

Monterey Formation as a Groundwater Resource*

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Search and Discovery Article #80702 (2019)**

Posted September 3, 2019

*Adapted from oral presentation given at 2019 AAPG Pacific Section Annual Convention, Long Beach, California, April 1-3, 2019

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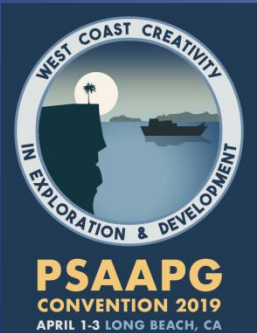
Abstract

Extensive data, publications, and field examples exist regarding the Monterey Formation and its petroleum capacity, fluid flow, fractured porosity and permeability. Recent demands for drought- and regulatory-compliant water resource development has steered significant investment in groundwater exploration in bedrock formations, specifically the Monterey. Given the history of exploration for petroleum, several new projects have relied on detailed, though often antiquated, notes of oil drilling and development in the Monterey Formation to justify the exploration of the groundwater resource. While results of production rates and groundwater quality can vary, deeper fractured sections of Monterey that have correlative exposures to recharge areas, have a history of "lost circulation" in petroleum exploration, and have geophysical log data that suggest a freshwater-bearing target have been most successful. Methods of feasibility assessment include research for the above, and case studies in the South Mountain (Ventura County) area and Lompoc (Santa Barbara County), among others, offer recent prime examples of melding petroleum geology exploration history and modern groundwater exploration and development.

Monterey Formation as a Groundwater Resource

PSAAPG Convention 2019
Long Beach, California

Jordan Kear, PG, CHG
02 April 2019



Discussion Outline

- Anecdotal evidence
- Early petroleum finds
- Increased demand
 - Drought
 - Regulatory limitations
- Protection of resource
- Potential recharge of by-product water

Monterey Formation

Exposed around and beneath many groundwater basins in southern coastal California

Central to California Oil exploration and production

Well studied

Porcelainitic, cherty, shales fracture tremendously well leading to high permeability to air, oil, gas, and water



Selected Recent Monterey Water Well Projects

- Sulphur Mountain
- Arroyo Grande
- Thousand Oaks
- Lompoc
- Malibu
- Buellton
- South Mountain
- McClure Valley

