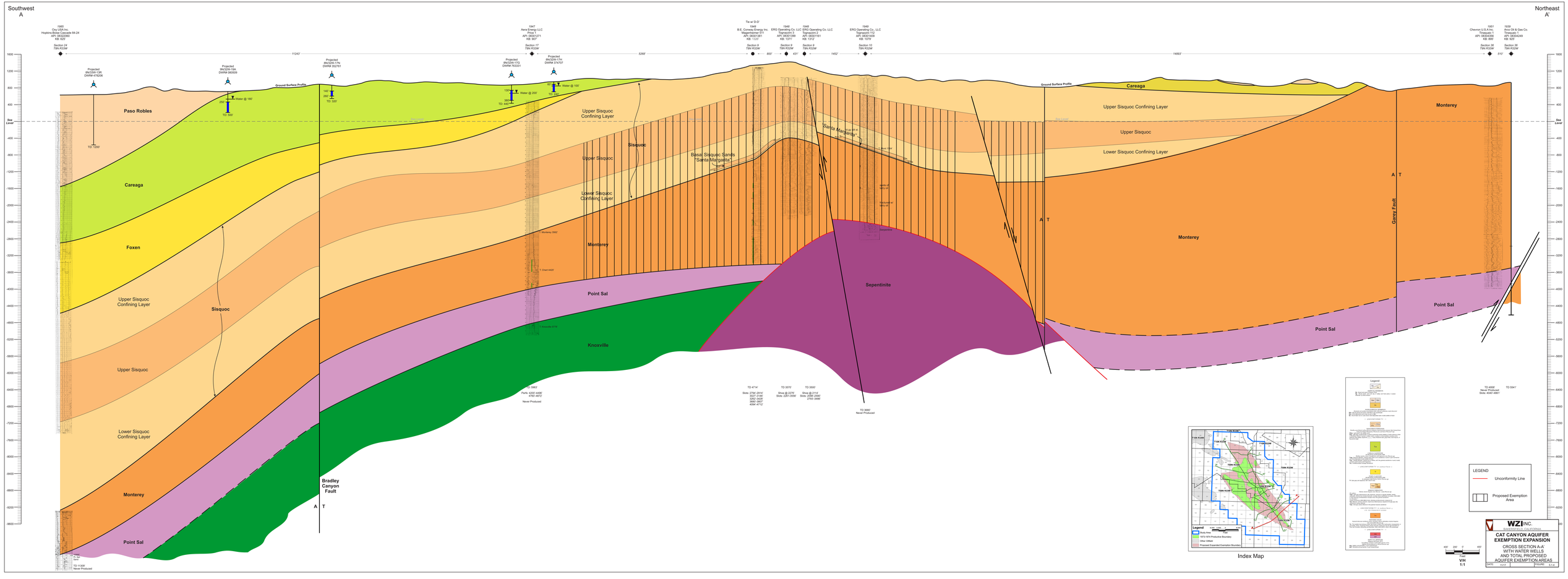
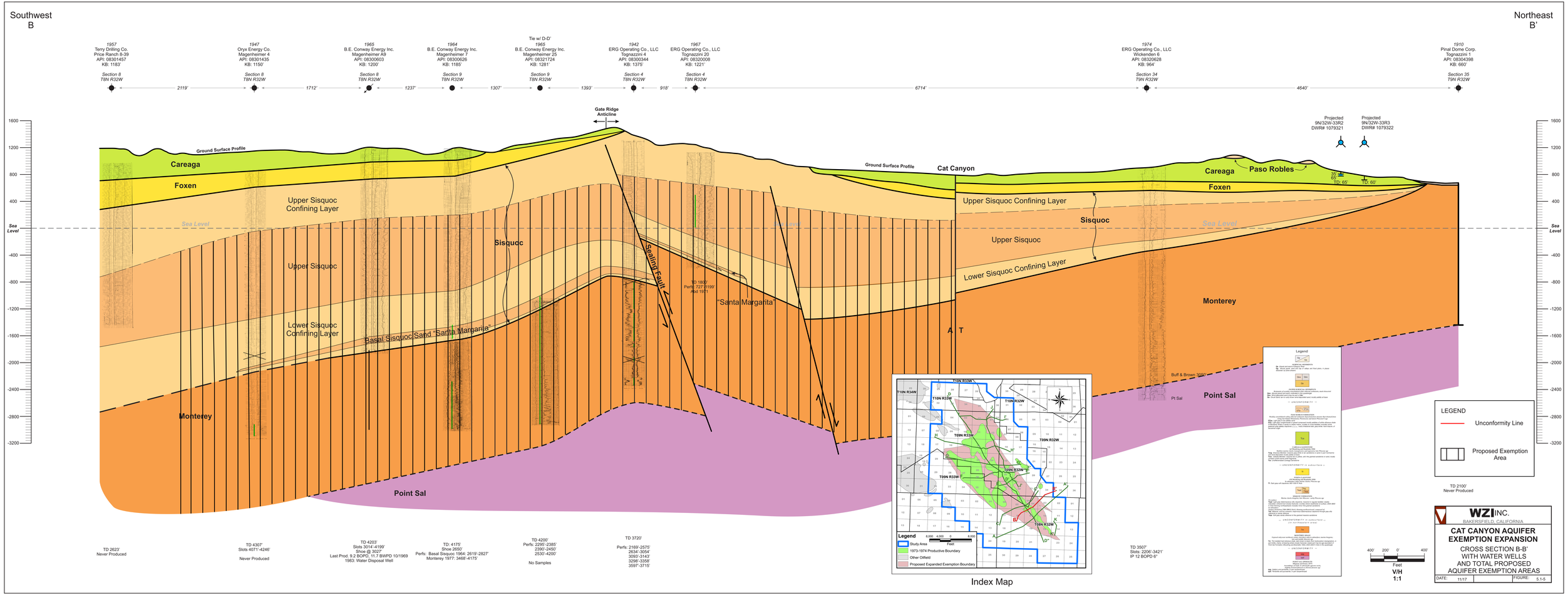
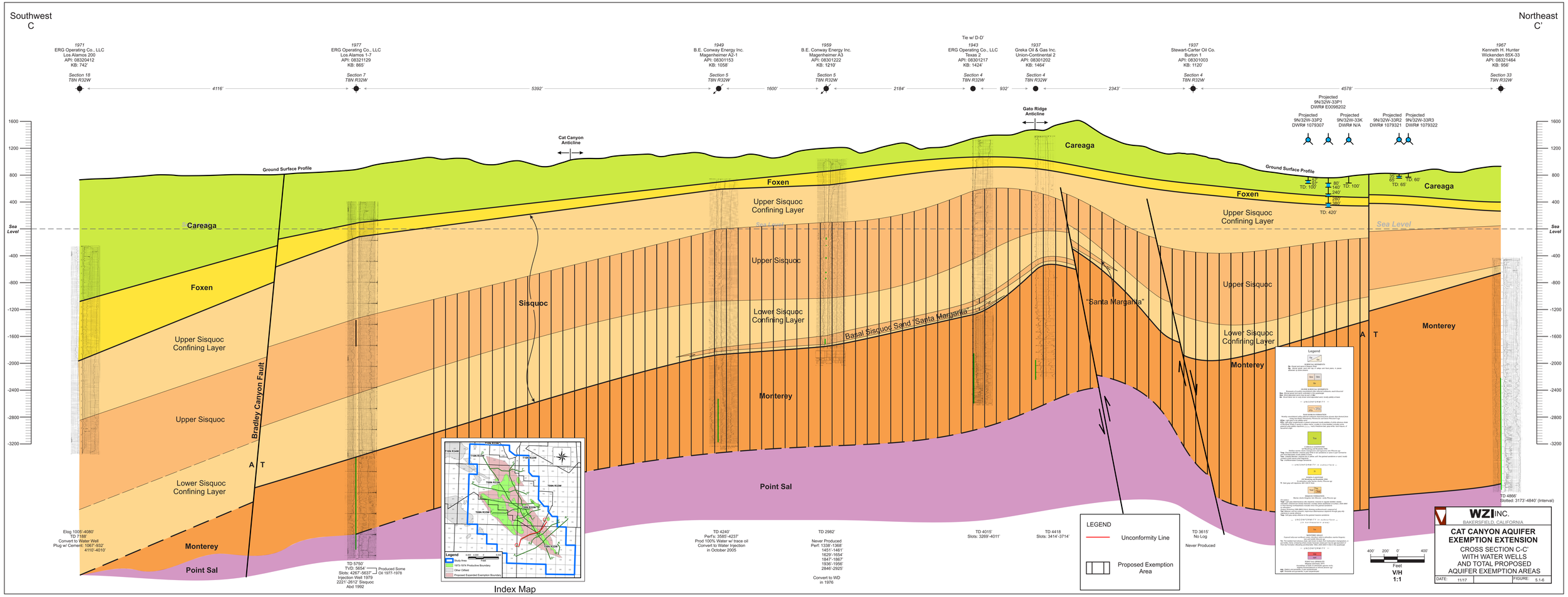
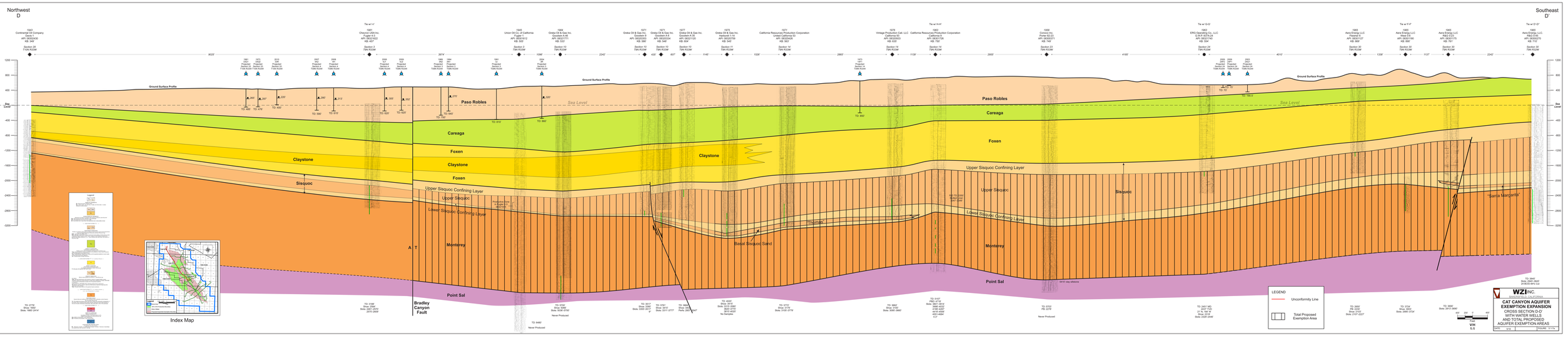

Southwest
A
Northeast
A'
1985
Dvy USA Inc.
Hopkins Ranch Grade 84-24
API: 0802080
KB: 620'
Section 24
T8N R10W
1948
B.E. Conway Energy Inc.
Conway Ranch 1
API: 0803181
KB: 1320'
Section 9
T8N R10W
1948
ERQ Operating Co. LLC
Cat Canyon Unit 1
API: 0803139
KB: 1371'
Section 9
T8N R10W
1948
ERQ Operating Co. LLC
Cat Canyon Unit 2
API: 0803153
KB: 1312'
Section 9
T8N R10W
1949
ERQ Operating Co., LLC
Cat Canyon Unit 3
API: 0803169
KB: 1079'
Section 10
T8N R10W
1957
Chevron U.S.A Inc.
Cat Canyon 1
API: 0804058
KB: 890'
Section 36
T9N R10W
1939
Arco Oil & Gas Co.
Gaffney 1
API: 0804049
KB: 925'
Section 36
T9N R10W
Tie w/ D-D'
1947
Aera Energy LLC
Cat 17
API: 0803271
KB: 907'
Section 17
T8N R10W
Projected
8N/33W-13K
DWR# 478206
Projected
8N/33W-18A
DWR# 080509
Projected
8N/33W-17N
DWR# 382781
Projected
8N/33W-17Q
DWR# 783331
Projected
8N/33W-17J
DWR# 314757
11243'
5256'
800'
431'
1452'
14693'
510'
Ground Surface Profile
Water @ 180'
TD: 500'
TD: 320'
Water @ 200'
TD: 440'
Water @ 100'
TD: 320'
TD: 1056'
Paso Robles
Careaga
Foxen
Upper Sisquoc Confining Layer
Upper Sisquoc
Lower Sisquoc Confining Layer
Monterey
Point Sal
Sisquoc
Bradley Canyon Fault
A T
Knoxville
Monterey 3962'
Chert 4422'
Knoxville 5770'
TD: 5963'
Perfs: 4350'-4496'
4760'-4872'
Never Produced
Point Sal
Sepentinite
Basal Sisquoc Sands "Santa Margarita"
Santa Margarita
Upper Sisquoc Confining Layer
Upper Sisquoc
Lower Sisquoc Confining Layer
Sisquoc
Monterey
Point Sal
Sepentinite
TD 4714'
Sicks: 2914'-2914'
2926'-2926'
3300'-3400'
3660'-3862'
4094'-4712'
TD 3570'
Show @ 2270'
Sicks: 2281'-3898'
TD 3500'
Show @ 2114'
Sicks: 2120'-2147'
2191'-3486'
TD 3680'
Never Produced
Ground Surface Profile
Careaga
Upper Sisquoc Confining Layer
Upper Sisquoc
Lower Sisquoc Confining Layer
Monterey
Point Sal
A T
Gaviy Fault
Monterey
Point Sal
TD 4005'
Never Produced
Sicks: 4040'-4880'
TD 5541'
Sea Level
1600
1200
800
400
-400
-800
-1200
-1600
-2000
-2400
-2800
-3200
-3600
-4000
-4400
-4800
-5200
-5600
-6000
-6400
-6800
-6800
-7200
-7600
-8000
-8400
-8800
-9200
-9600
TD: 11090'
Never Produced
Legend
Unconformity Line
Proposed Exemption Area
Index Map
Legend
Study Area
1875 1876 Productive Boundary
Other Oilfield
Proposed Expanded Exemption Boundary
T10N R33W
T10N R32W
T10N R31W
T9N R33W
T9N R32W
T9N R31W
T8N R33W
T8N R32W
T8N R31W
Cat Canyon Unit 1
Cat Canyon Unit 2
Cat Canyon Unit 3
A
A'
LEGEND
Unconformity Line
Proposed Exemption Area
WZI INC.
SANTA BARBARA, CALIFORNIA
CAT CANYON AQUIFER EXEMPTION EXPANSION
CROSS SECTION A-A'
WITH WATER WELLS
AND TOTAL PROPOSED
AQUIFER EXEMPTION AREAS
DATE: 10/23
FIGURE: 5.1-4
40' 20' 0' 40'
Feet
V/H
1:1

