UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

Kenneth A. Harris Jr.
State Oil and Gas Supervisor
Division of Oil, Gas, and Geothermal Resources
California Department of Conservation
801 K Street, MS 18-05
Sacramento, CA 95814-3530

Re: Approval of Aquifer Exemption for the McKittrick Oil Field, Kern County, California

Dear Mr. Harris:

Based on a thorough review of the supporting documents submitted by the California Department of Conservation, Division of Oil, Gas, and Geothermal Resources and the State Water Resources Control Board, the U.S. Environmental Protection Agency (EPA) hereby approves the aquifer exemption request for portions of the Tulare Formation in the McKittrick Oil Field in Kern County, California.

The approved aquifer exemption boundaries and depths, along with EPA's analyses and rationale in support of the approval, are detailed in the enclosed Record of Decision. In accordance with applicable regulations at 40 C.F.R. Parts 144, 145, and 146, we find that this aquifer exemption request is a non-substantial program revision, and the requested formation meets the following federal exemption criteria:

- The portions of the formation proposed for exemption in the field do not currently serve as a source of drinking water; and
- The portions of the formation proposed for exemption in the field cannot now and will not in the future serve as a source of drinking water because they are commercially hydrocarbon-producing.

If you have any questions, please contact David Albright, Manager of our Drinking Water Protection Section, at (415) 972-3971.

Sincerely,

Tomás Torres September 28, 2018
Director, Water Division

Enclosure: Aquifer Exemption Record of Decision for McKittrick Oil Field

cc: Jonathan Bishop, Chief Deputy Director, State Water Resources Control Board

US Environmental Protection Agency Region 9

Underground Injection Control (UIC) Program

AQUIFER EXEMPTION RECORD OF DECISION

This Record of Decision (ROD) provides the EPA's decision to approve an aquifer exemption (AE) for portions of the Tulare Formation in the McKittrick Oil Field, background information concerning the AE request, and the basis for the AE decision.

Primacy Agency: California Division of Oil, Gas, & Geothermal Resources (DOGGR)

Date of Aquifer Exemption Request: July 16, 2018

Exemption Criteria: DOGGR requests this exemption because it has determined that it meets the criteria at 40 CFR § 146.4(a) and § 146.4(b)(1).

Substantial or Non-Substantial Program Revision: Non-Substantial

Although the EPA must approve all revisions to EPA-approved state UIC programs, the process differs depending on whether the EPA finds the revision to be a substantial or non-substantial program revision. The EPA determined that this is a non-substantial program revision because it is associated with an active oil field and is not a state-wide programmatic change or a program revision with unique or significant implications for the State's UIC program. The decision to treat this AE request as a non-substantial program revision is also consistent with the EPA's "Guidance for Review and Approval of State Underground Injection Control (UIC) Programs and Revisions to Approved State Programs" ("Guidance 34"), which explains that the determination of whether a program revision is substantial or non-substantial is made on a case-by-case basis.

Operators: Aera Energy, LLC; Chevron U.S.A., Inc.; E&B Natural Resources Management; Sentinel Peak, Griffin Oil Co.; Linn Operating, LLC; Longbow, LLC; and McKittrick Limited.

Well/Project Name: The Tulare Formation in the McKittrick Oil Field.

Well/Project Permit Number: There are 479 Class II enhanced oil recovery (EOR) wells and 1 water disposal well in the McKittrick Oil Field within the portion of the aquifer proposed for exemption.

Well/Project Location: The aquifer proposed for exemption underlies portions of Township 30 South, Range 22 East, Sections 7, 8, 9, 16, 17, 18, 19, 20, and 21 and Township 30 South, Range 21 East, Sections 12 and 13, Mount Diablo Base and Meridian (MDB&M). Refer to Figures 1 and 2.

County: Kern **State:** California

Well Class/Type: Class II EOR and produced water disposal.

DESCRIPTION OF PROPOSED AQUIFER EXEMPTION

Aquifer to be Exempted: Portions of the Tulare Formation within the McKittrick Oil Field

Areal Extent of Aquifer Exemption: The areal extent of the existing AE and the proposed expansion in the McKittrick Oil Field is approximately 5,239 acres. This acreage includes 2,971 acres of productive boundaries (approved at primacy in 1983), and approximately 2,268 acres comprising the current oil producing area outside the boundaries and areas planned for future commercial hydrocarbon production. The lateral extent of the proposed exempt area is defined by: the extent of the hydrocarbon-bearing Tulare Formation to the northeast and southwest; the Railroad Gap and Asphalto Oil Fields to the east; the Cymric Oil Field to the north; and erosion and the McKittrick Thrust Fault to the west. See Figure 2 for a depiction of the proposed exempt formation.

Lithology, Total Dissolved Solids (TDS), Depth, Thickness, Porosity, and Permeability of the Aquifer: The following table presents the lithology, range of TDS levels, depth, and thickness, and average porosity and permeability information about the aquifer proposed for exemption.

Aquifer	Tulare Formation.
Lithology	Interbedded, poorly consolidated conglomerate, sand, silt, and clay.
TDS (mg/L)	6,067 mg/L (average); ranges from 1,412 to 21,861 mg/L.
Depth to Top	0 to 985 feet (averaging 390 feet) BGS; -189 to +1,322 feet (averaging 634 feet) MSL.
Thickness (feet)	400 feet to approximately 1,200 feet (averaging approximately 750 feet).
Porosity and Permeability	Porosity ranges from 25 to 40%. Permeability averages 2,500 millidarcies (mD).

Confining Zone(s): In the McKittrick Oil Field, the Tulare Formation is confined above by clay and shale layers and below by a regionally extensive shale. Lateral confinement in the area proposed for exemption is provided by an inward pressure gradient (i.e., a "pressure sink" caused by the withdrawal of fluids) to the northeast and southwest, a fault and erosion to the west, and exempted portions of the Tulare Formation to the east and north. See Figures 3.1 through 3.5.

BACKGROUND

On July 16, 2018, the EPA received a request from DOGGR for approval to exempt portions of the Tulare Formation of the McKittrick Oil Field, in Kern County, California. DOGGR reviewed the operator's request and proposed this AE based on the criteria at 40 CFR §146.4(a): it does not currently serve as a source of drinking water; and at 40 CFR §146.4(b)(1): it cannot now and will not in the future serve as a source of drinking water because it is mineral, hydrocarbon, or geothermal energy-producing, or can be demonstrated by a permit applicant as part of a permit application for a Class II or III operation to contain minerals or hydrocarbons that considering their quantity and location are expected to be commercially producible. After EPA's approval of the AE, the exempt formation would not be protected as an "underground source of drinking water" (USDW) under the Safe Drinking Water Act (SDWA) and DOGGR would be authorized, subject to state regulatory requirements, to approve Class II injection into the identified formation.

