11.14 Groundwater Resources

This section discusses, at a programmatic level, groundwater resources in the vicinity of the Wilmington, Inglewood, and Sespe Oil and Gas Fields. The regulatory setting for the three fields is described in EIR Section 11.14.2. Groundwater resources beneath and in the vicinity of the fields are discussed in EIR Section 11.14.3. The methodology and significance criteria used to analyze potential impacts to groundwater resources from well stimulation treatments are presented in EIR Section 11.14.4. Potential impacts to groundwater quantity and quality are assessed in EIR Section 11.14.5 and summarized in 11.14.6. Any relevant discussion and analysis in EIR Section 10.14 is incorporated herein to support conclusions about the significance of impacts in the Wilmington, Inglewood, and Sespe Oil and Gas Fields.

11.14.1 Introduction

The Wilmington, Inglewood, and Sespe Oil and Gas Fields represent unique settings with respect to potential groundwater impacts. The Wilmington Oil and Gas Field is located in Los Angeles County beneath the West Coast Groundwater Basin, which supplies groundwater to the overlying users. The Inglewood Oil and Gas Field is located in Los Angeles County beneath portions of the Central, West Coast and Santa Monica Groundwater Basins. However, it is located mostly in the uplifted Baldwin Hills, which are not active areas of groundwater production. The Sespe Oil and Gas Field is located in Ventura County in a rugged mountainous setting outside of any designated groundwater basin.

11.14.2 Regulatory Setting

The regulatory setting for groundwater resources in all study regions was described in EIR Section 10.14.2. Additional regulations and local issues specific to each of the two fields are described below.

11.14.2.1 Study Region 1: Wilmington Oil and Gas Field Onshore and Offshore

The onshore portion of the Wilmington Oil and Gas Field, located in Los Angeles County, overlies the West Coast Subbasin (Basin No. 4-11.03) as defined by the California Department of Water Resources (DWR, 2003) and commonly referred to as the West Coast Basin. The onshore Wilmington Oil and Gas Field is located in the southwestern portion of the West Coast Basin and underlies portions of the cities of Los Angeles, Long Beach, and Carson.

The offshore portion of the Wilmington Oil and Gas Field includes four man-made offshore islands (Grisom, White, Chafee, and Freeman) and Pier J located in the Long Beach Harbor. Pier J is within the boundary of the DWR-defined West Coast Basin, while the offshore islands are not.

Los Angeles Regional Water Quality Control Board (LARWQCB). The LARWQCB has developed and is responsible for administering the Water Quality Control Plan for the Los Angeles Region, Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties (LARWQCB, 1994 and amendments through 2013). The Basin Plan designates beneficial uses for surface water and groundwater and establishes water quality objectives (narrative and numerical) for protection of the designated beneficial use and for compliance with California’s anti-degradation policy (LARWQCB, 1994 and amendments through 2013). The Basin Plan also describes implementation programs to protect beneficial uses and monitoring activities to evaluate their effectiveness.

GeoTracker is the State Water Resource Control Boards’ (SWRCB) online data management system for managing and providing public information on sites that impact groundwater, especially those that require groundwater cleanup (Underground Storage Tanks [USTs], Department of Defense, Site Cleanup Program)
as well as permitted facilities such as operating USTs and land disposal sites (http://geotracker.waterboards.ca.gov/). GeoTracker identifies numerous environmental release sites in the Wilmington field area. The SWRCB’s GeoTracker GAMA site integrates and geographically displays water quality data from multiple sources through public and secure password-protected web access portals (http://geotracker.waterboards.ca.gov/gama/).

Surface water discharges in the Wilmington Oil and Gas Field area are subject to the Final Waste Discharge Requirements for Municipal Separate Storm Sewer System (MS4) Discharges within the Coastal Watersheds of Los Angeles County, except those discharges originating from the City of Long Beach MS4 (Municipal Permit) under Order R4-2012-0175 (NPDES Permit No. CAS004001). The MS4 Permit requires municipalities to implement stormwater quality management programs with the ultimate goal of reducing the amount of pollutants in stormwater and urban runoff.

**California Department of Toxic Substances Control (DTSC).** DTSC is responsible for hazardous waste storage, treatment and disposal for industrial facilities in the West Coast Basin. Along with the LARWQCB, DTSC also is involved in regulating groundwater remediation activities. DTSC also maintains a comprehensive publicly accessible website and data base of existing permits and corrective action at hazardous waste facilities, known as the EnviroStor Data Management System (EnviroStor) (http://www.envirostor.dtsc.ca.gov/public/). EnviroStor identifies numerous environmental investigation and cleanup sites located within the Wilmington Oil and Gas Field area.

**United States Environmental Protection Agency (EPA).** As described in EIR Section 11.13, EPA lists 20 Superfund sites in Los Angeles County, two of which are located in the West Coast Basin. Both sites are located several miles northwest of the Wilmington field.

**West Coast Basin Adjudication.** The West Coast Basin was adjudicated in 1961 (Judgment for California Water Service Company et al. v. City of Compton, LASC Case No. 506806), to control groundwater levels and prevent seawater intrusion by limiting pumping. Prior to the adjudication of the West Coast Basin, annual pumping far exceeded natural safe yield\(^1\) of the basin determined by the DWR in 1962. Due to the overdraft conditions, water levels declined, groundwater was lost from storage, and seawater intruded into the aquifers along the coast. To remedy this, the courts adjudicated the West Coast Basin to place restrictions on pumping and to allocate the resource among basin users.

The adjudicated pumping amount for the West Coast Basin is set at 64,468 acre-feet per year (AFY), which is based on historical pumping rather than the safe yield of the basin. This pumping volume is predicated on seawater intrusion barrier projects, which allow pumping in excess of the natural safe yield of the basin (CH2MHill, 2012). These projects involve a series of injection wells that recharge a combination of imported and recycled water (and moving toward 100 percent recycled water) creating a hydraulic barrier in the groundwater system. The Judgment has the following West Coast Basin management provisions (CH2MHill, 2012):

- **Carryover.** Pumpers can carry over unused pumping rights to the next administrative year (up to 2 AF or 20 percent of the adjudicated right, whichever is greater).

- **Over-Pumping.** Pumpers can pump up to 110 percent of their adjudicated right provided that any over production is made up by under production the following year. In addition, up to 10,000 AFY of emergency over-pumping is allowed under certain conditions.

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\(^1\) The natural safe yield is the amount of groundwater that can be withdrawn from the aquifer without adverse impacts, assuming natural replenishment of the aquifer.
Lease or Sell. Pumpers are able to lease or sell their rights.

Exchange Pool. Pumpers can use an exchange pool through which pumpers with access to supplemental imported water can make their pumping rights available to pumpers who do not have imported water access for a price not to exceed the cost of the supplemental imported water. The exchange pool operates on an annual basis, as compared to leasing of rights, which is between specific parties and can extend for a longer time.

In 2009, motions were filed with the court to amend the West Coast Basin adjudication (“Judgment”) as well as the adjacent Central Basin Judgment to allow use of currently unused storage space in the basins, estimated at 120,000 AF in the West Coast Basin. The amendments also would allow transfer of storage rights between the West Coast Basin and the Central Basin and the use of water augmentation projects, where recharge and extraction volumes are matched within an established timeframe to allow pumping greater than adjudicated rights without using the allotted storage space. After several challenges to these motions, a final decision on the amendment for the West Coast Basin is still pending (The similar amendment for the Central Basin has been recently approved).

The West Coast Basin is managed through the coordination of the Los Angeles County Public Works Department, the California Department of Water Resources (DWR) and the Water Replenishment District of Southern California (WRD) (WBMWD, 2014). The court appointed the DWR as the Watermaster to administer and enforce the terms of the Judgment and prepare annual summary reports.

Water Replenishment District of Southern California (WRD). WRD was established in 1959 to protect the groundwater resources of the Central and West Coast Groundwater Basins. WRD protects the basins through groundwater level and quality monitoring, safe drinking water programs, seawater intrusion prevention, and groundwater replenishment operations throughout southern Los Angeles County (WRD, 2014). Imported water and recycled water are acquired to recharge groundwater and to prevent seawater intrusion at the Alamitos Gap. West Coast Basin and Dominguez Gap Seawater Intrusion Barrier projects. WRD raises revenue through assessments on water pumped from the WRD service area. Basin management and enhanced recharge are needed because the adjudicated pumping amounts are greater than the natural replenishment of the groundwater aquifers, creating an annual deficit or overdraft under natural recharge conditions. Because recycled water is recharged in the seawater intrusion barriers, WRD has adopted resolutions to limit potentially new domestic supply wells within 2,000 feet of the seawater intrusion barriers. While they do not have the regulatory authority to deny well permits, which are issued by the Los Angeles County Department of Public Health (LACDPHS), the LACDPHS has agreed to ask for WRD’s opinion if someone were to propose a domestic supply well permit near the barriers (WRD, 2001).

Sustainable Groundwater Management Act. California’s recently enacted Sustainable Groundwater Management Act does not apply to the adjudicated West Coast Basin, except for specific annual reporting requirements addressing groundwater elevations, extractions, surface water supply used for in-lieu use or recharge, total water use, and change in groundwater storage.

County of Los Angeles Department of Public Works and Los Angeles County Flood Control District. Among other responsibilities, the County of Los Angeles Department of Public Works (LACDPW)/Los Angeles County Flood Control District (LACFCD) are responsible for the design, construction, operation, maintenance, and repair of roads, traffic signals, bridges, airports, sewers, water supply, flood control, water quality, and water conservation facilities, as well as for the design and construction of capital projects, (LACDPW, 2014). For water supply, the LACDPW recharges storm flows, recycled water, and imported water into groundwater basins for future use and owns and operates seawater intrusion barriers.
barriers, including the Dominguez Gap Barrier that runs through the Wilmington field. LACDPW also implements a Stormwater Quality Management Program in accordance with the Los Angeles County Municipal Storm Sewer System NPDES Permit (LACDPW, 2009-2011 Biennial Report) and MS4 Permit.

**Division of Oil, Gas, and Geothermal Resources (DOGGR), District 1.** DOGGR District 1 regulates oil and gas operations in the Wilmington Oil and Gas Field including, regulations relating to the protection of groundwater resources. DOGGR provides permits for injection under the Underground Injection Control (UIC) program and implements the interim SB 4 regulations for well stimulation treatments. DOGGR District 1 lists the Gaspur Aquifer under a portion of the field as an Exempt Aquifer (under CFR part 146.4) for protected groundwater as defined by the proposed SB 4 Well Stimulation Treatment Regulations (see Table 10.14-26) (DOC, 1981).

11.14.2.2 Study Region 1: Inglewood Oil and Gas Field

The Inglewood Oil and Gas Field, located in Los Angeles County, overlies a very small portion of the Central Subbasin (Basin No. 4-11.04) and West Coast Subbasin (Basin No. 4-11.03) and a relatively larger portion of the Santa Monica Subbasin (Basin No. 4-11.01) as defined by the DWR (2003), all commonly referred to as basins rather than subbasins. The Inglewood Oil and Gas Field is located at the southeastern end of the Santa Monica Basin, with a small portion underlying the mostly uplifted bedrock areas of the northern West Coast Basin and western Central Basin. The Inglewood Oil and Gas Field underlies portions of the cities of Culver City and Los Angeles.

**Los Angeles Regional Water Quality Control Board (LARWQCB).** The Inglewood Oil and Gas Field is within the LARWQCB region and thus subject to the regulatory document entitled, Water Quality Control Plan for the Los Angeles Region, Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties (LARWQCB, 1994 and amendments through 2013), as discussed above in EIR Section 11.14.2.1.

**California Department of Toxic Substances Control (DTSC).** DTSC has the same responsibilities for hazardous waste storage, treatment and disposal oversight for industrial facilities in the Santa Monica, Central, and West Coast Basins as described in EIR Section 11.14.2.1 for the West Coast Basin.

**United States Environmental Protection Agency (EPA).** As described in EIR Section 11.13, EPA lists 20 Superfund sites in Los Angeles County, none of which is located near the Inglewood Field.

**Santa Monica Basin Governance.** The Santa Monica Basin is not an adjudicated basin. The primary basin manager and groundwater producer is the City of Santa Monica.

**West Coast Basin Adjudication.** The West Coast Basin is an adjudicated basin, as described above in EIR Section 11.14.2.1.

**Central Basin Adjudication.** The Central Basin was adjudicated in 1965 (Central and West Basin Water Replenishment District v. Adams, Case No. 786656) in order to control groundwater levels and prevent seawater intrusion by limiting pumping. Prior to the adjudication of the Central Basin, annual pumping far exceeded natural safe yield of the basin determined by the DWR. Due to the overdraft conditions, water levels declined, groundwater was lost from storage, and seawater intruded into the aquifers along the coast. To remedy these problems, the court adjudicated the Central Basin to place restrictions on pumping and to allocate the resource among basin users.

The judgment establishes adjudicated rights totaling 267,900 AFY but limits pumping to an Allowable Pumping Allocation (APA) of approximately 80 percent of this amount, which is equivalent to 217,367 AFY. Both amounts exceed the natural yield of the basin, and the judgment recognizes that WRD artificially replenishes the basin to make up the difference.
The judgment has the following provisions:

- **Carryover:** Pumpers are allowed to carryover up to 20 percent of their APA into the following year.

- **Over-Pumping:** Pumpers are allowed to pump up to 120 percent of their APA (or 20 AF, whichever is greater), provided that any over production is made up by under production in the following year. Under certain circumstances, parties may over-extract in greater amounts; however, prior approval by the Watermaster must be obtained.

- **Lease:** Parties are able to lease their rights. Terms of the leases can vary, including whether or not to include carryover.

- **Sales:** Parties are able to sell their rights.

- **Exchange Pool:** The Central Basin Judgment creates an exchange pool through which pumpers who have access to supplemental imported water can make their pumping rights available to pumpers who do not have access to imported water for a price not to exceed the cost of the supplemental imported water.

On December 18, 2013, an amendment to the judgment for the Central Basin was issued by the court. The amendment enables large-scale changes in the management practices within the basin, which are expected to enhance opportunities to develop recycled water for recharge and to improve the capability to utilize the basin’s storage for conjunctive use. As a result of the judgment amendment, the Watermaster in the Central Basin is now comprised of three entities: 1) Administrative Body, 2) Water Rights Panel, and 3) Storage Panel. WRD was designated as the Administrative Body and is responsible for preparing the annual *Watermaster Service* reports and submitting them to the Water Rights Panel. The Water Rights Panel is ultimately responsible for submitting the final *Watermaster Service* reports to the Superior Court of the State of California for filing.

**Water Replenishment District of Southern California (WRD).** WRD’s responsibilities described above in EIR Section 11.14.2.1 for the West Coast Basin are the same in the portion of the Central Basin overlying the Inglewood Oil and Gas Field. In addition, as described in the previous paragraph, WRD recently has been designated as the Administrative Body of the Watermaster for the Central Basin.

**Sustainable Groundwater Management Act.** California’s recently enacted Sustainable Groundwater Management Act does not apply to the adjudicated basins, including the Central and West Coast basins, except for specific annual reporting requirements addressing groundwater elevations, extractions, surface water supply used for in-lieu use or recharge, total water use, and change in groundwater storage. For the Santa Monica Basin, a future groundwater sustainability plan may be prepared that could have an effect on potential future pumping in the Inglewood Oil and Gas Field portion that overlies the basin.

**County of Los Angeles Department of Public Works and Los Angeles County Flood Control District.** LACDPW/LACFCD’s responsibilities described above in EIR Section 11.14.2.1 for the West Coast Basin are the same in the Santa Monica and Central Basins overlying the Inglewood Oil and Gas Field.

**Division of Oil, Gas, and Geothermal Resources (DOGGR), District 1.** DOGGR District 1 regulates oil and gas operations in the Inglewood Oil and Gas Field as described in EIR Section 11.14.2.1 for the Wilmington field. There are no Exempt Aquifers (under CFR title 40 part 146.4) designated beneath the field.

**Baldwin Hills Community Standards District (BHCSD).** In October 2008, the County of Los Angeles approved the BHCSD, creating a supplemental district to improve the compatibility of oil production with adjacent urban land use, including an enhanced set of oil and natural gas regulations and standards designed specifically for Baldwin Hills and surrounding communities (MRS, 2008; Cardno ENTRIX, 2012).
11.14.2.3 Study Region 2: Sespe Oil and Gas Field

The Sespe Oil and Gas Field is located in Ventura County and does not overlie a DWR-defined groundwater basin or subbasin.

Los Angeles Regional Water Quality Control Board (LARWQCB). The Sespe Oil and Gas Field is within the LARWQCB region and thus subject to the regulatory document entitled, Water Quality Control Plan for the Los Angeles Region, Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties (LARWQCB, 1994 and amendments through 2013), as discussed above in EIR Section 11.14.2.1.

Because the field is not in a designated groundwater basin or subbasin, it does not have specific groundwater quality objectives defined in the Basin Plan. Regional water quality objectives apply to all groundwaters in the LARWQCB.

The Sespe field is not within a medium- or high-priority groundwater basin as currently defined by DWR and the recently enacted Sustainable Groundwater Management Act does not apply directly. The Fillmore Groundwater Subbasin (Subbasin No. 4-4.05) extends close to the southern extent of the Sespe Wellfield one-half mile oil and gas field buffer. The basin has been designated as a medium-priority basin and thus the Act is applicable.

United States Environmental Protection Agency (EPA). As described in EIR Sections 10.13 and 10.14, EPA provides oversight for cleanup at numerous Superfund sites in California. EPA lists two Superfund sites in Ventura County, one of which is located on the outskirts of the City of Fillmore south of the Sespe field.

California Department of Toxic Substances Control (DTSC). DTSC has the same responsibilities for hazardous waste storage, treatment and disposal oversight for industrial facilities in the Sespe field as described in EIR Section 11.14.2.1 for the Wilmington field.

Division of Oil, Gas, and Geothermal Resources (DOGGR), District 2. DOGGR District 2 regulates oil and gas operations in Sespe Oil and Gas Field, including regulations relating to the protection of groundwater resources. DOGGR provides permits for injection under the UIC program and implements the interim SB 4 regulations for well stimulation treatments. There are no Exempt Aquifers (under CFR title 40 part 146.4) designated beneath the field.