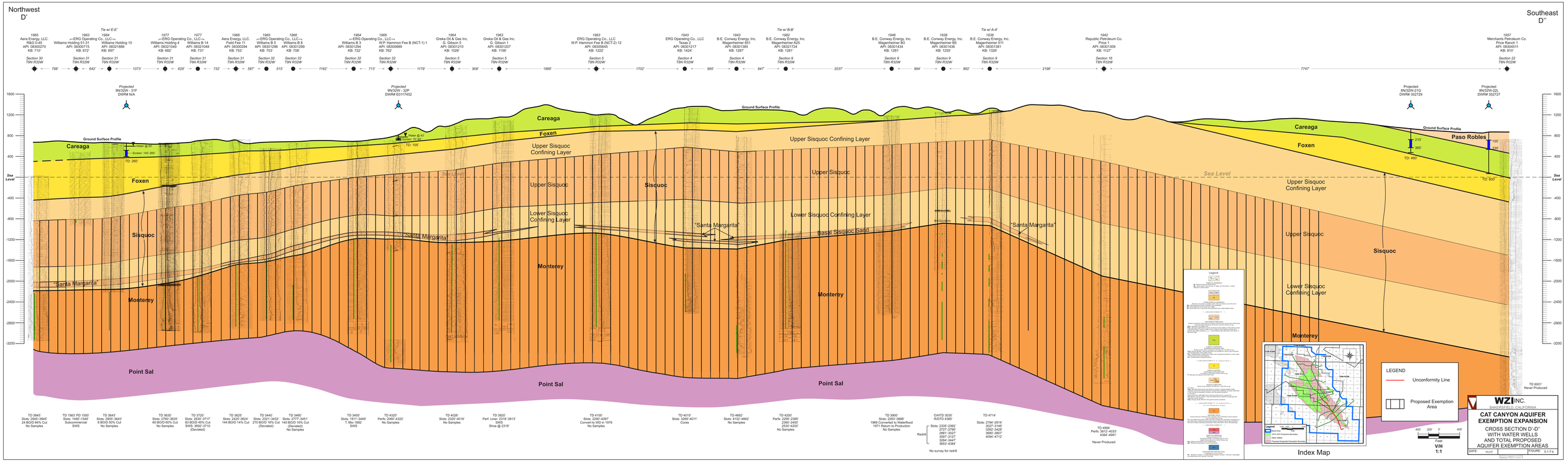


Southwest
B
Northeast
B'
1957
Terry Drilling Co.
Price Ranch 8-39
API: 08301457
KB: 1183'
Section 8
T8N R32W
1947
Oryx Energy Co.
Magenheimer 4
API: 08301435
KB: 1150'
Section 8
T8N R32W
1965
B.E. Conway Energy Inc.
Magenheimer A9
API: 08300603
KB: 1200'
Section 8
T8N R32W
1964
B.E. Conway Energy Inc.
Magenheimer 7
API: 08300626
KB: 1185'
Section 9
T8N R32W
Tie w/ D-D'
1965
B.E. Conway Energy Inc.
Magenheimer 25
API: 08321724
KB: 1281'
Section 9
T8N R32W
1942
ERG Operating Co., LLC
Tognazzini 4
API: 08300344
KB: 1375'
Section 4
T8N R32W
1967
ERG Operating Co., LLC
Tognazzini 20
API: 08320008
KB: 1221'
Section 4
T8N R32W
1974
ERG Operating Co., LLC
Wickenden 6
API: 08320628
KB: 964'
Section 34
T9N R32W
1910
Pinal Dome Corp.
Tognazzini 1
API: 08304398
KB: 660'
Section 35
T9N R32W
2119'
1712'
1237'
1307'
1393'
918'
6714'
4640'
Gate Ridge Anticline
Projected
9N/32W-33R2
DWR# 1079321
Projected
9N/32W-33R3
DWR# 1079322
Ground Surface Profile
Careaga
Foxen
Upper Sisquoc Confining Layer
Sea Level
Sisquoc
Upper Sisquoc
Lower Sisquoc Confining Layer
Basal Sisquoc Sand "Santa Margarita"
Sealing Fault
TD 1800'
Perfs: 727'-1199'
Abd 1971
"Santa Margarita"
Monterey
Point Sal
Cat Canyon
Paso Robles
35'
65'
TD: 65'
TD: 60'
Buff & Brown 3050'
Pt Sal
1600
1200
800
400
Sea Level
-400
-800
-1200
-1600
-2000
-2400
-2800
-3200
TD 2623'
Never Produced
TD 4307'
Slots 4071'-4246'
Never Produced
TD 4203'
Slots 3014'-4199'
Shoe @ 3027'
Last Prod. 9.2 BOPD, 11.7 BWPD 10/1969
1983: Water Disposal Well
TD: 4175'
Shoe 2650'
Perfs: Basal Sisquoc 1964: 2619'-2827'
Monterey 1977: 3468'-4175'
TD 4200'
Perfs: 2295'-2385'
2390'-2450'
2530'-4200'
No Samples
TD 3720'
Perfs: 2169'-2575'
2634'-3054'
3093'-3143'
3298'-3358'
3597'-3715'
TD 3507'
Slots: 2206'-3421'
IP 12 BOPD 6"
TD 2100'
Never Produced
Legend
Unconformity Line
Proposed Exemption Area
Legend
Study Area
Feet
1973-1974 Productive Boundary
Other Oilfield
Proposed Expanded Exemption Boundary
Index Map
400' 200' 0' 400'
Feet
V/H
1:1
WZI INC.
BAKERSFIELD, CALIFORNIA
CAT CANYON AQUIFER EXEMPTION EXPANSION
CROSS SECTION B-B' WITH WATER WELLS AND TOTAL PROPOSED AQUIFER EXEMPTION AREAS
DATE: 11/17
FIGURE: 5.1-5

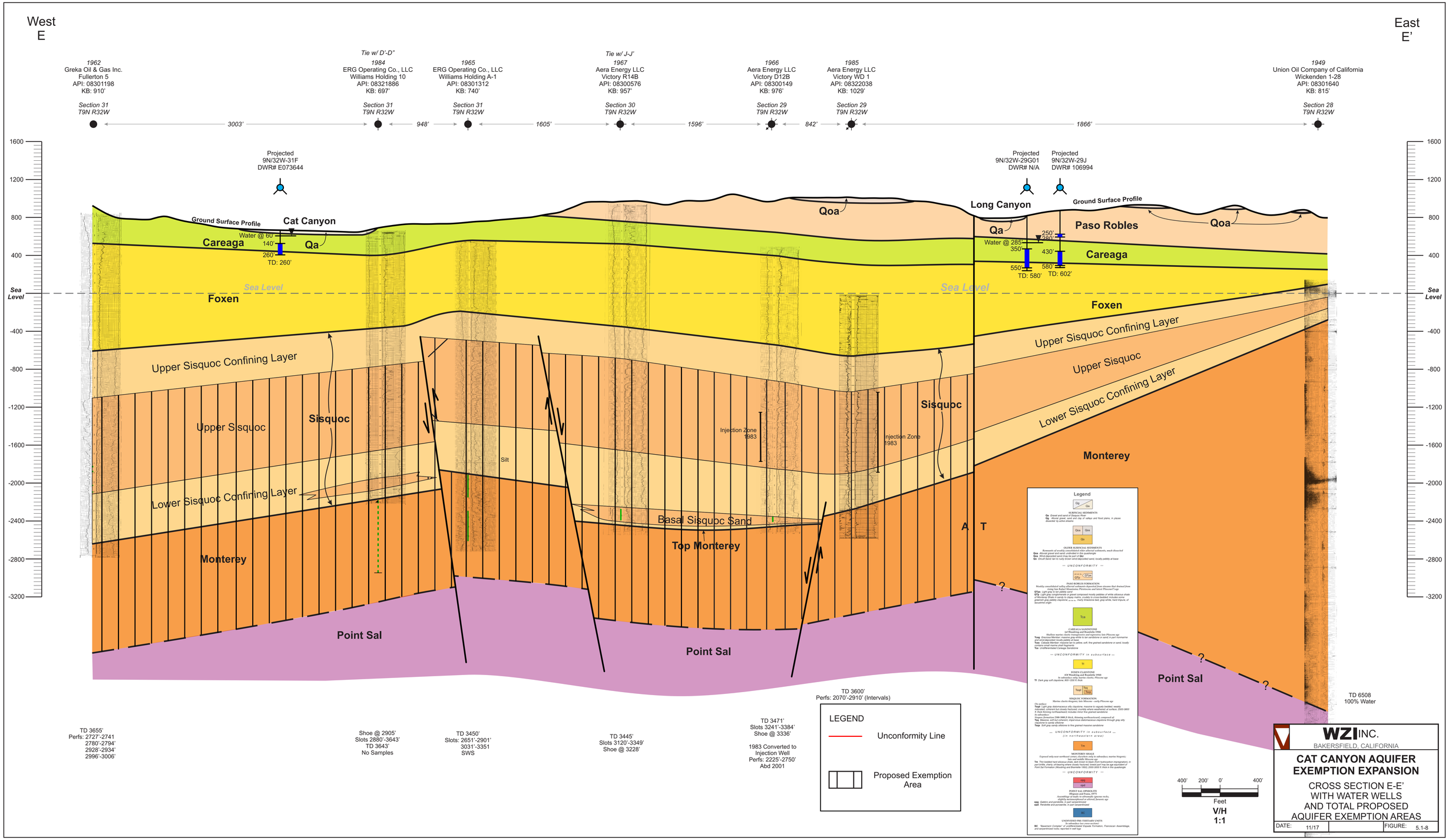

Southwest
C
Northeast
C'
1971
ERG Operating Co., LLC
Los Alamos 200
API: 08320412
KB: 742'
Section 18
T8N R32W
1977
ERG Operating Co., LLC
Los Alamos 1-7
API: 08321129
KB: 865'
Section 7
T8N R32W
1949
B.E. Conway Energy Inc.
Magenheimer A2-1
API: 08301153
KB: 1058'
Section 5
T8N R32W
1959
B.E. Conway Energy Inc.
Magenheimer A3
API: 08301222
KB: 1210'
Section 5
T8N R32W
Tie w/ D-D'
1943
ERG Operating Co., LLC
Texas 2
API: 08301217
KB: 1424'
Section 4
T8N R32W
1937
Greka Oil & Gas Inc.
Union-Continental 2
API: 08301202
KB: 1464'
Section 4
T8N R32W
1937
Stewart-Carter Oil Co.
Burton 1
API: 08301003
KB: 1120'
Section 4
T8N R32W
1967
Kenneth H. Hunter
Wickenden 85X-33
API: 08321464
KB: 956'
Section 33
T9N R32W
4116'
5392'
1600'
2184'
932'
2343'
4578'
Projected
9N/32W-33P1
DWR# E0098202
Projected
9N/32W-33P2
DWR# 1079307
Projected
9N/32W-33K
DWR# N/A
Projected
9N/32W-33R2
DWR# 1079321
Projected
9N/32W-33R3
DWR# 1079322
Gato Ridge
Anticline
Cat Canyon
Anticline
Ground Surface Profile
Careaga
Foxen
Upper Sisquoc
Confining Layer
Sea Level
Upper Sisquoc
Lower Sisquoc
Confining Layer
Basal Sisquoc Sand "Santa Margarita"
Sisquoc
"Santa Margarita"
Monterey
Point Sal
Bradley Canyon Fault
A T
Elog 1005'-4080'
TD 7188'
Convert to Water Well
Plug w/ Cement: 1067'-932'
4110'-4010'
TD 5750'
TVD: 5654'
Slots: 4267'-5637'
Injection Well 1979
2221'-2612' Sisquoc
Abd 1992
Produced Some
Oil 1977-1978
TD 4240'
Perf's: 3585'-4237'
Prod 100% Water w/ trace oil
Convert to Water Injection
in October 2005
TD 2982'
Never Produced
Perf: 1338'-1368'
1451'-1461'
1629'-1654'
1847'-1867'
1936'-1956'
2846'-2925'
Convert to WD
in 1976
TD 4015'
Slots: 3269'-4011'
TD 4418
Slots: 3414'-3714'
TD 3615'
No Log
Never Produced
TD 4866'
Slotted: 3173'-4840' (Interval)
Index Map
Legend
Study Area
1973-1974 Productive Boundary
Other Oilfield
Proposed Expanded Exemption Boundary
LEGEND
Unconformity Line
Proposed Exemption Area
400' 200' 0' 400'
Feet
V/H
1:1
WZI INC.
BAKERSFIELD, CALIFORNIA
CAT CANYON AQUIFER
EXEMPTION EXTENSION
CROSS SECTION C-C'
WITH WATER WELLS
AND TOTAL PROPOSED
AQUIFER EXEMPTION AREAS
DATE: 11/17
FIGURE: 5.1-6



Northwest
D
Southeast
D'
Ground Surface Profile
Sea Level
Paso Robles
Careaga
Foxen
Claystone
Sisquoc
Upper Sisquoc Confining Layer
Upper Sisquoc
Lower Sisquoc Confining Layer
Monterey
Point Sal
Bradley Canyon Fault
Basal Sisquoc Sand
Thomas
"Santa Margarita"
Index Map
LEGEND
Unconformity Line
Total Proposed Exemption Area
WZI INC.
CAT CANYON AQUIFER EXEMPTION EXPANSION
CROSS SECTION D-D'
WITH WATER WELLS
AND TOTAL PROPOSED
AQUIFER EXEMPTION AREAS



Northwest
D'
Southeast
D''
Ground Surface Profile
Careaga
Foxen
Upper Sisquoc Confining Layer
Upper Sisquoc
Sisquoc
Lower Sisquoc Confining Layer
"Santa Margarita"
Basal Sisquoc Sand
Monterey
Point Sal
Paso Robles
Sea Level
Sea Level
Legend
Index Map
LEGEND
Unconformity Line
Proposed Exemption Area
WZI INC.
BAKERSFIELD, CALIFORNIA
CAT CANYON AQUIFER EXEMPTION EXPANSION
CROSS SECTION D'-D'' WITH WATER WELLS AND TOTAL PROPOSED AQUIFER EXEMPTION AREAS
DATE: 11/17
FIGURE: 5.1-7 b