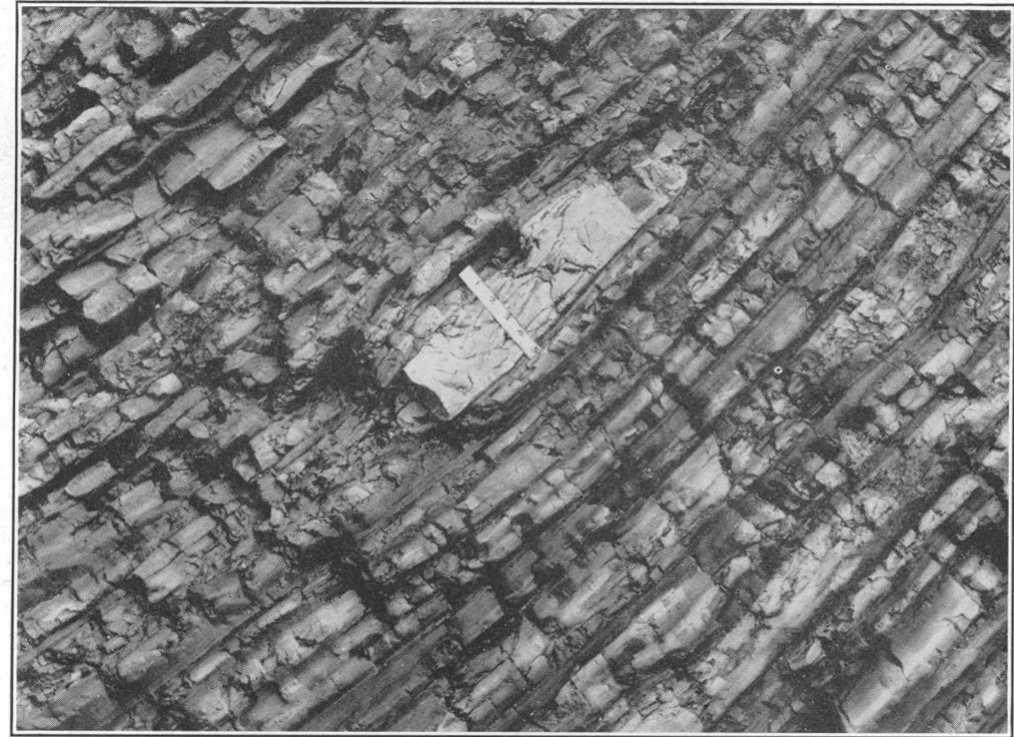


1900s-era California
Exploration and
production

“Obvious” fields
Anticlines, domes,
Monterey

Detailed logging and
mapping that remains
valid and useful

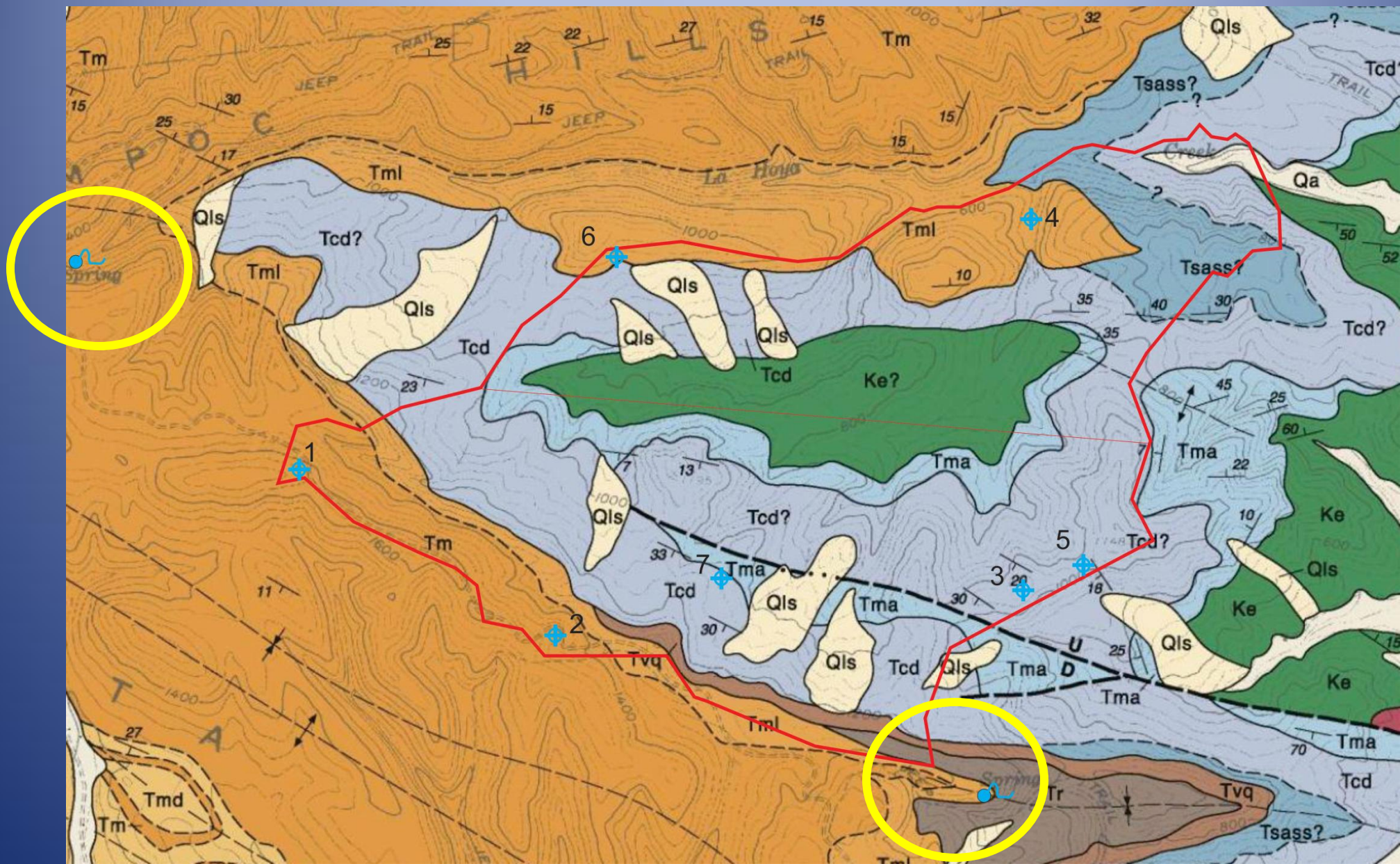