The first oil well in the McKittrick Oil Field was drilled in 1896 into the Olig Sandstone of the Reef Ridge Formation. The first oil well producing from the Tulare Formation was drilled in 1948. In 1959, natural gas was discovered in the Amnicola zone of the Tulare Formation. Production activities throughout the field have included primary, cyclic steam, steam flood, and fireflood recovery methods. Cyclic steam (i.e., steaming) began in 1968, and is currently the primary method for enhancing oil recovery at the McKittrick Oil Field. There are over 600 active production wells in the oil field.

BASIS FOR DECISION

Regulatory Criteria under which the AE is Requested and Approved

40 CFR § 146.4(a) *It does not currently serve as a source of drinking water.*

In their concurrence on this AE request, the State Water Resources Control Board (State Water Board) determined that the portion of the Tulare Formation proposed for exemption does not currently serve as a source of drinking water, and it is not hydraulically connected to any domestic or public water supply wells. This is based on an evaluation of information about water supply wells in the area, groundwater flow patterns, and confinement of groundwater flow. These reviews demonstrate that the aquifer proposed for exemption does not currently serve as a source of drinking water because there are no existing drinking water supply wells, public or private, that currently or in the future would draw water from the Tulare Formation. In addition, no aquifers that serve as sources of drinking water are hydraulically connected to the formation. Further, within the State's water well search area (described more fully below), the Tulare Formation is not currently a source of drinking water.

Water Supply Wells: DOGGR's AE request included information about wells in the area proposed for exemption to establish that no drinking water wells draw from the aquifer proposed for exemption. The applicant searched well records in accordance with a request from the Central Valley Regional Water Quality Control Board to identify wells within a water supply well search area ("study area") that extended one mile beyond the administrative boundary of the McKittrick Oil Field and one mile beyond the proposed aquifer exemption boundary where the boundary is outside the administrative limits of the McKittrick field.

The water supply well search involved reviewing the following sources: the State Water Board's GeoTracker GAMA database, DOGGR's Well Finder database, Kern County Environmental Health Department data, well completion reports from the Department of Water Resources, the West Kern Water District (WKWD) 2011 Urban Water Management Plan, and well searches associated with AE proposals in nearby oil fields, including the Cymric, Kern River, Lost Hills, and Midway-Sunset Oil Fields. The AE proposal identified two water supply wells in the study area. One is a domestic well (for "unspecified use") that is over 2 miles away from the boundary of the proposed AE area. This well is 200 feet deep and draws water from the Alluvium, which is separated from the Tulare Formation by the Basal Alluvial Clay. The other water well within the study area is an industrial well that is screened in the Monterey Formation, which is below the Tulare and separated by San Joaquin-Etchegoin, and Reef Ridge Formations (See Table 1). For completeness, the State's submittal also identifies 52 non-water supply wells in the search area; these include monitoring wells, corrosion protection wells, or wells that were destroyed, could not be field verified, or were determined not to be wells. No municipal public water supply wells were identified within 1 mile of the field. The AE request includes a statement from the WKWD that the Tulare Formation does not currently serve as a source of drinking water and is not reasonably expected to be used in the future in the area proposed for exemption, due to a lack of demand.

The closest public water supply wells to the McKittrick Oil Field are operated by the Buttonwillow County Water District, and are located about 8.5 miles northwest of the study area.

Groundwater Flow Patterns: To estimate groundwater flow patterns, DOGGR evaluated available hydrogeologic information on the Tulare Formation, including information about injection and production activities in the region, fluid levels in wells within the field, and log data. Fluid flow in the Tulare Formation is to the southwest, toward the producing wells in the center of the field (i.e., from high to low pressure), and away from the boundaries of the area proposed for exemption.

Confinement of the Formation to Groundwater Flow: Primary vertical upper confinement of the Tulare Formation is provided by the Basal Alluvial Clay and capping shale (where present). The Basal Alluvial Clay ranges from 10 feet to 240 feet thick as shown in isochore contour maps in the request. It has a permeability ranging from 0.1 to 1.2 mD; these values are based on analyses of samples of cores taken from wells in the area. The oil-bearing sands of the Tulare Formation are present as discontinuous "baffles" that are separated by shale intervals that act as confining layers within and above the sands to prevent migration of injected fluids. The discontinuous nature of the sands is evidenced by temperature logs that show that the heat from the injected steam is contained within the injection intervals. Additional upper confinement is provided by a negative pressure sink due to production of fluids from the formation (see below) and the McKittrick Thrust overlying the Tulare Formation. The absence of fluids or seeps at the surface provides additional evidence that the McKittrick Thrust is not a conduit for upward flow.

Below the Tulare Formation, a regionally extensive shale layer acts as a lower confining layer. The permeability of this shale ranges from 1.7 to less than 5 mD based on logs from wells in the proposed AE area. The continuity of the shale unit is demonstrated in cross sections provided in the AE package.

Lateral confinement in the area proposed for exemption is provided by an inward pressure gradient (i.e., a "pressure sink" caused by the withdrawal of fluids) to the northeast and southwest, a fault to the west, and exempted portions of the Tulare Formation to the east and north. See Figures 3.1 through 3.5.

- *To the northeast and southwest:* confinement is provided by an inward pressure gradient created by the withdrawal of fluids from the Tulare Formation. Fluid balance data provided in the AE request indicate that significantly more fluid has been withdrawn from the Tulare Formation than has been injected. Between 1999 and 2017, operators injected 78,390,602 barrels (bbls) of fluid and produced 9,586,199 bbls of oil and 123,534,109 bbls of water from the Tulare Formation in the McKittrick Oil Field; this equates to a net withdrawal of 54,729,706 bbls of fluid during that time period. This withdrawal results in the movement of fluids within the proposed AE area, toward the producing wells. Additional confinement is provided by geologic features that have deformed and folded the Tulare Formation; these features are depicted in cross sections provided in the AE request and are included as Figures 3.1 through 3.3.
- *To the east:* the Tulare Formation in the McKittrick Oil Field is contiguous with the Railroad Gap and Asphalto Oil Fields, where the Tulare Formation in these fields is already exempted.
- *To the north,* the Tulare Formation extends into the adjacent Cymric Oil Field. The Tulare Formation is exempted in the Cymric Oil Field.
- *To the west:* the oil-bearing Tulare Formation is confined by erosion and the McKittrick Thrust Fault, which juxtaposes it with the Antelope Shale, and acts as a seal. The Antelope Shale is a low permeability shale (~1- 100 mD) as evidenced by core holes drilled through the shale. Further evidence of this confinement is based on reviews of video logs, analyses of cores, and the lack of seeps of fluids at the surface.