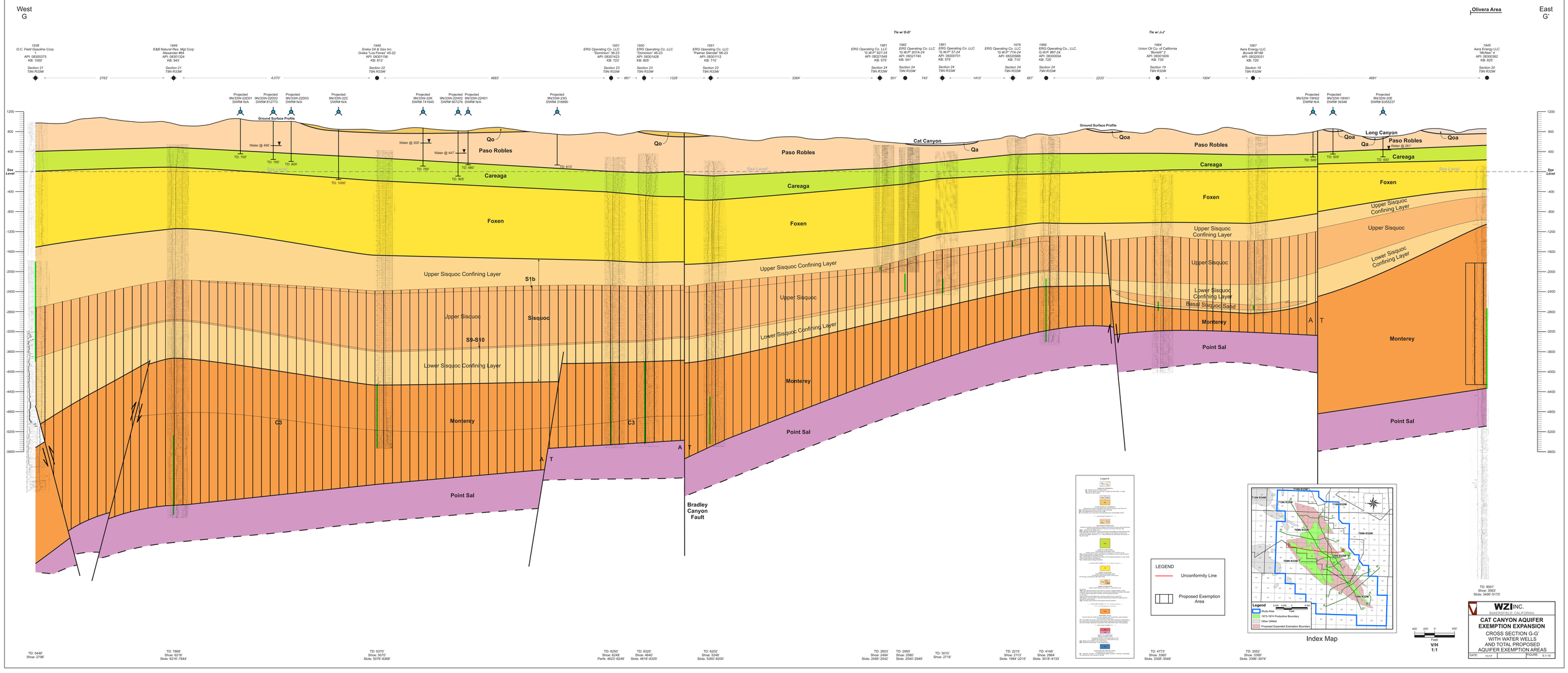

West
E
East
E'
1962
Greka Oil & Gas Inc.
Fullerton 5
API: 08301198
KB: 910'
Section 31
T9N R32W
Tie w/ D'-D"
1984
ERG Operating Co., LLC
Williams Holding 10
API: 08321886
KB: 697'
Section 31
T9N R32W
1965
ERG Operating Co., LLC
Williams Holding A-1
API: 08301312
KB: 740'
Section 31
T9N R32W
Tie w/ J-J'
1967
Aera Energy LLC
Victory R14B
API: 08300576
KB: 957'
Section 30
T9N R32W
1966
Aera Energy LLC
Victory D12B
API: 08300149
KB: 976'
Section 29
T9N R32W
1985
Aera Energy LLC
Victory WD 1
API: 08322038
KB: 1029'
Section 29
T9N R32W
1949
Union Oil Company of California
Wickenden 1-28
API: 08301640
KB: 815'
Section 28
T9N R32W
3003'
948'
1605'
1596'
842'
1866'
1600
1200
800
400
Sea Level
-400
-800
-1200
-1600
-2000
-2400
-2800
-3200
Projected
9N/32W-31F
DWR# E073644
Projected
9N/32W-29G01
DWR# N/A
Projected
9N/32W-29J
DWR# 106994
Ground Surface Profile
Cat Canyon
Water @ 60'
140'
260'
TD: 260'
Careaga
Qa
Qoa
Long Canyon
Ground Surface Profile
Qa
Paso Robles
Qoa
250'
280'
Water @ 285'
350'
430'
Careaga
550'
TD: 580'
580'
TD: 602'
Sea Level
Sea Level
Foxen
Foxen
Upper Sisquoc Confining Layer
Upper Sisquoc Confining Layer
Upper Sisquoc
Lower Sisquoc Confining Layer
Upper Sisquoc
Sisquoc
Sisquoc
Injection Zone
1983
Injection Zone
1983
Silt
Lower Sisquoc Confining Layer
Basal Sisquoc Sand
Top Monterey
Monterey
Monterey
A
T
Point Sal
Point Sal
Point Sal
?
?
?
TD 3655'
Perfs: 2727'-2741
2780'-2794'
2928'-2934'
2996'-3006'
Shoe @ 2905'
Slots 2880'-3643'
TD 3643'
No Samples
TD 3450'
Slots: 2651'-2901'
3031'-3351
SWS
TD 3445'
Slots 3120'-3349'
Shoe @ 3228'
TD 3471'
Slots 3241'-3384'
Shoe @ 3336'
1983 Converted to
Injection Well
Perfs: 2225'-2750'
Abd 2001
TD 3600'
Perfs: 2070'-2910' (Intervals)
TD 6508
100% Water
LEGEND
Unconformity Line
Proposed Exemption Area
Legend
Qg
Qal
SURFICIAL SEDIMENTS
Qa Gravel and sand of Sisquoc River
Qg Alluvial gravel, sand and clay of valleys and flood plains, in places dissected by active streams
Qoa
Qos
Qo
OLDER SURFICIAL SEDIMENTS
Remnants of weakly consolidated older alluvial sediments, much dissected
Qoa Alluvial gravel, sand and clay of Paso Robles Formation
Qos Wind-deposited sand (may be part of Qa)
Qo Orcutt Sand: tan to rusty brown wind-deposited sand, locally pebbly at base
— U N C O N F O R M I T Y —
PASO ROBLES FORMATION
Weakly consolidated sediments of alluvial fans and flow-stresses that derived from rising San Rafael Mountains; Pleistocene and latest Pliocene(?) age
QTpr Light gray to tan pebbly sand
Tpr Paso Robles Formation: varied composed mostly pebbles of white siliceous shale of Monterey Shale in sandy to clayey matrix, crudely to cross-bedded; includes some greenish gray pebbly claystone; locally, marly limestone bed; gray-white, hard tripoli, of lacustrine origin
Tca
CAREAGA SANDSTONE
(of Woodring and Bramlette 1950)
Shallow marine clastic transgressive and regressive; late Pliocene age
Tcmp Orcutt Member: massive to tan sandstone or sand; in part nonmarine and wind-deposited; locally pebbly at base
Tcac Cebada Member: massive tan to yellow, soft, fine grained sandstone or sand; locally pebbly at base; marine to nonmarine
Tca Undifferentiated Careaga Sandstone
— U N C O N F O R M I T Y i n s u b s u r f a c e —
Tf
FOXEN CLAYSTONE
(Of Woodring and Bramlette 1950)
In subsurface only; Miocene to Pliocene age
Tf Dark gray soft claystone; MZ-1202 E Area
Tsqc
Tsq
Tsqu
SISQUOC FORMATION
Marine clastic-biogenic; late Miocene - early Pliocene age
On surface:
Tsqc Light gray diatomaceous silty claystone, massive to vaguely bedded; weakly indurated; coherent but closely fractured; crumbly where weathered; at surface, ZSS-3850 is a strong northeastward; includes minor fine grained sandstone
In subsurface:
Tsqsu Sisquoc formation 2100-3000 ft BGS, thinning northeastward; composed of: Tsqu Upper Sisquoc Confining Layer: impervious diatomaceous claystone through gray silty claystone to sandy siltstone
Tsqs Soft gray sandy siltstone to fine grained massive sandstone
— U N C O N F O R M I T Y i n s u b s u r f a c e —
(in northeastern area)
Tm
MONTEREY SHALE
Exposed only near northeast corner; characters only in subsurface; marine biogenic; late Miocene age
Tm Thin bedded hard siliceous shale, dark brown to black (from hydrocarbon impregnation); in part brittle, chary; oil-bearing where closest; fractured; lowest part may be age equivalent of Point Sal Formation (Mesalna and Vaqueros Formations); only rock in this quadrangle
— U N C O N F O R M I T Y —
ppb
opd
POINT SAL OPHIOLITE
(Point Sal Formation)
Assemblage of mostly to ultramafic igneous rocks, slightly metamorphosed or altered; Jurassic age
ppg Gabbro and pyroxenite, in part layered
ppd Peridotite and pyroxenite, in part serpentinized
PC
UNDIVIDED PRE-TERTIARY UNITS
In subsurface (see cross-sections)
BC "Basement Complex" = Franciscan Assemblage, Salinas Formation, Franciscan Assemblage, and serpentinized rocks; reported in well logs
400'
200'
0'
400'
Feet
V/H
1:1
WZI INC.
BAKERSFIELD, CALIFORNIA
CAT CANYON AQUIFER
EXEMPTION EXPANSION
CROSS SECTION E-E'
WITH WATER WELLS
AND TOTAL PROPOSED
AQUIFER EXEMPTION AREAS
DATE: 11/17
FIGURE: 5.1-8

