostly located within the boundaries of influence of the intake (see Figures ES-1 and ES-2). The Dana Point project intake site has no wetlands, major highways, landfills that may leach hazardous materials, or other coastal structures that could be affected by the aquifer drawdown caused by the intake operations.

Key Subsurface Intake Constraints and Impacts

The use of subsurface intakes for the Huntington Beach Desalination Project site is not viable because of the following constraints:

1. Aquifer transmissivity, storativity, and aquifer thickness (see Table 3-3)) of the coastal aquifer limit the maximum amount of intake source water that could be collected by vertical beach wells to only 18.2 MGD while the total amount of

source water needed to produce 50 MGD of fresh water is approximately 100 MGD. Operation of the vertical beach wells of total capacity of only 18.2 MGD (i.e. a desalination plant as small as 9 MGD) could cause the water level in the vicinity of the wells to drop from 5 feet to 110 feet below ground surface and the water table to be reduced down to 20 to 90 feet below the ground surface in a vast 4,000 feet wide zone (strip) located parallel to the shore and perpendicular to the well field line. The boundary of the aquifer drawdown zone is shown on Figure ES-1. Over 180 acres of wetlands located within the aquifer drawdown zone will be partially or completely dewatered and their ecological balance and productivity would be significantly affected.

2. The structures and roads located in the area of this significant groundwater level drawdown (i.e., the PSH, the Ascon landfill, the AES Power Plant, the Hyatt Hotel, the Huntington Beach pier, etc.) would be exposed to potential soil subsidence, which in turn may compromise their structural integrity.

3. Operation of the slant wells at a total capacity of 100 MGD will cause the water level in the vicinity of the wells to drop from 5 feet to 60 feet below ground surface and the water table in a 4,000 feet wide zone (strip) located parallel to the shore and perpendicular to the well field line. The estimated boundary of the aquifer drawdown zone is shown on Figure ES-2. Use of slant wells will also have negative impacts on intake operations on the nearby wetlands (i.e., Talbert Marsh); the potential for the drinking water contamination from the Ascon landfill; and subsidence of coastal structures and the PSH highway (see Figure ES-2 for the zone of drawdown influence of the slant well intake system).

4. Due to the source water quality variations that might be expected from water produced from the nearshore groundwater system, this variability will require more complex treatment system and will have a negative impact on the reliability of the water supply and the costs associated with water production..

Key Differences between the Feasibility Conditions of the Huntington Beach and Dana Point Plant Sites

Although the use of slant wells/horizontal intakes may have been found to be viable for the Dana Point plant location, the conditions at the Huntington Beach desalination plant site differ as follows:

1. The presence of wetlands (including the Brookhurst, Magnolia, Newland and Talbert Marshes) in the immediate vicinity to the intake area and the hydraulic connection of these marshes to the water supply aquifer – the Dana Point site has no adjacent wetlands;

2. The Dana Point site has no landfill or other potential source of hazardous materials contamination within the zone of influence of the intake system. In contrast, the Ascon Landfill is located within the zone of influence of the

subsurface intake of the Huntington Beach plant and potential leaching of landfill pollutants may contaminate the drinking water supplies (see Figures ES-1 and ES-2);

3. The Dana Point site is not located in an area of fine grained sediments that underlay major roads and highways and therefore does not present a hazard for the structural integrity of nearby roads and highways. Soil subsidence under the PCH, the AES Plant, the Huntington Beach Hyatt and other coastal structures near the Huntington Beach site is likely due to the fine-grained sediments that dominate the local near surface soil conditions.

4. There is no man-made seawater intrusion barrier that can interfere with the operations and water quality of the Dana Point subsurface intake. The Talbert Gap, which is the aquifer that would be contributing to the source water of the Huntington Beach seawater subsurface intake, has a seawater intrusion barrier operated by the Orange County Water District. This barrier is a man made water curtain used to keep seawater from entering into the groundwater supply used to store drinking water. Approximately, 10 MGD (with plans to expand to 30 MGD) of reclaimed wastewater is injected into the same aquifer to maintain the water curtain. Since the seawater intrusion barrier is relatively close to the subsurface intake zone this intake would create a relatively steep gradient from the barrier to the ocean, hence, the subsurface intake water could be contaminated with the reclaimed wastewater, which is not permitted for direct use by the California Department of Health Services.

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Imagery Source: Google Earth Pro

0 400 800 1,600 2,400 3,200 Feet

Proposed Vertical Well Locations

Area of Drawdown Influence (4,000' setback)

Conceptual Layout and Cross Section of Vertical Extraction Wells

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Feasibility of Alternative Seawater Intakes for the Huntington Beach Seawater Desalination Project

Figure ES-1

Imagery Source: Google Earth Pro

0 400 800 1,600 2,400 3,200 Feet

- Proposed Well Locations
- Slant Casing (~ 400' long)
- Area of Drawdown Influence (4,000' setback)

Conceptual Layout and Cross Section of Slant Extraction Wells

1.0 Introduction

Poseidon Resources Corporation (Poseidon) has proposed to construct a 50 million gallons per day (MGD) seawater desalination facility adjacent to the AES Huntington Beach Generating Station in the City of Huntington Beach, California. In response to the California Coastal Commission's request for further analysis of alternative seawater intake structures for the proposed Huntington Beach Seawater Desalination Plant (HBSDP), Poseidon is evaluating the possibility of using an intake system that would utilize vertical, slant and horizontal wells as sea water intake structures for the proposed desalination plant.

1.1 Project Description

The proposed project consists of construction of a seawater desalination plant, storage facilities and pipelines to produce drinking water for delivery into the regional water distribution system to meet the needs of Orange County. The proposed project involves the implementation of a desalination plant producing approximately 50 MGD, or 56,000 acre feet per year (afy) of potable water with an input supply requirement of 100 MGD or 69,444 gallons per minute (gpm).

1.2 Methodology

The documentation and analysis provided in this report is based on available reports and literature. A list of the studies used and information obtained are included in Section 7.0 References.

2.0 Site Description

The following discussion presents an overview of the project area including site location and physical setting (climate, wetlands, surface water, geology, and hydrogeology).

2.1 Site Location

The proposed HBSDP site is approximately 11 acres in size and is located in the southeastern portion of the city of Huntington Beach. The site is bordered by a fuel oil storage tank to the north, the Orange County Flood Control District (OCFCD) flood channel to the east, a wetland area to the southeast, AES Huntington Beach Generating Station facilities to the southwest and an electrical switchyard to the west.

The proposed project site is approximately 0.5 miles from the Pacific Ocean on the seaward edge of the coastal floodplain of Orange County. The area is relatively flat with a surface elevation of approximately 5 feet above mean sea level (msl). The region is mostly developed with residential housing, and commercial and industrial facilities. Figure 2-1, *Site Location Map*, presents a general overview of the area surrounding the proposed site.

2.2 Physical Setting

2.2.1 Climate

The climate of the area is characterized as Mediterranean with warm, dry summers, tempered by ocean breezes, and mild winters. Annual temperatures generally range from 35 to 100 degrees Fahrenheit. The mean annual rainfall is 12 inches occurring primarily between November and April.