Ventura County Watershed Protection District (VCWPD). The Sespe Oil and Gas Field is in the Santa Clara River watershed. VCWPD, a special district within the Public Works Agency of the County of Ventura, manages the watershed to protect life, property, watercourses, watersheds, and public infrastructure from the dangers and damages associated with floods and stormwater. The VCWPD is the NPDES permit holder for the County-wide permit, and is the agency responsible for ensuring compliance with the County Stormwater Management Program (VCWPD, 2008).

Surface water discharges in the Sespe Oil and Gas Field area are subject to the Waste Discharge Requirements for Storm Water (Wet Weather) and Non-Storm Water (Dry Weather) Discharges from the Municipal Separate Storm Sewer Systems within the VCWPD, County of Ventura and the Incorporated Cities Therein under Order R4-2010-0108 (NPDES Permit No. CAS004002). The permit requires municipalities to implement stormwater quality management programs with the ultimate goal of reducing the amount of pollutants in stormwater and urban runoff.

Bureau of Land Management (BLM). Most of the field is in the Los Padres National Forest, where a large portion of the surface land is owned by the U.S. Forest Service. The BLM is responsible for reviewing applications and issuing leases for federal mineral estate within the national forest (BLM, date
unknown). BLM has Onshore Oil and Gas Orders to implement and supplement the oil and gas regulations found in 43 CFR 3160 for conducting oil and gas operations on Federal and Indian lands. The orders include: Approval of Operations; Drilling; Site Security; Measurement of Oil; Measurement of Gas; Hydrogen Sulfide Operations; Disposal of Produced Water; Well Completions/Workovers/Abandonment (Proposed Rule); and Waste Prevention and Beneficial Use of Oil and Gas (BLM, 2014).

11.14.3 Affected Environment

Groundwater resources at and in the vicinity of three fields are described below. For onshore and offshore Wilmington Oil and Gas Fields, the description focuses on the southern West Coast Basin where the field is located. For the Inglewood Oil and Gas Field, the description focuses on the West Coast, Central, and Santa Monica Basins. Both the Wilmington and Inglewood Oil and Gas Fields are in the Monterey play. Although the Sespe Oil and Gas Field is not located within a designated groundwater basin, potential groundwater resources beneath the field as well as connectivity to adjacent groundwater basins are evaluated. The Sespe Oil and Gas Field is outside Monterey play but inside the Monterey Formation.

11.14.3.1 Study Region 1: Wilmington Oil and Gas Field

Hydrologic Setting – Wilmington Oil and Gas Field

The onshore and offshore Wilmington Oil and Gas Field lie within Los Angeles-San Gabriel Hydrologic Unit, which encompasses all coastal drainages flowing into the Pacific Ocean between Rincon Point and the eastern Los Angeles County line. The Los Angeles–San Gabriel Hydrologic Region covers a drainage area of 1,608 square miles, which is most of Los Angeles County and parts of southeastern Ventura County. The primary drainage systems are the Los Angeles River, the San Gabriel River, and Ballona Creek. The field lies within the West Coast Hydrologic Subarea of the large hydrologic unit (LARWQCB, 1994 and amendments through 2013). Any runoff generated in the area of the onshore Wilmington Oil and Gas Field eventually drains to the Pacific Ocean.

The climate in the Los Angeles area ranges from subtropical along the Pacific Ocean to arid in the Mojave Desert on the inland side of the San Gabriel Mountains. Nearly all precipitation in the region occurs during the months of December through March. During the summer months, precipitation is infrequent and dry periods often last several months. Extended multiple years of below normal rainfall constitute drought periods. Precipitation varies considerably from year to year. In the West Coast Basin, the long-term mean precipitation is 12.64 inches (DWR, 2013).

Groundwater Basin and Aquifers – Wilmington Oil and Gas Field

The onshore Wilmington Oil and Gas Field and Pier J of the offshore Wilmington Oil and Gas Field underlie the DWR-designated West Coast Groundwater Subbasin (West Coast Basin) within the Coastal Plain of Los Angeles County Groundwater Basin (DWR, 2004). The West Coast Basin has a CASGEM ranking of 5, indicating that it is a high priority basin with respect to groundwater resources. The West Coast Basin (DWR Basin No. 4-11.03) covers an area of 142 square miles. Figure 11.14-1 shows the location of the West Coast Basin and adjacent groundwater basins. The figure also includes the onshore and offshore Wilmington and Inglewood Oil and Gas Fields with a one-quarter mile buffer zone around the fields.

The West Coast Basin extends north to the adjacent Santa Monica Basin and Ballona Gap, which is a paleo-channel of the Los Angeles River. It is bounded by the Newport-Inglewood Uplift and the adjacent
Central Basin on the northeast and by the Pacific Ocean and Palos Verdes Hills on the west and south. A small portion of the southwest boundary of the West Coast Basin abuts the Orange County Groundwater Basin. Most of the basin is composed of a poorly drained coastal plain.

The West Coast Basin is a northwest-trending structural basin underlain by Quaternary-age (less than 1.8 million years old) sedimentary deposits of gravel, sand, silt, and clay. These materials were deposited from the erosion of nearby hills and mountains, and from ancient beaches and shallow ocean floors that covered the area in the past (WRD, 2004). Underlying these Quaternary sediments are consolidated rocks such as the Pliocene Pico Formation that generally do not provide sufficient quantities of groundwater for pumping.

Groundwater occurs in the pore spaces of the sediments in the groundwater basin. Sediments layers that are adequately thick and transmissive to supply sufficient quantities of water to wells for beneficial use are called aquifers. Lower permeability (low hydraulic conductivity) silt and clay layers that separate the aquifers are referred to as aquitards or confining units. An unconfined aquifer contains a water table or upper groundwater surface at atmospheric pressure. Confined aquifers located below confining units or aquitards contain groundwater that is typically under pressure greater than atmospheric.

Aquifers in the West Coast Basin are generally confined and most of the natural recharge is from adjacent groundwater basins or from the Pacific Ocean (seawater intrusion). Groundwater recharge from direct infiltration of precipitation is limited due to low permeability materials overlying the primary aquifers and extensive impermeable surfaces due to urban development (i.e., pavement and buildings), (Reichard, 2003).

The West Coast, Central, and Santa Monica Basins are characterized by a layered aquifer/aquitard system. Aquifer depths can reach over 1,500 feet in the West Coast Basin, although production wells generally do not need to be constructed this deep to extract sufficient water. Table 11.14-1 summarizes the aquifers and aquitards in the West Coast, Central, and Santa Monica Basins, their age, and associated formations as defined by the DWR (1961). Not all aquifers and aquitards occur in all areas of each of the basins.

<table>
<thead>
<tr>
<th>Age</th>
<th>Formation</th>
<th>Aquifer/Aquitard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holocene (Recent)</td>
<td>Active Dune Sand</td>
<td>Semi-Perched Aquifer</td>
</tr>
<tr>
<td></td>
<td>Alluvium</td>
<td>Bellflower Aquitard</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gaspur/Ballona Aquifer</td>
</tr>
<tr>
<td>Upper Pleistocene</td>
<td>Older dune sand</td>
<td>Semi-Perched Aquifer</td>
</tr>
<tr>
<td></td>
<td>Lakewood</td>
<td>Exposition-Artesia Aquifer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gardena-Gage Aquifer (200-Foot Sand Aquifer)</td>
</tr>
<tr>
<td>Lower Pleistocene</td>
<td>San Pedro (subdivided into the Inglewood Aquifer in the Baldwin Hills)</td>
<td>Hollydale Aquifer</td>
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<tr>
<td></td>
<td></td>
<td>Jefferson Aquifer</td>
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<tr>
<td></td>
<td></td>
<td>Lynwood Aquifer (400-Foot Gravel Aquifer)</td>
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<td></td>
<td></td>
<td>Silverado Aquifer</td>
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<tr>
<td></td>
<td></td>
<td>Sunnyside Aquifer</td>
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<tr>
<td></td>
<td></td>
<td>Lower San Pedro</td>
</tr>
</tbody>
</table>

Figure 11.14-2 shows the locations of two geologic cross sections in the vicinity of the onshore Wilmington field. The aquifers and aquitards (confining units) listed above that occur in the vicinity of the Wilmington field are generally illustrated by Cross Section A-A' on Figure 11.14-3. This cross section is oriented...
from west to east across the onshore Wilmington Oil and Gas Field as shown on Figure 11.14-2 and represents a simplified hydrogeologic conceptual model used for groundwater modeling in the vicinity of the Dominguez Gap Seawater Intrusion Barrier (Golder, 2006). The aquifers on Figure 11.14-3 include the following, from shallowest to deepest: the Gaspur Aquifer comprised of Holocene Recent Alluvium; the Gage Aquifers (also referred to as the 200-Foot Sand Aquifer) of the Upper Pleistocene Lakewood Formation; and the Lynwood (also referred to as the 400-Foot Gravel Aquifer) and Silverado Aquifers of the Lower Pleistocene Upper San Pedro Formation; all of which are underlain by the Pico Formation.

These aquifers extend beneath some areas of San Pedro Bay as evidenced by seawater intrusion into the Gaspur and 200-Foot Sand Aquifers and possibly the 400-Foot Gravel Aquifer (Zielbauer et al., 1962).

The Gaspur Aquifer consists of permeable coarse gravel and sand. The Gaspur Aquifer is located in the eastern portion of Study Region 1 in a north-south trend along the present Los Angeles River floodplain. As illustrated on Figure 11.14-3, the aquifer is limited in extent over onshore Wilmington Oil and Gas Field. The Gaspur Aquifer does not extend under the offshore Wilmington Oil and Gas Field in the Long Beach Harbor area. The maximum thickness of the Gaspur Aquifer is about 180 feet but is less than about 50 feet in the local area of the Gaspur Aquifer in direct physical contact with the underlying Gage Aquifer as shown in Figure 11.14-3. Such a localized “mergence” of aquifers allows groundwater to flow more readily from one aquifer zone to the other (hydraulic connectivity).

The Gage Aquifer (or 200 Foot Sand Aquifer) is composed mainly of gravelly sand, sand, silt, and silty clay. The Gage Aquifer is believed to be exposed to direct seawater intrusion by dredging of the Los Angeles Harbor. The Gage Aquifer is continuous over most of the southern West Coast Basin and varies from approximately 150 to 200 feet in thickness and also extends under Long Beach Harbor in the vicinity of the offshore Wilmington Oil and Gas Field. The Gage Aquifer and deeper Lynwood Aquifer may be also be in direct contact locally as suggested by the thinning of the confining unit in the central portion of the cross section on Figure 11.14-3. Both the Gaspur and Gage Aquifers are in hydraulic continuity with the San Pedro Bay, while the aquifers deeper than the Lynwood Aquifer are generally protected from direct contact with seawater (LADWP and WRD, 1998).

The Lynwood Aquifer (or 400 Foot Sand Aquifer) is uniformly distributed across the southern West Coast Basin and consists of coarse sand and gravelly sand lenses ranging from about 50 to 75 feet thick. The Lynwood Aquifer extends under the Long Beach Harbor in the vicinity of the offshore Wilmington Oil and Gas Field. The Lynwood Aquifer and underlying Silverado Aquifer are also merged in a portion of the study area as illustrated by the zone of mergence on Figure 11.14-3.

The Silverado Aquifer consists of sand and gravel with localized, discontinuous beds of sandy silt, and clay. The Silverado Aquifer reaches its maximum depth of below 1,200 feet mean sea level (ft-msl) in the Dominguez Gap. The Silverado Aquifer ranges in thickness from 350 to about 700 feet in Study Region 1 (CDM, 1995). The Silverado is divided into upper and lower zones by a clayey silt zone. The lower zone, a thick coarse sand and gravel lens, is the coarsest of the two zones and sustains most of the groundwater withdrawal within and adjacent to area. The Silverado Aquifer is the most productive aquifer in the West Coast Basin and yields 80 percent to 90 percent of the groundwater extracted annually (CDWR, 2004). Minor yield also comes from the Gage and Lynwood Aquifers. The Silverado Aquifer extends under Long Beach Harbor in the vicinity of the offshore Wilmington Oil and Gas Field.

All aquifers in the region are essentially flat-lying with minor faulting and warping in the Lynwood, Silverado, and Pico units. The minor folding occurs along the northwest-trending anticlines and synclines between the Palos Verdes Fault Zone on the southwest and the Newport-INGLEWOOD Uplift to the north. The Newport-INGLEWOOD Uplift and associated faulting acts as a partial barrier to groundwater flow
between the Central Basin and West Coast Basin. The uplift is eroded by ancestral stream-cut channels that form the Dominguez Gap and Alamitos Gap, allowing for groundwater flow to occur across the gaps. Groundwater can also flow between the West Coast Basin aquifers and adjacent aquifers to the south (Orange County Basin) and to the north (Santa Monica Basin).

The Pliocene Pico Formation is beneath the West Coast Basin aquifers and is composed of semi-consolidated marine sand and silty clay, with some gravel. In general, these sediments have lower permeability than overlying aquifers and are not used for water supply. Locally, they contain brackish connate water and naturally occurring hydrocarbons. The Pico Formation extends under Long Beach Harbor in the vicinity of the offshore Wilmington Oil and Gas Field.

Aquifer depths in the West Coast Basin can reach depths below 1,500 feet. DOC lists the average depth to the base of fresh water at 1,600 feet for the Wilmington Oil and Gas Field (DOC, 1991). The deepest water supply well with a well log in the vicinity of the field is 1,100 feet deep.

The Wilmington Oil and Gas Field extracts hydrocarbons from five major oil-producing sand units in the onshore portion of the field ranging in depths between about 2,200 and 5,850 feet (DOC, 1991). The shallowest hydrocarbon zone is the Repetto Formation (Lower Pliocene), located beneath the Upper Pliocene Pico Formation described above. The vertical distance between the shallowest producing hydrocarbon zone (2,200 feet) and the base of fresh water (1,600 feet) is estimated at 500 feet (see Table J-3 of Draft EIR Appendix J, Los Angeles County, Wilmington Field).

**Aquifer Properties – Wilmington Oil and Gas Field**

Aquifer properties describe the ease with or rate at which groundwater travels through the subsurface and how much water is contained within an aquifer or confining unit. Transmissivity is the rate at which groundwater is transmitted through a unit width of aquifer under a unit hydraulic gradient. Transmissivity values for the primary West Coast Basin aquifers as described by DWR (1961) are provided in Table 11.14-2. The table also provides estimates of transmissivity values based on drill cuttings published in the Dominguez Gap Geological Investigations (Zielbauer, 1962).

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Transmissivity</th>
<th>Transmissivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gaspur</td>
<td>7,000 to 20,000</td>
<td>4,000 to 13,000</td>
</tr>
<tr>
<td>Gage (200-Foot Sand)</td>
<td>1,500 to 16,000</td>
<td>1,000 to 26,000</td>
</tr>
<tr>
<td>Lynwood (400-Foot Gravel)</td>
<td>7,000</td>
<td>0 to 26,000</td>
</tr>
<tr>
<td>Silverado</td>
<td>30,000 to &gt;50,000</td>
<td>4,000 to 121,000</td>
</tr>
</tbody>
</table>

1 - Source: CDWR, 1961
2 - Source: Zielbauer, 1962

The USGS (Reichard, 2003) performed particle tracking to simulate the movement of groundwater near the seawater intrusion barriers as part of modeling conducted for the West Coast Basin and adjacent Central Basin. Based on flow paths presented by the USGS, the groundwater velocity is from 0.1 to 1.0 feet per day (ft/d) along San Pedro Bay in the West Coast Basin in the vicinity of the Wilmington Oil and Gas Field. WRD estimated the groundwater velocity in the Gage Aquifer in the vicinity of the Dominguez Gap Barrier using the empirical relationship between the groundwater gradient and specific aquifer properties. Based on a hydraulic gradient of 0.004 feet/foot (observed in 2013), hydraulic conductivity of 80 ft/d (calibrated flow model value, and effective porosity of 0.25, WRD calculated a groundwater velocity in the Gage Aquifer of 1.3 ft/day near the Dominguez Gap Barrier (WRD, 2013).
**Groundwater Use in the West Coast Basin and at Wilmington Oil and Gas Field**

The West Coast Basin is an important source of water for residents and businesses in the area overlying the basin. Typically, groundwater in the West Coast Basin meets approximately 20 percent of the overall water supply needs. Imported water and recycled water make up the remainder of the supply.

Groundwater production wells within the Wilmington Oil and Gas Field area and buffer zone, used by entities other than the oil and gas owners/operators, are shown on Figure 11.14-2. As shown on the figure, there are six active production wells within the buffer zone. Table 11.14-3 provides available use and construction information for the wells. In 2011, these wells collectively pumped a total of 6,769 AF of groundwater.

### Table 11.14-3. Active Production Wells in the Vicinity of Wilmington Oil and Gas Field

<table>
<thead>
<tr>
<th>Well ID</th>
<th>34F7</th>
<th>29E6</th>
<th>31P3</th>
<th>19J6</th>
<th>20C1</th>
<th>27N6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well use</td>
<td>Industrial</td>
<td>Domestic</td>
<td>Industrial</td>
<td>Irrigation</td>
<td>Domestic</td>
<td>Industrial</td>
</tr>
<tr>
<td>Depth borehole (ft-bgs)</td>
<td>—</td>
<td>580</td>
<td>1,020</td>
<td>—</td>
<td>925</td>
<td>970</td>
</tr>
<tr>
<td>Well depth (ft-bgs)</td>
<td>—</td>
<td>570</td>
<td>940</td>
<td>—</td>
<td>925</td>
<td>954</td>
</tr>
<tr>
<td>Top of perforations (ft-bgs)</td>
<td>—</td>
<td>210</td>
<td>570</td>
<td>—</td>
<td>480</td>
<td>544</td>
</tr>
<tr>
<td>Bottom of perforations (ft-bgs)</td>
<td>—</td>
<td>550</td>
<td>920</td>
<td>—</td>
<td>652</td>
<td>944</td>
</tr>
<tr>
<td>Casing diameter (inches)</td>
<td>—</td>
<td>16</td>
<td>18</td>
<td>2</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td>Casing type</td>
<td>—</td>
<td>Steel</td>
<td>Steel</td>
<td>—</td>
<td>Steel</td>
<td>Steel</td>
</tr>
<tr>
<td>Gravel pack</td>
<td>—</td>
<td>Yes</td>
<td>Yes</td>
<td>—</td>
<td>—</td>
<td>Yes</td>
</tr>
<tr>
<td>Sanitary seal</td>
<td>—</td>
<td>Yes</td>
<td>Yes</td>
<td>—</td>
<td>—</td>
<td>Yes</td>
</tr>
<tr>
<td>Well log available?</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Data source</td>
<td>—</td>
<td>CDWR</td>
<td>CDWR</td>
<td>LACDPW</td>
<td>OWNER</td>
<td>CDWR</td>
</tr>
</tbody>
</table>

Source: WRD  
ft-bgs = feet below ground surface  
CDWR = California Department of Water Resources  
LACDPW = Los Angeles County Department of Public Works

As shown in Table 11.14-3, three wells are used for industrial purposes, one is a small-diameter irrigation well, and two are used for domestic water supply. Water supply well construction regulations require surface seals to prevent the migration of surface releases along the borehole outside the well casing. Four of the six wells have surface seals to prevent the downward leakage of contaminants from the near surface along the well casing. Two wells owned by entities other than the oil and gas owners/operators do not have available well logs and their completion details are unknown. For the wells with available data, the borehole depths range from 580 to 1,020 feet below ground surface (ft-bgs).