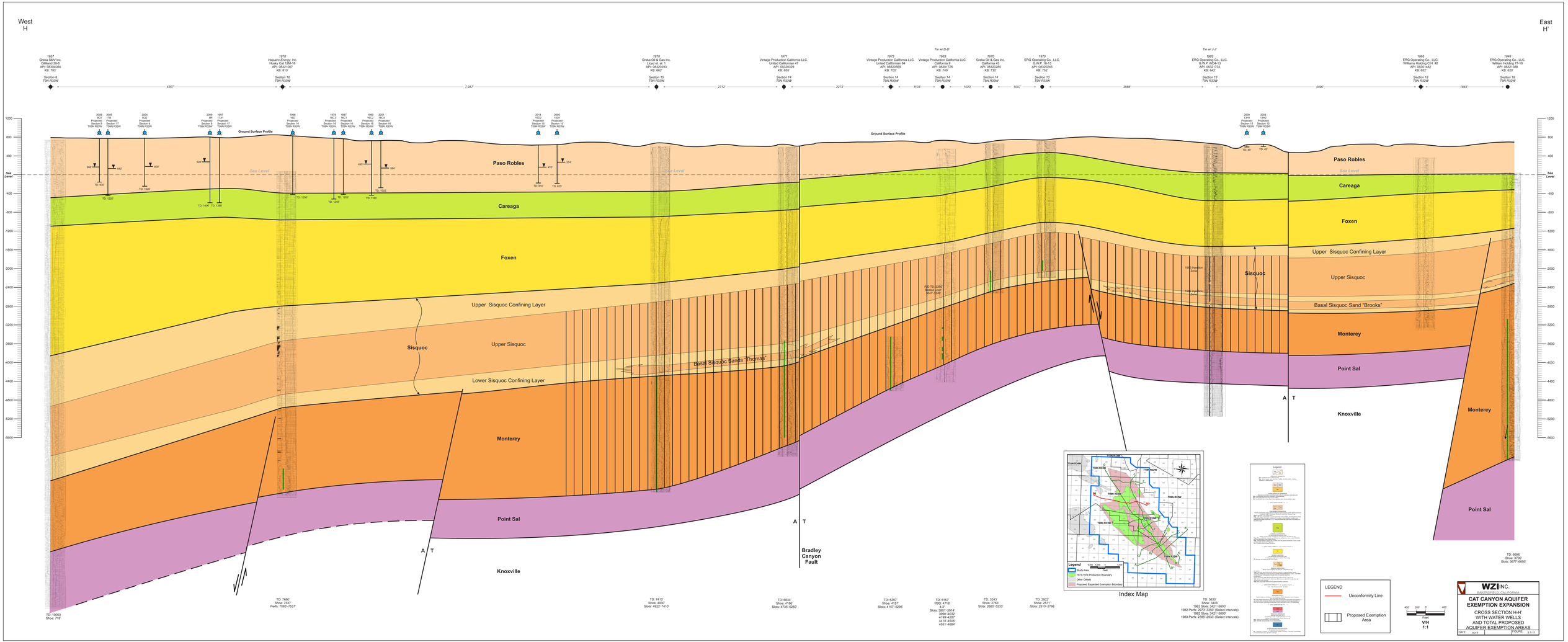
WZI INC.
BAKERSFIELD, CALIFORNIA

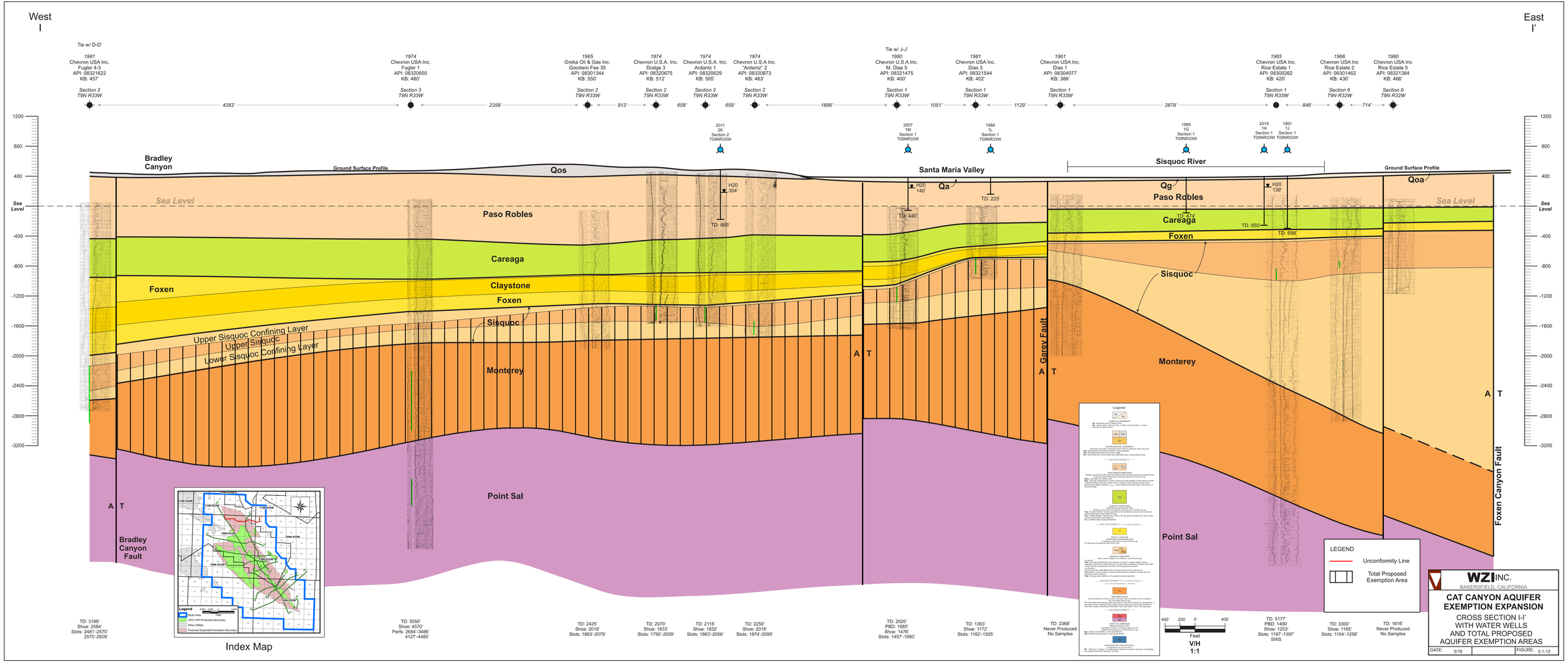
CAT CANYON AQUIFER EXEMPTION EXPANSION

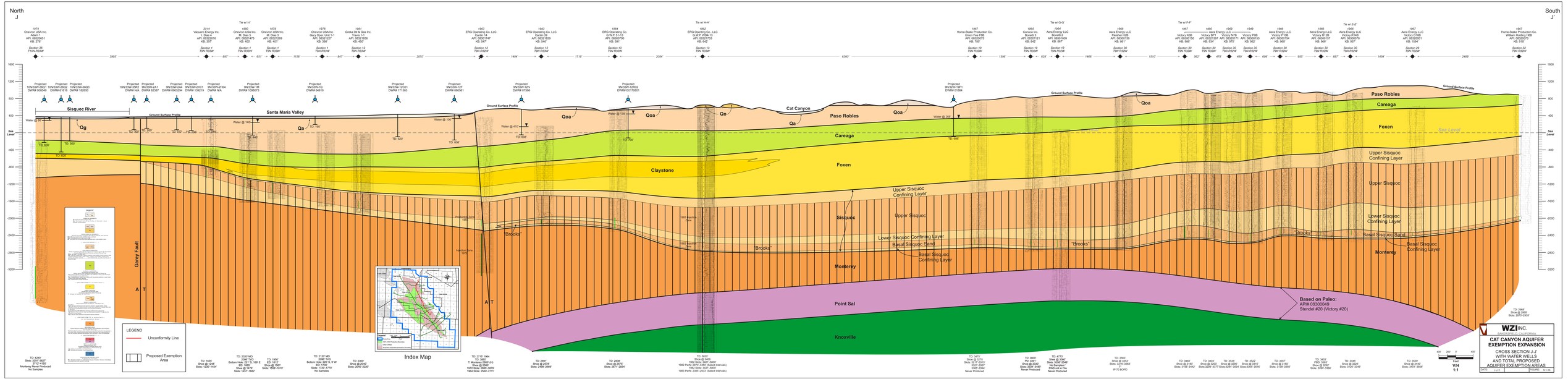
CROSS SECTION F-F'
WITH WATER WELLS
AND TOTAL PROPOSED
AQUIFER EXEMPTION AREAS

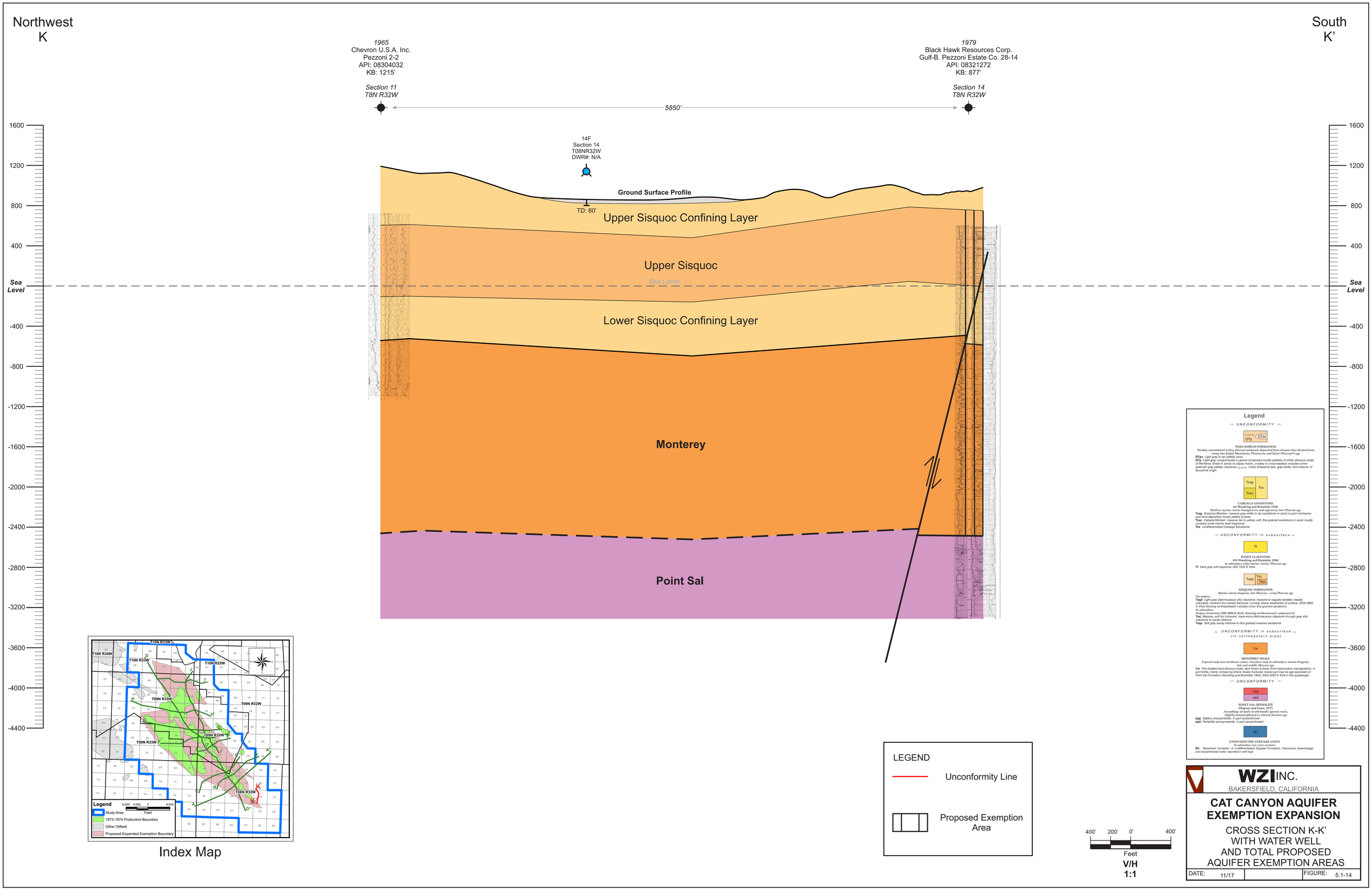
DATE: 11/17		FIGURE: 5.1-9


West
G
East
G'
Olivera Area
Tie w/ D-D'
Tie w/ J-J'
Ground Surface Profile
Paso Robles
Careaga
Foxen
Upper Sisquoc Confining Layer
Upper Sisquoc
Lower Sisquoc Confining Layer
Basal Sisquoc Sand
Monterey
Point Sal
Sisquoc
S1b
S9-S10
C3
Qo
Qa
Qoa
Cat Canyon
Long Canyon
Bradley Canyon Fault
Sea Level
LEGEND
Unconformity Line
Proposed Exemption Area
Index Map
Legend
Study Area
1973-1974 Productive Boundary
Other Oilfield
Proposed Expanded Exemption Boundary
Feet
V/H
1:1
WZI INC.
BAKERSFIELD, CALIFORNIA
CAT CANYON AQUIFER EXEMPTION EXPANSION
CROSS SECTION G-G'
WITH WATER WELLS
AND TOTAL PROPOSED
AQUIFER EXEMPTION AREAS
DATE: 11/17
FIGURE: 5.1-10


West
H
East
H'
Tie w/ D-D'
Tie w/ J-J'
1957
Greka SMV Inc.
Gilliland 36-8
API: 08304084
KB: 793
Section 8
T9N R33W
1976
Vaquero Energy, Inc.
Husky Cat 12M-16
API: 08321007
KB: 810
Section 16
T9N R33W
1970
Greka Oil & Gas Inc.
Lloyd et. al. 1
API: 08320293
KB: 662
Section 15
T9N R33W
1971
Vintage Production California LLC.
United Californian 47
API: 08320329
KB: 655
Section 14
T9N R33W
1973
Vintage Production California LLC.
United Californian 84
API: 08320569
KB: 700
Section 14
T9N R33W
1963
Vintage Production California LLC.
California 9
API: 08301726
KB: 749
Section 14
T9N R33W
1970
Greka Oil & Gas Inc.
California 43
API: 08320285
KB: 730
Section 14
T9N R33W
1970
ERG Operating Co., LLC.
G.W.P. 16-13
API: 08320340
KB: 752
Section 13
T9N R33W
1982
ERG Operating Co., LLC.
G.W.P. WD4-13
API: 08321753
KB: 642
Section 13
T9N R33W
1965
ERG Operating Co., LLC.
Williams Holding C.H. #2
API: 08301452
KB: 652
Section 18
T9N R32W
1948
ERG Operating Co., LLC.
William Holding 77-18
API: 08301388
KB: 620
Section 18
T9N R32W
4300'
7,957'
2712'
2273'
1103'
1023'
1097'
3566'
4490'
1948'
2008 2005
Projected Projected
Section 8 Section 17
T09N R32W T09N R32W
2004
Projected
Section 8
T09N R32W
2009 1997
Projected Projected
Section 9 Section 1
T09N R32W T09N R32W
1996
Projected
Section 16
T09N R32W
1978 1987
Projected Projected
Section 16 Section 16
T09N R32W T09N R32W
1999 2001
Projected Projected
Section 16 Section 16
T09N R32W T09N R32W
2014 2005
Projected Projected
Section 15 Section 15
T09N R32W T09N R32W
2009 2003
Projected Projected
Section 13 Section 13
T09N R32W T09N R32W
Ground Surface Profile
Ground Surface Profile
1200
800
400
Sea Level
-400
-800
-1200
-1600
-2000
-2400
-2800
-3200
-3600
-4000
-4400
-4800
-5200
-5600
602'
642'
800'
528'
451'
584'
370'
374'
TD: 930'
TD: 1020'
TD: 1240'
TD: 1400'
TD: 1399'
TD: 1280'
TD: 1240'
TD: 1290'
TD: 1390'
TD: 1082'
TD: 810'
TD: 820'
TD: 48'
TD: 45'
Paso Robles
Careaga
Foxen
Upper Sisquoc Confining Layer
Upper Sisquoc
Basal Sisquoc Sands "Thomas"
Lower Sisquoc Confining Layer
Sisquoc
Monterey
Point Sal
Knoxville
Bradley Canyon Fault
A T
A T
1963 Injection Zone
1963 Injection Zone
Sisquoc
Upper Sisquoc Confining Layer
Basal Sisquoc Sand "Brooks"
Paso Robles
Careaga
Foxen
Upper Sisquoc
Monterey
Point Sal
Knoxville
Monterey
Point Sal
TD: 10003
Shoe: 718'
TD: 7680'
Shoe: 7537'
Perfs: 7083'-7537'
TD: 7410'
Shoe: 4892'
Slots: 4922'-7410'
TD: 6634'
Shoe: 4198'
Slots: 4735'-6250'
TD: 5297'
Shoe: 4157'
Slots: 4157'-5250'
TD: 5157'
PBD: 4719'
4.3"
Slots: 3801'-3914'
3918'-3966'
4199'-4232'
4416'-4506'
4557'-4664'
TD: 3243'
Shoe: 2763'
Slots: 2660'-3233'
TD: 2922'
Shoe: 2571'
Slots: 2810'-2798'
TD: 5830'
Shoe: 3436'
1962 Slots: 3421'-5800'
1982 Perfs: 2973'-3302' (Select Intervals)
1982 Slots: 3421'-5800'
1983 Perfs: 2385'-2933' (Select Intervals)
TD: 6696'
Shoe: 3700'
Slots: 3677'-6695'
Index Map
T10N R24W
T10N R23W
T10N R22W
T10N R21W
T9N R24W
T9N R23W
T9N R22W
T9N R21W
T8N R24W
T8N R23W
T8N R22W
T8N R21W
Legend
Study Area
1973-1974 Productive Boundary
Other Oilfield
Proposed Expanded Exemption Boundary
Legend
LEGEND
Unconformity Line
Proposed Exemption Area
400' 200' 0' 400'
Feet
VH
1:1
WZI INC.
WATER SERVICE SOLUTIONS
CAT CANYON AQUIFER EXEMPTION EXPANSION
CROSS SECTION H-H'
WITH WATER WELLS
AND TOTAL PROPOSED
AQUIFER EXEMPTION AREAS
DATE: 10.2.21
FIGURE: 5-3-15