2.2.2 Wetlands

Adjacent to the proposed desalination project site area is a series of wetlands. The Huntington Beach (HB) wetlands are a relic wetland area in the vicinity of the former Santa Ana Rivermouth. Over time, the wetlands have been modified (including filling) for development, infrastructure, flood and drainage control, refuse disposal; they have also been used for oil drilling, gas extraction, and other purposes. They were isolated from the ocean by construction of Pacific Coast Highway (PCH) and the Santa Ana River Flood Control levees. Approximately 180 acres remain of the former larger wetland (Moffat & Nichol, 2004). The remnant wetlands consist of salt marsh, seasonal ponds, and coastal dune habitat, with 27 acres of restored marsh (Talbert Marsh). Unrestored areas of the HB wetlands consist of non-tidal salt marsh vegetation that varies from relatively poor to moderate quality.

Imagery Source: Google Earth Pro

0 400 800 1,600 2,400 3,200 Feet

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Site Location Map

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Feasibility of Alternative Seawater Intakes for the Huntington Beach Seawater Desalination Project

Figure 2-1

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Merkel and Associates (2004) designated the wetlands as marshes and referred to them as the Newland Marsh (located northwest of the proposed facility), the Magnolia Marsh (located between Magnolia street bridge and the proposed facility), the Brookhurst Marsh (located between the Magnolia Street bridge and Brookhurst Street bridge), and the Talbert Marsh (located to the southwest of the Brookhurst Street bridge).

As part of a study to evaluate the existing hydrologic and hydraulic conditions and create a numerical model to characterize the hydraulic flow patterns, Moffatt and Nichol (2004) conducted studies to assess the landward progression of tidal influence into the Talbert Marsh and adjoining Talbert and Huntington Beach flood control channels.

During high tide, the flood current was observed to take floats from the tidal inlet upstream in the Talbert Channel as far north as Adams Avenue (Figure 2-1, *Site Location Map*). In addition, floats dropped in Huntington Beach Channel were observed to travel as far west as between Newland and Atlanta Streets near Newland Marsh. This suggests that if the Newland, Magnolia and Brookhurst marshes were connected to permit tidal influence to occur, that they would be partially flooded by tidal influenced seawater.

2.2.3 Surface Water

The site of the proposed project lies in the Recent alluvial floodplain of the Santa Ana River. This floodplain comprises the inland surface of the proposed project site, which extends seaward through the Talbert Gap. The slight relief (20 feet) of the immediate vicinity of the proposed project is interrupted by minor streams, improved flood control channels, and by subsidence depressions associated with peat deposits (DWR, 1966). Historically, the Talbert Gap was characterized by freshwater swamps merging seaward to tidal marshes. During the 1900s, much of the area was modified by clearing, draining and placement of fill material.

The Talbert Channel Watershed has mild slopes with elevations ranging from sea level to approximately 130 feet above mean sea level. Surface runoff is collected in three main flood control channels that include the Talbert Channel, the Fountain Valley Channel, and the Huntington Beach Channel.

The Talbert Channel drains the southern and central portions of the watershed and empties into the Talbert Marsh. According to the Orange County Flood Control District (Jones, 2005), the channel is unlined from the ocean to Yorktown Avenue. The Fountain Valley Channel drains about 3.9 square miles of watershed and joins with the Talbert Channel fairly high up in the watershed. The Huntington Beach Channel drains about 4.3 square miles in the northern portion of the watershed and joins the Talbert Channel just upstream of Brookhurst Street bridge. According to Orange County Flood Control District (Jones, 2005), the Huntington Beach channel is unlined along its entire reach until it joins with Talbert Channel.

The existing tidally-influenced hydraulic system includes the restored Talbert Marsh, Talbert inlet channel (ocean connection under PCH), the Talbert Channel, and the Huntington Beach Channel. The remaining wetlands in the project area are not currently connected to the existing hydraulic system except by two 2-foot diameter culverts with flap gates (that prevent seawater from entering the wetlands area), one of which connects a small marsh north of the AES Plant to the Huntington Beach Channel and the other which connects Newland Marsh to the Huntington Beach channel. However, review of literature including soil boring logs indicates that the groundwater aquifers that could be used for supplying the desalination project are most likely hydraulically connected to the wetlands.

2.2.4 Geology

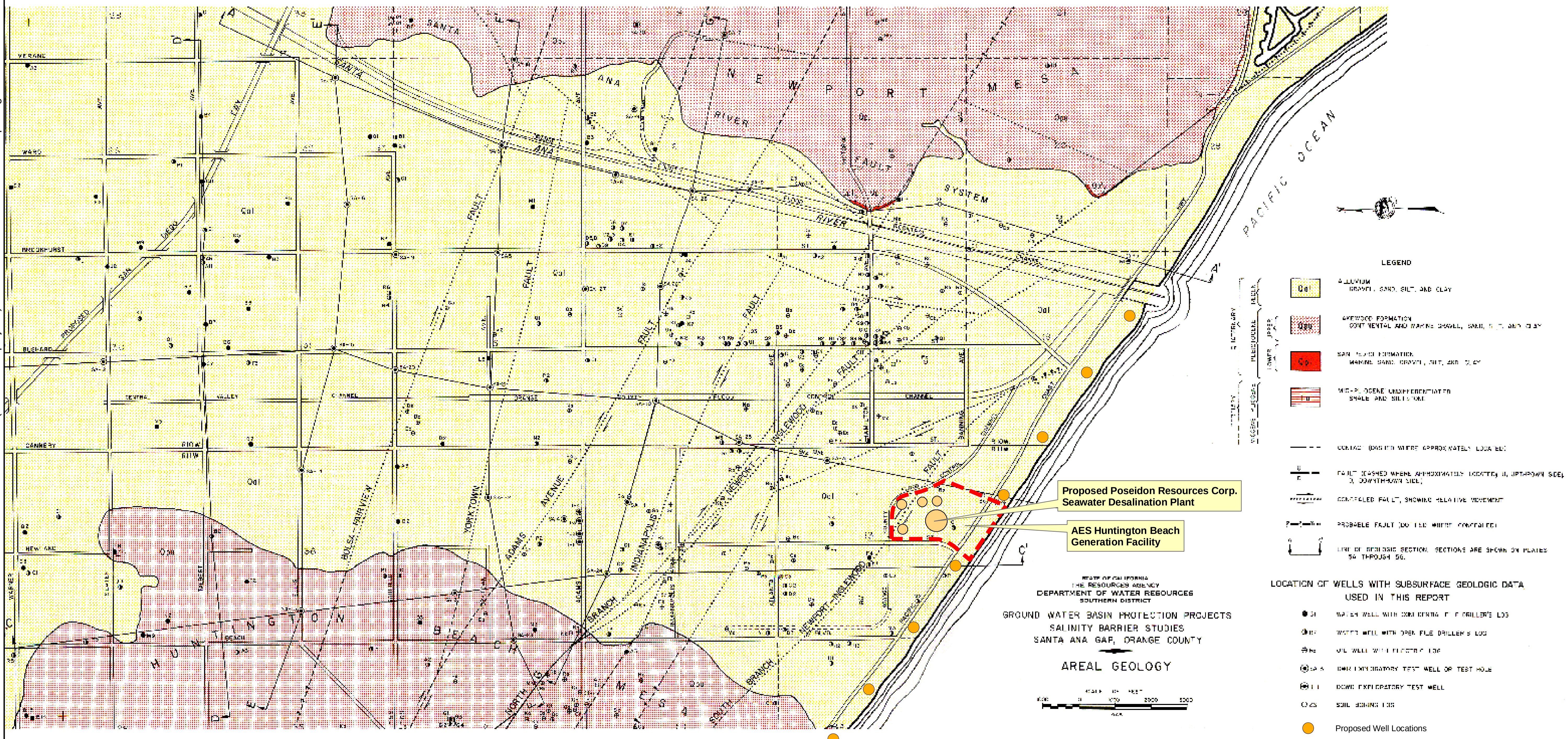
The project site is situated within a coastal lowland area referred to as the Santa Ana Gap (and herein referred to as the Talbert Gap) that is bordered by gentle slopes of Huntington Beach mesa to the northwest and Newport mesa to the southeast. Huntington Beach and Newport mesas are upper Pleistocene surfaces elevated by faulting and anticlinal folding along the Newport-Inglewood structural zone. The creation of the Talbert Gap began in Late Pleistocene time and continued until the end of the last glacial period, approximately 15,000 years before present (ybp).