Limited Geophysical logs
“Antique” by modern
petroleum standards

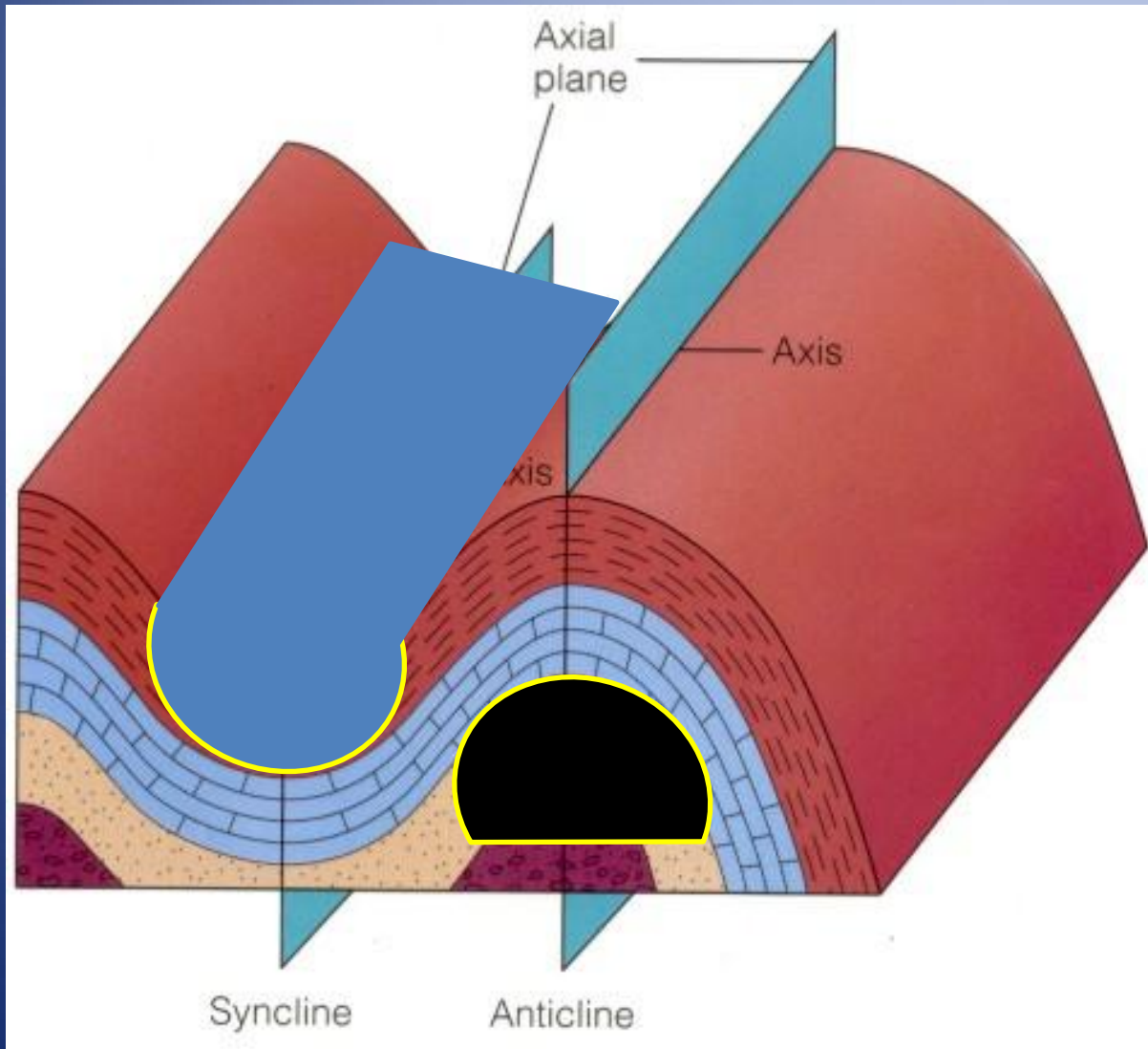


CALCAREOUS CONCRETION IN CHERTY SHALE IN SEA CLIFF ABOUT 2½ MILES NORTHWEST OF PISMO, SAN LUIS OBISPO COUNTY.