West
I
East
I'
Tie w/ D-D'
1981
Chevron USA Inc.
Fugler 4-3
API: 08321622
KB: 457'
Section 3
T9N R33W
1974
Chevron USA Inc.
Fugler 1
API: 08320650
KB: 480'
Section 3
T9N R33W
1965
Greka Oil & Gas Inc.
Goodwin Fee 30
API: 08301344
KB: 550'
Section 2
T9N R33W
1974
Chevron U.S.A. Inc.
Dodge 3
API: 08320675
KB: 512'
Section 2
T9N R33W
1974
Chevron U.S.A. Inc.
Ardantz 1
API: 08320629
KB: 505'
Section 2
T9N R33W
1974
Chevron U.S.A Inc.
"Ardantz" 2
API: 08320673
KB: 483'
Section 2
T9N R33W
Tie w/ J-J'
1980
Chevron U.S.A Inc.
M. Dias 5
API: 08321475
KB: 400'
Section 1
T9N R33W
1981
Chevron USA Inc.
Dias 3
API: 08321544
KB: 402'
Section 1
T9N R33W
1961
Chevron USA Inc.
Dias 1
API: 08304077
KB: 386'
Section 1
T9N R33W
1965
Chevron USA Inc.
Rice Estate 1
API: 08300262
KB: 420'
Section 1
T9N R33W
1966
Chevron USA Inc
Rice Estate 2
API: 08301462
KB: 430'
Section 6
T9N R32W
1980
Chevron USA Inc
Rice Estate 5
API: 08321384
KB: 466'
Section 6
T9N R32W
4283'
2358'
913'
658'
659'
1896'
1051'
1129'
2879'
846'
714'
2011
2K
Section 2
T09NR33W
2007
1M
Section 1
T09NR33W
1988
1L
Section 1
T09NR33W
1988
1G
Section 1
T09NR33W
2015
1H
Section 1
T09NR33W
1991
1J
Section 1
T09NR33W
1200
800
400
Sea Level
-400
-800
-1200
-1600
-2000
-2400
-2800
-3200
Bradley Canyon
Ground Surface Profile
Qos
Santa Maria Valley
Sisquoc River
Ground Surface Profile
Qoa
Sea Level
Paso Robles
Qg
Qa
H20
304'
TD: 665'
H20
140'
TD: 440'
TD: 225'
H20
139'
TD: 474'
TD: 650'
TD: 698'
Careaga
Foxen
Claystone
Foxen
Sisquoc
Upper Sisquoc Confining Layer
Upper Sisquoc
Lower Sisquoc Confining Layer
Monterey
Point Sal
A T
Bradley Canyon Fault
Garey Fault
Foxen Canyon Fault
Index Map
Legend
Study Area
1975-1974 Productive Boundary
Other Oilfield
Proposed Expanded Exemption Boundary
Legend
Unconformity Line
Total Proposed Exemption Area
400'
200'
0'
400'
Feet
V/H
1:1
TD: 3188'
Shoe: 2584'
Slots: 2481'-2570'
2570'-2609'
TD: 5050'
Shoe: 4570'
Perfs: 2684'-3486'
4127'-4480'
TD: 2425'
Shoe: 2018'
Slots: 1863'-2078'
TD: 2070'
Shoe: 1833'
Slots: 1792'-2039'
TD: 2115'
Shoe: 1832'
Slots: 1863'-2056'
TD: 2250'
Shoe: 2018'
Slots: 1974'-2095'
TD: 2020'
PBD: 1685'
Shoe: 1476'
Slots: 1457'-1680'
TD: 1363'
Shoe: 1172'
Slots: 1182'-1305'
TD: 2368'
Never Produced
No Samples
TD: 5177'
PBD: 1400'
Shoe: 1253'
Slots: 1197'-1397'
SWS
TD: 3300'
Shoe: 1165'
Slots: 1104'-1258'
TD: 1616'
Never Produced
No Samples
WZI INC.
BAKERSFIELD, CALIFORNIA
CAT CANYON AQUIFER
EXEMPTION EXPANSION
CROSS SECTION I-I'
WITH WATER WELLS
AND TOTAL PROPOSED
AQUIFER EXEMPTION AREAS
DATE: 5/18
FIGURE: 5.1-12


North
J
South
J'
Tie w/ I-I'
Tie w/ H-H'
Tie w/ G-G'
Tie w/ F-F'
Tie w/ E-E'
1974 Chevron USA Inc. Adam 1 API: 08320651 KB: 278' Section 36 T10N R23W
1972 Vaquero Energy Inc. U Dias 4-1 API: 08320816 KB: 397' Section 1 T9N R23W
1969 Chevron USA Inc. M. Dias 5 API: 08321475 KB: 402' Section 1 T9N R23W
1979 Chevron USA Inc. M. Dias 3 API: 08321289 KB: 401' Section 1 T9N R23W
1978 Chevron USA Inc. Gary Oper. Unit 1-1 API: 08321227 KB: 398' Section 1 T9N R23W
1991 Greka Oil & Gas Inc. Travis 1-1 API: 08321656 KB: 450' Section 12 T9N R23W
1983 ERG Operating Co. LLC Cardin 14 API: 08301747 KB: 547' Section 12 T9N R23W
1983 ERG Operating Co. LLC Cardin 3A API: 08321859 KB: 546' Section 12 T9N R23W
1982 ERG Operating Co. G.R.P. W3A-13 API: 08300700 KB: 591' Section 13 T9N R23W
1982 ERG Operating Co., LLC G.R.P. W2A-13 API: 08321733 KB: 542' Section 13 T9N R23W
1967 Home-Stake Production Co. Union Fee F8B API: 08320075 KB: 785' Section 19 T9N R23W
1955 Cuyama Inc. Bonelli 3 API: 08301121 KB: 842' Section 19 T9N R23W
1964 Aera Energy LLC Bonelli 2 API: 08301609 KB: 785' Section 19 T9N R23W
1968 Aera Energy LLC Fleisher H2B API: 08300139 KB: 861' Section 30 T9N R23W
1967 Victory H8B API: 08300150 KB: 986' Section 30 T9N R23W
1965 Aera Energy LLC Victory BP1 API: 08321587 KB: 934' Section 30 T9N R23W
1969 Victory NTB API: 08320171 KB: 975' Section 30 T9N R23W
1949 Victory PIB API: 08300153 KB: 962' Section 30 T9N R23W
1996 Aera Energy LLC Victory F12B API: 08300154 KB: 968' Section 30 T9N R23W
1996 Aera Energy LLC Victory E12B API: 08300157 KB: 960' Section 30 T9N R23W
1996 Aera Energy LLC Victory E10B API: 08300576 KB: 957' Section 30 T9N R23W
1997 Aera Energy LLC Victory D16B API: 08320001 KB: 1094' Section 29 T9N R23W
1967 Home-Stake Production Co. William Holding H6B API: 08320073 KB: 918' Section 32 T9N R23W
Sisquoc River
Santa Maria Valley
Ground Surface Profile
Cat Canyon
Paso Robles
Careaga
Foxen
Sea Level
Upper Sisquoc Confining Layer
Upper Sisquoc
Lower Sisquoc Confining Layer
Basal Sisquoc Sand
Basal Sisquoc Confining Layer
Monterey
Point Sal
Knoxville
Claystone
Sisquoc
Qg
Qa
Qoa
Qo
Grey Fault
A T
"Brooks"
Rincon Zone 1983
Rincon Zone 1982
Weldon Zone 1972
Based on Paleo:
AP#8 08320049
Stendel #20 (Victory #20)
Legend
LEGEND
Unconformity Line
Proposed Exemption Area
Index Map
WZI INC.
CAT CANYON AQUIFER EXEMPTION EXPANSION
CROSS SECTION J-J'
WITH WATER WELLS
AND TOTAL PROPOSED AQUIFER EXEMPTION AREAS
DATE 12/4/18
DRAWN 8.1/13
VH 1:1



Northwest
K
South
K'
1965
Chevron U.S.A. Inc.
Pezzoni 2-2
API: 08304032
KB: 1215'
Section 11
T8N R32W
1979
Black Hawk Resources Corp.
Gulf-B. Pezzoni Estate Co. 28-14
API: 08321272
KB: 877'
Section 14
T8N R32W
5850'
14F
Section 14
T08NR32W
DWR#: N/A
Ground Surface Profile
TD: 60'
Upper Sisquoc Confining Layer
Upper Sisquoc
Sea Level
Lower Sisquoc Confining Layer
Monterey
Point Sal
1600
1200
800
400
Sea Level
-400
-800
-1200
-1600
-2000
-2400
-2800
-3200
-3600
-4000
-4400
Legend
UNCONFORMITY
QTp
QTps
PASO ROBLES FORMATION
Weakly consolidated valley alluvial sediments deposited from streams that drained from rising San Rafael Mountains; Pleistocene and latest Pliocene(?) age
QTps Light gray to tan pebbly sand
QTp Light gray conglomerate or gravel composed mostly pebbles of white siliceous shale of Monterey Shale in sandy to clayey matrix, crudely to cross-bedded; includes some greenish gray pebbly claystone; ... marly limestone bed, gray-white, hard impure, of lacustrine origin
Tcag
Tca
Tcac
CARRAGA SANDSTONE
(of Woodring and Bramlette 1950)
Shallow marine clastic transgressive and regressive; late Pliocene age
Tcag Gracious Member: massive gray-white to tan sandstone or sand; in part nonmarine and wind-deposited; locally pebbly at base
Tcac Cebada Member: massive tan to yellow, soft, fine grained sandstone or sand, locally contains small marine shell fragments
Tca Undifferentiated Careaga Sandstone
UNCONFORMITY in subsurface
Tf
FOXEN CLAYSTONE
(Of Woodring and Bramlette 1950)
In subsurface only; marine clastic; Pliocene age
Tf Dark gray soft claystone; 900-1200 ft. thick
Tsqd
Tsq
Tsqs
SISQUOC FORMATION
Marine clastic-biogenic; late Miocene - early Pliocene age
On surface:
Tsqd Light gray diatomaceous silty claystone, massive to vaguely bedded, weakly indurated, coherent but closely fractured, crumbly where weathered; at surface, 2500-3800 ft. thick thinning northeastward; includes minor fine grained sandstone
In subsurface:
Sisquoc formation 2500-3000 ft thick, thinning northeastward, composed of:
Tsq Massive, soft but coherent, impervious diatomaceous claystone through gray silty claystone to sandy siltstone
Tsqs Soft gray sandy siltstone to fine grained massive sandstone
UNCONFORMITY in subsurface
(in northeastern area)
Tm
MONTEREY SHALE
Exposed only near northeast corner, elsewhere only in subsurface; marine biogenic; late and middle Miocene age
Tm Thin-bedded hard siliceous shale, dark brown to black (from hydrocarbon impregnation); in part brittle, cherty; oil-bearing where closely fractured; lowest part may be age equivalent of Point Sal Formation (Woodring and Bramlette 1950); 2000-3000 ft. thick in this quadrangle
UNCONFORMITY
opg
opd
POINT SAL OPHIOLITE
(Hopson and Frano, 1977)
Assemblage of mafic to ultramafic igneous rocks, slightly metamorphosed or altered; Jurassic age
opg Gabbro and peridotite, in part serpentinized
opd Peridotite and pyroxenite, in part serpentinized
BC
UNDIVIDED PRE-TERTIARY UNITS
In subsurface (see cross-section)
BC "Basement Complex" of undifferentiated Espada Formation, Franciscan Assemblage, and serpentinized rocks; reported in well logs
T10N R34W
T10N R33W
T10N R32W
T09N R33W
T09N R32W
T08N R32W
Legend
Study Area
1973-1974 Productive Boundary
Other Oilfield
Proposed Expanded Exemption Boundary
Feet
Index Map
LEGEND
Unconformity Line
Proposed Exemption Area
400' 200' 0' 400'
Feet
V/H
1:1
WZI INC.
BAKERSFIELD, CALIFORNIA
CAT CANYON AQUIFER EXEMPTION EXPANSION
CROSS SECTION K-K'
WITH WATER WELL
AND TOTAL PROPOSED
AQUIFER EXEMPTION AREAS
DATE: 11/17
FIGURE: 5.1-14

The water wells are generally screened within the Alluvium, Paso Robles, Careaga and Foxen Formations. To the south of Gato Ridge Area, there are two water wells completed in the upper portion of the Sisquoc confining layer. **Figure 5.1-14, Cross Section K-K'**, was constructed specifically to illustrate the relationship of the confinement between the oil producing strata and these water wells. In addition **Figure 5.1-6, Cross Section C-C' with water wells and total proposed aquifer exemption areas** shows the same condition of a water well completed in the upper portion of the Sisquoc confining layer.[11] The maximum water well depth in the study area is approximately 1400 feet below ground, in the Careaga zone. No irrigation or drinking water supply wells are completed within the confined Exemption Expansion formations in the exemption expansion boundaries.

Community Service Water Wells

The proposed Aquifer Exemption Expansion Study Area covers a wide area with distinct oil field relationships to communities. Gato Ridge, which extends to the southeast of the main body of the field, is closer to Los Alamos CDP while the remainder of the areas are closer to the communities of Garey CDP and Sisquoc CDP.

The nearest municipal well to the proposed exemption area is (LACSD Well #5, No. 421002-007) located on Gonzalez Street in Los Alamos CDP, adjacent to the southern edge of the study area. There are also water wells serving as drinking water within the study area. Well #5 is 1000 feet deep and is located 8 miles from the centrus of the Cat Canyon Oil Field Aquifer Exemption study area, (Bernard, Letter to B. Falkenhagen, 2016), (Bernard, Los Alamos CDP, Director Public Works, 2017). However, two other wells (4210002-003 and -004) are situated nearly equidistant from the operational field boundary of the Gato Ridge Area approximately 3 miles away, **Appendix 6-I, Treatment Feasibility Study**, (GeoTracker, 2017). A fourth well is identified as Well Name 4210002-002 which is in a remote agricultural location 1.4 miles from the nearest point of contact with the Community Service District (CSD) Boundary of the Los Alamos CDP was not reported as used for community service, (Bernard, Los Alamos CDP, Director Public Works, 2017).

[11] The drilling records document the entry into the clay of the upper confining layer.

Table 5.1-2, Water Wells Serving Target Communities identifies the nearest community service wells to the study area.

Table 5.1-2:Community Service Provider Water Wells Serving Target Communities					
Los Alamos CDP GeoTracker GAMA Community Well Locations[12]					
DATASET	WELL ID	WELL NAME	STREET	LATITUDE	LONGITUDE
DHS	W0604210002	4210002-003	Bell St.	34.74075	-120.27036
DHS	W0604210002	4210002-004	Price Ranch	34.73937	-120.26542
DHS	W0604210002	4210002-007	Gonzalez St.	34.74710	-120.28228
		420002-002			
Sisquoc CDP Community Well Locations[13]					
GSWC	Sisquoc #1	4200560-009	Foxen Cyn Rd.	34.864748	-120.29552
GSWC	No Facilities	4200560-001 and -007	Foxen Cyn. Rd	Same	Same

Gato Ridge Area
None of the community service provider's drinking water wells were found to be completed within the proposed aquifer exemption area in the Gato Ridge Area of the Cat Canyon Oil Field. The nearest community is in the Los Alamos CDP. The general distance to Los Alamos CDP from Gato Ridge Area centrus is 3.5 miles to the south by southeast.

Central, East, West and Sisquoc Areas
The community of Sisquoc is located inside the Aquifer Exemption Expansion Study Area. The community is served by Golden State Water Company which has currently inactive legacy wells within the community (which in turn is inside the proposed Aquifer Exemption Expansion Study Area). The community of Garey is served by individual residential wells, (no name given, 2017).

5.1.2 Groundwater Quality

Water quality data from sampled water wells is shown in **Table 5.1-3, Water Well - Water Quality Information**. The area-wide TDS ranged from 40mg/L to 1690 mg/L with an average of 709 (above the 500 mg/L drinking water standards); the area-wide Boron concentration ranged from non-detect to 0.75 mg/L with an average of 0.167 mg/L. Analytical data for groundwater supply wells were obtained from the numerous studies of the subject region that incorporate the study area, (Martin, 1985), (Worts & Thomasson, 1951), (Muir, 1964), (Schadt, 2015), (Golden State Water Company, 2014), (Hutchinson, 1980), (California Department of Water Resources Board, 2004), (California Department of Water Resources Board, 2004), (County S. B., 2013). This information is contained in Appendix 5-I, Water Well Data and the GAMA data are summarized in **Table 5.1-2, Water Well - Water Quality Information**. Although total depth and screened intervals are reported on some of the well completion reports, the official aquifer information is not included. Where the completion interval was known, the formation of the water well completion was designated by the professional geologist and placed

[12] Per Los Alamos CDP, Utilities Manager
[13] Per Blochman SD Superintendent (D. Brown) and Golden State Water Company Annual Report Plant Facility Index.

