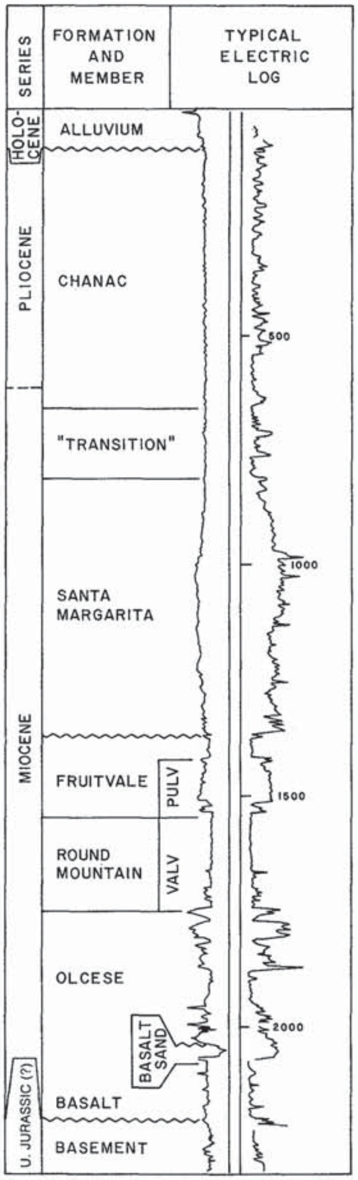
APPENDIX A

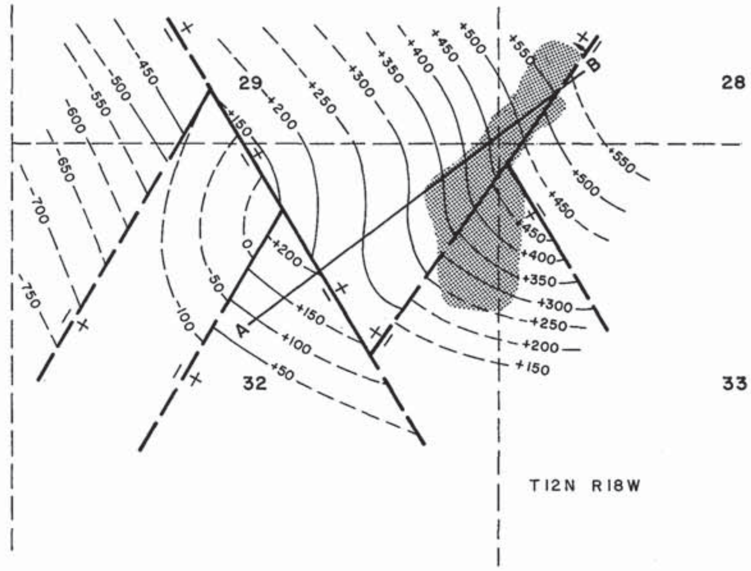
Selected DOGGR Oil Field Information

Appendix A.1

Comanche Point

COMANCHE POINT OIL FIELD





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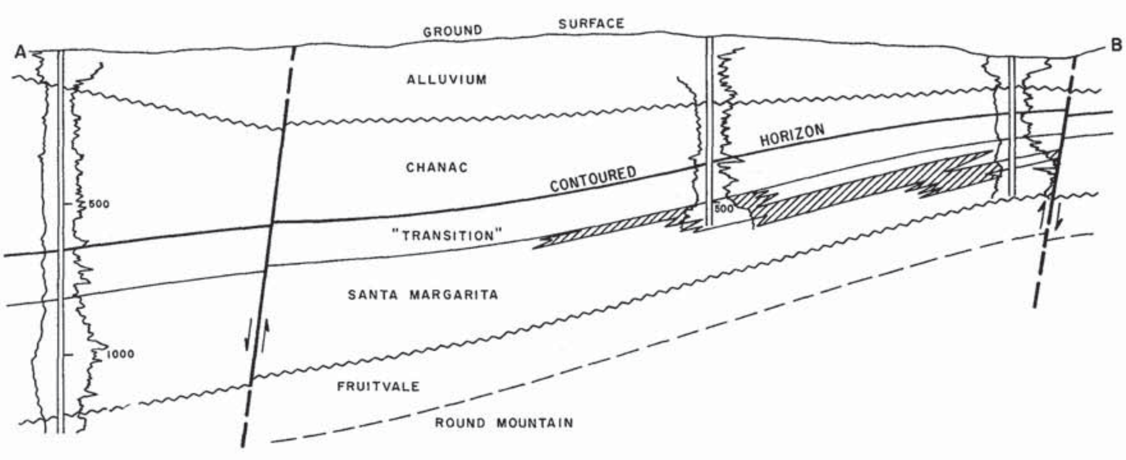


FEBRUARY 1980

COUNTY: KERN

COMANCHE POINT OIL FIELD

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well	Alamo Oil Company "Tejon Ranch" 3	Horace Steele & L.C. Gould "Gould" 1	32 12N 18W	SB	1,592	Santa Margarita	
Deepest well	Gene Reid Exploration Co. "G.R. Finch Associates" No. 1	G.R. Finch & Associates No. 1	29 12N 18W	SB	4,000		basement Lt. Jurassic(?)

POOL DATA

ITEM	SANTA MARGARITA					FIELD OR AREA DATA
Discovery date	October 1947					
Initial production rates						
Oil (bbl/day)	25					
Gas (Mcf/day)	3					
Flow pressure (psi)						
Bean size (in.)						
Initial reservoir pressure (psi)	200**					
Reservoir temperature (°F)	80**					
Initial oil content (STB/ac.-ft.)	1,050**					
Initial gas content (MSCF/ac.-ft.)	202					
Formation	Santa Margarita					
Geologic age	Miocene					
Average depth (ft.)	650					
Average net thickness (ft.)	100					
Maximum productive area (acres)	55					
RESERVOIR ROCK PROPERTIES						
Porosity (%)	25					
So_i (%)	60**					
Sw_i (%)	40**					
Sg_i (%)						
Permeability to air (md)	300					
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	14-16					
Sulfur content (% by wt.)						
Initial solution GOR (SCF/STB)	104					
Initial oil FVF (RB/STB)	1.02**					
Bubble point press. (psia)	900**					
Viscosity (cp) @ °F						
Gas:						
Specific gravity (air = 1.0)	0.60**					
Heating value (Btu/cu. ft.)						
Water:						
Salinity, NaCl (ppm)	250					
T.D.S. (ppm)						
R_w (ohm/m) (77°F)						
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects						
Date started						
Date discontinued						
Peak oil production (bbl)	10,687					
Year	1951					
Peak gas production, net (Mcf)						
Year						

Base of fresh water (ft.): 750

Remarks: Separated from Tejon Hills field on January 1, 1954.

Selected References: Kasline, F.E., 1953, Tejon Hills Oil Field: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, Vol. 39, No. 1.

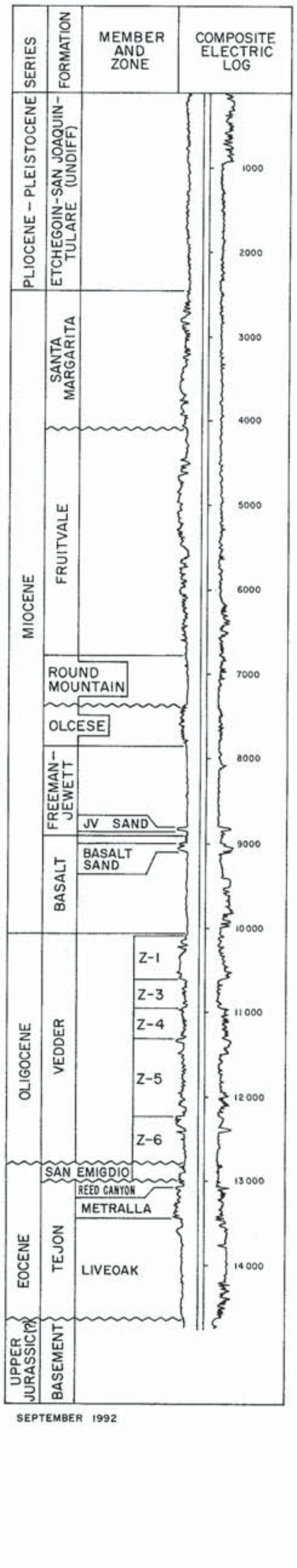
DATE: January 1983 **Estimated value

DEPARTMENT OF CONSERVATION / DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

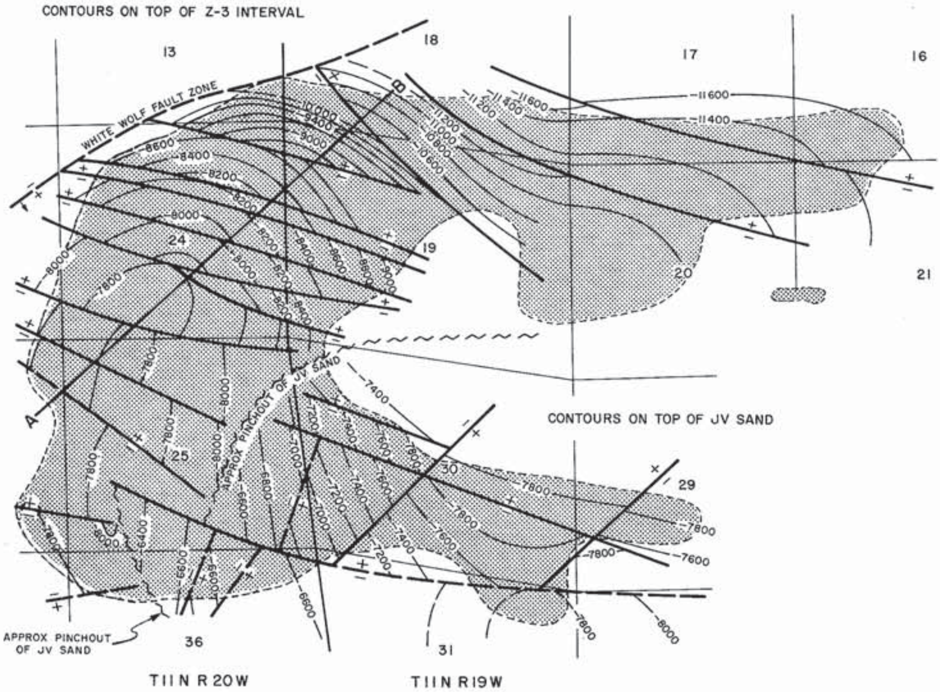
Appendix A.2

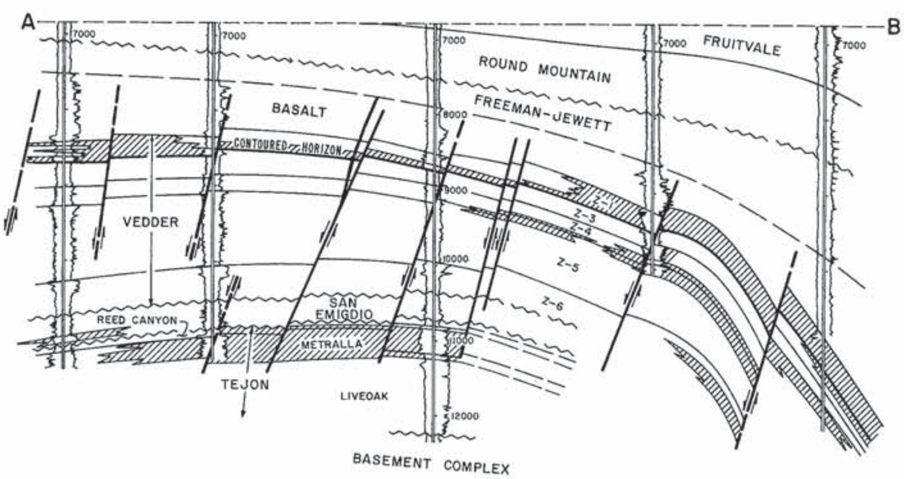
North Tejon

NORTH TEJON OIL FIELD



SEPTEMBER 1992





COUNTY: KERN

TEJON, NORTH, OIL FIELD

SHEET 1 OF 2

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well	ARCO Oil and Gas Co. "KCL F" 52-36	Richfield Oil Corp. "KCL F" 52-36	36 11N 20W	SB	9,213	Vedder	
Deepest well	Reserve Oil Inc. "R-S-T" 187-19	Reserve Oil and Gas Co. "R-S-T" 187-19	19 11N 19W	SB	14,205		Tejon Eocene

POOL DATA

ITEM	FRUITVALE (PULV)	OLCESE	JV	"BASAL" SAND	VEDDER a/	FIELD OR AREA DATA
Discovery date	September 1956	July 1958	February 1957	December 1960	March 1956	
Initial production rates						
Oil (bbl/day)	97	521	592	285	154	
Gas (Mcf/day)	20	432	8,700	430	883	
Flow pressure (psi)	50/110	870/970	2,300/pkr	825/pkr	1,760/pkr	
Bean size (in.)	20/64	18/64	24/64	15/64	48/64	
Initial reservoir pressure (psi)	1,500**	3,300	3,550	3,400	5,470	
Reservoir temperature (°F)	122	137	149	145	239	
Initial oil content (STB/ac.-ft.)	1,250**	950**	800**	750**	500**	
Initial gas content (MSCF/ac.-ft.)	450**	800**	900**	600**	650-1,200**	
Formation	Fruitvale	Olcese	Freeman-Jewett	Basalt	Vedder	
Geologic age	Miocene	Miocene	Miocene	Miocene	Oligocene	
Average depth (ft.)	4,275-5,370	7,300	8,150	7,800	10,000	
Average net thickness (ft.)	230-1,000	180	85	50	700-2,000	
Maximum productive area (acres)	-	-	-	-	2,000	
RESERVOIR ROCK PROPERTIES						
Porosity (%)	26**	25	25	23**	19**	
So_i (%)	70**	75**	70**	72**	60**	
Sw_i (%)	30**	25**	30**	28**	40**	
Sg_i (%)						
Permeability to air (md)	600.0**	300.0-500.0	400.0**	200.0**	0.2-52.0	
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	19-27	36	37-60	38-51	31-60	
Sulfur content (% by wt.)	-	-	0.16	-	-	
Initial solution GOR (SCF/STB)	100**	800**	1,050**	1,160**	1,257	
Initial oil FVF (RB/STB)	1.08**	1.48**	1.60**	1.68**	1.67	
Bubble point press. (psia)	900**	2,400**	3,300**	3,150**	4,970	
Viscosity (cp) @ °F						
Gas:						
Specific gravity (air = 1.0)	0.63**	0.90**	0.85**	0.92**	0.75**	
Heating value (Btu/cu. ft.)						
Water:						
Salinity, NaCl (ppm)	-	31,700	25,500	-	33,100	
T.D.S. (ppm)	-	31,800	26,700	-	34,000	
R_w (ohm/m) (77°F)	-	0.18	0.27	-	0.22	
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects						
Date started						
Date discontinued						
Peak oil production (bbl)	6,796	66,000	236,000		1,392,815**	
Year	1970	1959	1961		1963	
Peak gas production, net (Mcf)					20,327,759**	
Year					1963	

Base of fresh water (ft.): 2,100

Remarks: a/ Natural fractures facilitate production. There are seven productive sand intervals in the Vedder.

Selected References: Park, W.H., 1961, North Tejon Oil Field: Calif. Div. of Oil and Gas, Summary of Operations -- Calif. Oil Fields, Vol. 47, No. 2.

DATE: October 1991 **Estimated value

DEPARTMENT OF CONSERVATION / DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

COUNTY: KERN

TEJON, NORTH, OIL FIELD

SHEET 2 OF 2

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well							
Deepest well							

POOL DATA

ITEM	SAN EMIGDIO	METRALLA				FIELD OR AREA DATA
Discovery date	March 1959	November 1958				
Initial production rates						
Oil (bbl/day)	164 a/	205				
Gas (Mcf/day)	2,163	2,175				
Flow pressure (psi)	3,300/pkr	3,450/pkr				
Bean size (in.)	10/64	12/64				
Initial reservoir pressure (psi)	5,750	5,100				
Reservoir temperature (°F)	189	189				
Initial oil content (STB/ac.-ft.)	450**	300**				
Initial gas content (MSCF/ac.-ft.)	900**	600**				
Formation	San Emigdio	Tejon				
Geologic age	Eocene	Eocene				
Average depth (ft.)	10,900	11,000				
Average net thickness (ft.)	100	400				
Maximum productive area (acres)	320	-				2,410
RESERVOIR ROCK PROPERTIES						
Porosity (%)	18**	6.3-17.9				
S_{oi} (%)	65**	68**				
S_{wi} (%)	35**	32**				
S_{gi} (%)						
Permeability to air (md)	10.00**	0.20-1.06				
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	43	33-53				
Sulfur content (% by wt.)	-	0.24				
Initial solution GOR (SCF/STB)	2,000**	1,700**				
Initial oil FVF (RB/STB)	1.9**	1.8**				
Bubble point press. (psia)	5,100**	5,400**				
Viscosity (cp) @ °F						
Gas:						
Specific gravity (air = 1.0)	0.81**	0.72**				
Heating value (Btu/cu. ft.)						
Water:						
Salinity, NaCl (ppm)						
T.D.S. (ppm)						
R_w (ohm/m) (77°F)						
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects						
Date started						
Date discontinued						
Peak oil production (bbl)		744,000				3,662,853
Year		1961				1960
Peak gas production, net (Mcf)						27,093,130
Year						1961

Base of fresh water (ft.):

Remarks: a/ Initial San Emigdio production commingled with Metralla zone.

Selected References:

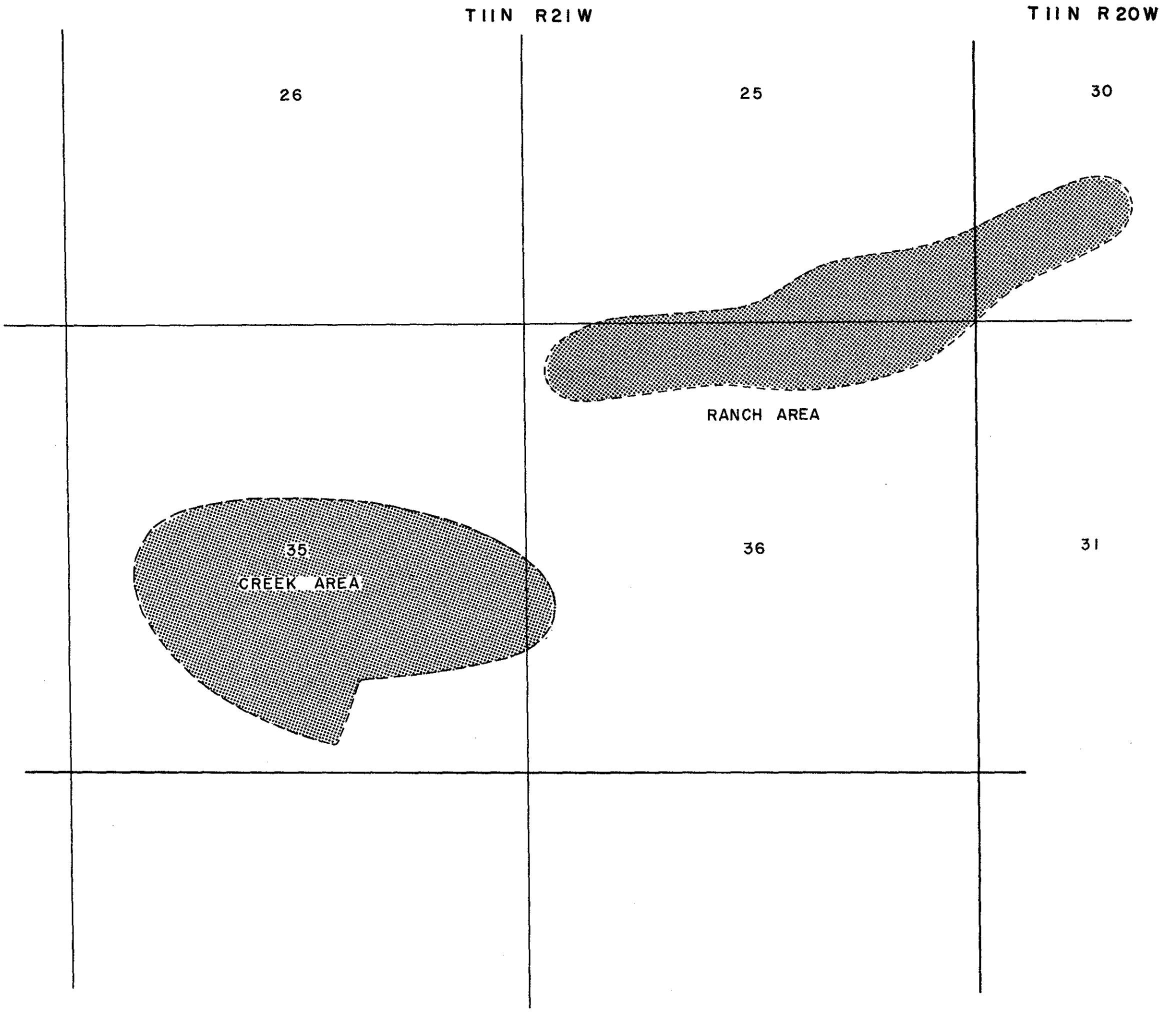
DATE: October 1991 **Estimated value

DEPARTMENT OF CONSERVATION / DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

Appendix A.3

Pleito

PLEITO OIL FIELD
Index Map



SEPTEMBER 1992

COUNTY: **KERN**

PLEITO OIL FIELD

(SEE AREAS FOR ADDITIONAL INFORMATION)

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well	Petro Resources, Inc. "Ten West" 1	Humble Oil & Rfg. Co. "Kern County Land Co. B (34-35)" 1	35 11N 21W	SB	5,451	Santa Margarita	
Deepest well	ARCO Oil & Gas Co. "Pleito Ranch" 48-25	Shell Oil Co. "KCL" 48-25	25 11N 21W	SB	15,177		Chanac Pliocene-Miocene

POOL DATA

ITEM	SANTA MARGARITA					FIELD OR AREA DATA
Discovery date	August 1951					
Initial production rates						
Oil (bbl/day)	55					
Gas (Mcf/day)	37					
Flow pressure (psi)	on pump					
Bean size (in.)						
Initial reservoir pressure (psi)	1,350**					
Reservoir temperature (°F)	109					
Initial oil content (STB/ac.-ft.)	1,350**					
Initial gas content (MSCF/ac.-ft.)	400**					
Formation	Santa Margarita					
Geologic age	Miocene					
Average depth (ft.)	4,300					
Average net thickness (ft.)	200					
Maximum productive area (acres)	200					435
RESERVOIR ROCK PROPERTIES						
Porosity (%)	18-30					
So_i (%)	70**					
Sw_i (%)	30**					
Sg_i (%)						
Permeability to air (md)	50-800					
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	15-19					
Sulfur content (% by wt.)						
Initial solution GOR (SCF/STB)	260**					
Initial oil FVF (RB/STB)	1.1**					
Bubble point press. (psia)	1,700**					
Viscosity (cp) @ °F						
Gas:						
Specific gravity (air = 1.0)	0.78**					
Heating value (Btu/cu. ft.)						
Water:						
Salinity, NaCl (ppm)	500-9,500					
T.D.S. (ppm)	2,000-12,100					
R_w (ohm/m) (77°F)	0.5-3.0					
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects	fireflood					
Date started	1959					
Date discontinued	1966					
Enhanced recovery projects	waterflood					
Date started	1954					
Date discontinued	1968					
Peak oil production (bbl)	159,073					597,004
Year	1953					1981
Peak gas production, net (Mcf)	111,216					305,145
Year	1958					1981

Base of fresh water (ft.): See areas

Remarks: Formerly known as Pleito Creek Oil Field.

Selected References: See areas

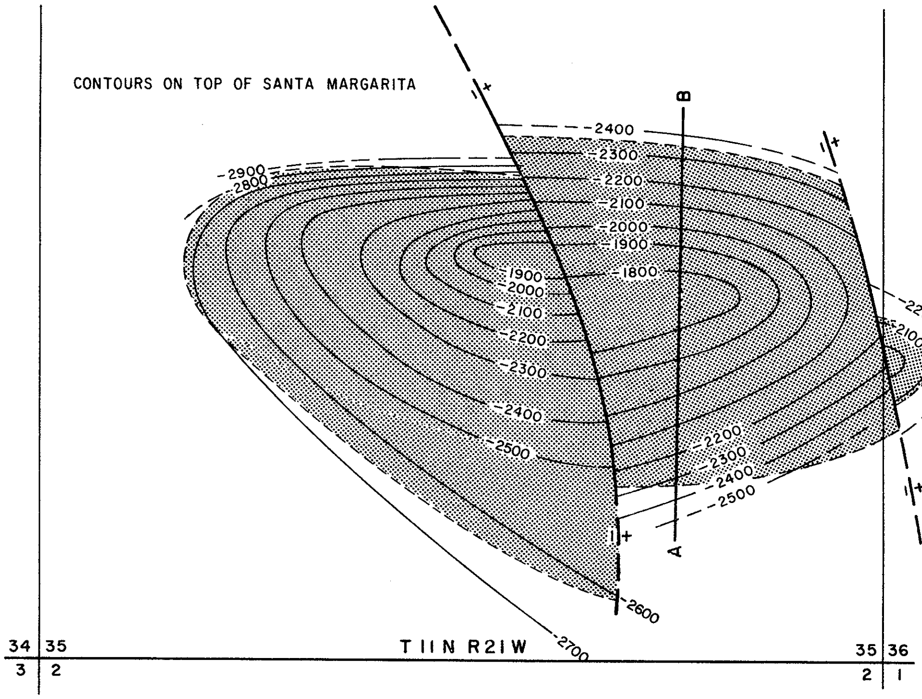
DATE: October 1991 **Estimated value

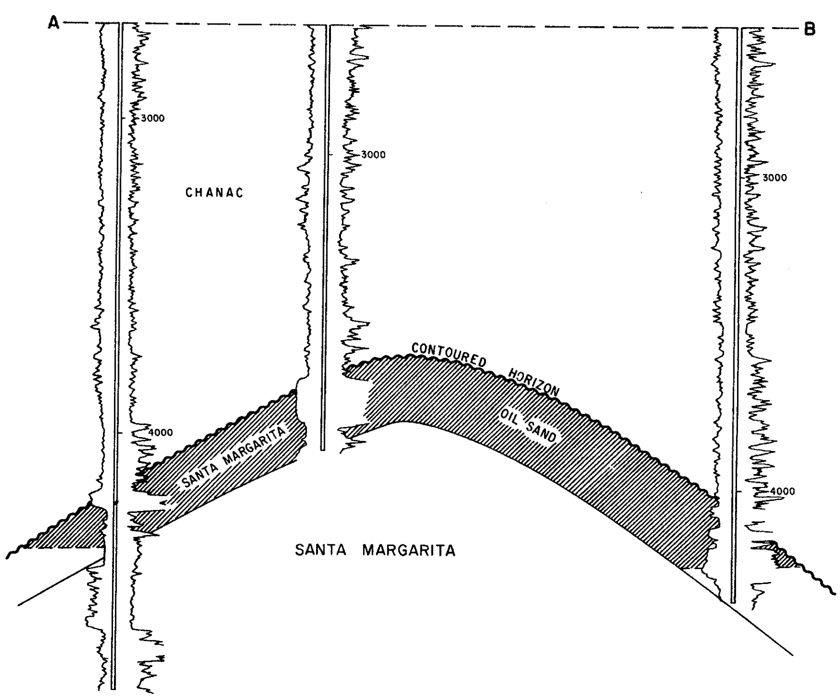
DEPARTMENT OF CONSERVATION / DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

PLEITO OIL FIELD
Creek Area

SERIES	FORMATION	THICKNESS (FEET)
PLEISTOCENE	TULARE	1900
PLIOCENE / MIOCENE	CHANAC	2300
MIOCENE	SANTA MARGARITA	500
MIOCENE	MONTEREY	575

SEPTEMBER 1992





COUNTY: KERN

PLEITO OIL FIELD
CREEK AREA

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well	Petro Resources, Inc. "Ten West" 1	Humble Oil & Rfg. Co. "Kern County Land Co. B (34-35)" 1	35 11N 21W	MD	5,451	Santa Margarita	
Deepest well	Petro Resources, Inc. "Ten West" 16	Humble Oil & Rfg. Co. "Kern County Land Co. B (57-35)" 16	35 11N 21W	MD	14,935		Chanac Pliocene-Miocene

POOL DATA

ITEM	SANTA MARGARITA					FIELD OR AREA DATA
Discovery date	August 1951					
Initial production rates						
Oil (bbl/day)	55					
Gas (Mcf/day)	37					
Flow pressure (psi)	on pump					
Bean size (in.)						
Initial reservoir pressure (psi)	1,350**					
Reservoir temperature (°F)	109					
Initial oil content (STB/ac.-ft.)	1,350**					
Initial gas content (MSCF/ac.-ft.)	400**					
Formation	Santa Margarita					
Geologic age	Miocene					
Average depth (ft.)	4,300					
Average net thickness (ft.)	200					
Maximum productive area (acres)	205					205
RESERVOIR ROCK PROPERTIES						
Porosity (%)	18-30					
S_{oi} (%)	70**					
S_{wi} (%)	30**					
S_{gi} (%)						
Permeability to air (md)	50-800					
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	15-19					
Sulfur content (% by wt.)						
Initial solution GOR (SCF/STB)	260**					
Initial oil FVF (RB/STB)	1.1**					
Bubble point press. (psia)	1,700**					
Viscosity (cp) @ °F						
Gas:						
Specific gravity (air = 1.0)	0.78**					
Heating value (Btu/cu. ft.)						
Water:						
Salinity, NaCl (ppm)	500-9,500					
T.D.S. (ppm)	2,200-12,100					
R_w (ohm/m) (77°F)	0.5-3.0					
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects	fireflood					
Date started	1959					
Date discontinued	1966					
	waterflood					
	1954					
	1968					
Peak oil production (bbl)	159,073					
Year	1953					
Peak gas production, net (Mcf)	111,216					
Year	1958					

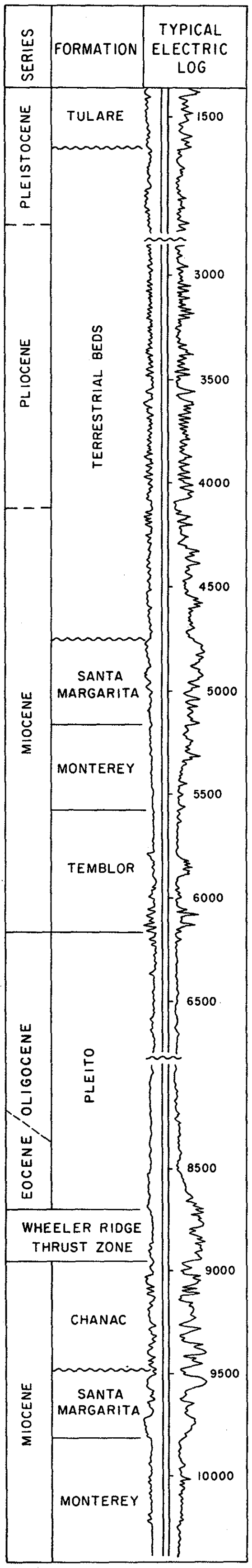
Base of fresh water (ft.): None; however, the Tulare Formation, where it outcrops, is in hydraulic continuity with fresh waters in the San Joaquin Valley.

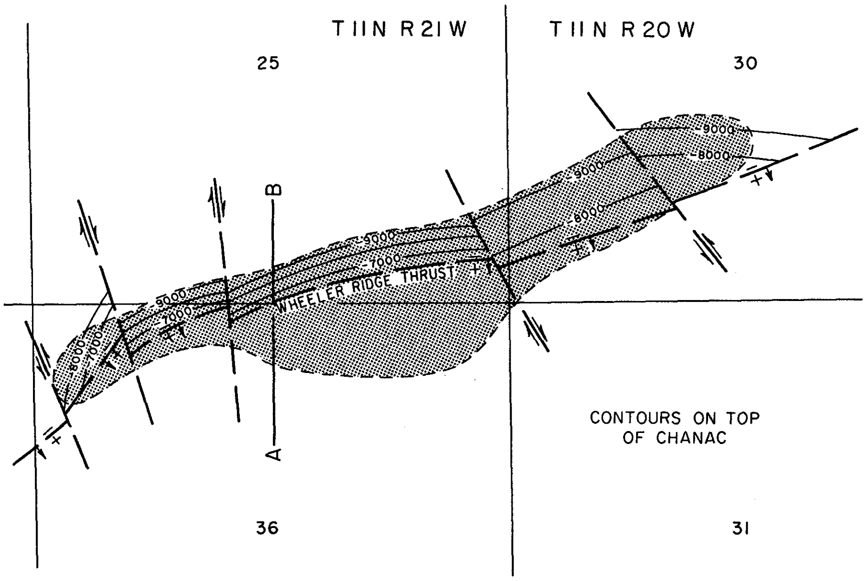
Remarks:

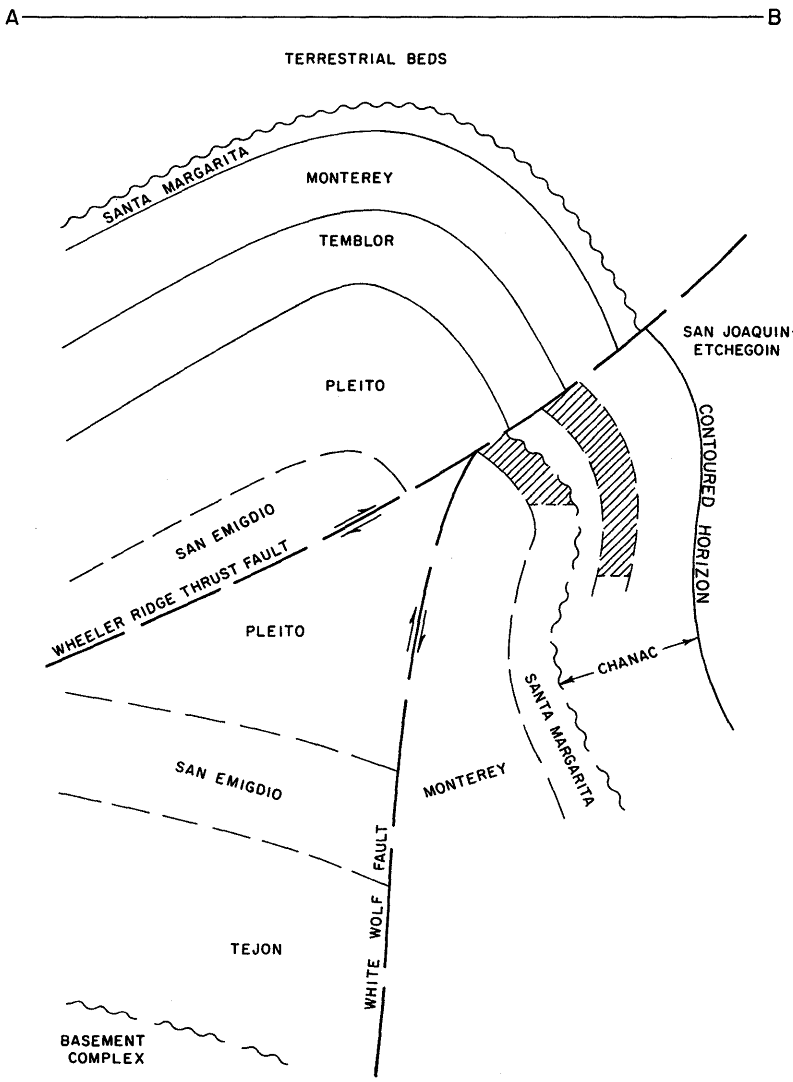
Selected References: Crowder, R.E., 1954, Pleito Creek Oil Field: Calif. Div. of Oil and Gas, Summary of Operations -- Calif. Oil Fields, Vol. 40, No. 2.

DATE: October 1991 **Estimated value

PLEITO OIL FIELD
Ranch Area







MAY 1980

COUNTY: KERN

PLEITO OIL FIELD
RANCH AREA

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well	ARCO Oil & Gas Co. "Pleito Ranch" 48-25	Shell Oil Co. "KCL" 48-25	25 11N 21W	SB	15,177	Chanac	Chanac Pliocene-Miocene
Deepest well	Same as above	"	"	"	"	"	"

POOL DATA

ITEM	CHANAC-SANTA MARGARITA					FIELD OR AREA DATA
Discovery date	September 1957					
Initial production rates						
Oil (bbl/day)	97					
Gas (Mcf/day)	17					
Flow pressure (psi)	on pump					
Bean size (in.)						
Initial reservoir pressure (psi)	4,200					
Reservoir temperature (°F)	158-201					
Initial oil content (STB/ac.-ft.)	554					
Initial gas content (MSCF/ac.-ft.)	283					
Formation	a/					
Geologic age	Pliocene-Miocene					
Average depth (ft.)	8,900-13,000					
Average net thickness (ft.)	300-750					
Maximum productive area (acres)	230					
RESERVOIR ROCK PROPERTIES						
Porosity (%)	13-24					
S_{oi} (%)	60					
S_{wi} (%)	40					
S_{gi} (%)						
Permeability to air (md)	20-800					
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	23					
Sulfur content (% by wt.)	1.18					
Initial solution GOR (SCF/STB)	175					
Initial oil FVF (RB/STB)	1.27					
Bubble point press. (psia)	3,370					
Viscosity (cp) @ °F	7.8 @ 190					
Gas:						
Specific gravity (air = 1.0)	0.729					
Heating value (Btu/cu. ft.)	1,277					
Water:						
Salinity, NaCl (ppm)	9,000-19,000					
T.D.S. (ppm)	10,000-30,000					
R_w (ohm/m) (77°F)	0.2-0.4					
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects						
Date started						
Date discontinued						
Peak oil production (bbl)	575,620					
Year	1981					
Peak gas production, net (Mcf)	296,145					
Year	1981					

Base of fresh water (ft.): None

Remarks: a/ Chanac-Santa Margarita

Selected References:

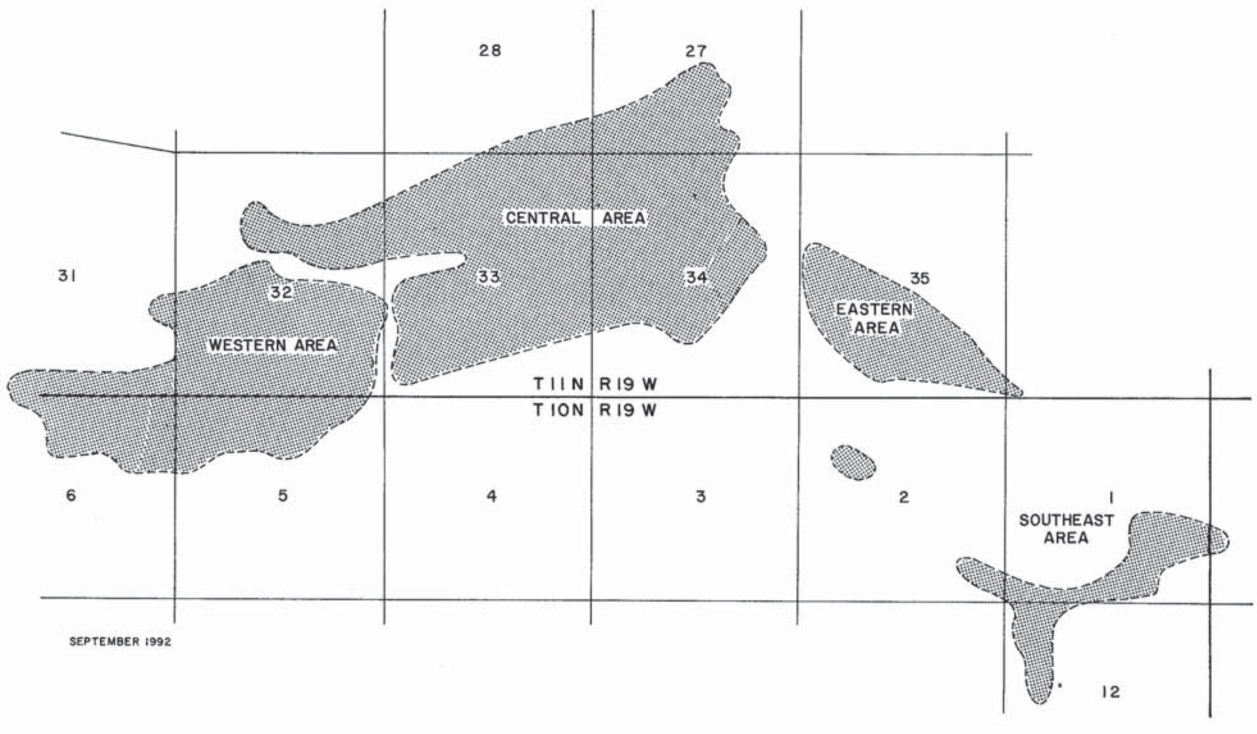
DATE: October 1991

DEPARTMENT OF CONSERVATION / DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

Appendix A.4

Tejon

TEJON OIL FIELD
INDEX MAP



COUNTY: KERN

TEJON OIL FIELD

(SEE AREAS FOR ADDITIONAL INFORMATION)

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well	Reserve Oil Inc. No. 2-1	Reserve Oil & Gas Co. "Tejon Ranch" 1	2 10N 19W	SB	3,708	2-1 Sand	
Deepest well	Santa Fe Energy Co. No. 4-1-32	Standard Oil Co. of Calif. "CCMO 4" 35	32 11N 19W	SB	13,239		Tejon Eocene

POOL DATA

ITEM	2-1 SAND					FIELD OR AREA DATA
Discovery date	June 1935					
Initial production rates						
Oil (bbl/day)	55					
Gas (Mcf/day)						
Flow pressure (psi)	on pump					
Bean size (in.)						
Initial reservoir pressure (psi)	825**					
Reservoir temperature (°F)	107					
Initial oil content (STB/ac.-ft.)	1,100**					
Initial gas content (MSCF/ac.-ft.)						
Formation	Fruitvale					
Geologic age	Miocene					
Average depth (ft.)	2,670					
Average net thickness (ft.)	20					
Maximum productive area (acres)						2,190
RESERVOIR ROCK PROPERTIES						
Porosity (%)	31**					
So_i (%)	48**					
Sw_i (%)	52**					
Sg_i (%)						
Permeability to air (md)	1,800**					
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	16					
Sulfur content (% by wt.)						
Initial solution GOR (SCF/STB)						
Initial oil FVF (RB/STB)	1.02**					
Bubble point press. (psia)						
Viscosity (cp) @ °F						
Gas:						
Specific gravity (air = 1.0)						
Heating value (Btu/cu. ft.)						
Water:						
Salinity, NaCl (ppm)						
T.D.S. (ppm)						
R_w (ohm/m) (77°F)						
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects						
Date started						
Date discontinued						
Peak oil production (bbl)						2,885,306
Year						1955
Peak gas production, net (Mcf)						2,887,931
Year						1956

Base of fresh water (ft.): See areas

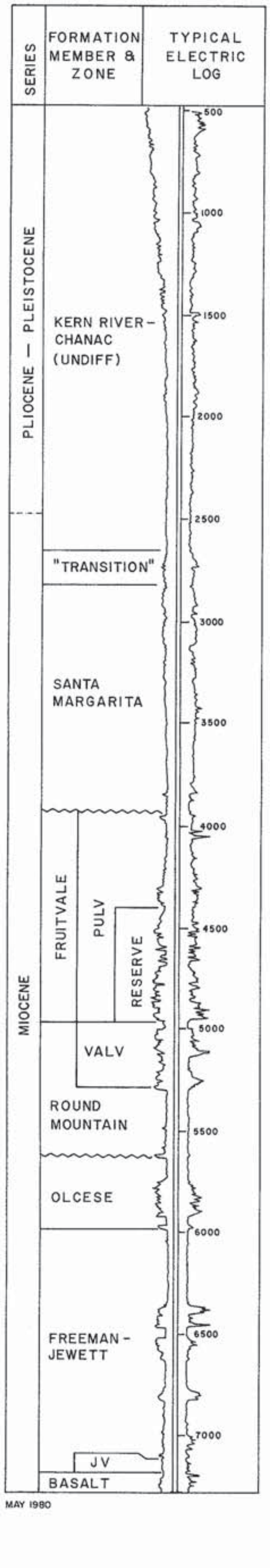
Remarks:

Selected References: See areas

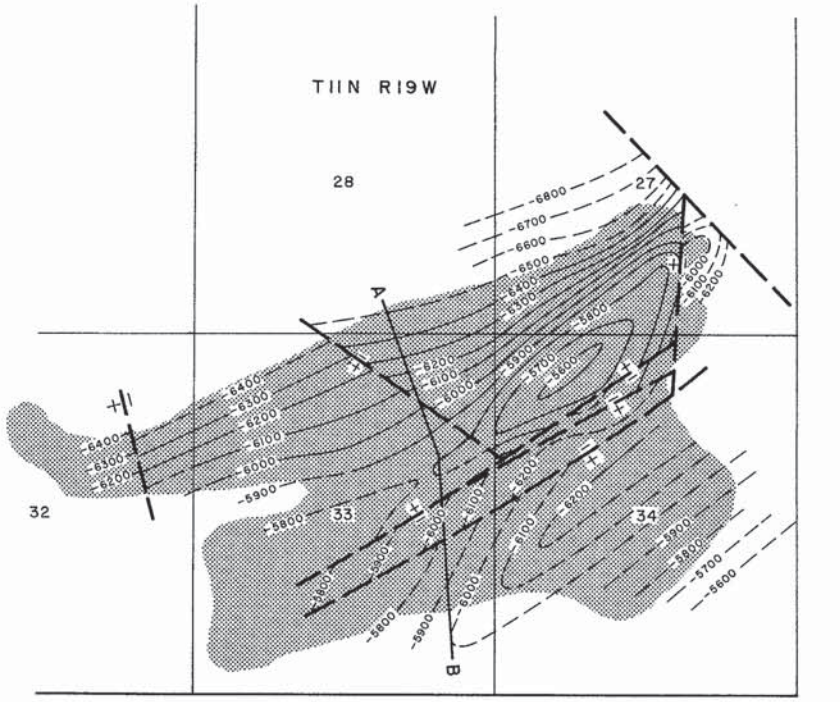
DATE: October 1991 **Estimated value

DEPARTMENT OF CONSERVATION / DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

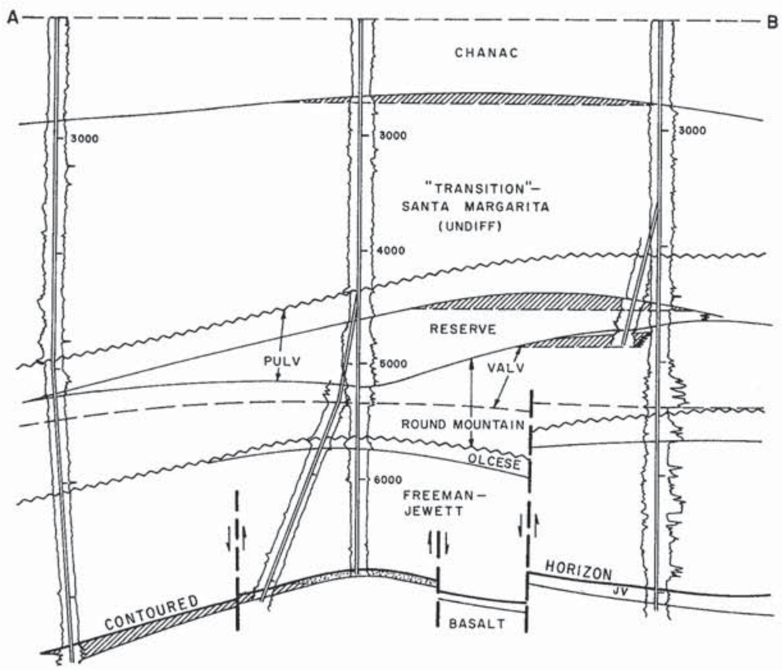
TEJON OIL FIELD
Central Area



MAY 1980



CONTOURS ON TOP OF THE JV SAND



COUNTY: **KERN**

TEJON OIL FIELD
CENTRAL AREA

SHEET 1 OF 2

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well	Reserve Oil Inc. "Reserve - E.W. Pauley" 3-33	Reserve Oil and Gas Co. No. 33-3	33 11N 19W	SB	4,431	Reserve	
Deepest well	Reserve Oil Inc. "Reserve - E.W. Pauley" 12-34	Reserve Oil and Gas Co. "Reserve - E.W. Pauley" 12-34	34 11N 19W	SB	11,687		Reed Canyon Eocene

POOL DATA

ITEM	TRANSITION a/	SANTA MARGARITA	RESERVE a/	VALV a/	OLCESE b/	FIELD OR AREA DATA
Discovery date	July 1944	April 1950	January 1937	December 1951	May 1954	
Initial production rates						
Oil (bbl/day)	1,500	200	12,000	3,000	477	
Gas (Mcf/day)	550/620		1,200/1,700	1,650/1,780	362	
Flow pressure (psi)	2/64	on pump	-	-	725/1,500	
Bean size (in.)		-			15/64	
Initial reservoir pressure (psi)	1,100**	990**	2,300**	2,200**	2,475	
Reservoir temperature (°F)	84	102	106	112	122	
Initial oil content (STB/ac.-ft.)	-	1,600**	-	-	1,600**	
Initial gas content (MSCF/ac.-ft.)	-	300**	-	-	700**	
Formation	"Transition"	Santa Margarita	Fruitvale	Round Mountain	Olcese	
Geologic age	Miocene	Miocene	Miocene	Miocene	Miocene	
Average depth (ft.)	2,725	2,900	4,400	4,650	5,600	
Average net thickness (ft.)	85	100	80	80	170	
Maximum productive area (acres)						
RESERVOIR ROCK PROPERTIES						
Porosity (%)	30.0**	29.0**	28.0**	29.0**	29.4	
S_{oi} (%)	-	68**	-	-	75**	
S_{wi} (%)	-	32**	-	-	25**	
S_{gi} (%)						
Permeability to air (md)	0-1,200	600-1,500	1,200**	1,200**	0-2,000	
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	17	18	23-28	33	29	
Sulfur content (% by wt.)	0.17	0.29	0.40	0.22	0.33	
Initial solution GOR (SCF/STB)	-	40**	-	-	400	
Initial oil FVF (RB/STB)	-	1.02**	-	-	1.2**	
Bubble point press. (psia)	-	420**	-	-	1,800**	
Viscosity (cp) @ °F	-	-	-	9.7 @ 100	-	
Gas:						
Specific gravity (air = 1.0)	-	0.60**	-	-	0.78**	
Heating value (Btu/cu. ft.)						
Water:						
Salinity, NaCl (ppm)	350	350	4,300	4,300	-	
T.D.S. (ppm)	2,200	2,200	6,900	6,900	-	
R_w (ohm/m) (77°F)	3.9	3.9	1.0	1.0	-	
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects						
Date started						
Date discontinued						
Peak oil production (bbl)	113,000	157,000	171,000	199,000	971,747	
Year	1955	1953	1961	1953	1955	
Peak gas production, net (Mcf)						
Year						

Base of fresh water (ft.): 1,600

Remarks: a/ Discovery well in gas cap.
b/ Pool has a large gas cap.