Source: Bramlette, 1946







Inverse of petroleum trap

Syncline storage and collection of water

Aquifers Recharged in human time

Aquifers: Bedrock Aquifers only
Secondary Porosity

Aquifer — A body of rock or sediment that is sufficiently porous and permeable to store, transmit, and yield significant quantities of groundwater to wells and springs.



Sulphur Mountain

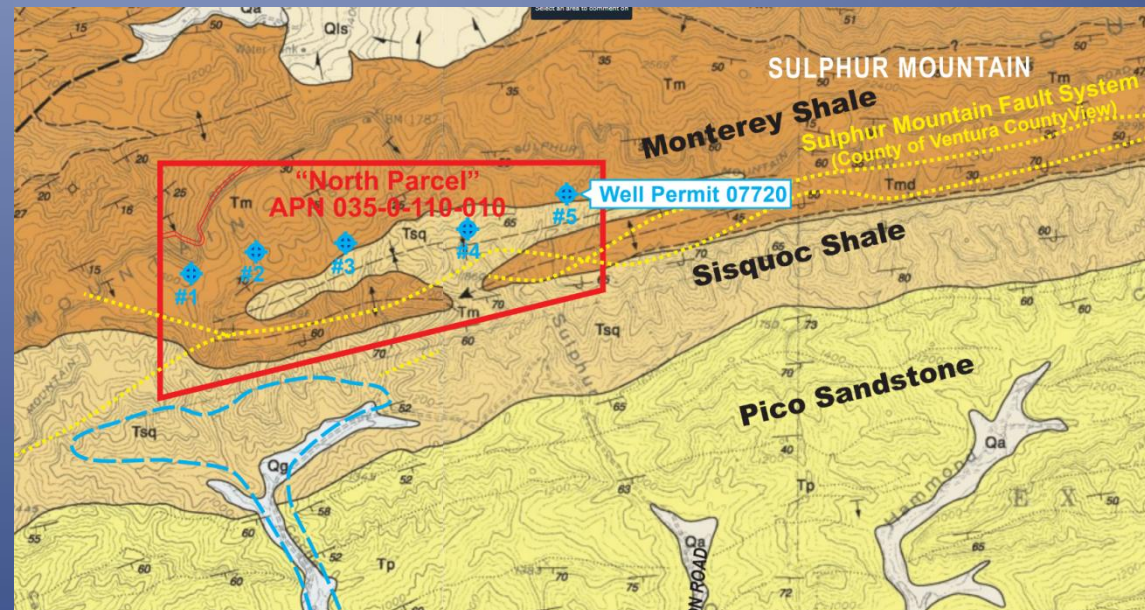
- Turn-of century wells encountered too much water to continue search for oil...
- Syncline along mountain crest core of Monterey

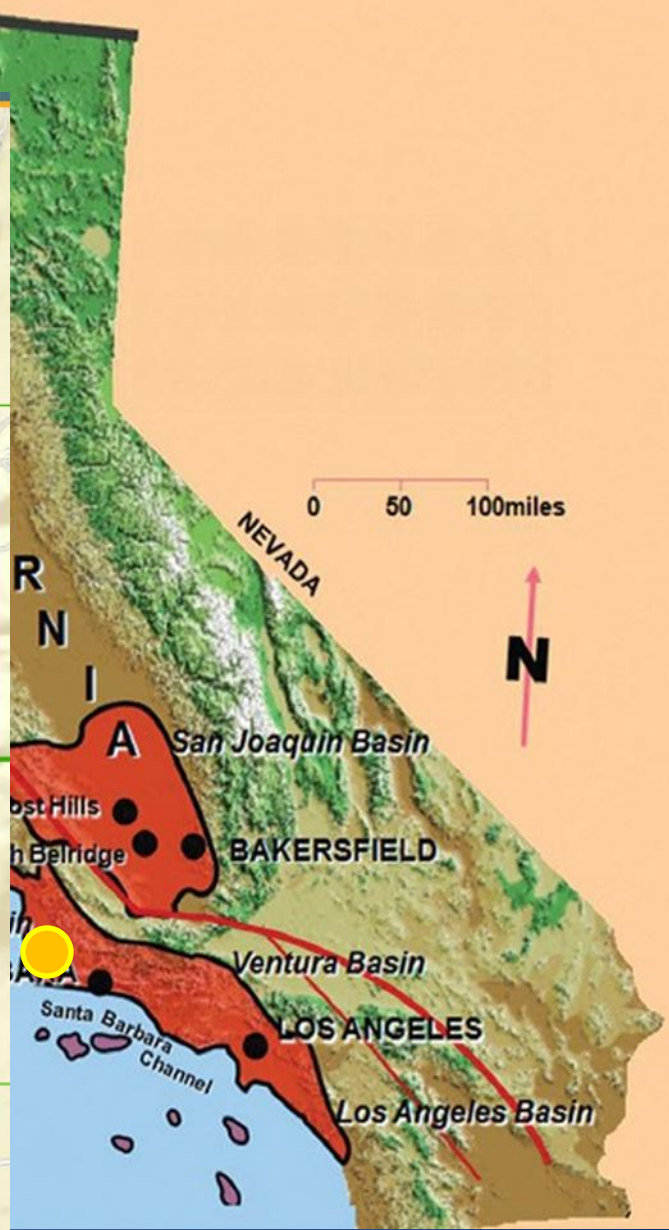
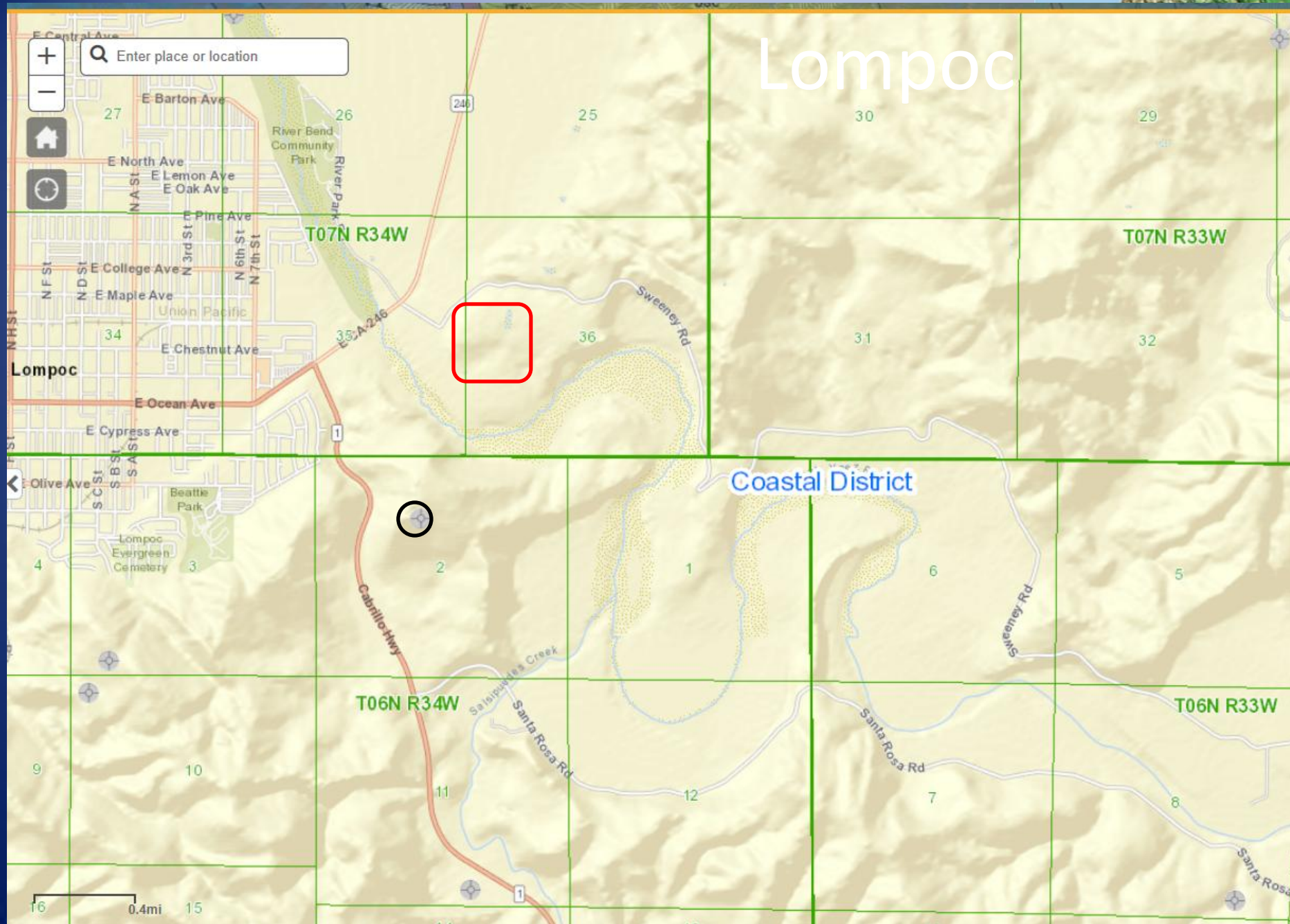
W. J. McMILLAN Well No. 1