After reviewing information regarding the location and depth of existing water supply wells, groundwater flow within the Tulare Formation, and the confinement of the formation as described in the AE request, the EPA concludes that the Tulare Formation is not currently a source of drinking water and is not hydraulically connected to any domestic or public drinking water supply wells. Therefore, the EPA has determined that the aquifer proposed for exemption meets the criteria at 40 CFR § 146.4(a).

40 CFR § 146.4(b)(1) *It cannot now and will not in the future serve as a source of drinking water because it is mineral, hydrocarbon, or geothermal energy producing, or can be demonstrated by a permit applicant as part of a permit application for a Class II or III operation to contain minerals or hydrocarbons that considering their quantity and location are expected to be commercially producible.*

DOGGR provided information on hydrocarbon production in the area proposed for exemption along with supporting documentation such as historic production data; the locations of current producing wells; and well logs, and sidewall core sample data to demonstrate the presence of commercially producible quantities of oil in the Tulare Formation within the McKittrick Oil Field.

The McKittrick Oil Field is the 19th most productive field in California. Since it was discovered in 1948, the Tulare Formation in the McKittrick Oil Field has produced over 55 million bbl of oil (through 2017). Figure 4 shows the location of the 600 producing wells within the area proposed for exemption.

The Tulare Formation is the uppermost hydrocarbon bearing zone and is productive throughout the McKittrick Oil Field. Throughout the field, the presence of hydrocarbons is demonstrated through historic production and the evaluation of well logs. DOGGR's request includes evaluations of logs and of the physical properties of cores that were generated when the wells were drilled that show the presence of oil within the Tulare Formation. Oil saturation within the Tulare Formation in the McKittrick Oil Field is 70%.

Based on a review of information such as well logs, production data, the history of oil production, and the implementation of enhanced recovery techniques such as steaming that have the potential to increase the productivity of the Tulare Formation, the EPA has determined that the aquifer proposed for exemption meets the criteria at 40 CFR § 146.4 (b)(1).

PUBLIC NOTICE AND COMMENT

DOGGR provided public notice of this proposed AE on January 26, 2018, and held a public hearing on February 27, 2018 in Bakersfield, CA. The public comment period closed on March 14, 2018. DOGGR provided the EPA a summary of the public comments, copies of the public comments submitted, a transcript of the public hearing, and their responses to the written and oral comments.

In making this decision, the EPA considered all the information submitted by the State, including all the written and oral comments submitted to the State during its public comment process. Most of the issues raised in the comments are outside of the scope of this AE decision; specific responses not addressed by DOGGR are provided below.

One commenter (The Center for Biological Diversity) wrote to DOGGR and commented that the EPA should reject the aquifer exemption request before an environmental review has occurred under the National Environmental Policy Act (NEPA). The EPA believes that the public comment and hearing process afforded by DOGGR, the technical analysis to protect USDWs required in the aquifer exemption proposal process under the EPA's UIC regulations and the enabling legislation in the SDWA provide a functionally equivalent environmental review for this decision.

The same commenter also raised concerns regarding protection of species under the federal Endangered Species Act. This issue is outside the scope of EPA's AE decision, as this action does not authorize future injection activities at the surface. Approval of this aquifer exemption concerns groundwater that is hundreds of feet below the surface, and a review of materials submitted by the commenter indicate that there are no subsurface listed threatened or endangered species that would be affected by the EPA's approval.

Additionally, the commenter questioned whether the current aquifer exemption criteria reflect changing climate conditions and modern water treatment technologies. In considering whether the aquifer proposed for exemption cannot now and will not in the future serve as a source of drinking water because it is hydrocarbon producing, the EPA reviewed data about hydrocarbon

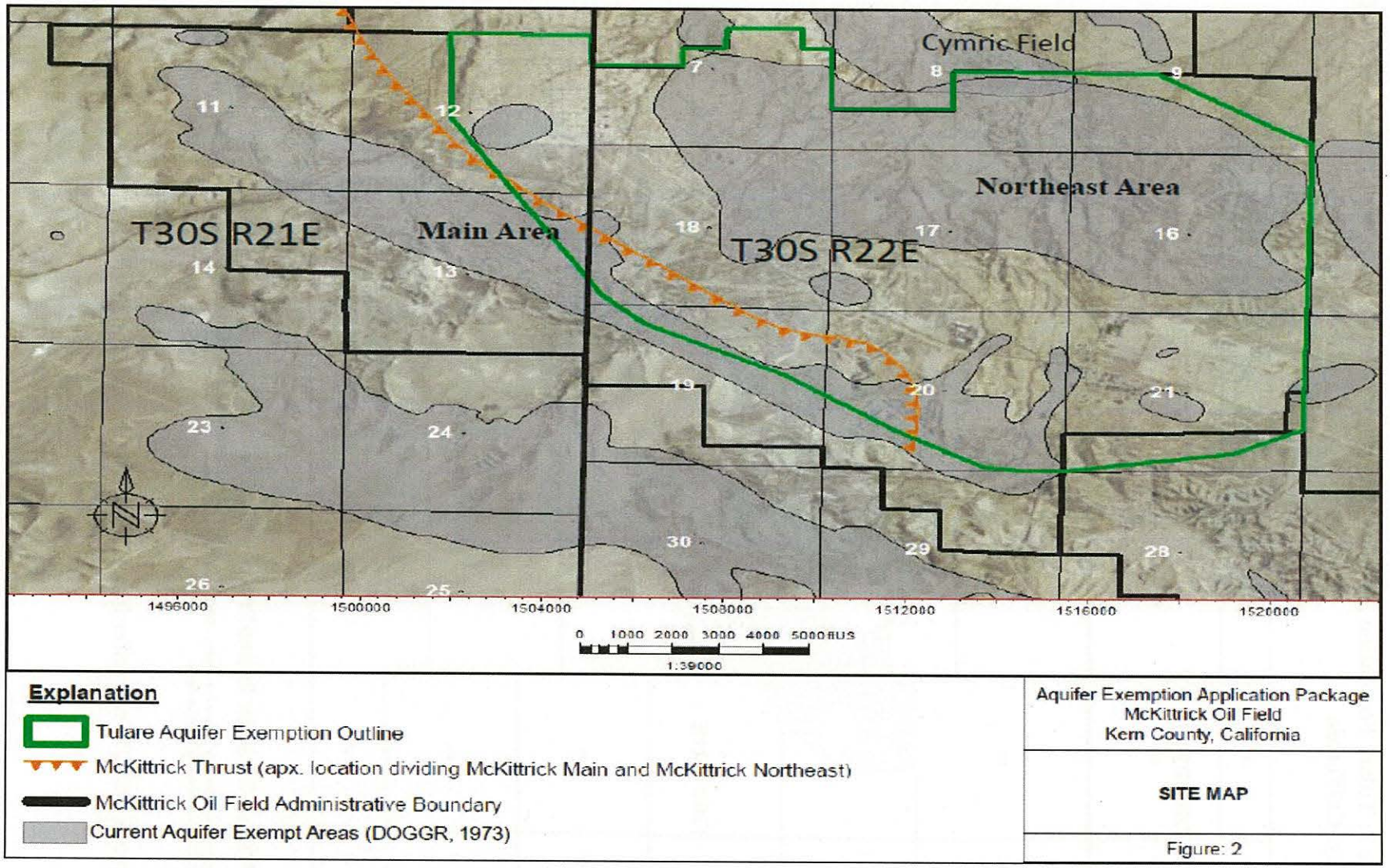
production in the portion of the Tulare Formation that is proposed for exemption. Based on a review of historic production data, well logs, and core data, the EPA believes that it is reasonable to conclude that the formation will continue to be commercially producible into the foreseeable future and meets the requirements at 40 CFR § 146.4(b)(1).