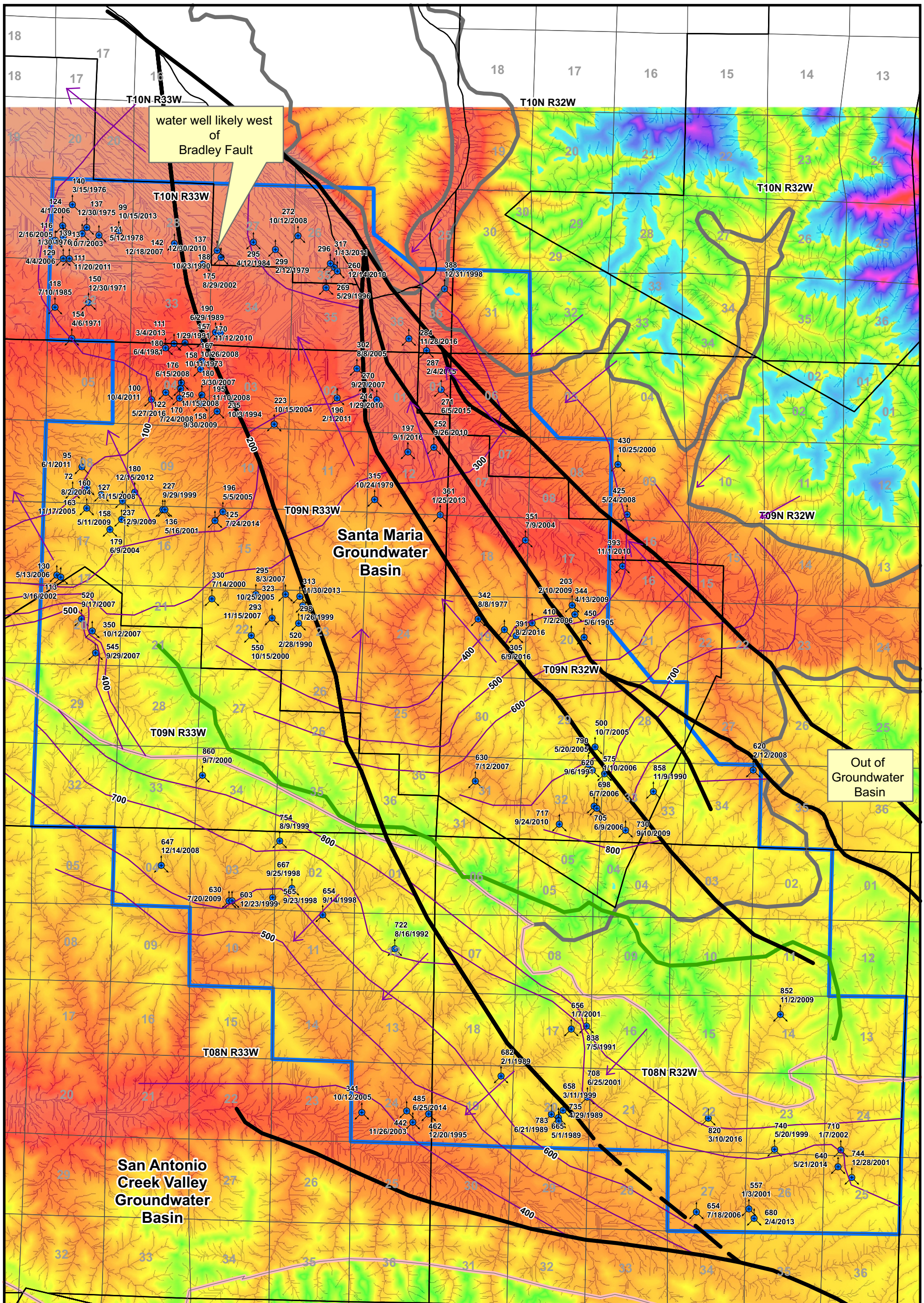
on the water well inventory. As stated previously, the water wells are screened in various formations including the Alluvium, Orcutt, Paso Robles, Careaga and Foxen Formations. The higher values are found close to the ocean and farther away from the surface recharge areas.

Table 5.1-3 Water Well - Water Quality Information		
	TDS, mg/L	Boron, mg/L
Average	709.95	0.1665
Standard Deviation	245.68	0.1162

The upper Sisquoc clay and the Foxen Formation provide confinement between the water wells and the Sisquoc producing interval which are above the producing Sisquoc Formation below the Upper Confining Layer:

Figure 5.1-4 Cross Section A-A' with water wells and total proposed aquifer exemption areas;
Figure 5.1-5 Cross Section B-B' with water wells and total proposed aquifer exemption areas;
Figure 5.1-6 Cross Section C-C' with water wells and total proposed aquifer exemption areas;
Figure 5.1-7a Cross Section D-D' with water wells and total proposed aquifer exemption areas;
Figure 5.1-7b Cross Section D'-D" with water wells and total proposed aquifer exemption areas;
Figure 5.1-8 Cross Section E-E' with water wells and total proposed aquifer exemption areas;
Figure 5.1-9 Cross Section F-F' with water wells and total proposed aquifer exemption areas;
Figure 5.1-10 Cross Section G-G' with water wells and total proposed aquifer exemption areas;
Figure 5.1-11 Cross Section H-H' with water wells and total proposed aquifer exemption areas;
Figure 5.1-12 Cross Section I-I' with water wells and total proposed aquifer exemption areas;
Figure 5.1-13 Cross Section J-J' with water wells and total proposed aquifer exemption areas; and
Figure 5.1-14 Cross Section K-K' with water wells.

The unconfined groundwater gradient in the vicinity of the study area is to the northwest and southwest, is consistent with the surface topography in this area with flows to the ocean. Well data collected within the study area as well as groundwater reports were utilized to construct a regional gradient map for the study area, **Figure 5.1-15, Unconfined Groundwater Gradient Map**.



Legend

- Surface Faults
- Water Level Contours
- Ridge Line
- Well With Water Level Data
- San Antonio Creek Valley
- Santa Maria
- Study Area

Groundwater Gradient Arrow (High) → (Low)

N W E S

6,000 3,000 0 6,000 Feet

WZI INC.
BAKERSFIELD, CALIFORNIA

CAT CANYON AQUIFER EXEMPTION EXPANSION

UNCONFINED GROUNDWATER GRADIENT MAP

DATE: 8/17 | FIGURE: 5.1-15

5.1.3 Proposed Exemption Formation Water Quality

5.1.3.1 Summary of all Cat Canyon Areas and Formations

All available formation water samples were reviewed for veracity and accuracy in terms of representing the conditions of water that would be found in the subject formations, **Appendix 5-IV, Formation Water Analysis and Data**. **Table 5.1-4, Summary of Reviewed Data by Area and Formation** show the results by Area and formation. The Sisquoc Area Monterey data was not available therefore the East Area Monterey data (mean [TDS] = 10,417 mg/L) were used as a close analog.

Table 5.1-4: Summary of Reviewed Data by Area and Formation(mg/L)

Area	Formation		TDS	B	Na	CL	SO4	HCO3	Ca	K	Mg
Sisquoc	All Sisquoc Data		10281	26	1143	3142	116	4530	118	49	207
		Std Dev.	8352	9	709	2839	211	4962	54	57	172
		Count	33	24	29	31	29	31	10	29	29
	Sisquoc: Post Steaming Production	Mean	5707	25	961	1756	75	2209	104	41	247
		Std Dev.	2422	9	426	980	46	1572	50	60	179
		Count	22	20	22	22	22	22	8	22	21
	Sisquoc: Native Sisquoc Formation	Mean	19862	34	2311	7436	295	11004	113	71	91
		Std Dev.	7558	17	1612	2269	500	6143	67	46	113
		Count	12	4	7	10	5	8	2	6	7
	Monterey	Mean	10417	7	1153	3216	57	4657	82	26	98
		Std Dev.	6445	5	798	1828	51	2395	73	23	82
		Count	14	14	14	14	14	14	6	14	12
Central	Sisquoc	Mean	10745	28	1641	4001	47	5539	29	36	21
		Std Dev.	3815	20	801	1420	22	2496	8	24	17
		Count	14	11	11	11	11	11	4	11	8
	Monterey	Mean	12314	19	1188	4033	67	5109	44	41	56
		Std Dev.	6823	22	454	1958	87	2221	7	68	37
		Count	17	7	16	16	17	17	5	16	15
East	Monterey	Mean	10417	7	1153	3216	57	4657	82	26	98
		Std Dev.	6445	5	798	1828	51	2395	73	23	82
		Count	14	14	14	14	14	14	6	14	12
	Sisquoc	Mean	7668	12	1263	2740	27	3528	41	16	75
		Std Dev.	2547	12	768	1019	20	1806	12	11	51
		Count	17	9	14	14	14	14	2	13	13
West	Monterey	Mean	12314	19	1188	4033	67	5109	44	41	56
		Std Dev.	6823	22	454	1958	87	2221	7	68	37
		Count	17	7	16	16	17	17	5	16	15
	Sisquoc	Mean	22007	42	876	8063	147	12252	15	50	49
		Std Dev.	5280	29	442	2096	103	3700		28	94
		Count	9	5	8	8	8	8	1	8	5
Gato Ridge	Monterey	Mean	9118	29	1769	3207	29	4003	41	14	62
		Std Dev.	1151	14	528	367	11	698	11	10	74
		Count	55	40	42	51	52	42	5	40	34
	Sisquoc	Mean	21000								
		Std Dev.									
		Count	1								
	Sisquoc/ Monterey	Mean	6333								
		Std Dev.	153								
		Count	3								

5.1.3.2 Sisquoc Formation Water Quality

Consistent formation water samples from the Sisquoc Formation are difficult to obtain in the higher oil saturation areas where the Sisquoc is most productive. The difficulty in obtaining formation water samples is due to the physical phenomena known as relative permeability as illustrated in a technical research study by Statoil, (Nejad, Berg, & Ringen, 2011). The oil contained in the Sisquoc in Cat Canyon varies from a high of 12.5° API to a low of 8.5°API both of which are crude oils with very high viscosities in the hundreds of thousands centipoises. In addition based on the core data gathered in the normal course of business, the oil saturations in the more permeable portions of the Sisquoc are unusually high for an oil and gas producing

formation in California often exceeding 70% of the total fluid saturations. The result is that there is little if any permeability, or ability to flow, for the native formation waters. The figure below illustrates the Sisquoc relative permeability to both oil and water.

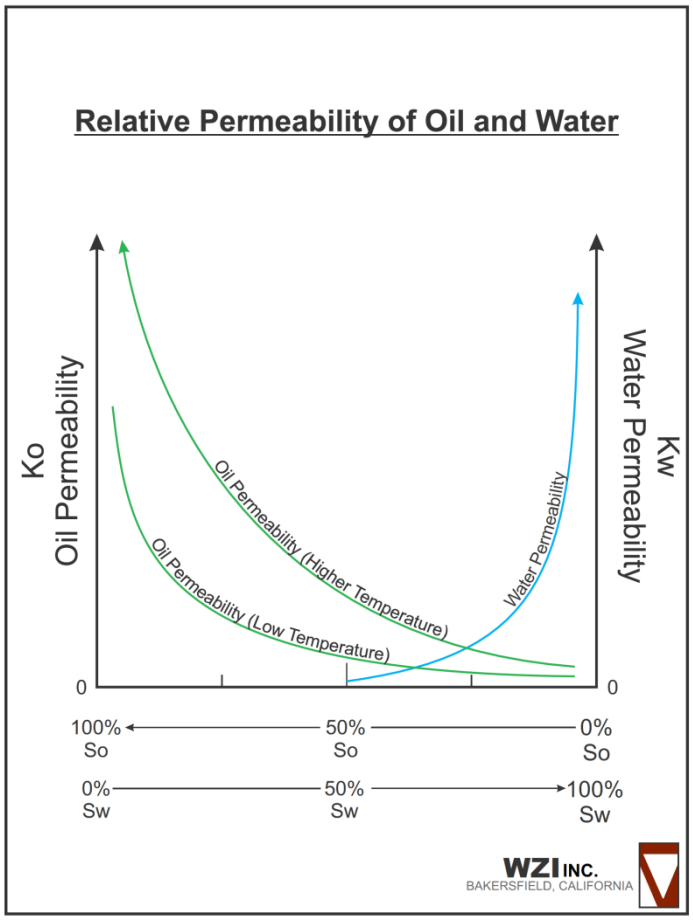


Figure 5.1-16

Initial production without the assistance of steam illustrates the point. At the initial saturation, the Sisquoc has low oil production with no measurable water.

With the addition of steam the viscosity of the oil is reduced and the near well bore saturation of water is increased allowing some of the water utilized in the cyclic steam to be produced back to the well. However, the near well bore radius is re-saturated with oil once again as the production takes place reducing the relative permeability to water to a low value. As the re-saturation process proceeds the near well bore radius relative permeability effect captures not only the formation water but also a portion of the water utilized in the steaming process. The water thus produced and sampled does not represent the native formation water chemical constituents but a combination of the water that is injected as steam including dissolved formation constituents, and some component of the formation water. As the cyclic process continues in an individual area and the depletion of the oil increases, the near well bore area increases in water saturation, however, the concentration of the adsorbed steam condensate also increases further confounding the ability for a reliable formation water sample to be collected.