In addition to these active wells, there are 16 currently inactive, capped or destroyed water supply wells owned by entities other than the oil and gas owners/operators, in the buffer area, 6 of which are shown on Figure 11.14-2. Well depths are available for 14 of these wells and range from 80 to 1,102 ft-bgs. Only 3 of the 16 wells have confirmed surface seals. There are also numerous groundwater extraction wells used for remediation activities at the refineries in the Wilmington Oil and Gas Field.

In addition to these water supply production wells owned by entities other than the oil and gas owners/operators, which are part of the West Coast Basin adjudication, there are additional water production wells screened in the shallow saline Gaspur Aquifer near San Pedro Bay, which are used to supply water to the oil and gas owners/operators. The Gaspur Aquifer is an Exempt Aquifer beneath a por-
tion of the Wilmington field as defined by the EPA (see discussion on Exempt Aquifers in Study Region 1 in EIR Section 10.14.5.1 and Table 10.14-26). The Exempt Aquifer is defined as the Gaspur Aquifer extending between Ford Avenue and the Los Angeles River (DOC, 1981). This exempt portion of the Gaspur Aquifer has high total dissolved solids (TDS) and chloride due to historical seawater intrusion and percolation of oil field brines. The exempt Gaspur Aquifer on the seaward side of the Dominguez Gap Barrier is separated from usable groundwater by operation of the barrier. The barrier results in a hydraulic groundwater ridge, which provides a barrier to the inland movement of groundwater from the seaward side of the barrier. These water supply wells in the Gaspur Aquifer reportedly located on the Long Beach Pier are used by the oil and gas producers as a source of water for water flooding in deep oil producing zones to mitigate subsidence and other drilling uses, but not for hydraulic fracturing treatments. In addition to being located in an Exempt Aquifer, the Gaspur Aquifer wells are located in an area that has been de-designated for municipal supply beneficial uses by the LARWQCB and thus is exempt from some water quality requirements (see Groundwater Quality Section below). The production from this area is not accounted for as part of the Basin adjudication.

Owners/operators in the Wilmington Oil and Gas Field were asked to provide information on groundwater use during preparation of this EIR. THUMS Long Beach Co. reports that all of its exempt Gaspur Aquifer water supply wells have been plugged and abandoned. Further, THUMS Long Beach Co. reports only using produced water or purchased reclaimed water (treated sewer) in all oil field operations. Warren E & P, Inc. (another operator at the Wilmington field) also reports that it uses no local groundwater because it uses produced water associated with extraction efforts.

Tidelands Oil Production Co/Oxy Long Beach, Inc., appears to be the only operator currently using groundwater (from the exempt seawater intruded Gaspur Aquifer) for oil field operations. It reports an annual use of approximately 11.8 million barrels per year (1,520 AFY) for water flooding and other drilling uses. However, the operator reports using only treated produced water for hydraulic fracturing treatments. It reports that the wells are located on the piers in the Long Beach Harbor area. There are three active, two idle, and two plugged water supply wells in the Gaspur Aquifer listed on the DOGGR website database. None of the Wilmington Oil and Gas Field operators reports using groundwater for well stimulation activities (McCullough, 2014).

Seawater Intrusion and Groundwater Management in the West Coast Basin – Wilmington Oil and Gas Field

Due to significant historical over-pumping of groundwater in the West Coast and adjacent Central Basin, seawater has intruded into formerly fresh-water aquifers along some coastal areas, including in the vicinity of the Wilmington Oil and Gas Field. In response, the West Coast and Central basins were adjudicated to limit pumping and associated groundwater overdraft. In addition, injection facilities were constructed to create hydraulic barriers to halt the seawater intrusion and to replenish the groundwater basin. Currently, three hydraulic barriers (Dominguez Gap Barrier, Alamitos Gap Barrier, and West Coast Basin Barrier) are operated to prevent further seawater intrusion (see Figure 11.14-1). These barriers consist of a series of injection wells to raise water levels locally and reverse the onshore hydraulic gradients. Currently, a blend of treated imported water and an increasing portion of advanced treated recycled water is injected at the barriers.

To support ongoing groundwater management and to track the performance of the seawater intrusion barriers, WRD monitors groundwater levels and quality in an extensive network of aquifer-specific monitoring wells (nested wells) and also compiles and reports groundwater quality data from water supply wells as provided to DPH. The LACDPW also collects water quality data (chloride) for wells near the
seawater intrusion barriers. In addition, groundwater quality near each barrier is monitored under permits issued by the LARWQCB.

Groundwater level monitoring, groundwater elevation contour maps, groundwater level change maps, and groundwater change in storage estimates are reported annually by WRD in *Regional Groundwater Monitoring Report and Engineering Survey and Report*. In those reports, WRD presents groundwater elevation contour maps for the major water supply aquifers (Upper San Pedro Formation Aquifers). These maps represent seasonal low groundwater levels measured in the fall, i.e., at the end of the summer dry season. These reports are used to indicate:

- Amount of storage in the basins and need for replenishment,
- Areas of recharge and discharge,
- Groundwater flow direction and hydraulic gradients, and
- Effectiveness of the seawater intrusion barriers.

**Groundwater Levels and Flow – Wilmington Oil and Gas Field**

Before the 20th century, groundwater flowed from the West Coast Basin south and westward, toward the Santa Monica Bay and San Pedro Bay. Discharge from the groundwater flow systems occurred offshore, at some fault zones, or in wetlands. Since then, discharge has been dominated by pumping from wells. By the 1920s, owing to development of groundwater resources, water levels were below sea level in much of the Central and West Coast Basin, resulting in seawater intrusion along the coastal areas (Reichard, 2003). Since that time, managed operation of the West Coast Basin, Dominguez Gap, and Alamitos Gap Barriers has allowed local groundwater to rise, reducing the inland flow of seawater past the barriers. Figure 11.14-1 shows the location of all three barrier projects on one map.

Figure 11.14-4 shows a Fall 2012 groundwater elevation contour map developed by WRD and based on monitoring of nested wells along with other selected wells screened in the Upper San Pedro Formation Aquifers (WRD, 2013b). Features that potentially control the regional pattern of groundwater movement in the basins include topographic highs and lows, faults, areas of recharge, and groundwater pumping (discharge). Areas with groundwater elevations below sea level are shown by red contour lines. Groundwater flow in the West Coast Basin in the Upper San Pedro Formation Aquifer is generally from west to east. The Newport-Inglewood Uplift restricts groundwater movement and produces marked discontinuities in groundwater levels between the West Coast and Central Basins.

The general direction of groundwater flow in the vicinity of the Wilmington Oil and Gas Field is shown by the arrows depicted on Figure 11.14-4. As shown by the southerly arrow, northward flow of seawater from San Pedro Bay persists in the southern portion of Wilmington Oil and Gas Field, southeast of the Dominguez Gap barrier (also see location of barriers on Figure 11.14-1). However, north of the Dominguez Gap barrier, groundwater is flowing east-northeast and originating from injection along the West Coast barrier project.

The flow patterns, based on the Fall 2012 groundwater elevation contour map are generally representative of recent and predicted future conditions because managed aquifer recharge operations and groundwater pumping are relatively stable influences on the flow regime.

**Long-Term Water Level Trends in Central and West Coast Basins – Wilmington Oil and Gas Field**

Figure 11.14-4 shows the locations of key wells in the Central Basin and West Coast Basin, for which long-term records of groundwater levels (hydrographs) are presented in WRD’s *Engineering Survey and Report*. These hydrographs depict long-term trends and help monitor overall groundwater conditions.
Figure 11.14-5 shows water levels recorded in three key wells including Wilmington 1_3 (location on Figure 11.14-4). Records from two nearby wells (868H and 869 – not included on Figure 11.14-5) were combined with data from Wilmington 1_3 to produce a more complete long-term hydrograph as key wells have been replaced over time. As shown on Figure 11.14-5, water levels declined sharply from the 1940s to about 1955. After 1955, the control of groundwater extraction in the West Coast Basin (i.e., adjudication) resulted in a reduction of the rate of water level declines in the vicinity of the Wilmington Oil and Gas Field. However, water levels continued to decline (albeit at a slower rate) until about 1971, when the startup of injection at the Dominguez Gap Seawater Intrusion Barrier led to a partial recovery in water levels. For most wells, water levels along the coast have been rising since the early 1970s in response to injection at the seawater intrusion barriers and reduced pumping (Reichard, 2003).

**Vertical Groundwater Flow in Central and West Coast Basins – Wilmington Oil and Gas Field**

The USGS (Reichard, 2003) has described the vertical movement of groundwater as part of groundwater modeling conducted in the Central and West Coast Basins. Because most of the active groundwater extraction is from the Upper San Pedro aquifers, vertical groundwater flow directions are downward from shallow aquifers to the Upper San Pedro aquifers. The vertical gradient between the Upper San Pedro aquifers and deeper Lower San Pedro Unit is mixed depending on the year.

**Basin Storage and Adjudication in West Coast Basin – Wilmington Oil and Gas Field**

Prior to the adjudication of the West Coast Basin in the early 1960s, annual production (pumping) far exceeded the natural safe yield of the basin determined by the DWR in 1962. The natural safe yield is the amount of groundwater that can be withdrawn from the aquifer without adverse impacts, assuming natural replenishment of the aquifer generally from runoff and precipitation. Due to this serious overdraft, water levels declined, groundwater was lost from storage, and seawater intruded into the aquifers along the coast. To remedy this problem, the courts adjudicated the West Coast Basin (and Central Basin) to put limits on pumping. The West Coast Basin adjudicated pumping was set at 64,468.25 AFY.

The adjudicated pumping amount is greater than the natural replenishment of the groundwater aquifers, creating an annual deficit or annual overdraft, under natural recharge conditions. Accordingly, WRD was established in 1959 under the California Water Code to purchase and recharge additional water to make up the overdraft, which is known as artificial replenishment or managed aquifer recharge.

DWR (1961) has estimated that the total storage in the West Coast Basin is approximately 6.5 million AF. Unused storage is approximately 1.1 million AF, resulting in approximately 120,000 AF of available storage, assuming that the basin can be filled to within 75 feet of the ground surface.

The existing adjudication (or Judgment) does not allow for use of currently unused storage space in the basin. In 2009, motions were filed in court to amend the Judgment to allow parties to the Judgment to store water for later extraction. The amendment (and similar amendment for the Central Basin) also would include provisions for the interbasin transfer of storage rights between the West Coast and Central Basins, not currently allowed. Most significantly, the implementation of water augmentation projects, wherein recharge and extraction volumes are matched within an established timeframe, would allow pumping beyond adjudicated rights, without using the allotted storage space described in the storage provisions. After several challenges to these motions, a final decision on the amendment for the West Coast Basin is still pending (the similar amendment for the Central Basin has been recently approved).
**Groundwater Quality – Wilmington Oil and Gas Field**

The groundwater quality in the vicinity of the Wilmington Oil and Gas Field has been degraded substantially due to contamination from many different land uses, including agricultural, industrial, and commercial activities, and seawater intrusion. Seawater intrusion has been controlled through installation and operation of the Dominguez Gap Barrier, although some saline water has been trapped inland of this facility. In addition, upper aquifers have been degraded by organic and inorganic pollutants from a variety of sources, including leaking tanks, sewer lines, and illegal discharges. According to the *Regional Groundwater Monitoring Report* (WRD, 2013), contaminants of concern primarily include TDS and volatile organic compounds (VOCs).

Total salinity is commonly expressed in terms of TDS as milligrams per liter (mg/L). The Basin-Specific Basin Plan Objective (BSBPO)\(^2\) for TDS in the West Coast Basin is 800 mg/L (LARWQCB, 1994 and amended in 2011). As established by the CDPH, the recommended secondary maximum contaminant level\(^3\) (SMCL) for TDS is 500 mg/L with an upper limit of 1,000 mg/L. It has a short-term limit of 1,500 mg/L.

Elevated TDS concentrations are undesirable for aesthetic reasons related to taste, odor, or appearance of the water and not for health reasons; however, elevated TDS concentrations in water can damage crops, affect plant growth, and damage municipal and industrial equipment. TDS is conservative\(^4\) and mobile in the environment.

Figure 11.14-6 shows TDS concentration contour maps for varying depths of aquifers in the vicinity of the Wilmington field. These contour maps were generated based on the average concentrations from a recent five-year period (2007 to 2011) as observed in WRD nested wells and in production wells monitored in accordance with CDPH requirements. These maps were developed to support a Salt and Nutrient Management Plan currently being prepared for the Central Basin and West Coast Basin (Todd, 2013).

As shown in Figure 11.14-6, large portions of the area beneath Wilmington Oil and Gas Field exhibit elevated TDS concentrations in all aquifer zones due to historical seawater intrusion and percolation of oil field brines. Concentrations exceed 2,000 mg/L for much of the area in most aquifers and exceed 4,000 mg/L over a wide area in the Upper and Lower Pleistocene (below the Silverado). Concentrations greater than 10,000 mg/L are not shown and only occur in several wells. As such, much of the area, although intruded with seawater, is still within the TDS criteria for protected groundwater. EIR Section 10.14.1 defines protected groundwater as “groundwater outside of a hydrocarbon zone that contains less than 10,000 mg/L TDS unless the water has been determined to be an exempt aquifer pursuant to the 40 CFR, part 146.4.”

As a result of high TDS concentrations, the LARWQCB has “de-designated” two areas of the West Coast Basin including a portion of the Wilmington Oil and Gas Field located seaward of the Dominguez Gap Barrier. The de-designation exempts these areas from municipal beneficial uses as determined by the Basin Plan (LARWQCB, 1994). Figure 11.14-7 shows the two de-designated areas. Groundwater in these

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2 BSBPOs are numerical limits unique to a particular basin or subbasin, as set forth in the Basin Plan.
3 A SMCL is a water quality standard established to manage drinking water for aesthetic considerations, such as taste, color, and odor. Contaminants with only SMCLs are not considered to pose a risk to human health.
4 Conservative, in this context, means a constituent is does not interact with subsurface media (vadose zone and saturated zone) and therefore, is not readily attenuated in the subsurface.
areas is characterized by the LARWQCB as brackish to saline and being tidally influenced in elevation (LARWQCB, 2009).

As previously described in EIR Section 10.14.2 and mentioned in EIR Section 11.14.2, the Gaspur Aquifer in the Long Beach Harbor Area of Wilmington Oil and Gas Field (between Ford Avenue and the Los Angeles River) has been designated as an Exempt Aquifer under 40 CFR 146.04. The aquifers under the Gaspur Aquifer would still be protected under SB 4. As such, this aquifer zone is not included in protected groundwater as defined by the proposed SB 4 Well Stimulation Treatment Regulations. This zone has been degraded by seawater intrusion and through injection of oil field brines (DOC, 1981).

**Wastewater Disposal – Wilmington Oil and Gas Field**

Treated produced water (wastewater) from oil and gas operations in the onshore and offshore Wilmington Oil and Gas Fields is disposed by reinjection into deep oil and gas formations and historically was injected into the shallow seawater-impacted Gaspur Aquifer in the Exempt Aquifer area. Because the Gaspur Aquifer in this area was also used to supply water for water flooding, wastewater was treated prior to injection to remove oxygen-bearing bacteria and other impurities (DOC, 1975). As of 1988, a total of 1,172,438,000 barrels (bbl) or 151,120 AF of treated wastewater had been injected into the Gaspur Aquifer and 971,000 bbl or 125 AF had been injected into the Ranger Pool (DOC, 1988). The DOGGR website database lists 67 waste disposal wells in the Gaspur Aquifer, all of which are plugged.

Operators at the Wilmington field, including THUMS Long Beach Co., Tidelands Oil Production Co., Warren E & P Inc., and E & B Natural Resources Management Corporation, report that all wastewater currently is injected into approved oil and gas formations at depths between 2,000 and 7,000 ft-bgs. There are currently five active (in the Lower Terminal Pool) and two idle (in the Terminal Pool and Lower Terminal Pool) Class II injection wells for disposal of wastewater in the onshore and offshore Wilmington fields listed on the DOGGR website database. Further, no wastewater is discharged to the harbor or ocean (McCullough, 2014).

Injection quantities associated with well stimulation fluid disposal would be equivalent to the amount of water used in the well stimulation treatment plus produced water/formation fluids. Because the quantity of flowback is so much lower than the produced water being re-injected into most EOR Class II wells, the extra amount of fluid would not be expected to require a significant number of new Class II wells. If injection occurs back into the producing formation, the produced water/formation fluids are simply being recycled and “space” within the reservoir has been created from the removal of oil, gas, and water. As a result, the formation typically has lower pressure, allowing for increased injection. Injection pressures are limited by the regulations and monitored for compliance. These wellhead pressures will provide early indications when and if additional capacity is required.

**Wellfield Induced Subsidence – Wilmington Oil and Gas Field**

As the Wilmington Oil and Gas Field was developed, land subsidence associated with oil and gas withdrawal became a significant problem. Historically, horizontal earth movement caused by subsidence sheared many oil well casings, making extensive remedial work and special completions necessary. By 1952, the center of the subsidence depression was sinking more than two feet per year. The maximum subsidence at the center of the depression was slightly more than 29 feet by the early 1960s. Following passage of the Subsidence Control Act of 1958, massive water flood projects were started and soon almost all large fault blocks were being flooded. Subsidence rates declined until about 1965, when subsi-

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5 Last annual report to report wastewater disposal volumes.
Additional details regarding subsidence are provided in EIR Section 11.11.