The Talbert Gap area is located within the extensive Los Angeles sedimentary basin and is crossed along its long axis by the northwest-trending Newport-Inglewood structural zone. During late Pliocene and Pleistocene time, coarse-grained sediments derived from uplifting mountain ranges were transported and deposited in the basin. The sediments were reworked by waves, offshore currents and were deposited with interbedded silts and clays in a marine embayment of moderate to shallow depths. Concurrently, anticlinal folding and faulting occurred intermittently along the Newport-Inglewood structural zone. Ancient meandering of the Santa Ana River carved notches through the uplifted area and left behind sand- and gravel-filled deposits beneath the lowland aquifers within the mesas, known as gaps (Poland et al., 1956).

Figures 2-2, *Surficial Geology and Section B-B' Location* and 2-3, *Geologic Section B-B'*, present a surficial geologic map of the area surrounding the proposed Poseidon Desalination Plant area along with a geologic cross-section for the area.

2.2.4.1 Stratigraphy

From a review of the geologic reference material, the following major geologic units underlie the site: Lower Pleistocene San Pedro Formation (composed of clays, silts, sands and fine-coarse gravels), Upper Pleistocene Lakewood Formation (composed of clays, silts, sands and fine-coarse gravels), and Recent age deposits (consisting mainly of alluvial and floodplain deposits of sands and fine to coarse gravels). Table 2-1, *Generalized Geologic Column* presents a generalized geologic column of the major geologic units found beneath the site.



Source: Santa Ana Gap Salinity Barrier, Orange County Department of Water Resources Bulletin 147-1, December, 1966.

Surficial Geology & Section B-B' Location

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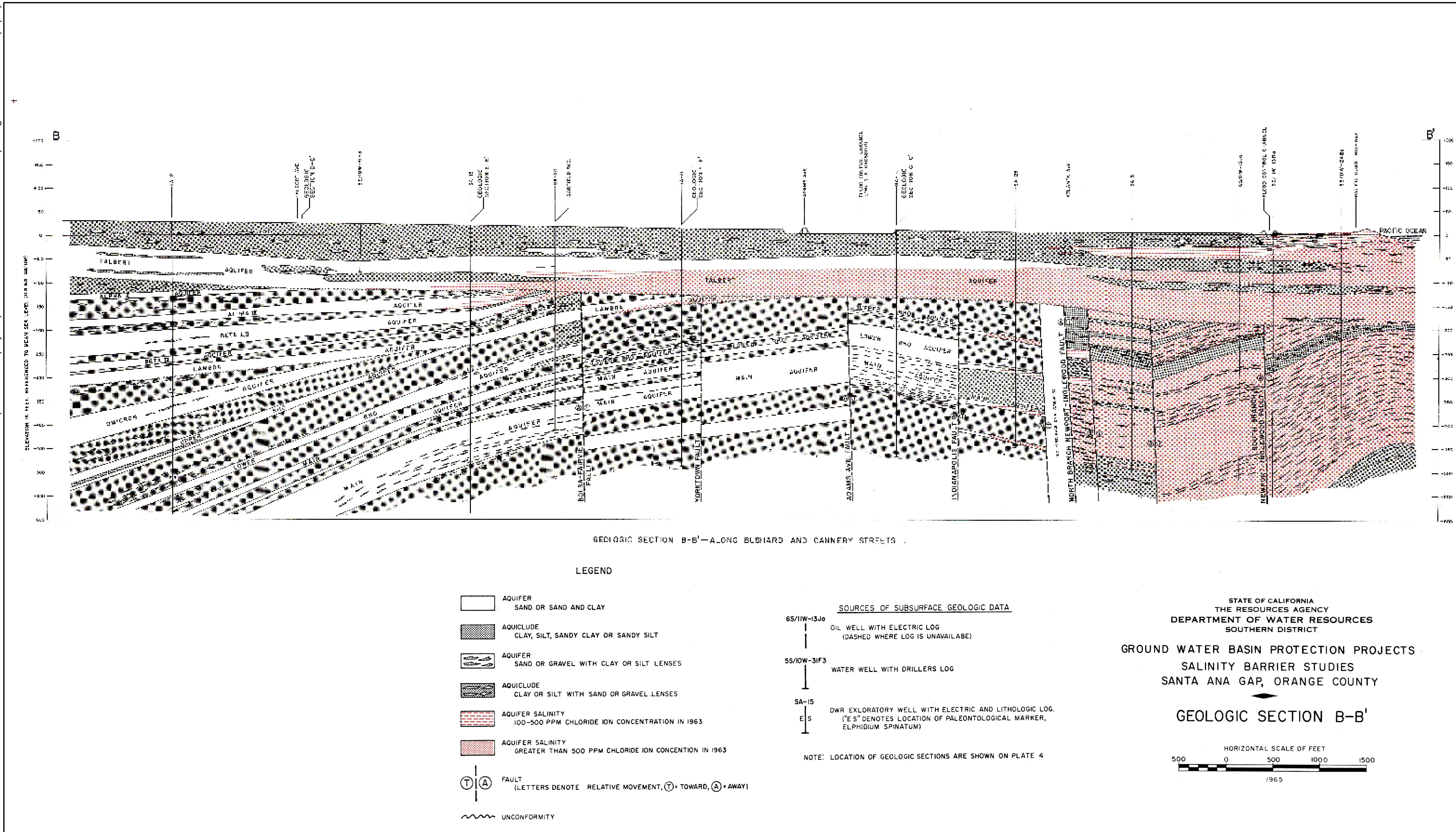

Source: Santa Ana Gap Salinity Barrier, Orange County Department of Water Resources Bulletin 147-1, December 1966.

Geologic Section B-B'

TABLE 2-1
GENERALIZED GEOLOGIC COLUMN
TALBERT GAP AREA

AGE	GEOLOGIC UNITS	AQUIFER UNITS	MAXIMUM THICKNESS (feet)	GENERAL LITHOLOGY
Recent	Recent Deposits	---	100	Silt, organic silt, and sandy clay, with interbedded peat, shell fragments and thin sand lenses. May be thin or absent along coast.
		Talbert	110	Fine to coarse sand, fine to very coarse gravel and boulder with lenses of silty clay, wood and shell fragments. High permeability.
Late Pleistocene	Lakewood Formation	Alpha I, II, III, Beta I, II, III, Lambda	400	Fine to coarse sand and gravel separated by clay and silt beds.
Early Pleistocene	San Pedro Formation	Omicron, Upper Rho, Lower Rho, Main	700	Fine to coarse sand and gravel separated by clay and silt beds.

Source: Derived from Generalized Geologic Column in DWR, 1966.

2.2.4.2 Structure

The most predominant structural feature affecting groundwater flow within the study area is the northwesterly-trending Newport-Inglewood Fault (NIF) zone. According to the California Department of Water Resources (DWR) [DWR, 1966], the northern branch of this system appears to impede groundwater flow in the Pleistocene sediments. CDM (2000), using multi-level monitoring wells located on either side of this zone, confirmed this assessment.