In areas where the oil saturation in the Sisquoc is lower than 45%, there is a higher likelihood of formation water sample collection. In these areas such as the West Area, the samples collected without the introduction of steam are considered to be formation water samples. The Sisquoc Formation below the Upper Confining Layer water quality (for the purpose of the proposed Aquifer Exemption Expansion in the Sisquoc Formation below the Upper Confining Layer) is considered to be variable within each Area of Cat Canyon Oil Field based on past production practices and quantities of steam condensate returned as production fluid. The individual areas and ranges of water quality are discussed briefly in the following section and in more detail in the **Appendix II, Formation Water Quality Study** of the proposed Aquifer Exemption Expansion Study **Appendix 6-1, Water Treatability Study.**

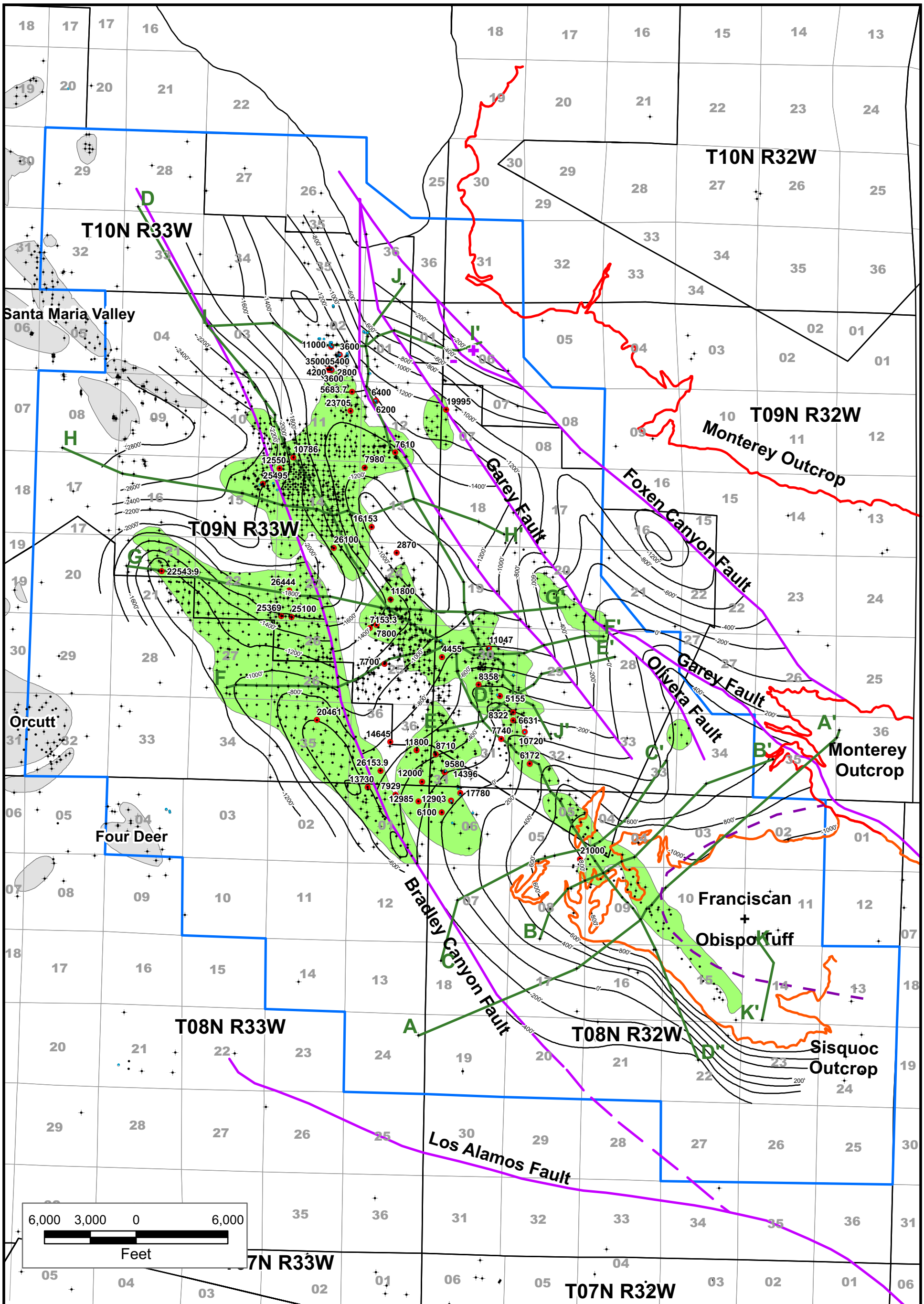
Table 5.1-5, Summary of Sisquoc Formation below the Upper Confining Layer Water Reviewed Data by Area below lists the water quality in TDS based on statistical analysis by Production Area. The table indicates the maximum deviation as well as the mean. Although the connate Sisquoc Formation below the Upper Confining Layer water TDS is most likely more than 10,000 mg/L, the samples that are able to be collected which include the steam condensate and the reinjected produced water, (which also includes the steam condensate), at the low end of the range may be less than 10,000 mg/L thus requiring an exemption expansion proposal.

Table 5.1-5: Summary of Sisquoc Formation below the Upper Confining Layer Water Reviewed Data by Area, (mg/L)

Area			TDS	B	Na	CL	SO4	HCO3	Ca	K	Mg
Sisquoc	All Sisquoc Data	Mean	10281	26	1143	3142	116	4530	118	49	207
		Std. Dev	8352	9	709	2839	211	4962	54	57	172
		Count	33	24	29	31	29	31	10	29	29
	Sisquoc: Post Steaming Production	Mean	5707	25	961	1756	75	2209	104	41	247
		Std. Dev	2422	9	426	980	46	1572	50	60	179
		Count	22	20	22	22	22	22	8	22	21
	Sisquoc: Native Sisquoc Formation	Mean	19862	34	2311	7436	295	11004	113	71	91
		Std. Dev	7558	17	1612	2269	500	6143	67	46	113
		Count	12	4	7	10	5	8	2	6	7
Other Areas	Central Area	Mean	10745	28	1641	4001	47	5539	29	36	21
		Std. Dev	3815	20	801	1420	22	2496	8	24	17
		Count	14	11	11	11	11	11	4	11	8
	East Area	Mean	7668	12	1263	2740	27	3528	41	16	75
		Std. Dev	2547	12	768	1019	20	1806	12	11	51
		Count	17	9	14	14	14	14	2	13	13
	West Area	Mean	22007	42	876	8063	147	12252	15	50	49
		Std. Dev	5280	29	442	2096	103	3700		28	94
		Count	9	5	8	8	8	8	1	8	5
	Gato Ridge Area	Mean	21000								
		Std. Dev									
		Count	1	0	0	0	0	0	0	0	0

In the West Area, as shown in the Table above the Sisquoc Formation below the Upper Confining Layer water sample average TDS of 22,007 mg/L with a standard deviation of 5280 mg/L, thus not requiring an exemption expansion proposal. However, due to future steaming potential the Aquifer Exemption Expansion is being sought for the Sisquoc Formation below the Upper Confining Layer in the West Area.

The Sisquoc Formation below the Upper Confining Layer water quality sampling results are shown in a map view on **Figure 5.1-17, Sisquoc Structure Water Quality Map**.



Legend

Well Status
- Active
- Buried
- Idle
- New
- Plugged
- Cross Section
- Volcanics
- Monterey Outcrop
- Sisquoc Outcrop
- Faults
- Top Sisquoc Structure Contours
- Study Area
- 1973-1974 Productive Boundary
- Other Oilfield

Fault Throw
- Down
- Up
- Sisquoc Water Quality Wells, Most Recent Data (TDS: mg/L)

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SISQUOC STRUCTURE WATER QUALITY MAP

DATE: 10/17 | FIGURE: 5.1-17

5.1.3.3 Monterey Formation Water Quality

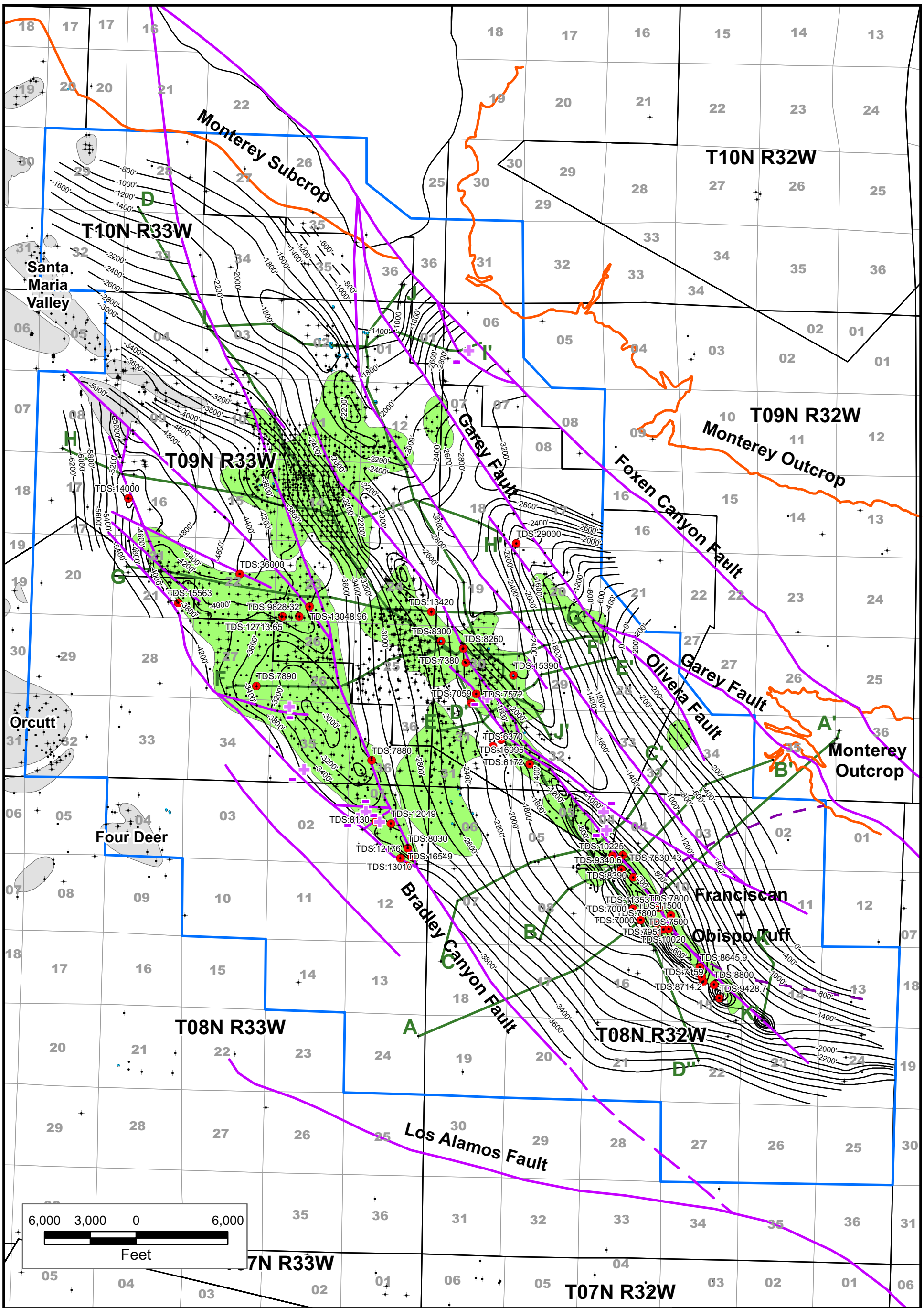
The Cat Canyon Oil field is a major producing area for the Monterey Formation. The produced water from the Monterey has been sampled on numerous occasions. The Monterey is subject to reinjection of produced water and occasionally produced natural gas for Waterflood and production at Maximum Efficient Rate, (MER). The samples are not confounded by steaming.

Table 5.1-6, Summary of Monterey Formation Water Reviewed Data by Area below lists the water Quality in TDS based on statistical analysis by production Area. The table indicates the maximum deviation as well as the mean.

Table 5.1-6: Summary of Reviewed Data by Area and Formation(mg/L)

Area	Formation		TDS	B	Na	CL	SO4	HCO3	Ca	K	Mg
	Sisquoc Area	Mean	10417	7	1153	3216	57	4657	82	26	98
		Std Dev.	6445	5	798	1828	51	2395	73	23	82
		Count	14	14	14	14	14	14	6	14	12
	Central Area	Mean	12314	19	1188	4033	67	5109	44	41	56
		Std Dev.	6823	22	454	1958	87	2221	7	68	37
		Count	17	7	16	16	17	17	5	16	15
	East Area	Mean	10417	7	1153	3216	57	4657	82	26	98
		Std Dev.	6445	5	798	1828	51	2395	73	23	82
		Count	14	14	14	14	14	14	6	14	12
	West Area	Mean	12314	19	1188	4033	67	5109	44	41	56
		Std Dev.	6823	22	454	1958	87	2221	7	68	37
		Count	17	7	16	16	17	17	5	16	15
	Gato Ridge Monterey Only	Mean	9118	29	1769	3207	29	4003	41	14	62
		Std Dev.	1151	14	528	367	11	698	11	10	74
		Count	55	40	42	51	52	42	5	40	34
	Gato Ridge Sisquoc/ Monterey	Mean	6333								
		Std Dev.	153								
		Count	3								

The Monterey Formation water quality in TDS is shown on **Figure 5.1-18, Monterey Formation Water Quality Map**. As noted on the map, the north western area of the Cat Canyon Oil Field as it deeps steeply into the Clark Area of the Santa Maria Oil Field contains formation waters that are significantly above 10,000 mg/L. The remainder of the Cat Canyon Oil Field is documented to have a water quality while greater than 3000 mg/L is less than 10,000 mg/L.