Sec. 30, T.4N., R.22W., Ojai Oil Field

The following data taken from California State Mining Bureau, Bulletin No. 69, page 40:

W. J. McMillan of Los Angeles has a well on Lot 4 of Section 30, T.4N., R.22W. This well was drilled about 1901, was carried to a depth of about 1000 ft., is reported to have found some oil, and was abandoned on account of water trouble.





Thirty days after completion well produced _____ barrels of oil per day.

The gravity of oil was _____ rees Baumé. Water in oil amounted to _____ per cent.

Marathon Oil Co. NAMES OF DRILLERS

WELL NO. 1

NAMES OF TOOL DRESSERS

W. Heath

2-6N-34W

J. Jackson

083-04510

D. Bivens

Date drilling started December, 23, 1929

abandoned
Date well was completed May, 3, 1930

FORMATIONS PENETRATED BY WELL

DEPTH TO		Thickness	Name of Formation
Top of Formation	Bottom of Formation		
0	630	630	Hard opal and siliceous shale and limestone interbedded. (Cored; 114-126, 503-506, 536-542, 643-645.) Hole cored continuously from this point; average recovery %
630	691	61	Thin bedded brown shale with occasional hard gray limestone breaks. Abundant fish scales and remains.
691	747	56	Very hard formation, well rounded pebbles in ditch (Not cored)
747	757	10	Fine, compact, bluish-gray, clayey sandstone, fish scales.
757	927	170	Hard, dark, slate gray, pyritic clay shale. Badly fractured. Breaks of soft, dark gray, fine sandstone with sulphur odor; 767-827.
927	946	19	Fine, compact, gray-brown sandy shale. Abundant fish remains. Inclusions of gray volcanic ash at base.
946	990	44	Light and dark gray volcanic ash or tuffa.
990	1087	97	Fine, soft, muddy, dark gray sandstone gradational to shale at base. Sulphur odor. Fossiliferous at 1023 and from 1041 to 1087.
1087	1580	493	Hard, compact, dark gray shale, upper part gritty and slightly sandy in laminations. Occasional hard limey streaks. Breaks of finely slickensided shale from 1399 to 1580.
1580	2280	700	Finely slickensided, dark gray clay shale. Occasional breaks thin hard limey shale.
2280	3805	1525	Hard, dense, dark gray mud shale with breaks of softer slickensided shale.
3805	4041	236	Finely slickensided dark gray mud shale with a few breaks of hard shale.
4041	4328	287	Hard, fine, dark gray, shaley sandstone and shale. Very pyritic. Scattered chert pebbles. Conglomerate 4283-4287.
4328	4536	208	Hard, grayish-green conglomerate, pebbles of red and black chert and fine, gray-green sandstone. Fine and coarse gray sandstone matrix.
4536	4656	120	Fine to medium, well sorted gray sandstone with scattered chert pebbles at top.
	Bottom.		

SUBMIT LOG IN DUPLICATE
Form ... IS BLANK IN WITH TYPEWRITER. WRITE ON ONE SIDE OF PAPER ONLYSTATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

(083-04510)

DIVISION OF OIL AND GAS

LOG OF OIL OR GAS WELL

Marathon Oil Co.