The existence and role of the south branch of the NIF is poorly understood. Some studies have suggested that this branch acts as a hydraulic barrier in the San Pedro Formation, whereas others have suggested the branch does not extend into the Pleistocene sediments and is non-existent beneath the mesas. The north-northeasterly trending Santa Ana River fault system also exists within the study area and is thought to affect groundwater flow within the Talbert Gap.

Structural folds have been identified in the DWR geologic sections and aquifer surfaces. Folding of Pleistocene and older deposits formed across the regional Huntington Beach anticline along the NIF zone. From the NIF zone, beds dip gently inland toward the Southgate-Santa Ana syncline, whose axis is located about 10 miles northeast of the study area. The local anticlinal folding has increased the flow of groundwater between aquifers because the Pleistocene aquifers merge across the fold crests due to thinning, facies change and/or erosion of intervening confining beds.

2.2.5 Hydrogeology

The following discussion was derived from the Orange County Water District's (OCWD) Groundwater Management Plan (OCWD, 1999), Poland et al (1967) and DWR (1966).

The region surrounding the site is part of the Santa Ana River Plain that includes a complex assemblage of sedimentary deposits and aquifer systems. The Basin has been divided into Forebay and Pressure areas. The Poseidon site is located in the Pressure area of the basin and is defined as the area in the Basin where surface water and near-surface groundwater are impeded from percolating in large quantities into the major producible aquifers by clay and silt layers at shallow depths (upper 50 feet). Most of the central and coastal portions of the Basin fall within the Pressure Area. Because the principal and deeper aquifers within the Pressure Area are under "confined" conditions (under hydrostatic pressure), the water levels in wells penetrating these aquifers can exhibit large seasonal variations in response to pumping.

The Talbert Gap is underlain at shallow depths by Holocene sediments consisting of ancient river and flood plain deposits associated with the Santa Ana River, and tidal flat lagoonal deposits. These sediments consist of unconsolidated sand, gravel, silt and clay that includes the marine sands and gravel that comprise what is known as the Talbert water-bearing zone/aquifer. The Talbert Aquifer, which extends from approximately 15 to 180 feet below the ground surface, is highly susceptible to seawater intrusion due to its interconnection with the ocean and the Huntington Beach Channel. Isolated pockets of peat and organic soil deposits also occur within the uppermost portions of these sediments.

With the exception of a few large-system municipal wells in the cities of Garden Grove, Anaheim, and Tustin, wells producing from the shallow aquifer system predominantly have small-system industrial and agricultural uses. Production from the shallow aquifer system is typically about five percent of total Basin production.

Moreover, due to seawater intrusion along the coast, generally the shallower and deeper aquifer systems along the coast are not utilized. As part of a plan to protect inland groundwater quality from seawater intrusion, a seawater intrusion barrier was constructed in the Talbert Gap. According to the Water Resources Report Highlights (OCWD, 2004), OCWD is currently injecting approximately 10 MGD of highly treated wastewater (with plans to increase to 30 MGD) in order to impede seawater intrusion in the Talbert Gap area.

Given the proximity of the site to the Pacific Ocean, and its reported interconnection with the nearby Huntington Beach Channel, depth to groundwater beneath the site is about five to seven feet. The actual elevation of the groundwater table will fluctuate with the ocean tides and water level in the neighboring flood control channel. Due to this interconnection, groundwater quality is considered brackish.

A review of the DWR report (DWR, 1966) suggests that the sands associated with the Talbert Aquifer that lie between the Huntington Beach Channel appear unconfined and are composed of sand/sand and clay with clay and/or silt lenses to a depth of approximately 25 feet. Clay and silt beds that appeared to be laterally extensive were encountered at depths between 50 and 75 feet below ground surface (bgs) and 100 and 120 feet bgs. The base of the Talbert Aquifer appeared to occur at a depth of 190 feet bgs.

CDM (2000) reported that the Talbert Aquifer had a range of transmissivity of between 17,500-23,400 ft^2/day and a storativity of 4.6×10^{-4} (under confined conditions). It is unknown what the storativity would be near the coast where the aquifer may be under unconfined or semi-confined conditions. It is estimated that storativity would range from 0.01 to 0.05 for unconfined conditions.

2.2.5.1 Groundwater Flow

Regionally, flow in the Talbert Aquifer is mostly from the northeast to the southwest toward the Talbert Gap area. CDM (2000) indicated that in the winter, when heads in the aquifer are generally at their highest, the heads in the wells near and seaward of the barrier are all within five feet of each other, indicating a relatively flat gradient across this area. As coastal production increases during the spring and summer months, the heads in the inland wells fall by as much as 15 feet from the winter highs, creating a relatively steep gradient from the ocean to the barrier. Operation of a subsurface intake for the Huntington Beach desalination plant will further increase this groundwater gradient, which in turn could introduce reclaimed wastewater injected as part of the Talbert saltwater barrier into the source water for the desalination plant. This would be a fatal flaw for the operation of the desalination plant because the California Department of Health Services prohibits the direct use of reclaimed wastewater as source water for drinking water supply.

2.2.5.2 Groundwater Quality

DWR (1966) indicated that the Talbert Aquifer in the vicinity of the coast was heavily impacted with saltwater with chloride concentrations exceeding 500 parts per million (ppm) in the lower portion of the Talbert Aquifer and 100-500 ppm in the near surface sediments.

A recent study (Boehm et al., 2004) also indicates that the Talbert Aquifer is anoxic and contains high levels of ammonia.

3.0 Potential Water Supply from Various Subsurface Intake Structures

The use of subsurface intake structures for desalination supply generally requires structures capable of pumping large quantities of high-quality saline groundwater while minimizing impacts to onshore fresh water sources (including both surface water and groundwater). This has resulted in the need to develop well construction technology to place well screens as far offshore as possible. In general, wells that penetrate sub-sea aquifers at an angle from the vertical have the potential to be more productive than vertical onshore wells that have screens limited in length to the vertical thickness of the aquifer. The two most common subsurface type intake systems that have been used under similar conditions for seawater intake structures are: (1) vertical wells and (2) collector wells.

Vertical intake wells consist of a non-metallic casting (typically, fiberglass reinforced pipe), well screens, and a stainless steel submersible or vertical turbine pump. The well casing diameter is between six inches and 24 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 can be relatively small in comparison to collector wells.

Collector wells consist of a large vertical caisson constructed adjacent to the water source that extends below the ground surface with water well collector screens (laterals) projected out horizontally from inside the caisson into the surrounding aquifer. Since the laterals in the collector wells are placed horizontally, a higher rate of source water collection is possible when compared to vertical wells. Collector wells are relatively shallow, rarely extending deeper than 100 feet below ground surface. Since the base of the Talbert Aquifer extends to a depth of 190 feet bgs, collector wells cannot reach this depth, and therefore were not considered as part of the evaluation process.

A third type of well recently considered as a potential subsurface intake structure was an angle well. Geosciences Support Services, Inc. (GSSI) evaluated the installation and test pumping of an angled (slant) well at the proposed Dana Point Ocean Desalination Project (DPOCP) and document in a draft report (GSSI, 2007). The following discussion presents an overview of the production requirements and conceptualization of how the subsurface intake system (for both vertical and slant wells) would manifest itself if employed for the proposed HBSDP.

3.1 Production Requirements

The production requirements are assumed to have a total production volume of 100 MGD or 69,444 gallons per minute (gpm).