Selected References: Carls, J.M., 1956, Central Area of Tejon Oil Field: Div. of Oil and Gas, Summary of Operations -- Calif. Oil Fields, Vol. 42, No. 2.
Kasline, F.E., 1948, Tejon Oil Field: Calif. Div. of Oil and Gas, Summary of Operations -- Calif. Oil Fields, Vol. 34, No. 1.

DATE: January 1983 **Estimated value

DEPARTMENT OF CONSERVATION / DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

COUNTY: KERN

TEJON OIL FIELD
CENTRAL AREA

SHEET 2 OF 2

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well							
Deepest well							

POOL DATA

ITEM	JV a/					FIELD OR AREA DATA
Discovery date	December 1954					
Initial production rates						
Oil (bbl/day)	482					
Gas (Mcf/day)	329					
Flow pressure (psi)	1,400/2,140					
Bean size (in.)						
Initial reservoir pressure (psi)	3,330					
Reservoir temperature (°F)	135					
Initial oil content (STB/ac.-ft.)	950**					
Initial gas content (MSCF/ac.-ft.)	1,000**					
Formation	Freeman-Jewett					
Geologic age	Miocene					
Average depth (ft.)	7,200					
Average net thickness (ft.)	50					
Maximum productive area (acres)						1,090
RESERVOIR ROCK PROPERTIES						
Porosity (%)	25-26					
So_i (%)						
Sw_i (%)	34					
Sg_i (%)						
Permeability to air (md)	3.5-5,000 (600*)					
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	34-40					
Sulfur content (% by wt.)						
Initial solution GOR (SCF/STB)	700					
Initial oil FVF (RB/STB)	1.39					
Bubble point press. (psia)	2,350					
Viscosity (cp) @ °F						
Gas:						
Specific gravity (air = 1.0)	0.85**					
Heating value (Btu/cu. ft.)						
Water:						
Salinity, NaCl (ppm)	6,100					
T.D.S. (ppm)	7,000					
R_w (ohm/m) (77°F)	0.81					
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects						
Date started						
Date discontinued						
Peak oil production (bbl)	1,202,106					2,377,486
Year	1956					1955
Peak gas production, net (Mcf)						7,342
Year						1984

Base of fresh water (ft.):

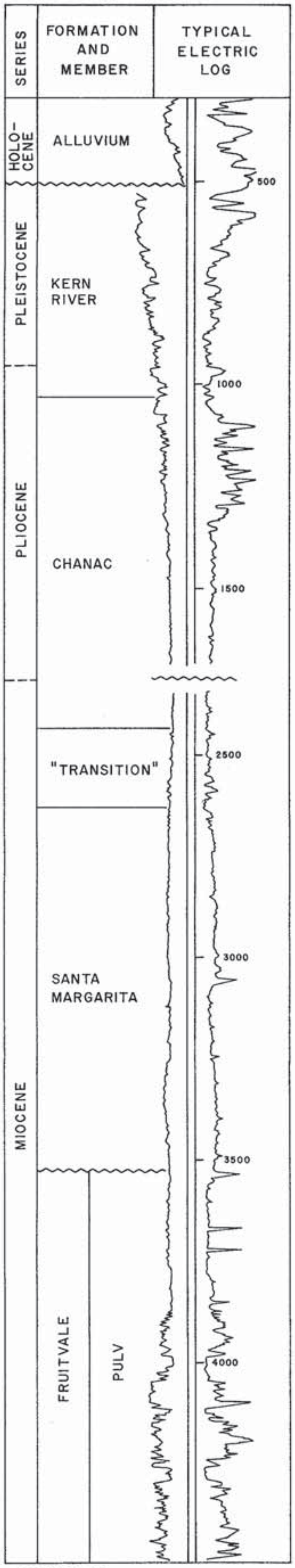
Remarks: a/ Pool had an original gas cap.

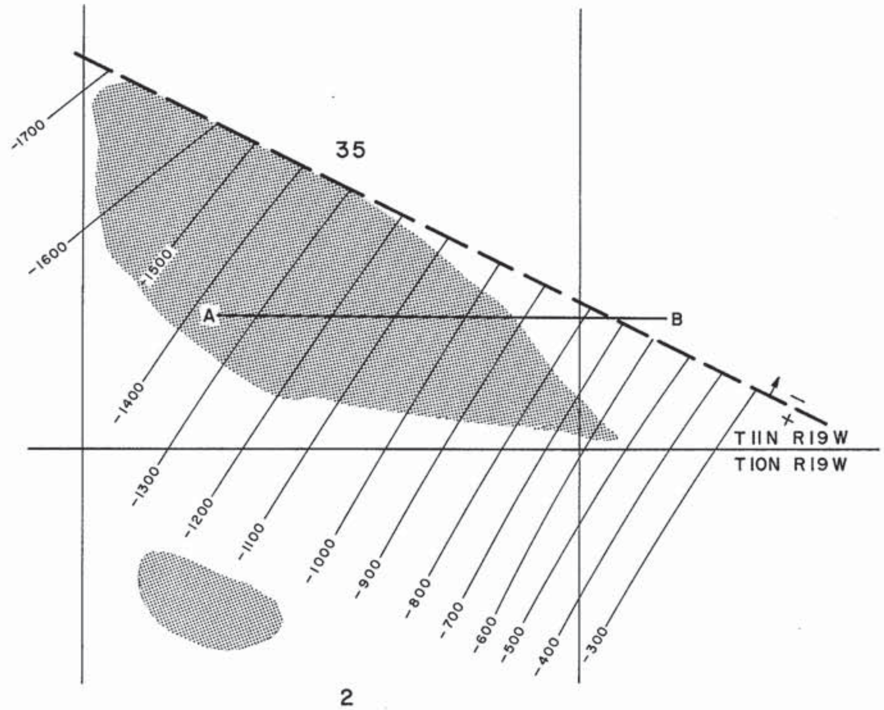
Selected References:

DATE: October 1991 *Average value **Estimated value

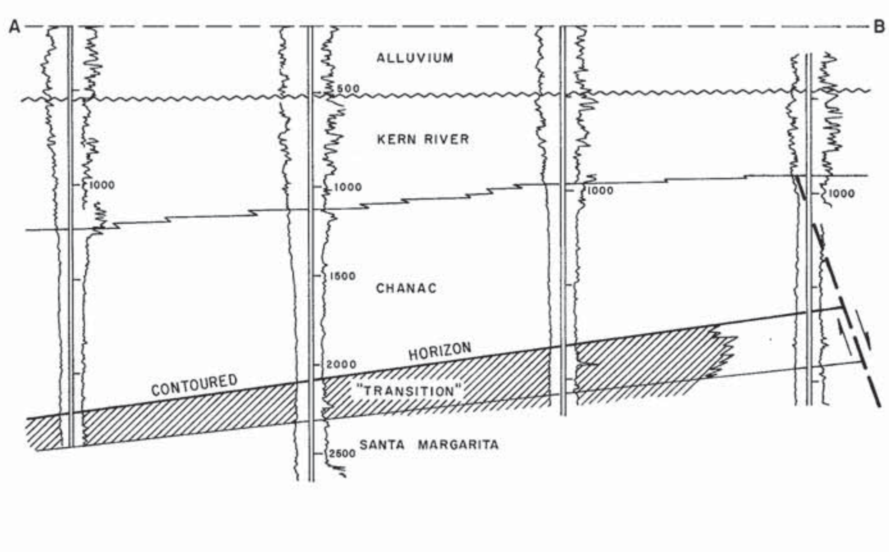
DEPARTMENT OF CONSERVATION / DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

TEJON OIL FIELD
Eastern Area





CONTOURS ON TOP OF "TRANSITION"



COUNTY: KERN

TEJON OIL FIELD
EASTERN AREA

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well	ARCO Oil and Gas Co. "Tejon A" 57-35	Richfield Oil Corp. "Tejon A" 57-35	35 11N 19W	SB	2,372	a/	
Deepest well	Marathon Oil Co. "Title Insurance & Trust" 1	The Ohio Oil Co. "Title Insurance & Trust" 1	36 11N 19W	SB	5,507		Tecuya (?) Oligocene/Eocene

POOL DATA

ITEM	a/					FIELD OR AREA DATA
Discovery date	November 1943					
Initial production rates						
Oil (bbl/day)	120					
Gas (Mcf/day)						
Flow pressure (psi)	on pump					
Bean size (in.)						
Initial reservoir pressure (psi)	620**					
Reservoir temperature (°F)	84					
Initial oil content (STB/ac.-ft.)	1,400**					
Initial gas content (MSCF/ac.-ft.)	200**					
Formation	a/					
Geologic age	Miocene					
Average depth (ft.)	2,000					
Average net thickness (ft.)	150					
Maximum productive area (acres)	220					220
RESERVOIR ROCK PROPERTIES						
Porosity (%)	26**					
So_i (%)	72**					
Sw_i (%)	28**					
Sg_i (%)						
Permeability to air (md)	200-1,200					
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	18					
Sulfur content (% by wt.)						
Initial solution GOR (SCF/STB)	40**					
Initial oil FVF (RB/STB)	1.02**					
Bubble point press. (psia)	400**					
Viscosity (cp) @ °F						
Gas:						
Specific gravity (air = 1.0)	0.6**					
Heating value (Btu/cu. ft.)						
Water:						
Salinity, NaCl (ppm)	450					
T.D.S. (ppm)	940					
R_w (ohm/m) (77°F)						
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects	waterflood					
Date started	1967					
Date discontinued	active					
Peak oil production (bbl)	118,690					
Year	1947					
Peak gas production, net (Mcf)	11,176					
Year	1965					

Base of fresh water (ft.): 1,300

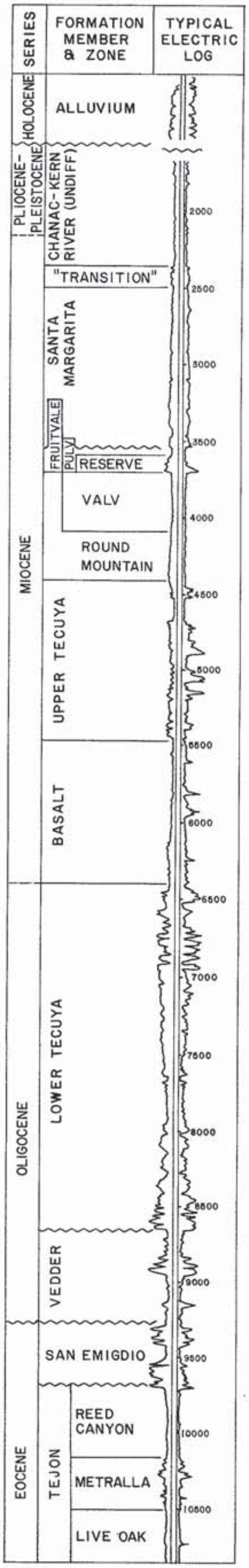
Remarks: a/ "Transition" - Santa Margarita

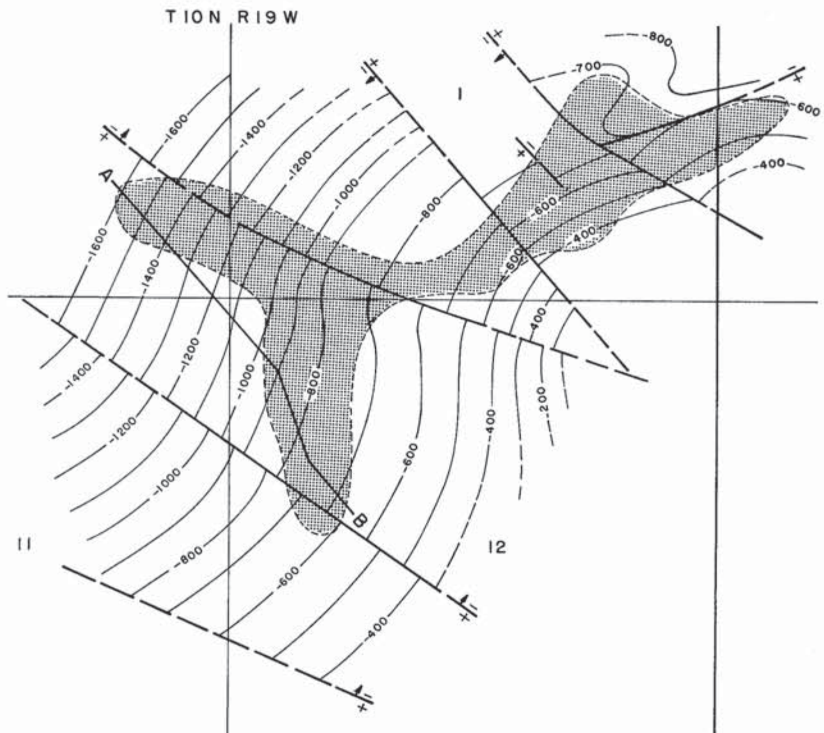
Selected References: Kasline, F.E., 1948, Tejon Oil Field: Calif. Div. of Oil and Gas, Summary of Operations -- Calif. Oil Fields, Vol. 34, No. 1.

DATE: October 1991 **Estimated value

DEPARTMENT OF CONSERVATION / DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

TEJON OIL FIELD
Southeast Area





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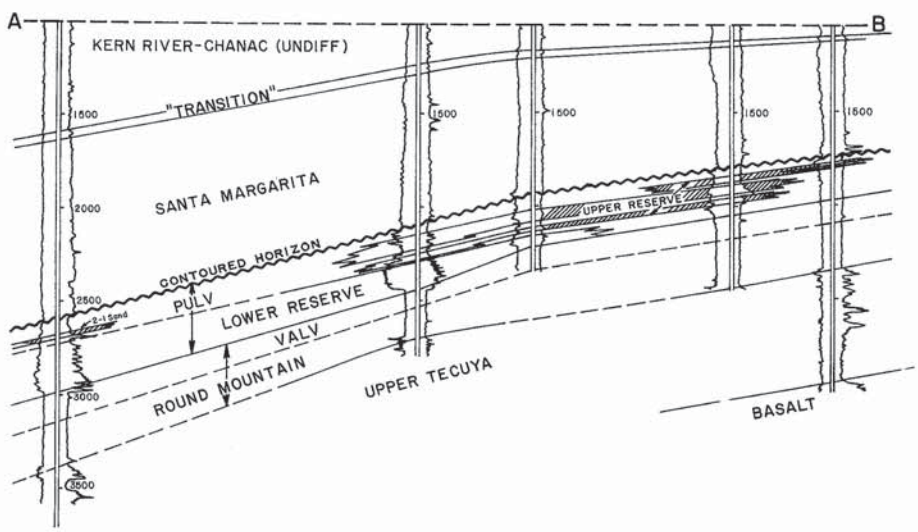


COUNTY: KERN

TEJON OIL FIELD
SOUTHEAST AREA

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well	Reserve Oil Inc. No. 2-1 a/	Reserve Oil and Gas Co. "Tejon Ranch" 1	2 10N 19W	SB	3,708	2-1 Sand	
Deepest well	ARCO Oil and Gas Co. "Tejon Ranch" 1	Richfield Oil Corp. "Tejon Ranch" 1	2 10N 19W	SB	10,940		Live Oak Eocene

POOL DATA

ITEM	2-1 SAND	UPPER RESERVE	LOWER RESERVE			FIELD OR AREA DATA
Discovery date	June 1935	March 1951	April 1967			
Initial production rates						
Oil (bbl/day)	55	7	90			
Gas (Mcf/day)	-	-	16			
Flow pressure (psi)	on pump	on pump	10/245			
Bean size (in.)	-	-	on pump			
Initial reservoir pressure (psi)	825**	560**	520**			
Reservoir temperature (°F)	107	100	100			
Initial oil content (STB/ac.-ft.)	1,100**	1,500**	1,100**			
Initial gas content (MSCF/ac.-ft.)	-	-	200**			
Formation	Fruitvale	Fruitvale	Fruitvale			
Geologic age	Miocene	Miocene	Miocene			
Average depth (ft.)	2,670	1,810	1,670			
Average net thickness (ft.)	20	20-190	150-250			
Maximum productive area (acres)						210
RESERVOIR ROCK PROPERTIES						
Porosity (%)	31**	33-37	26-36			
Soi (%)	48**	63**	29			
Swi (%)	52**	37**	50			
Sgi (%)	-	-	21			
Permeability to air (md)	1,800**	63-3,350	45-1,760			
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	16	17	23			
Sulfur content (% by wt.)						
Initial solution GOR (SCF/STB)	-	-	70**			
Initial oil FVF (RB/STB)	1.02**	1.02**	1.03**			
Bubble point press. (psia)	-	-	580**			
Viscosity (cp) @ °F						
Gas:						
Specific gravity (air = 1.0)	-	-	0.594			
Heating value (Btu/cu. ft.)	-	-	1,042			
Water:						
Salinity, NaCl (ppm)	-	4,800	4,800			
T.D.S. (ppm)						
R_w (ohm/m) (77°F)						
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects						
Date started						
Date discontinued						
Peak oil production (bbl)						191,958
Year						1970
Peak gas production, net (Mcf)						60,864
Year						1970

Base of fresh water (ft.): 1,100 - 1,700

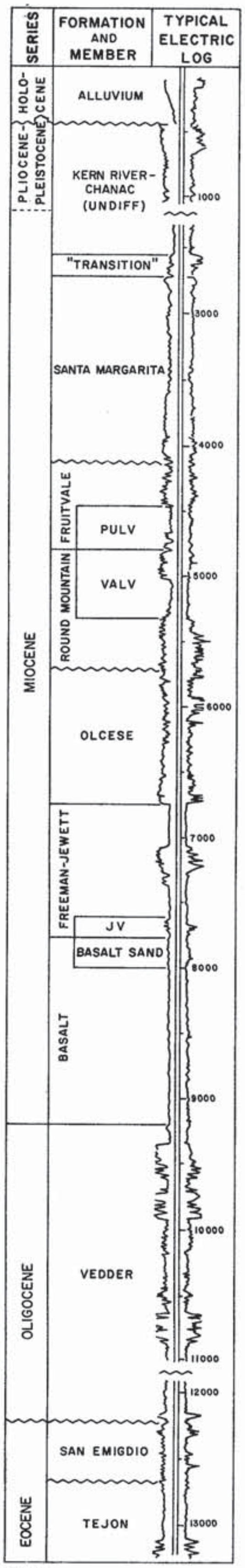
Remarks: a/ Only one well completed in the 2-1 sand, abandoned in 1936. Cumulative production is 3,871 bbl of oil.

Selected References: Barnes, J.A., 1968, Southeast Area of Tejon Oil Field: Calif. Div. of Oil and Gas, Summary of Operations -- Calif. Oil Fields, Vol. 54, No. 1.

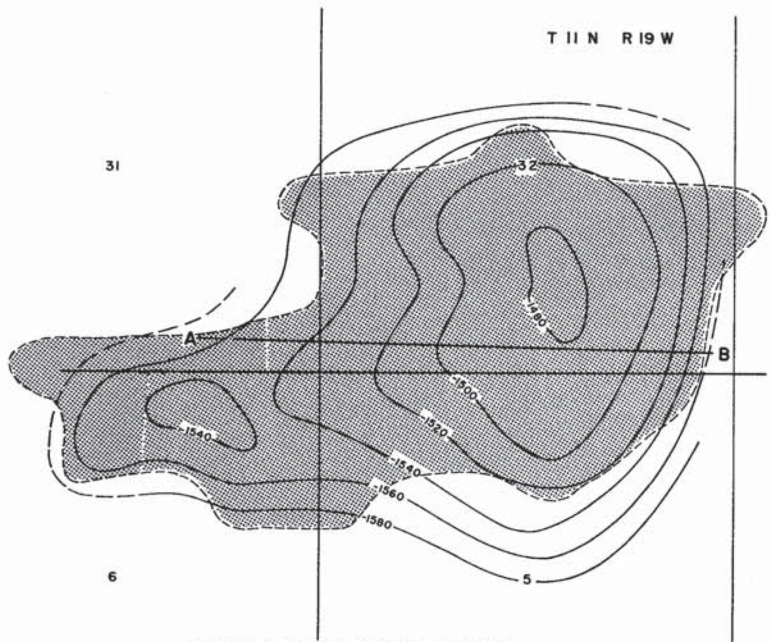
DATE: October 1991 **Estimated value

DEPARTMENT OF CONSERVATION / DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

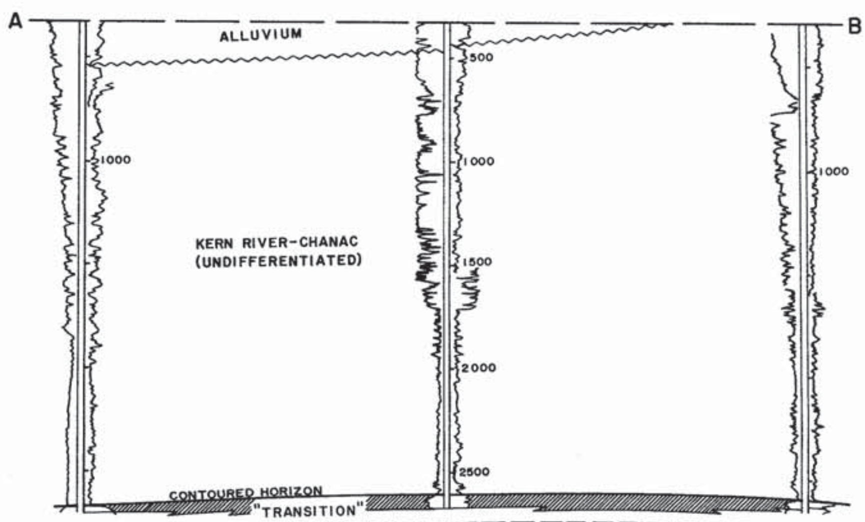
TEJON OIL FIELD
Western Area



MAY 1980



CONTOURS ON TOP OF "TRANSITION"



COUNTY: KERN

TEJON OIL FIELD
WESTERN AREA

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well	Chevron U.S.A. Inc. "Tejon Ranch" 41-5	British-American Oil Prod. Co. "Tejon Ranch" 41-5	5 10N 19W	SB	2,660	a/	
Deepest well	Standard Oil and Gas, Inc. No. 4-1-32	Standard Oil Co. of Calif. "CCMO 4" 35	32 11N 19W	SB	13,239		Tejon Eocene

POOL DATA

ITEM	a/	PULV (Reserve)	VALV			FIELD OR AREA DATA
Discovery date	December 1945	December 1949	October 1957			
Initial production rates						
Oil (bbl/day)	144	27	154			
Gas (Mcf/day)	-	60	36			
Flow pressure (psi)	on pump	on pump	80/350			
Bean size (in.)	-	-	18/64			
Initial reservoir pressure (psi)	1,120-1,160	1,560**	2,230			
Reservoir temperature (°F)	112-115	117	135			
Initial oil content (STB/ac.-ft.)	1,339	1,225**	1,123			
Initial gas content (MSCF/ac.-ft.)	400**	500**	700**			
Formation	a/	Fruitvale	Round Mountain			
Geologic age	Miocene	Miocene	Miocene			
Average depth (ft.)	2,600	4,600	5,400			
Average net thickness (ft.)	55	125	60			
Maximum productive area (acres)						670
RESERVOIR ROCK PROPERTIES						
Porosity (%)	29-30	28**	25-30			
S_{oi} (%)	61**	65**	66			
S_{wi} (%)	39**	35**	34			
S_{gi} (%)						
Permeability to air (md)	2,000-3,000	1,200**	500-520			
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	16	20	19-20			
Sulfur content (% by wt.)	0.31-0.54	-	0.37			
Initial solution GOR (SCF/STB)	130-215	120**	200			
Initial oil FVF (RB/STB)	1.06	1.08**	1.14			
Bubble point press. (psia)	1,080	1,000**	1,700			
Viscosity (cp) @ °F	190 @ 115	-	28 @ 130			
Gas:						
Specific gravity (air = 1.0)	0.57**	0.64**	0.57			
Heating value (Btu/cu. ft.)	-	-	990			
Water:						
Salinity, NaCl (ppm)	1,100	-	15,000			
T.D.S. (ppm)	2,500	-	17,200			
R_w (ohm/m) (77°F)	2.20	-	0.35			
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects	cyclic steam		fireflood			
Date started	1964		1982			
Date discontinued	1967		active			
Enhanced recovery projects	waterflood					
Date started	1959					
Date discontinued	active					
Peak oil production (bbl)	984,473	8,400	194,200			984,473
Year	1947	1956	1961			1947
Peak gas production, net (Mcf)						45,820
Year						1983

Base of fresh water (ft.): 1,200 - 1,800

Remarks: a/ "Transition" - Santa Margarita. Portions are also referred to as Chanac zone.

Selected References: Kasline, F.E., 1948, Tejon Oil Field: Calif. Div. of Oil and Gas, Summary of Operations -- Calif. Oil Fields, Vol. 34, No. 1.

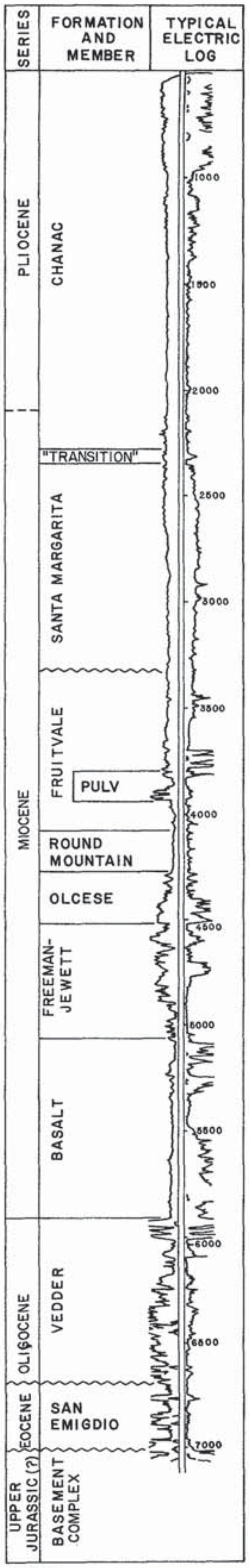
DATE: October 1991 **Estimated value

DEPARTMENT OF CONSERVATION / DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

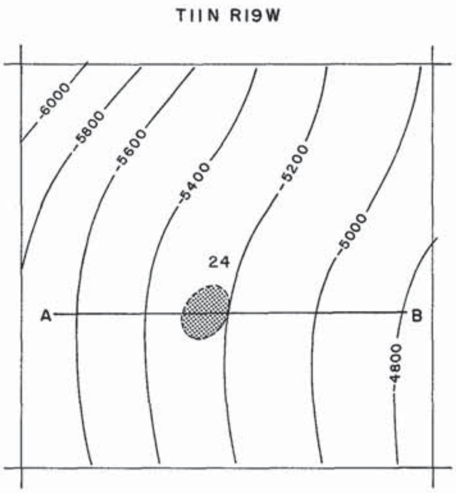
Appendix A.5

Tejon Flats

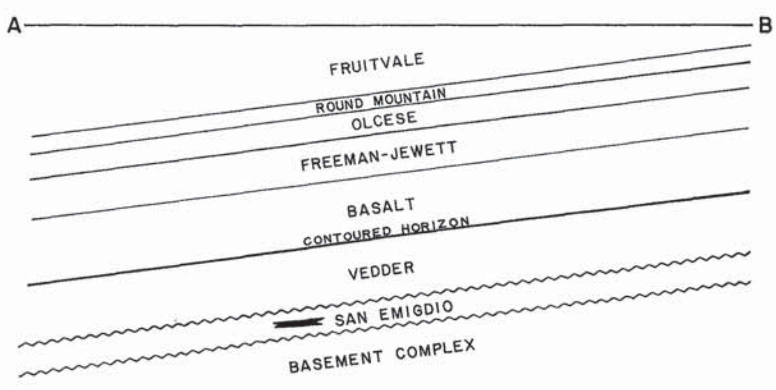
TEJON FLATS OIL FIELD
(Abandoned)



MAY 1980



CONTOURS ON TOP OF VEDDER



COUNTY: **KERN**

TEJON FLATS OIL FIELD (ABD)

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well	Union Oil Co. of Calif. "Reserve-Kerr" 46-24	Same as present	24 11N 19W	SB	7,076	San Emigdio	
Deepest well	Reserve Oil Inc. "Reserve-Union-Kerr" 38-24	Reserve Oil and Gas Co. "Reserve-Union-Kerr" 38-24	24 11N 19W	SB	7,407		basement Late Jurassic(?)

POOL DATA

ITEM	SAN EMIGDIO					FIELD OR AREA DATA
Discovery date	March 1953					
Initial production rates						
Oil (bbl/day)	27					
Gas (Mcf/day)	5					
Flow pressure (psi)	22/pkr					
Bean size (in.)	24/64					
Initial reservoir pressure (psi)	2,550					
Reservoir temperature (°F)	130					
Initial oil content (STB/ac.-ft.)	950**					
Initial gas content (MSCF/ac.-ft.)	700**					
Formation	San Emigdio					
Geologic age	Eocene					
Average depth (ft.)	6,900					
Average net thickness (ft.)	7					
Maximum productive area (acres)	10					
RESERVOIR ROCK PROPERTIES						
Porosity (%)	22**					
So_i (%)	66**					
Sw_i (%)	34**					
Sg_i (%)						
Permeability to air (md)	150**					
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	30					
Sulfur content (% by wt.)						
Initial solution GOR (SCF/STB)	200**					
Initial oil FVF (RB/STB)	1.1**					
Bubble point press. (psia)	950**					
Viscosity (cp) @ °F						
Gas:						
Specific gravity (air = 1.0)	0.83**					
Heating value (Btu/cu. ft.)						
Water:						
Salinity, NaCl (ppm)	27,000					
T.D.S. (ppm)						
R_w (ohm/m) (77°F)						
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects						
Date started						
Date discontinued						
Peak oil production (bbl)	4,969					
Year	1955					
Peak gas production, net (Mcf)	1,137					
Year	1953					

Base of fresh water (ft.): 2,200

Remarks: Field produced from one well. Abandoned in 1958. Cumulative production is 22,118 bbl of oil and 7,632 Mcf of gas.

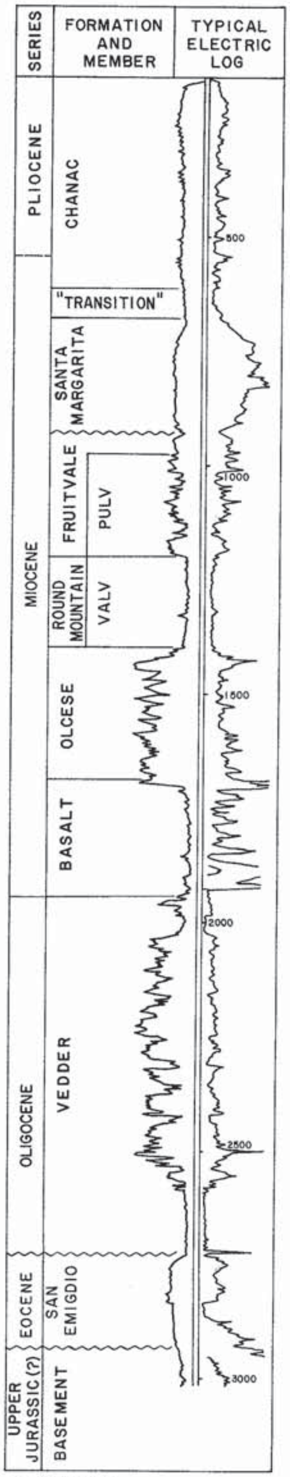
Selected References: Kasline, F.E., 1953, Tejon Hills Oil Field: Calif. Div. of Oil and Gas, Summary of Operations -- Calif. Oil Fields, Vol. 39, No. 1.

DATE: January 1983 **Estimated value

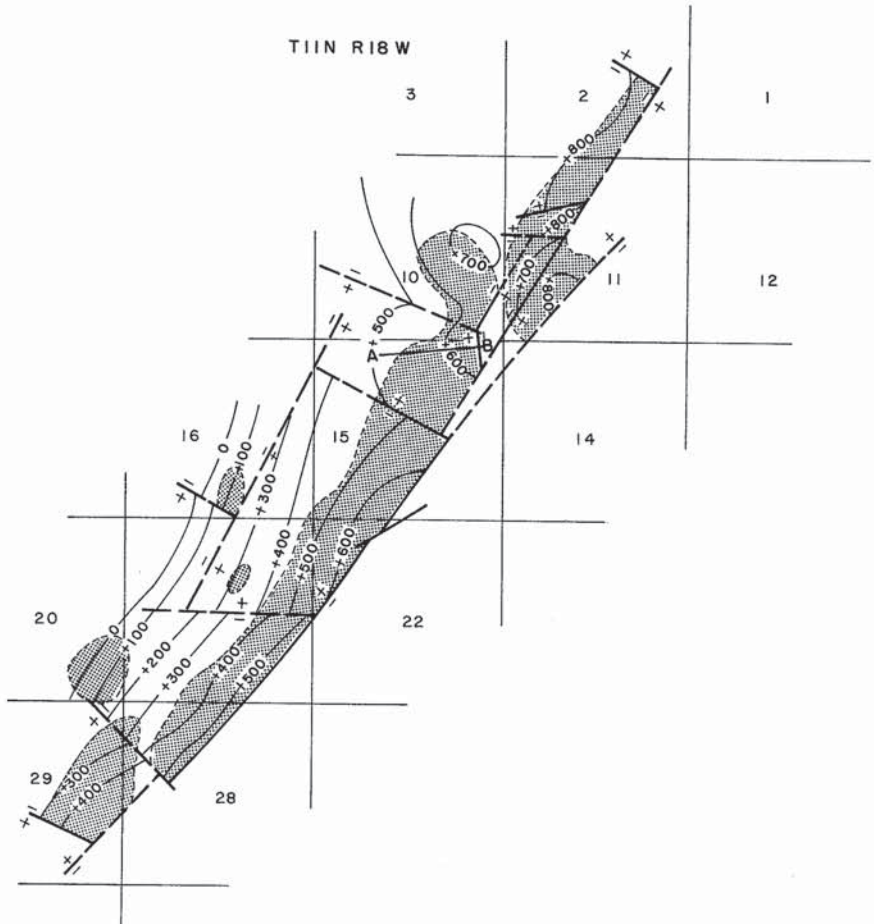
Appendix A.6

Tejon Hills

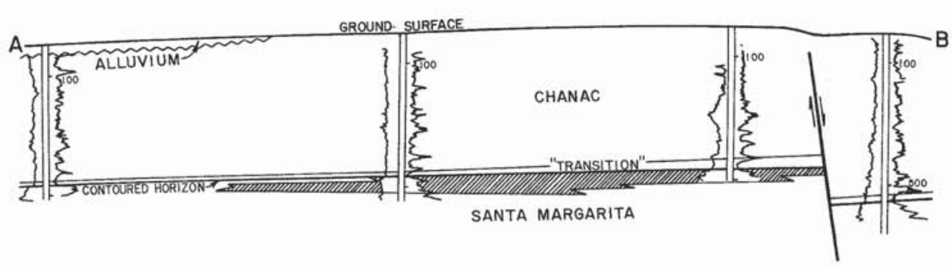
TEJON HILLS OIL FIELD



SEPTEMBER 1992



CONTOURS ON TOP OF SANTA MARGARITA



COUNTY: KERN

TEJON HILLS OIL FIELD

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well	Sherman Havens "Sunset-Tejon" 2	The Tejon Hills Co. "Tejon Hills" 2	10 11N 18W	SB	408	Santa Margarita	
Deepest well	Chevron U.S.A. Inc. "Tejon Ranch" 1	Western Gulf Oil Co. 1 - "Tejon Ranch"	29 11N 18W	SB	4,231		granite Lt. Jurassic(?)

POOL DATA

ITEM	SANTA MARGARITA a/	VALV	VEDDER (DK)	SAN EMIGDIO (LO)		FIELD OR AREA DATA
Discovery date	August 1948	February 1950	June 1950	October 1952		
Initial production rates						
Oil (bbl/day)	62	200	435	32		
Gas (Mcf/day)	50	-	-	-		
Flow pressure (psi)	40/85	110/220	-	35/35		
Bean size (in.)	24/64	14/64	12/64	on pump		
Initial reservoir pressure (psi)	200	600**	2,230	750**		
Reservoir temperature (°F)	75	93	106	114		
Initial oil content (STB/ac.-ft.)	1,400	1,525**	900**	1,150**		
Initial gas content (MSCF/ac.-ft.)	100**	200**	1,200**	200**		
Formation	Santa Margarita	Round Mountain	Vedder	San Emigdio		
Geologic age	Miocene	Miocene	Oligocene	Eocene		
Average depth (ft.)	450	1,350	1,565	2,100		
Average net thickness (ft.)	50	30	100	75		
Maximum productive area (acres)						870
RESERVOIR ROCK PROPERTIES						
Porosity (%)	29.8-36.5	30.3-44.8	29.2-31.5	24**		
S_{oi} (%)	60	68**	52**	70**		
S_{wi} (%)	40	32**	48	30**		
S_{gi} (%)						
Permeability to air (md)	1,146-3,178	120-3,200	40-8,000	100**		
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	29	29	33	32		
Sulfur content (% by wt.)	0.29	0.29	-	-		
Initial solution GOR (SCF/STB)	40**	110**	550**	170**		
Initial oil FVF (RB/STB)		1.06**	1.28**	1.1**		
Bubble point press. (psia)	210**	530**	1,900**	710**		
Viscosity (cp) @ °F						
Gas:						
Specific gravity (air = 1.0)	0.81**	0.83**	0.84**	0.87**		
Heating value (Btu/cu. ft.)						
Water:						
Salinity, NaCl (ppm)	60	90	-	-		
T.D.S. (ppm)	1,000	400	-	-		
R_w (ohm/m) (77°F)						
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects	cyclic steam	waterflood				
Date started	1968	1960				
Date discontinued	1969	1964				
	waterflood					
	1954					
	active					
Peak oil production (bbl)	1,060,000					1,604,301
Year	1953					1952
Peak gas production, net (Mcf)						294,864
Year						1952

Base of fresh water (ft.): 800

Remarks: a/ Some pools had original gas caps.

Selected References: Kasline, F.E., 1953, Tejon Hills Oil Field: Calif. Div. of Oil and Gas, Summary of Operations -- Calif. Oil Fields, Vol. 39, No. 1.