### 11.14.3.2 Study Region 1: Inglewood Oil and Gas Field

**Hydrogeologic Setting – Inglewood Oil and Gas Field**

The Inglewood Oil and Gas Field lies within Los Angeles-San Gabriel Hydrologic Unit as described in EIR Section 11.14.3.1. The primary drainage systems are the Los Angeles River, the San Gabriel River, and Ballona Creek. The climate in the Los Angeles area was described in EIR Section 11.14.3.1.

The Inglewood Oil and Gas Field is located in the Baldwin Hills and a portion of the Santa Monica Basin. The Baldwin Hills are part of a group of hills along the Newport-Inglewood Fault Zone. The Baldwin Hills are relatively non-water bearing compared to the main areas of the groundwater basins and form a barrier to groundwater movement (MRS, 2008).

**Groundwater Basins and Aquifers – Inglewood Oil and Gas Field**

The Inglewood Oil and Gas field straddles three groundwater subbasins⁶ within the larger Coastal Plain of Los Angeles Groundwater Basin: Santa Monica (4-11.01), West Coast (4-11.03), and Central (4-11.04) Basins (see Figure 11.14-1). The West Coast and Central Basins have a CASGEM ranking of 5, indicating that the basins have been impacted by overdraft conditions and groundwater quality degradation. The Santa Monica Basin has a ranking of 3, also indicating groundwater quality degradation in some areas (Figure 10.14-7). The West Coast and Central Basins are adjudicated basins, managed through a Watermaster. The Santa Monica Basin is not adjudicated.

The West Coast, Central, and Santa Monica Basins cover areas of 142 square miles, 277 square miles, and 50.2 square miles, respectively. Figure 11.14-1 shows the location of the three basins and also includes Inglewood Oil and Gas Field with a one-quarter mile buffer zone around the field. The Inglewood Oil and Gas Field is situated mostly in the Baldwin Hills, which are considered relatively non-water bearing when compared with the main portions of the groundwater basins. The field extends to the northwest beyond the Baldwin Hills into the Santa Monica Basin, where field boundaries overlie more permeable aquifers.

The West Coast, Central and Santa Monica Basins aquifer systems are described above in Table 11.14-1. Due to the uplift associated with the Newport-Inglewood Fault, most of the water-bearing units in the Baldwin Hills area of the Inglewood Oil and Gas Field have been uplifted and eroded. As shown in Figure 11.14-10, of the water-bearing units, only the Lakewood, San Pedro, and Inglewood Formations occur in the Baldwin Hills area of the Inglewood Oil and Gas Field. The San Pedro Formation in this area consists primarily of silt to very fine-grained sand, with localized beds of coarse sands and pebbles. This formation, which is locally clay-rich, such as in the northwest portion of the field, has also locally been renamed the Inglewood Formation. The overlying Lakewood Formation, which generally forms the tops of ridges and hills consists of relatively unconsolidated, medium- to coarse-grained sands, with localized lenses of very fine sand and clay. Small canyon bottoms and canyon mouths within the active surface field boundary contain minor amounts of Holocene alluvium, consisting primarily of unconsolidated, fine-grained sand, with minor amounts of gravel, silt, and clay.

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⁶ Although these are subbasins in a larger groundwater basin, they are typically referred to as basins.
The San Pedro Formation, which is approximately 400 to 500 feet thick in the Baldwin Hills portion of the field, is underlain by a thick sequence (i.e., 10,000 to 15,000 feet) of Tertiary sedimentary rock, from which the oil in the Inglewood Oil Field is derived. Figure 11.14-11 shows a geologic cross section beneath the Inglewood Field. The Inglewood Oil and Gas Field produces hydrocarbons from nine zones within interbedded sandstone and shale units, ranging in depth from 900 to 10,000 feet (Cardno ENTRIX, 2012). The Pico Formation is thought to be designated as the base of fresh water across the Los Angeles Basin at the Inglewood Field (Cardno ENTRIX 2012; DWR, 1961).

Based on information from DOGGR, the depth to the base of fresh water at the Inglewood Oil and Gas Field is approximately 350 feet and the depth to the top of the hydrocarbon zone is 950 feet. Therefore, the vertical distance between the base of the fresh water and the top of the hydrocarbon zone is approximately 600 feet. Water salinity measurements made within the hydrocarbon zone show that TDS ranges from approximately 30,000 to 40,000 mg/L, well above the threshold of protected groundwater.

The northwest portion of the Inglewood Field underlies the Santa Monica Basin. Geologic faults have been used to subdivide the basin into five subbasins (see Figure 11.14-9) with the northwestern portion of the Inglewood Oil and Gas Field underlying the Crestal Subbasin. The total depth of the Santa Monica Basin is as much as 500 feet (MWD, 2007).

The Silverado Aquifer is the primary source of groundwater in the Crestal Subbasin and the main source of groundwater in the Santa Monica Basin (SAA, 2010). The Silverado Aquifer is about 100 feet thick in the Crestal Subbasin and can reach thicknesses of up to 280 feet elsewhere in the Santa Monica Basin. The Ballona Aquifer is also a source of groundwater in the basin.

Aquifers in the Santa Monica Basin are generally confined with some areas of unconfined or perched groundwater (MWD, 2007). Groundwater is replenished by percolation from precipitation and by surface runoff from the Santa Monica Mountains, which bound the basin to the north. The Inglewood Fault separates the Santa Monica and Central Basins (see Figure 11.14-1 and 11.14-9) and impedes groundwater movement, reducing groundwater replenishment to the Santa Monica Basin from the Central Basin. Since the Santa Monica basin is mostly urbanized and soil surfaces have been paved, groundwater recharge from direct infiltration of precipitation is limited.

**Groundwater Use in the West Coast Basin, Central Basin, and Santa Monica Basin and at the Inglewood Oil and Gas Field**

Groundwater is used for water supply by water purveyors and entities other than oil and gas owners/operators in the West Coast, Central, and Santa Monica Basins. The basins are important sources of water for residents and businesses in the areas overlying the basins. Typically, groundwater provides about a third of the water supply for the Central Basin and West Coast Basin. Because the Santa Monica Basin is not adjudicated, current production is not known. The City of Santa Monica is the major water producer and relies on groundwater for about 13 percent of its water supply. The percentage of reliance on groundwater is expected to rise to about 50 percent when the City’s Charnock Well Field is returned to service; the wells have been out of service for many years due to contamination with methy-tet-butylether (MTBE) (SAA, 2010). Imported water (e.g., from the Metropolitan Water District of Southern California) and recycled water make up the remainder of the supply in these basins.

Figure 11.14-12 shows groundwater production in the West Coast Basin and in the portion of the Central Basin within WRD’s boundary for Water Year 2011-12 (October 1 through September 30) (WRD, 2013b). Because the Central and West Coast Basins are adjudicated, production wells and production are well documented. The City of Santa Monica is the major pumper in the Santa Monica Basin and their
pumping is reported to DWR (SAA, 2010). Figure 11.14-13 shows pumping in all three basins in 2000. The Charnock Wellfield area is shown on the figure because this field is expected to resume significant pumping in 2015, if not sooner (SAA, 2010). There are production wells located within about 3,000 feet from the DOGGR-designated Inglewood Oil and Gas Field limit boundary and approximately 11,500 feet from the field property boundary.

In addition to the groundwater used by entities other than oil and gas owner/operators, fresh water and recycled produced water are used for hydraulic fracturing in the Inglewood Oil and Gas Field (Cardno ENTRIX, 2012). Fresh water is used for hydraulic fracturing when a potassium chloride gel is added to the hydraulic fracturing fluid (Cardno ENTRIX, 2012). High-volume hydraulic fracturing uses 100% fresh water. High rate gravel packing uses primarily fresh water; although, sometimes produced water may also be used (Freeport-McMoRan, 2015). Recycled water consists of produced water that has been treated at an on-site water treatment plant. Between 2006 and 2008, the Inglewood Oil and Gas Field used an average of 160,000 gallons (0.49 AF/day or 179 AFY) of fresh water per day for oil and gas field operations (not just hydraulic fracturing) (MRS, 2008). This fresh water use is projected to increase to 278,800 gallons (0.86 AF/day or 314 AFY) per day (MRS, 2008). Fresh water is provided by Golden State Water Company and the California American Water Company, although the source of the water is unclear. According to Golden State Water Company’s website, the water provided to Culver City, which abuts the Inglewood Oil and Gas Field, is from the Colorado River Aqueduct and the State Water Project, imported and distributed by Metropolitan Water District (GSWC, 2014). California American Water Company provides fresh water which obtains water from a variety of sources including purchased water from the Metropolitan Water District of Southern California (i.e., imported State Water Project and Colorado River Water) and groundwater from the adjudicated Central and West Coast Basins (Freeport-McMoRan, 2015). No groundwater wells are owned by the operator (Freeport-McMoRan, 2015). Water purchased from the West Basin Water District or pumped from the Central Basin (Cardno ENTRIX, 2012).

The exact volume of water, fresh or recycled, used for past hydraulic fracturing jobs at the Inglewood Oil and Gas Field is not known. As summarized previously, approximately 65 stages of hydraulic fracturing occurred between 2003 and 2010, when a Hydraulic Fracturing Study (Cardno ENTRIX, 2012) was published. This included hydraulic fracturing by conventional methods in 21 wells and high-volume methods in 2 wells. The water use for conventional methods is estimated to have been from about 6 AF to 241 AF (using estimates discussed in EIR Section 10.14.5). The two high-volume hydraulic fracturing jobs completed prior to the Hydraulic Fracturing Study used 123,354 and 94,248 gallons of fresh water, a total of approximately 0.67 AF. The total groundwater use in the West Coast Basin of approximately 197,000 AFY.

The Hydraulic Fracturing Study involved one-stage, high-volume hydraulic fracturing in each of two wells (Cardno ENTRIX, 2012). Multiple stages per well would increase the amount of water use. As summarized previously, exploratory wells in the Monterey Formation can involve up to 20 stages of high-volume hydraulic fracturing. The quantity of water used for the high-volume hydraulic fracturing in the Hydraulic Fracturing Study is significantly less than may be used in future wells in the Monterey Formation.

The Central and West Coast Basins are the only current source of groundwater to the Inglewood Oil and Gas Field. Since these basins are adjudicated, water use for hydraulic fracturing would not impact quantity because groundwater use would be allocated by the courts. If, in the future, the Santa Monica Basin is used as a source of groundwater to the Inglewood Oil and Gas Field, impacts to groundwater quantity would need to be re-evaluated.
Groundwater Flow in the Vicinity of Inglewood Oil and Gas Field

Groundwater flow in the Central and West Coast Basins in the vicinity of the Inglewood Oil and Gas Field is to the southeast toward pumping depressions in the basins (see Figure 11.14-4). Groundwater levels in most of the two basins are generally stable and below sea level.

Groundwater flow in the Santa Monica Basin is generally from the Santa Monica Mountains in the north to the West Coast Basin in the south. Groundwater outflows to the West Coast Basin are estimated to be about 1,000 AFY. Additional outflow to the Hollywood and Central Basins is restricted by the Newport-Inglewood Uplift. Groundwater levels are above sea level in most of the Santa Monica Basin, although low water levels at or below sea level in the Coastal Subbasin allow for the possibility of seawater intrusion in that subbasin (SAA, 2010).

Basin Storage and Adjudication – Inglewood Oil and Gas Field

Basin storage and adjudication for the Central and West Coast and Central Basins were described previously in Sections 11.14.2.1 and 11.14.2.2. Basin storage in the West Coast Basin was described previously in Section 11.14.3.1. Similar to the West Coast Basin, prior to the adjudication of the West Coast and Central Basins, annual production (pumping) far exceeded the natural safe yield of the basins determined by the DWR. Due to this serious overdraft, water levels declined, groundwater was lost from storage, and seawater intruded into the aquifers along the coast. To remedy this problem, the court adjudicated the basins Central Basin to put limits on pumping. The West Coast Basin adjudicated pumping was set at 64,468 AFY. The Central Basin adjudicated pumping was set at 267,900 AFY; although, the judgment set a lower allowed pumping allocation (APA) at 217,367 AFY to impose stricter control.

DWR has estimated that the total storage in the West Coast and Central Basins are approximately 6.5 million AF and 13.8 million AF, respectively (1961). Unused storage is estimated to be approximately 1.1 million AF in both basins, resulting in 120,000 AF of available storage in the West Coast Basin and 330,000 AF of available storage in the Central Basin, assuming that the basin can be filled to within 75 feet of the ground surface (Golder, 2006).

The Santa Monica Basin is not adjudicated and there are no limits on groundwater pumping. The total storage capacity of the basin is estimated to be approximately 1.1 million AF. Although no formal safe yield determination has been made for the basin, USGS has estimated an average yield of about 7,500 AFY, based on inflows and outflows between 1971 and 2000.

Groundwater Quality – Inglewood Oil and Gas Field

Using TDS as a general indicator, groundwater quality is fair to good in the primary producing aquifer in West Coast, Central, and Santa Monica Basins (in the vicinity of the Inglewood Oil and Gas Field). TDS levels in the Silverado Aquifer in the West Coast Basin are in the range of 1,000 to 2,000 mg/L, while the levels are less than 500 mg/L in the Central Basin near the field (CH2M Hill and RMC, 2012). Contamination associated with environmental release sites in the area are typically confined to the shallower aquifer, which is not used for water supply.

Overall TDS concentrations in the Santa Monica Basin are typically high and exceed the secondary MCL of 500 mg/l in all three of the groundwater producing subbasins used by the City of Santa Monica. The City treats its groundwater to meet drinking water standards. In addition, between 1995 and 2010 the City’s reliance on groundwater was significantly impacted as a result of MTBE contamination in its Arcadia and Charnock Subbasins. During this time, the City’s five Charnock wells were kept offline as
remediation efforts continued. For its Arcadia wells, the City installed remediation systems to remediate the MTBE affected zones. For its Charnock wells, the City settled with responsible parties of the MTBE contamination in order to construct and operate a treatment facility to clean up residual MTBE contamination.

The Hydraulic Fracturing Study (Cardno ENTRIX, 2012) provides the most comprehensive evaluation of water quality impacts at the Inglewood Oil and Gas Field from high-volume hydraulic fracturing. Following two high-volume hydraulic fracturing events, the Hydraulic Fracturing Study monitored water quality in 15 monitoring wells ranging in depth from 30 to 500 ft-bgs (Cardno ENTRIX, 2012). Two oil wells, completed to depths of 8,000 and 8,450 feet, each underwent one stage of high-volume hydraulic fracturing, one well in September 2011 and the other in January 2012. Two rounds of water quality data were collected in April and August 2012, following the high-volume hydraulic fracturing. The data were compared to baseline data collected in 2010 and 2011 (Cardno ENTRIX, 2012). The study concluded the hydraulic fracturing did not result in a detectable change to groundwater quality based on the comparison of baseline results to post-hydraulic fracturing results (Cardno ENTRIX, 2012).

There are limitations to the study conclusion with respect to the potential impact to groundwater quality. First, the monitoring wells did not extend beyond 500 ft-bgs, the reported base of fresh water (i.e., 3,000 mg/L TDS). Therefore, it is uncertain whether there were impacts to the quality of protected groundwater below a depth of 500 feet. Second, there were temporary increases in concentrations of diesel (i.e., TPH-DRO with silica gel), benzene, toluene, ethylbenzene, xylene, and zinc, in select monitoring wells following the high-volume hydraulic fracturing (Cardno ENTRIX, 2012). Although the concentrations of these chemicals did not exceed their respective California Maximum Contaminant Levels (MCLs), the study did not provide an explanation for the temporary increases in concentration.

Abandoned wells may be potential pathways for hydraulic fracturing fluids in the Inglewood Oil and Gas Field. From the 1920s through the 1940s wells were not properly abandoned; they were filled with construction debris, such as telephone holes or railroad ties, and then covered with soil at the surface (MRS, 2008). Also, the locations of these wells are unknown since the abandonments were not properly documented. Consequently, improperly abandoned wells provide potential pathways for the migration of hydraulic fracturing fluids that might reach them from newly stimulated wells.

Based on the limitations of the Hydraulic Fracturing Study and the presence of improperly abandoned wells, the impact to groundwater quality at the Inglewood Oil and Gas Field is potentially significant without further mitigation, see EIR Section 11.14.5.

**Wastewater Disposal – Inglewood Oil and Gas Field**

At the Inglewood Oil and Gas Field, produced water is transported by pipeline to the field’s water treatment plant where it is mixed with other produced water generated at the field, treated, and re-injected into the oil and gas producing formations (Cardno ENTRIX, 2012). This reinjection, referred to as water flooding, enhances oil recovery from the field. DOGGR reports about 271 active Class II wells currently being used for water flooding. The DOGGR website database lists one waste disposal well injecting into the Vickers-Rindge, West Pool, which is an approved oil and gas formations at a depth of about 2,000 ft-bgs.

Injection quantities associated with well stimulation fluid disposal would be equivalent to the amount of water used in the well stimulation treatment plus produced water/formation fluids. Because the quantity of flowback is so much lower than the produced water being re-injected into most EOR Class II wells, the extra amount of fluid would not be expected to require a significant number of new Class II...
wells. If injection occurs back into the producing formation, the produced water/formation fluids are simply being recycled and “space” within the reservoir has been created from the removal of oil, gas, and water. As a result, the formation typically has lower pressure, allowing for increased injection. Injection pressures are limited by the regulations and monitored for compliance. These wellhead pressures will provide early indications when and if additional capacity is required.

11.14.3.3 Study Region 2: Sespe Oil and Gas Field

The Sespe Oil and Gas Field is located on the southern side of the Topanga and Piru Mountains in Ventura County north of the Fillmore Groundwater Subbasin (Subbasin No. 4-4.05) of the larger Santa Clara River Valley Groundwater Basin (Figure 11.14-14). The DWR-designated Fillmore Subbasin boundary extends just into the area below the southern extent of the half-mile oil and gas field buffer. The Monterey Formation crops out in the southeastern Sespe Oil and Gas Field and dips beneath the Fillmore Subbasin south of the field, forming the deep syncline associated with one of the Monterey plays (see also Figure 10.14-2 for the location of Sespe Oil and Gas Field and the Monterey play).