3.2 Conceptual Well Designs

The key element in well field design is assessing what quantity of water can be produced from each well. Psomas (2005) evaluated the optimum pumping rate for a vertical production well and is discussed in subsection 3.2.1, Vertical Wells. With respect to slant wells, the study conducted by GSSI (2007b) was used to evaluate the feasibility of slant wells to supply the required feedwater for the proposed desalination facility and is discussed in subsection 3.2.2.

3.2.1 Vertical Wells

Psomas (2005) proposed that vertical wells, completed to the base of the Talbert Aquifer (approximately 200 feet in depth), could be used to supply the proposed HBSDP feedwater. Of particular importance in deciding the number and spacing of the wells was the optimum production capable from each well. This optimum production was based on aquifer characteristics, maximum drawdown, and well field layout. The following discussion summarizes the evaluation presented in the Psomas (2005) report.

3.2.1.1 Aquifer Characteristics

As previously stated, the area underlying the proposed HBSDP is underlain at shallow depths by Holocene sediments consisting of ancient river and flood plain deposits associated with the Santa Ana River, and tidal flat lagoonal deposits. These sediments consist of unconsolidated sand, gravel, silt and clay that includes the marine sands and gravel that comprise what is known as the Talbert water-bearing zone/aquifer. The Talbert Aquifer, which extends from approximately 15 to 180 feet below the ground surface, is highly susceptible to seawater intrusion due to its interconnection with the ocean. Table 3-1, *Talbert Aquifer Characteristics*, summarizes specific aquifer characteristics that were used to develop optimum production rates from vertical wells.

Table 3-1
Talbert Aquifer Characteristics

AQUIFER CHARACTERISTIC	VALUE	UNITS
Depth to Water	10	Feet bgs
Depth to Bottom of Well	190	Feet bgs
Transmissivity	23,400	Ft^2/day
Storativity	0.01	Unitless

Source: Derived from Psomas, 2005.

3.2.1.2 Well Field Layout

Psomas (2005) estimated that the maximum available drawdown was110 feet. Psomas also estimated that 50 percent of the available drawdown could be used for a single well resulting in a theoretical production rate of 3,900 gpm. However, due to the excessive drawdown with the high production, wells would have to be spaced at approximately 6,100 feet apart. This spacing resulted in an overall production of 7,800 gpm, far below the required production of 69,444 gpm. Psomas (2005) went on to state that the highest total production of 12,600 gpm would be from a well field with a spacing of 1,800 feet with a single well production rate of 1,560 gpm. However, the total production of 12,600 gpm is only 18 percent of the target production of 69,444 gpm.

Thus, the subsurface conditions analysis conducted by Psomas indicated that the proposed HBSDP will not be able to collect more than 12,600 gpm (18.2 MGD) of source water using vertical wells from the main groundwater aquifer that is available in the area. This available flow would limit the desalination plant to only 9 MGD. The proposed project is of 50 MGD capacity and needs 100 MGD of source water flow. Even at this limited capacity, the project boundary of influence in terms of water level drawdown and potential for subsidence due to dewatering is significant and could extend inland from 2,000-4,000 feet from shore (see Figure 3-1). The conceptual layout of the 18.2 MGD vertical well field subsurface intake is shown on Figure 3-1, *Conceptual Vertical Well Field Layout*.

3.2.1.3 Effects of Sustained Production (1-Year)

Psomas evaluated what the effects of sustained production from the proposed well field would have on the Talbert Aquifer if the system were in operation for a period of one year. Preliminary results indicated drawdowns at the wells of 110 feet and then dropping off to 80-90 feet at approximately 4000 feet east perpendicular to the well field line. With respect to the ocean side of the well field, it is expected that the drawdown will be less due to interception of the constant head boundary that the ocean would represent.

3.2.2 Slant Wells

The Dana Point Ocean Desalination Project (DPODP) is located in a similar hydrogeologic regime as the Huntington Beach facility. The DPODP project is located at the mouth of San Juan Creek that drains the western slopes of the Santa Ana Mountains. The groundwater basin consists of an elongated alluvial basin and contains the primary aquifers in the area. The aquifers consist primarily of interbedded cobbles, gravel, sand, silt and clay overlying very low permeability sedimentary basement rocks. The basin is bounded on the sides by low lying hills composed of the same material as the basement rock and the alluvium reaches a total depth of approximately 200 feet at the mouth of San Juan Creek.

One notable feature that is distinctly different is that the DPODP is located in a semi-protected cove of Dana Point and less susceptible to coastal erosion than the proposed HBSDP.

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Imagery Source: Google Earth Pro

0 400 800 1,600 2,400 3,200 Feet

Proposed Vertical Well Locations

Area of Drawdown Influence (4,000' setback)

Conceptual Layout and Cross Section of Vertical Extraction Wells

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3.2.2.1 Aquifer Characteristics

As previously stated, the DPODP is located in a similar hydrogeologic regime as the Huntington Beach facility. The aquifer consists of primarily interbedded cobbles, gravel, sand, silt and clay overlying very low permeability sedimentary basement rocks. Table 3-2, *San Juan Creek Aquifer Characteristics and Optimum Well Yield Assumptions*, presents the aquifer characteristics that were used in the development of the DPODP well field and are very similar to the Talbert Gap area proposed for the HBSDP.

Table 3-2
San Juan Creek Aquifer Characteristics and Optimum Well Yield Assumptions

AQUIFER CHARACTERISTIC	VALUE	UNITS
Depth to Water	10	Feet bgs
Depth to Bottom of Production Zone	200	Feet bgs
Transmissivity (average)	15,508	ft^2/day
Storativity (average)	0.0019	Unitless

Source: Derived from GSSI, 2007.

3.2.2.2 Well Field Layout

In the testing conducted by GSSI (2007), it was determined that an optimum slant well configuration would consist of wells drilled at an angle of approximately 20 degrees below horizontal. The wells were grouped into clusters of three extending radially outward from a common entry location (Figure 3-2, *Conceptual Layout and Cross Section of Slant Extraction Wells*). Each well would have a capacity of approximately 3,000 gpm and each cluster approximately 9,000 gpm. Clusters were positioned approximately 700-1,000 feet apart at the mouth of San Juan Creek for a total of seven supply wells (capacity of 30 MGD) with two backup wells for a total of nine wells.

Given that the configuration of the mouth of San Juan Creek basin is similar (Table 3-3, *Comparison of Dana Point and Huntington Beach Alluvial Aquifer Systems*) to the mouth of the Santa Ana River at the Talbert Gap, it is reasonable to assume that a similar slant well configuration might be achieved as an alternative for subsurface intake structure for the Huntington Beach desalination project.

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Conceptual Layout and Cross Section of Slant Extraction Wells

PSOMAS

Feasibility of Alternative Seawater Intakes for the Huntington Beach Seawater Desalination Project

Figure 3-2

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Table 3-3
Comparison of Dana Point and Huntington Beach Alluvial Aquifer Systems

AQUIFER CHARACTERISTIC	Dana Point (DPODP)	Huntington Beach (HBSDP)
Depth to Water (feet bgs)	10	10
Depth to Bottom of Production Zone (feet)	200	190
Transmissivity (ft^2/day)	15,508	23,400
Storativity (unitless)	0.0019	0.01
Width of Gap (feet)	2,800	15,000

A comparison was made between the effects of the aquifer characteristics on the drawdown field (cone of depression) that would result using the pertinent aquifer characteristics (transmissivity, storativity) for a pump rate of 3,000 gpm for a period of one year. The comparison utilized an approximation of the Theis equation to estimate drawdown at specific distances from the pumping well. Assumptions included: an aquifer of infinite extent, no boundary conditions encountered, and no interferences from other wells or discharge points during the period of extraction. The comparison is presented in Figure 3-3, *Comparison of the effects of Aquifer Characteristics on Cone of Depression for 3,000 gpm Pumping Well over a Period of 1 Year*. As would be expected, the differences in drawdown at various distances from the pumping well are small. Moreover, the expected drawdown for the subsurface slant wells for the proposed HBSDP would be greater than what was calculated for the proposed DPODP.