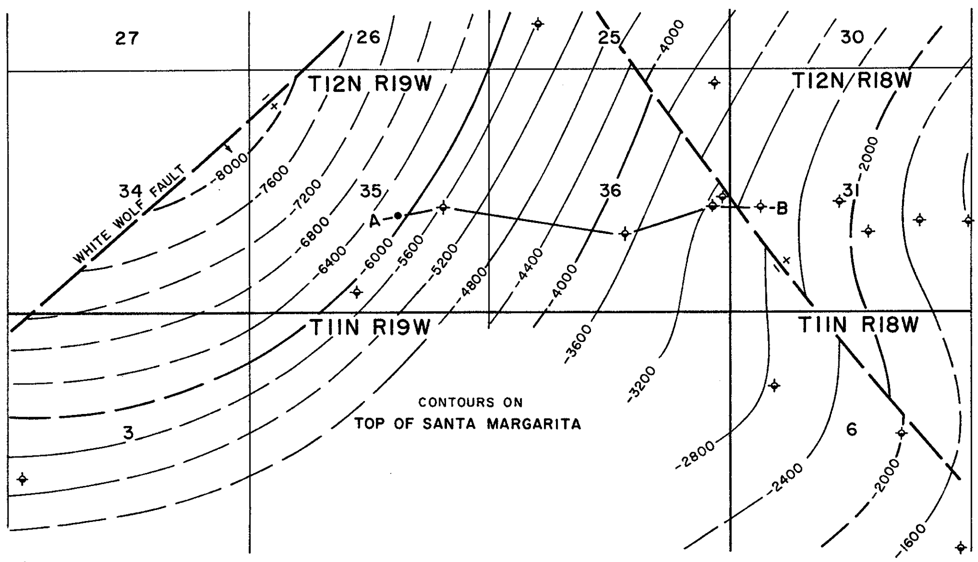
DATE: October 1991 **Estimated value

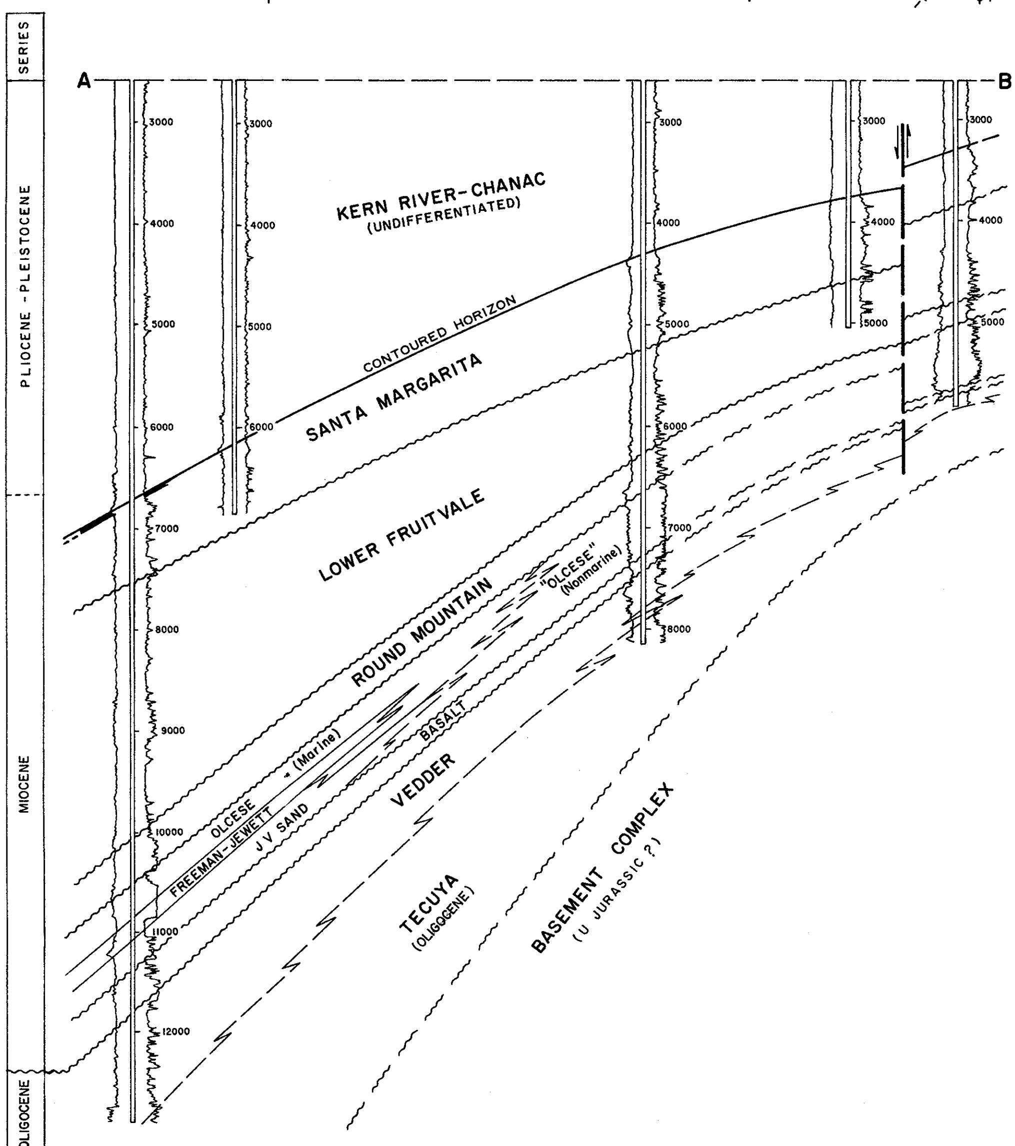
DEPARTMENT OF CONSERVATION / DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

Appendix A.7

Valpredo

VALPREDO OIL FIELD





COUNTY: KERN

VALPREDO OIL FIELD

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well	K.R. Evans, Opr. "S.P.-48" 1	Phillips Petroleum Co. "S.P.-48" 1	35 12N 19W	SB	12,894	Santa Margarita	Tecuya Oligocene
Deepest well	Same as above	"	"	"	"	"	"

POOL DATA

ITEM	SANTA MARGARITA					FIELD OR AREA DATA
Discovery date	November 1961					
Initial production rates						
Oil (bbl/day)	103					
Gas (Mcf/day)	8**					
Flow pressure (psi)	on pump					
Bean size (in.)						
Initial reservoir pressure (psi)	2,100**					
Reservoir temperature (°F)	138					
Initial oil content (STB/ac.-ft.)	1,000**					
Initial gas content (MSCF/ac.-ft.)	200**					
Formation	Santa Margarita					
Geologic age	Miocene					
Average depth (ft.)	6,715					
Average net thickness (ft.)	30					
Maximum productive area (acres)	10					
RESERVOIR ROCK PROPERTIES						
Porosity (%)	24					
S_{oi} (%)	60**					
S_{wi} (%)	40**					
S_{gi} (%)						
Permeability to air (md)	200**					
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	26					
Sulfur content (% by wt.)	1.8					
Initial solution GOR (SCF/STB)	100**					
Initial oil FVF (RB/STB)	1.10					
Bubble point press. (psia)	1,250**					
Viscosity (cp) @ °F						
Gas:						
Specific gravity (air = 1.0)	0.74**					
Heating value (Btu/cu. ft.)						
Water:						
Salinity, NaCl (ppm)	20,000					
T.D.S. (ppm)						
R_w (ohm/m) (77°F)						
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects						
Date started						
Date discontinued						
Peak oil production (bbl)	9,406					
Year	1962					
Peak gas production, net (Mcf)	5,697					
Year	1962					

Base of fresh water (ft.): 5,700

Remarks:

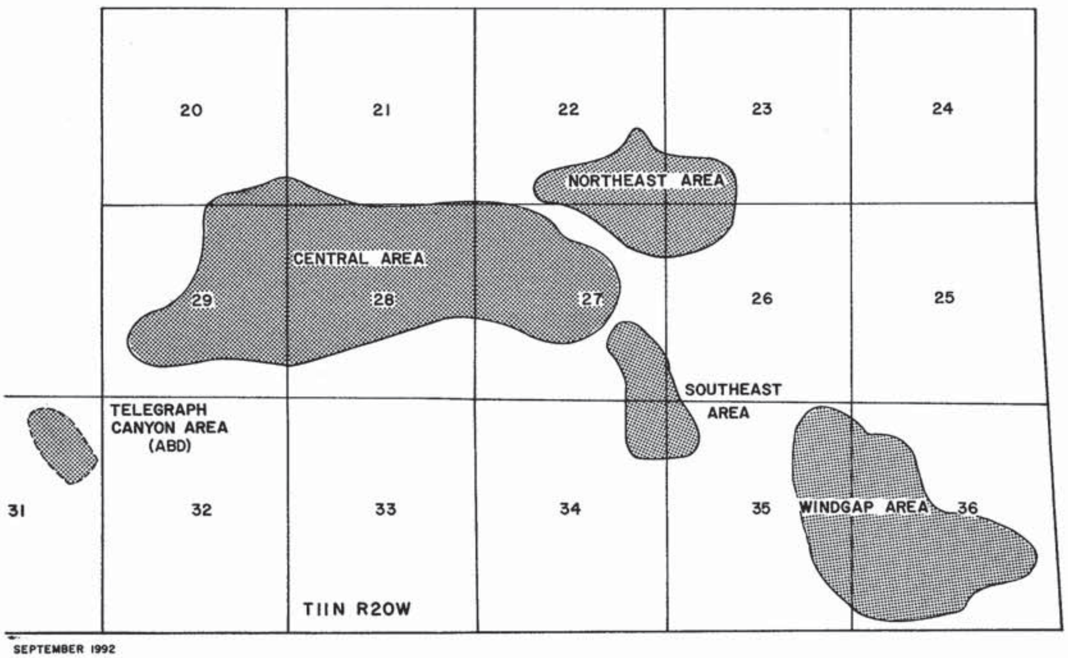
Selected References: Welge, E.A., 1969, Valpredo Oil Field: Calif. Div. of Oil and Gas Summary of Operations -- Calif. Oil Fields, Vol. 55, No. 1.

DATE: January 1983 **Estimated value

Appendix A.8

Wheeler Ridge

WHEELER RIDGE OIL FIELD
Index Map



COUNTY: KERN

WHEELER RIDGE OIL FIELD

(SEE AREAS FOR ADDITIONAL INFORMATION)

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well	ARCO Oil & Gas Co. No. 1	Standard Oil Co. of Calif. "Kern County Lease No. 2" 1	28 11N 20W	SB	2,185	Main	
Deepest well	Chevron U.S.A. Inc. "KCL 2" 337	Standard Oil Co. of Calif. "KCL 2" 337	27 11N 20W	SB	12,514		Tejon Eocene

POOL DATA

ITEM	MAIN					FIELD OR AREA DATA
Discovery date	November 1922					
Initial production rates						
Oil (bbl/day)	275					
Gas (Mcf/day)						
Flow pressure (psi)						
Bean size (in.)						
Initial reservoir pressure (psi)	650**					
Reservoir temperature (°F)	89					
Initial oil content (STB/ac.-ft.)	1,650**					
Initial gas content (MSCF/ac.-ft.)	200**					
Formation	Fruitvale					
Geologic age	Miocene					
Average depth (ft.)	2,050					
Average net thickness (ft.)	200					
Maximum productive area (acres)						1,560
RESERVOIR ROCK PROPERTIES						
Porosity (%)	31**					
So_i (%)	72**					
Sw_i (%)	28**					
Sg_i (%)						
Permeability to air (md)	2,000**					
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	30					
Sulfur content (% by wt.)	0.69					
Initial solution GOR (SCF/STB)	130					
Initial oil FVF (RB/STB)	1.02**					
Bubble point press. (psia)	620**					
Viscosity (cp) @ °F						
Gas:						
Specific gravity (air = 1.0)	0.83**					
Heating value (Btu/cu. ft.)						
Water:						
Salinity, NaCl (ppm)	7,500					
T.D.S. (ppm)	8,900					
R_w (ohm/m) (77°F)	0.68					
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects	waterflood					
Date started	1970					
Date discontinued	1977					
Peak oil production (bbl)						2,587,703
Year						1956
Peak gas production, net (Mcf)						4,621,953
Year						1957

Base of fresh water (ft.): See areas

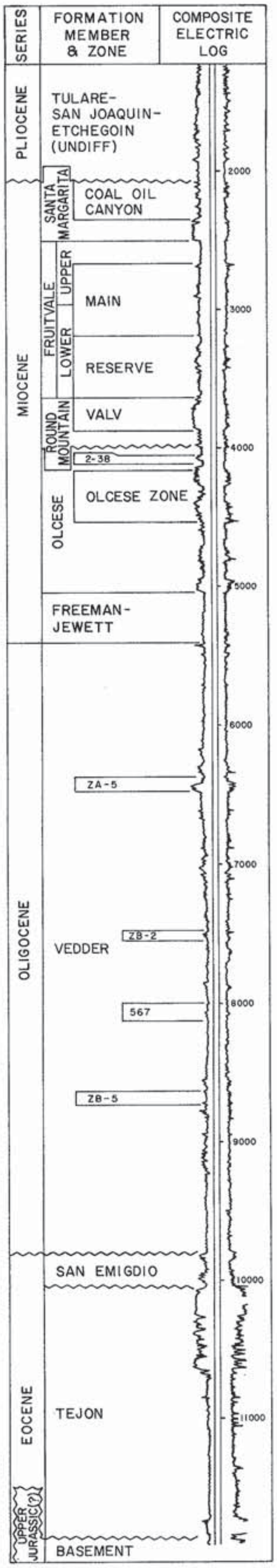
Remarks:

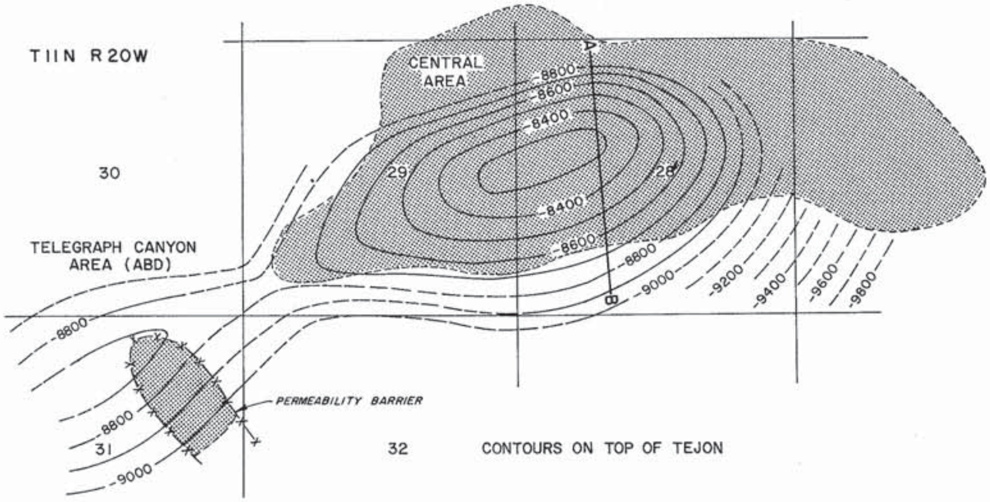
Selected References: See areas

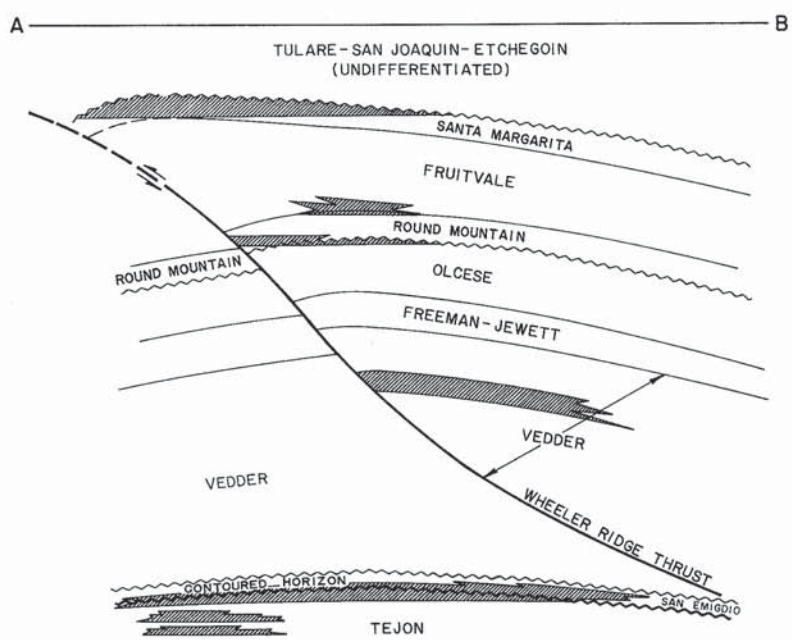
DATE: October 1991 **Estimated value

DEPARTMENT OF CONSERVATION / DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

WHEELER RIDGE OIL FIELD
Central and Telegraph Canyon Areas







SEPTEMBER 1992

COUNTY: **KERN**

WHEELER RIDGE OIL FIELD
CENTRAL AREA

SHEET 1 OF 2

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well	Vintage Petroleum Inc. No. 1	Standard Oil Co. of Calif. "Kern County Lease No. 2" 1	28 11N 20W	SB	2,185	Main	
Deepest well	Chevron U.S.A. Inc. "KCL 2" 337	Standard Oil Co. of Calif. "KCL 2" 337	27 11N 20W	SB	12,514		Tejon Eocene

POOL DATA

ITEM	COAL OIL CANYON	MAIN	VALV	2-38	OLCESE	FIELD OR AREA DATA
Discovery date	May 1948	November 1922	November 1953	March 1951	August 1953	
Initial production rates						
Oil (bbl/day)	165	275	85	202	240	
Gas (Mcf/day)	10	-	-	-	130	
Flow pressure (psi)	on pump	-	gas lift	-	600/pkr	
Bean size (in.)	-	-	-	-	13/64	
Initial reservoir pressure (psi)	320**	650**	1,100**	1,300**	1,700**	
Reservoir temperature (°F)	76	89	103	112	108	
Initial oil content (STB/ac.-ft.)	1,457	1,650**	1,425**	1,250**	1,000**	
Initial gas content (MSCF/ac.-ft.)	-	200**	450**	400**	475**	
Formation	Santa Margarita	Fruitvale	Round Mountain	Olcese	Olcese	
Geologic age	Miocene	Miocene	Miocene	Miocene	Miocene	
Average depth (ft.)	1,000	2,050	3,400	4,250	3,900	
Average net thickness (ft.)	170	200	70	50	180	
Maximum productive area (acres)						
RESERVOIR ROCK PROPERTIES						
Porosity (%)	29-32	31**	29**	29**	25**	
So_i (%)	68**	72**	61**	72**	70**	
Sw_i (%)	32**	28**	39**	28**	30**	
Sg_i (%)					500**	
Permeability to air (md)	800-2,000**	2,000**	1,600**	1,600**	-	
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	20-26	30	26	40	40	
Sulfur content (% by wt.)	0.69	0.69	0.40	0.40		
Initial solution GOR (SCF/STB)	-	130**	170**	440**	570**	
Initial oil FVF (RB/STB)	-	1.02**	1.10**	1.24**	1.33**	
Bubble point press. (psia)	-	620**	950**	1,150**	1,450**	
Viscosity (cp) @ °F						
Gas:						
Specific gravity (air = 1.0)	-	0.83**	0.75**	0.98**	0.96**	
Heating value (Btu/cu. ft.)						
Water:						
Salinity, NaCl (ppm)	3,500-6,000	7,500	-	-	20,000	
T.D.S. (ppm)	5,200-8,400	8,900	-	-	23,000	
R_w (ohm/m) (77°F)	0.94-1.30	0.68	-	-	0.43	
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects / Date started / Date discontinued	waterflood 1962 active; cyclic steam 1965 1974; steamflood 1971 1988; fireflood 1978 1978	waterflood 1970 1981				
Peak oil production (bbl)	209,000		86,000			
Year	1950		1956			
Peak gas production, net (Mcf)						
Year						

Base of fresh water (ft.): None

Remarks:

Selected References:
Carls, J.M., 1951, Recent Developments in Wheeler Ridge Oil Field: Calif. Div. of Oil and Gas, Summary of Operations -- Calif. Oil Fields, Vol. 37, No. 1.
Carls, J.M., 1955, Wheeler Ridge Oil Field Eocene Developments: Calif. Div. of Oil and Gas, Summary of Operations -- Calif. Oil Fields, Vol. 41, No. 1.
Kaiser, C.L., 1924, Wheeler Ridge Oil Field: State Mining Bureau, Summary of Operations -- Calif. Oil Fields, Vol. 9, No. 12.

DATE: November 1997 **Estimated value

COUNTY: **KERN**

WHEELER RIDGE OIL FIELD
CENTRAL AREA

SHEET 2 OF 2

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well							
Deepest well							

POOL DATA

ITEM	ZA-5	ZB-5	REFUGIAN	EOCENE		FIELD OR AREA DATA
Discovery date	August 1953	September 1956	July 1953	May 1952		
Initial production rates						
Oil (bbl/day)	158	195	21	419		
Gas (Mcf/day)	155	170	20	678		
Flow pressure (psi)	740/pkr	800/pkr	100/pkr	2,950/pkr		
Bean size (in.)	11/64	32/64	-	-		
Initial reservoir pressure (psi)	2,850**	3,850**	4,200**	5,470		
Reservoir temperature (°F)	137	162	172	205		
Initial oil content (STB/ac.-ft.)	800**	625**	650**	590		
Initial gas content (MSCF/ac.-ft.)	700**	700**	700**	138		
Formation	Vedder	Vedder	San Emigdio	Tejon		
Geologic age	Oligocene	Oligocene	Eocene	Eocene		
Average depth (ft.)	6,500	8,700	9,600	9,800		
Average net thickness (ft.)	70	70	170	400		
Maximum productive area (acres)	-	-	-	410		730
RESERVOIR ROCK PROPERTIES						
Porosity (%)	23.0**	21.0**	19.0**	15.2		
So_i (%)	70**	72**	72**	68**		
Sw_i (%)	30**	28**	28**	32**		
Sg_i (%)						
Permeability to air (md)	250**	150**	100**	146		
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	44	44	35	36		
Sulfur content (% by wt.)	-	-	0.29	0.29		
Initial solution GOR (SCF/STB)	980**	1,350**	950**	1,482		
Initial oil FVF (RB/STB)	1.57**	1.78**	1.53**	1.62		
Bubble point press. (psia)	2,100**	3,100**	3,300**	5,425		
Viscosity (cp) @ °F	-	-	-	38 @ 100		
Gas:						
Specific gravity (air = 1.0)	0.98**	0.92**	0.83**	0.85		
Heating value (Btu/cu. ft.)						
Water:						
Salinity, NaCl (ppm)	-	45,000	-	38,000		
T.D.S. (ppm)	-	46,000	-	39,000		
R_w (ohm/m) (77°F)	-	0.18	-	0.23		
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects				waterflood		
Date started				1982		
Date discontinued				active		
Peak oil production (bbl)	33,000	166,000		1,760,000 a/		640,449
Year	1954	1958		1956		1990
Peak gas production, net (Mcf)						
Year						

Base of fresh water (ft.): None

Remarks: a/ Combined Refugian and Eocene production.

Selected References:

DATE: October 1991 **Estimated value

DEPARTMENT OF CONSERVATION / DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

COUNTY: KERN

WHEELER RIDGE OIL FIELD
TELEGRAPH CANYON AREA (ABD)

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well	ARCO Western Energy "K.C.L. D" 84-31	Richfield Oil Corp. "K.C.L. D" 84-31	31 11N 20W	SB	10,926	Tejon	Tejon Eocene
Deepest well	Same as above	"	"	"	"	"	"

POOL DATA

ITEM	TEJON					FIELD OR AREA DATA
Discovery date	August 1955					
Initial production rates						
Oil (bbl/day)	31					
Gas (Mcf/day)						
Flow pressure (psi)	50/0					
Bean size (in.)	14/64					
Initial reservoir pressure (psi)	4,600**					
Reservoir temperature (°F)	179					
Initial oil content (STB/ac.-ft.)						
Initial gas content (MSCF/ac.-ft.)						
Formation	Tejon					
Geologic age	Eocene					
Average depth (ft.)	10,580					
Average net thickness (ft.)	60					
Maximum productive area (acres)	30					30
RESERVOIR ROCK PROPERTIES						
Porosity (%)	18**					
Soi (%)						
Swi (%)	50**					
Sgi (%)						
Permeability to air (md)	100**					
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	50					
Sulfur content (% by wt.)						
Initial solution GOR (SCF/STB)	a/					
Initial oil FVF (RB/STB)						
Bubble point press. (psia)						
Viscosity (cp) @ °F						
Gas:						
Specific gravity (air = 1.0)	0.58**					
Heating value (Btu/cu. ft.)						
Water:						
Salinity, NaCl (ppm)						
T.D.S. (ppm)						
R_w (ohm/m) (77°F)						
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects						
Date started						
Date discontinued						
Peak oil production (bbl)	60,590					
Year	1957					
Peak gas production, net (Mcf)	889,152					
Year	1957					

Base of fresh water (ft.): None

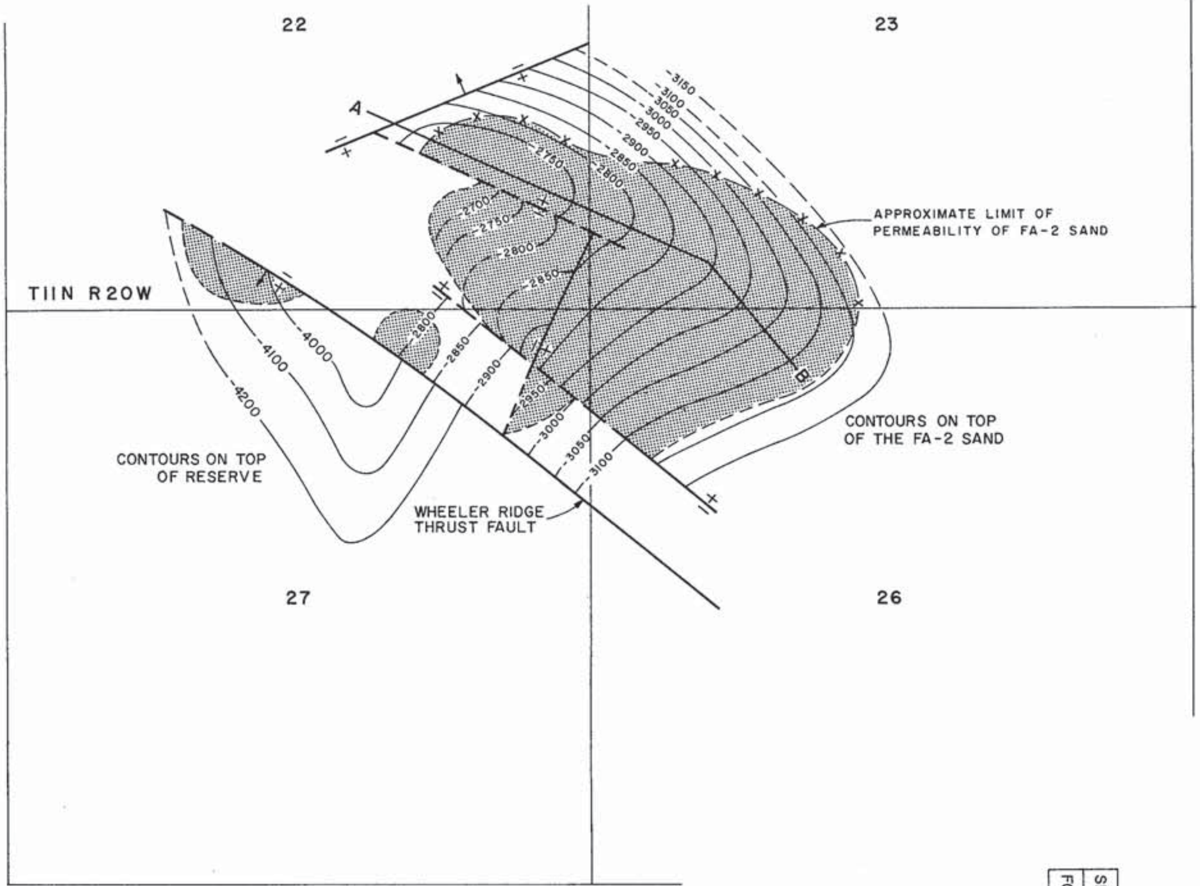
Remarks: Area was abandoned in 1963. Cumulative production is 99,785 bbl of oil and 2,005,872 Mcf of gas.
a/ Data incomplete, zone apparently had free gas.

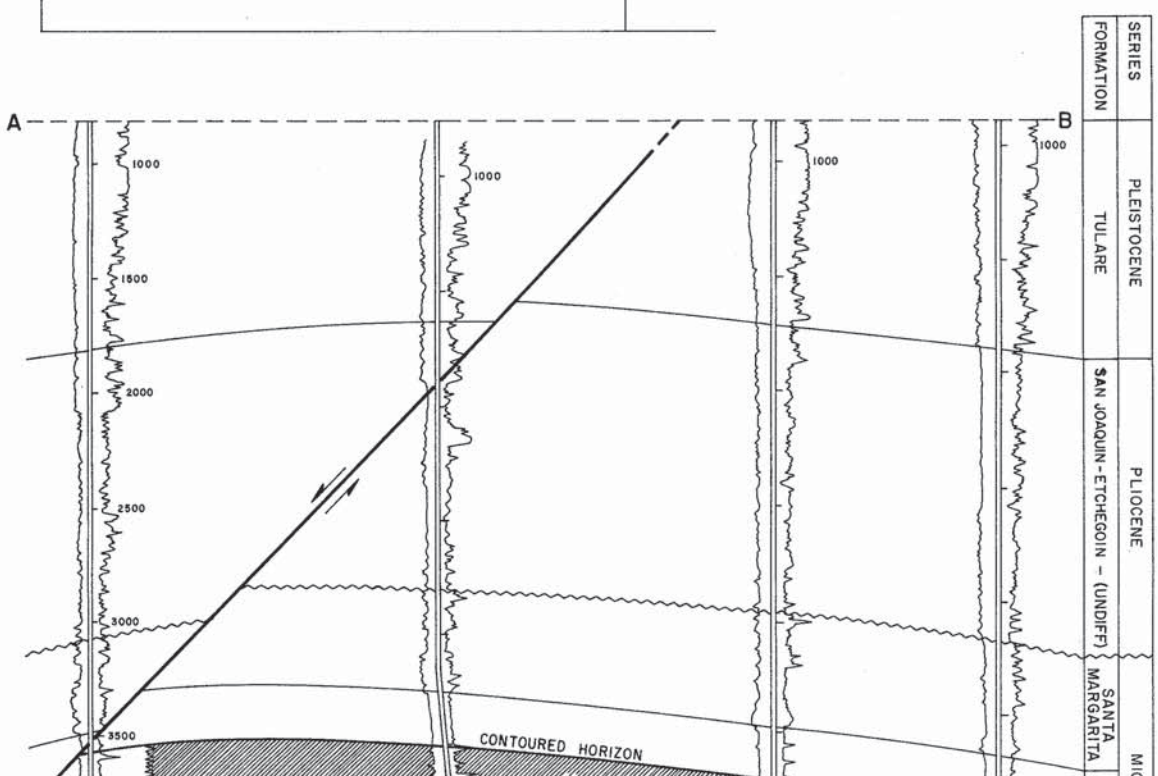
Selected References:

DATE: November 1997 **Estimated value

DEPARTMENT OF CONSERVATION / DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

WHEELER RIDGE OIL FIELD
Northeast Area





COUNTY: KERN

WHEELER RIDGE OIL FIELD
NORTHEAST AREA

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well	ARCO Western Energy "ROC-KCL G" 87-22	Richfield Oil Corp. "ROC-KCL G" 87-22	22 11N 20W	SB	11,064 a/	FA-2	
Deepest well	ARCO Western Energy "KCL S" 61-27	Richfield Oil Corp. "KCL S" 61-27	27 11N 20W	SB	11,972		Tejon Eocene

POOL DATA

ITEM	FA-2	HAGOOD b/	ZB-3 c/			FIELD OR AREA DATA
Discovery date	May 1955	October 1955	January 1964			
Initial production rates						
Oil (bbl/day)	106	90	18			
Gas (Mcf/day)	20	11	40			
Flow pressure (psi)	50/pkr	60/360	75/00			
Bean size (in.)	-	18/64	3/4			
Initial reservoir pressure (psi)	950**	2,200**	3,850**			
Reservoir temperature (°F)	90	130	160			
Initial oil content (STB/ac.-ft.)	1,650**	1,350**	600**			
Initial gas content (MSCF/ac.-ft.)	300**	600**	700**			
Formation	Fruitvale	Fruitvale	Vedder			
Geologic age	Miocene	Miocene	Oligocene			
Average depth (ft.)	2,900	5,100	8,760			
Average net thickness (ft.)	240	73	22			
Maximum productive area (acres)						140
RESERVOIR ROCK PROPERTIES						
Porosity (%)	31	27**	20**			
So_i (%)	72**	70**	73**			
Sw_i (%)	28	30**	27**			
Sg_i (%)						
Permeability to air (md)	200	700**	120**			
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	18	17	39			
Sulfur content (% by wt.)						
Initial solution GOR (SCF/STB)	40**	110**	1,240**			
Initial oil FVF (RB/STB)	1.02**	1.08**	1.70**			
Bubble point press. (psia)	420**	1,100**	3,500**			
Viscosity (cp) @ °F						
Gas:						
Specific gravity (air = 1.0)	0.60**	0.60**	0.86**			
Heating value (Btu/cu. ft.)						
Water:						
Salinity, NaCl (ppm)	7,000-8,500	-	-			
T.D.S. (ppm)	7,700-8,800	-	-			
R_w (ohm/m) (77°F)	0.74-0.91	-	-			
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects						
Date started						
Date discontinued						
Peak oil production (bbl)	250,776	4,732	1,935			255,508
Year	1956	1956	1964			1956
Peak gas production, net (Mcf)	58,822	3,814	9,416			62,636
Year	1956	1956	1964			1956

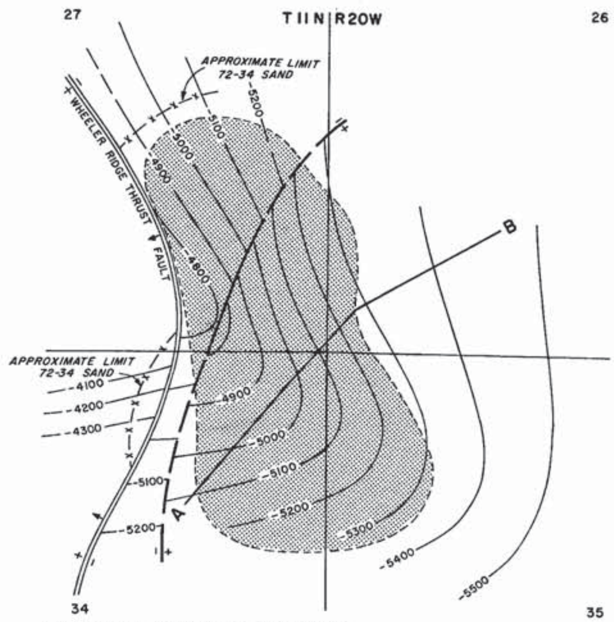
Base of fresh water (ft.): None

Remarks:
a/ Total depth of original hole. Well was completed following a second redrill.
b/ Hagood zone abandoned in 1966. Cumulative production is 15,127 bbl of oil and 6,785 Mcf of gas.
c/ ZB-3 zone abandoned in 1970. Cumulative production is 4,601 bbl of oil and 14,196 Mcf of gas.

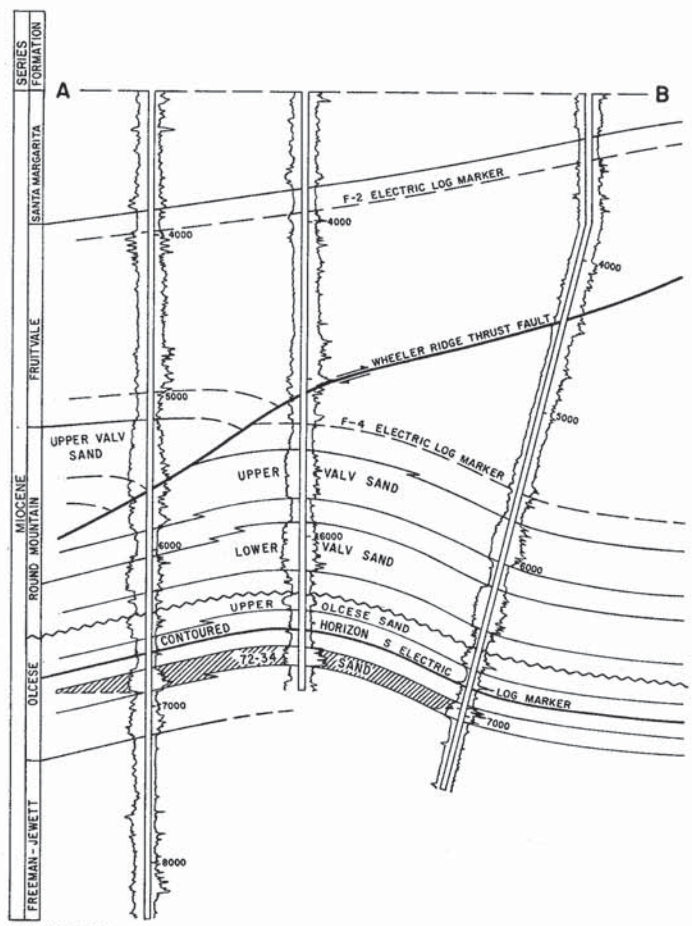
Selected References: Hluza, A.G., 1960, Northeast Area of Wheeler Ridge Oil Field: Calif. Div. of Oil and Gas, Summary of Operations -- Calif. Oil Fields, Vol. 46, No. 2.

DATE: November 1997 **Estimated value

WHEELER RIDGE OIL FIELD
Southeast Area



CONTOURS ON S ELECTRIC LOG MARKER
SCALE 1" = APPROX 1500'



SEPTEMBER 1992

COUNTY: **KERN**

WHEELER RIDGE OIL FIELD
SOUTHEAST AREA

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well	Vintage Petroleum Inc. "KCL L" 72-34	Richfield Oil Corp. "KCL L" 72-34	34 11N 20W	SB	8,354	72-34	
Deepest well	ARCO Western Energy "ROC-KCL F" 65-27	Richfield Oil Corp. "ROC-KCL G" 65-27	27 11N 20W	SB	9,823		Vedder Oligocene

POOL DATA

ITEM	72-34 (OLCESE)					FIELD OR AREA DATA
Discovery date	September 1961					
Initial production rates						
Oil (bbl/day)	149					
Gas (Mcf/day)	122					
Flow pressure (psi)	1,100/900					
Bean size (in.)						
Initial reservoir pressure (psi)	2,845					
Reservoir temperature (°F)	160					
Initial oil content (STB/ac.-ft.)	745					
Initial gas content (MSCF/ac.-ft.)	1,000**					
Formation	Olcese					
Geologic age	Miocene					
Average depth (ft.)	6,875					
Average net thickness (ft.)	130					
Maximum productive area (acres)	100					
RESERVOIR ROCK PROPERTIES						
Porosity (%)	24					
So_i (%)	62**					
Sw_i (%)	38					
Sg_i (%)						
Permeability to air (md)	570					
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	43					
Sulfur content (% by wt.)						
Initial solution GOR (SCF/STB)	965					
Initial oil FVF (RB/STB)	1.53					
Bubble point press. (psia)	2,530					
Viscosity (cp) @ °F						
Gas:						
Specific gravity (air = 1.0)	0.665					
Heating value (Btu/cu. ft.)	1,158					
Water:						
Salinity, NaCl (ppm)	44,000					
T.D.S. (ppm)						
R_w (ohm/m) (77°F)						
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects	waterflood					
Date started	1970					
Date discontinued	1972					
Peak oil production (bbl)	282,474					
Year	1962					
Peak gas production, net (Mcf)	640,283					
Year	1963					

Base of fresh water (ft.): None

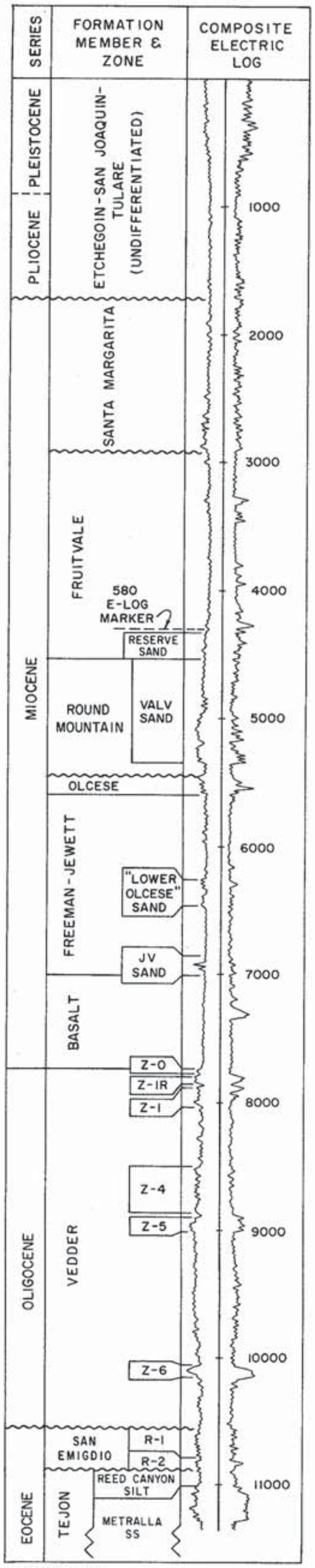
Remarks:

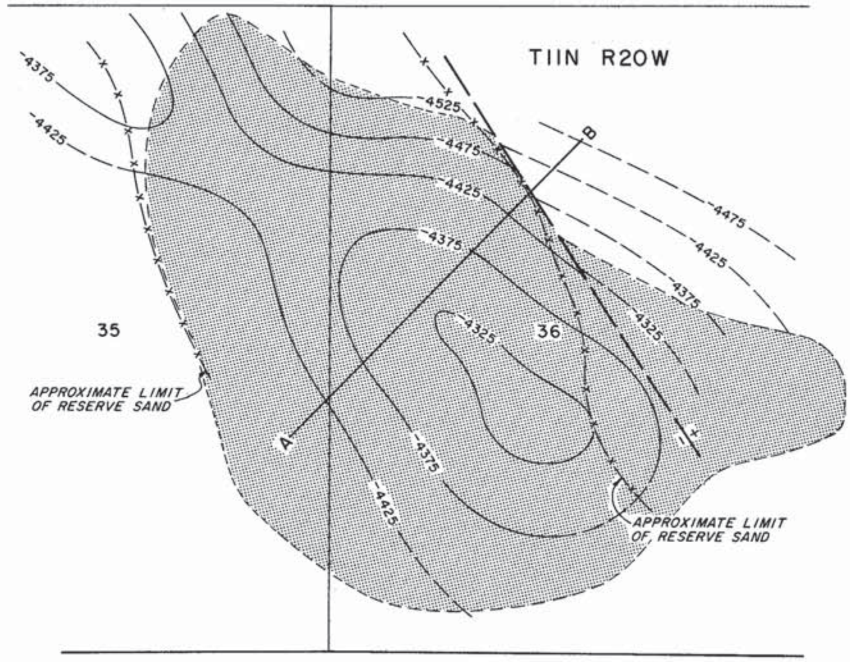
Selected References: Barnes, J.A., 1964, Southeast Area of Wheeler Ridge Oil Field: Calif. Div. of Oil and Gas, Summary of Operations -- Calif. Oil Fields, Vol. 50, No. 2.

DATE: November 1997 **Estimated value

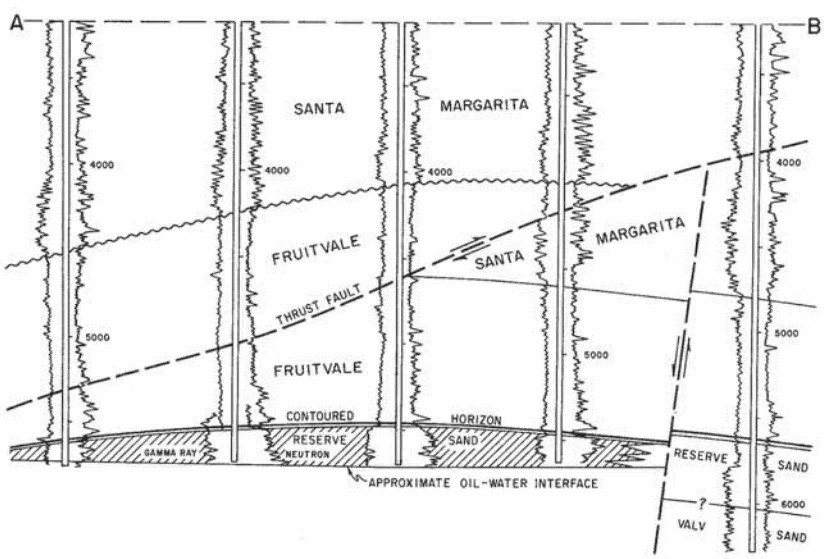
DEPARTMENT OF CONSERVATION / DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

WHEELER RIDGE OIL FIELD
Windgap Area





CONTOURS ON 580 ELECTRIC LOG MARKER



COUNTY: KERN

WHEELER RIDGE OIL FIELD
WINDGAP AREA

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well	Vintage Petroleum Inc. "KCL L" 56-36	Richfield Oil Corp. "KCL L" 56-36	36 11N 20W	SB	8,254	"Lower Olcese"	
Deepest well	ARCO Western Energy "KCL F" 63-36	Richfield Oil Corp. "KCL F" 63-36	36 11N 20W	SB	10,019		Vedder Oligocene

POOL DATA

ITEM	RESERVE	"LOWER OLCESE"				FIELD OR AREA DATA
Discovery date	September 1959	May 1959				
Initial production rates						
Oil (bbl/day)	244	76				
Gas (Mcf/day)	46	1,595				
Flow pressure (psi)	325/pkr	2,475/pkr				
Bean size (in.)	13/64	12/64				
Initial reservoir pressure (psi)	2,305	3,500**				
Reservoir temperature (°F)	140	163				
Initial oil content (STB/ac.-ft.)	1,250**	-				
Initial gas content (MSCF/ac.-ft.)	800**	-				
Formation	Fruitvale	Freeman-Jewett				
Geologic age	Miocene	Miocene				
Average depth (ft.)	5,600	7,400				
Average net thickness (ft.)	150	40				
Maximum productive area (acres)						560
RESERVOIR ROCK PROPERTIES						
Porosity (%)	29	22				
So_i (%)	65**	a/				
Sw_i (%)	35	30**				
Sg_i (%)						
Permeability to air (md)	855	110				
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	21	64				
Sulfur content (% by wt.)						
Initial solution GOR (SCF/STB)	83**	-				
Initial oil FVF (RB/STB)	1.12	-				
Bubble point press. (psia)	2,305	-				
Viscosity (cp) @ °F						
Gas:						
Specific gravity (air = 1.0)	0.7**	-				
Heating value (Btu/cu. ft.)						
Water:						
Salinity, NaCl (ppm)	10,600	-				
T.D.S. (ppm)	11,400	36,000				
R_w (ohm/m) (77°F)	0.60	0.30				
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects	waterflood					
Date started	1962					
Date discontinued	active					
Enhanced recovery projects	pressure maintenance					
Date started	1961					
Date discontinued	1968					
Peak oil production (bbl)	1,611,475	76,338				1,623,974
Year	1969	1965				1969
Peak gas production, net (Mcf)	498,292	1,045,534				1,507,705
Year	1965	1964				1965

Base of fresh water (ft.): 1,800

Remarks: a/ Condensate pool.

Selected References: Park, W.H., 1960, Windgap Area of Wheeler Ridge Oil Field: Calif. Div. of Oil and Gas, Summary of Operations -- Calif. Oil Fields, Vol. 46, No. 2.