CONCLUSION AND DECISION

Based on a review of the entire record, including all written and oral comments submitted to DOGGR during its public comment process, the EPA finds that the exemption criteria at 40 CFR § 146.4(a) and § 146.4(b)(1) have been met, and the EPA approves the aquifer exemption request as a non-substantial program revision.

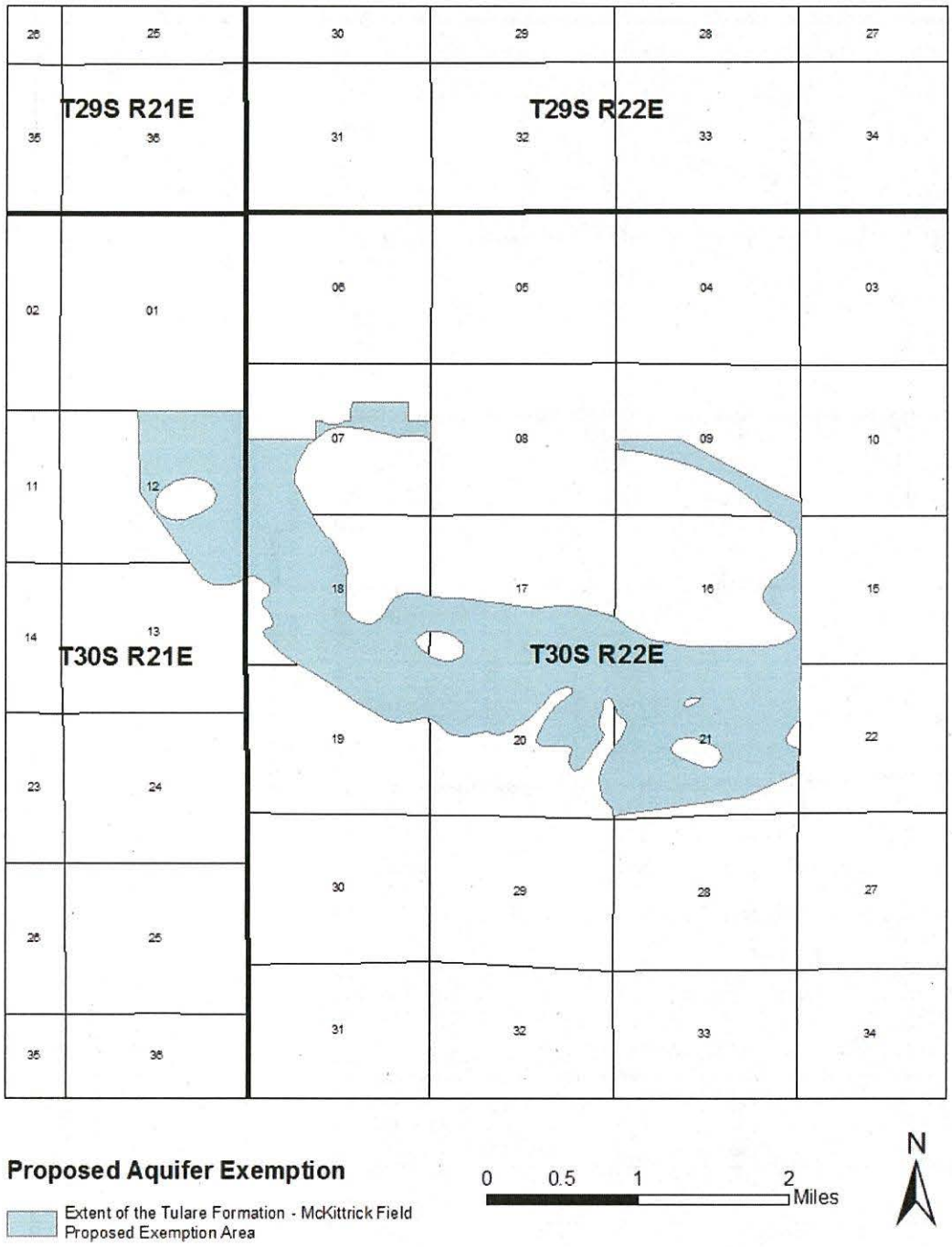
Effective Date: September 28, 2018

Figure 1: Location of the McKittrick Oil Field, Kern County, California



Source: Figure 2, DOGGR's Aquifer Exemption Application for the McKittrick Oil Field