Legend

Well Status
- Active
- Buried
- Idle
- New
- Plugged
- Faults

- Monterey Pinchout
- Volcanics
- Approx. Top Monterey Structure
- Top Monterey Structure
- Monterey Outcrop
- Cross Section
- Study Area

Fault Throw
- Down
- Up
- Monterey Water Quality Wells, Most Recent Data (TDS: mg/L)
- 1973-1974 Productive Boundary
- Other Oilfield

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MONTEREY STRUCTURE WATER QUALITY MAP

DATE: 10/17 | FIGURE: 5.1-18

5.1.4 Proposed Aquifer Exemption Ground Water Gradient

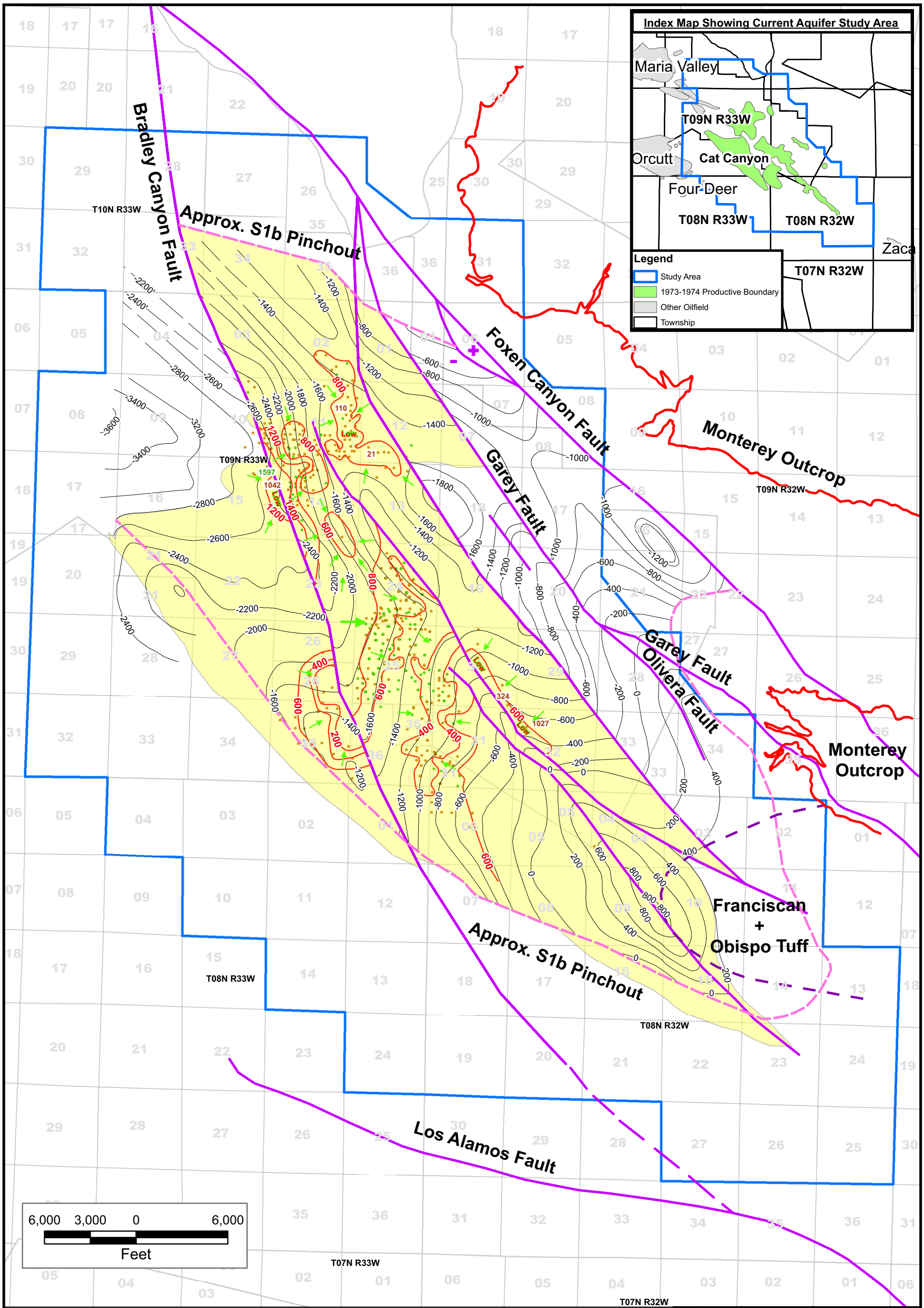
The direction of groundwater flow in the Sisquoc Formation below the Upper Confining Layer, and Monterey Formation in the various producing areas of Cat Canyon Oil Field is toward the producing wells and is controlled by the production processes due to the withdrawal of fluids, both oil, water and gas as well as the introduction of water used for steam and subsequent reinjection of produced water and gas in achieving Maximum Efficient Rates of Production (MER), **Figure 5.1-19, Sisquoc Formation Gradient Map with Pressures** and **Figure 5.1-20, Monterey Formation Gradient Map with Pressures**. The maps were constructed based on static fluid level data collected as a portion of this study. The fluid levels were converted to pressures and the pressures were then plotted to indicate the direction of flow. The pressure data also documents the sealing nature of the faults in the Cat Canyon Oil Field. In addition to the pressure gradient evidence, the direction of flow is documented by the Material Balance calculations for the year 2016. The direction of flow and the gradients are dependent on the volumes of production and injection. Since the material balance demonstrates a significant decrease in fluid content in the reservoirs, the inward gradient and decrease of pressure in the productive areas will remain in effect for the life of the field and thereafter until pressure equalization is completed. Once the pressure has been equalized flow will cease.

Table 5.1-7, Cumulative Material Balance Field Wide Summary – Cat Canyon shows the Cat Canyon Oil Field cumulative production and injection for the period up to 1977 (the start of DOGGR records) and up to 2016 (the last complete record year as of this study). The water injection into the Cat Canyon Oil Field is from the formations in the Cat Canyon Oil Field. No water is imported to the Cat Canyon Oil Field from any other oil field. Historically, most produced water was not reinjected but rather was sent out of the Study Area to the Santa Maria River, Pacific Ocean, or piped to the Battles Gas Plant where it was treated and then put into the outfall. **Appendix 5-V, Fluid Levels and Material Balance** contains a map showing the historic gathering system. Starting in 1947 water was reintroduced for disposal and in 1963 water was reintroduced for cyclic steaming purposes and starting in 1954 water was reintroduced for flooding. Since then the practice of reinjection of in-field produced water has increased to promote Enhanced Oil Recovery.

Presently, the water is injected as steam, water flood and produced water reinjection. The quality of the reinjected water is dependent on the steaming operations due to the relative permeability of the oil and water. The reinjected water has a major component of steam condensate. Once-through boilers are tolerant of high dissolved solids (up to 7,000 mg/L). They are designed to deliver low-quality steam (steam that is not 100% vapor) but these boilers are still limited by scaling, oxygen and sulfates thus requiring treatment and mixing, lowering the TDS of the reinjected (low quality) steam relative to the native formations, (Henry L. Dogherty Series , 1986). The returned condensate (scheduled for reuse after treatment) may contain some formation water from the capture radius depending on the specific formation conditions.

Table 5.1-7: Cumulative Material Balance Field Wide – Cat Canyon						
	Production		Injection			
Cumulative to:	Oil	Produced Water	WF	SF/SC	WD	Balance
1977	228,852,985	898,501,621	176,028,000	33,360,333	63,722,653	(805,407,026)
2016	310,496,930	1,416,140,580	880,702,927			(845,934,583)

Individual operators have provided information where possible delineating the inter-formation mass balance by the area and/or by their lease, **Appendix 5-V, Fluid Levels and Material Balance**. The long term net negative balance for the Study Area is supported by the injection and production data as well as the pressure gradients of the formations. A copy of the calculations and data are included in **Appendix 5-V, Fluid Level Data and Material Balance**.



Legend

Fault Throw
- Down
- Up
- Monterey Outcrop
- Volcanic Subcrop
- 1998 S1B Pressure Contours
- Approx. S1b Pinchout
- S1B Faults
- S1b Structure Contour
- Approx. S1b Structure Contour
- 1998 Directionally Drilled Well with Pressure
- 1998 Well Pressure
- Proposed Expanded Sisquoc Exemption Boundary
- Study Area
- Fluid Direction on S1b Structure Map

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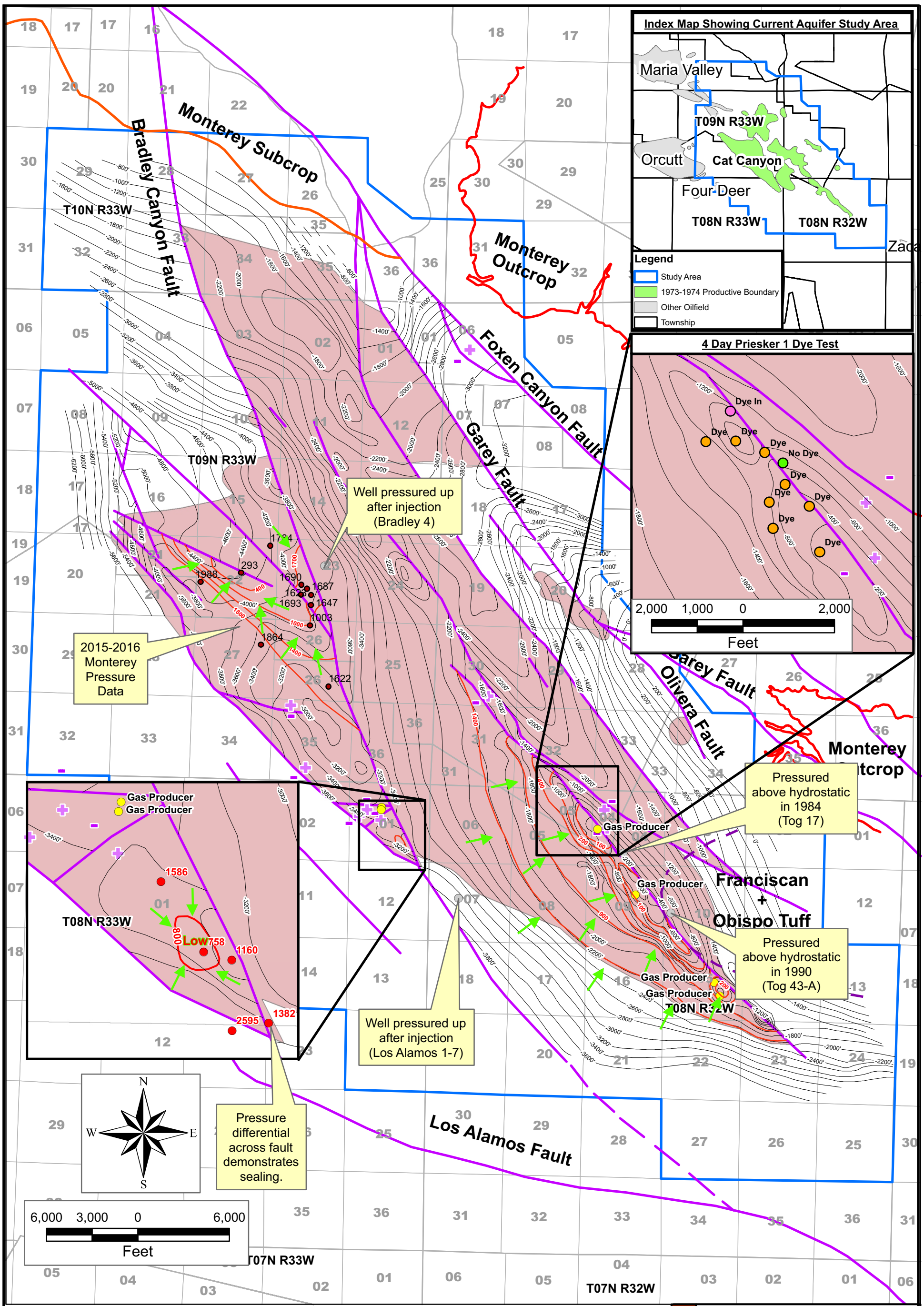
CAT CANYON AQUIFER EXEMPTION EXPANSION

SISQUOC FORMATION
GRADIENT MAP WITH PRESSURES

DATE: 10/17 | FIGURE: 5.1-19


Index Map Showing Current Aquifer Study Area
Maria Valley
T09N R33W
Orcutt
Cat Canyon
Four-Deer
T08N R33W
T08N R32W
Legend
Study Area
1973-1974 Productive Boundary
Other Oilfield
Township
4 Day Priesker 1 Dye Test
Dye In
Dye
No Dye
2,000 1,000 0 2,000
Feet
Monterey Subcrop
Bradley Canyon Fault
Monterey Outcrop
Foxen Canyon Fault
Garey Fault
Olivera Fault
Los Alamos Fault
T10N R33W
T09N R33W
T08N R33W
T08N R32W
T07N R33W
T07N R32W
Well pressured up after injection (Bradley 4)
2015-2016 Monterey Pressure Data
Pressured above hydrostatic in 1984 (Tog 17)
Pressured above hydrostatic in 1990 (Tog 43-A)
Well pressured up after injection (Los Alamos 1-7)
Pressure differential across fault demonstrates sealing.
Gas Producer
Low
Franciscan + Obispo Tuff
N
S
E
W
6,000 3,000 0 6,000
Feet
Legend
2015-2016 Monterey Well Pressure
Monterey Pressure Contour
Noted Wells
Gas Producer
Pressured Up
Fault Throw
Down
Up
Monterey Subcrop
Volcanic Subcrop
Top Monterey Structure
Top Monterey Structure
Monterey Outcrop
Monterey Faults
Study Area
Proposed Expanded Monterey Exemption Boundary
Fluid Travel Direction
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CAT CANYON AQUIFER EXEMPTION EXPANSION
MONTEREY FORMATION GRADIENT MAP WITH PRESSURES
DATE: 10/17
FIGURE: 5.1-20

6 Geology and Confinement

6.1 *Stratigraphy and Structure of the **Sisquoc Formation below the Upper Confining Layer and Monterey** Formation*

6.1.1 Stratigraphy and Confinement

The Sisquoc, and Monterey Formations are present in the Cat Canyon Oil Field. **Figures 4.1-1 a through 4.1-1e, Type Logs (for areas)**, demonstrate the stratigraphy of the area including some of the stratigraphic changes across the area. Five type logs are presented for the Cat Canyon Field, one near the western area, and one in the eastern area and one for the southern area of the field. From the surface to the deepest penetration for the Cat Canyon Oil field, the column is described as follows:

6.1.1.1 Alluvium

The surface alluvium is thin to nonexistent over most of the study area, **Figure 6.1-1 Surface Geology Map with Anticlinal Structures.** Where present (in historic stream channels), the formation consists of interbedded unconsolidated yellowish–brown sands, gravels and clays with pebbles and grains of igneous rock and quartzite, (Bradley & al, 1943). Trending to the north and west of the Cat Canyon Oil Field Aquifer Exemption Expansion study area (into the Santa Maria Valley Oil Field) the Alluvium progressively thickens and becomes a major source of groundwater. (Worts & Thomasson, 1951), (Bradley & al, 1943).

6.1.1.2 Paso Robles Formation

The Paso Robles Formation is of Pleistocene age and consists of interbedded conglomerates, sands and clays of continental origin. There are thin fresh-water limestone beds at the base of the clays. The conglomerate of the Paso Robles is composed of black siliceous shale pebbles as well as Monterey shale and chert fragments. On the top of the Gato Ridge, the Paso Robles is not present. Trending to the south and west of the study area the formation reaches a thickness of 2000 feet beneath the central part of the San Antonio Creek Valley, (California Department of Water Resources Board, 2004). The Paso Robles Formation is the main water bearing formation in the San Antonio Creek Valley, (California Department of Water Resources Board, 2004).

6.1.1.3 Careaga Formation

The Careaga Formation is composed of an upper and a lower member and is Pliocene in age. The upper member is a conglomerate composed of black igneous pebbles and ranges in thickness from 50 to 350 feet in thickness. The lower member of the Careaga Formation is separated from the upper member by a thin calcareous sandstone and can be 350 feet thick of loose yellow fine grained sand. Trending from the center of the study area into the adjacent valleys, the Careaga thickens. The Careaga is not found in all areas of the study area. On the top of Gato Ridge, which extends through the study area, the Careaga is not present, (Worts & Thomasson, 1951), (Bradley & al, 1943). To the north of the study area (Northeast corner of Section 35, T10N, R33W) the Careaga outcrops on Fugler Point with tar saturated sands, (Worts & Thomasson, 1951). The outcrop of the Careaga contains tar as the Foxen and the Sisquoc have been eroded and the faulted Careaga sits on the Monterey. In the Cat Canyon Oil Field the Careaga is a source of drinking water.