With respect to the other characteristics, the largest variance resulted in the width of the gap between adjacent highland areas which for the HBSDP, afforded more area to place the slant wells. Accordingly, slant wells were assumed to have a capacity of 3,000 gpm each and were grouped into clusters of three with a total capacity of 9,000 gpm. Assuming a feedwater requirement of 69,444 gpm (100 MGD), this would equate to a requirement of eight well clusters or a total of 24 slant wells. Assuming a spacing of 1,000 feet, well clusters were positioned emanating out from the proposed Huntington Beach Desalination facility location parallel to the existing shoreline (see Figure 3-2, *Conceptual Layout and Cross Section of Slant Extraction Wells*).

3.2.2.3 Effects of Long-Term Pumping

As part of the evaluation process of the viability of slant wells as an alternative subsurface feedwater supply option, Psomas evaluated the effects that long-term pumping might have on the prevailing groundwater conditions in the vicinity of the proposed well field. Assuming that the effects will be similar to that modeled for the San Juan Creek basin conducted by GSSI, Psomas referred to the study conducted by GSSI (2007) at the proposed DPODP.

In order for GSSI to evaluate potential impacts on groundwater levels and quality from the proposed DPODP, GSSI developed a groundwater flow and variable density solute transport model of the San Juan Creek groundwater basin at the mouth of the creek. Following calibration, several operational scenarios were run assuming a project extraction rate of 30 MGD from seven wells over a period of 10 years under an above-normal (wet) hydrologic condition as well as a below-normal (dry) hydrologic condition. The results of the analysis for the above-normal (wet) hydrologic condition indicated that at the end of 10 years, drawdowns of existing water levels exceeded 60 feet in depth approximately 1,000 feet inland and were up to 40 feet approximately 4,000 feet inland. For below-normal (dry) conditions, the amount of drawdown is expected to be greater.

It is expected that a slant well type subsurface intake structure at the proposed HBSDP (see Figure 3-3, *Comparison of the effects of Aquifer Characteristics on Cone of Depression for 3,000 gpm Pumping Well over a Period of 1 Year*) will create a similar effect in the vicinity of the proposed well clusters as modeled in the San Juan Creek basin by GSSI. Assuming a production of 69,444 gpm from 24 slant wells, it would be expected that similar ranges in declines in water levels would be observed as that modeled in the San Juan Creek basin by GSSI (2007). It is anticipated that declines between 20 to 60 feet could be observed from 2,000 to 4,000 feet inland after a period of 10 years.

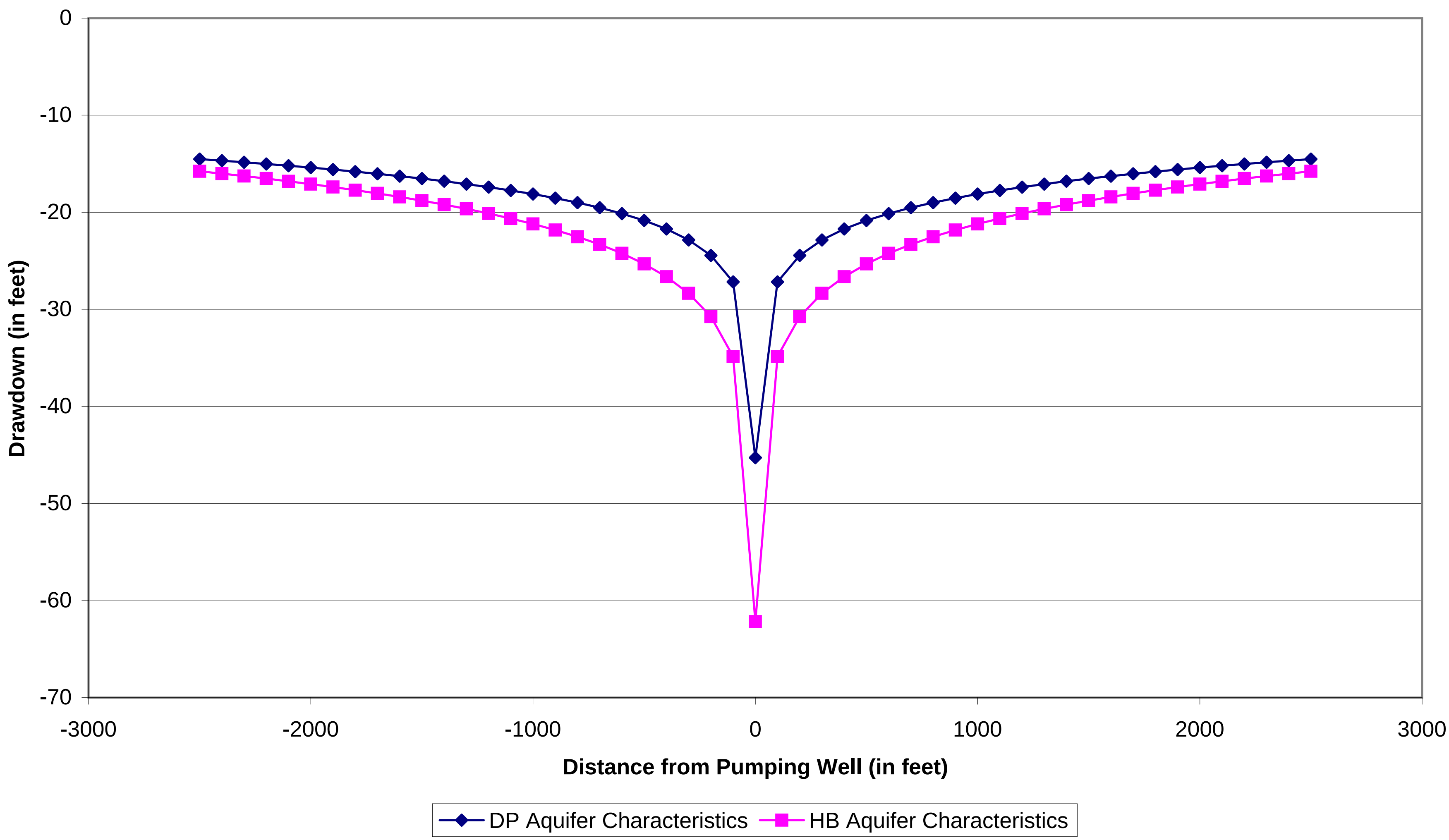
3.3 Groundwater Water Quality

Subsurface intake structures extracting water from the existing groundwater aquifers will encounter differing water quality as compared to open ocean seawater. This variation is due to contributory sources including dissolution of natural rocks through which the groundwater is passing, contaminants contributed by industrial sources including the Ascon landfill, and interception of highly treated sanitary wastewater injected approximately two miles east of the proposed HBSDP.