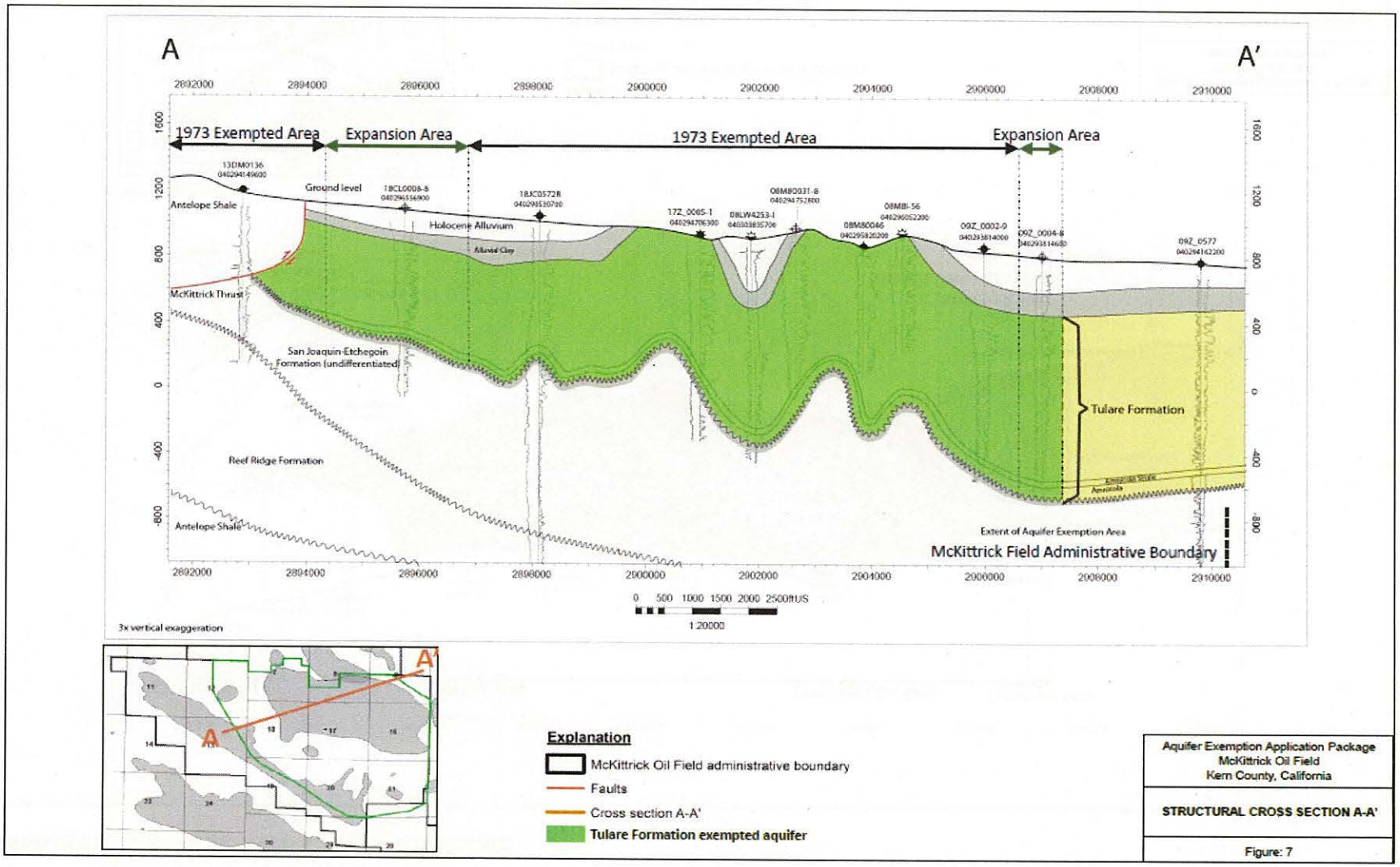
Figure 2: Tulare Formation Aquifer Exemption Location Map, McKittrick Oil Field, Kern County, California



Source: DOGGR's Aquifer Exemption Application for the McKittrick Oil Field

Figure 3.1: Cross Section A-A' across the Tulare Formation Aquifer Exemption Area

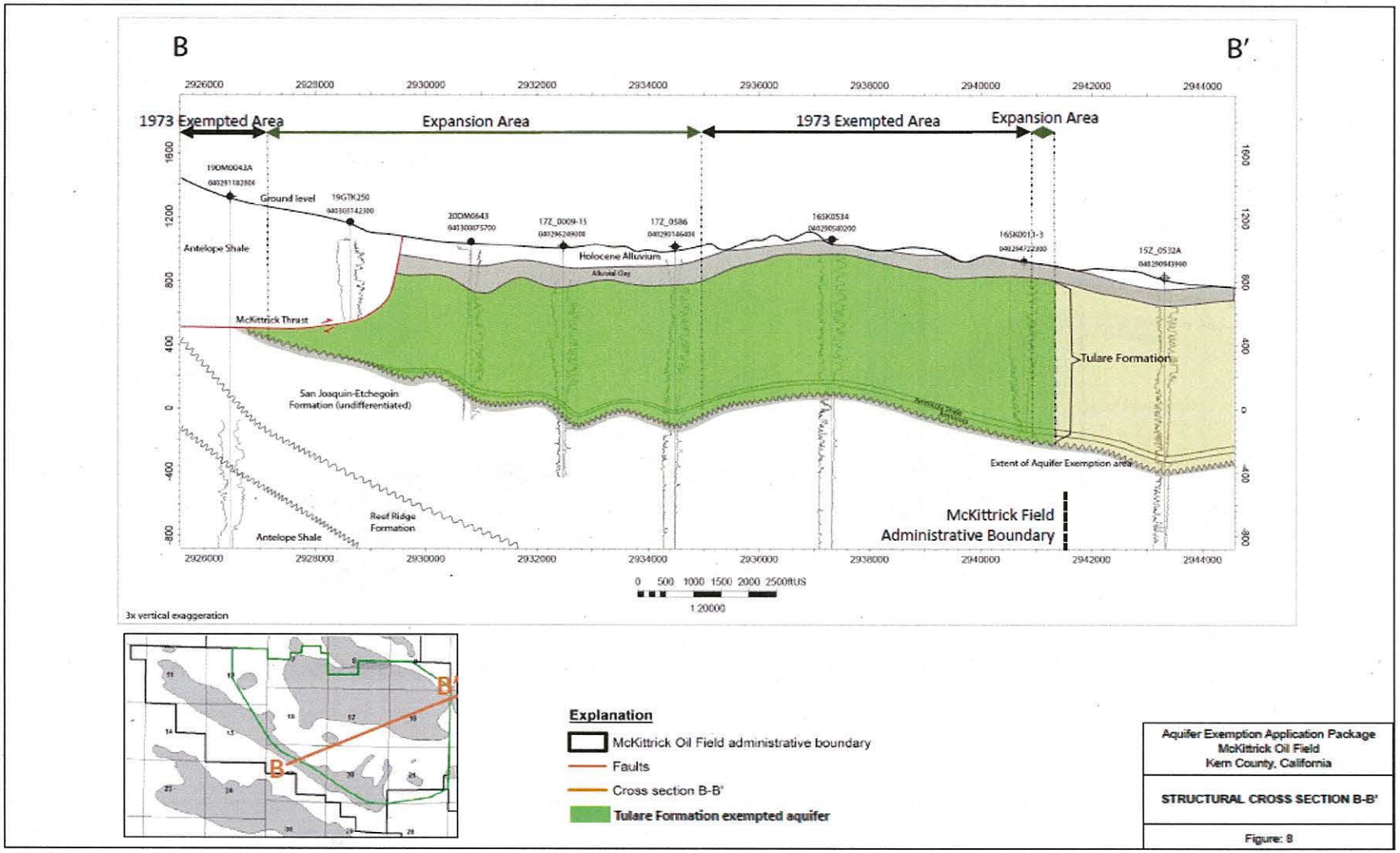
McKittrick Oil Field, Kern County, California