DATE: November 1997 **Estimated value

APPENDIX B

Geology and Stratigraphy of the White Wolf Subbasin

Appendix B.1

WRMWSD (2007)

FINAL

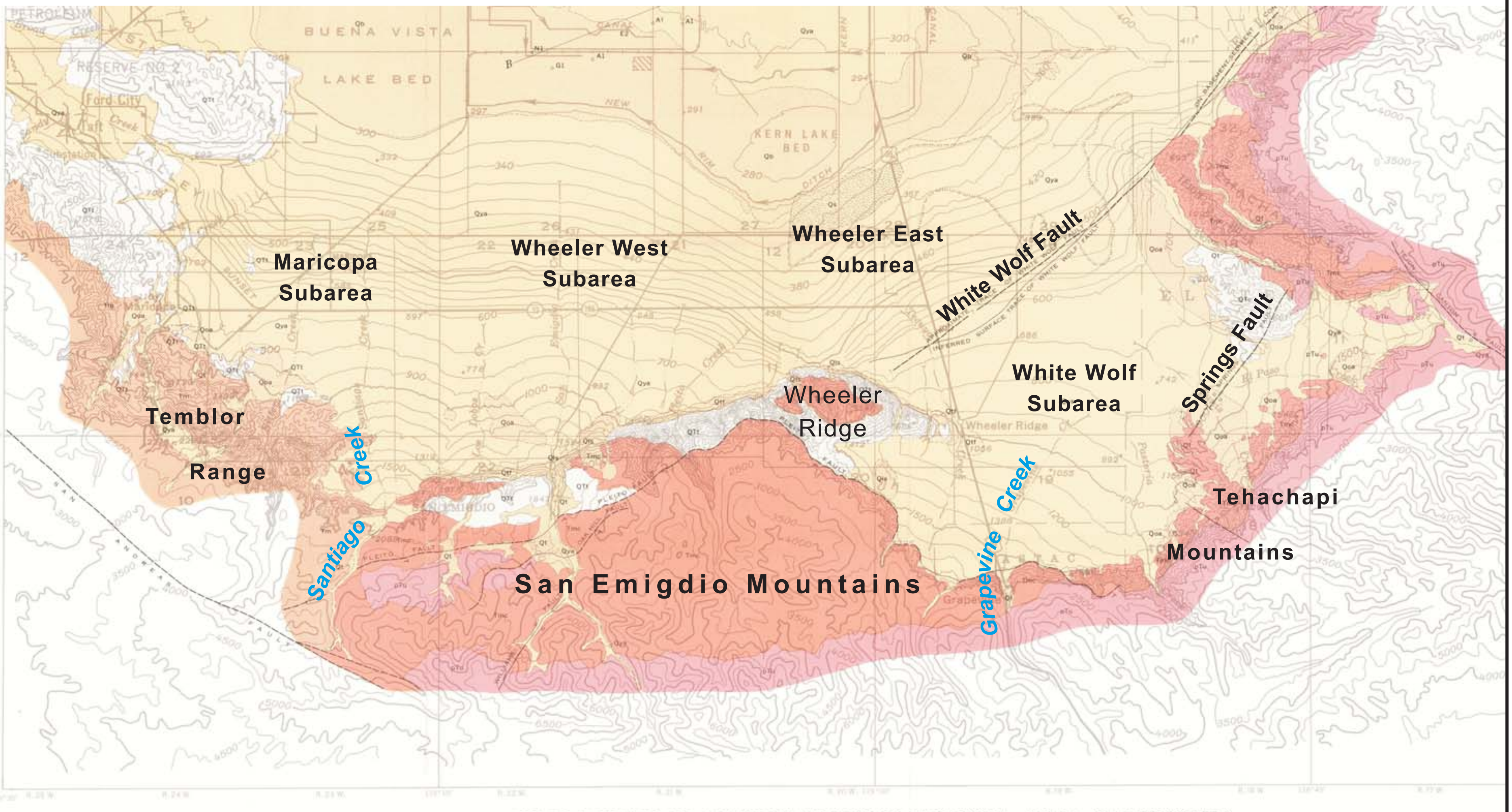
AB3030
Groundwater Management Plan

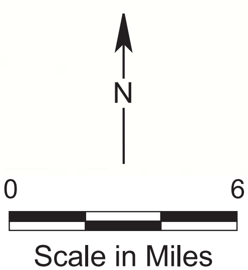
Prepared for

Wheeler Ridge-Maricopa
Water Storage District

November 2007

Todd Engineers
with Kennedy/Jenks Consultants





Source: Wood and Dale, 1964.

November 2007

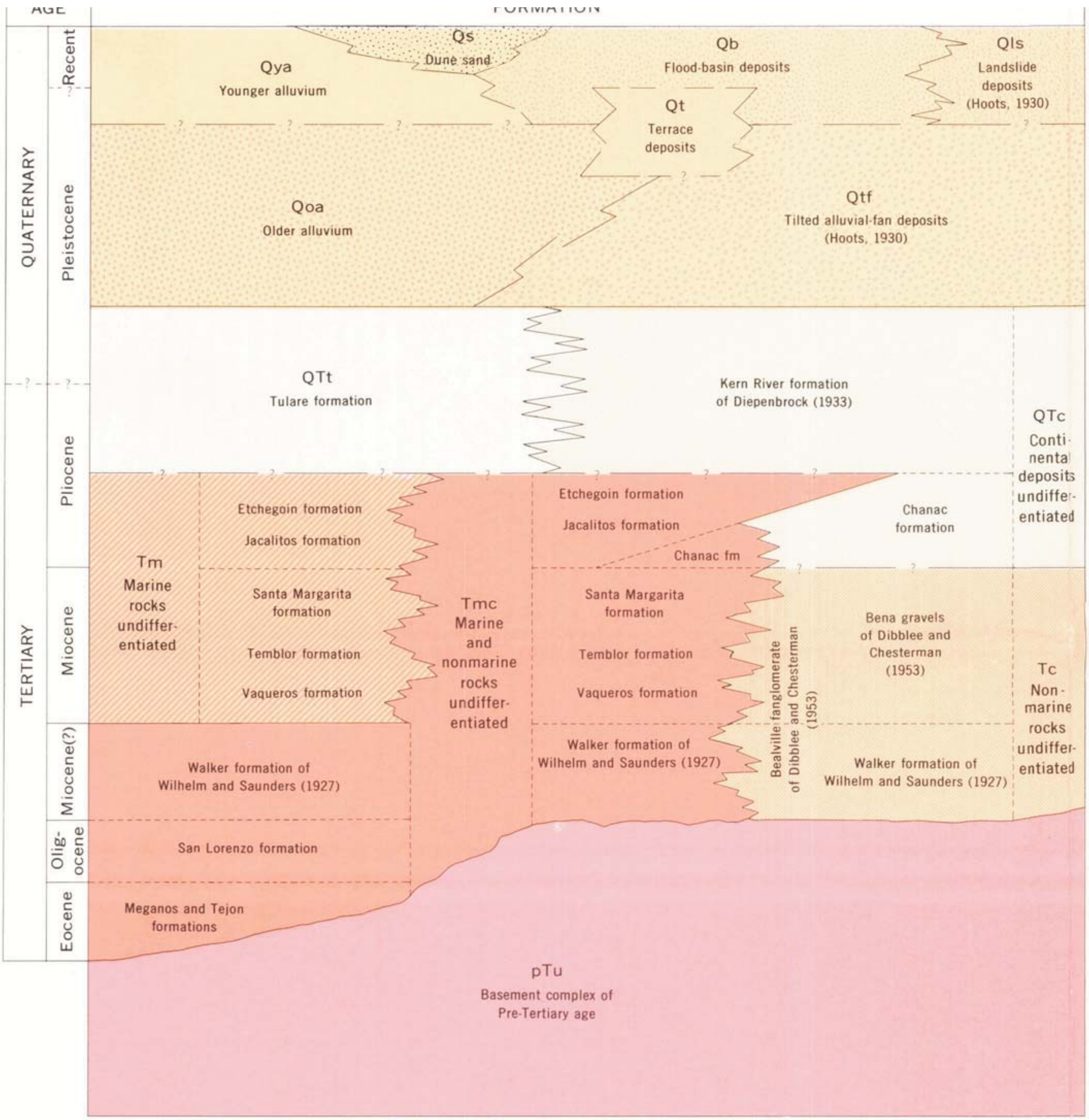
TODD ENGINEERS
Emeryville, California

Figure 4
Geologic Map

Stratigraphic Nomenclature

Maricopa/Wheeler
West Subareas

White Wolf/Wheeler
East Subareas



DIAGRAMMATIC STRATIGRAPHIC SECTION IN THE EDISON-MARICOPA AREA

Source: Wood and Dale, 1964.

November 2007

TODD ENGINEERS
Emeryville, California

Figure 3
Stratigraphic Nomenclature

Appendix B.2

Sheirer (2003)

Petroleum Systems and Geologic Assessment of Oil and Gas in the San Joaquin Basin Province, California

Chapter 7

The Three-Dimensional Geologic Model Used for the 2003 National Oil and Gas Assessment of the San Joaquin Basin Province, California

By Allegra Hosford Scheirer[1]

Contents

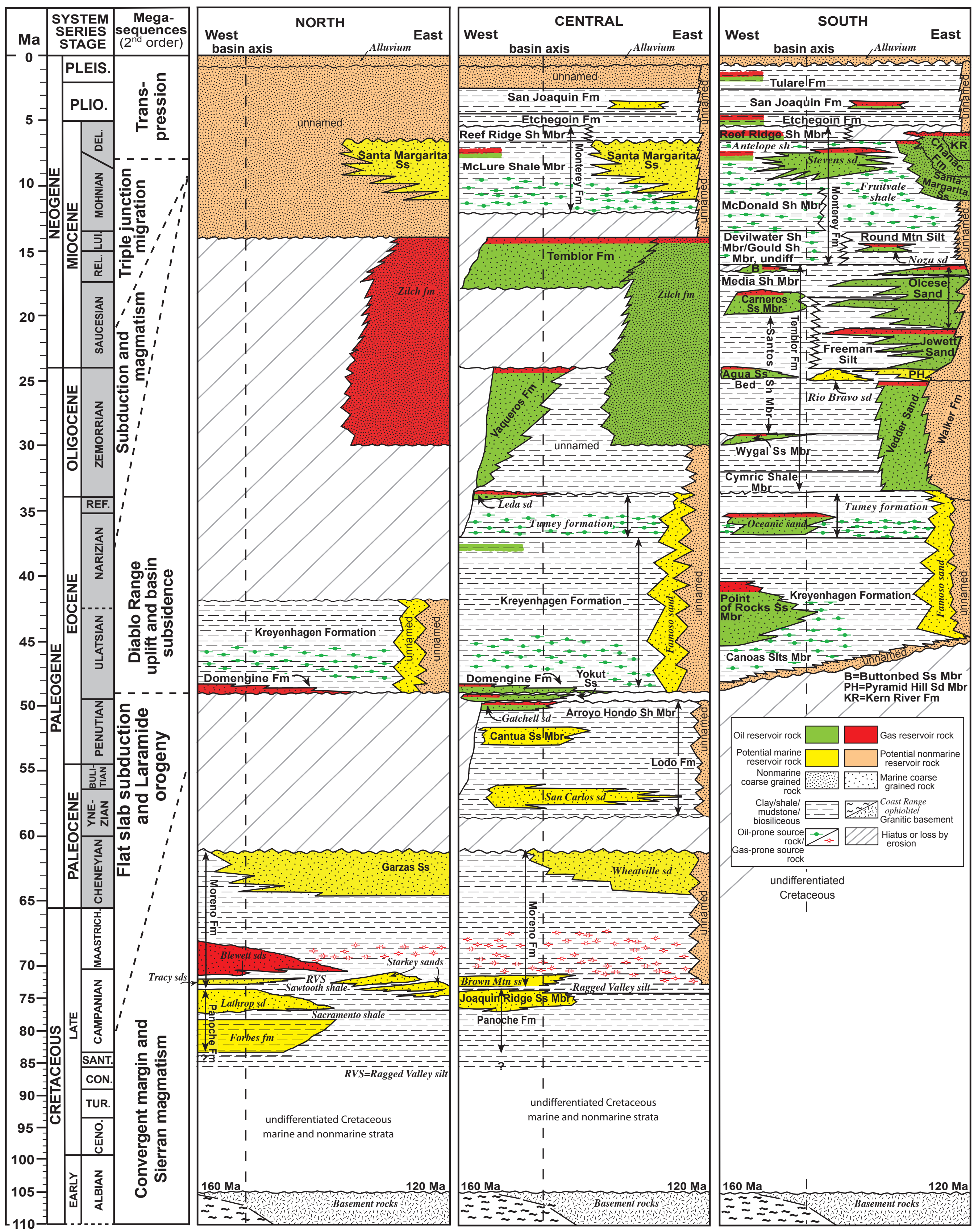
[1]Now at Department of Geological and Environmental Sciences, Stanford University, *allegras@stanford.edu*.

Abstract

We present a three-dimensional geologic model of the San Joaquin Basin (SJB) that may be the first compilation of subsurface data spanning the entire basin. The model volume spans 200 × 90 miles, oriented along the basin axis, and extends to ~11 miles depth, for a total of more than 1 million grid nodes. This model supported the 2003 U.S. Geological Survey assessment of future additions to reserves of oil and gas in the SJB. Data sources include well-top picks from more than 3,200 wildcat and production wells, published cross sections, regional seismic grids, and fault maps. The model consists of 15 chronostratigraphic horizons ranging from the Mesozoic crystalline basement to the topographic surface. Many of the model units are hydrocarbon reservoir rocks and three—the Cretaceous Moreno Formation, the Eocene Kreyenhagen Formation, and the Miocene Monterey Formation—are

Figure 7.2. *A*, San Joaquin Basin Province stratigraphy showing petroleum reservoir rocks and potential petroleum source rocks. See Hosford Scheirer and Magoon (this volume, chapter 5) for complete explanation of the figure. Note that ages of basement rock exceed the timescale shown in figure. Formation names in italics are informal and are defined as follows (in approximate age order): Forbes formation of Kirby (1943), Sacramento shale and Lathrop sand of Callaway (1964), Sawtooth shale and Tracy sands of Hoffman (1964), Brown Mountain sandstone of Bishop (1970), Ragged Valley silt, Starkey sands, and Blewett sands of Hoffman (1964), Wheatville sand of Callaway (1964), San Carlos sand of Wilkinson (1960), Gatchell sand of Goudkoff (1943), Oceanic sand of McMasters (1948), Leda sand of Sullivan (1963), Tumey formation of Atwill (1935), Famoso sand of Edwards (1943), Rio Bravo sand of Noble (1940), Nozu sand of Kasline (1942), Zilch formation of Loken (1959), Stevens sand of Eckis (1940), Fruitvale shale of Miller and Bloom (1939), and Antelope shale of Graham and Williams (1985). *B*, Stratigraphic columns shown in figure 7.2*A* except rock units are grouped chronostratigraphically, colored as in accompanying three-dimensional model, and numbered as in table 7.1. Heavy, red dashed lines indicate the composite surfaces. *C*, Explanation of additional features in San Joaquin Basin Province (black outline). The regional subdivisions—north, central, and south—are explained in Hosford Scheirer and Magoon (this volume, chapter 5). The subsurface trace (dashed line) of the White Wolf Fault (WWF) bounds the stratigraphic column on the south. Oil fields are outlined in green and gas fields are outlined in red. The basin axis (heavy red line) is mapped in the three-dimensional model on the Temblor Composite Surface in the central and southern regions and on the Ragged Valley Composite Surface in the northern region. Heavy gray line that is somewhat parallel to the basin axis divides the area of correspondence (east) from the area of unresolved complexity (hachured area to the west).

A


Ma
SYSTEM SERIES STAGE
Mega-sequences (2nd order)
NORTH
CENTRAL
SOUTH
West
East
basin axis
Alluvium
NEOGENE
PALEOGENE
CRETACEOUS
PLEIS.
PLIO.
MIOCENE
OLIGOCENE
EOCENE
PALEOCENE
LATE
EARLY
DEL.
MOHNIAN
LUI.
REL.
SAUCESIAN
ZEMORRIAN
REF.
NARIZIAN
ULATSIAN
PENUTIAN
BULI-TIAN
YNE-ZIAN
CHENEYIAN
MAASTRICH.
CAMPANIAN
SANT.
CON.
TUR.
CENO.
ALBIAN
Trans-pression
Triple junction migration
Subduction and magmatism
Diablo Range uplift and basin subsidence
Flat slab subduction and Laramide orogeny
Convergent margin and Sierran magmatism
unnamed
Santa Margarita Ss
Zilch fm
Kreyenhagen Formation
Domengine Fm
Garzas Ss
Moreno Fm
Blewett sds
Starkey sands
Tracy sds
RVS
Sawtooth shale
Lathrop sd
Sacramento shale
Panoche Fm
Forbes fm
RVS=Ragged Valley silt
undifferentiated Cretaceous marine and nonmarine strata
160 Ma
120 Ma
Basement rocks
San Joaquin Fm
Etchegoin Fm
Reef Ridge Sh Mbr
McLure Shale Mbr
Monterey Fm
Temblor Fm
Vaqueros Fm
Leda sd
Tumey formation
Famoso sand
Yokut Ss
Gatchell sd
Arroyo Hondo Sh Mbr
Cantua Ss Mbr
Lodo Fm
San Carlos sd
Wheatville sd
Brown Mtn ss
Ragged Valley silt
Joaquin Ridge Ss Mbr
Panoche Fm
Tulare Fm
Antelope sh
Stevens sd
KR
Chanac Fm
Fruitvale shale
McDonald Sh Mbr
Devilwater Sh Mbr/Gould Sh Mbr, undiff
Round Mtn Silt
Nozu sd
Media Sh Mbr
Olcese Sand
Carneros Ss Mbr
Santos Sh Mbr
Freeman Silt
Jewett Sand
Agua Ss Bed
PH
Rio Bravo sd
Vedder Sand
Walker Fm
Wygal Ss Mbr
Cymric Shale Mbr
Oceanic sand
Point of Rocks Ss Mbr
Canoas Slts Mbr
B=Buttonbed Ss Mbr
PH=Pyramid Hill Sd Mbr
KR=Kern River Fm
Oil reservoir rock
Gas reservoir rock
Potential marine reservoir rock
Potential nonmarine reservoir rock
Nonmarine coarse grained rock
Marine coarse grained rock
Clay/shale/mudstone/biosiliceous
Coast Range ophiolite/ Granitic basement
Oil-prone source rock/ Gas-prone source rock
Hiatus or loss by erosion
undifferentiated Cretaceous

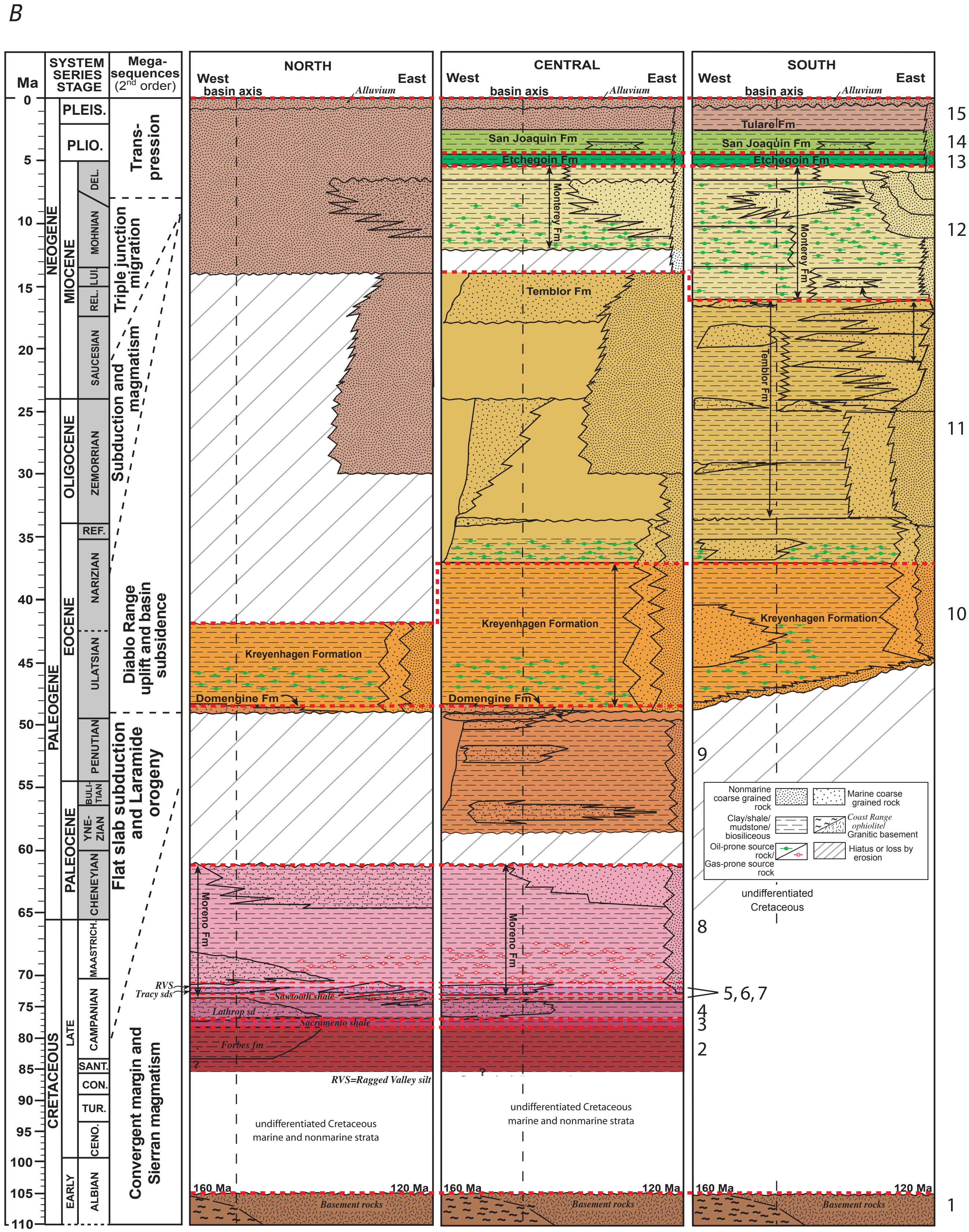


Figure 7.2.—Continued

C

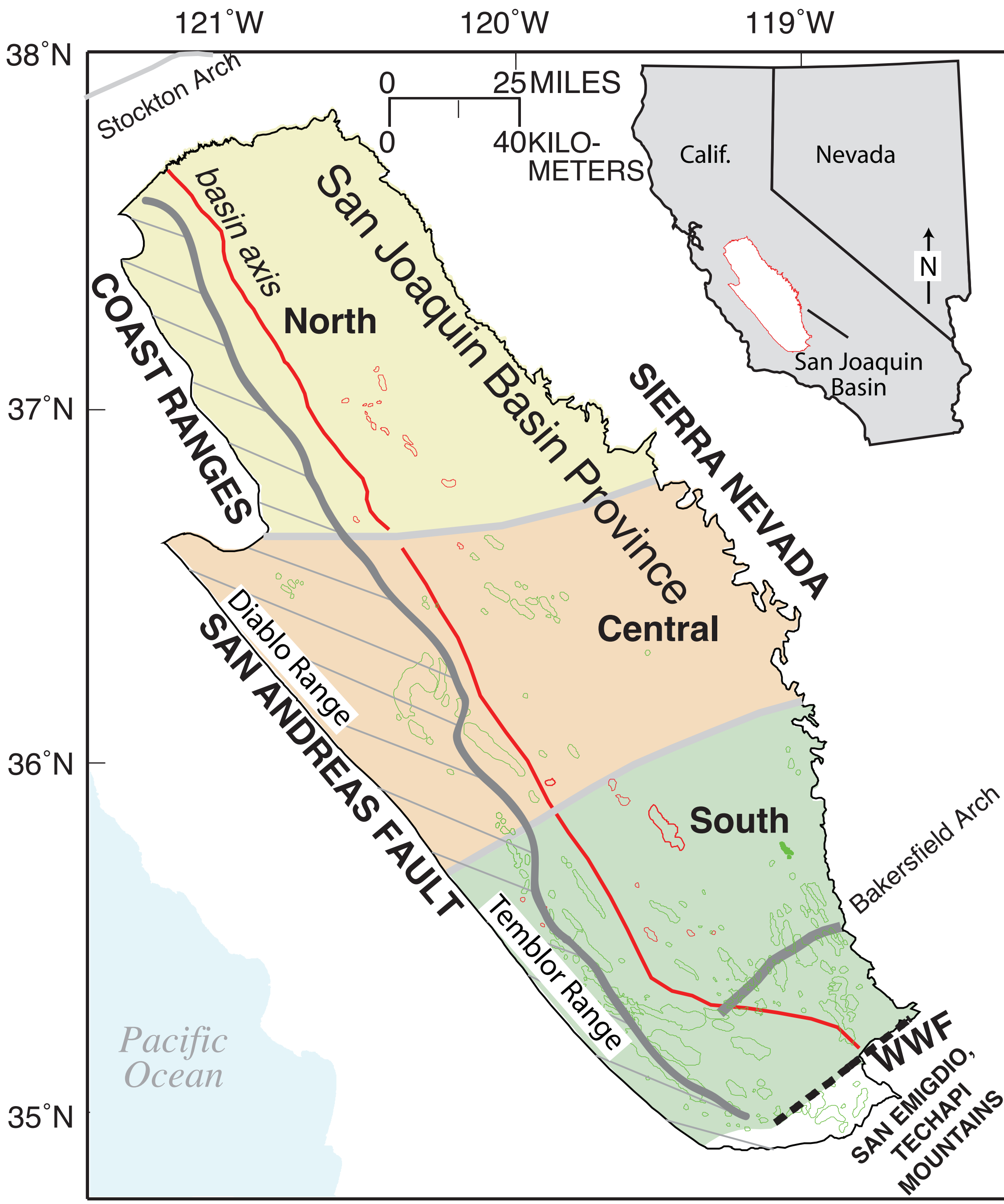


Figure 7.2.—Continued

Appendix B.3

Goodman and Malin (1992)

TECTONICS, VOL. 11, NO. 3, PAGES 478-498, JUNE 1992

EVOLUTION OF THE SOUTHERN SAN JOAQUIN BASIN AND MID-TERTIARY "TRANSITIONAL" TECTONICS, CENTRAL CALIFORNIA

Emery D. Goodman[1] and Peter E. Malin[2],
California Consortium for Crustal Studies (CALCRUST), Department of Geological Sciences and Institute for Crustal Studies, University of California, Santa Barbara

Abstract. A Cenozoic tectonic and sedimentary history is proposed for the Southern San Joaquin Basin (SSJB) and Tehachapi Mountains that evolved adjacent to the plate margin off central California. Seismic reflection, borehole, field, biostratigraphic, and paleomagnetic data are integrated into geologic and fault structure maps, cross sections, and geohistory plots and are analyzed with previous work in the region to develop a model relating the sequence, timing, and distribution of complex, tectonically linked events. The largely buried structures and strata in the SSJB preserve an unusually complete record of the mid-Tertiary transition from convergent to transform plate boundary as well as the regional transition to contraction during the Pliocene. Significant structural relief, existing across both extensional and contractile features, is preserved in the subsurface and an active fold-thrust belt propagates basinward along the margin of the U-shaped Tejon embayment. The Cenozoic evolution of the SSJB reflects the regional deformation of central California as different tectonic events followed each other along the adjacent North American plate margin. Five Oligocene-Miocene basin phases are identified in the SSJB: (1) late Oligocene/early Miocene extensional subsidence, with high- and low-angle normal faulting, accompanied by volcanism and deposition of coarse syntectonic conglomerates; (2) middle Miocene uplift; (3) later mid-Miocene transtensional subsidence to lower bathyal depths; (4) alternating subsidence and uplift until the late Miocene; and (5) flexural subsidence due to Pliocene to Recent contraction. Reconstructions of mid-Tertiary California place the southern San Joaquin/Tehachapi extensional terrane as a paleotectonic block located between the Western Mojave terrane (then to the east) and the Western California terrane (then to the south and west). Regional extension occurred during a long transition period between convergent and transform boundaries along the North American plate margin. Significant slip along the San Andreas transform postdates this extensional event. Its origin apparently coincided with a regional middle Miocene uplift event, indicating that the San Andreas fault is younger than previously supposed. The Tertiary SSJB has subsided due to extension/transtension, crustal tilting, and thrust-related loading. The Maricopa Subbasin floor is likely composed of ensimatic and mafic rocks like those along the west side of the Sierra Nevada and locally has subsided beyond 12 km. In contrast, the relatively stable Tejon embayment, underlain by Sierran crystalline crust, achieved its maximum subsidence in the Miocene. Since Pliocene time, the SSJB has filled and continued to deepen after the basin was tectonically shut off from the Pacific Ocean.

[1]Now at Exxon Production Research Company, Houston, Texas.

[2]Now at Department of Geology, Duke University, Durham, North Carolina.

Paper number 91TC02871.
0278-7407/92/91TC-02871$10.00

INTRODUCTION

Different tectonic settings have prevailed in southern California during the Cenozoic; however, the sequence, timing, and transition between regional events are not fully understood. Many California basins preserve a record of these events, despite significant overprinting. These basins opened, filled, subsided, and were deformed in variable settings while, at times, bodily translated and rotated [e.g. Crowell, 1987]. Wide varieties of subsurface data, including multifold seismic reflection and borehole data, and field access to exposed portions of the basins, provide an opportunity to reconstruct their polycyclic histories. As these basin histories unfold, it appears that existing plate-scale models constructed to explain their origin are not entirely consistent with information concerning the timing and regional distribution of tectonic events, as discussed below.

Recent geological and geophysical work in the southern Sierra Nevada addressing Mesozoic paleogeographic problems, including a CALCRUST deep-crustal seismic profile, identified the need for new investigations of the structure and Cenozoic history of the SSJB [Sams and Saleeby, 1988] (P. E. Malin et al., Evidence for crustal-scale tilting beneath the Tehachapi Mountains and Tejon embayment, submitted to Journal of Geophysical Research, 1990). Furthermore, an unusually complete record of the structures and strata necessary to unravel part of the Cenozoic history of southern California exists in the southern end of the basin. Therefore the Tejon embayment, a topographic depression located at the southern end of the SSJB, 40 km south of Bakersfield was selected for study (Figures 1 and 2). Our paper presents new field and subsurface data and describes the structure and tectonic evolution of the SSJB over the past 30 m.y. as different tectonic events followed each other along the plate margin. The relationships between the local structural styles, the transitions between them, and the sequence and timing of relevant regional events are examined.

Two basic problems underlie this study: (1) the nature and timing of major transitions between Cenozoic tectonic events along the North American plate margin and (2) how changes at the plate scale are expressed in adjacent basins. Thus the geologic history of the SSJB described in this paper has implications for (1) regional tectonic history and paleogeography of southern and central California; (2) how tectonic events follow one another along rapidly changing plate margins; and (3) Cenozoic evolution of petroliferous California basins.

DATA AND METHODS

Data bearing on the subsurface of the shallow central Tejon embayment along with field exposures of the basement rocks and Cenozoic strata that rim its margins provide a means for studying the history of the SSJB, other portions of which are beyond the reach of boreholes and conventional seismic profiling. For the basin analysis, subsurface data from seismic reflection profiles and several hundred boreholes from the alluviated basin were integrated with field data from the uplifted basin margins. Borehole data include electric logs, dipmeter logs, biostratigraphic data, well histories, and velocity surveys. Structural mapping and analysis of the tectonic history were accomplished through interpretation of 17 industrial seismic profiles and a CALCRUST seismic survey; construction of borehole and seismic-based structural cross sections and stratigraphic diagrams; and compilation of geologic maps [Dibblee, 1973; Bartow and Dibblee, 1981], with new mapping and field observations in critical areas. Access to good exposures is limited by vegetation and few fresh roadcuts.

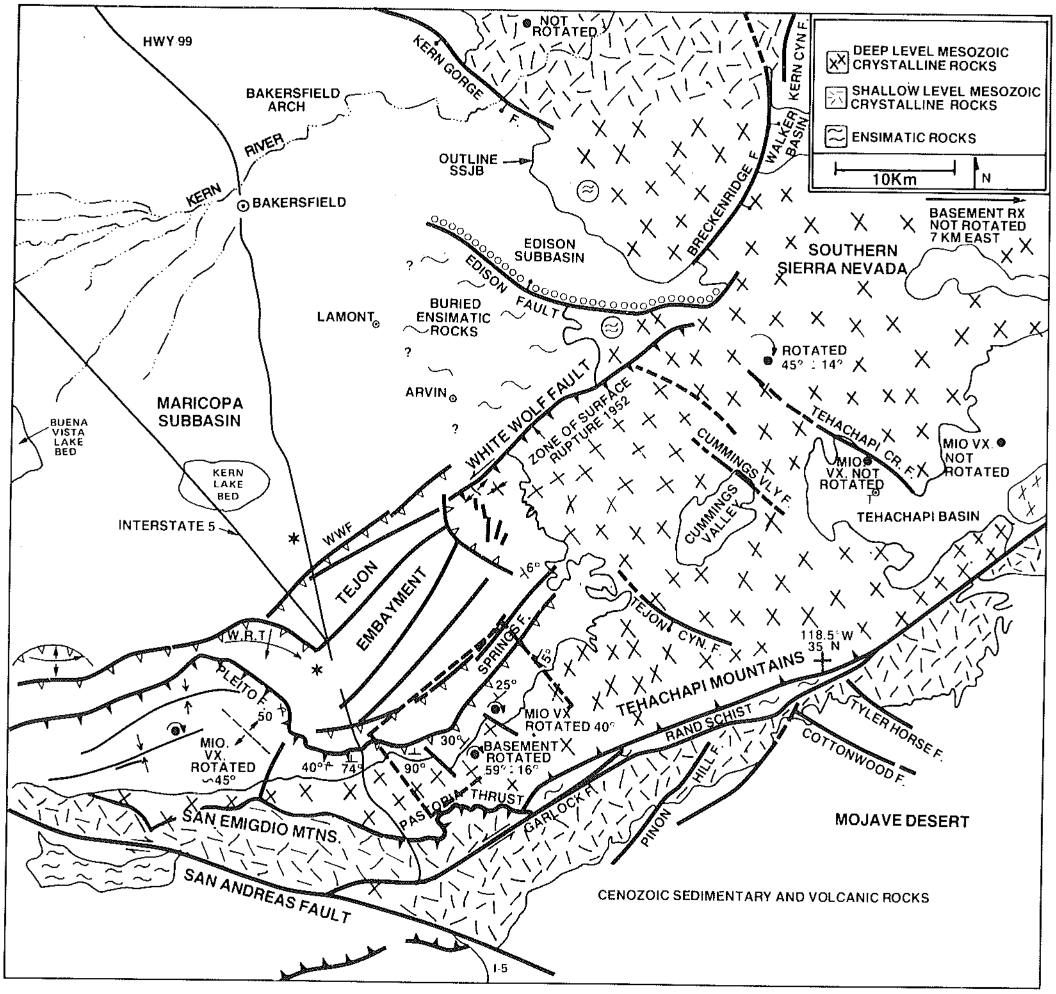


Fig. 2. Index map to the southern San Joaquin Basin and southern Sierra Nevada. Barbs represent blind thrusts (open) and exposed thrusts (closed). Heavy dots indicate sites of published paleomagnetic results, and stars indicate geohistory sites discussed in the text. Dashed rectangle shows location of Plate 1. Abbreviations are T, Tehachapi (town); Mio.VX, Miocene volcanic rocks; W.R.T., Wheeler Ridge Thrust; F, fault; WWF, White Wolf fault; CYN, canyon and CR, creek.

Mendocino Triple Junction (MTJ, Figure 1)[McKenzie and Morgan, 1969; Blake et al., 1978; Dickinson and Snyder, 1979; Fox et al., 1985]. In this model, pull-apart basins are created and then subside under a transtensional setting of oblique-slip and normal faulting coupled with volcanism, while the San Andreas system evolves from its nascent offshore position to its present inboard trace [Crowell, 1974, 1987]. Specifically, it has been proposed that the Neogene history of the SSJB has been controlled by the migration of the MTJ and by subsequent wrench tectonics along the SAF system [Bartow, 1987; Harding, 1976].

On the other hand, the timing of localized extension and volcanism does not show a clear northward reduction in age over the past 30 Ma [Stanley, 1987]. Regarding the SSJB, Goodman et al. [1989] suggested that late Oligocene-early Miocene basin subsidence, normal faulting, and syntectonic volcanic flows, and coarse clastic deposits were all part of regional mid-Tertiary extension that cannot be explained solely by triple junction instability (see also Tennyson [1989] and Davis and Lagoe [1988]). The subsequent late Tertiary transition from general extension to contraction in a direction normal to the San Andreas fault has resulted in substantial shortening and structural overprinting that has obscured this mid-Tertiary record. This paper presents new insights into these two transitions and attempts to synthesize this information with previous studies from the region.

REGIONAL SETTING

In the active tectonic setting, the SSJB and southern Sierra Nevada are transitional locales residing between Great Basin extension to the east and transpression along the Pacific-North American plate boundary to the west. The Sacramento-San Joaquin Basin is divided into several smaller subbasins by west trending arches (Figure 1). The SSJB is situated south of the Bakersfield Arch and just north of the intersection of the San Andreas and Garlock faults, with 315 and 64 kms of Neogene strike-slip, respectively (Figures 1 and 2)[Crowell, 1979; Carter, 1987]. The deep crustal-level rocks of the Tehachapi Mountains that project under the Tejon embayment crop out in scattered exposures. There, tectonic elements curve sharply from a regional southern Sierran N-NW trend to an E-NE trend near the Garlock fault [Sharry, 1981], which separates the deep-crustal southern Sierras from less deformed granites of the

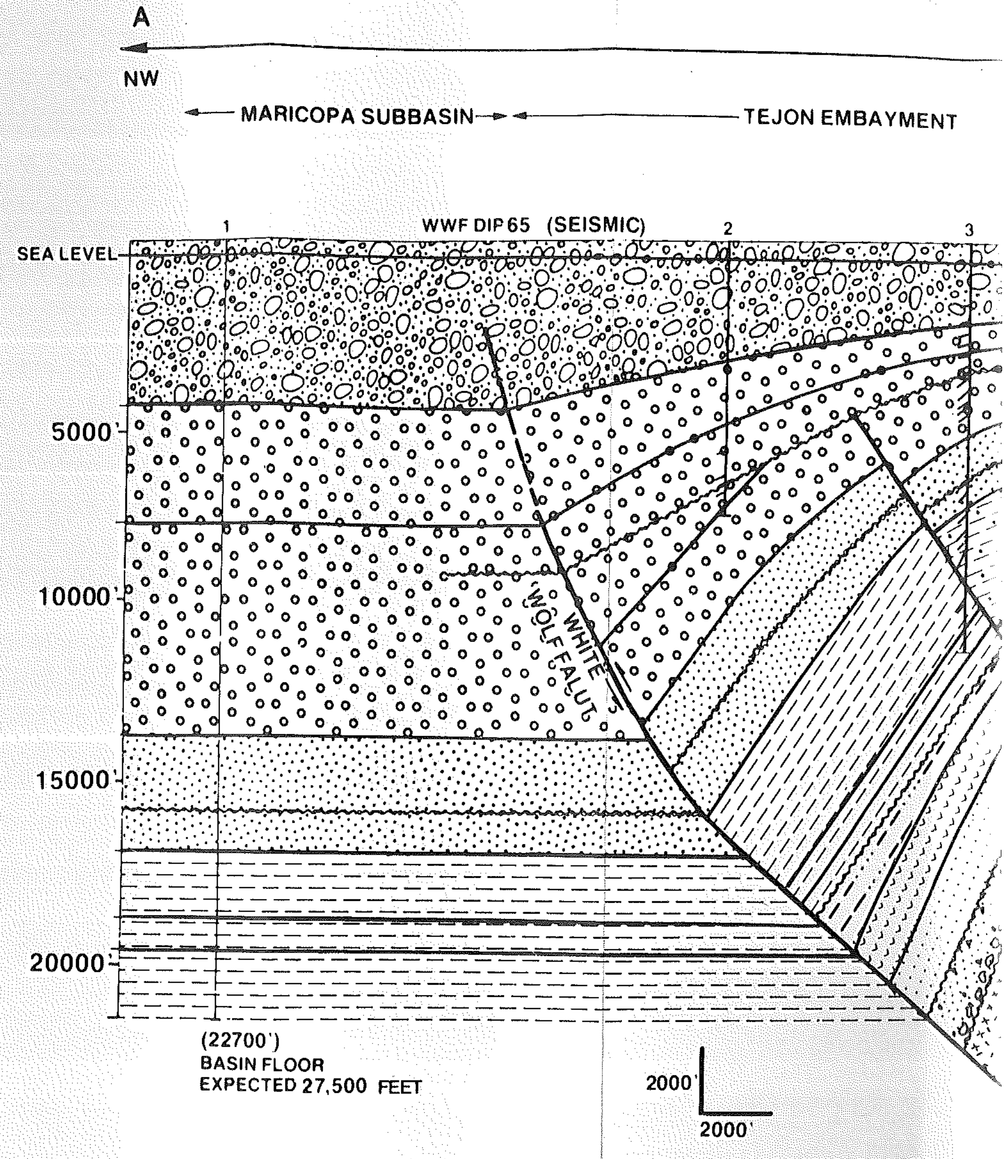
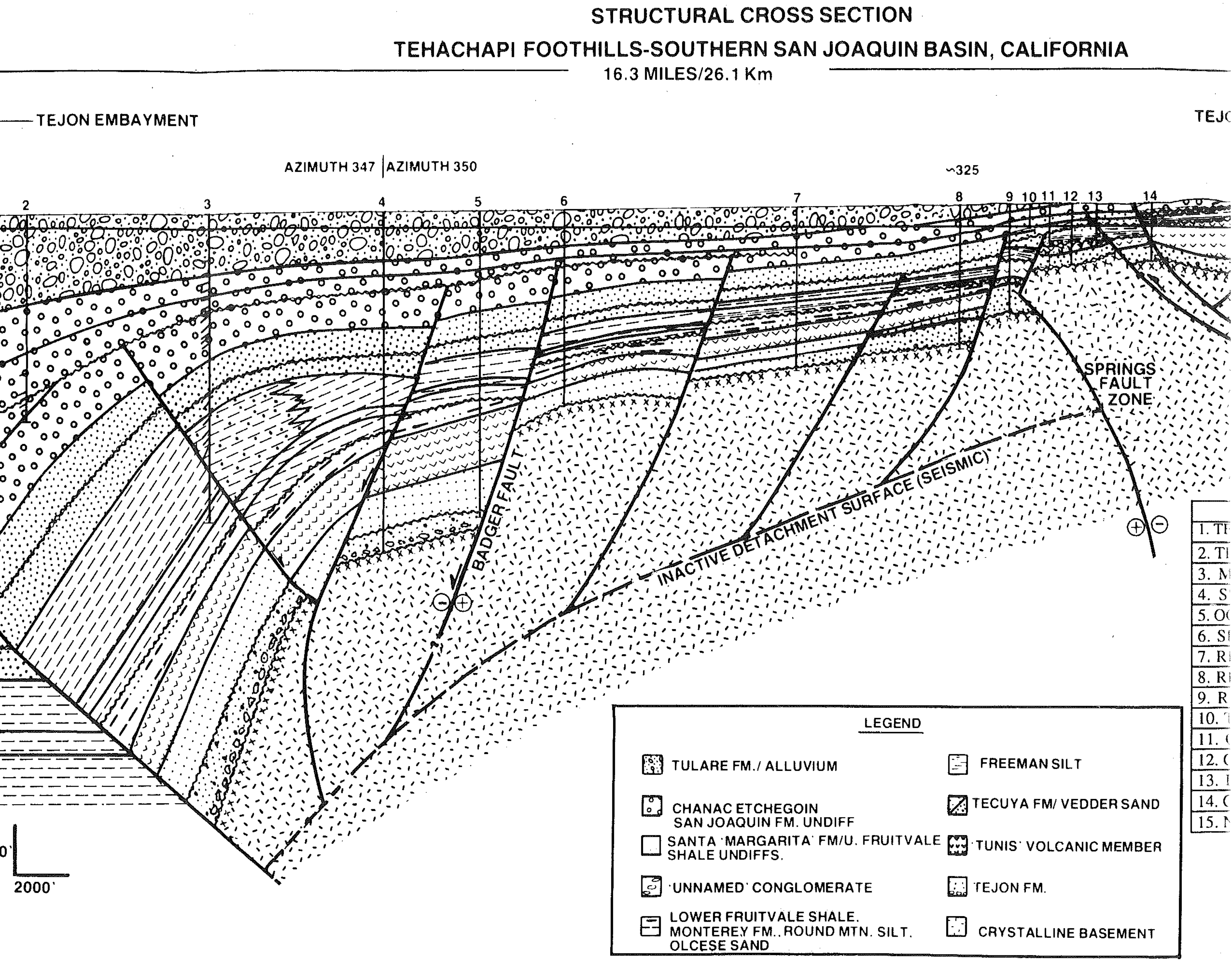
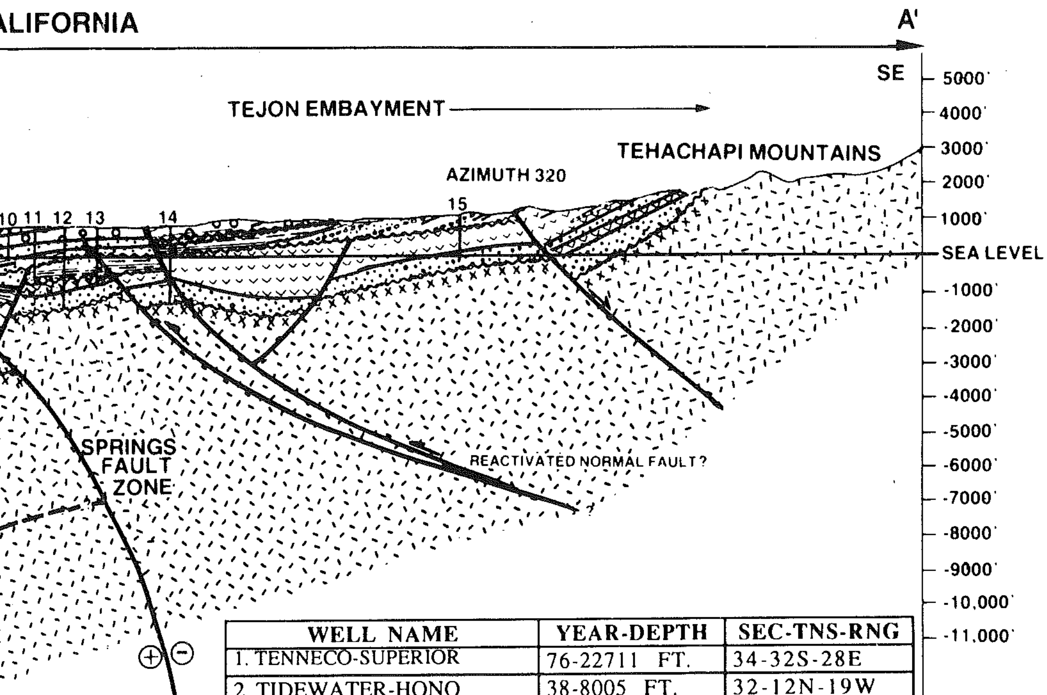


Plate 2. Structural cross section A-A' constructed from field, boreh
hanging wall. Vertical offset decreases towards the fault tip. The h
generally approximate the lithostratigraphic facies (see Figure 4).



' constructed from field, borehole, and seismic data (located on Figure 5). Tick marks on boreholes show dipmeter data constraints. The White Wolf fault
es towards the fault tip. The high-angle Springs fault is overprinted by shallow-dipping thrusts. Detachment surface projected from seismic reflection dat
graphic facies (see Figure 4).