FIELD Santa Barbara County COMPANY The Ohio Oil CompanySec. 2, T. 6 N, R. 34 W, S. B. & M., Elevation 608 Well No. 1

In compliance with the provisions of Chapter 718, Statutes of 1915, as amended, the information given herewith is a complete and correct record of the present condition of the well and all work done thereon, so far as can be determined from all available records.

Signed Thomas K BowlesDate May, 3, 1930Title Agent

(President, Secretary or Agent)

The summary on this page is for the ORIGINAL condition of the well

OIL SANDS
No oil sands1st sand from _____ to _____ 4th sand from _____ to _____
2d sand from _____ to _____ 5th sand from _____ to _____
3d sand from _____ to _____ 6th sand from _____ to _____

IMPORTANT WATER SANDS

1st sand from _____ to _____ None 3d sand from _____ to _____
2d sand from _____ to _____ 4th sand from _____ to _____RECEIVED
MAY 5 - 1930
SANTA BARBARA, CALIFORNIA

CASING RECORD

Size of Casing	Where Landed	Where Cut	Weight Per Foot	Threads Per Inch	Kind of Shoe	Make of Casing	CEMENTED		Number of Sacks
							Yes	No	
9"	672		40#	8		DBX	X		

CEMENTING OR OTHER SHUT-OFF RECORD

Casing, Size	Sacks	Time Set	Method	Test and Result (Give water level and boiling results)

PLUGS AND ADAPTERS

Heaving Plug—Material _____ Length _____ Where set _____
Adapters —Material _____ Size _____

TOOLS

Rotary Tools were used from 0 ft. to 4656 ft.

Cable Tools were used from _____ ft. to _____ ft.

PERFORATIONS

State clearly whether a machine was used or casing was drilled in shop

From	To	Size of Holes	Number of Rows	Holes Per Foot	Machine—Shop
ft.	ft.				
ft.	ft.				

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

DIVISION OF OIL AND GAS

Div. of Oil & Gas
Rec. August 6, 1930
Santa Barbara, Cal.

LOG OF OIL OR GAS WELL

FIELD SANTA BARBARA COUNTY COMPANY Marathon Oil Co.
~~THE OHIO OIL COMPANY~~

Sec. 2, T. 6N, R. 34W, S.B. B. & M., Well No. 1

In compliance with the provisions of Chapter 718, Statutes 1915, as amended, the information given herewith is a complete and correct record of all work done on the well since the previous record, dated May 3, 1930, was filed.

SIGNED Thomas K. Bowler

Date August 2nd, 1930

Title Agent
(President, Secretary or Agent)

Well spudded December 23, 1929.

Unable to maintain circulation from 0 - 691

9" DBX-40 casing landed at 672 to regain circulation. During later operations 275 sax of cement were put in hole to obtain circulation. The casing was unintentionally cemented at this time.

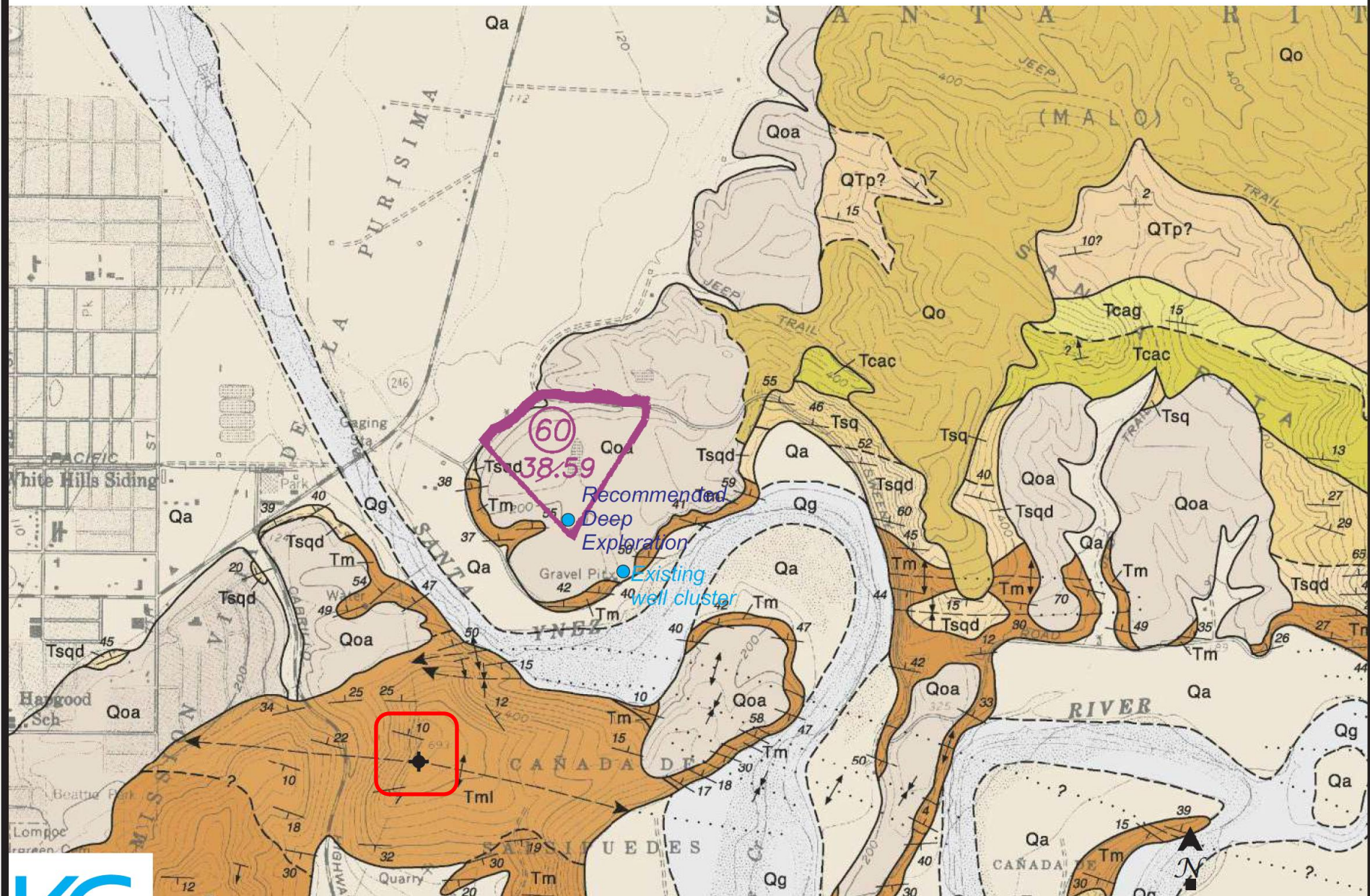
The hole was drilled to 4656' at which depth it was abandoned without encountering showings of oil or gas.