Source: Figure 7, DOGGR's Aquifer Exemption Application for the McKittrick Oil Field

Figure 3.2: Cross Section B-B' across the Tulare Formation Aquifer Exemption Area

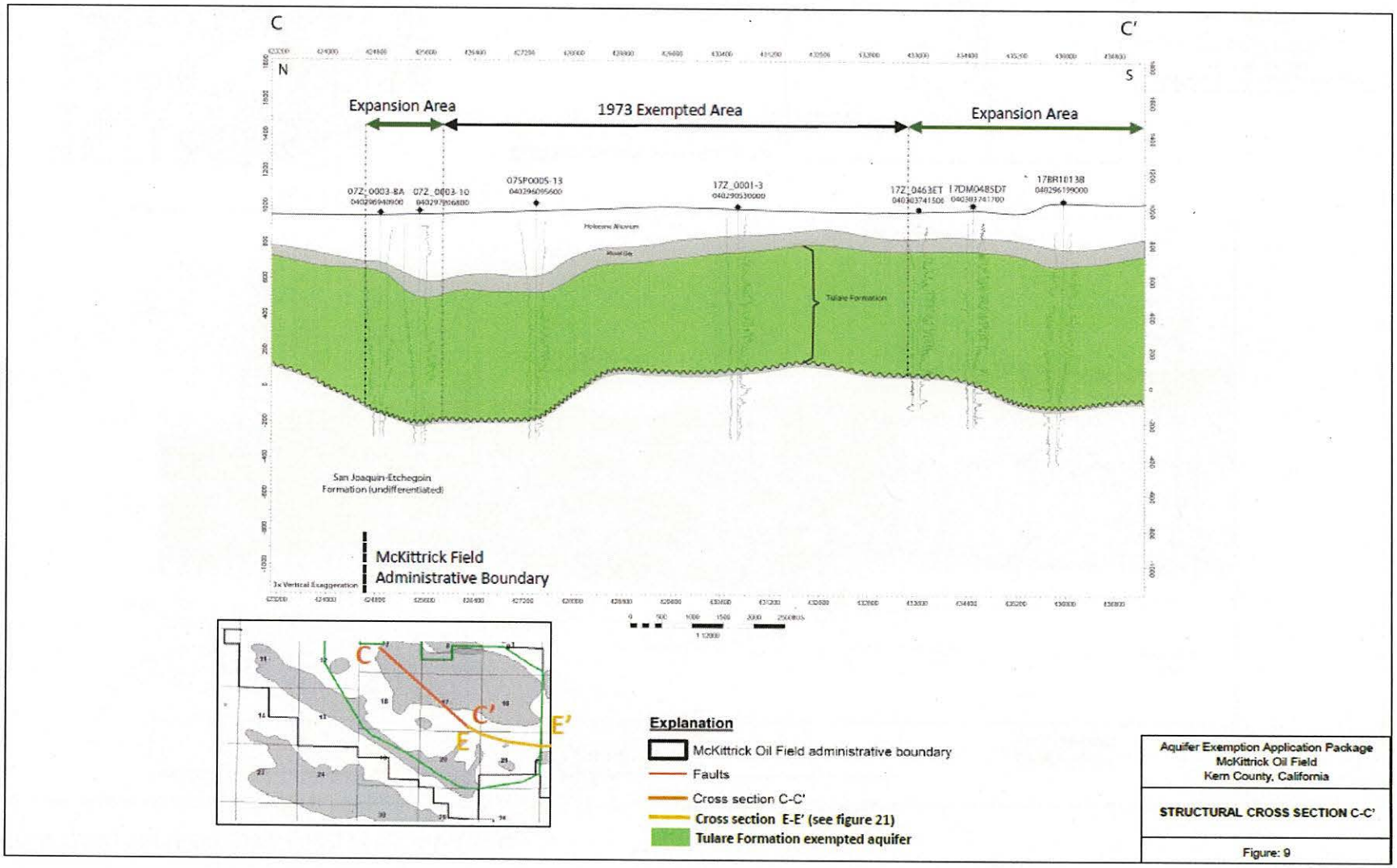
McKittrick Oil Field, Kern County, California



Source: Figure 8, DOGGR's Aquifer Exemption Application for the McKittrick Oil Field

Figure 3.3: Cross Section C-C' across the Tulare Formation Aquifer Exemption Area