The topography of the Sespe field is extremely rugged with elevations ranging between 600 and 4,200 feet.

The Sespe Oil and Gas Field is one of the oldest in California. Discovered in the late 1880s, it spans an era of evolution in the oil industry from early cable-tool to present-day rotary-air drilling (DOC, 1967).

Watersheds and Hydrological Characteristics – Sespe Oil and Gas Field

The field lies within Santa Clara–Calleguas Hydrologic Unit, which encompasses most of Ventura County, part of northern Los Angeles County, and small parts of Santa Barbara and Kern Counties. More specifically, the Sespe Oil and Gas Field lies within the Sespe Hydrologic Subarea (LARWQCB, 1994 and amendments through 2013). The Santa Clara–Calleguas Hydrologic Unit covers a drainage area of 1,760 square miles. The Sespe Oil and Gas Field area is drained by a number of perennial and intermittent streams that flow westward into Sespe Creek, which in turn flows south to the Santa Clara River in the Fillmore Subbasin. The major drainage systems within the Santa Clara–Calleguas Hydrologic Unit are the Santa Clara River and Calleguas Creek. Storm runoff and base flow from the Sespe Creek watershed recharges the Fillmore Subbasin (UWCD, 2013).

Climate and Precipitation – Sespe Oil and Gas Field

Nearly all precipitation in the region occurs during the months of December through March. During the summer months, precipitation is infrequent and dry periods often last several months. Extended multiple years of below normal rainfall constitute drought periods. Precipitation varies considerably from year to year. Annual rainfall in the Sespe Oil and Gas Field ranges between 30 and 50 inches (DOC, 1967).

Groundwater Resources beneath Sespe Oil and Gas Field

The Sespe Oil and Gas Field does not overlie a DWR-designated groundwater basin or subbasin, although the field buffer area does overlie a very small portion of the Fillmore Subbasin. The available DWR groundwater well completion reports for the Sespe Oil and Gas Field were assessed for the occurrence of groundwater resources underlying the field. Table 11.14-4 summarizes all of the available water well information. Based on the table, it appears there is very little available groundwater beneath Sespe Oil and Gas Field.
Table 11.14-4. Groundwater Supply and Monitoring Wells in Sespe Oil and Gas Field

<table>
<thead>
<tr>
<th>Owner</th>
<th>Well Name</th>
<th>Screen Interval (ft-bgs)</th>
<th>Material Screened</th>
<th>Prop. Use</th>
<th>Depth to Water (ft-bgs)</th>
<th>Yield (gpm)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holguin, Fahan Assoc</td>
<td>MW-7</td>
<td>3–18</td>
<td>Bedrock</td>
<td>MW</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Holguin, Fahan Assoc</td>
<td>MW-13</td>
<td>3–18</td>
<td>Bedrock</td>
<td>MW</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>U.S. Forest Service</td>
<td>—</td>
<td>15–45</td>
<td>Landslide Debris</td>
<td>Dom</td>
<td>5</td>
<td>6</td>
<td>Located on Sespe Creek north of Fillmore Basin</td>
</tr>
<tr>
<td>United Water</td>
<td>SC-1</td>
<td>—</td>
<td>Upper Zone</td>
<td>TW</td>
<td>—</td>
<td>—</td>
<td>Located on Sespe Creek north of Fillmore Basin</td>
</tr>
<tr>
<td>Conservation District</td>
<td>SC-2</td>
<td>—</td>
<td>Upper Zone</td>
<td>TW</td>
<td>—</td>
<td>—</td>
<td>Located on Sespe Creek north of Fillmore Basin</td>
</tr>
<tr>
<td>United Water</td>
<td>SC-3</td>
<td>—</td>
<td>Upper Zone</td>
<td>TW</td>
<td>—</td>
<td>—</td>
<td>Located on Sespe Creek north of Fillmore Basin</td>
</tr>
<tr>
<td>Conservation District</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>James Van Trees</td>
<td>—</td>
<td>40–175</td>
<td>Gravel/Silt</td>
<td>Dom</td>
<td>27</td>
<td>20</td>
<td>Not used; brackish water</td>
</tr>
<tr>
<td>Shell Oil Co.</td>
<td>—</td>
<td>N/A</td>
<td>N/A</td>
<td>CP</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>E. McReynolds</td>
<td>—</td>
<td>&lt;400</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Rushing-Whiteley Ranch</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>TW</td>
<td>Dry</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Rushing-Whiteley Ranch</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>Irrigation</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Biophilia Associates</td>
<td>—</td>
<td>20–40</td>
<td>Gravel</td>
<td>Irrigation</td>
<td>20</td>
<td>23</td>
<td>—</td>
</tr>
<tr>
<td>Hugh</td>
<td>—</td>
<td>—</td>
<td>Clay</td>
<td>Domestic,</td>
<td>8</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Irrigation</td>
<td></td>
<td></td>
<td>Log notes very little water</td>
</tr>
<tr>
<td>Edward</td>
<td>—</td>
<td>80–100</td>
<td>—</td>
<td>Domestic,</td>
<td>10</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Irrigation</td>
<td></td>
<td></td>
<td>—</td>
</tr>
<tr>
<td>Vedder</td>
<td>—</td>
<td>—</td>
<td>Gravel</td>
<td>—</td>
<td>28</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Burson</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

1 - Total depth 28 feet; no well completed
2 - Total depth 12 feet; no well completed
ft-bgs = feet below ground surface
gpm = gallons per minute.
MW = monitoring well
TW = test well
CP = cathodic protection
— = no data

Even though the field is not directly overlying a groundwater basin, bedrock areas adjacent to groundwater basins can be hydraulically connected to the groundwater system and provide recharge via subsurface inflow. While the rate of recharge may be limited by the lower permeability of the bedrock, the subsurface area where such inflow occurs can be large and significant as a recharge component. However, the subsurface hydraulic connection between Sespe Oil and Gas Field and the adjacent Fillmore Subbasin is not likely to be large, given the subsurface geologic conditions described below.

Relatively shallow sands produce oil and gas beneath the field at an average depth of about 600 feet. The cross section on Figure 11.14-15 illustrates these shallow sands; the location of the cross section is shown on Figure 11.14-14. As shown by the cross section on Figure 11.14-15, these zones dip steeply to the south beneath the Fillmore Subbasin and are overlain by the Monterey Formation, which also contains hydrocarbons and dips south beneath the subbasin. These hydrocarbon-bearing formations separate any shallow groundwater resources that may occur at the site from the groundwater subbasin to the south. The base of fresh water beneath the field is reported to be 0 feet (not present) to 100 feet...
deep. For this shallow groundwater to provide inflow into the Fillmore Subbasin, groundwater would have to migrate south through existing hydrocarbon zones, an unlikely occurrence (Figure 11.14-15).

The primary potential pathway for any groundwater beneath Sespe Oil and Gas Field to reach the Fillmore Subbasin would be groundwater flow or underflow beneath natural drainageways such as Sespe Creek. Surface water in the creek provides surface inflow and recharge to the groundwater basin (UWCD, 2013). The surface water drainage system is often mimicked by groundwater flow systems in bedrock areas. Sespe Creek is shown on Figure 11.14-14.

**Groundwater Use in the Fillmore Subbasin – Sespe Oil and Gas Field**

Most of the groundwater use in the Fillmore Subbasin is for agriculture (approximately 93 percent) with the remainder used for municipal, industrial, and domestic purposes. Groundwater is produced from alluvium and the upper portion of the underlying San Pedro Formation. The average annual reported groundwater extractions for the Fillmore Subbasin from 1980 to 2012 are 44,191 AFY (UWCD, 2013). There are no restrictions on pumping groundwater from the Fillmore Subbasin. The United Water Conservation District (UWCD) provides local groundwater management and compiles pumping data for the subbasin (UWCD, 2013).

**Groundwater Levels and Flow in the Fillmore Subbasin – Sespe Oil and Gas Field**

Groundwater levels and trends in the Fillmore Subbasin are monitored by UWCD. The groundwater subbasin fills quickly in wet years and UWCD releases from Lake Piru, upstream of the subbasin, have a stabilizing effect on long-term groundwater levels. Groundwater flows into the Fillmore Subbasin from the upgradient Piru Subbasin. Groundwater flows westward out of the Fillmore Subbasin into the adjacent Santa Paula Subbasin to the west. The Fillmore Subbasin generally is considered unconfined and there currently is no significant observed land subsidence (UWCD, 2013).

**Water Use in the Fillmore Subbasin and Sespe Oil and Gas Field**

In response to a data request, Seneca Resources Corp. (Seneca, the primary operator in the field) and DOGGR staff provided information regarding the amount and source of water used in the Sespe Oil and Gas Field (Hesson, 2014). Currently, only produced water is used for oil field operations and well stimulation. The operator has four water supply wells in the field that can be pumped for make-up water as needed. However, the wells are currently reported to be idle and no pumping amounts have been filed. Further, the operators do not use any groundwater derived from the adjacent Fillmore Groundwater Subbasin. Seneca uses up to approximately 2,254,315 gallons (6.5 AFY) of produced water annually, which includes water used for well stimulation treatments (Hesson, 2014). A small unknown amount of water is used by other owners/operators in the field, but that amount is reported to be very small compared to operations by Seneca Resources Corp. Seneca estimates that future water use will be between 5 and 8 AFY. Although this amount will include water needed for all oil and gas field activities, approximately 80 to 90 percent of it will be used for hydraulic fracturing (Hesson, 2014).

**Wastewater Disposal – Sespe Oil and Gas Field**

There are currently eight active Class II injection wells for in the Sespe Oil and Gas Field used for water flooding. The water flood wells re-inject flowback and produced water back into oil and gas producing formations for enhanced oil recovery (EOR wells). Numbers of active wells vary from year to year. The DOGGR website database lists seven Class II wells injecting into the Basal Sespe and one into the Rincon-Vaqueros Pools, which are approved oil and gas formations. The depths of these formations vary consid-
erably based on location on the field as shown in Figure 11.14-15. DOGGR reports an additional 19 Class II wells that are used for water disposal.

Injection quantities associated with well stimulation fluid disposal would be equivalent to the amount of water used in the well stimulation treatment plus produced water/formation fluids. Because the quantity of flowback is so much lower than the produced water being re-injected into most EOR Class II wells, the extra amount of fluid would not be expected to require a significant number of new Class II wells. If injection occurs back into the producing formation, the produced water/formation fluids are simply being recycled and “space” within the reservoir has been created from the removal of oil, gas, and water. As a result, the formation typically has lower pressure, allowing for increased injection. Injection pressures are limited by the regulations and monitored for compliance. These wellhead pressures will provide early indications when and if additional capacity is required.

11.14.4 Impact Methodology and Significance Criteria

Based on guidance from the CEQA Environmental Checklist (State CEQA Guidelines, Appendix G), significance criteria for groundwater resources have been developed for the project. Impact significance criteria are as described in EIR Section 10.14.4. For groundwater quality, the mechanisms and pathways discussed in EIR Section 10.14.4 are incorporated into this analysis.

These significance criteria are applied to the potential for well stimulation activities at Wilmington, Inglewood, and Sespe Oil and Gas Fields. The analysis assumes that the two project standards, the Water Recycling Standard and the Groundwater Protection Standard, apply. Further, it is assumed that DOGGR’s proposed permanent regulations are adopted and implemented. Mitigation measures, including those proposed in EIR Section 10.14.5 and summarized on Table 10.14-20, also are considered for application to these fields.

11.14.5 Impact Analysis and Mitigation Measures

Impacts to groundwater quantity and quality are analyzed in the following sections.

11.14.5.1 Study Region 1: Wilmington Oil and Gas Field

Groundwater Quantity

The West Coast Basin is considered to be a critically impacted groundwater basin as described in EIR Section 10.14.5.1. As an adjudicated basin, pumping in this basin is controlled by the court and managed through coordinated operations by Water Replenishment District of Southern California (WRD), Los Angeles County Department of Public Works, and DWR (as the court-appointed Watermaster). However, oil and gas operators in the Wilmington field may not be parties to the adjudication and do not report groundwater pumping to the Watermaster; therefore, groundwater use data are not well known (Johnson, personal communication, 2014). As previously discussed, DOGGR’s best information indicates that groundwater is not used for well stimulation treatments in Wilmington Oil and Gas Field. Further, the only operator reportedly using groundwater (Tidelands Oil Production Co./Oxy Long Beach) has coastal wells that pump from the Gaspur Aquifer, an Exempt Aquifer in some portions of the field7 (McCullough, 2014).

7 The exempt portion is reported to extend from Ford Avenue to the Los Angeles River (DOC, 1981).
In response to a data request, operators for the Wilmington Oil and Gas Field provided information on water use to DOGGR (McCullough, 2014). Based on this information, it appears that operators rely primarily on produced water from oil and gas formations and recycled municipal wastewater purchased from the City of Long Beach for their water supply. THUMS Long Beach Co. reports purchasing approximately 29 million barrels (about 3,700 AFY) of recycled water from the City of Long Beach in 2013. They also used approximately 380 million barrels (49,000 AFY) of produced water in 2013. Shallow seawater-impacted Gaspur Aquifer wells located on the seaward side of the Dominguez Gap Seawater Intrusion Barrier, historically used for wellfield water supply, are no longer in use by at least two operators in the field (THUMS Long Beach Co. and Warren E&P, Inc.).

Tidelands Oil Production Co.\Oxy Long Beach, Inc. reports using water supply wells completed in the Gaspur Aquifer (up to 11.8 million barrels per year or 1,521 AFY). The 1,521 AFY is used for water flooding and other drilling uses. These wells are located on the piers in the Long Beach Harbor area. It is not clear whether these wells are located within the Exempt Aquifer area or in other sections of the field (McCullough, 2014). As reported by the operators, none of this groundwater is used for well stimulation treatments. Oxy Long Beach reports using treated produced water for well stimulation treatments (McCullough, 2014).

As previously noted, up to 100 wells could be drilled per year at Wilmington field, with up to 20 hydraulically fractured wells. Additionally, well stimulation would occur at some existing wells (five per year assumed) at THUMS/Long Beach Unit. Based on these projections, a range of water use is estimated for future hydraulic fracturing in the Wilmington Oil and Gas Field as presented in Table 11.14-5. Consistent with the projections discussed in EIR Section 7.3.8, all are hydraulic fracturing is assumed to be conventional well stimulation treatments. It is not possible to estimate the number, if any, of unconventional well stimulation treatments that may take place in the Monterey Formation, but it is noted that such treatments can use up to about 20 AF of water per treatment.

### Table 11.14-5. Projected Water Use for Future Hydraulic Fracturing in Conventional Wells

<table>
<thead>
<tr>
<th>Study Region</th>
<th>Oil &amp; Gas Field</th>
<th>Maximum Projected Number of Wells per Year for Hydraulic Fracturing¹</th>
<th>Range of Water Use per Hydraulic Fracturing Job (AF)²</th>
<th>Range of Projected Water Use (AFY)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>New</td>
<td>Existing</td>
<td>Total</td>
</tr>
<tr>
<td>1</td>
<td>Wilmington</td>
<td>20</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Inglewood</td>
<td>6</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>Sespe</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>

¹ - Assumptions for the number of wells used for hydraulic fracturing were made based on Industry projections, as follows:

- **Study Region 1, Wilmington Oil and Gas Field**
  - New wells: 0 to 20 would be hydraulically fractured annually, maximum assumed.
  - Existing wells: well stimulation would occur on a “limited basis,” five per year assumed.

- **Study Region 1, Inglewood Oil and Gas Field**
  - New wells: over 50 production and injection wells drilled per year; 25% production wells and no injection wells would be hydraulically fractured. Assumed 25 new production wells; 6 of which would be used for hydraulic fracturing.
  - Existing wells: less than 15 wells per year, assumed 14.

- **Study Region 2, Sespe Oil and Gas Field**
  - New wells: a few wells per year would be hydraulically fractured; assumed 4 based on current well drilling application with Los Padres National Forest.

² - Estimated water used based on Interim Well Stimulation Treatment Disclosures for 448 hydraulic fracturing jobs completed between January 7, 2014 and September 30, 2014. The disclosure data were downloaded from the DOGGR website on December 2, 2014.
As shown in Table 11.14-5, the estimated water use for the projected well stimulation treatments in the Wilmington field range from about 0.25 AFY to about 47 AFY, with an average (arithmetic mean) of 7.25 AFY. These are relatively small volumes compared to the total basin safe yield of 64,468 AFY. Even nearby industrial wells pump about 7,000 AFY (2011 pumping records). Nonetheless, in an overdrafted groundwater basin, even small amounts are significant.

All operators have committed to DOGGR that they will not be using protected groundwater for the treatments identified above. However, without enforceable assurances, it is not clear whether pumping could increase with a change in operator plans. Given the uncertainty associated with the onsite wells and unreported pumping quantities within a critically impacted groundwater basin, the impacts to groundwater quantity are assumed to be potentially significant without mitigation. Mitigation measures for groundwater quantity and quality are discussed together at the end of this section.

**Groundwater Quality**

As discussed in more detail in EIR Sections 10.13.5, 10.14.4 and 10.14.5, potential pathways may exist for well stimulation treatments to impact groundwater quality. These pathways are evaluated in previous sections of this EIR as summarized below:

- **Surface release** (e.g., spills or leaks) of well stimulation fluids that could infiltrate surface soils and percolate to the water table (evaluated in EIR Section 10.13 Hazards and Hazardous Materials);
- **Natural subsurface pathways**, such as geologic faults or existing fractures, which could serve as conduits for upward or lateral migration of well stimulation fluids (evaluated in EIR Section 10.11 Geology, Soils, and Mineral Resources);
- **Subsurface pathways along fractures** that are induced by the hydraulic fracturing process (evaluated in EIR Section 10.11 Geology, Soils, and Mineral Resources);
- **Subsurface pathways associated with a well or borehole**, including new or existing wells being used for well stimulation and other existing wells/boreholes (evaluated in EIR Section 10.14 Groundwater Resources); and
- **A combination of the pathways** listed above.