WELL NAME	YEAR-DEPTH	SEC-TNS-RNG
1. TENNECO-SUPERIOR	76-22711 FT.	34-32S-28E
2. TIDEWATER-HONO	38-8005 FT.	32-12N-19W
3. MOBIL -16 SP	54-11963 FT.	3-11N-19W
4. SUN-23 SP	56-13134 FT.	11-11N-19W
5. OCCIDENTAL	76-11803 FT.	11-11N-19W
6. SESNON-PORTER 83-14	58-7638 FT.	14-11N-19W
7. RESERVE-RESERVE 86-24	56-6222 FT	24-11N-19W
8. RESERVE-RESERVE 56-30	58-5549 FT.	30-11N-18W
9. RESERVE 88-30	TD 4176 FT.	30-11N-18W
10. TERMO	43-950 FT.	29-11N-18W
11. CHEVRON-29	51-2449 FT.	29-11N-18W
12. CHEVRON CH-4	TD 2388 FT.	32-11N-18W
13. DRILL. & PROD. 33-3	48-1693 FT.	32-11N-18W
14. CHEVRON TEJON 3, CH 2	52-2310 FT.	32-11N-18W
15. NORTH STAR	33-1609 FT.	4-10N-18W

MAN SILT

A FM/ VEDDER SAND

VOLCANIC MEMBER

FM.

TALLINE BASEMENT

nts. The White Wolf fault is a reverse fault with associated folding on its
rom seismic reflection data on shelf. The patterns shown in the legend only

APPENDIX C

Water Level Data Showing the White Wolf Fault
as a Significant Impediment to Groundwater Flow

Appendix C.1

DWR

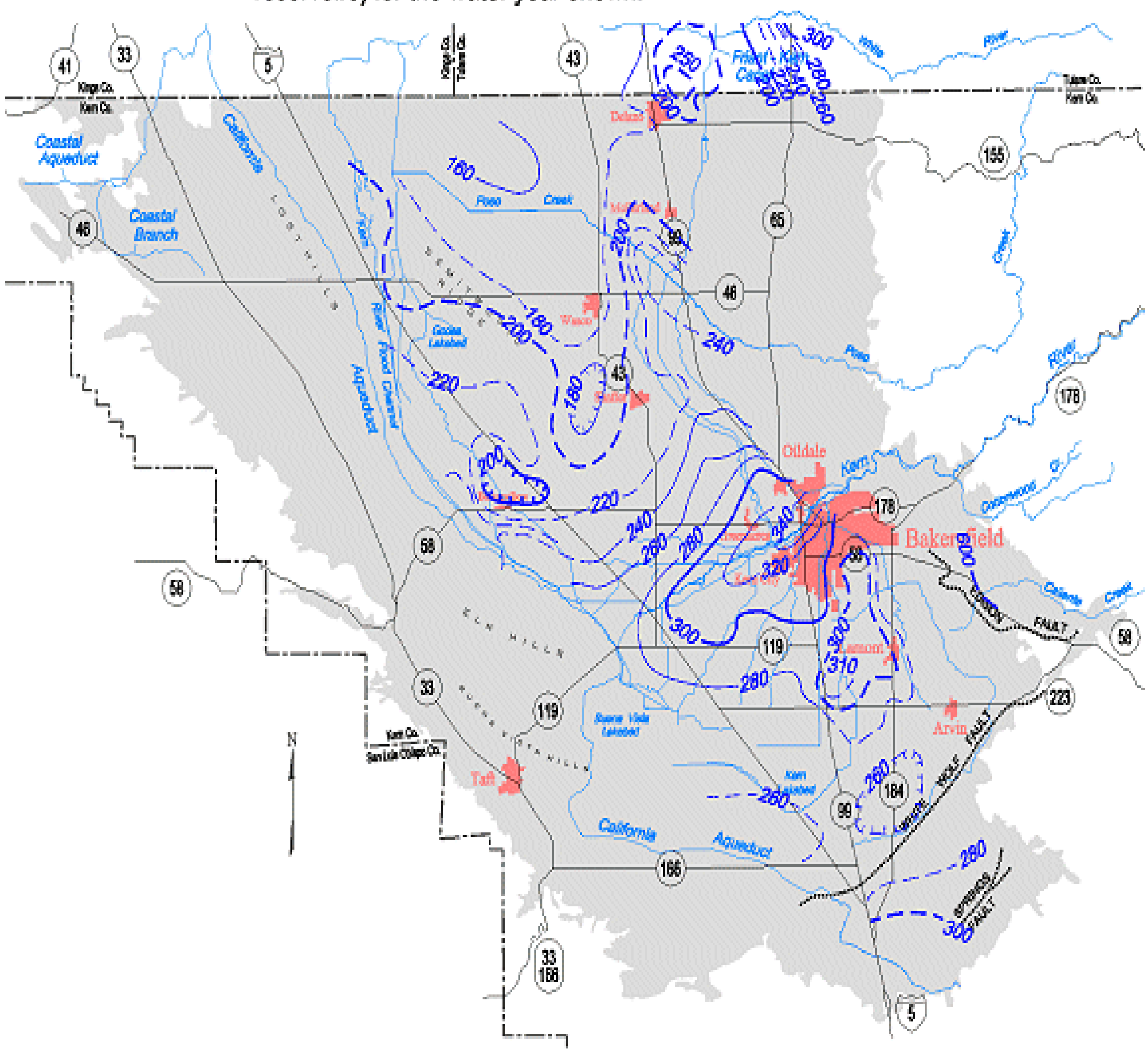
Kern Groundwater Basin

Spring 1958, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer

Scale of Miles

4 0 4 8 12 16

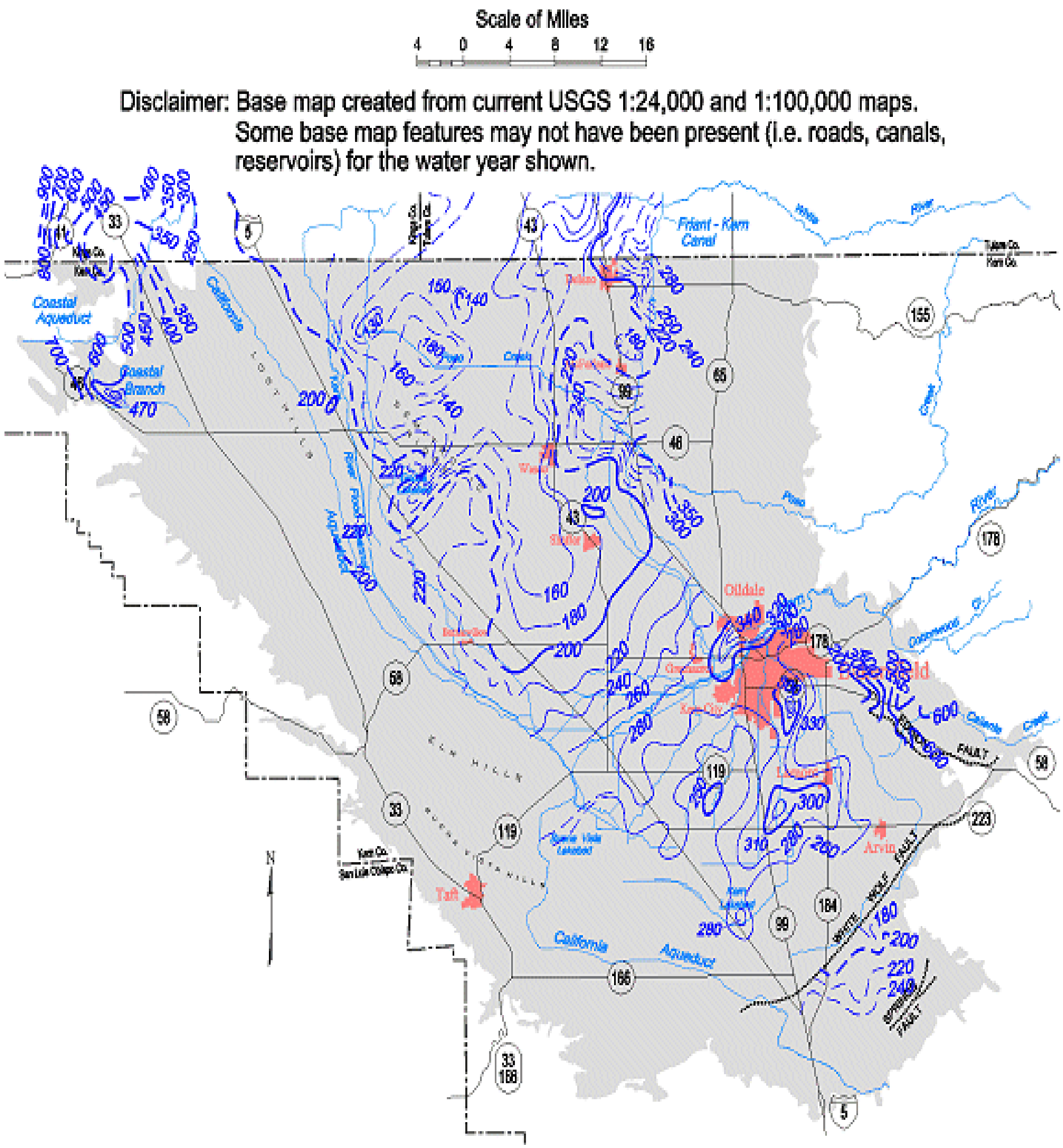
Disclaimer: Base map created from current USGS 1:24,000 and 1:100,000 maps. Some base map features may not have been present (i.e. roads, canals, reservoirs) for the water year shown.



Contours are dashed where inferred. Contour interval is 10, 20 and 50 feet.

Kern Groundwater Basin

Spring 1962, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10, 20, 50 and 100 feet.

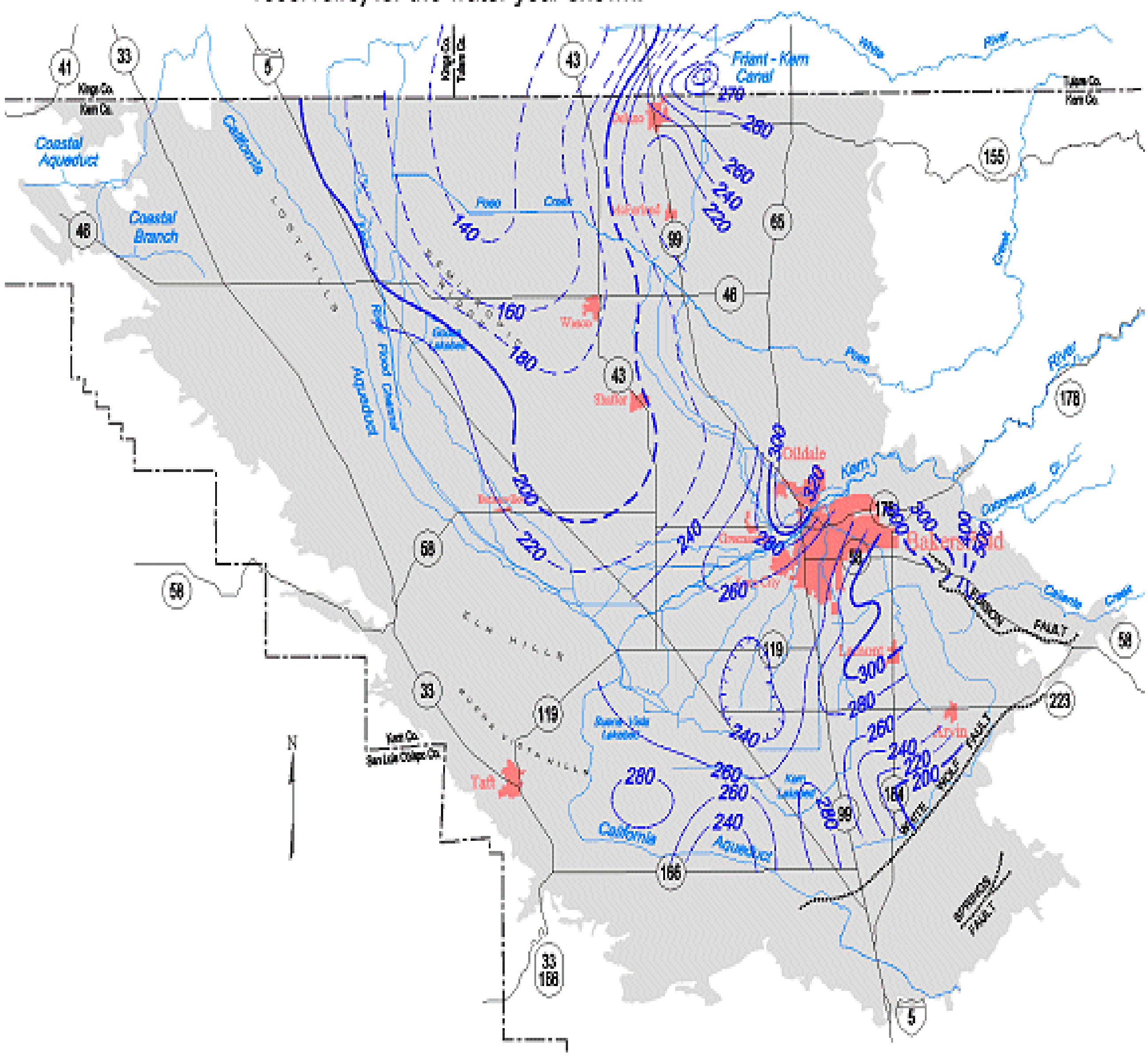
Kern Groundwater Basin

Spring 1969, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer

Scale of Miles

4 0 4 8 12 16

Disclaimer: Base map created from current USGS 1:24,000 and 1:100,000 maps. Some base map features may not have been present (i.e. roads, canals, reservoirs) for the water year shown.

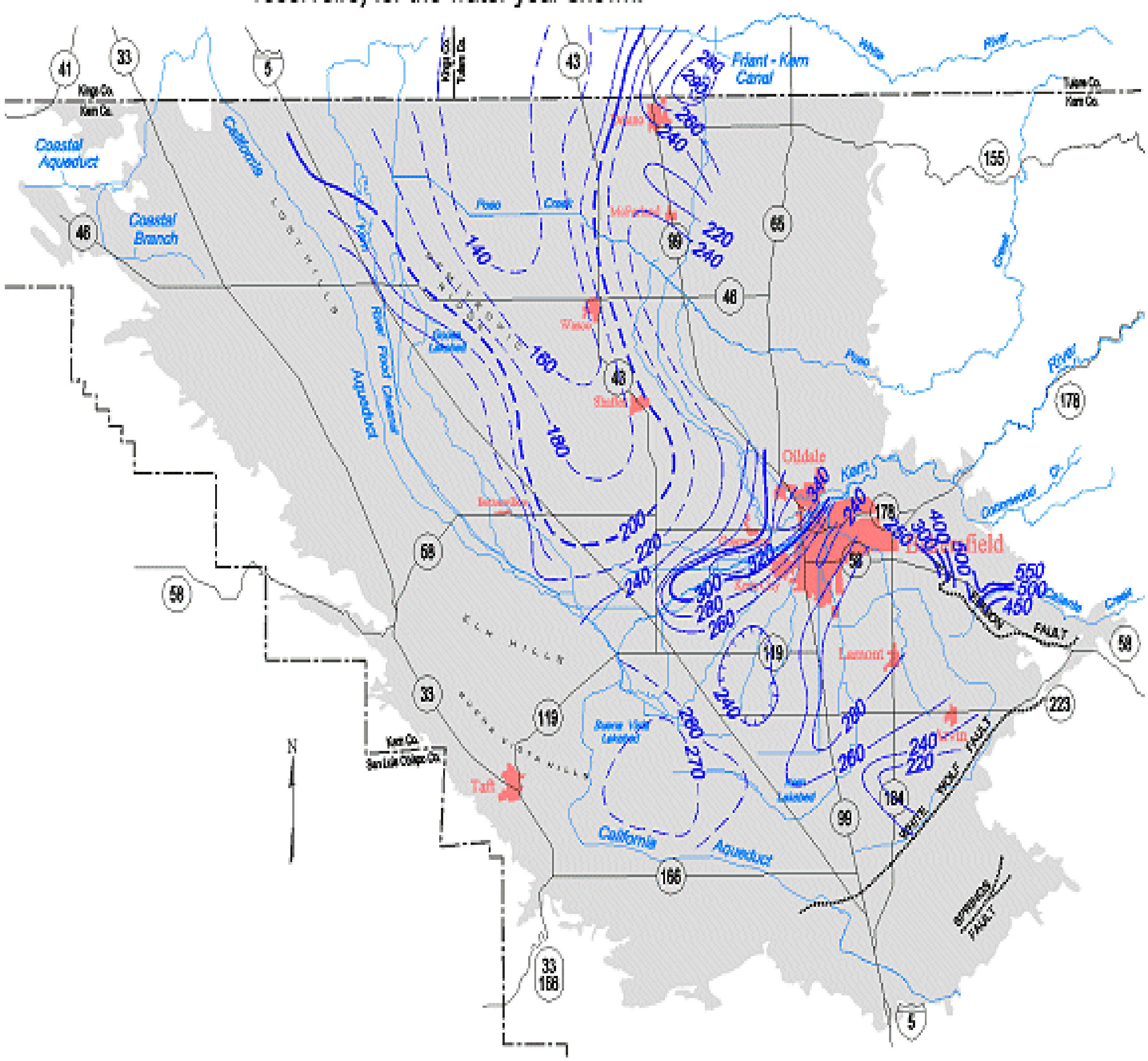


Contours are dashed where inferred. Contour interval is 10, 20 and 100 feet.

Kern Groundwater Basin

Spring 1970, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer

Disclaimer: Base map created from current USGS 1:24,000 and 1:100,000 maps. Some base map features may not have been present (i.e. roads, canals, reservoirs) for the water year shown.



Contours are dashed where inferred. Contour interval is 10, 20, 50 and 100 feet.

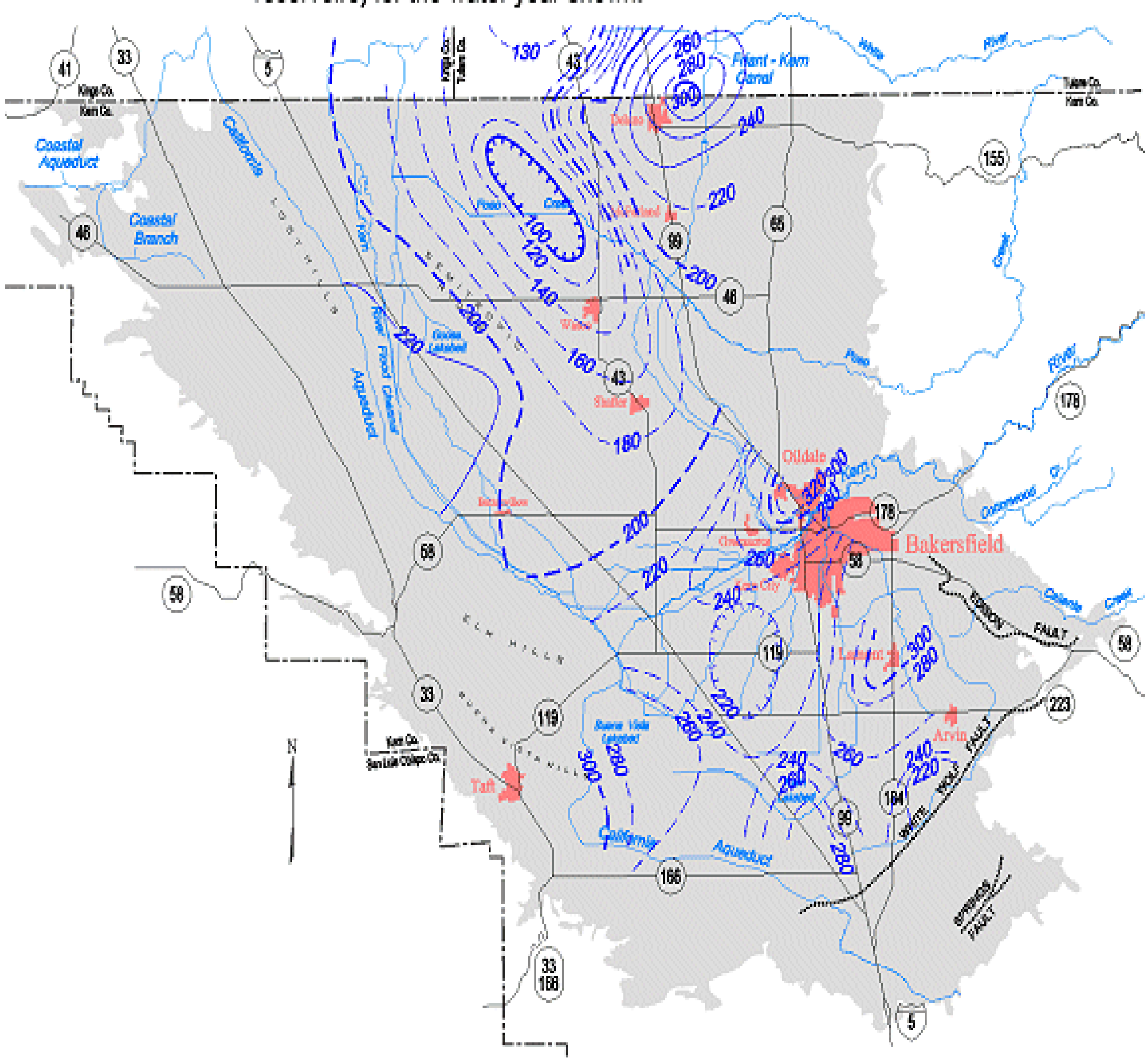
Kern Groundwater Basin

Spring 1976, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer

Scale of Miles

4 0 4 8 12 16

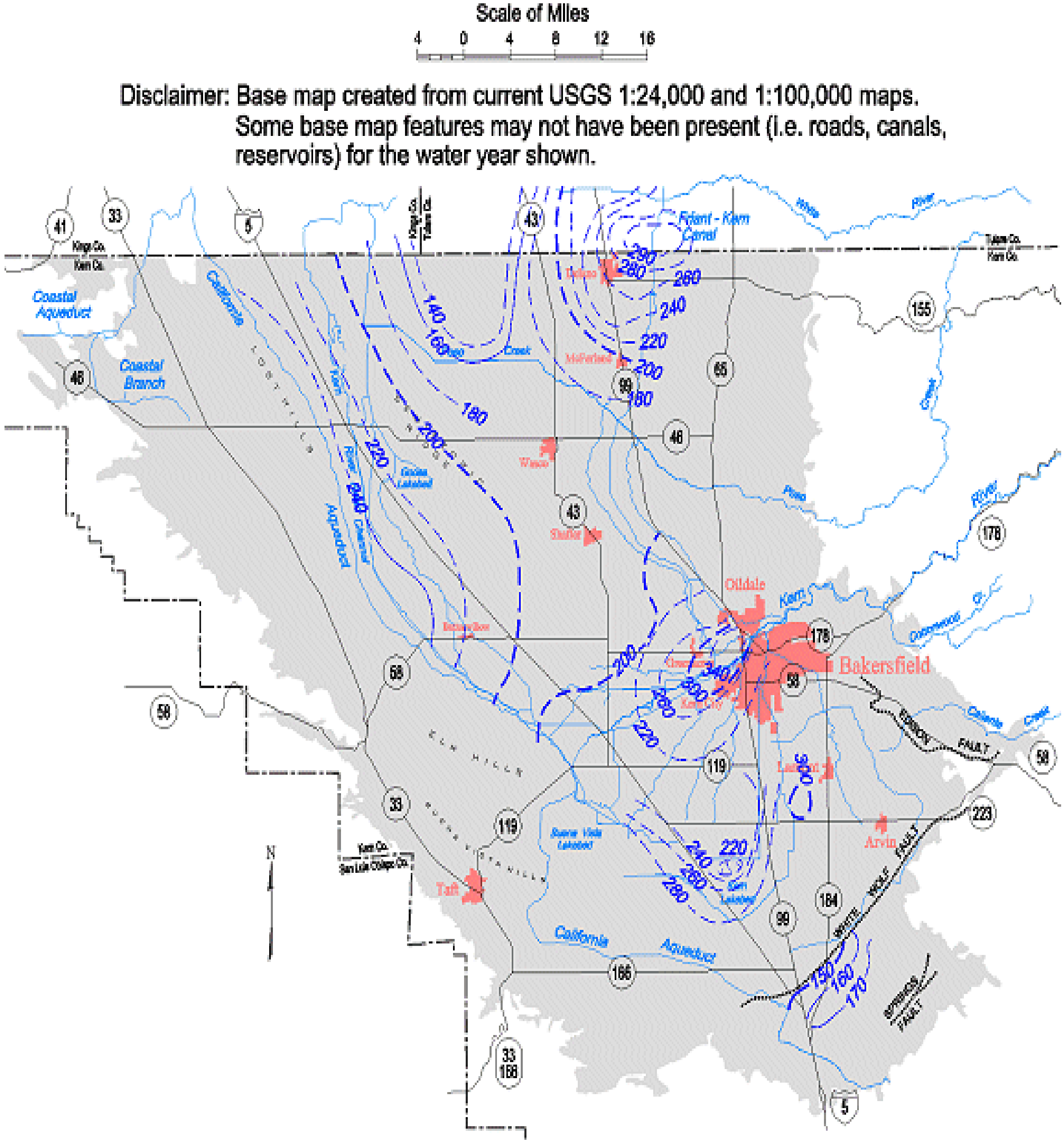
Disclaimer: Base map created from current USGS 1:24,000 and 1:100,000 maps. Some base map features may not have been present (i.e. roads, canals, reservoirs) for the water year shown.



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Kern Groundwater Basin

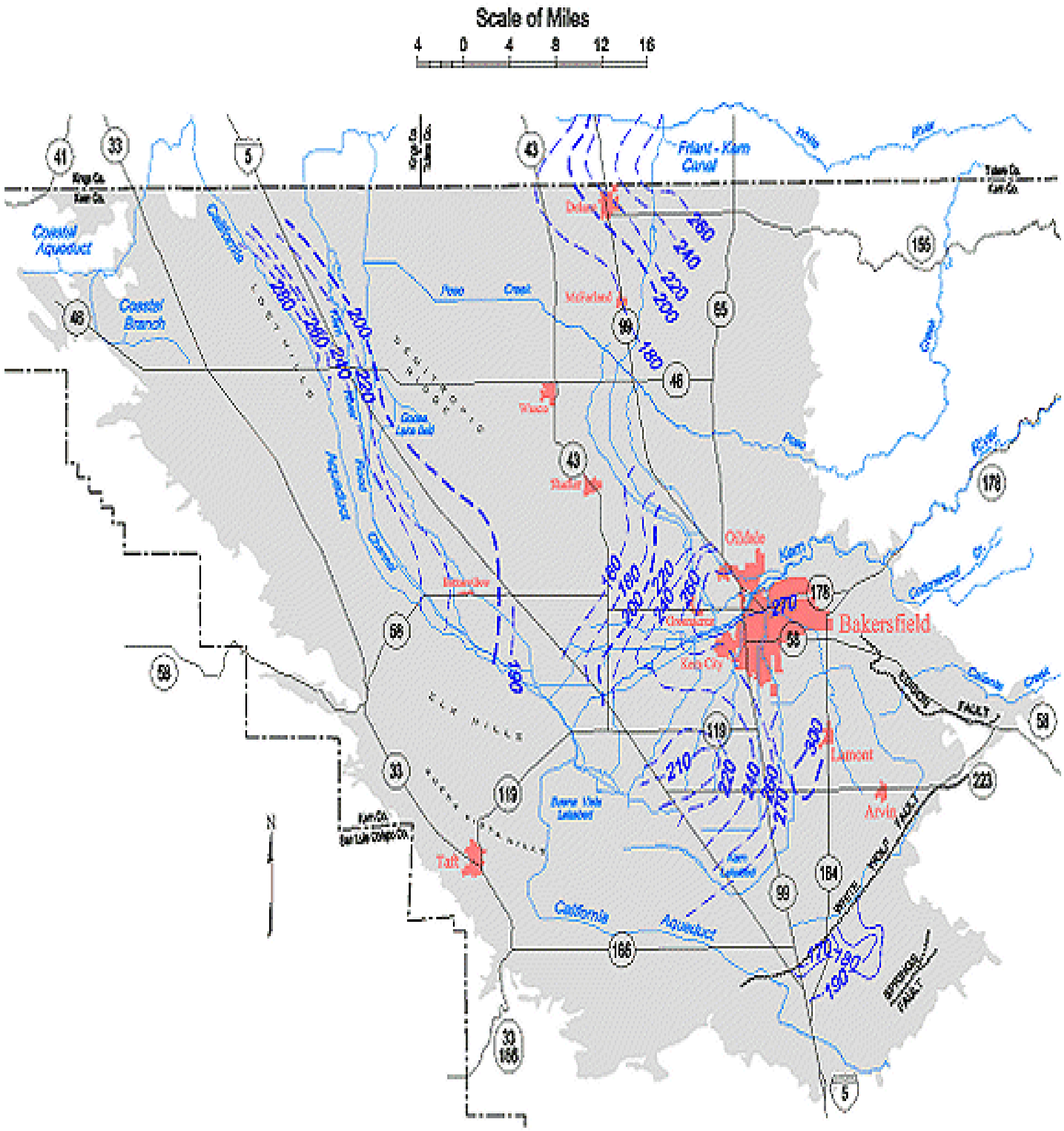
Spring 1984, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10, 20 and 40 feet.

Kern Groundwater Basin

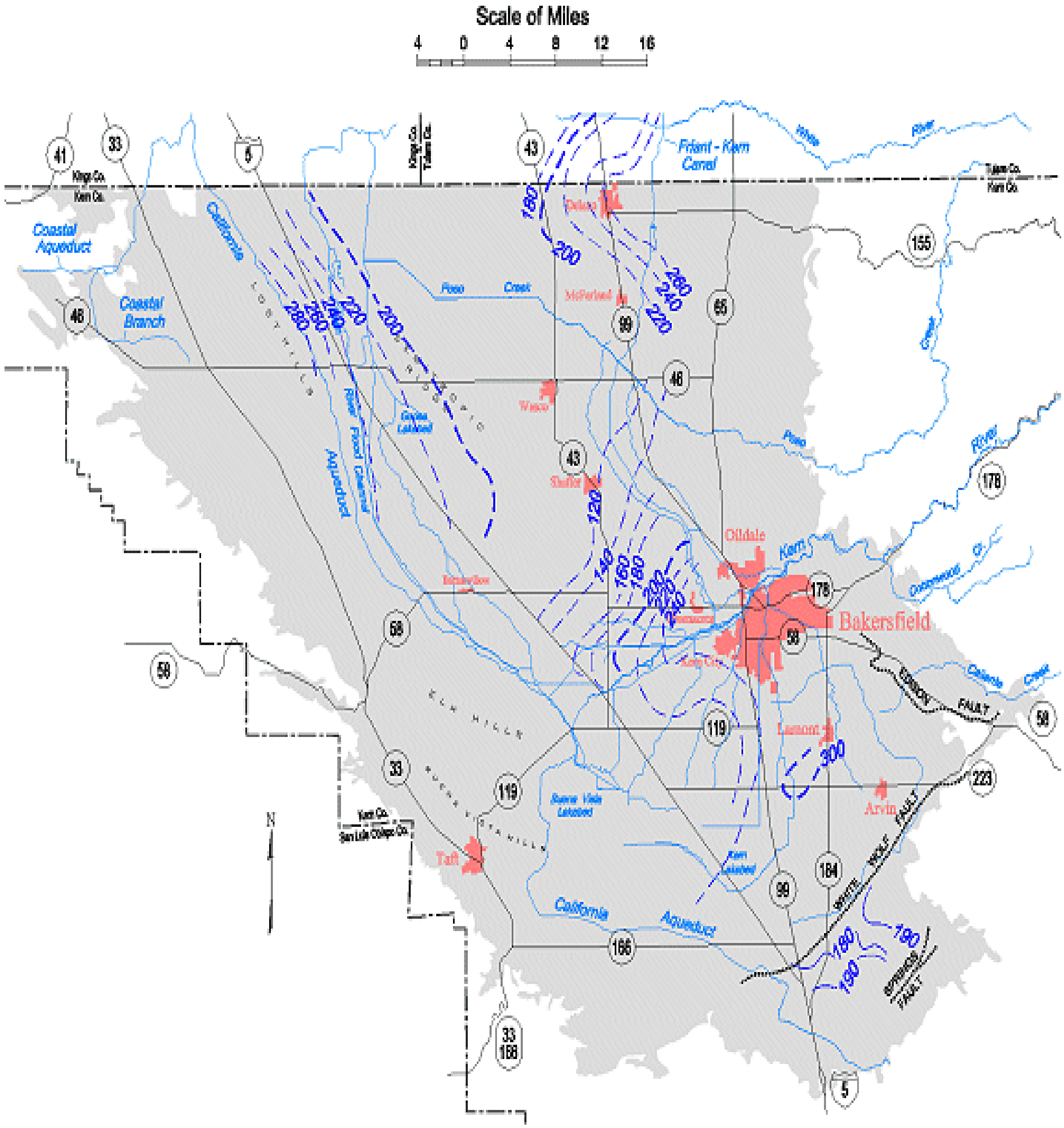
Spring 1989, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Kern Groundwater Basin

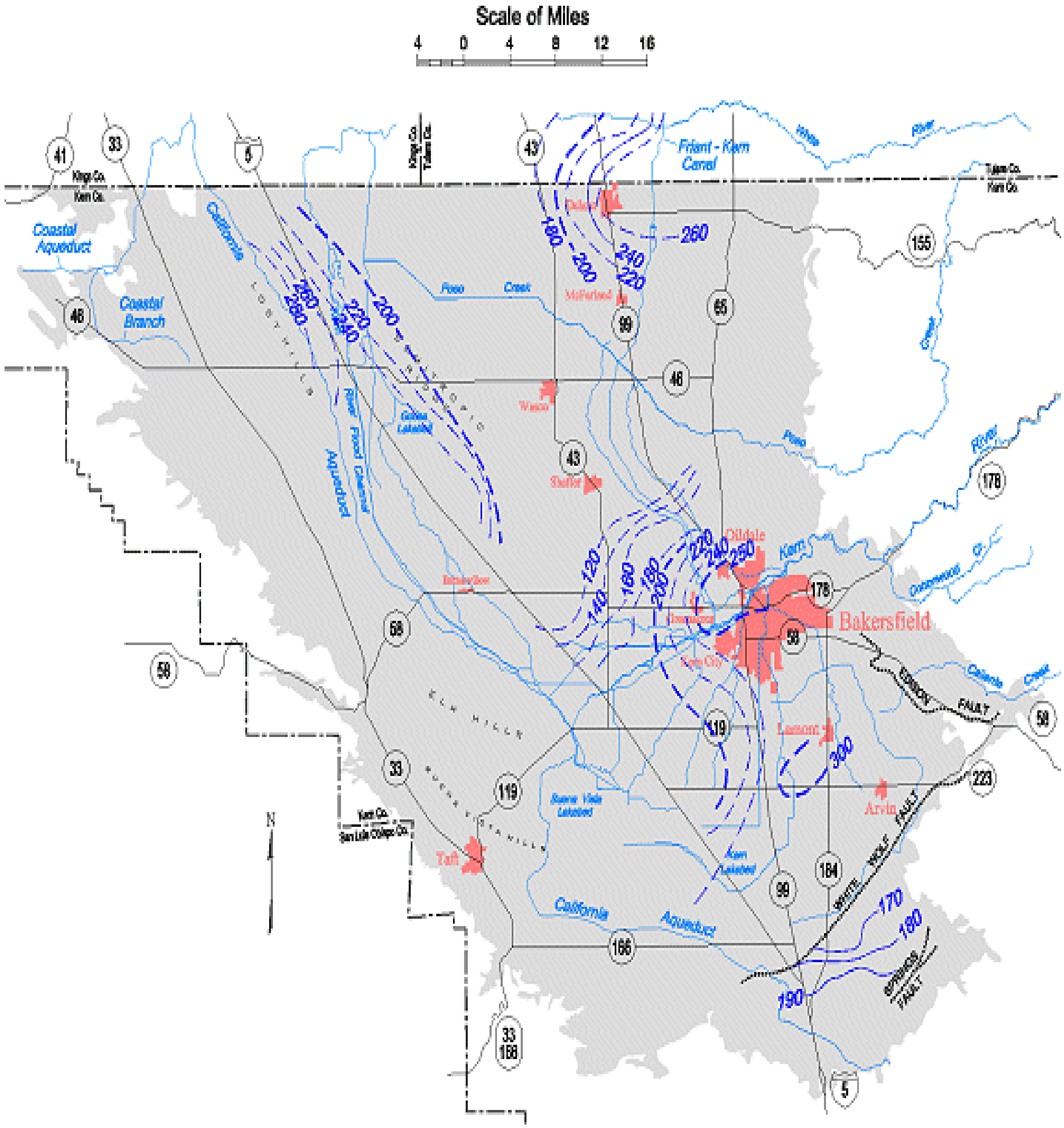
Spring 1990, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Kern Groundwater Basin

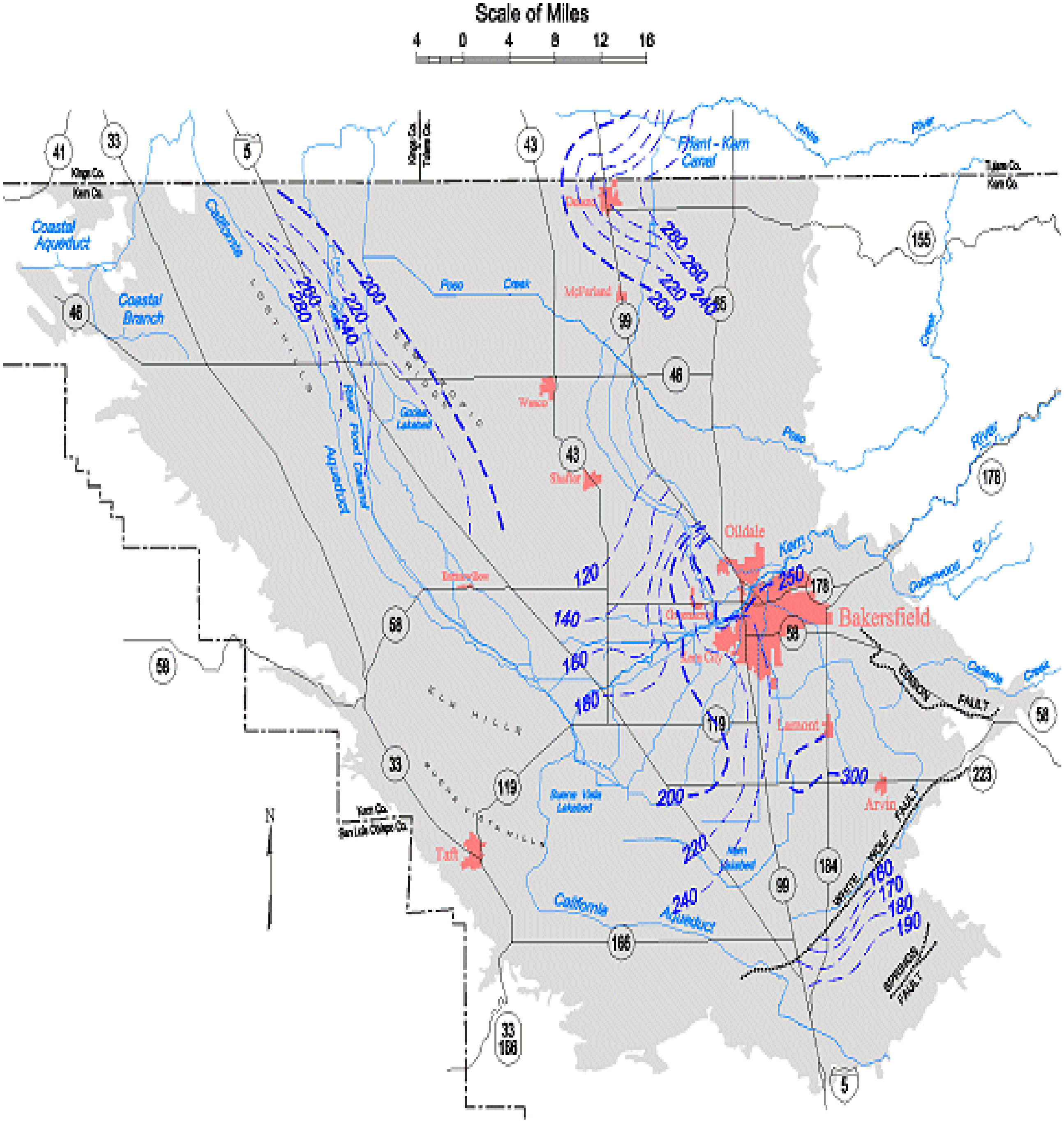
Spring 1991, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Kern Groundwater Basin

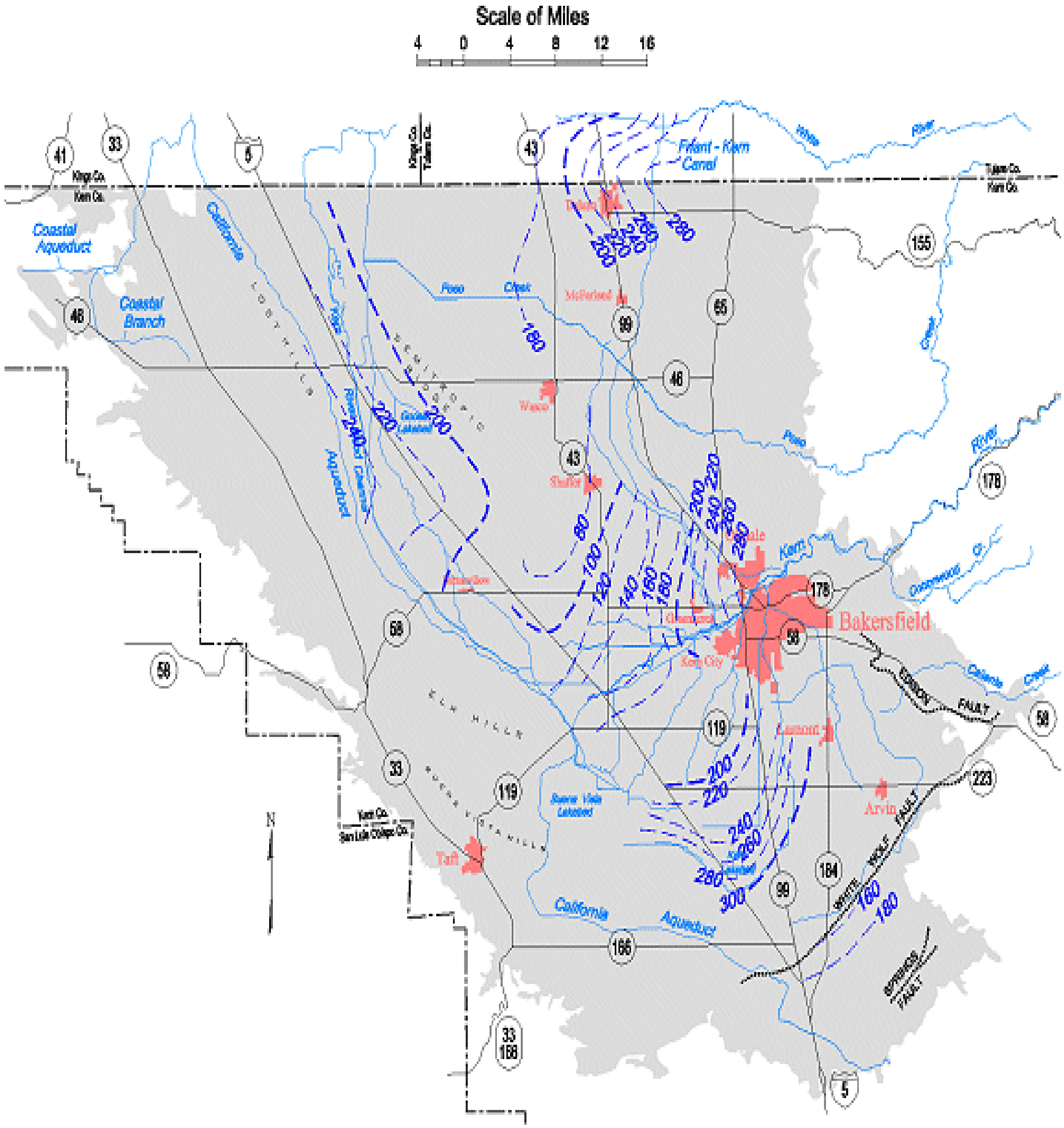
Spring 1992, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Kern Groundwater Basin

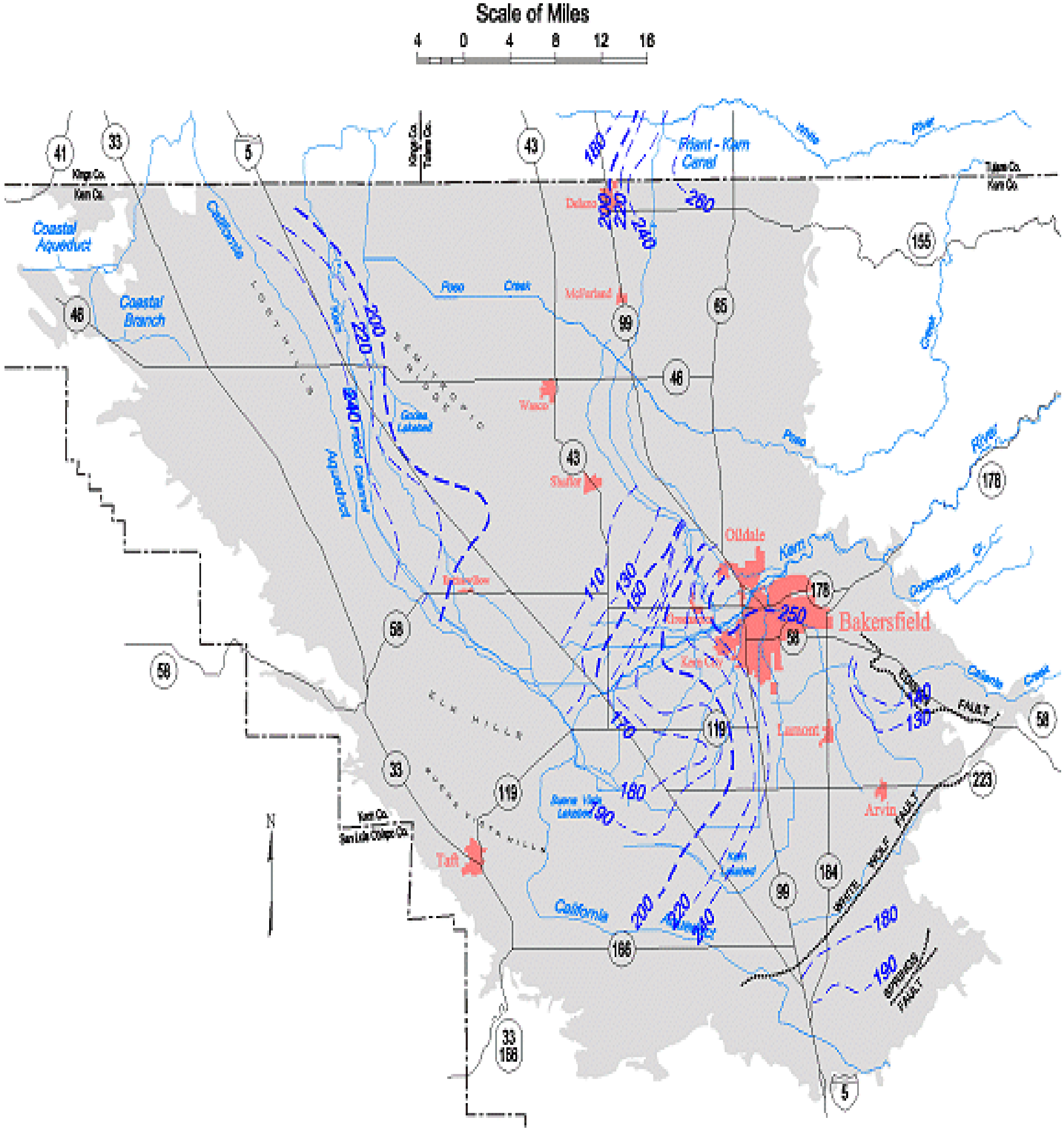
Spring 1993, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 20 feet.