The hole was filled with heavy mud to 700'. 70 sax of S.C.O.W. cement was pumped in through 4" drill pipe at 700'.

Top of plug was located at 500' and plug sustained the weight of the drill pipe (This operation was witnessed by W. E. Heater).

The hole was then filled with heavy mud, capped and abandoned.

OK. Final Letter
Mo Map



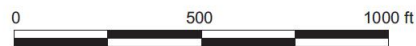
Base Geology after Dibblee, 1988a, 1988b, 1988c, and 1993
Well Locations and information from USGS
Parcels from County of Santa Barbara



TONY HUANG
Geology of Sweeney Road Property Area



Santa Ynez River Valley
Groundwater Basin Boundary
from DWR gic database
Parcels from County of Santa Barbara



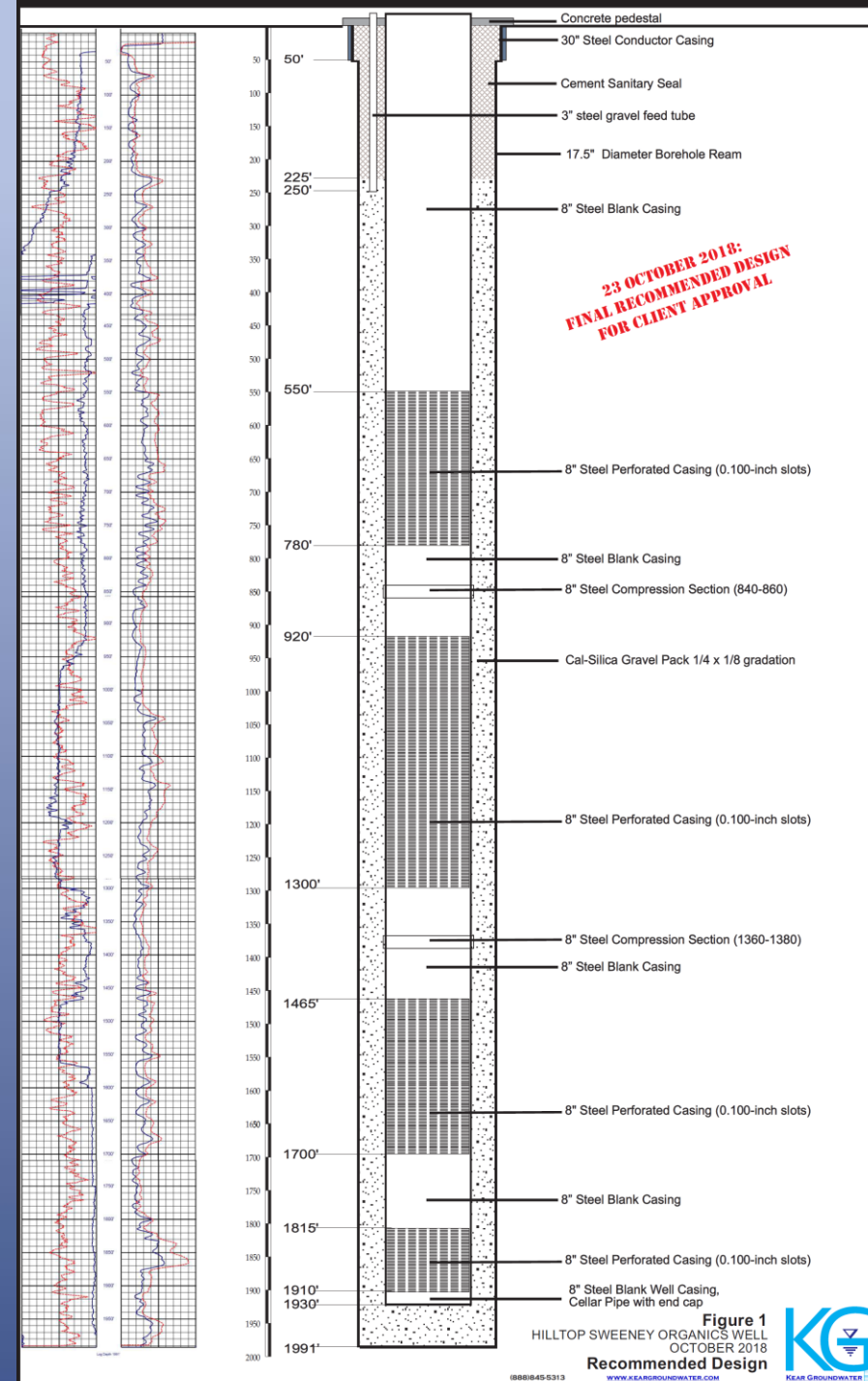
TONY HUANG

Groundwater Basin Boundary near Sweeney Road Property



Modern Water Well

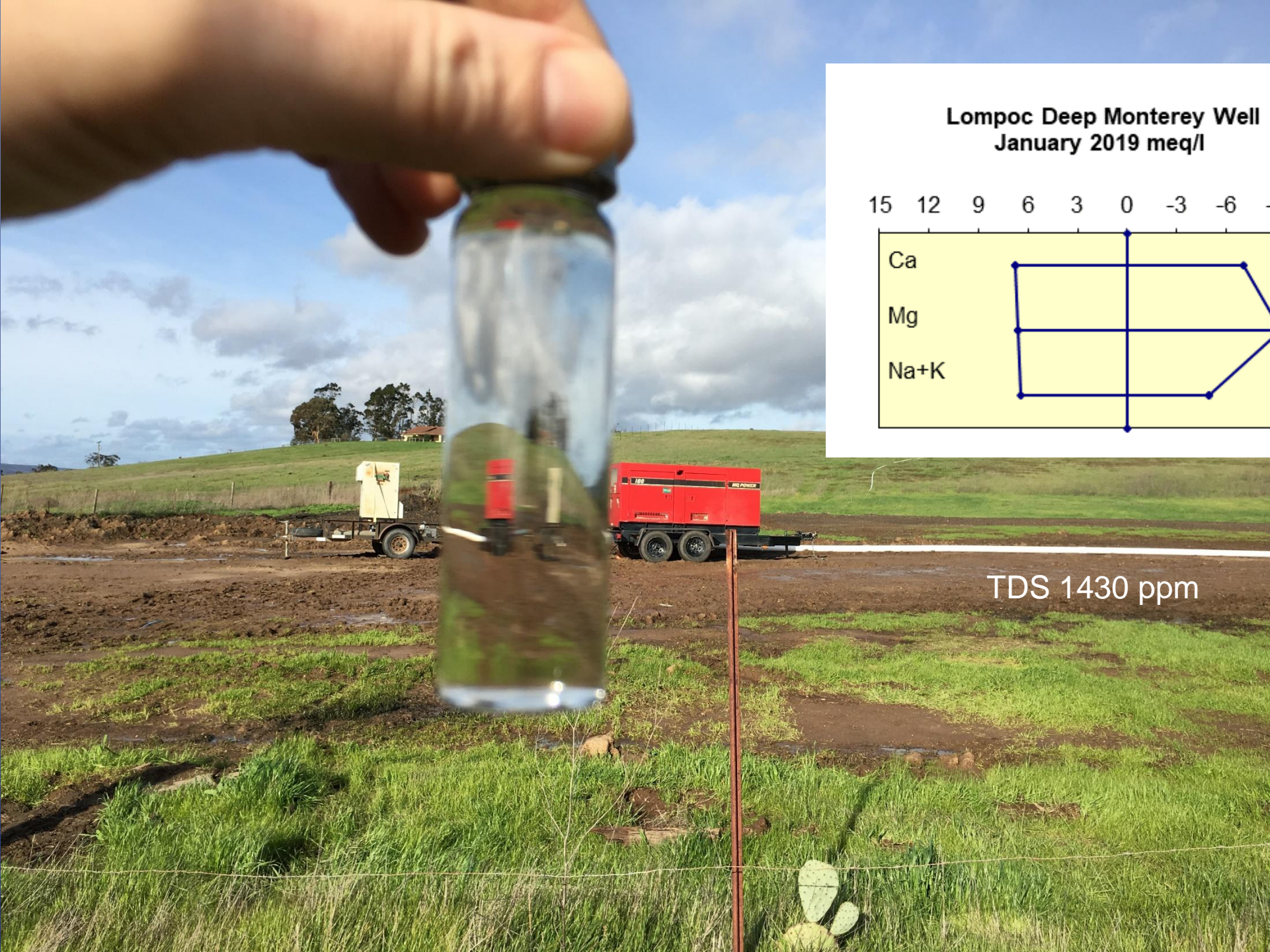
- Elog similar to 1950s oil wells
- Establish correlation of high porosity zone
- Water quality appears favorable
- Outside of groundwater basin
- All Monterey Formation



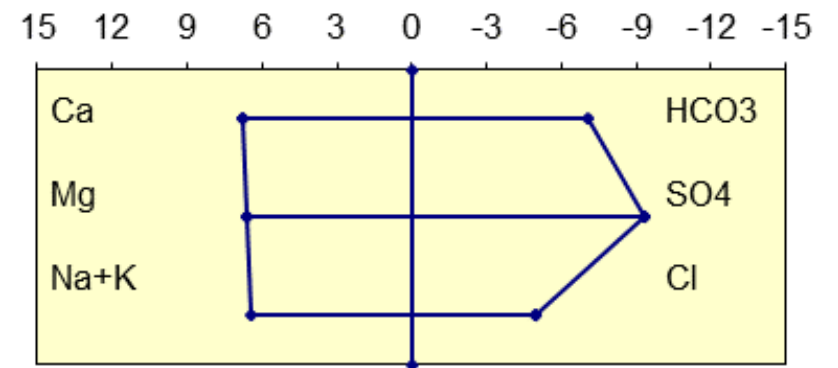


- Hydrogeologist's "Gusher"