Groundwater impacts may vary with location at Wilmington Oil and Gas Field, depending on whether the area overlies a protected groundwater aquifer. As mentioned previously, the Gaspur Aquifer near San Pedro Bay has been exempted from protected groundwater classification. Other portions of the aquifers under Wilmington field contain saline water due to seawater intrusion and may contain TDS concentrations that also exclude them from protected groundwater. However, these details are difficult to quantify until a specific well stimulation permit application is received, along with the information and analysis required by the SB 4 Well Stimulation Treatment Regulations. For the purposes of this EIR, it is therefore assumed that other aquifers (besides Gaspur) can be classified as protected groundwater aquifers.

To evaluate the potential for a subsurface release, subsurface conditions were reviewed. Figure 11.14-8 shows a block diagram in the Wilmington Oil and Gas Field illustrating the water supply aquifers, base of fresh water, and the upper oil and gas producing zones (Tar and Ranger) (Zielbauer, 1962). The location of the cross section is shown in Figure 11.14-2. The base of fresh water is indicated as the base of the Pico Formation. The minimum thickness between the upper Tar Zone and the base of fresh water is 400

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8 Borehole refers to a drilled boring in which a well has not been installed. Wellbore refers to the drilled boring in which a well has been installed.
feet, as depicted on Figure 11.14-8. The depth of the protected zone with groundwater at TDS concentrations less than 10,000 mg/L is not known but occurs, by definition, within that 400-foot zone. The Tar Zone is reported to have a TDS of 28,000 mg/L (DOGGR, 1991). Accordingly, if the upper hydrocarbon zone was subject to hydraulic fracturing, there would be less than 400 feet vertical separation between the target zone and protected groundwater. Based on this limited vertical separation, groundwater is vulnerable to hydraulic fracturing impacts. Even if hydraulic fracturing occurred in deeper zones, potential pathways along unsealed wellbores could allow well stimulation fluids, especially gases, to reach protected groundwater.

See EIR Section 10.14.5 for additional information on groundwater quality impacts. In particular, an analysis of subsurface pathways along wells is provided. The analysis includes information on well construction, well seals, and the potential for upward migration of fluids including gas. The analysis also provides a discussion on the potential for methane migration and its impacts on groundwater quality. Wellbore pressure monitoring requirements before, during, and after the well stimulation treatment are discussed. Specific requirements for testing and monitoring well performance and other activities related to well stimulation treatments from the proposed permanent SB 4 regulations are also listed.

Notwithstanding the concerns with well seals, cement seals represent the best line of defense for fluids and gas migration. Cementing practices have improved over time and many of the well seal problems identified have been in older wells. Mechanical integrity testing can provide information on well seals by demonstrating the well’s ability to hold pressure. Geophysical techniques including cement bond logs, temperature surveys, and other surveys are used to evaluate the quality of the cement seal. Accordingly, most of the mitigation measures for groundwater quality focus on well integrity and well seals.

For the groundwater quality analysis, all of the impacts assessed in the programmatic level analysis of groundwater quality impacts along with the conclusions and mitigation measures apply to Wilmington Oil and Gas Field. These impacts are designated GW-3, GW-4, GW-5, GW-6, and GW-7. These impacts, along with mitigation measures identified as applicable for Wilmington Oil and Gas Field are discussed below. By incorporating the analysis from EIR Section 10.14 and the mitigation measures below, groundwater quality impacts at the Wilmington Oil and Gas Field as a result of well stimulation are less than significant (Class II).

Based on the previous analysis, potential impacts to groundwater quantity and quality, along with associated mitigation measures, are described below. This is followed by a discussion of impacts to each study region. The impacts and mitigation measures are also applicable to each study region.

<table>
<thead>
<tr>
<th>Impact GW-1</th>
<th>Cause or contribute to overdraft conditions</th>
</tr>
</thead>
</table>

For groundwater quantity, significant impacts could occur if an increase in groundwater use for well stimulation occurs in a critically impacted groundwater basin, including those where overdraft conditions have been documented. Even though some estimates of groundwater use for well stimulation are small, any increase in groundwater use in a critically impacted groundwater basin is assumed to be significant without mitigation.

For the Wilmington Oil and Gas Field, the applicable groundwater basin is adjudicated; pumping is controlled by the court and managed by local agencies including DWR as the court-appointed Watermaster. However, operators of the field do not appear to report pumping amounts to DWR and WRD, as do other parties to the adjudication (Johnson, personal communication, 2014). Therefore, it is not known whether groundwater pumping occurs in the adjudicated portion of the basin. Although operators do not reportedly use groundwater as a source for well stimulation currently, there are no assurances that
wells within the adjudicated area of the West Coast Basin will not be used for future treatments. As such, mitigation measures are incorporated to ensure that overdraft conditions within the West Coast Basin are not exacerbated by groundwater pumping in the adjudicated area for the Wilmington Oil and Gas Field.

Mitigation Measure GW-1a requires the operators to use alternative water sources other than protected groundwater. Because operators at Wilmington Oil and Gas Field are currently using other sources, this mitigation measure is already being fulfilled and provides assurances for the future. In the event that groundwater within the adjudicated areas is used in the future, GW-1b provides for an assessment to determine whether overdraft conditions would be exacerbated by this use. In this way, mitigation measures GW-1a and GW-1b lessen the potential impacts to groundwater quantity. Descriptions of the mitigation measures are repeated below from EIR Section 10.14.

**MM GW-1a** Use Alternative Water Sources to the Extent Feasible. (Full text in EIR Section 10.14.5.)

**MM GW-1b** Prepare a Third-Party Technical Report to Analyze Overdraft Impacts Minimize Groundwater Impacts. (Full text in EIR Section 10.14.5.)

**Impact GW-2** Lower groundwater levels through pumping, resulting in significant and unreasonable inelastic land subsidence or significant and unreasonable impacts to nearby water wells or interconnected surface water

For the current conditions in the Wilmington Oil and Gas Field, this impact is not associated with well stimulation treatments because alternative water sources are being used. In the event that groundwater wells are used for well stimulation in the future, this Mitigation Measure GW-1b would require an independent review by a Certified Hydrogeologist to evaluate and mitigate specific impacts from groundwater pumping as indicated in the impact statement above (GW-2). The proposed permanent DOGGR regulations require submittal of a Water Management Plan as part of an application for a well stimulation treatment permit. The Water Management Plan must define the volume, source, and disposal (including recycling) of the water to be used. For projects considering use of groundwater, additional specific information should be included in the plan, as specified in Mitigation Measure GW-2aGW-1b.

Implementation of Mitigation Measures GW-21a and GW-1b would reduce Impact GW-2 to a less than significant level (Class II) because alternative water sources will be used to the extent feasible (MM GW-1a) and fulfillment of the technical report independent review required by the Mitigation Measure GW-1b will provide a clear and transparent analysis of potential impacts from groundwater pumping. By requiring an independent third-party, State-certified Hydrogeologist to prepare the report, the analysis will be based on credible hydrogeologic principles and methods.

**MM GW-1a** Use Alternative Water Sources to the Extent Feasible. (Full text in EIR Section 10.14.5.)

**MM GW-1b** Minimize Groundwater Impacts. (Full text in EIR Section 10.14.5.)

**MM GW-2a** Prepare a Third-Party Technical Report to Analyze Local Impacts of Pumping. (Full text in EIR Section 10.14.5.)

**Impact GW-3** Adversely impact groundwater quality from surface spills or leaks during well stimulation

The significance of impacts for the surface pathway focuses on potential spills and leaks of hazardous materials onto the ground, especially where sites overlie protected groundwater. Although numerous
current and proposed regulations provide substantial protective measures to prevent a surface release, including a Spill Contingency Plan. In some areas, an additional protective measure may be appropriate would require applicants to provide—containing a physical barrier (cover) on the land surface beneath vessels, pipes, and other equipment containing hazardous materials at the site pad for all well stimulation production facilities. This could be paving or installation of other material suitable for preventing any spilled or released material from reaching the soil.

This impact is applicable to conditions at the Wilmington Oil and Gas Field. Although much of the site is paved, there are areas of exposed soil. In addition, spills and leaks onto pavement can readily become runoff unless managed and contained. DOGGR has discretion within the mitigation measure to allow alternative barriers and/or secondary containment options based on site-specific conditions.

The mitigation measure supplements ensures that the operator’s Spill Contingency Plan will provide adequate protection against spills or leaks to prevent migration of well stimulation fluids into underlying protected groundwater. Although secondary containment is required for equipment and containers involving hazardous materials, the proposed permanent SB 4 regulations remove that requirement for production facilities that are in one location for less than 30 days (Section 1786(a)(1)). Most well stimulation activities only occur over a few days. This mitigation, to be required at DOGGR’s discretion, would provide a secondary line of defense to prevent an accidental release from reaching protected groundwater in sensitive areas. Although spills and leaks are essentially impossible to fully prevent, this mitigation measure will allow for the release to be immediately detected and contained, following steps and procedures in the Spill Contingency Plan (Section 1786). Details of this mitigation measure are also provided in EIR Section 10.13.5.

Implementation of Mitigation Measure HAZ-1a would reduce Impact GW-3 to a less than significant level (Class II) for the Wilmington Oil and Gas Field by requiring a barrier to reduce impacts from hazardous materials.

**MM HAZ-1a**  Ensure that Spill Contingency Plan Provides Adequate Protection Against Leaks or Discharges of Dangerous Fluids and Other Potentially Dangerous Materials Provide a Physical Barrier on the Ground Surface at the Site Pad for All Production Facilities, Regardless of the Amount of Time They Are in Place, Prior to Moving in Hazardous Materials and Manage Surface Water Runoff and Drainage on the Barrier Using Best Management Practices. (Full text in EIR Section 10.13.5.)

**Impact GW-4**  Migration of well stimulation fluids or formation fluids including gas to protected groundwater through non-existent or ineffective annular well seals

The most likely subsurface pathway associated with a well involves any unsealed portion of the annular space between the outer casing and the borehole, assuming that fluids can reach this space but other potential pathways are also present. A pathway does not necessarily mean that well stimulation fluids would migrate into protected groundwater but if they did, this would result in an impact to protected groundwater. Given the uncertainty associated with subsurface migration and importance of annular well seals for the protection of groundwater resources, three important mitigation measures are proposed to bolster the protective measures in the proposed SB 4 regulations to identify and manage potential impacts from wells.

These mitigation measures address directly both the well being used for well stimulation and other wells in the area of influence or ADSA, the first line of defense for fluid (including gas) migration. Combined with other **M**onitoring and testing **R**equired **R**equirements with the proposed in the SB 4 regulations,
these mitigation measures address will demonstrate the performance of these well seals and gas detectors and the potential for fluids/gas migration to protected groundwater in the well being stimulated and in surrounding potential conduit wells. The migration of methane gas in the L.A. Basin is well-documented (Chilingar and Endres, 2005). Accordingly, this impact and all three of the mitigation measures are incorporated into the analysis for Wilmington Oil and Gas Field. With implementation of the mitigation measures, the impacts would be less than significant (Class II).

**MM GW-4a** Demonstrate that Wells within the ADSA Have Effective Cement Well Seals and Monitor Wells during Well Stimulation. (Full text in EIR Section 10.14.5.)

**MM GW-4b** Install a Well Seal Across Protected Groundwater for New Wells Subject to Well Stimulation Treatments. Full Length Seal between the Casing String and the Wellbore for Wells within the Boundaries of a DWR Groundwater Basin (Full text in EIR Section 10.14.5.)

**MM GW-4c** Install Methane Sensors on Wells Subject to Well Stimulation Treatments in the ADSA. (Full text in EIR Section 10.14.5.)

**Impact GW-5** Migration of well stimulation fluids or formation fluids including gas into protected groundwater through damaged or improperly abandoned wells

Since oil discovery in 1932, more than 6,000 wells have been drilled in Wilmington Oil and Gas Field. Poorly abandoned wells within the ADSA of a well stimulation treatment could provide a conduit for upward migration of well stimulation fluids (including gas) to potentially reach protected groundwater. The proposed permanent SB 4 regulations require an operator to identify any existing wells/wellbores within twice the area of the ADSA and design the test such that geologic and hydrologic isolation of the formation can be demonstrated. However, there may be wells that are undocumented, and whose condition and/or location is unknown. Accordingly, DOGGR will require a detailed record review of potential conduits including the potential for un-located abandoned wells and may require a field program needs to be conducted or other method to locate older and abandoned wells within the ADSA. This measure will to ensure that locate poorly abandoned wells do that may not provide a conduit for migration of well stimulation fluids. Implementation of this mitigation measure is discussed below and would reduce the impact **GW-5** to less than significant (Class II).

**MM GW-5a** Conduct Surface Geophysical Surveys or Apply Other Field Methods to Locate Improperly Abandoned Wells and Mitigate. (Full text in EIR Section 10.14.5.)

**Impact GW-6** Improper disposal of flowback in injection wells could potentially impact groundwater quality

Wilmington Oil and Gas Field has used water flooding techniques since the 1950s for enhanced oil recovery, and accordingly has historically had more than 300 Class II injection wells. There is the potential for non-existent or ineffective well seals that would place protected groundwater at risk, especially in older wells.

As previously discussed, Class II injection wells are required under the UIC program regulations to contain an isolating cement seal above the injection zone as well as a minimum 100-foot seal across the base of the fresh water zone. Current program requirements do not include an annular seal across the entire zone of USDW. The Groundwater Protection Standard applies to a well used for stimulation (EIR Section 7.5.4) and requires an annular cement seal across the entire zone of protected groundwater defined by a TDS concentration less than 10,000 mg/l, a definition slightly broader but generally
consistent with the definition of USDWs in the UIC program. This mitigation measure would make the well seal requirements for a Class II well where well stimulation fluids shall be disposed consistent with the cement seal requirements of the well used for stimulation. This mitigation measure will ensure that current and future regulations are followed with regards to proper disposal in Class II wells to protect groundwater resources.

MM GW-6a  **Require Wastewater Disposal Wells to Inject Only into Exempted Aquifers to Protect Groundwater**

**Install a Cement Seal across Protected Groundwater.** (Full text in EIR Section 10.14.5.)

### Impact GW-7

**Inability to identify specific impacts to groundwater quality from well stimulation activity**

It would be difficult for any groundwater monitoring program at the Wilmington Oil and Gas Field to differentiate impacts from well stimulation treatments from those resulting from other activities. At this field, groundwater chemistry may be complicated from seawater intrusion and historical injection of wastewater. Accordingly, a mitigation measure to include a tracer in the well stimulation fluids has been identified that would allow differentiation of material and function as a forensic signature for the fluids used. Alternatively, intrinsic tracers such as stable isotopic signatures could be used as suggested by others (Sharma et al., 2014).

The ability to identify the source of any impacts quickly would facilitate containment and remediation of the problem. Potential impacts would be handled on a site-by-site basis, but would allow for remedial actions under the jurisdiction of the Regional Water Board. In combination with other mitigation measures, project standards, and proposed regulations, implementation of Mitigation Measure GW-7a would reduce Impact GW-7 to a less than significant level (Class II) as explained below.

MM GW-7a  **Add a Tracer to Well Stimulation Fluids or Develop a Reasonable Method to Distinguish These Fluids in the Environment.** (Full text in EIR Section 10.14.5.)

### 11.14.5.2 Study Region 2: Inglewood Oil and Gas Field

Based on the information summarized herein and in other sections of the EIR (10.14.5, 10.13.5, and 10.11.5), potential impacts to groundwater quantity and quality as a result of well stimulation treatments in the Inglewood Oil and Gas Field are summarized below. The summary is followed by a description of the mitigation measures proposed to address these impacts.

**Groundwater Quantity**

As previously discussed, both fresh water and recycled water is used for well stimulation at the Inglewood Oil and Gas Field. Between 2006 and 2008, the Inglewood Oil and Gas Field used an average of 160,000 gallons (0.49 AF/day or 179 AFY) of fresh water per day for oil and gas field operations (not just well stimulation) (MRS, 2008). This fresh water use is projected to increase to 278,800 gallons (0.86 AF/day or 314 AFY) per day (MRS, 2008). Fresh water is provided by the California American Water Company, which obtains water from a variety of sources including purchased water from the Metropolitan Water District of Southern California (i.e., imported State Water Project and Colorado River Water) and groundwater from the adjudicated Central and West Coast Basins (Freeport-McMoRan, 2015). Fresh water is purchased from Golden State Water Company and the California American Water Company, but the groundwater portion of this water supply is unknown. Although Golden State Water Company provides imported water supplies, California American Water Company provides groundwater pumped from the Central Basin or purchased from West Basin Water District (GSWC, 2014; Cardno ENTRIX,
Because both the Central Basin and West Basin are adjudicated, pumping is managed for basin users, and the potential for this supply to cause or contribute to overdraft conditions in these two basins is assumed to be mitigated. Further, as part of the Recycled Water Standard (part of the project – see EIR Section 7.5.1), mitigation in EIR Section 10.15, applicants for well stimulation permits will be required to prepare a feasibility study regarding the increased use of recycled water including produced water or saline groundwater.

The exact volume of water, fresh or recycled, used for past hydraulic fracturing jobs at the Inglewood Oil and Gas Field is not known. As summarized previously, approximately 65 stages of hydraulic fracturing occurred between 2003 and 2010, when a Hydraulic Fracturing Study (Cardno ENTRIX, 2012) was published. Using estimates of water use per stage (0.26 AF to 0.74 AF) as shown in Table 10.14-4, this water use is estimated to range from about 17 AF to more than 48 AF over the 7-year period. These volumes represent a small portion of the total groundwater use in the Central and West Coast Basins of approximately 197,000-240,000 AFY.

However, projections for water use for future well stimulation are higher. As discussed in EIR Section 7.3.8 and shown in Table 11.14-5, approximately 20 wells per year are estimated for hydraulic fracturing treatments (including 6 new wells and 14 existing wells). As shown in the table, water use for these treatments is estimated to range between 0.2 AFY to 37.4 AFY (with a mean estimate of 5.8 AFY). Again, the portion of this water that will be supplied by groundwater is not known.

The Central and West Coast Basins are the only current sources of groundwater to the Inglewood Oil and Gas Field. Since these basins are adjudicated, water use for hydraulic fracturing would not impact quantity because groundwater use would be allocated by the courts. However, the DOGGR designated field boundary and field limit boundary (Figure 11.0-2a) does overlap with a portion of the regional water supply aquifers of the Santa Monica Basin. If that basin is used as a source of groundwater (e.g., through purchases of water from a local water purveyor) in the future, impacts to groundwater quantity would need to be re-evaluated. Given this uncertainty, impacts to groundwater quantity at Inglewood Oil and Gas Field are potentially significant without additional mitigation measures.