3.3.1 Existing Groundwater Quality

Previous sampling efforts have indicated that the existing natural water quality of the Talbert Aquifer and shallow brackish groundwater is poor with total dissolved solids ranging from 10,000 to 15,000 mg/L. Orange County Water District maintains observation wells near the coast and has collected limited water quality data from selected wells. The data suggests that groundwater has been impacted by seawater as well as other potential sources. OCWD has suggested that some upwelling from deeper (potentially connate water) water-bearing zones may be occurring in the vicinity of observation well M31.

Figure 3-3
Comparison of the Effects of Aquifer Characteristics on Cone of Depression for 3000 gpm Pumping Well over a Period of 1 Year



A study conducted on the surf zone and brackish water zone interaction near the proposed HBSDP by Boehm et al. (2004) indicated substantial variation in the groundwater quality of the brackish groundwater when compared to seawater. Specific components that were elevated in the groundwater were nitrate and ammonia (NH_4). For instance, in the Talbert Aquifer, ammonia (NH_4) was reported at a concentration of 20.6 mg/L (1140 µM) whereas seawater (1500 meters offshore) was reported at 0.01 mg/L (0.7 µM). They stated that the Talbert Aquifer was under anoxic conditions (very low oxygen). The brackish water had reported concentrations of nitrate of 6.15 mg/L (341 µM) whereas seawater (1500 meters offshore) was reported at 0.005 mg/L (0.3 µM)

3.3.2 Ascon Landfill

The Ascon Landfill site is a vacant 38-acre parcel which formally operated as a landfill from 1938 through 1984. The site is located at 21641 Magnolia Street at Hamilton Avenue in the city of Huntington Beach, California. In the early years of operation the site was a disposal area for oil drilling operations which includes waste drilling mud, waste water brines, and other associated drilling wastes. Records indicate that from 1957 to 1971, chromic acid, sulfuric acid, aluminum slag, fuel oils, and styrene were disposed at the site. Then from 1971 through 1984 the landfill was use for dumping of solid waste materials such as construction materials.

The Ascon Landfill site has five existing lagoons covering approximately 30 percent of the site and eight pits. Analytical results reveal that groundwater has been impacted from actives at the former Ascon Landfill site. Free-phase hydrocarbon have been observed on the groundwater surface in several locations on-site. Table 3-3, *Constituents Confirmed in Groundwater beneath the Ascon Landfill* reveals a list of compounds with reportable concentrations. This list is was created from records obtained from the Department of Toxic Substances Control website.

The proposed desalination site is immediately adjacent to the Ascon Landfill. It is likely that groundwater extraction to supply the desalination facility could draw contaminated groundwater from the landfill exacerbating the groundwater contamination and contaminate the feedwater for the proposed desalination plant water, thereby rendering it unsuitable for public water supply.

3.3.3 Talbert Gap Injection Barrier

The OCWD currently injects approximately 10 MGD into the Talbert Barrier project to stem saltwater intrusion into the underlying aquifers in the Talbert Gap area. Based on recent discussions with OCWD, the Talbert Barrier project is preparing to expand injection to 30 MGD or approximately 33,600 AFY using water derived from the highly-treated effluent from the sanitation district wastewater plant.

While the Talbert Barrier is located approximately two miles inland from the location of any proposed subsurface intake structures for the HBSDP, it is highly probable that the operation of the proposed beach well intake (slant or vertical wells) and associated long-term groundwater extraction near the proposed desalination plant site will draw a portion of the reclaimed water injected by the Talbert Barrier project towards the extraction wells. Extraction of a portion of this water may reduce the effectiveness of the salt intrusion barrier and at the same time introduce highly treated wastewater (reclaimed water) from the OCWD project into the desalination plant intake. Since use of reclaimed water for direct potable water consumption is prohibited under the current applicable regulations, the use of beach well intake may result in production of water not suitable for drinking purposes.

Table 3-4
Constituents Confirmed in Groundwater Beneath the ASCON Landfill

Constituents	
Inorganic Sampling (trace Minerals)	**Semivolatile Organic Compounds**
Antimony	Acenaphthene
Arsenic	Anthrocene
Barium	Benz[A]anthracene
Beryllium	Benzo[B]fluorathene
Cadmium	Benzo[K]fluoranthene
Chromium	Benzo[A]pyrene
Cobalt	Benzindine
Copper	1,1-Biphenyl
Lead	Chrysene
Mercury	Dibenzofuran
Molybdenum	Fluoranthene
	Naphthalene
Nickel	N-Nitrosodiphenylamine
Selenium	Pyrene
Silver	DDE
Thallium	PCBS
Vanadium	**Total Petroleum Hydrocarbons**
Zinc	TPHd
Volatile Organic Compounds	TPHg
Acetone	TPHjet fuel
Benzene	
Chlorobenzene	
Chloroform	
1,2-Dichlorobenzene	
1,2-Dichloroethylene	
EDC	
Ethylbenzene	
Methylene Chloride	
Styrene	
1,1,1-TCA	
Toluene	
Trichlorofluoromethane	
Xylenes	

4.0 Impact Analysis

In general, potential benefits of subsurface intake over traditional open ocean intake for desalination feedwater supply may include:

- Reduction of entrainment and impingement (interference) of marine organisms;
- The potential to eliminate the costly pre-filtration step for seawater reverse osmosis (RO) process;
- Protection from shock loading from events such as storms, spills and algal blooms.

The subsurface intakes also have some potential detractions that could include:

- Potential impacts to nearby surface water resources (and dependent biota) including streams, lakes, wetlands and other water bodies that are dependent on interaction with near surface groundwater;
- Varying water quality (when compared to seawater) that could include iron, manganese, and organic materials including nitrogen compounds that require extensive costly pretreatment to prevent fouling of the RO membranes;
- Potential interception of contaminated groundwater from leaking underground fuel tanks, industrial plants, landfills, and other manmade sources.

The California Water Desalination Task Force (CWDTF) (2003) indicated that *"in some cases however, beachwells may not be an adequate option such as the case where a large volume of feedwater is needed"* (for plants with a maximum capacity of 13 MGD [40 AF/day]).

With respect to the proposed HBSDP, there are a number of specific potential impacts that could occur from operation of the proposed groundwater extraction system. While not all inclusive, the following represent the major potential impacts that could occur from long-term operation of a well field in the vicinity of the proposed desalination plant:

- Extensive dewatering of Talbert Marsh and adjacent areas, and disruption of ecological system;
- Interception of injection water from Talbert Barrier;
- Interception of contaminated groundwater from nearby release points (such as Ascon Landfill);
- Subsidence due to dewatering of fine-grained sediments;
- Exposure of subsurface intakes from excessive beach erosion due to Pacific Storms
- Expansion of treatment requirements for brackish and/or impacted groundwater

The following discussion presents a general overview of each of the proposed impacts.

4.1 Extensive Dewatering of Talbert Marsh and Adjacent Areas

The Talbert, Newland, Magnolia and Brookhurst marshes are a delicate ecosystem that relies on the hydrologic interaction of surface water with the ocean as well as with the underlying groundwater system. Excessive dewatering beneath and adjacent to these marshes may have a long-term detrimental impact to the hydrology of the marshes, which could significantly affect habitat for plant and wildlife species. Presently, very little is known about the hydrologic interaction between surface water, groundwater, and the ocean and how it may be affected by long-term groundwater extraction beneath the site. Therefore, the use of beach well intake (slant or vertical wells) at this location would likely result in significant and difficult to predict environmental damage to the marsh ecosystem.