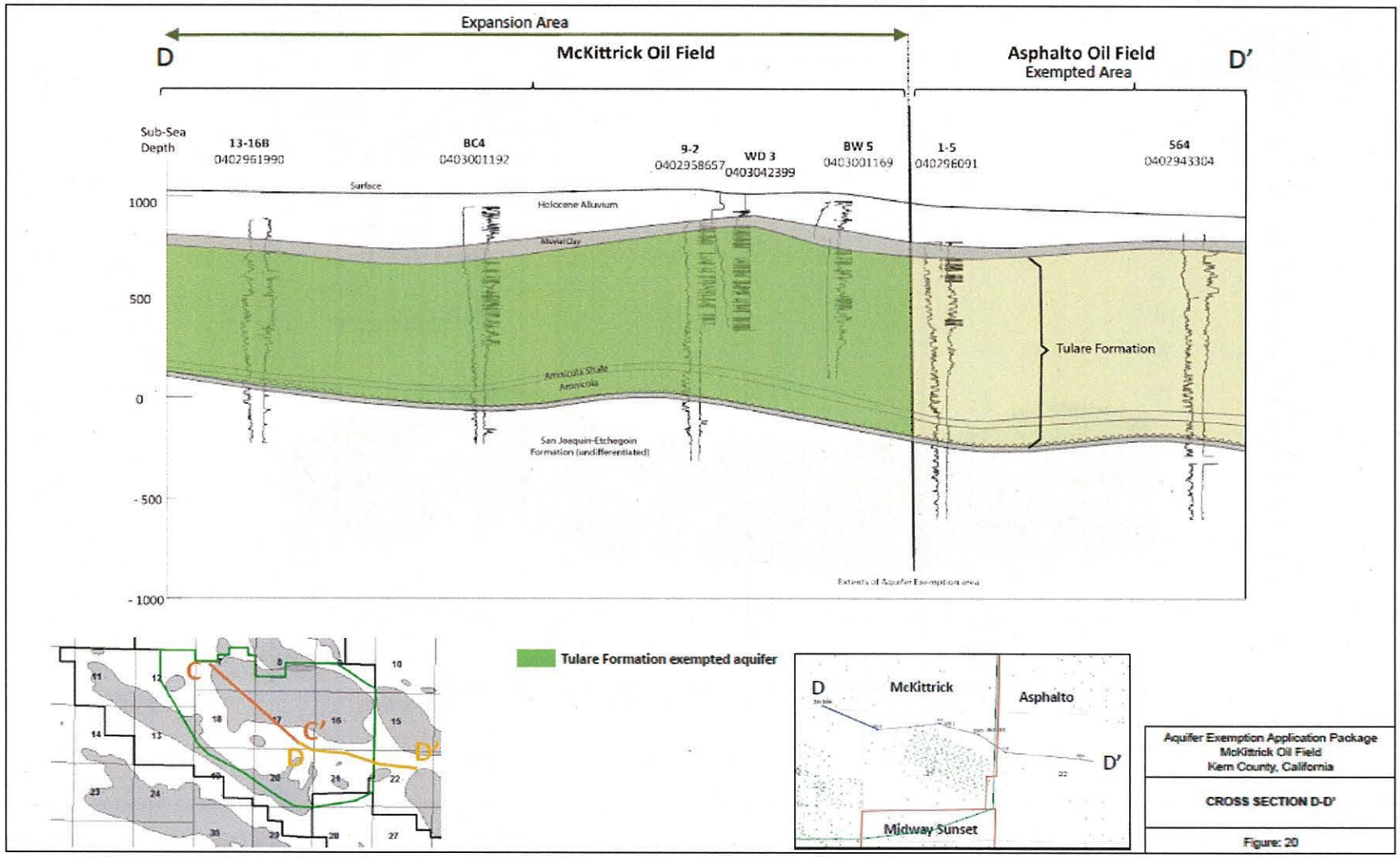
McKittrick Oil Field, Kern County, California



Source: Figure 9, DOGGR's Aquifer Exemption Application for the McKittrick Oil Field

Figure 3.4: Cross Section D-D' across the Tulare Formation Aquifer Exemption Area

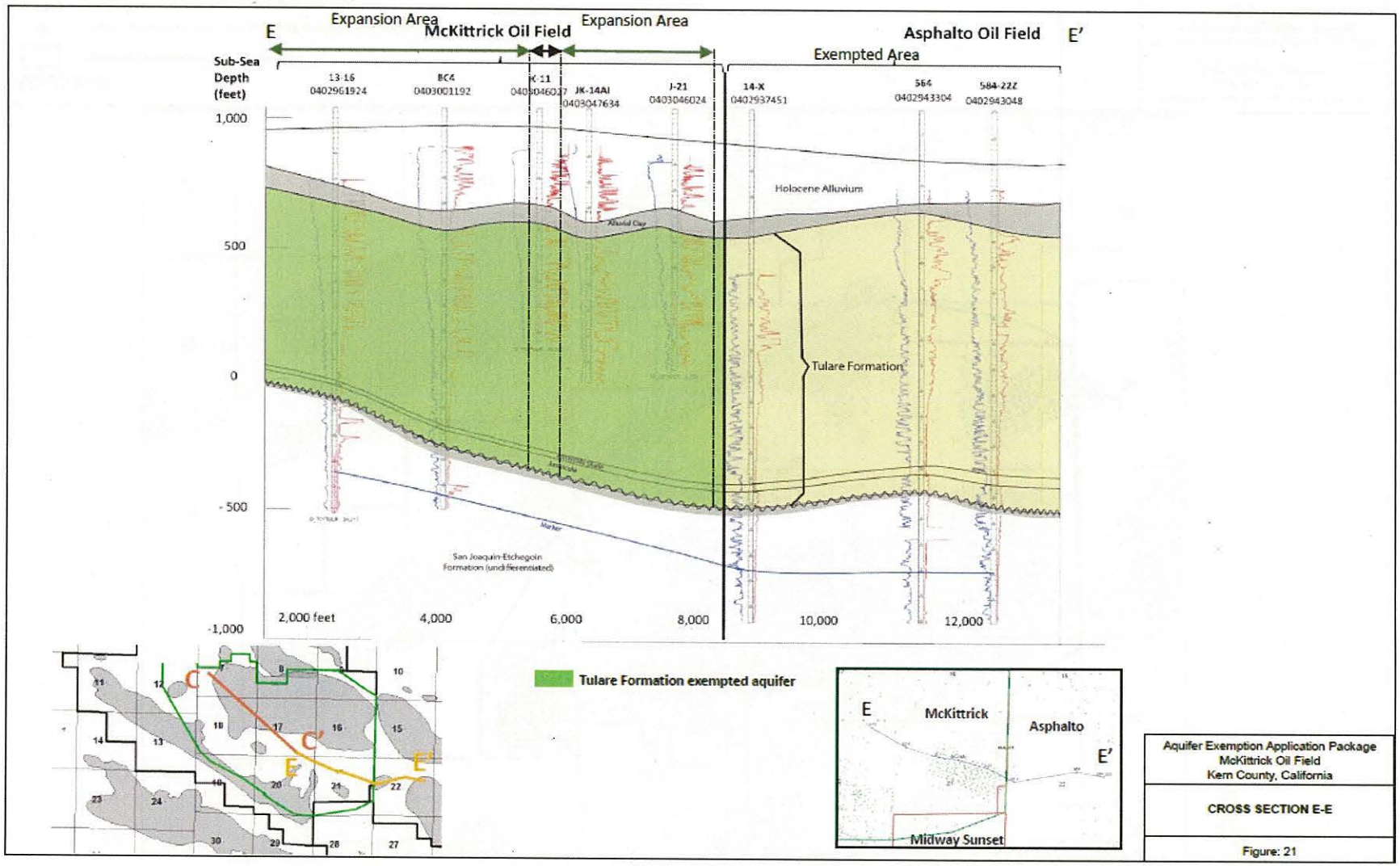
McKittrick Oil Field, Kern County, California