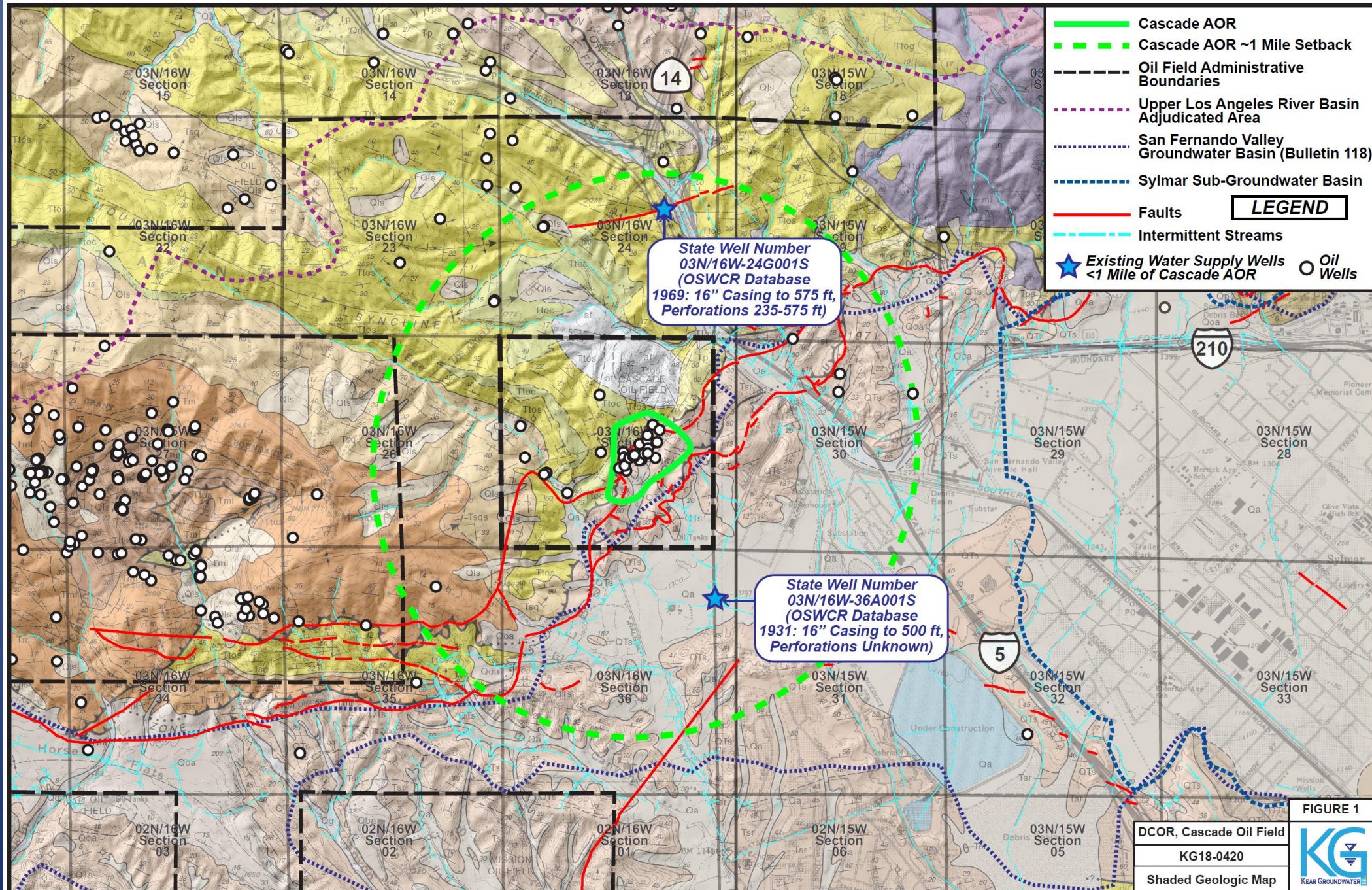




Lompoc Deep Monterey Well
January 2019 meq/l



TDS 1430 ppm



Water Well Databases: LA County DPW; CA DWR WDL; USGS NWIS
Oil Wells/Fields: DOC DOGGR
Geologic Basemaps: Dibblee (1991, 1992)

Streams: USGS NHD; Faults: USGS EHP
Groundwater/Adjudicated Basins: CA DWR
Shaded Relief: Modified from USGS NED

0 0.5 1.0 miles



Aquifer Protection during oil well drilling, stimulation, injection, discharge, etc....

- Demonstrate adequate distance from wells
- Demonstrate presence/absence/activity of water wells
- Demonstrate adequate sealing of usable groundwater (10,000 ppm)



Recharge Potential

Proximity to oil fields

Beneficial use

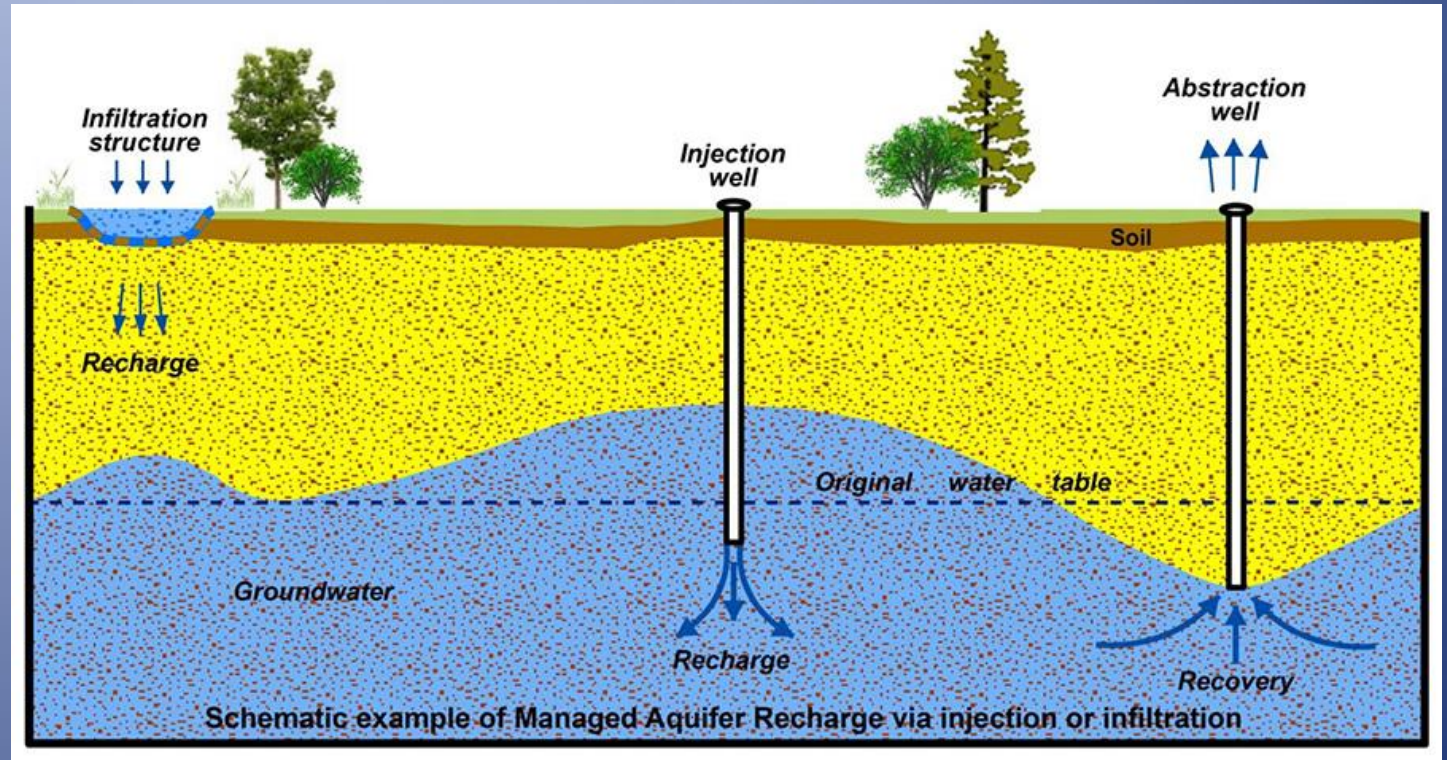
Processed brine water

Injection as a benefit, not a waste

Typical deep water levels allow for significant storage

Outcrop of Monterey

Formation can yield surface water impoundments for recharge



Thank You

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