It is expected that the Talbert, Newland, Magnolia and Brookhurst marshes are in hydraulic communication with the underlying groundwater system. This communication likely exists as a combination of freshwater input (from surface water discharges into the marsh), saltwater input from tidal flux into the marsh, and influx of the directly underlying groundwater. If the groundwater surface is depressed because of the beach well intake operations, it is expected that the communication with the surface water and the tidal flux will be altered and that plants utilizing the dynamic brackish water interface may be adversely affected. Specifically, it is expected that the interface will fall beyond the depth the plants could extract water for use as a result the marsh flora and fauna may be adversely impacted. In addition, it would be anticipated that the water quality of the groundwater would be adversely affected in the vicinity of the marshes with a tendency towards more saline water quality and potential soil drainage.

In summary, it would be expected that dewatering in the vicinity of the marshes would potentially have an adverse impact on the ecological system including loss/alteration of vegetation, changes in fauna visiting/inhabiting the system, and overall water quality of the near surface water and groundwater quality in the marshes.

4.2 Interception of Injection Water from Talbert Barrier

The OCWD currently injects approximately 10 MGD with plans to expand injection to 30 MGD into the Talbert Barrier project to stem saltwater intrusion into the underlying aquifers in the Talbert Gap area. It is highly probable that the operation of the beach well intake and associated long-term groundwater extraction near the proposed desalination plant site will draw a portion of the reclaimed water injected by the Talbert Barrier project towards the extraction wells. Extraction of a portion of this water may reduce the effectiveness of the salt intrusion barrier and at the same time introduce highly treated wastewater (reclaimed water) from the OCWD project into the desalination plant intake. Since the direct use of reclaimed water for direct potable water consumption is prohibited under the current applicable regulations, the use of beach well intake may result in production of water not suitable for drinking purposes.

4.3 Interception of Contaminated Groundwater

The proposed desalination site lies immediately adjacent to the closed Ascon Landfill, a hazardous waste site. The site was used as a disposal facility from 1938 to 1984 with industrial and oil field waste disposed at the site until 1971. From 1971 to 1984 construction debris was also disposed at the site.

The Ascon Landfill site has five existing lagoons covering approximately 30 percent of the site and eight pits. Studies are currently ongoing to assess the extent of groundwater potentially impacted beneath the site. It is likely that groundwater extraction to supply the desalination facility could draw contaminated groundwater from the landfill exacerbating the groundwater contamination and contaminate the desalinated water, thereby rendering it unsuitable for public water supply.

The CWDTF (2003) stated that *"beachwell withdrawals may also be unsatisfactory in the case of contaminated groundwater (e.g., the case where wells are contaminated with high levels of contaminants such as MTBE and hydrocarbons)."*

4.4 Subsidence Due to Dewatering of Fine-Grained Sediments

The proposed groundwater extraction system would likely permanently dewater a portion of the near-surface sediments that are comprised of both coarse and fine-grained material. There is a potential that dewatering of the near-surface fine-grained sediments may induce subsidence to occur. This long-term dewatering in turn may damage the public beach structures and utilities and the structural integrity of the generating station.

4.5 Exposure of Subsurface Intakes Due to Beach Erosion from Pacific Storms

The studies conducted by GSSI (2007a, 2007b) were for proposed slant wells in a semi-protected cove near Dana Point. This cove is somewhat protected from excessive beach erosion from Pacific storms and it is unlikely that the subsurface intake structures would be exposed under most foreseeable conditions.

However, the proposed HBSDP is located along an unprotected coastal shoreline where beach erosion has been documented (COE, 1993). It is unclear if during severe Pacific storm events whether the proposed subsurface intakes (specifically the slant wells) could be damaged/exposed from severe coastal erosional processes.

4.6 Expansion of Treatment Requirements for Brackish and/or Impacted Groundwater

Adequate pretreatment is a major component of the RO desalination process. In the instance of a subsurface intake structure such as a slant or vertical well, the alluvial sediments act as a filter media providing pretreatment and effective removal of particulates, suspended solids, and other matter. However, with the subsurface intake structures a portion of the water produced originates from the groundwater contained in the alluvial aquifer.

GSSI (2007) estimated that for the DPDP, approximately 7 percent of feedwater would originate groundwater and the remaining 93 percent would come from seawater. GSSI also indicated that in the initial startup a higher percentage (greater than 7 percent) would originate from groundwater and would steadily decrease until reaching the 7 percent contribution. In the instance of the DPDP facility, there was extreme concern related to the potential presence of iron and manganese and the additional treatment required for these constituents.

In the instance of the HBSDP, there is concern related to the potential presence of inorganic constituents (bicarbonate, metals), nutrients (ammonia, nitrate), organic contaminants (VOCs, SVOCs, petroleum hydrocarbons), as well as highly treated wastewater that could eventually be drawn into the slant or vertical wells supplying feedwater to the HBSDP. It is probable that the concentrations would be of sufficient concentration that it would require pretreatment prior to submission to the RO treatment process. In several instances, the typical treatment process to remove the constituents of concern (such as air stripping for VOCs) will cause an adverse reaction with other constituents requiring addition of chemical additives including but not limited to acids, bases, descalers, and other chemical treatments to prevent a domino effect with the constituents that are part of the feedwater supply.

Based upon experience with desalters and other process water treatment systems, the compounding problems of dealing with a myriad of constituents and concentrations that may change based on seasonal events, effects of dewatering, as well as other external influences, developing an effective pretreatment system for the constituents that may be encountered while maintaining a constant viable feedwater supply using slant or vertical wells to the HBSDP may be close to impossible.

5.0 Conclusions

While the use of subsurface intake structures appears to be technically possible with respect to extracting a sufficient quantity of feedwater to support the proposed HBSDP, a number of issues would need to be managed, including:

- Potential to dewater adjacent wetlands. Drawdown of groundwater resources would potentially dewater the adjacent remnant wetlands which would constitute an adverse impact to the wetlands and to the plant and animal species which utilize the wetlands as habitat.
- Potential to increase subsidence. Drawdown of groundwater resources has the potential to dewater fine-grained subsurface sediments which could result in increased incidence of subsidence of the ground surface and potential adverse effects on existing surface structures, including the AES Power Generating Plant and Pacific Coast Highway.
- Water quality. Groundwater resources, which would be accessed by either slant wells or vertical wells, are of poor quality due to an infusion of brackish water and contamination from the adjacent closed landfill. Significant pre-treatment would be required before any water could be used as feedwater in the proposed HBSDP.
- Interference with Talbert Gap Injection Barrier. Highly treated wastewater is currently being injected into the Talbert Gap Injection Barrier. This wastewater could become part of the groundwater resources available to the HBSDP. It is unclear whether this would be acceptable as feedwater for the proposed HBSDP under current federal, state, and local regulations for potable water.

If the amount of feedwater required to supply the HBSDP were reduced, the severity of the first two issues would not necessarily be reduced, just the time frame in which the impact would manifest itself would be extended. Both issues related to the potential effects related to water quality concerns and pre-treatment requirements for the desalinization of the brackish groundwater would remain.

6.0 Limitations

This report has been prepared in accordance with that degree of care and skill ordinarily exercised by professionals currently practicing under similar circumstances and in this or similar localities. The conclusions and recommendations provided in this report relied on a limited amount of visual observations, site visit, and previous reports. The nature of many sites is such that variations in geological and/or hydrogeological conditions can occur over small distances and that varying interpretations could result. No other warranty, either expressed or implied, is made to the professional advice presented herein.

In addition, this report has been prepared for the exclusive use of the entity listed on the cover of the report. Unauthorized reuse is not permitted without the written permission of Psomas.

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