Source: Figure 20, DOGGR's Aquifer Exemption Application for the McKittrick Oil Field

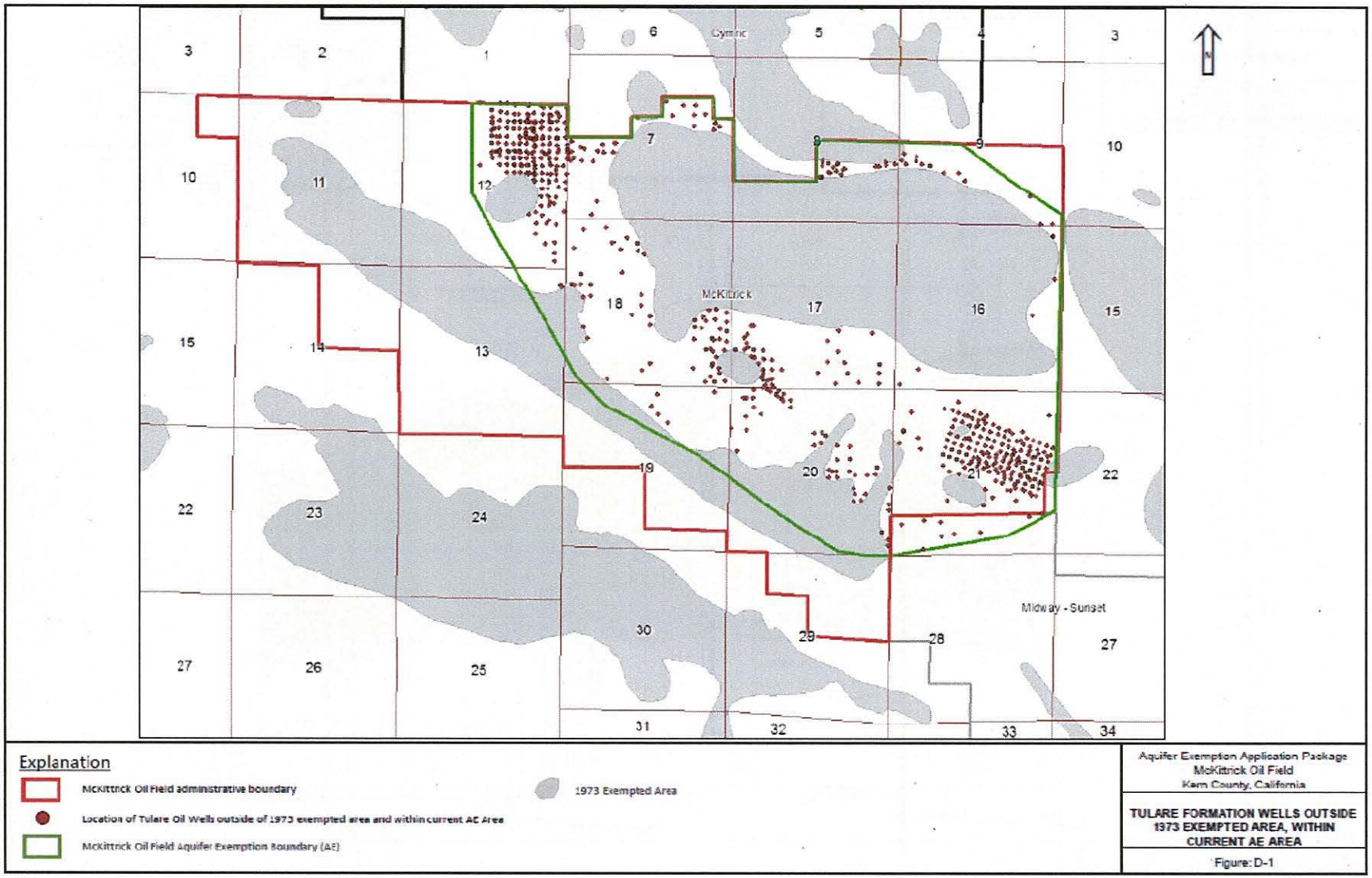
Figure 3.5: Cross Section E-E' across the Tulare Formation Aquifer Exemption Area

McKittrick Oil Field, Kern County, California



Source: Figure 21, DOGGR's Aquifer Exemption Application for the McKittrick Oil Field

Figure 4: Location of Oil Wells in the McKittrick Oil Field, Kern County, California



Source: Figure D-1, DOGGR's Aquifer Exemption Application for the McKittrick Oil Field

Table 1: List of Water Supply Wells

Well ID/ Name	Water Well Type	Distance from proposed area (feet)	Total Depth of Well (feet bgs)	Top of Well Screen (feet bgs)	Geologic Formation in Screen/Perf Interval	Township	Range	Section	Latitude	Longitude	Address (or Description) of Well
30S21E15Q001M	Industrial	5104' from McKittrick Field Boundary, 12348' from proposed area	750	250	Monterey Formation	30S	21E	15	35.3069008	-119.70184	150 west of Reward Road, 50ft north of Hwy 178 (from drillers log) - Field verified by EnviroTech 2015
30S/21E-15D	Unspecified Use (well not field verified)	4,706 from field boundary and 12,522 from AE boundary	200		Alluvium	30S	21E	15D	35.318654	-119.71111	About 0.75 miles north of junction of Reward-McKittrick Road and State Highway 178, Little Santa Maria Valley

Source: Table 1, Appendix B of DOGGR's Aquifer Exemption Application for the McKittrick Oil Field