Kern Groundwater Basin

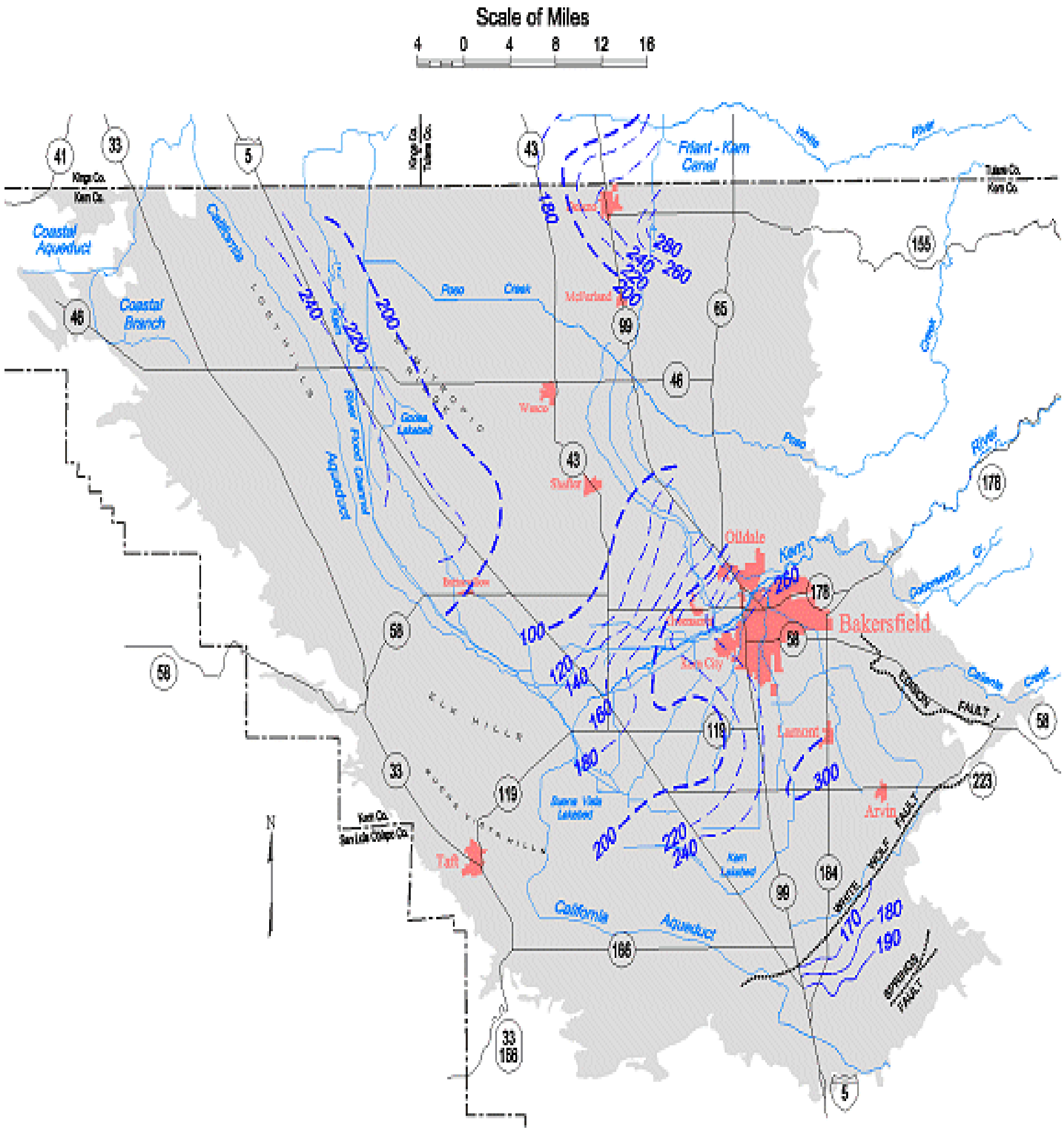
Spring 1994, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Kern Groundwater Basin

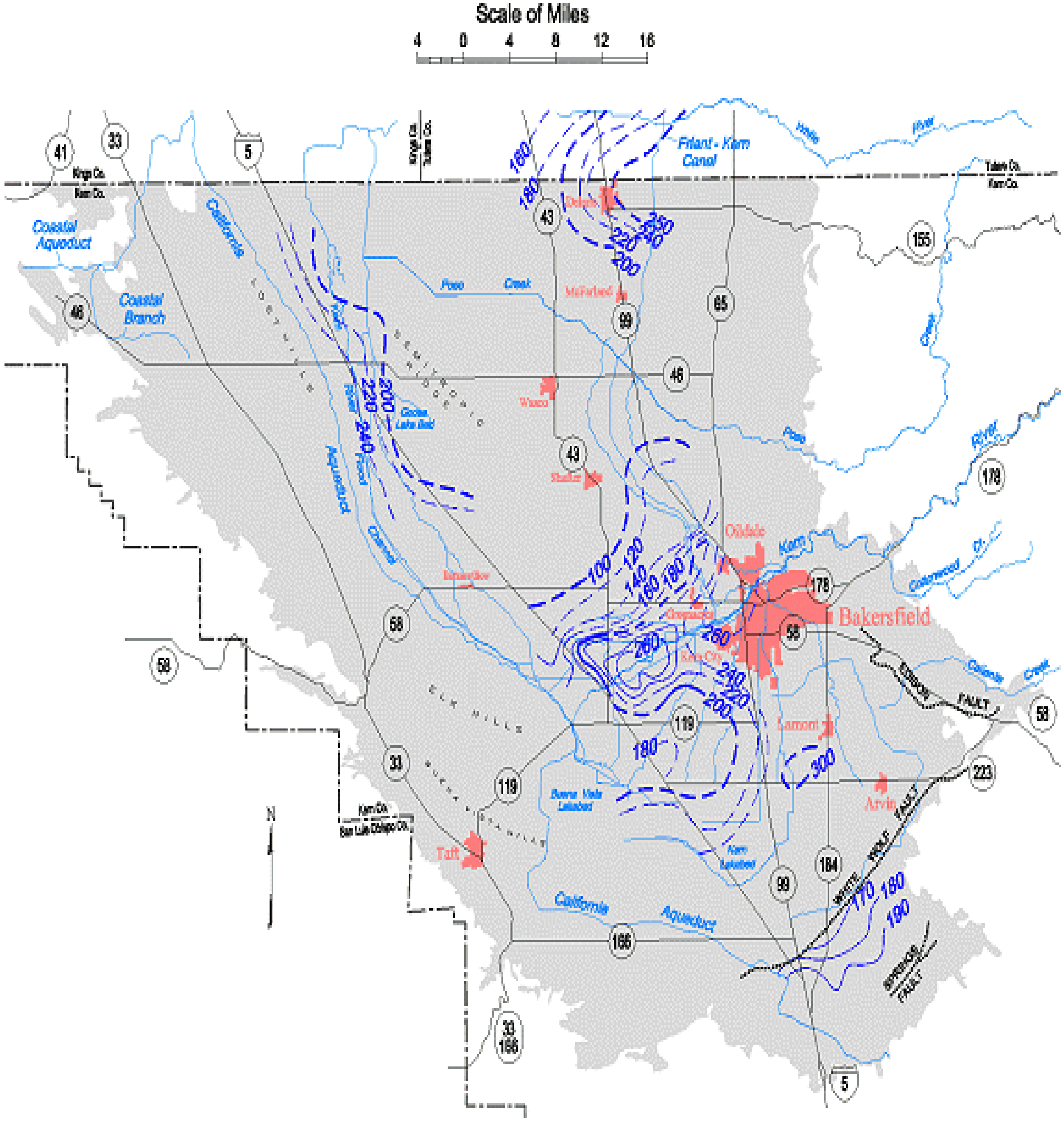
Spring 1995, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Kern Groundwater Basin

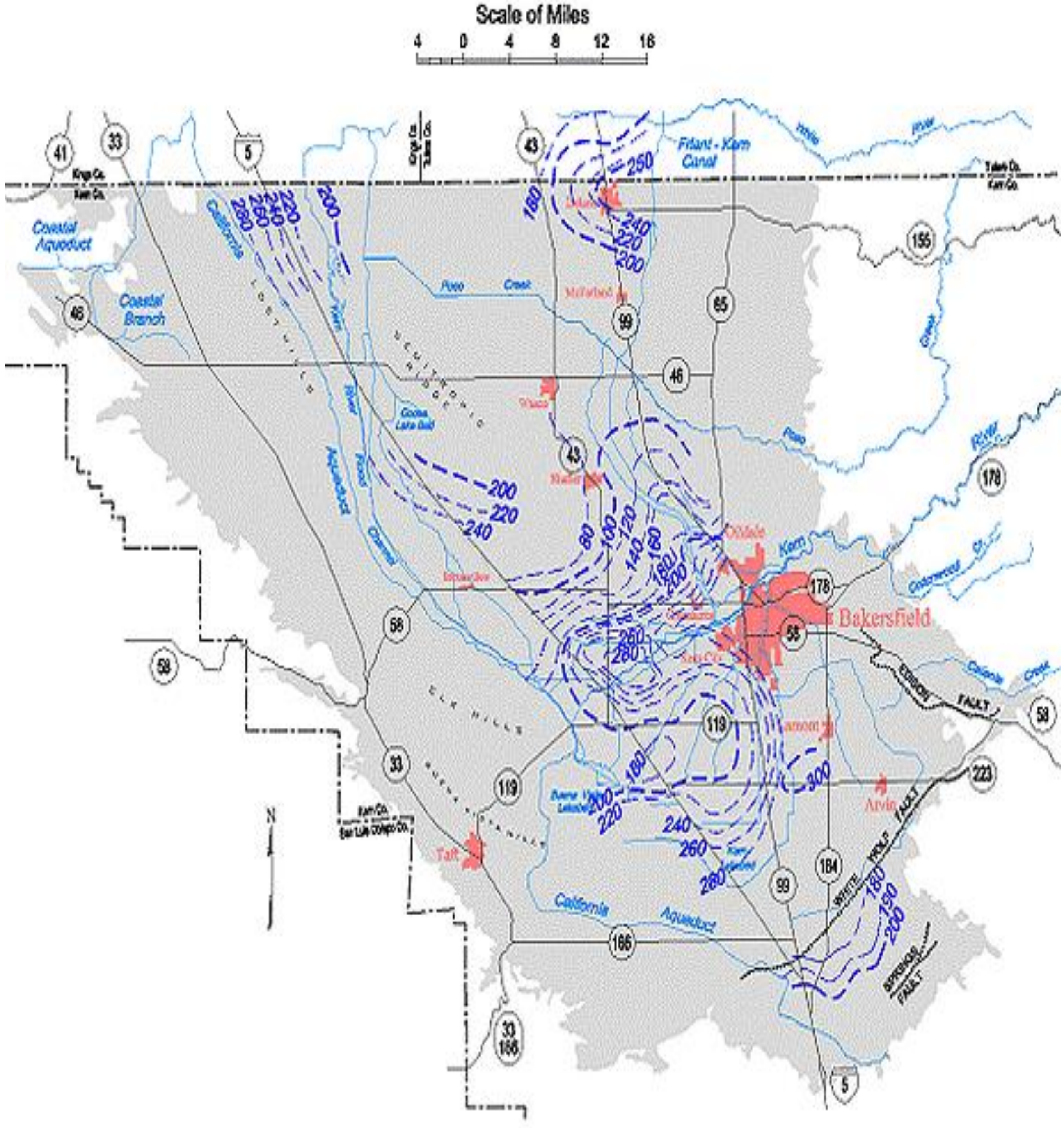
Spring 1996, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Kern Groundwater Basin

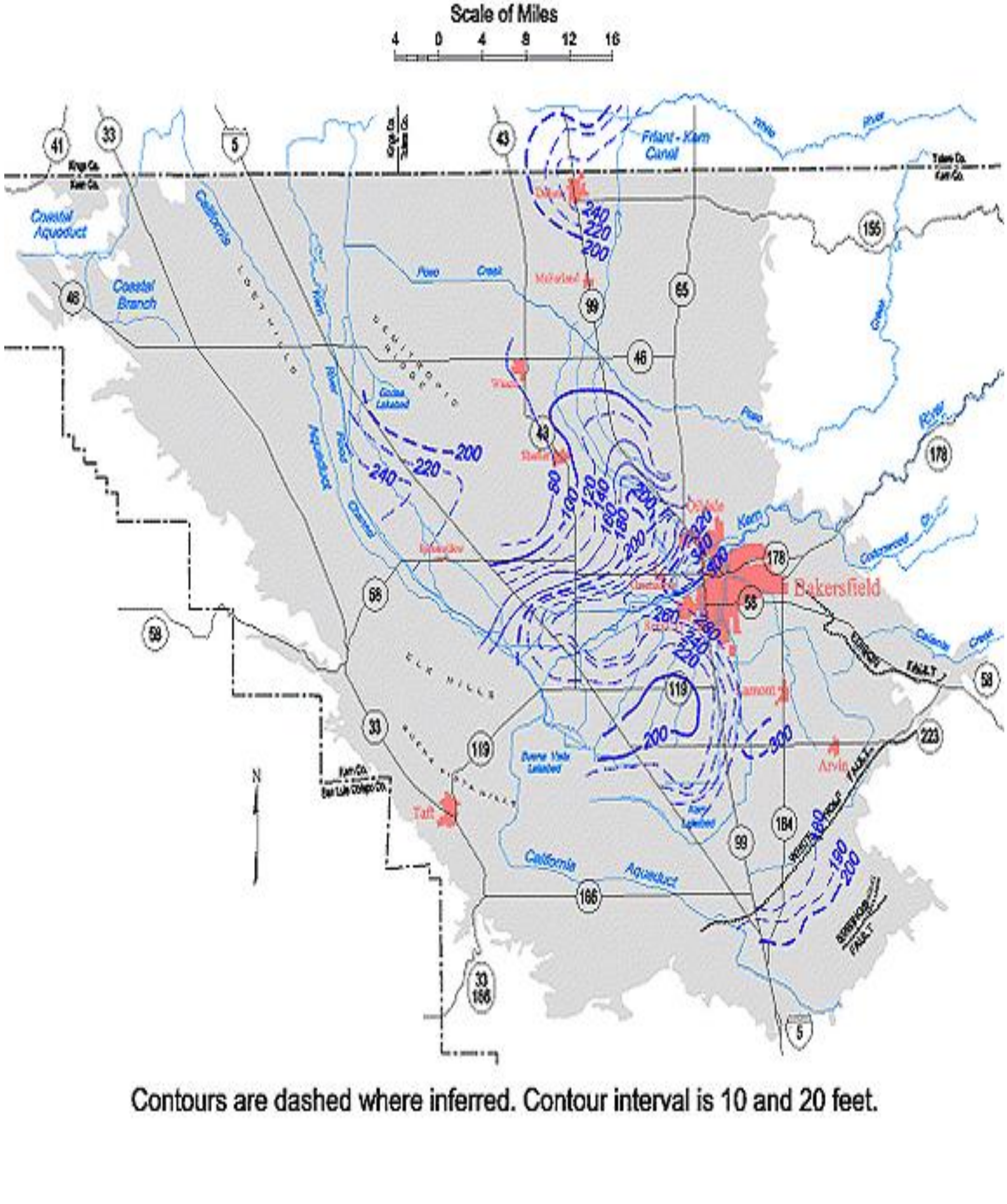
Spring 1997, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Kern Groundwater Basin

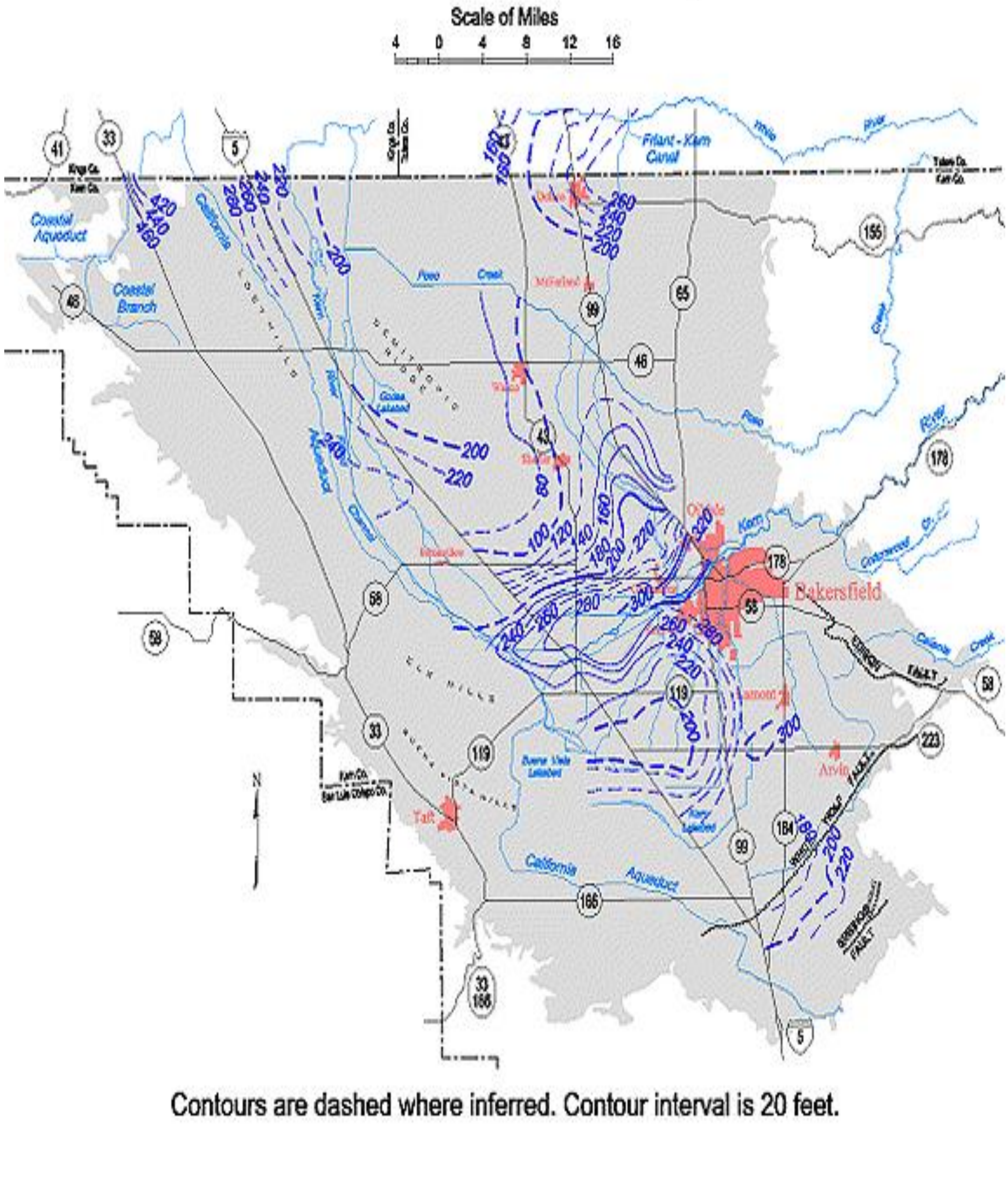
Spring 1998, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Kern Groundwater Basin

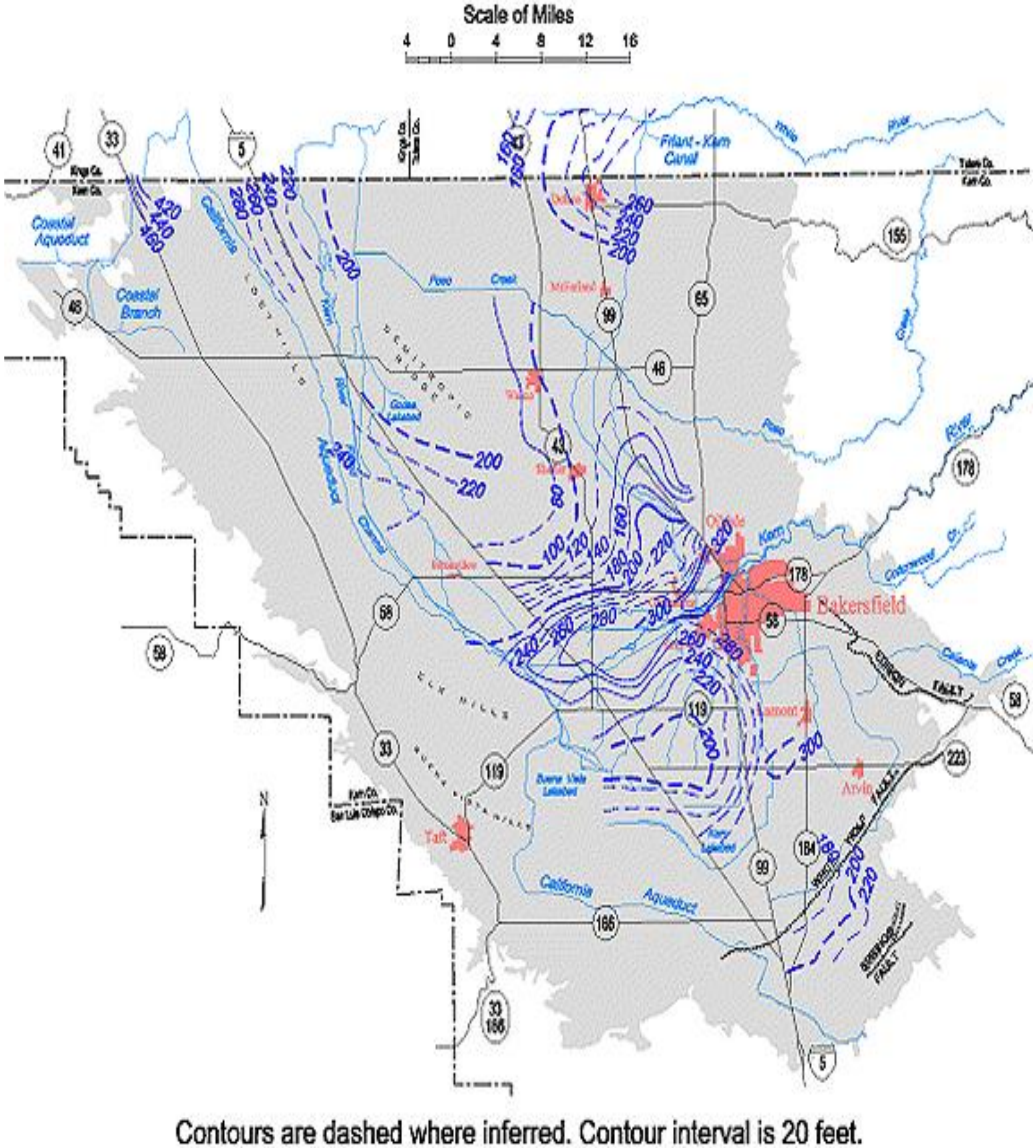
Spring 1999, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 20 feet.

Kern Groundwater Basin

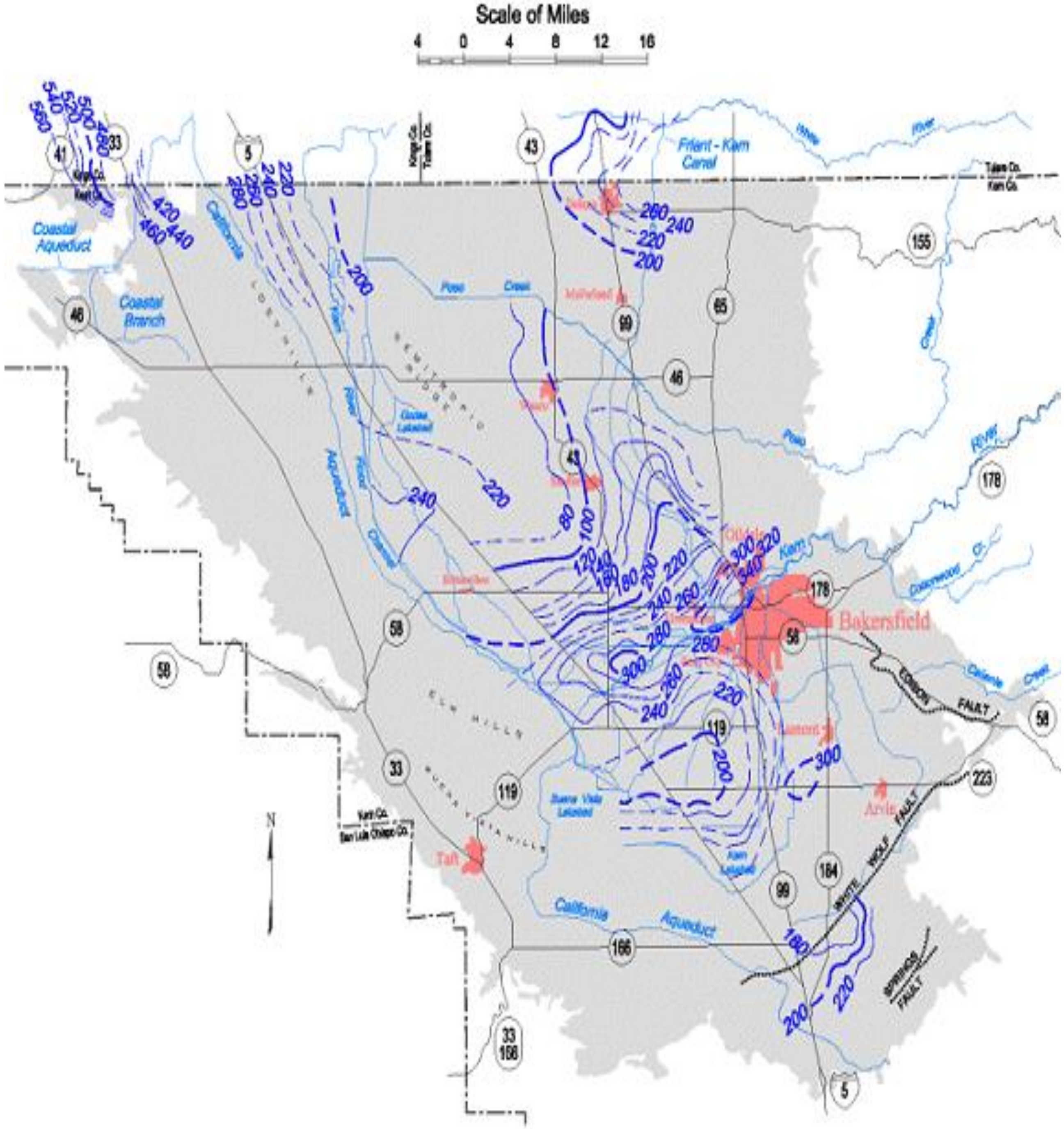
Spring 1999, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 20 feet.

Kern Groundwater Basin

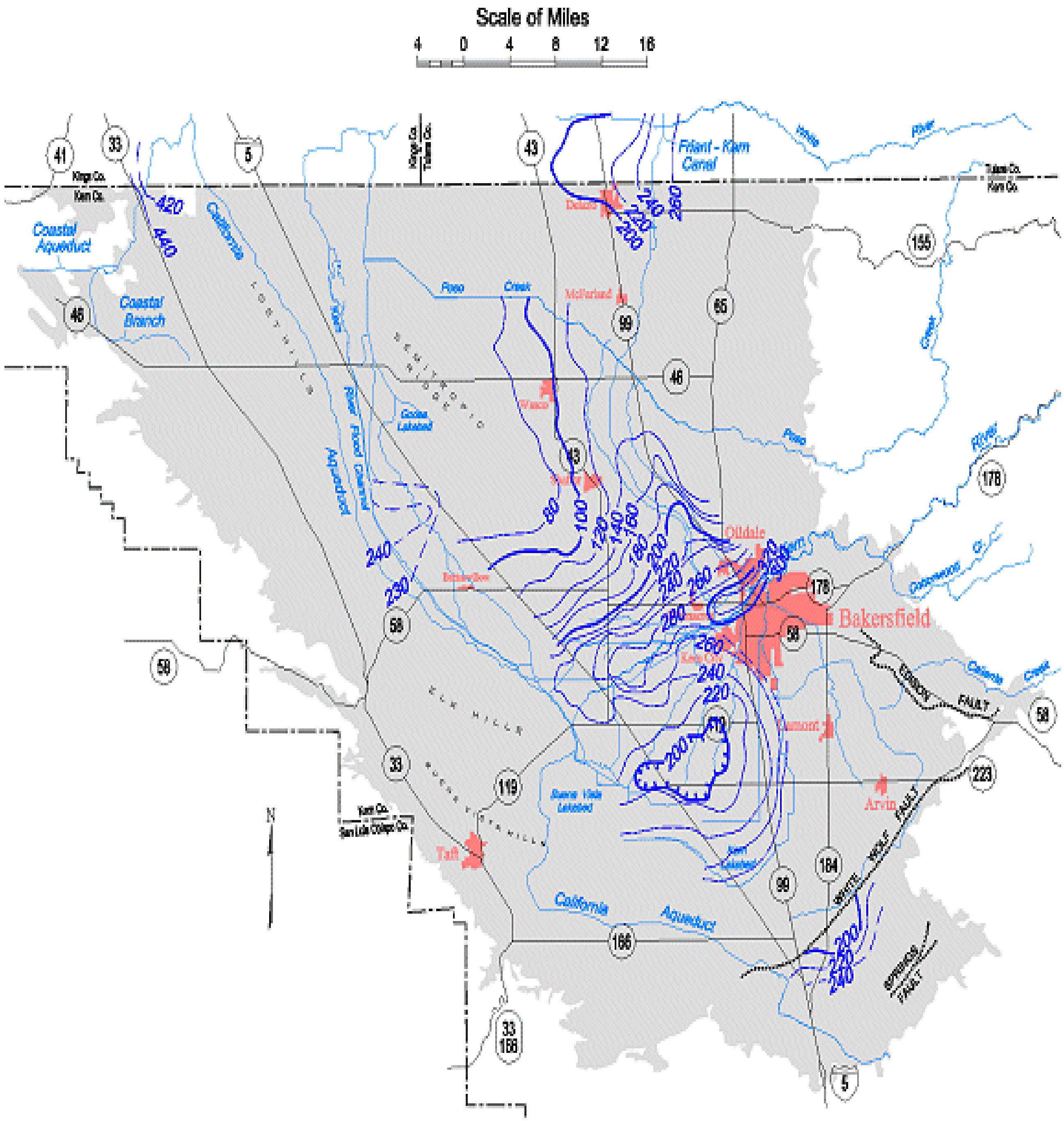
Spring 2000, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 20 feet.

Kern Groundwater Basin

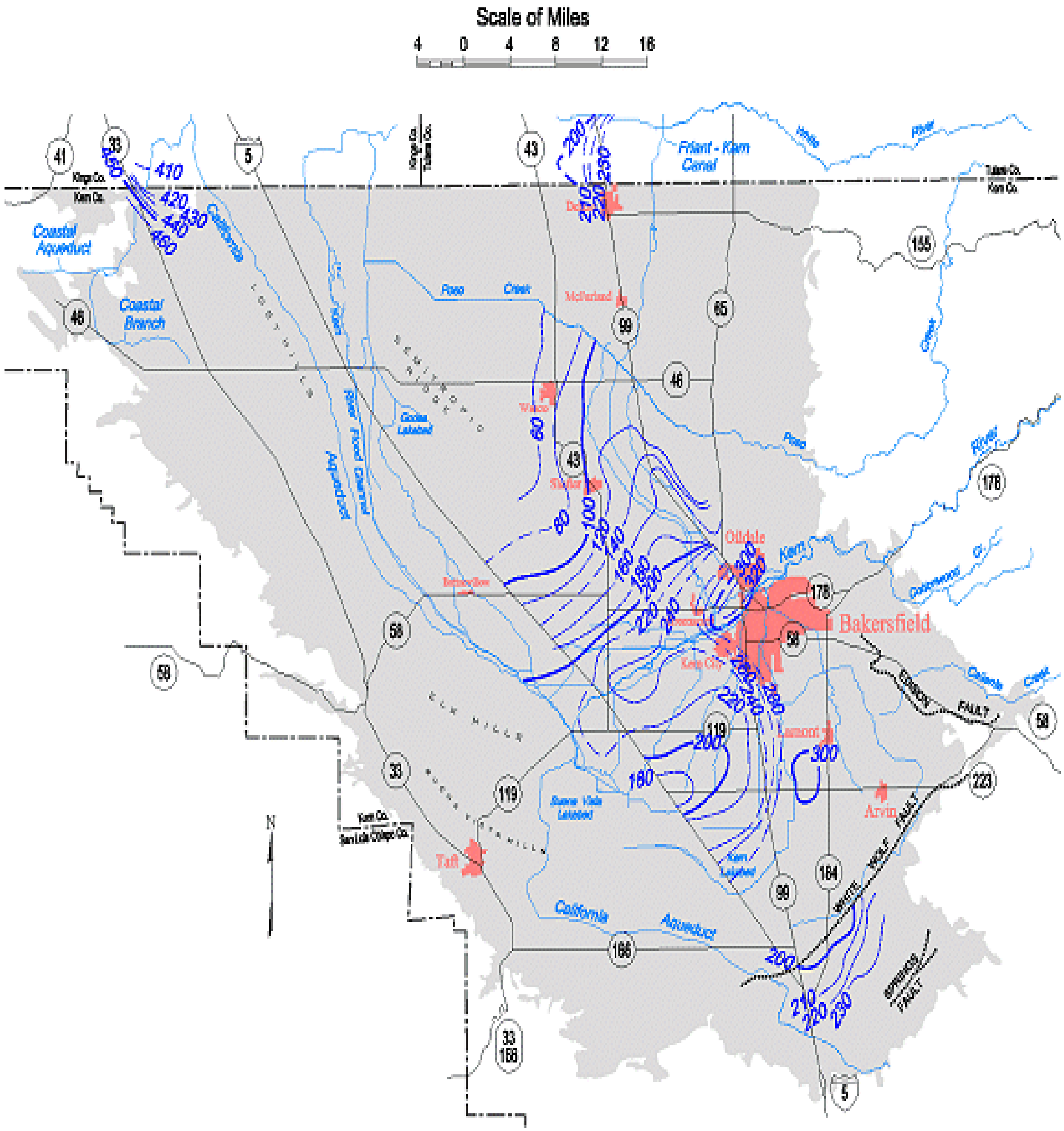
Spring 2001, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Kern Groundwater Basin

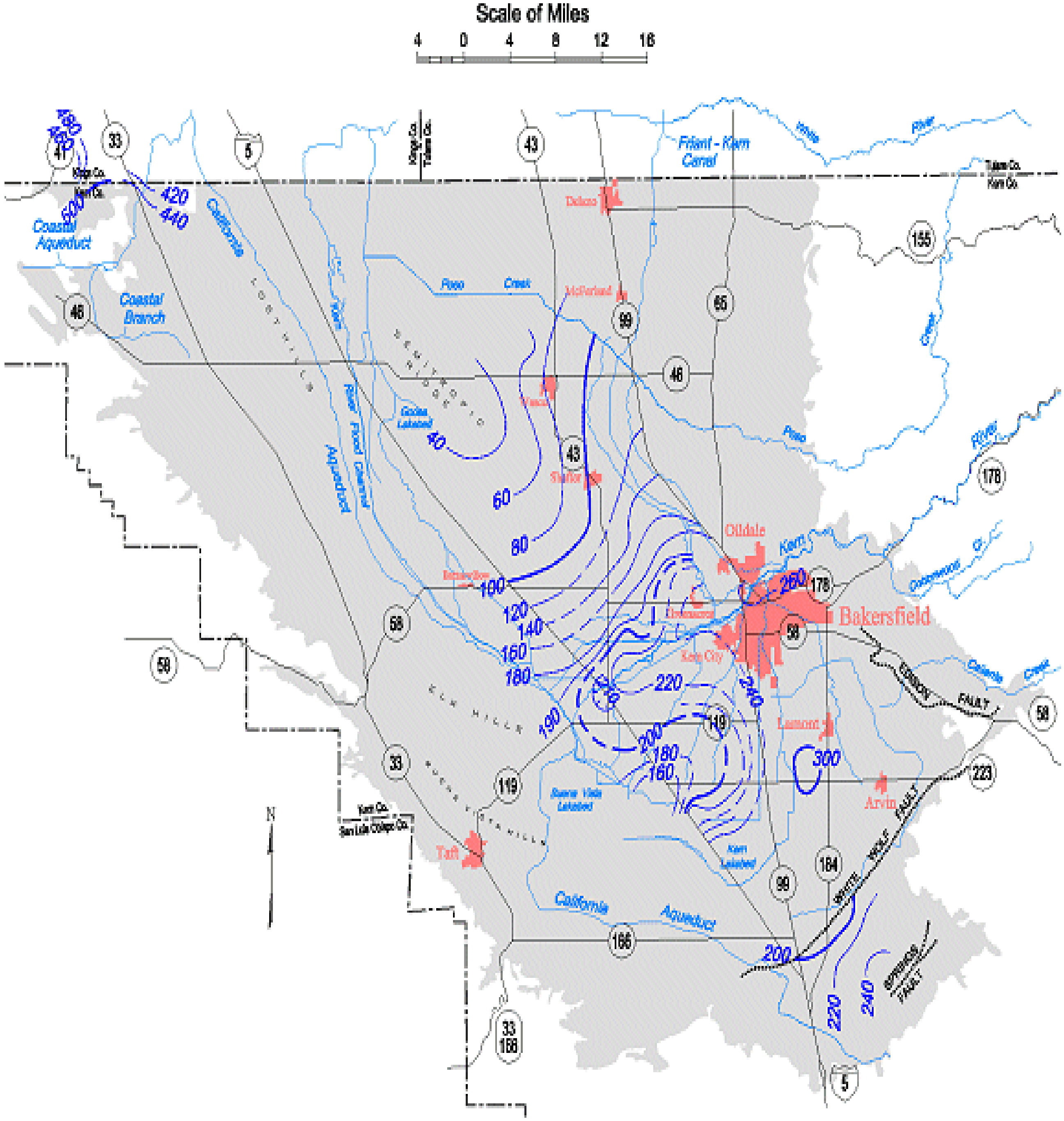
Spring 2002, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Kern Groundwater Basin

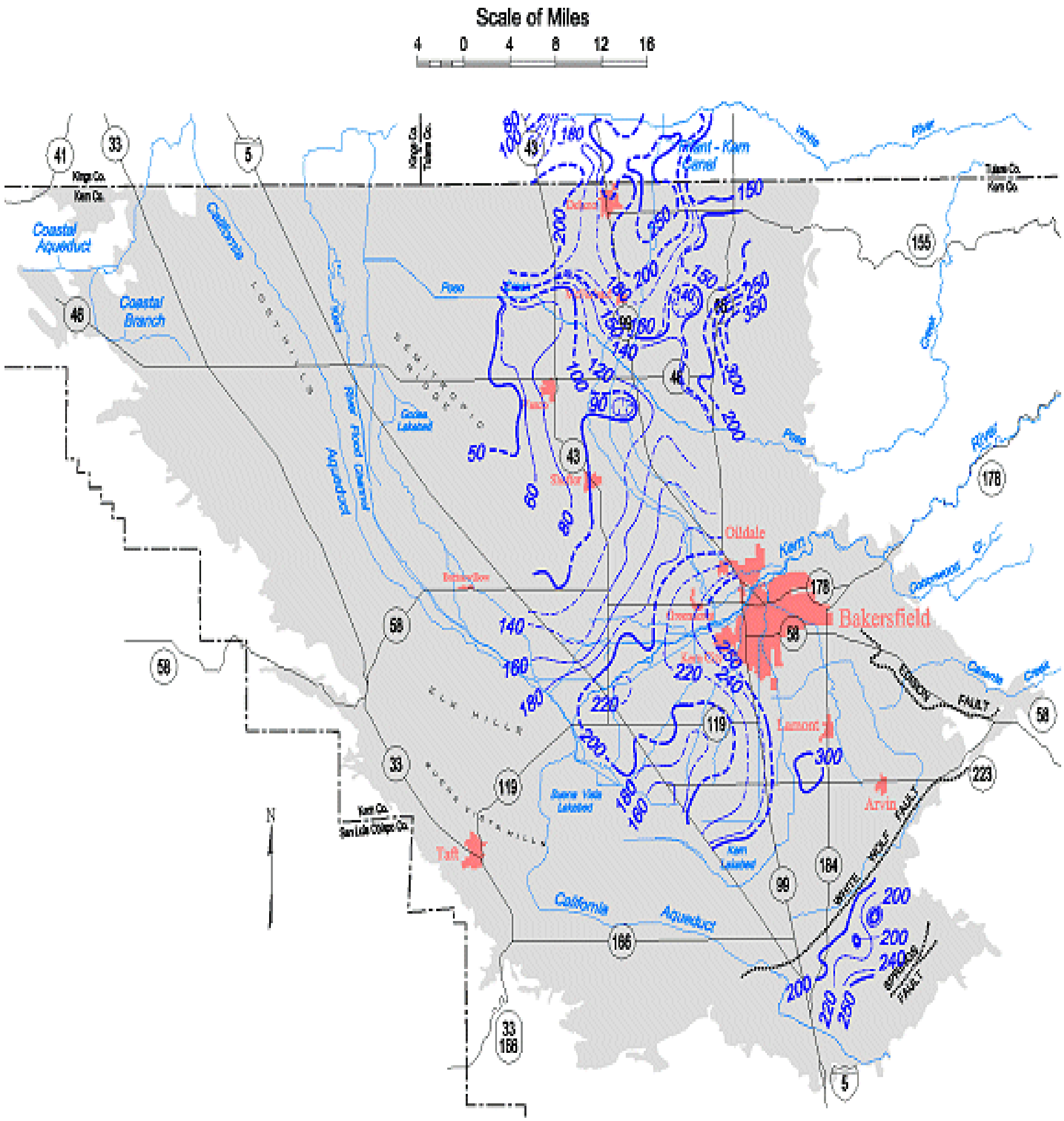
Spring 2003, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Kern Groundwater Basin

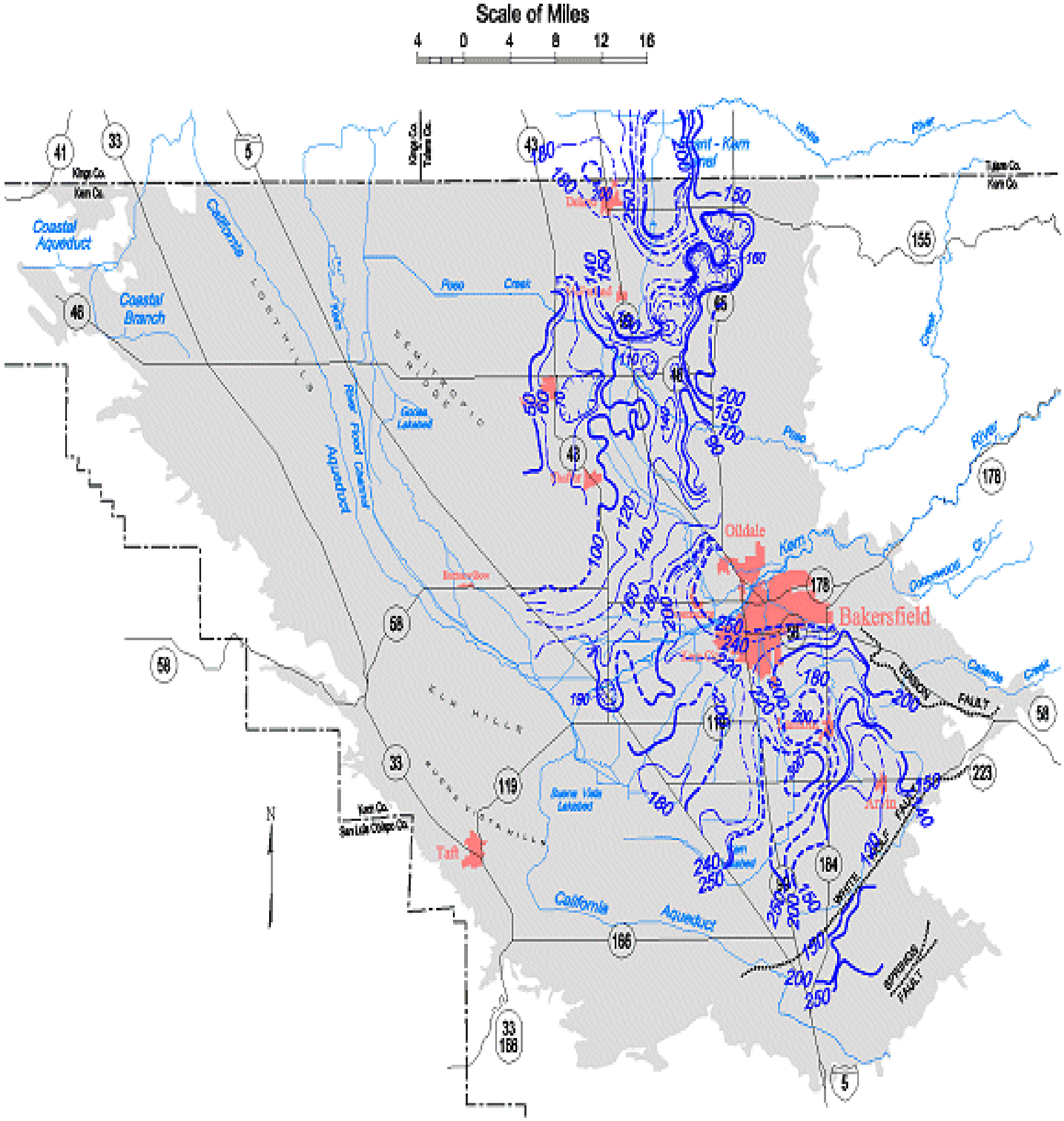
Spring 2004, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10, 20 and 50 feet.