To address this issue, mitigation measures developed to mitigate groundwater quantity impacts (Impact GW-1 and Impact GW-2) are applied to the field. A description of these mitigation measures (GW-1a/b and GW-2a/b), along with additional mitigation measures for groundwater quality impacts, follow the discussion on groundwater quality impacts below. By incorporating the analysis from EIR Section 10.14 and the mitigation measures below, groundwater quality quantity impacts at the Inglewood Oil and Gas Field as a result of well stimulation are less than significant (Class II).

**Groundwater Quality**

As discussed in more detail in EIR Sections 10.13.5, 10.14.4 and 10.14.5, potential pathways exist for well stimulation treatments to impact groundwater quality. These pathways are the same as those listed in EIR Section 11.14.5.1.

See EIR Section 10.14.5 for additional information on potential groundwater quality impacts that also apply to the Inglewood Field. In particular, an analysis of subsurface pathways along wells is provided. That analysis includes information on well construction, well seals, and the potential for upward migration of fluids including gas. The analysis also provides a discussion on the potential for methane migration and its impacts on groundwater quality.
In addition, wellbore pressure monitoring requirements before, during, and after the well stimulation treatment are discussed in EIR Section 10.14.5. Specific requirements for testing and monitoring well performance and other activities related to well stimulation treatments from the proposed permanent SB 4 regulations are also listed.

Notwithstanding the concerns with well seals, cement seals represent the best line of defense for fluids and gas migration. Cementing practices have improved over time and many of the well seal problems identified have been in older wells. Mechanical integrity testing can provide information on well seals by demonstrating the well’s ability to prevent fluid migration internally (within the wellbore) and externally (in the annular space between the casing and formation). Strict well construction requirements, casing cementing, and cement bond logs involving the casing prior to hydraulic fracturing, form the foundation of the SB 4 regulations. Geophysical techniques including cement bond logs, temperature surveys, and other surveys are used to evaluate the quality of the cement seal. Accordingly, most of the mitigation measures for groundwater quality focus on well integrity and well construction.

For the groundwater quality analysis, all of the impacts assessed in the programmatic level analysis of groundwater quality impacts along with the conclusions and mitigation measures apply to the Inglewood Oil and Gas Field. These impacts are designated Impact GW-3, Impact GW-4, Impact GW-5, Impact GW-6, and Impact GW-7. These impacts, along with mitigation measures identified as applicable for Wilmington Oil and Gas Field, are discussed below. By incorporating the analysis from EIR Section 10.14 and the mitigation measures below, groundwater quality impacts at the Inglewood Oil and Gas Field as a result of well stimulation are less than significant (Class II).

### Impact GW-1  Cause or contribute to overdraft conditions

For groundwater quantity, significant impacts could occur if an increase in groundwater use for well stimulation occurs in a critically impacted groundwater basin, including those where overdraft conditions have been documented. Even though some estimates of groundwater use for well stimulation are small, any increase in groundwater use in a critically impacted groundwater basin is assumed to be significant without mitigation.

For the Inglewood Oil and Gas Field, two of the applicable groundwater basins are adjudicated; pumping is controlled by the court and managed by local agencies, including DWR as the court-appointed Watermaster. Those impacts for groundwater use in those basins are assumed to be mitigated. However, this mitigation measure covers may be required for potential groundwater use if future pumping occurs from the Santa Monica Basin (or other unadjudicated groundwater basin), which overlaps with a portion of the field.

Mitigation Measure GW-1a requires an operator to evaluate and use alternative water sources to the extent feasible. MM GW-1b provides for an assessment to determine whether overdraft conditions would be exacerbated by groundwater use for well stimulation if undesirable effects may result from groundwater pumping, including overdraft. In this way, Mitigation Measures GW-1a and GW-1b lessen the potential impacts to groundwater quantity with respect to the criterion for not causing or contributing to overdraft conditions. A description of the mitigation measure is found in EIR Section 10.14.5.

**MM GW-1a  Use Alternative Water Sources to the Extent Feasible.** (Full text in EIR Section 10.14.5.)

**MM GW-1b  Prepare a Third-Party Technical Report to Analyze Overdraft Minimize Groundwater Impacts.** (Full text in EIR Section 10.14.5.)
Impact GW-2  Lower groundwater levels through pumping, resulting in significant and unreasonable inelastic land subsidence or significant and unreasonable impacts to nearby water wells or interconnected surface water

Currently, the Inglewood Oil and Gas Field purchases its water supply from imported water sources and an two adjudicated basins; as such, this impact would not apply. However, if the operators decide to pump or purchase groundwater from the Santa Monica Basin (or other unadjudicated basin), this impact could result in lowering ground levels in the Santa Monica Basin and would be considered potentially significant without mitigation. Mitigation Measure GW-2a–1b would require an independent review by a Certified Hydrogeologist technical analysis to evaluate and mitigate specific impacts from groundwater pumping. The technical report would be enclosed in the applicant’s Water Management Plan, required by the proposed permanent SB 4 regulations as part of an application for a well stimulation treatment permit. The Water Management Plan must define the volume, source, and disposal (including recycling) of the water to be used. Mitigation Measure GW-2a–1b is described in EIR Section 10.14.5.

Implementation of Mitigation Measure GW-2a–1b would apply if groundwater were supplied in the future from an unadjudicated groundwater basin and, if that occurred, would reduce Impact GW-2 to a less than significant level (Class II) for the Inglewood Oil and Gas Field.

MM GW-1b  Minimize Groundwater Impacts. (Full text in EIR Section 10.14.5.)

MM GW-2a  Prepare a Third-Party Technical Report to Analyze Local Impacts of Pumping. (Full text in EIR Section 10.14.5.)

Impact GW-3  Adversely impact groundwater quality from surface spills or leaks during well stimulation

The significance of impacts for the surface pathway focuses on potential spills and leaks of hazardous materials onto the ground, especially where sites overlie protected groundwater. Although numerous current and proposed regulations provide substantial protective measures to prevent a surface release, an additional protective measure would require applicants to provide a physical barrier (cover) on the land surface beneath vessels, pipes, and other equipment containing hazardous materials at the site pad for all well stimulation production facilities. This could be paving or installation of other material suitable for preventing any spilled or released material from reaching the soil.

This impact, described in EIR Section 11.14.5.1, is applicable to conditions at Inglewood Oil and Gas Field. Implementation of Mitigation Measure HAZ-1a would reduce Impact GW-3 to a less than significant level (Class II) for the Inglewood Oil and Gas Field.

MM HAZ-1a  Ensure that Spill Contingency Plan Provides Adequate Protection Against Leaks or Discharges of Dangerous Fluids and Other Potentially Dangerous MaterialsProvide a Physical Barrier on the Ground Surface at the Site Pad for All Production Facilities, Regardless of the Amount of Time They Are in Place, Prior to Moving in Hazardous Materials and Manage Surface Water Runoff and Drainage on the Barrier Using Best Management Practices. (Full text in EIR Section 10.13.5.)

Impact GW-4  Migration of well stimulation fluids or formation fluids including gas to protected groundwater through non-existent or ineffective annular well seals

The most likely subsurface pathway associated with a well involves any unsealed portion of the annular space between the outer casing and the borehole, assuming that fluids can reach this space but other potential pathways are also present. A pathway does not necessarily mean that well stimulation fluids
would migrate into protected groundwater but if they did, this would result in an impact to protected groundwater. Given the uncertainty associated with subsurface migration and importance of annular well seals for the protection of groundwater resources, three important mitigation measures are proposed for the Inglewood Oil and Gas Field to bolster the protective measures in the proposed SB 4 regulations to identify and manage potential impacts from wells. These mitigation measures address directly the first line of defense—the potential for fluid (including gas) migration (i.e., through ineffective cement annular seals in the well used for well stimulation and other wells in the ADSA).

-The migration of methane gas in the L.A. Basin is well-documented, as is the risk of gas migration along wellbores (Chilingar and Endres, 2003). Monitoring and testing required in the proposed SB 4 regulations will demonstrate the performance of the well seals and gas detectors required in these mitigation measures. Thousands of wells have been drilled in the Inglewood Oil and Gas Field, and more than 610 wells are currently active. Fulfillment of Mitigation Measure GW-4a provides a records examination and prevents monitoring for other wells within the ADSA from serving that could serve as a conduit for migration of fluids (including gas) into protected groundwater. As mentioned previously, seals in wells being used for the well stimulation treatment are associated with more stringent requirements and are covered by the Groundwater Protection Standard (EIR Section 7.5.4). Mitigation Measure GW-4b for wells that are not within a DWR groundwater basin and by Mitigation Measure GW-4b for those wells within the boundaries of a DWR groundwater basin (see below).

Although much of the Inglewood Field is located in the Baldwin Hills, the field remains within the boundaries of DWR groundwater basins, and, therefore, the mitigation measures apply. It is recognized that the aquifer system beneath the Baldwin Hills is thin and contains relatively low-permeability units at depth. Nonetheless, recharge to the Baldwin Hills aquifers can provide subsurface inflow into the groundwater basins, even if amounts are relatively small. The fact that the hills are surrounded by more permeable aquifers and hydraulically connected (at some level), the migration measures are appropriate for application to the entire area of the field and would reduce the impact to less than significant (Class II).

| MM GW-4a | Demonstrate that Wells within the ADSA Have Effective Cement Well Seals and Monitor Wells during Well Stimulation. (Full text in EIR Section 10.14.5.) |
| MM GW-4b | Install a Well Seal Across Protected Groundwater for New Wells Subject to Well Stimulation Treatments. Full Length Seal Between the Casing String and the Wellbore for Wells within the Boundaries of a DWR Groundwater Basin. (Full text in EIR Section 10.14.5.) |
| MM GW-4c | Install Methane Sensors on Wells Subject to Well Stimulation Treatments. (Full text in EIR Section 10.14.5.) |
| **Impact GW-5** | Migration of well stimulation fluids or formation fluids including gas into protected groundwater through damaged or improperly abandoned wells |

Poorly abandoned wells have been identified as an issue in the Inglewood Oil and Gas Field (Cardno ENTRIX, 2012). From the 1920s through the 1940s, wells were not properly abandoned; they were filled with construction debris, such as telephone holes or railroad ties, and then covered with soil at the surface (MRS, 2008). Also, the locations of these wells are unknown since the abandonments were not properly documented.

Poorly abandoned wells within the ADSA of a well stimulation treatment could provide a conduit for upward migration of well stimulation fluids (including gas) to potentially reach protected groundwater.
The proposed permanent SB 4 regulations require an operator to identify any existing wells/wellbores within twice the area of the ADSA and design the test such that geologic and hydrologic isolation of the formation can be demonstrated. However, there may be wells that are undocumented, and whose condition and/or location is unknown. Mitigation Measure GW-5a would allow DOGGR to require a field program be conducted to locate older and abandoned wells within the ADSA to ensure that poorly abandoned wells do not provide a conduit for migration of well stimulation fluids reducing the impact to less than significant.

**MM GW-5a**  
**Conduct Surface Geophysical Surveys or Apply Other Field Methods to Locate Improperly Abandoned Wells and Mitigate.** (Full text in EIR Section 10.14.5.)

| Impact GW-6 | Improper disposal of flowback in injection wells could potentially impact groundwater quality |

The Inglewood Oil and Gas Field operates about 271 Class II injection wells for water flooding and one additional Class II well for water disposal (numbers from 2013 active wells, Habel, personal communication, 2014). Any non-existent or ineffective well seals in these wells would place protected groundwater at risk (especially in older wells).

As previously discussed, Class II injection wells are required under the UIC program regulations to contain an isolating cement seal above the injection zone as well as a minimum 100-foot seal across the base of the fresh water zone. Current program requirements do not include an annular seal across the entire zone of USDW. The Groundwater Protection Standard applies to a well used for stimulation (EIR Section 7.5.4) and requires an annular cement seal across the entire zone of protected groundwater defined by a TDS concentration less than 10,000 mg/L, a definition slightly broader but generally consistent with the definition of USDWs in the UIC program. Mitigation Measure GW-6a would make the well seal requirements for a Class II well where well stimulation fluids shall be disposed consistent with the cement seal requirements of the well used for stimulation and DOGGR is currently working on UIC regulations. At DOGGR’s recommendation, a mitigation measure is added to ensure proper disposal in exempt aquifers only for protection of protected groundwater. Assuming proper disposal would reduce the impact to less than significant (Class II).

**MM GW-6a**  
**Require Wastewater Disposal Wells to Inject Only into Exempted Aquifers to Protect Groundwater Install a Cement Seal across Protected Groundwater.** (Full text in EIR Section 10.14.5.)

| Impact GW-7 | Inability to identify specific impacts to groundwater quality from well stimulation activity |

It will be difficult for any groundwater monitoring program to differentiate impacts from well stimulation treatments from those resulting from other activities. Groundwater monitoring results for two hydraulic fracturing treatments at Inglewood Oil and Gas Field focused on constituents that may already have been present in groundwater. Although investigators concluded that the results did not indicate impacts from hydraulic fracturing, the methodology did not allow for clear differentiation between potential effects from well stimulation and other potential causes of impacts. Accordingly, a mitigation measure to include a tracer in the well stimulation fluids has been identified. It would allow differentiation of the impact and function as a forensic signature for the fluids used. Alternatively, intrinsic tracers such as stable isotopic signatures could be used as suggested by others (Sharma et al., 2014).

The ability to identify the source of any impacts quickly would facilitate containment and remediation of the problem. Potential impacts would be handled on a site-by-site basis, but would allow for remedial
actions under the jurisdiction of the Regional Water Board. In combination with other mitigation measures, project standards, and proposed regulations, implementation of Mitigation Measure GW-7a would reduce Impact GW-7 to a less than significant level (Class II).

**MM GW-7a**  Add a Tracer to Well Stimulation Fluids or Develop a Reasonable Method to Distinguish These Fluids in the Environment. (Full text in EIR Section 10.14.5.)

### 11.14.5.3 Study Region 3: Sespe Oil and Gas Field

#### Groundwater Quantity

The average water supply (approximately 6.5 AFY) currently and previously used in the Sespe Oil and Gas Field is provided by produced water. Water use in the field is projected to range from 5 to 8 AFY over the next 20 years, most of which will be used for hydraulic fracturing (Hesson, 2014). Produced water is expected to remain as the sole source of future water supplies for well stimulation (Hesson, 2014). Although the operator has four groundwater supply wells, the wells are reported as idle and will be available for make-up water only, as needed. However, there is no prohibition for these wells to be pumped for well stimulation water supply in the future.

As previously noted in Table 11.1-5, only a few wells are expected to be drilled per year in the Sespe Oil and Gas Field. All of these new wells will be hydraulically fractured. At this time, none of the wells are expected to be unconventional wells to stimulate the Monterey Formation. Estimated water use is based on conventional well stimulation water use as shown on Table 7.3-4 and repeated on Table 11.14-5. Based on these estimates, water use is projected to range between 0.04 AFY and 7.5 AFY for four new wells. If future wells are drilled to stimulate the Monterey Formation, about 20 AFY/well could be assumed.

Because groundwater is not currently used for well stimulation treatments by the major operator in the field, there has been no impact to groundwater quantity from current well stimulation treatments. However, the operator has groundwater wells, and there is no prohibition against using groundwater. Thus, at least in part, for future well stimulation activities, groundwater may be used.

As discussed in EIR Section 11.14.3.3, groundwater resources are not likely to be in direct hydraulic connection with the adjacent groundwater basin and pumping would not affect in-basin wells. Further, proposed SB 4 regulations require any local well owners to be notified and private wells to be tested, if requested. If groundwater is pumped from the watershed, there may be a very small decrease in recharge along potentially connected areas such as Sespe Creek. However, this estimated recharge amount is very small and any decrease could be accommodated in the downgradient managed groundwater subbasin without a significant impact.

Therefore, the impacts to groundwater quantity (Impact GW-1 and Impact GW-2) from well stimulation treatments at Sespe Oil and Gas Field are determined to be less than significant (Class III).

#### Groundwater Quality

Figure 11.14-2 shows current active, idle and permitted new oil and gas wells in the Sespe Oil and Gas Field. As of 2014, there are over 300 active oil and gas wells within the field. In addition to production wells, Seneca operates 12 injection wells used for hydraulic fracturing or the disposal of produced water or other substances resulting from extraction operations, water flood, stream flood, and cyclic steam. The average depth of these 12 injection wells is 3,979 feet. Hydraulic fracturing has occurred in ten wells
in the field over the past three years. Additionally, Seneca has proposed 8,000 feet of new pipeline, with 285 feet of this pipeline in undisturbed areas.

The Sespe Oil and Gas Field does not overlie a groundwater basin or subbasin. Further, as explained in EIR Section 11.14.3.3, it seems likely that any local protected groundwater in fractured bedrock is limited in extent and quality and is not likely in direct hydraulic connection with the Fillmore Subbasin due to the folding associated with the Monterey Formation. However, in order to ensure that all protected groundwater is considered, groundwater quality impacts are applicable as defined in the significance criteria (EIR Section 10.14.4). Further, given the remote location of the field, responses to a release and ability to implement remedial measures would likely be delayed. In Section 11.13, a mitigation measure was added to increase the response time in the operator's Spill Contingency Plan. Nonetheless, Therefore, on a programmatic basis, it is concluded that groundwater quality impacts at the Sespe Oil and Gas Field could be potentially significant without additional mitigation.

As discussed in more detail in EIR Sections 10.13.5 and 10.14.4 and 10.14.5, potential pathways may exist for well stimulation treatments to impact groundwater quality. These pathways are the same as those listed in EIR Section 11.14.5.1.

See EIR Section 10.14.5 for additional information on groundwater quality impacts. In particular, an analysis of subsurface pathways along wells is provided. The analysis includes information on well construction, well seals, and the potential for upward migration of fluids including gas. The analysis also provides a discussion on the potential for methane migration and its impacts on groundwater quality.

Wellbore pressure monitoring requirements before, during, and after the well stimulation treatment are discussed. Specific requirements for testing and monitoring well performance and other activities related to well stimulation treatments from the proposed permanent SB 4 regulations are also listed.