Kern Groundwater Basin

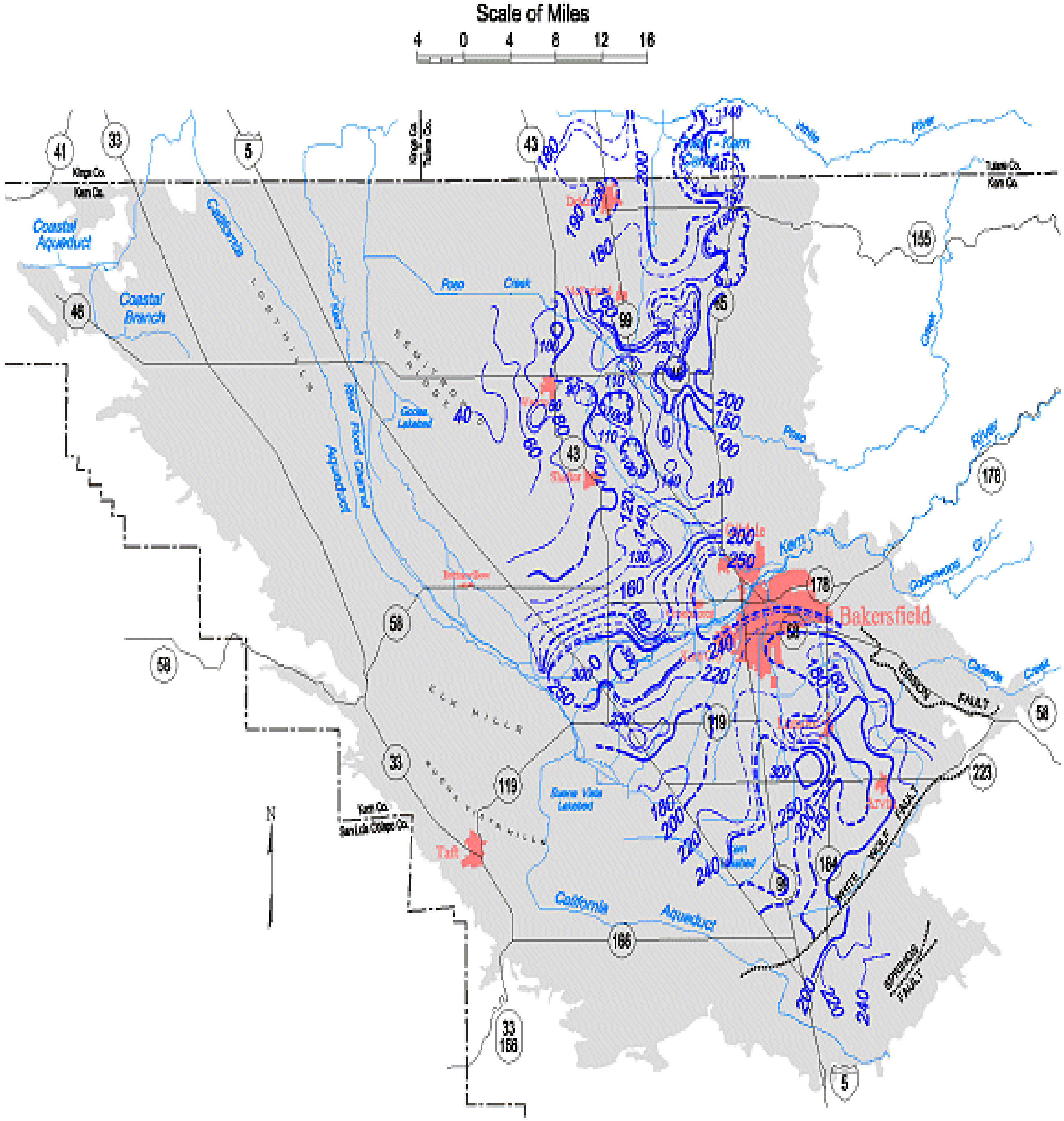
Spring 2005, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10, 20 and 50 feet.

Kern Groundwater Basin

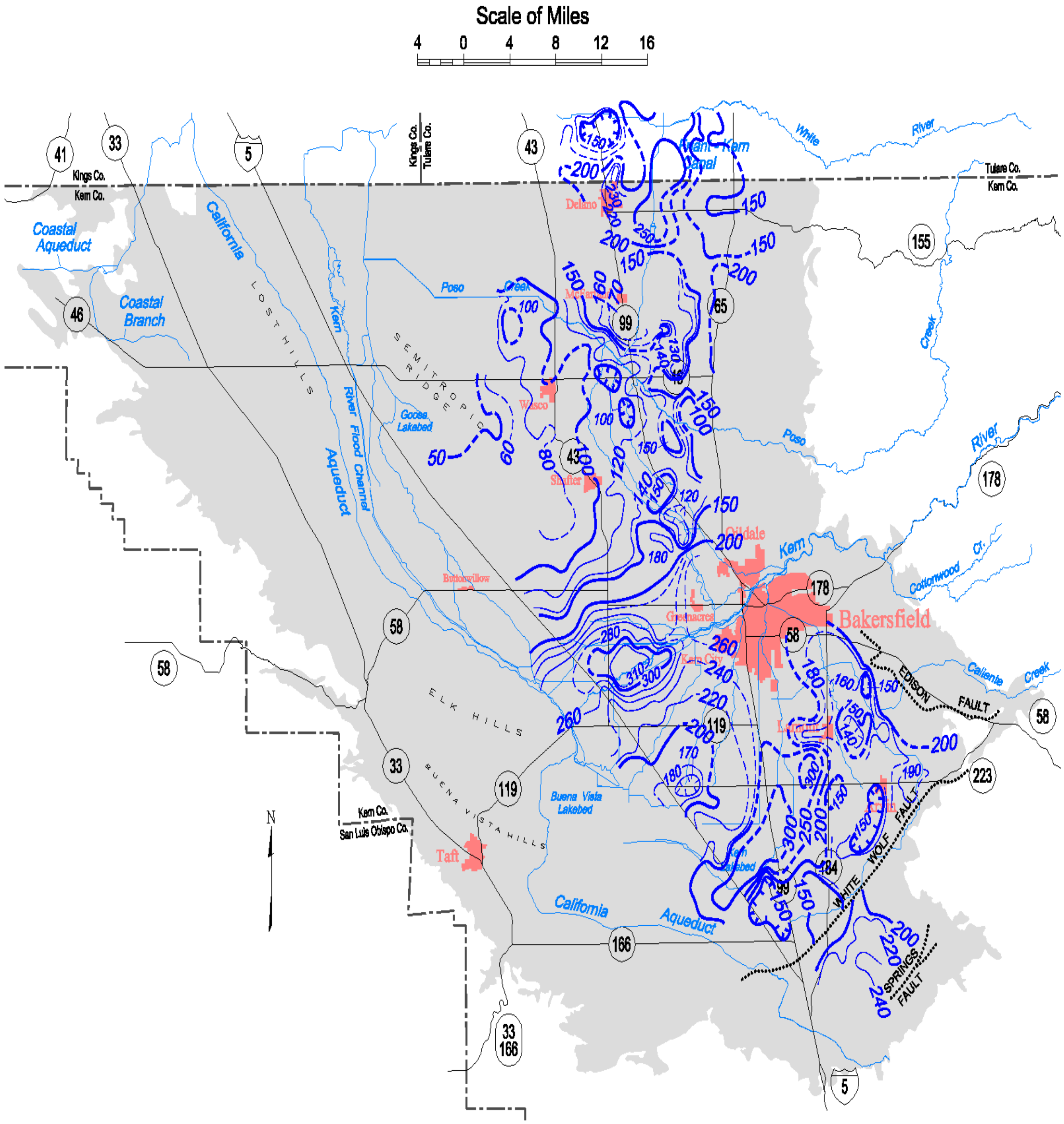
Spring 2006, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10, 20 and 50 feet.

Kern Groundwater Basin

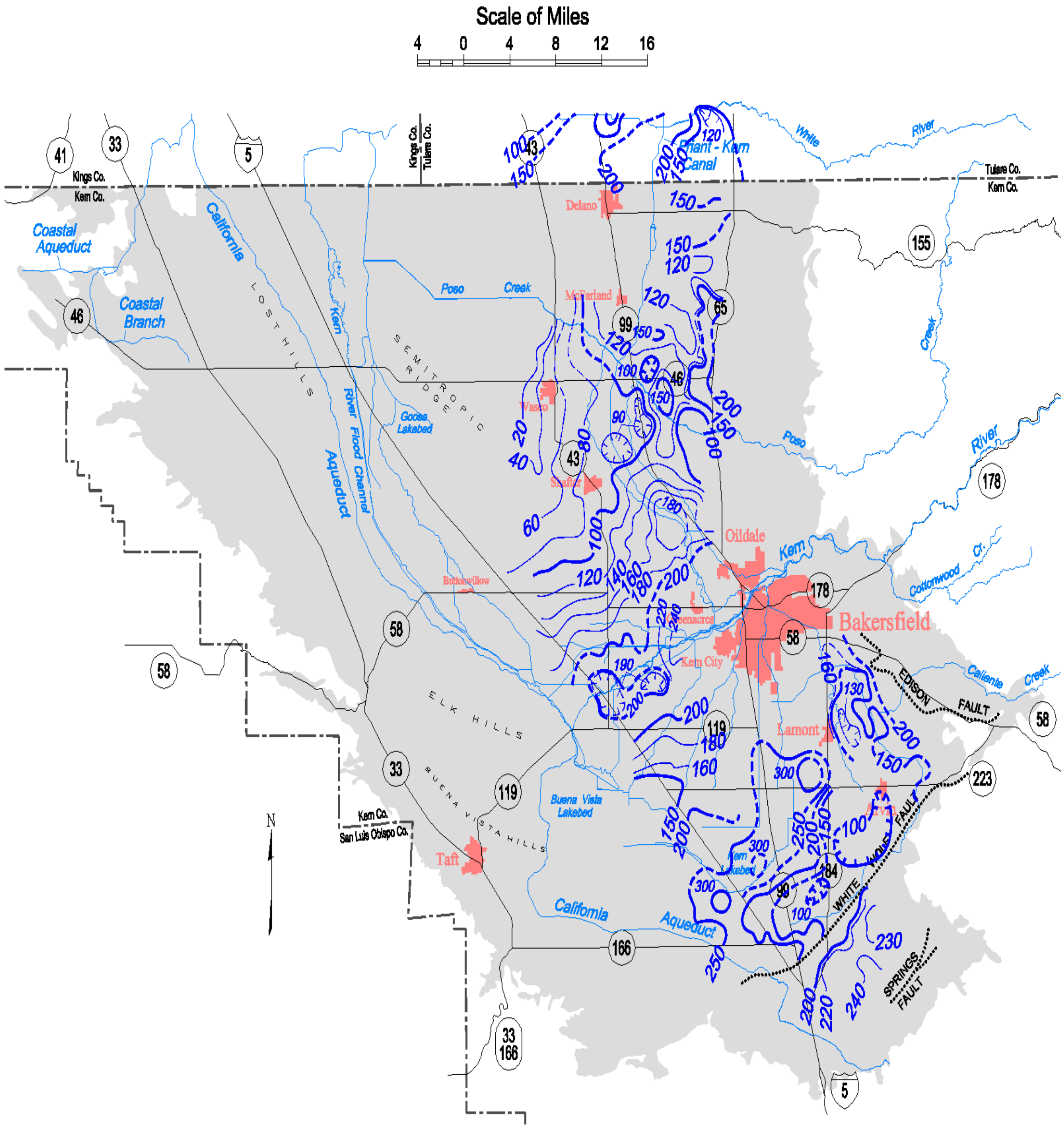
Spring 2007, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10, 20 and 50 feet.

Kern Groundwater Basin

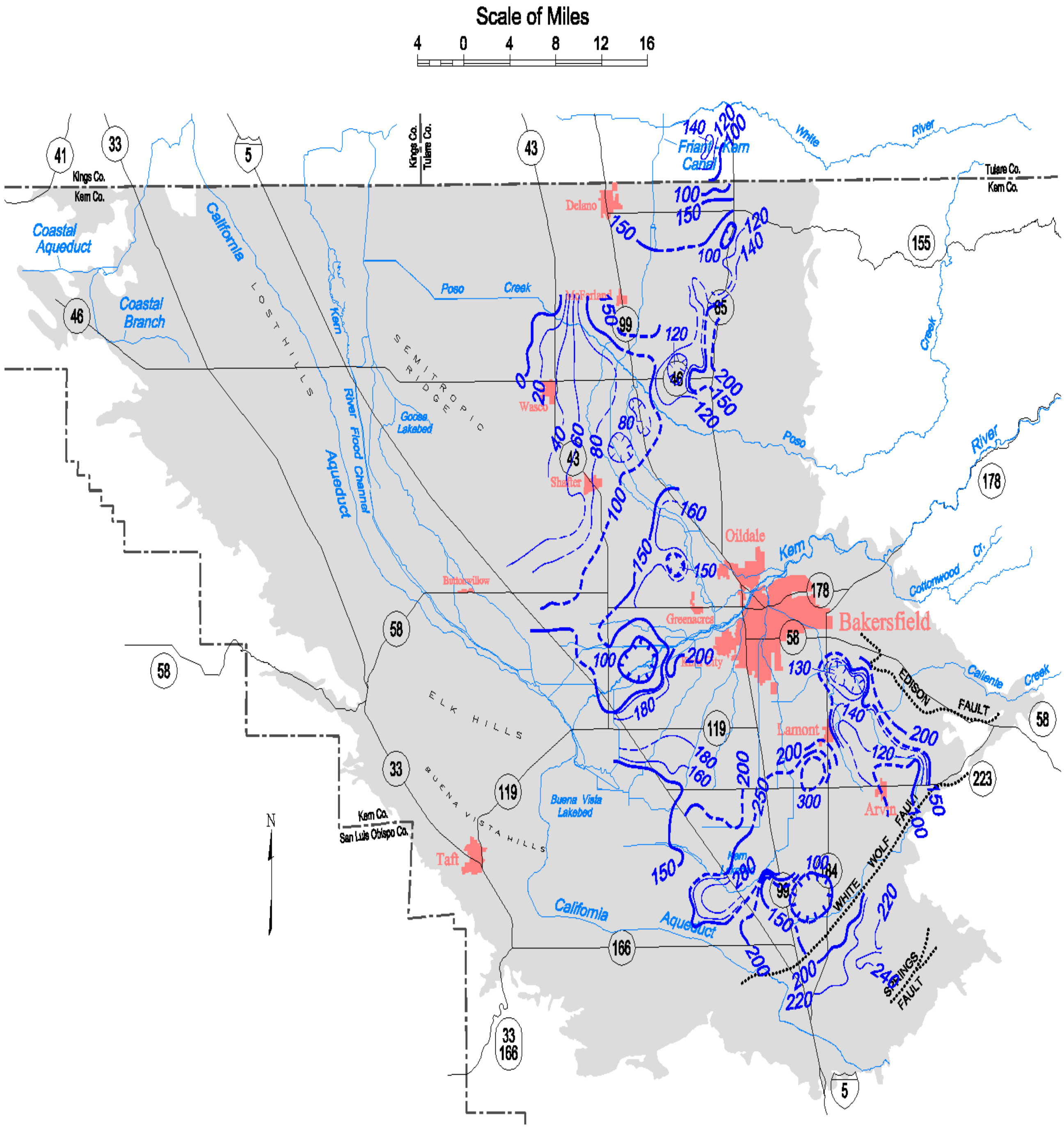
Spring 2008, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10, 20 and 50 feet.

Kern Groundwater Basin

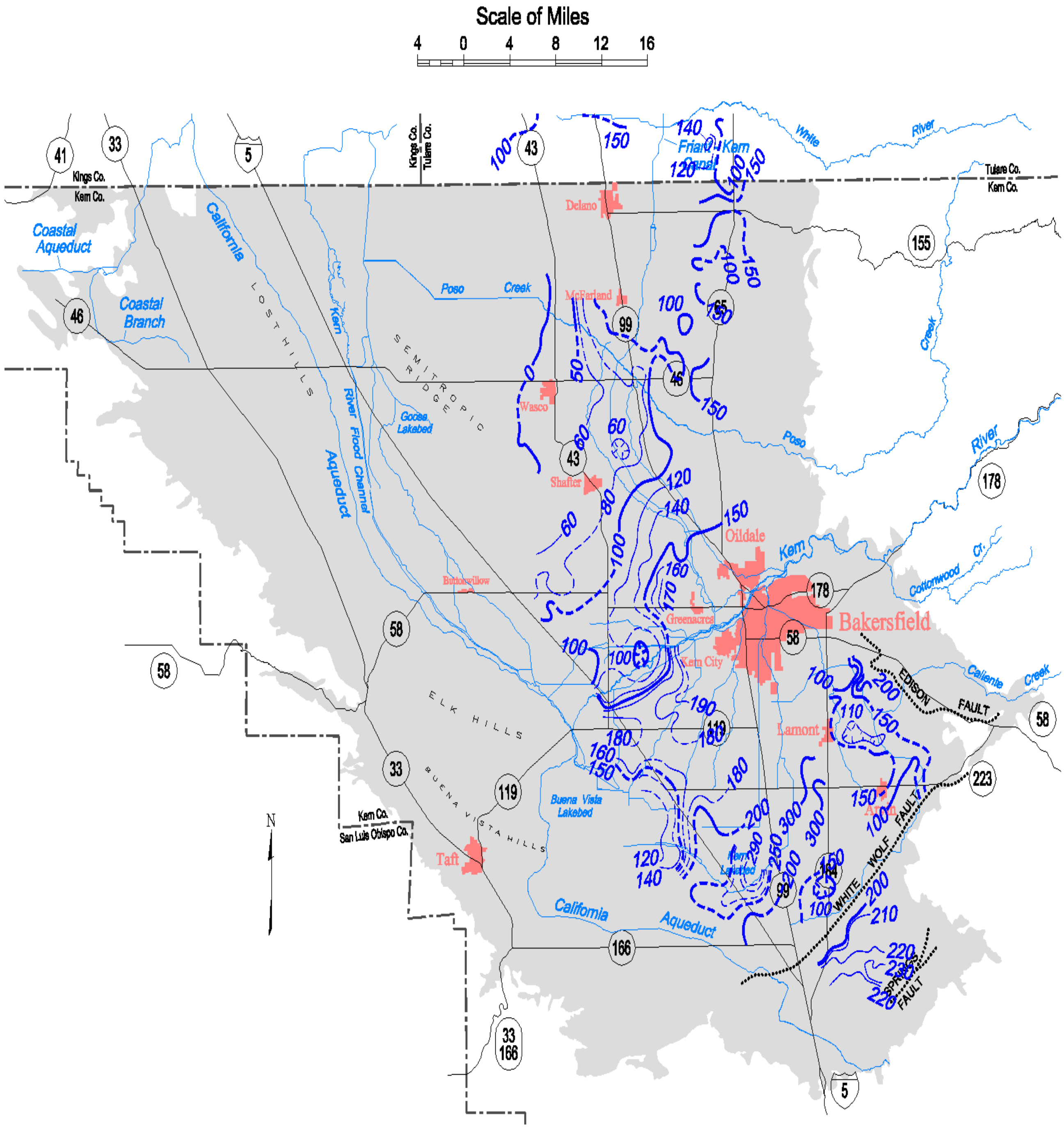
Spring 2009, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10, 20 and 50 feet.

Kern Groundwater Basin

Spring 2010, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10, 20 and 50 feet.

Appendix C.2

USGS

EXPLANATION

● 275 / 300-804
Well that taps Pleistocene and Recent alluvium
Upper number indicates altitude of water level in December, 1958; lower numbers indicate perforated interval, or reported depth of well

Water-level contour for the main water body in Pleistocene and Recent alluvium
Contours queried where uncertain. Contour interval 10 and 20 feet. Datum is mean sea level

○ 281 / 238-328
Well that taps a shallow, semiperched water body
Upper number indicates altitude of water level in December, 1958; lower numbers indicate perforated interval, or reported depth of well

Water-level contour for the shallow semiperched water body
Contours queried where uncertain. Contour interval 10 feet. Datum is mean sea level

Approximate southern edge of area in which wells of average depth chiefly tap the Kern River formation of Diepenbrock, 1933

▲ 304 / 600-1280
Well that taps undifferentiated marine and continental rocks of Tertiary age
Upper number indicates altitude of water level in December, 1958; lower numbers indicate perforated interval, or reported depth of well

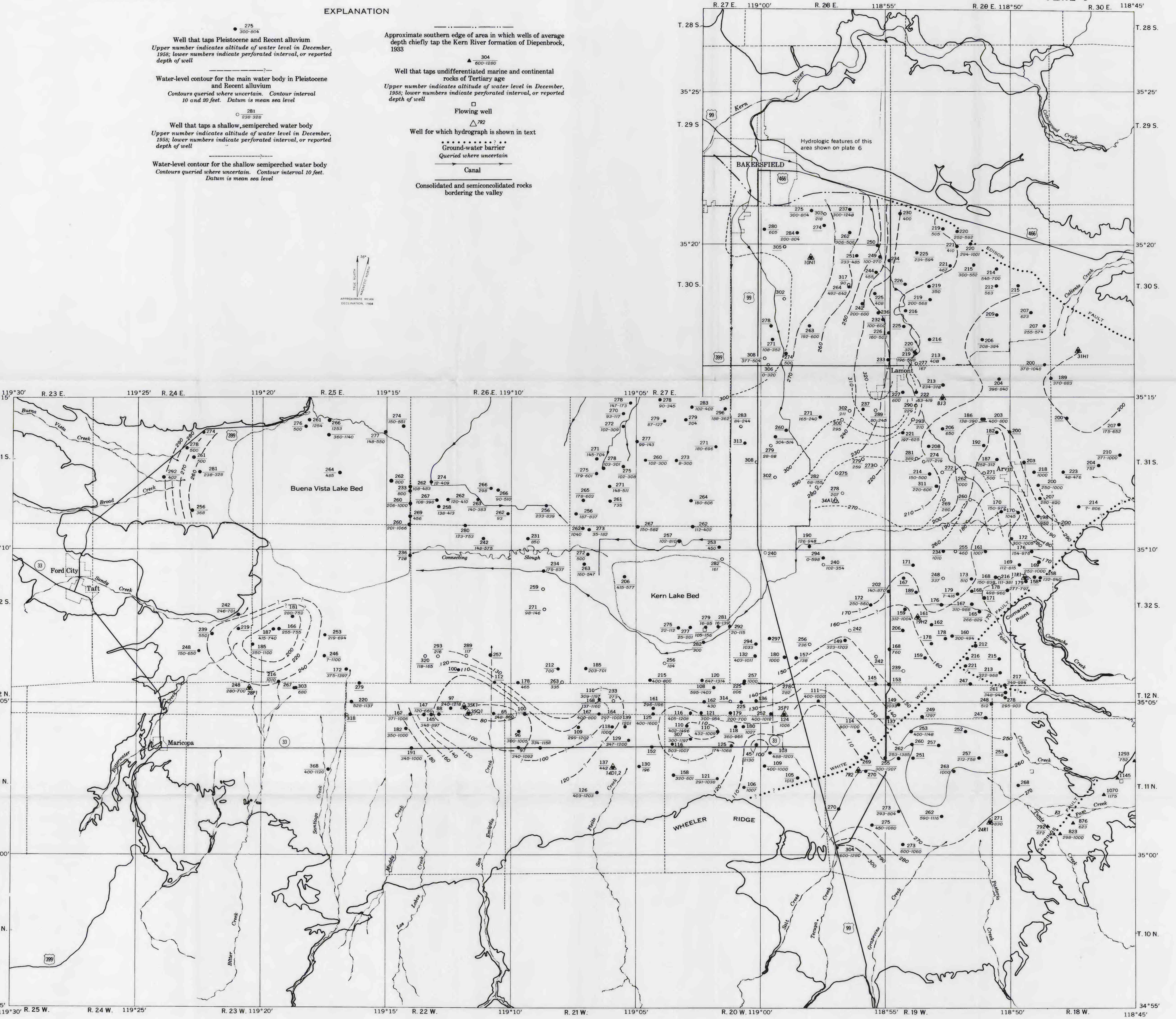
□
Flowing well

△ 7R2
Well for which hydrograph is shown in text

Ground-water barrier
Queried where uncertain

Canal

Consolidated and semiconsolidated rocks bordering the valley



WATER-LEVEL CONTOURS FOR THE MAIN WATER BODY IN THE EDISON-MARICOPA AREA, CALIFORNIA, DECEMBER 1958

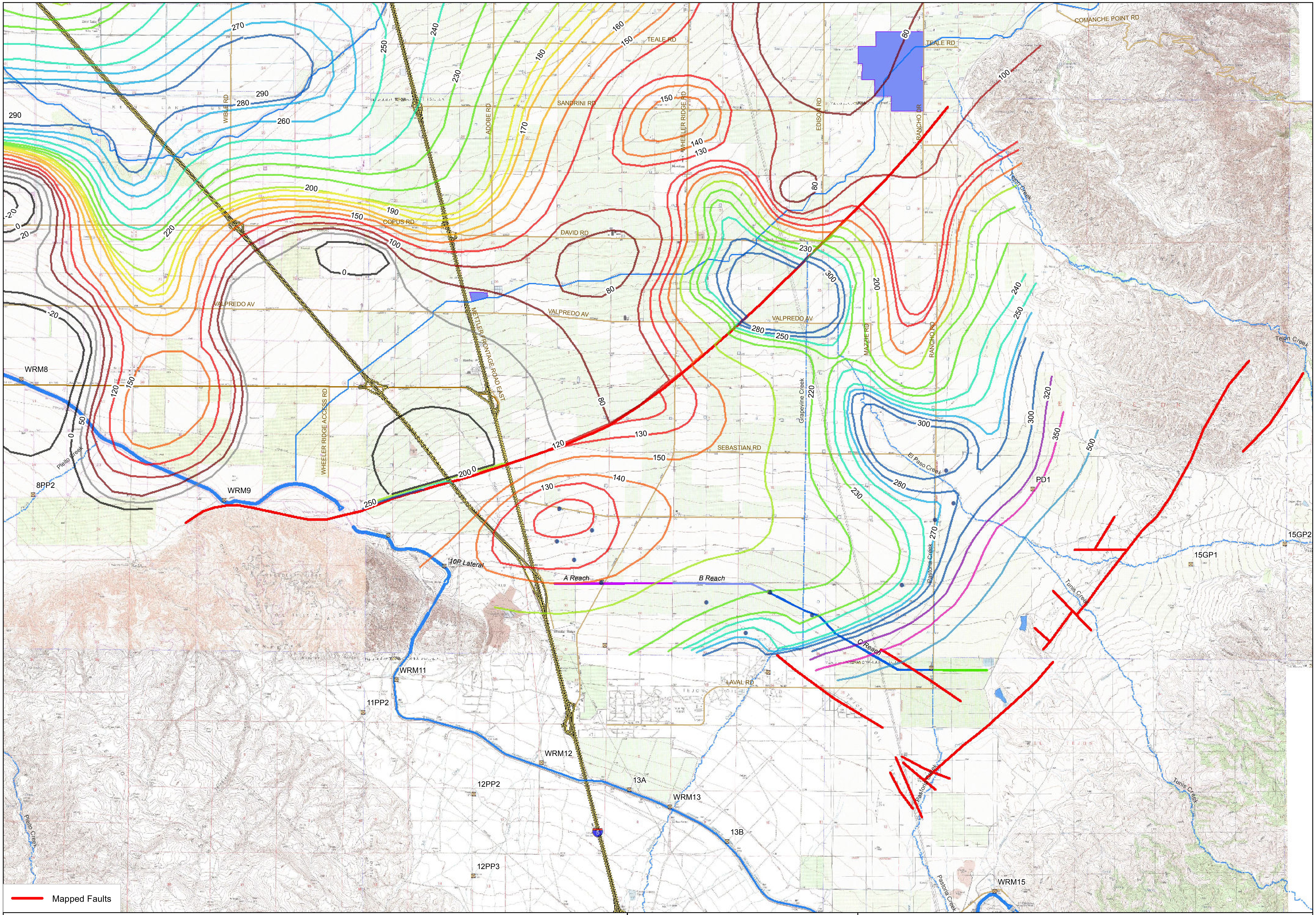
SCALE 1:125 000

1 0 1 2 3 4 MILES

714-848 O - 64 (In pocket)

Appendix C.3

WRMWSD



Author: Thomas Suggs
Name: WRM_C_Size_2015-12-10_Spring_1970_WL

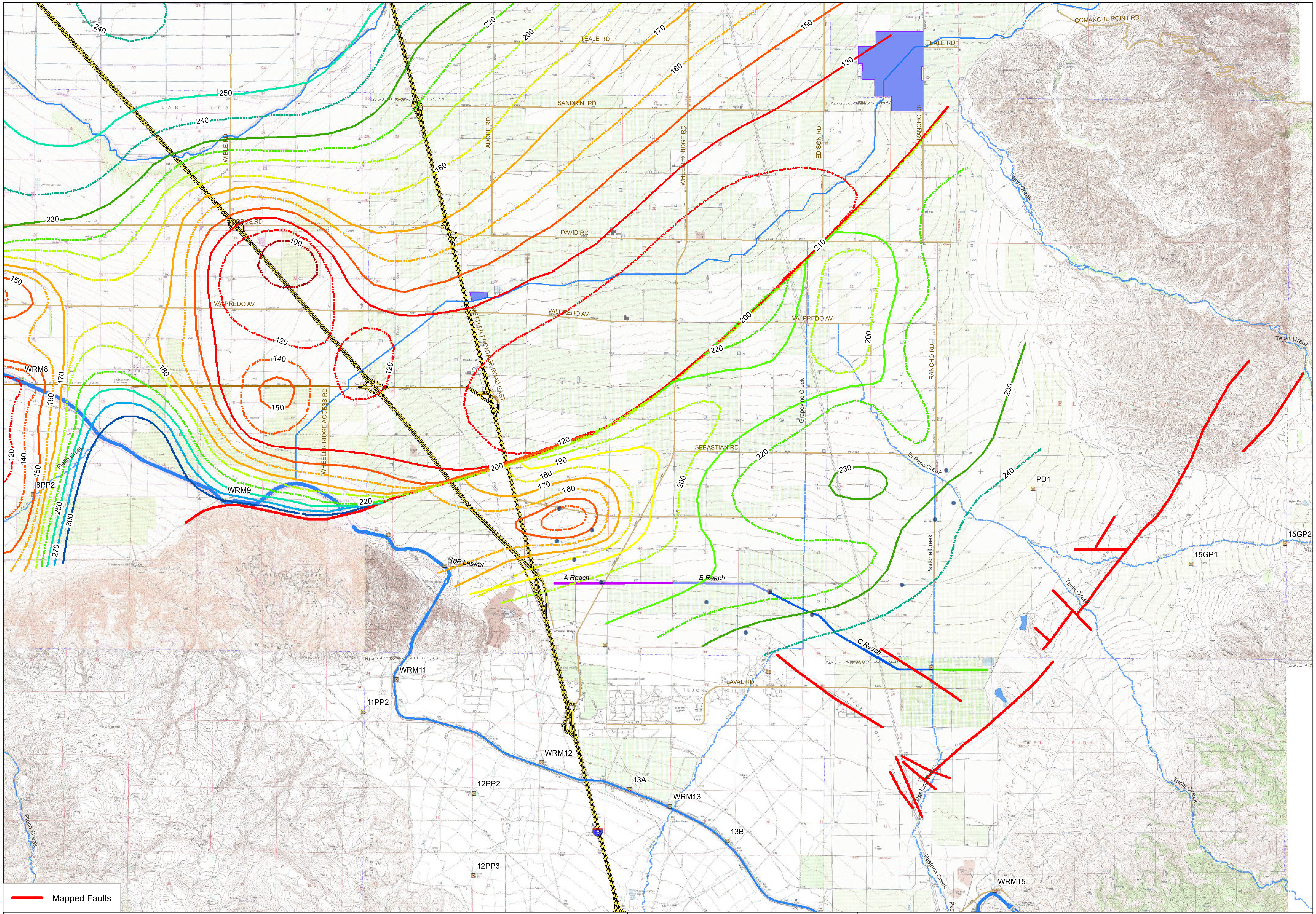
N

0 0.275 0.55 1.1 1.65 2.2 Miles

DECEMBER 2015

WHEELER RIDGE-MARICOPA
WATER STORAGE DISTRICT
BAKERSFIELD, CA

Spring 1970 Groundwater Level Contours (feet MSL)



Author: Thomas Suggs

Name: WRM_C_Size_2015-12-10_Spring_1990_WL

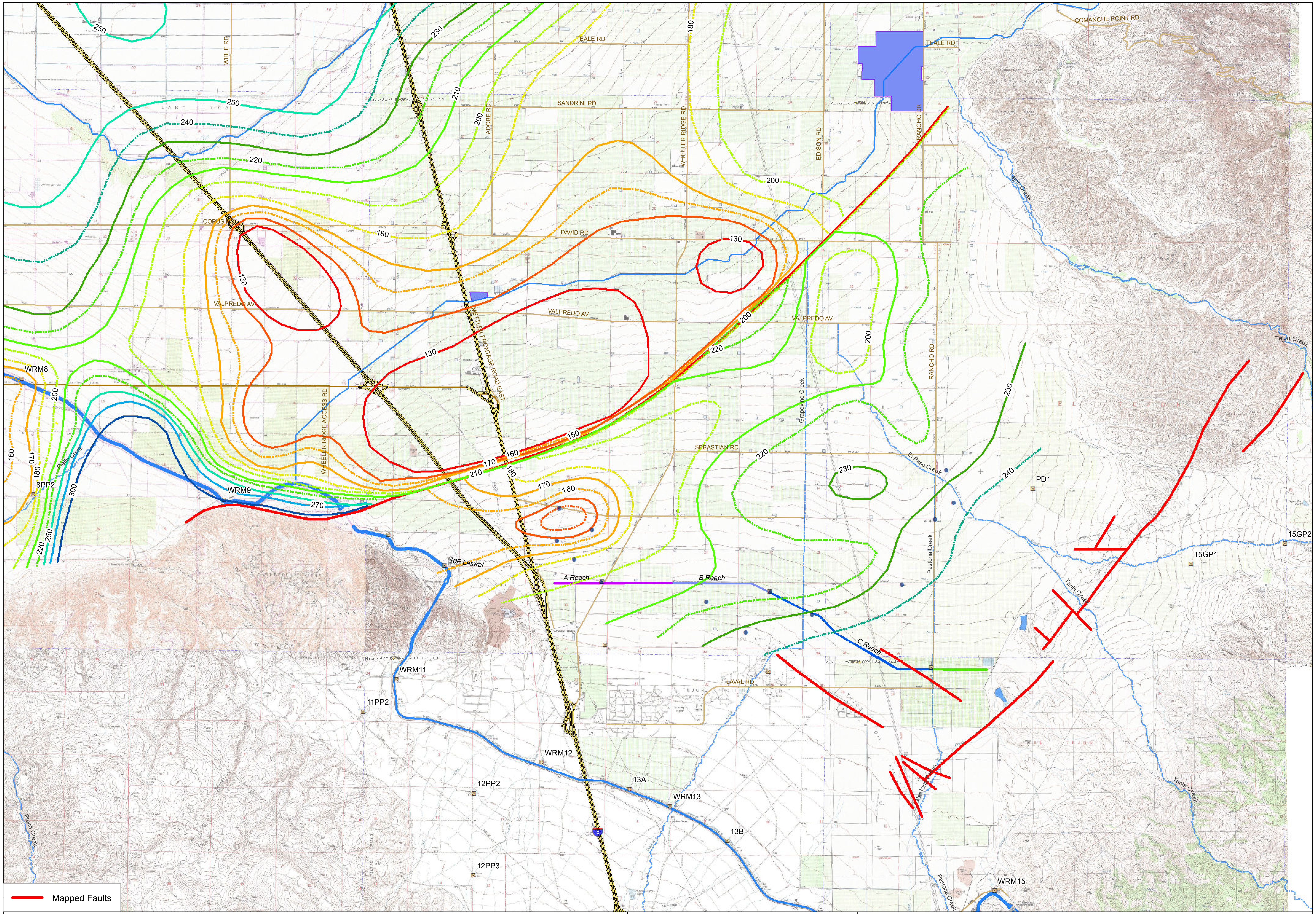
N

0 0.275 0.55 1.1 1.65 2.2 Miles

DECEMBER 2015

WHEELER RIDGE-MARICOPA
WATER STORAGE DISTRICT
BAKERSFIELD, CA

Spring 1990 Groundwater Level Contours (feet MSL)



Author: Thomas Suggs
Name: WRM_C_Size_2015-12-10_Spring_2000_WL

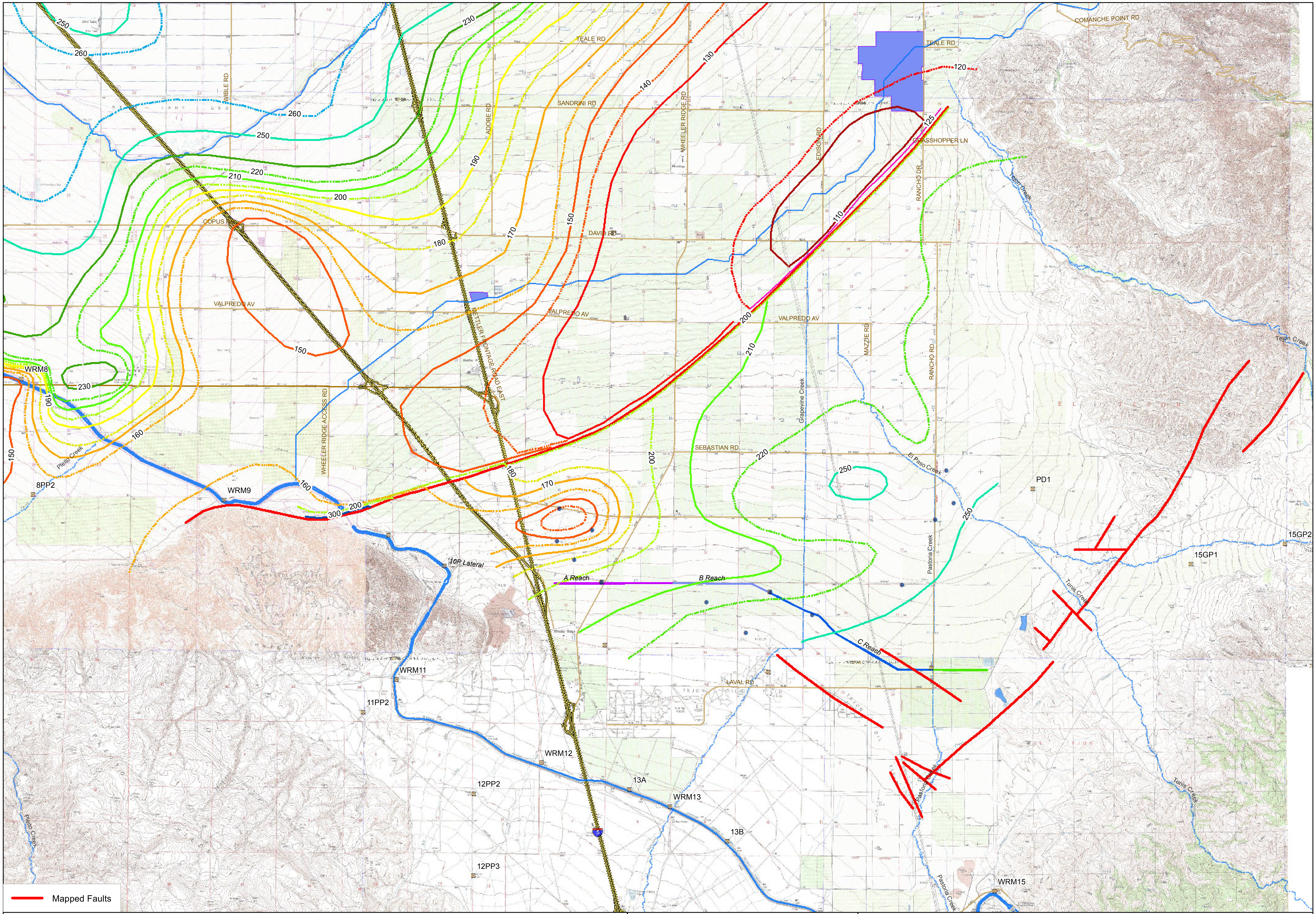
N

0 0.275 0.55 1.1 1.65 2.2 Miles

DECEMBER 2015

WHEELER RIDGE-MARICOPA
WATER STORAGE DISTRICT
BAKERSFIELD, CA

Spring 2000 Groundwater Level Contours (feet MSL)



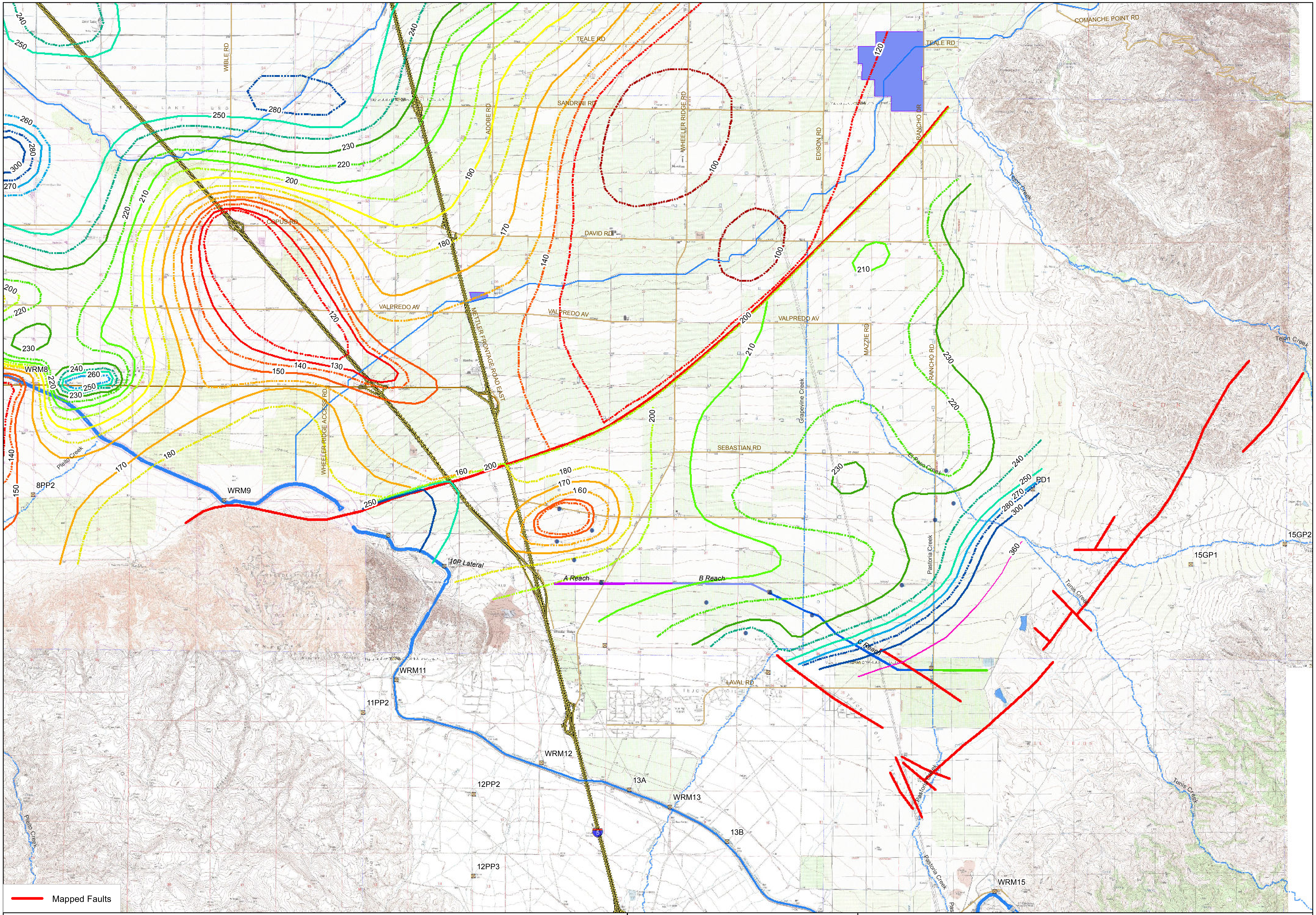
Author: Thomas Suggs
Name: WRM_C_Size_2015-12-10_Spring_2005_WL

0 0.275 0.55 1.1 1.65 2.2 Miles

DECEMBER 2015

WHEELER RIDGE-MARICOPA
WATER STORAGE DISTRICT
BAKERSFIELD, CA

Spring 2005 Groundwater Level Contours (feet MSL)