Notwithstanding the concerns with well seals, cement seals represent the best line of defense for fluids and gas migration. Cementing practices have improved over time and many of the well seal problems identified have been in older wells. Mechanical integrity testing can provide information on well seals by demonstrating the well's ability to prevent fluid migration internally (within the wellbore) and externally (in the annular space between the casing and formation). Strict well construction requirements, casing and cementing, together with cement bond logs and pressure testing of the casing prior to hydraulic fracturing, form the foundation of the SB 4 regulations, hold pressure. Geophysical techniques including cement bond logs, temperature surveys, and other surveys are used to evaluate the quality of the cement seal. Accordingly, however, due to the uncertainty of a subsurface release, most of the mitigation measures for groundwater quality focus on monitoring well integrity and improving well seals.

For the groundwater quality analysis, all of the impacts assessed in the programmatic level analysis of groundwater quality impacts along with the conclusions and mitigation measures apply to Sespe Oil and Gas Field. These impacts are designated Impact GW-3, Impact GW-4, Impact GW-5, Impact GW-6, and Impact GW-7. These impacts, along with mitigation measures identified as applicable for the field are discussed below. By incorporating the analysis from EIR Section 10.14 and the mitigation measures below, groundwater quality impacts at the Sespe Oil and Gas Field resulting from well stimulation are less than significant (Class II).

| Impact GW-3 | Adversely impact groundwater quality from surface spills or leaks during well stimulation |

The significance of impacts for the surface pathway focuses on potential spills and leaks of hazardous materials onto the ground, especially where sites overlie protected groundwater. Although numerous
current and proposed SB 4 regulations provide substantial protective measures to prevent a surface release as described in a required Spill Contingency Plan. In some cases, an additional protective measure would may be required by DOGGR that requires applicants to provide a physical barrier (cover) on the land surface beneath vessels, pipes, and other equipment containing hazardous materials at the site pad for all well stimulation production facilities. This could be paving or installation of other material suitable for preventing any spilled or released material from reaching the soil. The requirement of such a barrier would consider the adequacy of the Spill Contingency Plan and would be required only if determined necessary by DOGGR.

This impact is particularly important at the Sespe Oil and Gas Field. The site is in an undeveloped, remote area with significant environmental resources. Site pads can be in rugged terrain, creating cramped conditions for well stimulation equipment and vehicles. Although addressed directly by a Spill Contingency Plan, a surface spill or leak could be more difficult to contain without additional protective measures in Mitigation Measure HAZ-1a provides DOGGR with the flexibility needed to ensure that protected groundwater is not impacted. DOGGR also has discretion within the mitigation measure to allow alternative barriers and/or secondary containment options based on site-specific conditions.

The mitigation measure supplements is based on the operator’s Spill Contingency Plan. Although secondary containment is required for equipment and containers involving hazardous materials, the proposed permanent SB 4 regulations remove that requirement for production facilities that are in one location for less than 30 days (Section 1786(a)(1)). Most well stimulation activities only occur over a few days. If necessary, the barrier This mitigation would provide a secondary line of defense to prevent an accidental release from reaching protected groundwater. Although spills and leaks are essentially impossible to fully prevent, this mitigation measure will allow for the release to be immediately detected and contained, following steps and procedures in the Spill Contingency Plan (Section 1786). Details of this mitigation measure are also provided in EIR Section 10.13.5.

Implementation of Mitigation Measure HAZ-1a would reduce Impact GW-3 to a less than significant level (Class II) for the Sespe Oil and Gas Field.

MM HAZ-1a Ensure that Spill Contingency Plan Provides Adequate Protection Against Leaks or Discharges of Dangerous Fluids and Other Potentially Dangerous Materials Provide a Physical Barrier on the Ground Surface at the Site Pad for All Production Facilities, Regardless of the Amount of Time They Are in Place, Prior to Moving in Hazardous Materials and Manage Surface Water Runoff and Drainage on the Barrier Using Best Management Practices. (Full text in EIR Section 10.13.5.)

| Impact GW-4 Migration of well stimulation fluids or formation fluids including gas to protected groundwater through non-existent or ineffective annular well seals |

The most likely subsurface pathway associated with a well involves any unsealed portion of the annular space between the outer casing and the borehole, assuming that fluids can reach this space but other potential pathways are also present. Hundreds of wells have been drilled in the Sespe Oil and Gas Field. Any such well within the ADSA provides a potential conduit for migration of fluids (including gas) into protected groundwater. A pathway does not necessarily mean that well stimulation fluids would migrate into protected groundwater; but if they did, this would result in an impact to protected groundwater. Given the uncertainty associated with subsurface migration and importance of annular well seals for the protection of groundwater resources, three important mitigation measures are proposed to bolster the protective measures in the proposed SB 4 regulations to identify and manage potential impacts from wells. Mitigation Measures GW-4a requires evaluations of well seals for wells within the ADSA and
requires monitoring of DOGGR-specified potential conduit wells during the well stimulation treatment. MM GW-4b requires the well seal to cover the base of protected groundwater in all new wells that are used for well stimulation, and MM GW-4c provides monitoring for potential gas migration in the well being stimulated. Collectively, these mitigation measures and SB 4 regulations address directly the first line of defense for fluid (including gas) migration. All of these mitigation measures are applicable for protected groundwater at the Sespe Oil and Gas Field. Monitoring and testing required with the proposed SB 4 regulations will demonstrate the performance of these well seals and gas detectors reducing the impact to less than significant (Class II).

**MM GW-4a** Demonstrate that Wells within the ADSA Have Effective Cement Well Seals and Monitor Wells during Well Stimulation. (Full text in EIR Section 10.14.5.)

**MM GW-4b** Well Seal Across Protected Groundwater for New Wells Subject to Well Stimulation Treatments

**MM GW-4c** Install Methane Sensors on Wells in the ADSA Subject to Well Stimulation. (Full text in EIR Section 10.14.5.)

| Impact GW-5 | Migration of well stimulation fluids or formation fluids including gas into protected groundwater through damaged or improperly abandoned wells |

Oil was discovered in the Sespe Oil and Gas Field in the late 1880s. As such, numerous older wells were likely poorly abandoned and represent potential conduits for liquid or gas migration to protected groundwater. The shallow nature of the oil and gas field increases the potential for impacts. The proposed permanent SB 4 regulations require an operator to identify any existing wells/wellbores within twice the area of the ADSA and design the test such that geologic and hydrologic isolation of the formation can be demonstrated. However, there may be wells that are undocumented, and whose condition and/or location is unknown. For this impact, a mitigation measure, MM GW-5a, has been developed requiring a detailed record review for potential conduits where fluids (including gas) may migrate into protected groundwater. At DOGGR’s discretion, a field program may also be required to locate older and abandoned wells within the ADSA to ensure that poorly abandoned wells do not provide a conduit for migration of well stimulation fluids as required by Mitigation Measure GW-5a, reducing the impact to less than significant (Class II).

**MM GW-5a** Conduct Surface Geophysical Surveys or Apply Other Field Methods to Locate Improperly Abandoned Wells and Mitigate. (Full text in EIR Section 10.14.5.)

| Impact GW-6 | Improper disposal of flowback in injection wells could potentially impact groundwater quality |

In 2013, Sespe Oil and Gas Field operated five Class II injection wells for waterflooding and 19 Class II wells for water disposal. Potential non-existent or ineffective well seals place protected groundwater at risk, especially in older wells.

As previously discussed, DOGGR is currently re-evaluating regulations for UIC compliance. Class II injection wells are required under the UIC program regulations to contain an isolating cement seal above the injection zone as well as a minimum 100 foot seal across the base of the fresh water zone. Current program requirements do not include an annular seal across the entire zone of USDW. The Groundwater Protection Standard applies to a well used for well stimulation (EIR Section 7.5.4) and requires an annular cement seal across the entire zone of protected groundwater defined by a TDS concentration less than 10,000 mg/L, a definition slightly broader but generally consistent with the definition of
USDWs in the UIC program. This mitigation measure would make the well seal requirements for a Class II well consistent with the cement seal requirements of the well used for stimulation reducing the impact to less than significant (Class II). A mitigation measure has been added by DOGGR to ensure proper disposal of flowback to reduce the risk of injected fluids from reaching protected groundwater. If implemented, this measure will reduce potential impacts to groundwater to a less than significant level.

**MM GW-6a**  
Require Wastewater Disposal Wells to Inject Only into Exempted Aquifers to Protect Install a Cement Seal across Protected Groundwater.  
(Full text in EIR Section 10.14.5.)

**Impact GW-7**  
Inability to identify specific impacts to groundwater quality from well stimulation activity

It will be difficult for any groundwater monitoring program to differentiate impacts from well stimulation treatments from those resulting from other activities. This would also be difficult at the Sespe Oil and Gas Field, where shallow groundwater may be brackish or slightly saline. Accordingly, a mitigation measure to include a tracer in the well stimulation fluids has been identified. It would allow differentiation of material and function as a forensic signature for the fluids used. Alternatively, intrinsic tracers such as stable isotopic signatures could be used as suggested by others (Sharma et al., 2014).

The ability to identify the source of any impacts quickly would facilitate containment and remediation of the problem. Potential impacts would be handled on a site-by-site basis, but would allow for remedial actions under the jurisdiction of the Regional Water Board. In combination with other mitigation measures, project standards, and proposed regulations, implementation of Mitigation Measure GW-7a would reduce Impact GW-7 to a less than significant level (Class II).

**MM GW-7a**  
Add a Tracer to Well Stimulation Fluids or Develop a Reasonable Method to Distinguish These Fluids in the Environment.  
(Full text in EIR Section 10.14.5.)

### 11.14.6 Impact Significance Summary

As described in the sections above, potential impacts to the quantity and quality of groundwater have been analyzed on a programmatic basis for the Wilmington Oil and Gas Field, Inglewood Oil and Gas Field and Sespe Oil and Gas Field. Potential impacts to groundwater as developed in EIR Section 10.14.5 were applied to each field. Where impacts were potentially significant, the proposed mitigation measures were considered for the ability to mitigate the impacts for each field. No additional field-specific mitigation measures were identified beyond those described in EIR Section 10.14.5.

Mitigation measures identified for each field are summarized in Table 11.14-6, below.

<table>
<thead>
<tr>
<th>Table 11.14-6. Summary of Impacts and Mitigation Measures – Groundwater Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Impact GW-1. Cause or contribute to overdraft conditions</strong></td>
</tr>
<tr>
<td><strong>Wilmington Oil and Gas Field</strong></td>
</tr>
<tr>
<td><strong>Impact Significance</strong></td>
</tr>
</tbody>
</table>
| **Mitigation Measure(s)** | GW-1a: Use Alternative Water Sources to the Extent Feasible  
GW-1b: Prepare a Third-Party Technical Report to Analyze Overdraft Minimize Groundwater Impacts |

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Table 11.14-6. Summary of Impacts and Mitigation Measures – Groundwater Resources

<table>
<thead>
<tr>
<th>Field</th>
<th>Impact Significance</th>
<th>Mitigation Measure(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inglewood Oil and Gas Field</strong></td>
<td>Class II</td>
<td>GW-1a: Use Alternative Water Sources to the Extent Feasible</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GW-1b: Prepare a Third Party Technical Report to Analyze Overdraft Minimize Groundwater Impacts</td>
</tr>
<tr>
<td><strong>Sespe Oil and Gas Field</strong></td>
<td>Class III</td>
<td>None required</td>
</tr>
<tr>
<td><strong>Wilmington Oil and Gas Field</strong></td>
<td>Class II</td>
<td>GW-2a: Prepare a Third Party Technical Report to Analyze Local Minimize Groundwater Impacts of Pumping</td>
</tr>
<tr>
<td><strong>Inglewood Oil and Gas Field</strong></td>
<td>Class II</td>
<td>GW-21a: Prepare a Third Party Technical Report to Analyze Local Minimize Groundwater Impacts of Pumping</td>
</tr>
<tr>
<td><strong>Sespe Oil and Gas Field</strong></td>
<td>Class II</td>
<td>None required</td>
</tr>
<tr>
<td><strong>Wilmington Oil and Gas Field</strong></td>
<td>Class II</td>
<td>HAZ-1a: Ensure that Spill Contingency Plan Provides Adequate Protection Against Leaks or Discharges of Dangerous Fluids and Other Potentially Dangerous Materials Provide a Physical Barrier on the Ground Surface at the Site Pad for All Production Facilities Regardless of the Amount of Time They Are in Place, Prior to Moving in Hazardous Materials and Manage Surface Water Runoff and Drainage on the Barrier Using Best Management Practices</td>
</tr>
<tr>
<td><strong>Inglewood Oil and Gas Field</strong></td>
<td>Class II</td>
<td>HAZ-1a: Ensure that Spill Contingency Plan Provides Adequate Protection Against Leaks or Discharges of Dangerous Fluids and Other Potentially Dangerous Materials Provide a Physical Barrier on the Ground Surface at the Site Pad for All Production Facilities Regardless of the Amount of Time They Are in Place, Prior to Moving in Hazardous Materials and Manage Surface Water Runoff and Drainage on the Barrier Using Best Management Practices</td>
</tr>
<tr>
<td><strong>Sespe Oil and Gas Field</strong></td>
<td>Class II</td>
<td>HAZ-1a: Ensure that Spill Contingency Plan Provides Adequate Protection Against Leaks or Discharges of Dangerous Fluids and Other Potentially Dangerous Materials Provide a Physical Barrier on the Ground Surface at the Site Pad for All Production Facilities Regardless of the Amount of Time They Are in Place, Prior to Moving in Hazardous Materials and Manage Surface Water Runoff and Drainage on the Barrier Using Best Management Practices</td>
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</table>
### Table 11.14-6. Summary of Impacts and Mitigation Measures – Groundwater Resources

<table>
<thead>
<tr>
<th>Impact GW-4. Migration of well stimulation fluids or formation fluids including gas to protected groundwater through non-existent or ineffective annular well seals</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wilmington Oil and Gas Field</strong></td>
</tr>
<tr>
<td>Impact Significance</td>
</tr>
</tbody>
</table>
| Mitigation Measure(s)                            | GW-4a: Demonstrate that Wells within the ADSA Have Effective Cement Well Seals and Monitor Wells during Well Stimulation Treatment  
GW-4b: Install a Well Seal Across Protected Groundwater for New Wells Subject to Well Stimulation Treatments  
GW-4c: Install Methane Sensors on Wells in the ADSA Subject to Well Stimulation Treatments |

| **Inglewood Oil and Gas Field**                   |
| Impact Significance                              | Class II                                      |
| Mitigation Measure(s)                            | GW-4a: Demonstrate that Wells within the ADSA Have Effective Cement Well Seals and Monitor Wells during Well Stimulation Treatment  
GW-4b: Install a Well Seal Across Protected Groundwater for New Wells Subject to Well Stimulation Treatments  
GW-4c: Install Methane Sensors on Wells in the ADSA Subject to Well Stimulation Treatments |

| **Sespe Oil and Gas Field**                       |
| Impact Significance                              | Class II                                      |
| Mitigation Measure(s)                            | GW-4a: Demonstrate that Wells within the ADSA Have Effective Cement Well Seals and Monitor Wells during Well Stimulation Treatment  
GW-4b: Install a Well Seal Across Protected Groundwater for New Wells Subject to Well Stimulation Treatments  
GW-4c: Install Methane Sensors on Wells in the ADSA Subject to Well Stimulation Treatments |

<table>
<thead>
<tr>
<th>Impact GW-5. Migration of well stimulation fluids or formation fluids including gas to protected groundwater through damaged or improperly abandoned wells</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wilmington Oil and Gas Field</strong></td>
</tr>
<tr>
<td>Impact Significance</td>
</tr>
<tr>
<td>Mitigation Measure(s)</td>
</tr>
</tbody>
</table>

| **Inglewood Oil and Gas Field**                   |
| Impact Significance                              | Class II                                      |
| Mitigation Measure(s)                            | GW-5a: Conduct Surface Geophysical Surveys or Apply Other Field Methods to Locate Improperly Abandoned Wells and Mitigate |

| **Sespe Oil and Gas Field**                       |
| Impact Significance                              | Class II                                      |
| Mitigation Measure(s)                            | GW-5a: Conduct Surface Geophysical Surveys or Apply Other Field Methods to Locate Improperly Abandoned Wells and Mitigate |

<table>
<thead>
<tr>
<th>Impact GW-6. Improper disposal of flowback in injection wells could potentially impact groundwater quality</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wilmington Oil and Gas Field</strong></td>
</tr>
<tr>
<td>Impact Significance</td>
</tr>
</tbody>
</table>
| Mitigation Measure(s)                            | GW-6a: Require Wastewater Disposal Wells to Inject Only into Exempted Aquifers to Protect Groundwater  
GW-6b: Install a Cement Seal across Protected Groundwater |

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Table 11.14-6. Summary of Impacts and Mitigation Measures – Groundwater Resources

<table>
<thead>
<tr>
<th>Groundwater Resources</th>
<th>Impact Significance</th>
<th>Mitigation Measure(s)</th>
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<td><strong>Inglewood Oil and Gas Field</strong></td>
<td>Class II</td>
<td>GW-6a: Require Wastewater Disposal Wells to Inject Only into Exempted Aquifers to Protect Groundwater; Install a Cement Seal across Protected Groundwater</td>
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<tr>
<td><strong>Sespe Oil and Gas Field</strong></td>
<td>Class II</td>
<td>GW-6a: Require Wastewater Disposal Wells to Inject Only into Exempted Aquifers to Protect Groundwater; Install a Cement Seal across Protected Groundwater</td>
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<tr>
<td><strong>Wilmington Oil and Gas Field</strong></td>
<td>Class II</td>
<td>GW-7a: Add a Tracer to Well Stimulation Fluids or Develop a Reasonable Method to Distinguish Well Stimulation Fluids in the Environment</td>
</tr>
<tr>
<td><strong>Inglewood Oil and Gas Field</strong></td>
<td>Class II</td>
<td>GW-7a: Add a Tracer to Well Stimulation Fluids or Develop a Reasonable Method to Distinguish Well Stimulation Fluids in the Environment</td>
</tr>
<tr>
<td><strong>Sespe Oil and Gas Field</strong></td>
<td>Class II</td>
<td>GW-7a: Add a Tracer to Well Stimulation Fluids or Develop a Reasonable Method to Distinguish Well Stimulation Fluids in the Environment</td>
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