Author: Thomas Suggs
Name: WRM_C_Size_2015-12-10_Spring_2010_WL

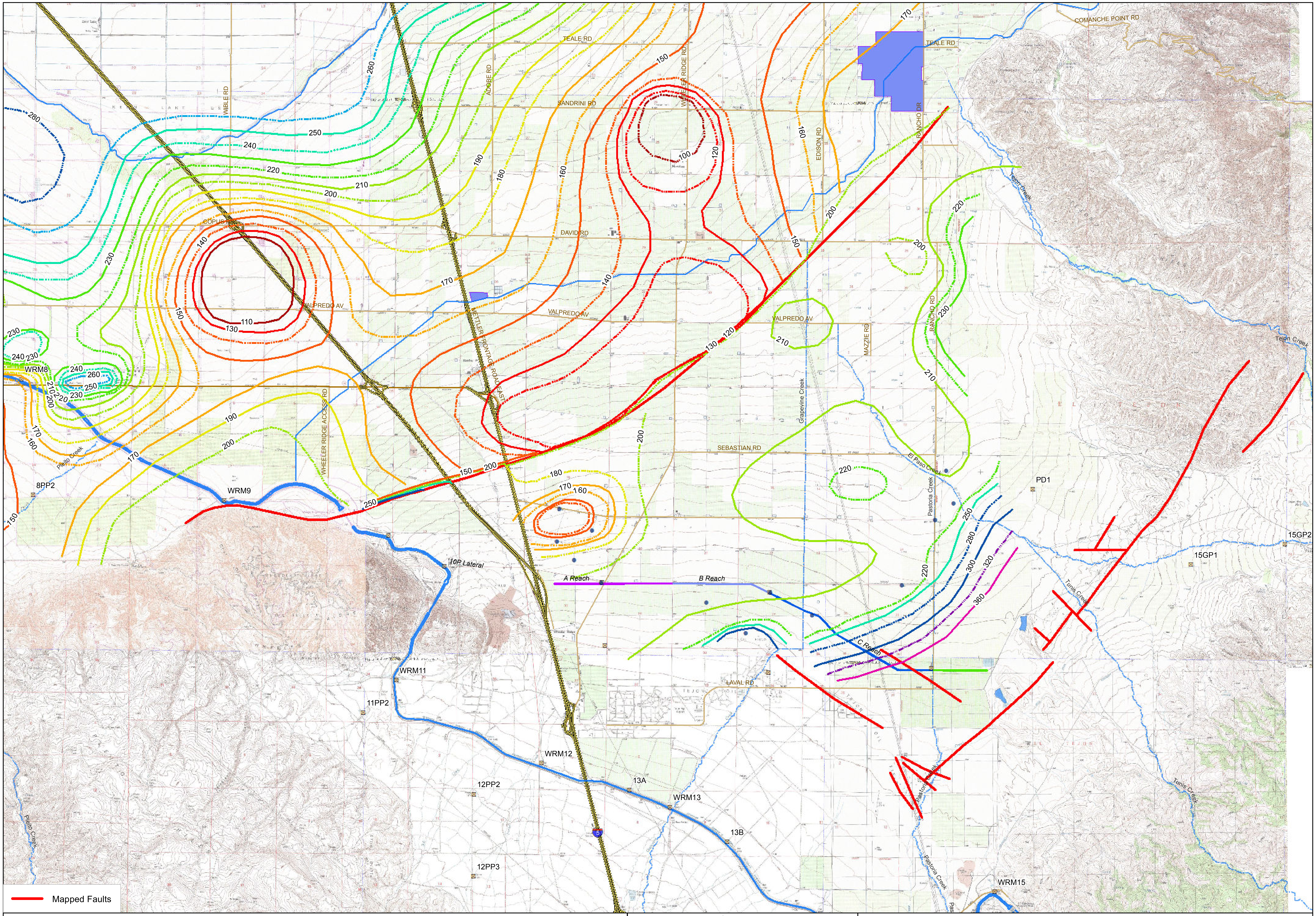
N

0 0.275 0.55 1.1 1.65 2.2 Miles

DECEMBER 2015

WHEELER RIDGE-MARICOPA
WATER STORAGE DISTRICT
BAKERSFIELD, CA

Spring 2010 Groundwater Level Contours (feet MSL)



Author: Thomas Suggs

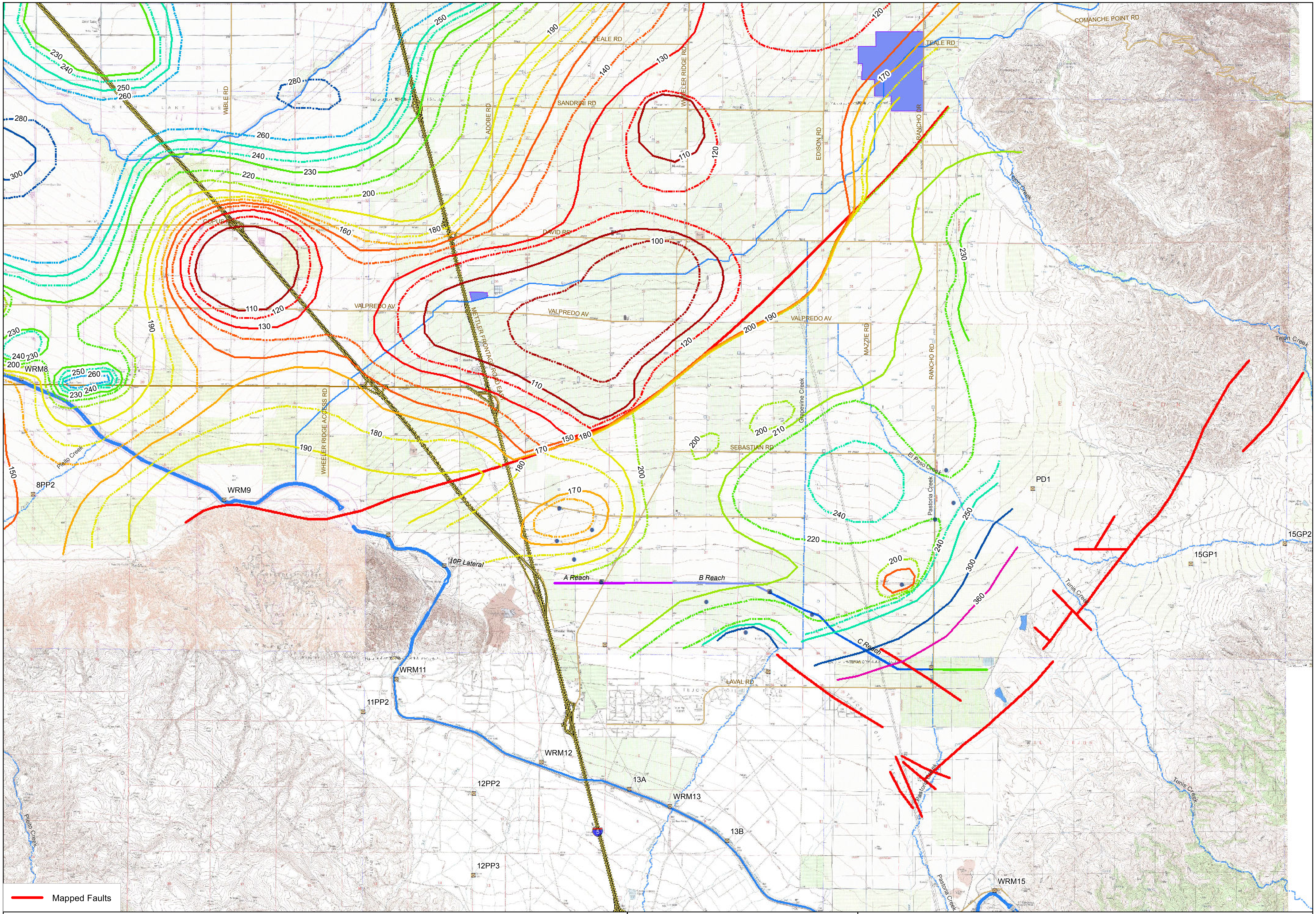
Name: WRM_C_Size_2015-12-10_Spring_2011_WL

0 0.275 0.55 1.1 1.65 2.2 Miles

DECEMBER 2015

WHEELER RIDGE-MARICOPA
WATER STORAGE DISTRICT
BAKERSFIELD, CA

Spring 2011 Groundwater Level Contours (feet MSL)



Author: Thomas Suggs
Name: WRM_C_Size_2015-12-10_Spring_2012_WL

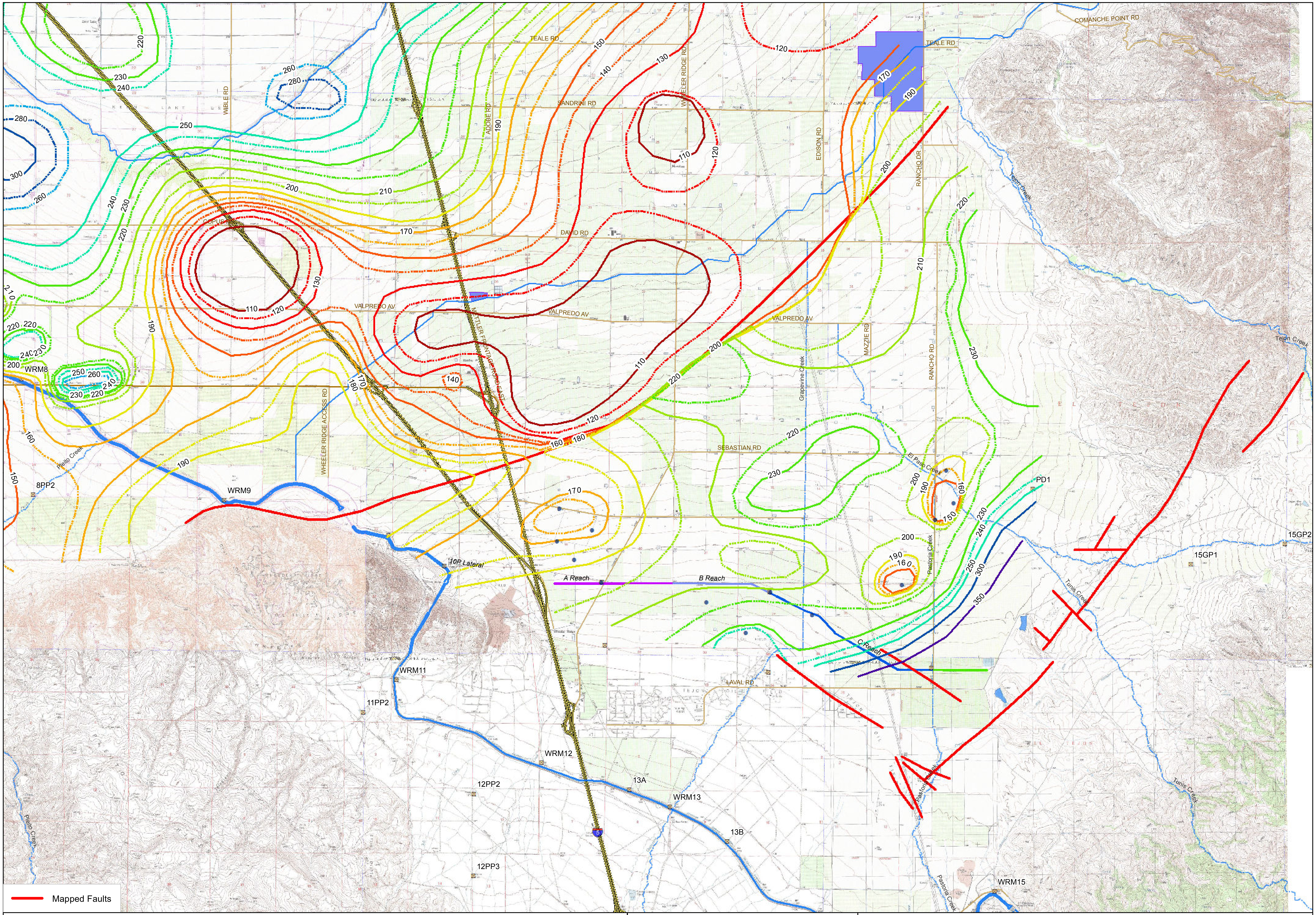
N

0 0.275 0.55 1.1 1.65 2.2 Miles

DECEMBER 2015

WHEELER RIDGE-MARICOPA
WATER STORAGE DISTRICT
BAKERSFIELD, CA

Spring 2012 Groundwater Level Contours (feet MSL)



Author: Thomas Suggs
Name: WRM_C_Size_2015-12-10_Spring_2013_WL

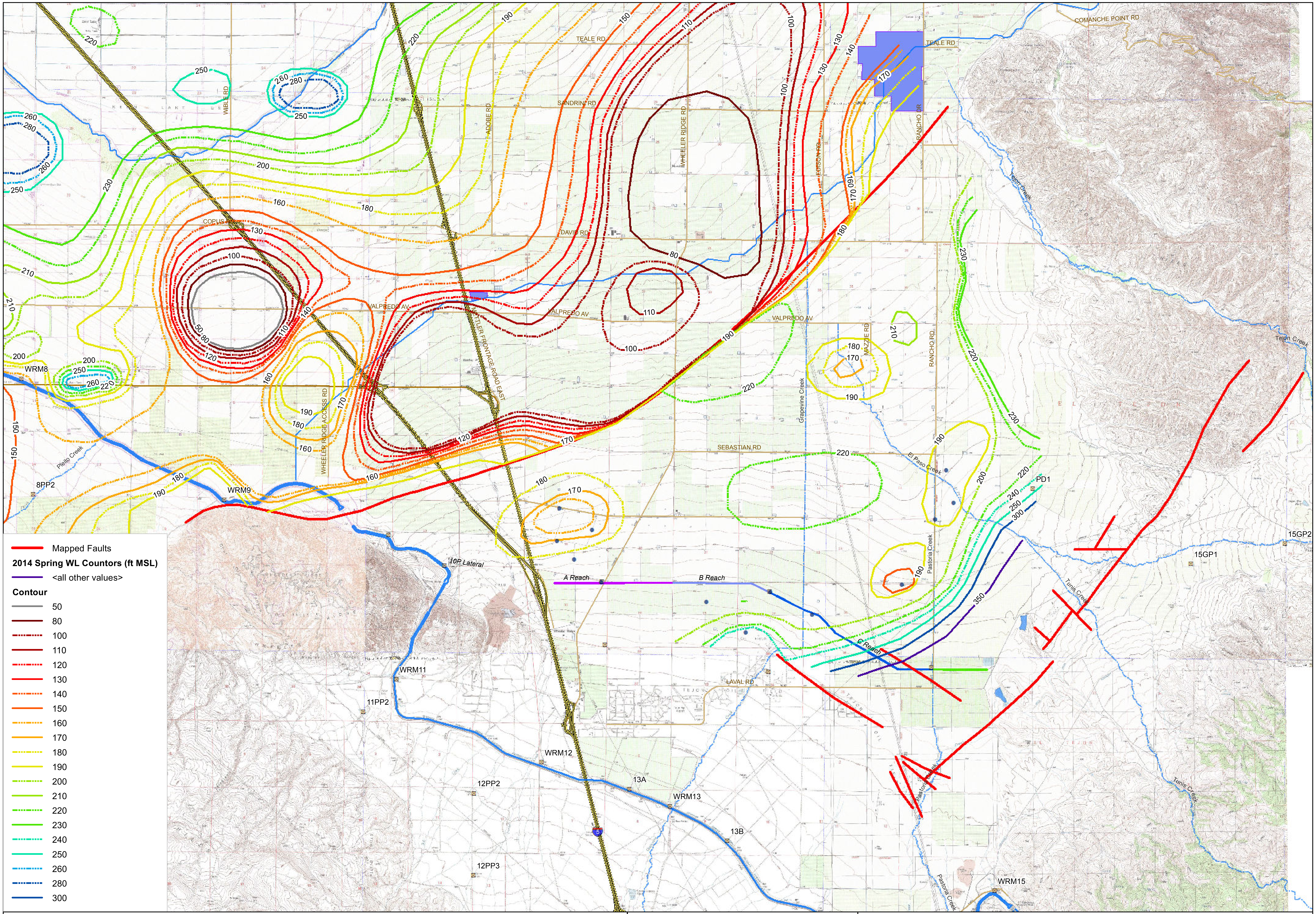
N

0 0.275 0.55 1.1 1.65 2.2 Miles

DECEMBER 2015

WHEELER RIDGE-MARICOPA
WATER STORAGE DISTRICT
BAKERSFIELD, CA

Spring 2013 Groundwater Level Contours (feet MSL)



Author: Thomas Suggs
Name: WRM_C_Size_2015-12-10_Spring_2014_WL

N

0 0.25 0.5 1 1.5 2 Miles

DECEMBER 2015

WHEELER RIDGE-MARICOPA
WATER STORAGE DISTRICT
BAKERSFIELD, CA

Spring 2014 Groundwater Level Contours (feet MSL)

Appendix C.4

AEWSD

0 0.5 1 1.5 Miles

EST. 1968
PROVOST& PRITCHARD
CONSULTING GROUP
An Employee Owned Company

286 W. Cromwell Ave.
Fresno, CA 93711-6162
(559) 449-2700

ARVIN - EDISON W.S.D.

SPRING 2004

ELEVATION OF WATER IN WELLS

12/4/2015 : G:\Arvin-Edison WSD-1215\1215OGV1\GIS\15V1-WW Fault Review\Map\Spring04_wse.mxd

0 0.5 1 1.5 Miles

EST. 1968
PROVOST& PRITCHARD
CONSULTING GROUP
An Employee Owned Company

286 W. Cromwell Ave.
Fresno, CA 93711-6162
(559) 449-2700

ARVIN - EDISON W.S.D.

SPRING 2005

ELEVATION OF WATER IN WELLS

12/3/2015 : G:\Arvin-Edison WSD-1215\1215OGV1\GIS\15V1-WW Fault Review\Map\Spring05_wse.mxd

0 0.5 1 1.5
Miles

EST. 1968
PROVOST& PRITCHARD
CONSULTING GROUP
An Employee Owned Company

286 W. Cromwell Ave.
Fresno, CA 93711-6162
(559) 449-2700

ARVIN - EDISON W.S.D.

SPRING 2006

ELEVATION OF WATER IN WELLS

12/3/2015 : G:\Arvin-Edison WSD-1215\1215OGV1\GIS\15V1-WW Fault Review\Map\Spring06_wse.mxd

EST. 1968
PROVOST& PRITCHARD
CONSULTING GROUP
An Employee Owned Company

286 W. Cromwell Ave.
Fresno, CA 93711-6162
(559) 449-2700

ARVIN - EDISON W.S.D.

SPRING 2007

ELEVATION OF WATER IN WELLS

0 0.5 1 1.5 Miles

EST. 1968
PROVOST& PRITCHARD
CONSULTING GROUP
An Employee Owned Company

286 W. Cromwell Ave.
Fresno, CA 93711-6162
(559) 449-2700

ARVIN - EDISON W.S.D.

SPRING 2008

ELEVATION OF WATER IN WELLS

12/3/2015 : G:\Arvin-Edison WSD-1215\1215OGV1\GIS\15V1-WW Fault Review\Map\Spring08_wse.mxd

0 0.5 1 1.5 Miles

EST. 1968
PROVOST& PRITCHARD
CONSULTING GROUP
An Employee Owned Company
286 W. Cromwell Ave.
Fresno, CA 93711-6162
(559) 449-2700

ARVIN - EDISON W.S.D.

SPRING 2009

ELEVATION OF WATER IN WELLS

12/3/2015 : G:\Arvin-Edison WSD-1215\1215OGV1\GIS\15V1-WW Fault Review\Map\Spring09_wse.mxd

0 0.5 1 1.5 Miles

EST. 1968
PROVOST& PRITCHARD
CONSULTING GROUP
An Employee Owned Company

286 W. Cromwell Ave.
Fresno, CA 93711-6162
(559) 449-2700

ARVIN - EDISON W.S.D.

SPRING 2010

ELEVATION OF WATER IN WELLS

12/3/2015 : G:\Arvin-Edison WSD-1215\1215OGV1\GIS\15V1-WW Fault Review\Map\Spring10_wse.mxd

0 0.5 1 1.5 Miles

EST. 1968
PROVOST & PRITCHARD
CONSULTING GROUP
An Employee Owned Company

286 W. Cromwell Ave.
Fresno, CA 93711-6162
(559) 449-2700

ARVIN - EDISON W.S.D.

SPRING 2011

ELEVATION OF WATER IN WELLS

0 0.5 1 1.5 Miles

EST. 1968
PROVOST& PRITCHARD
CONSULTING GROUP
An Employee Owned Company

286 W. Cromwell Ave.
Fresno, CA 93711-6162
(559) 449-2700

ARVIN - EDISON W.S.D.

SPRING 2012

ELEVATION OF WATER IN WELLS

12/3/2015 : G:\Arvin-Edison WSD-1215\1215OGV1\GIS\15V1-WW Fault Review\Map\Spring12_wse.mxd

0 0.5 1 1.5 Miles

EST. 1968
PROVOST& PRITCHARD
CONSULTING GROUP
An Employee Owned Company

286 W. Cromwell Ave.
Fresno, CA 93711-6162
(559) 449-2700

ARVIN - EDISON W.S.D.

SPRING 2013

ELEVATION OF WATER IN WELLS

12/3/2015 : G:\Arvin-Edison WSD-1215\1215OGV1\GIS\15V1-WW Fault Review\Map\Spring13_wse.mxd

0 0.5 1 1.5 Miles

EST. 1968
PROVOST& PRITCHARD
CONSULTING GROUP
An Employee Owned Company

286 W. Cromwell Ave.
Fresno, CA 93711-6162
(559) 449-2700

ARVIN - EDISON W.S.D.

SPRING 2014

ELEVATION OF WATER IN WELLS

12/3/2015 : G:\Arvin-Edison WSD-1215\1215OGV1\GIS\15V1-WW Fault Review\Map\Spring14_wse.mxd

EST. 1968
PROVOST& PRITCHARD
CONSULTING GROUP
An Employee Owned Company
286 W. Cromwell Ave.
Fresno, CA 93711-6162
(559) 449-2700

ARVIN - EDISON W.S.D.

SPRING 2015

ELEVATION OF WATER IN WELLS

12/1/2015 : G:\Arvin-Edison WSD-1215\1215OGV1\GIS\15V1 - WW Fault Review\Map\Spring15_wse.mxd

Appendix C.5

Bookman-Edmonston (2005)

GROUND WATER STUDIES

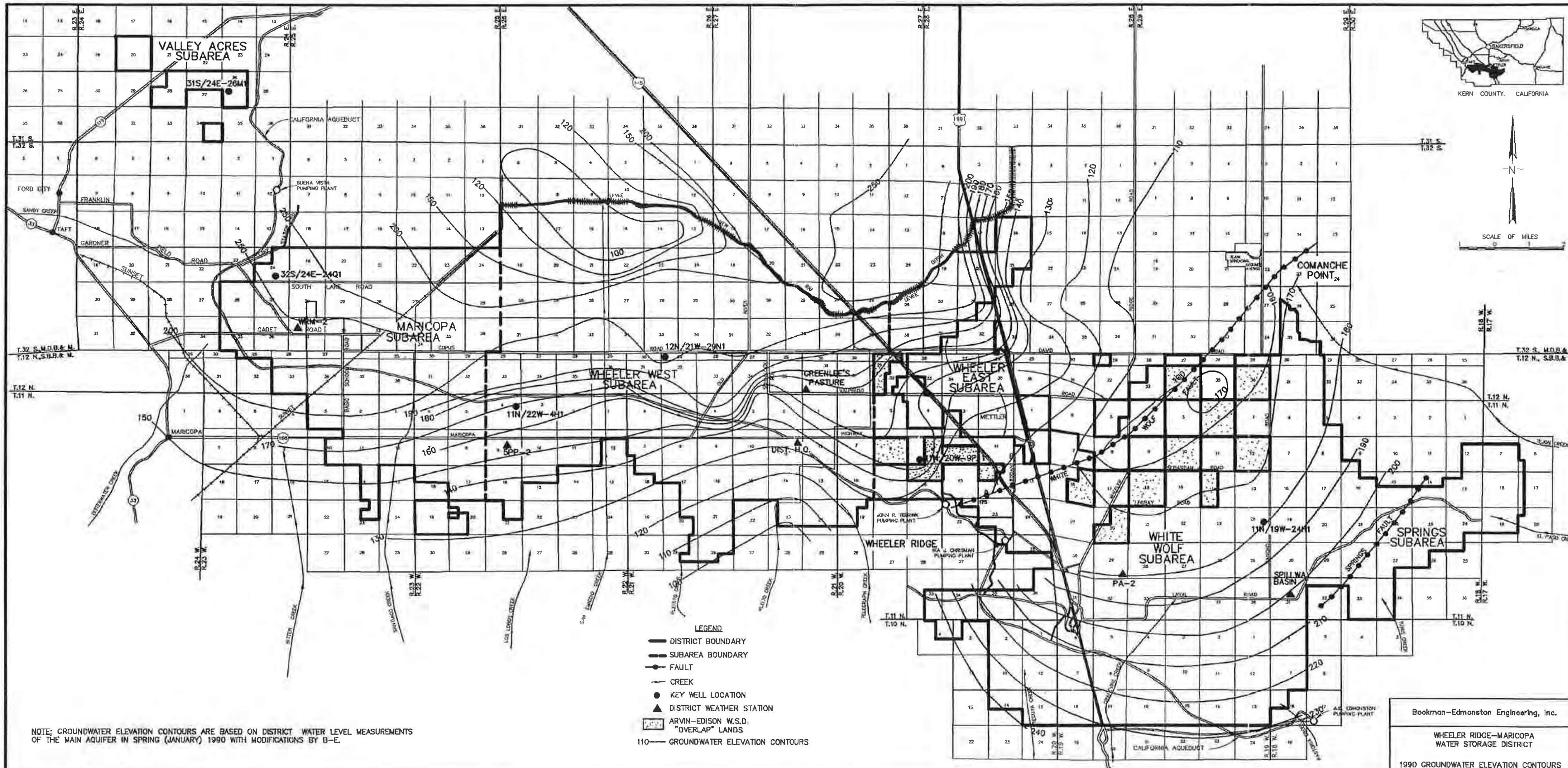
PREPARED FOR

WHEELER RIDGE-MARICOPA WATER STORAGE DISTRICT

PREPARED BY

BOOKMAN-EDMONSTON ENGINEERING, INC.

PLATE 3


VALLEY ACRES SUBAREA
31S/24E-26M1
CALIFORNIA AQUEDUCT
BUENA VISTA PUMPING PLANT
FORD CITY
SANDY CREEK
TAFT
FRANKLIN
GARDNER
ROAD
SUNSET
32S/24E-24Q1
SOUTH LAKE ROAD
MARICOPA SUBAREA
CADET ROAD
COPUS
12N/21W-29N1
WHEELER WEST SUBAREA
GREENLEE'S PASTURE
WHEELER EAST SUBAREA
METTLER
11N/22W-4H1
MARICOPA
11N/20W-9P1
JOHN R. TEERINK PUMPING PLANT
WHEELER RIDGE
IRA J. CHRISMAN PUMPING PLANT
WHITE WOLF SUBAREA
WHITE WOLF FAULT
11N/19W-24H1
SPRINGS SUBAREA
SPRINGS FAULT
SPILLWAY BASIN
COMANCHE POINT
PA-2
LAVAL ROAD
A.D. EDMONSTON PUMPING PLANT
CALIFORNIA AQUEDUCT
KERN COUNTY, CALIFORNIA
SCALE OF MILES
LEGEND
DISTRICT BOUNDARY
SUBAREA BOUNDARY
FAULT
CREEK
KEY WELL LOCATION
DISTRICT WEATHER STATION
ARVIN-EDISON W.S.D. "OVERLAP" LANDS
110 GROUNDWATER ELEVATION CONTOURS
NOTE: GROUNDWATER ELEVATION CONTOURS ARE BASED ON DISTRICT WATER LEVEL MEASUREMENTS OF THE MAIN AQUIFER IN SPRING (JANUARY) 1990 WITH MODIFICATIONS BY B-E.
Bookman-Edmonston Engineering, Inc.
WHEELER RIDGE-MARICOPA WATER STORAGE DISTRICT
1990 GROUNDWATER ELEVATION CONTOURS

Appendix C.6

Hagan (2001)

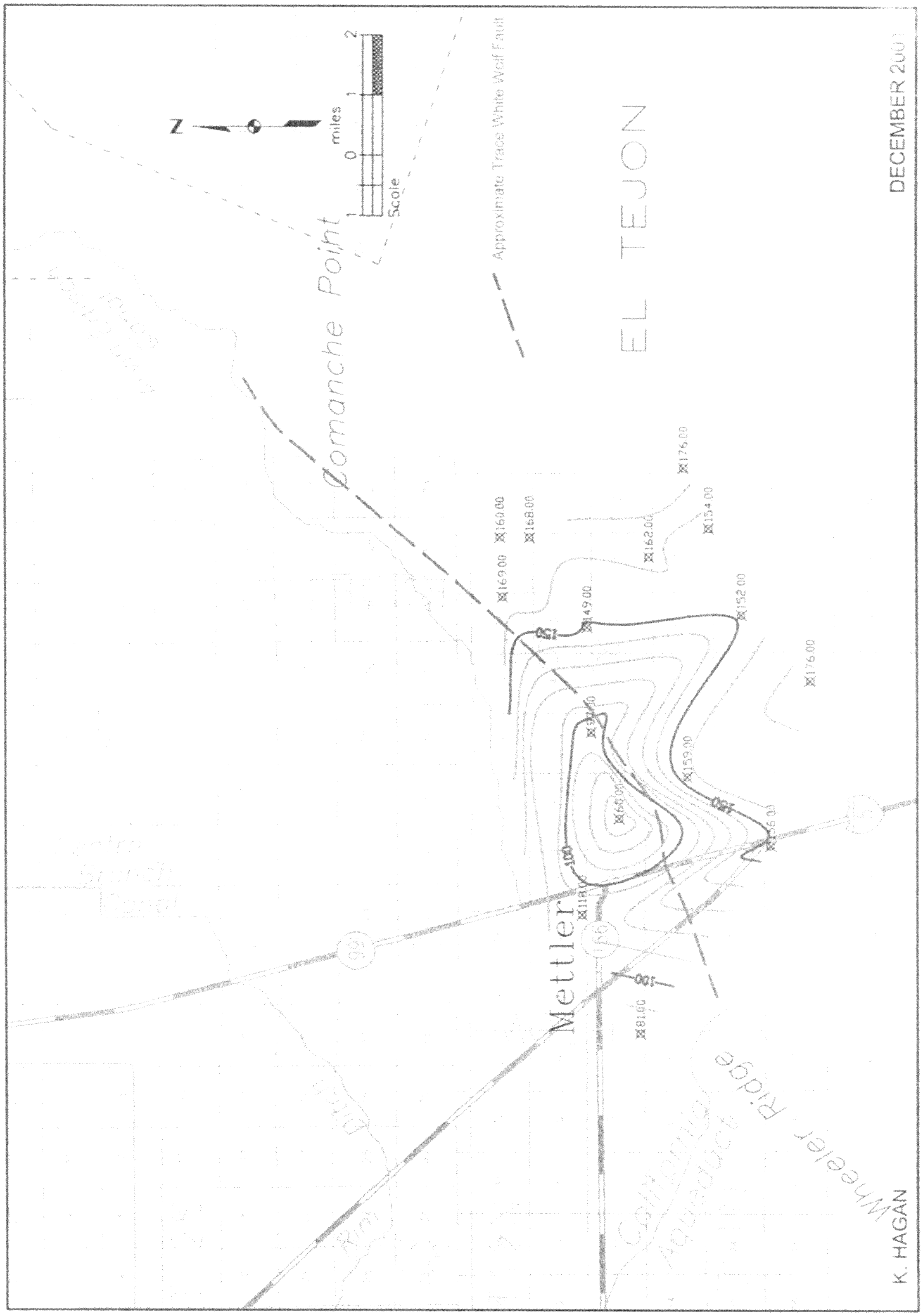


Figure 21. Groundwater elevation contour map for Spring 1985. Contour Interval is 10 feet.

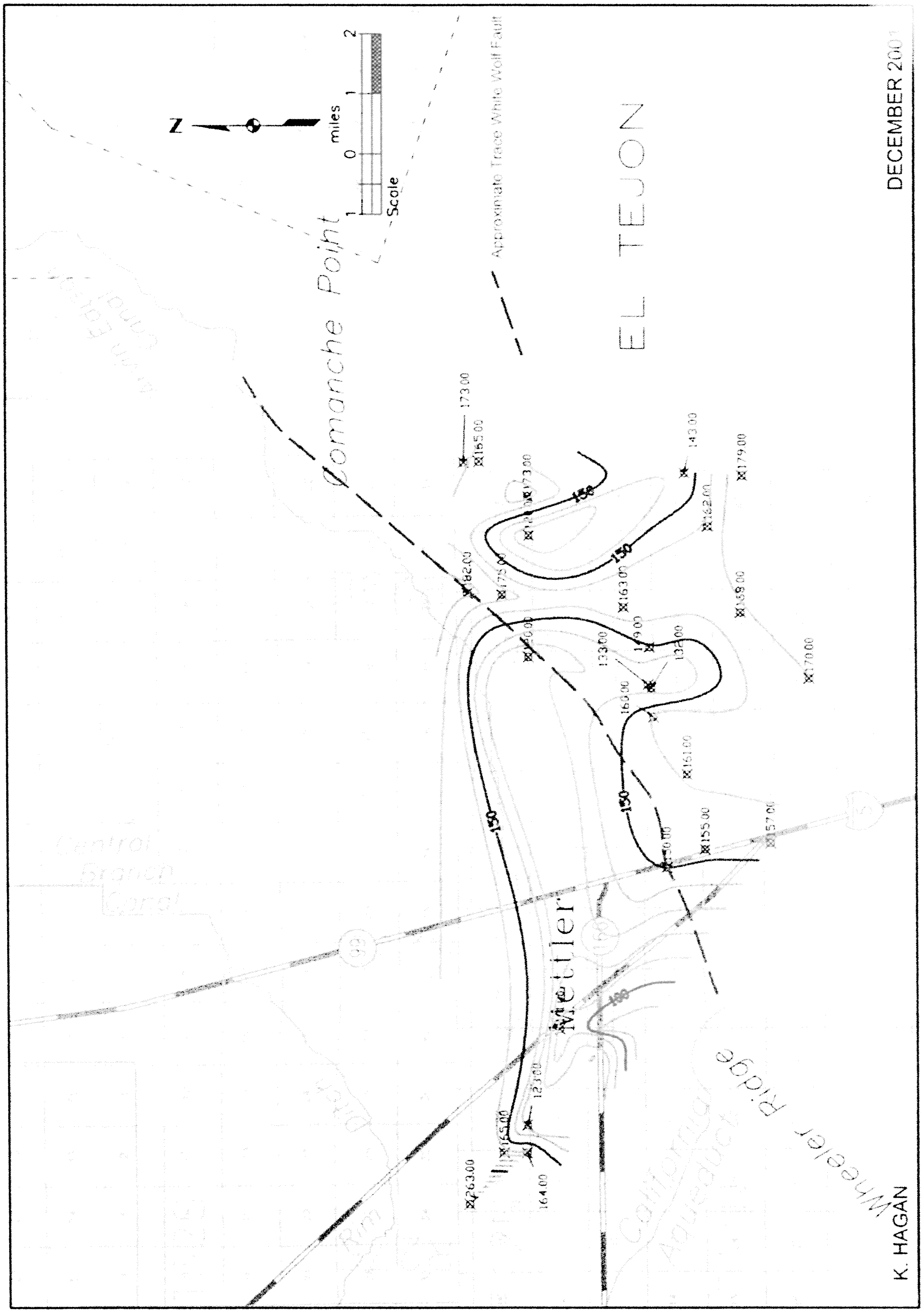


Figure 22. Groundwater elevation contour map for Spring 1986. Contour Interval is 10 feet.

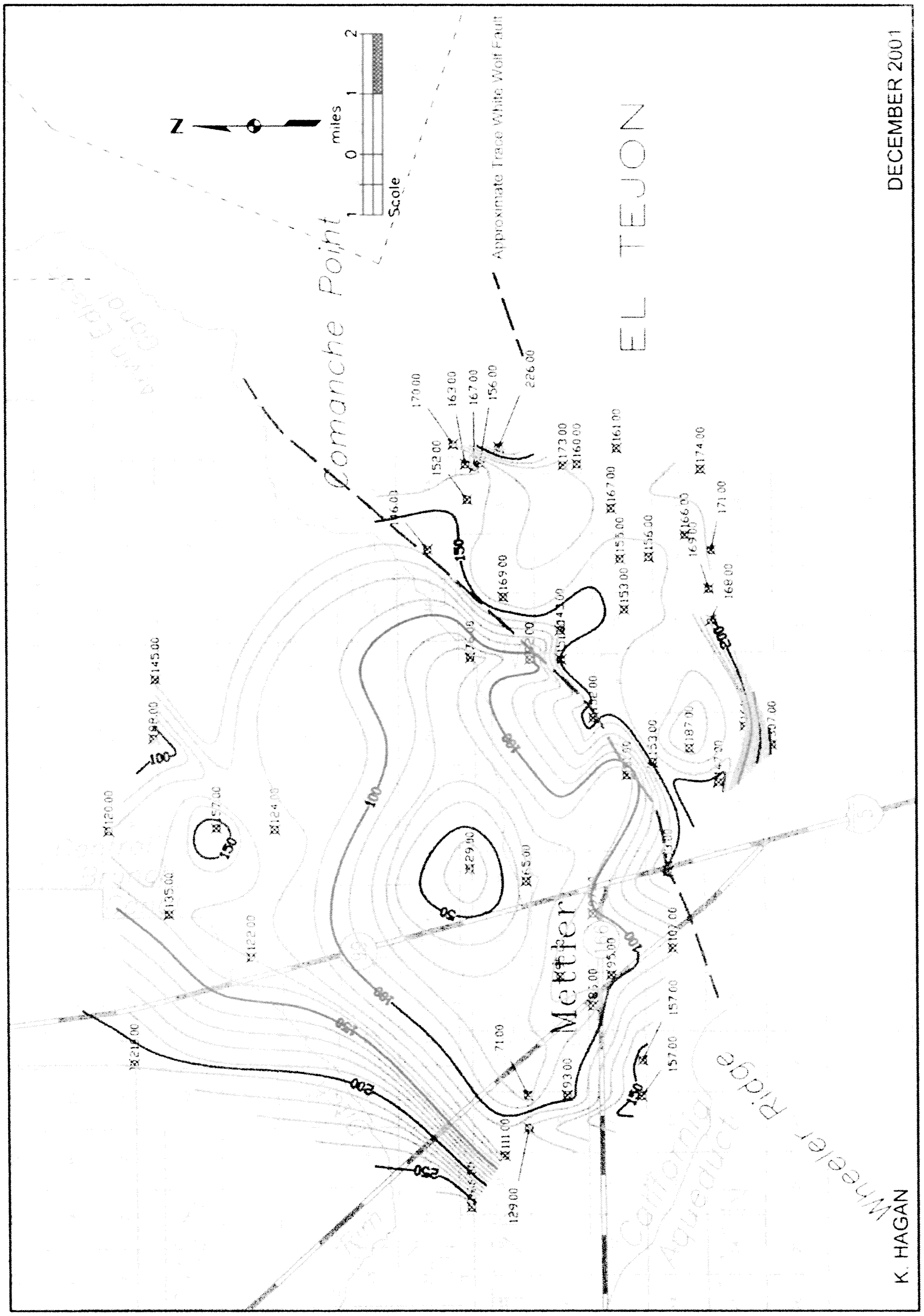


Figure 24. Groundwater elevation contour map for Spring 1992. Contour Interval is 10 feet.

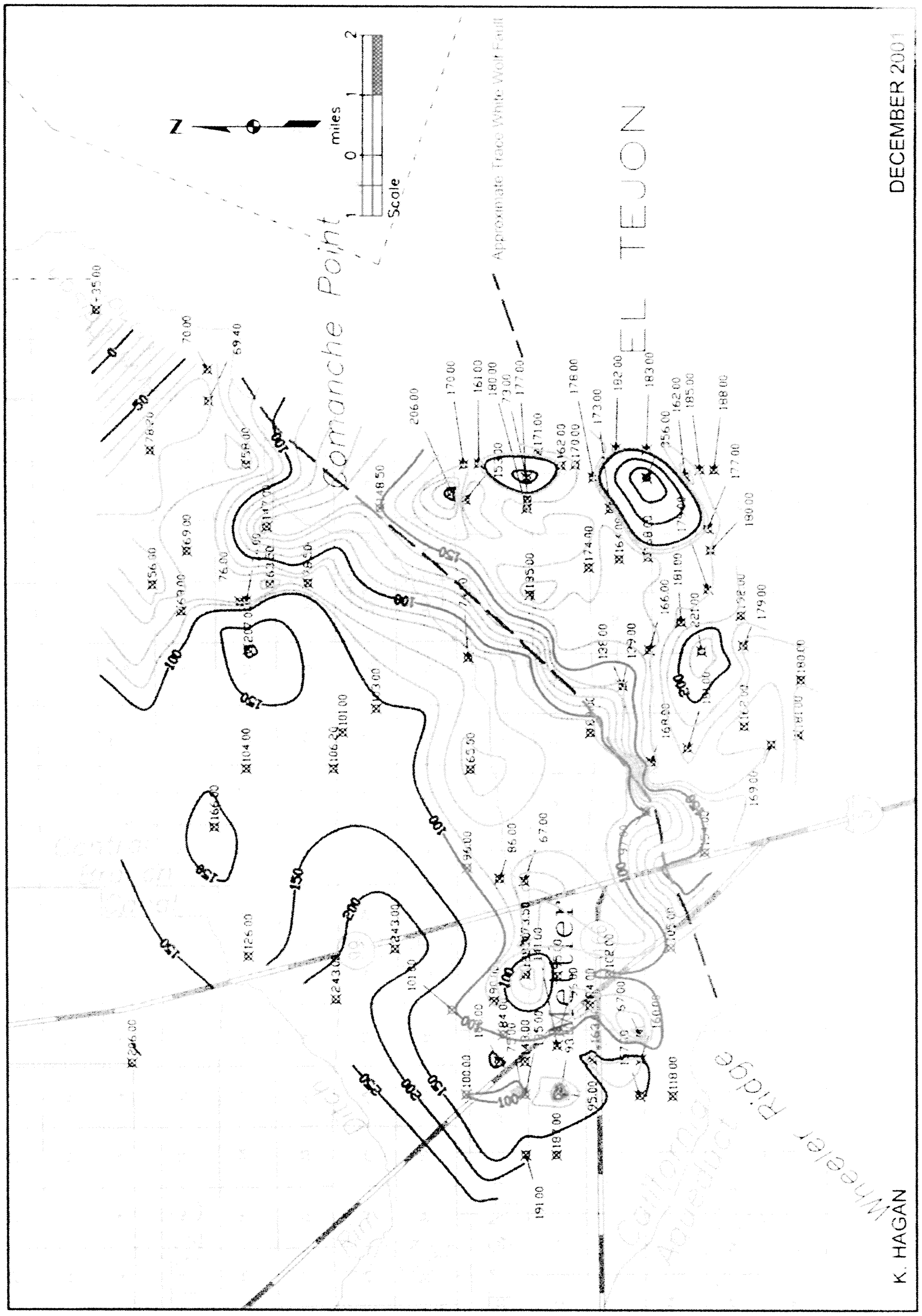


Figure 25. Groundwater elevation contour map for Spring 1993. Contour Interval is 10 feet.

APPENDIX D

Selected References Regarding the White Wolf Fault
as a Significant Impediment to Groundwater Flow

Appendix D.1

Dibblee (1955)

2. GEOLOGY OF THE SOUTHEASTERN MARGIN OF THE SAN JOAQUIN VALLEY CALIFORNIA

By T. W. Dibblee, Jr.*

ABSTRACT

The southern Sierra Nevada and Tehachapi Mountains are made up of a pre-Cretaceous crystalline complex composed of Jurassic (?) plutonic rocks with hornblende-biotite quartz diorite predominating, and linear inclusions of Paleozoic (?) schists, quartzite, and marble. The crystalline complex is overlain by a Tertiary-Quaternary marine and continental sedimentary series cropping out along the foothill areas and underlying the San Joaquin Valley where the series thickens southwestward to an estimated total of about 25,000 feet just north of Wheeler Ridge. The Tertiary series dips under San Joaquin Valley with the crystalline-rock contact sloping southwest at an average angle of about 6°, steepening to about 20° immediately northwest of the White Wolf fault.

The White Wolf fault, nearly parallel to the Garlock fault and about 18 miles northwest of it, is a major fault traceable from Tehachapi Canyon southwest along the base of the steep northwest slope of Bear Mountain for 17 miles, and probably extends under San Joaquin Valley toward Wheeler Ridge. The southeastern block has been elevated on this fault to a maximum displacement of at least 10,000 feet as indicated by surface and subsurface data, with the maximum displacement near the mouth of Sycamore Canyon.

Surface effects along the White Wolf fault zone produced on July 21, 1952, including overthrusting in the mole-track scarplets formed, shortening of fences and the railroad tracks crossing the fault, and dips of the more continuous fault-trace ruptures, strongly suggest thrusting. Seismographic evidence favors a high-angle reverse fault at depth. Ground cracks and small pressure ridges oblique to the fault trace, and small ground offsets indicate some left lateral movement.

The White Wolf fault is essentially a reverse fault, locally a thrust, elevated in the southeast block, with a small left lateral component of movement. It is more closely related to the Garlock and Pleito faults than to faults in the northern part of the area mapped.

INTRODUCTION

The southeastern margin of the San Joaquin Valley and the adjacent mountain area was the scene of the violent earthquake of July 21, 1952, which severely damaged the small towns of Arvin and Tehachapi in Kern County. The cause of this major earthquake was found to be a movement on the White Wolf fault at the base of the steep northwest slope of Bear Mountain as indicated by ground ruptures formed along the supposed course of this fault.

The topographic base map which most adequately covers the area which the White Wolf fault traverses is the 30-minute Caliente quadrangle, scale 1 inch = 2 miles, issued by the U. S. Geological Survey in 1914.

The geology of the northeastern quarter of the Caliente quadrangle was taken from previous detailed mapping done by the writer in 1950 (Dibblee, 1953). The geology of the northwestern quarter of the quadrangle is based on mapping by the writer during several weekends in 1950, accompanied several days by A. H. Warne. The geology of the southern portion of the quadrangle and northernmost portion of the adjoining Tejon quadrangle is based on published maps and reports by Hoots (1930), Marks (1938), and Wiese (1949), although a week was spent in remapping critical portions of these areas. Two weeks of the present investigation were spent in the southeastern quarter of the Caliente quadrangle in the vicinity of Bear Mountain and southwest into the Tejon Hills; as time was limited, the mapping is largely of reconnaissance nature.

Acknowledgments are due the geological staff of Richfield Oil Corporation for access to well logs used to determine the subsurface structure of the top of the basement complex buried under the San Joaquin Valley.

STRATIGRAPHY

Basement Complex

The pre-Cretaceous basement complex exposed throughout the southern Sierra Nevada, Tehachapi and San Emigidio Mountains, and buried under Tertiary strata in the San Joaquin Valley, is composed of granitic igneous rocks that form the Sierra Nevada granitic batholith. They range from granite to gabbro; quartz diorite predominates. The metamorphic rocks occur within the granitic batholith as roof-pendants or linear remnants of a once tremendous thickness of gneiss, schist, quartzite and limestone. The age of the metamorphic and igneous rocks is not definitely known, although the former are believed to range from pre-Cambrian to early Mesozoic, and the latter are directly traceable into the granitic rocks of late Jurassic age in the north central Sierra Nevada where they intrude the Upper Jurassic Mariposa slate and are unconformably overlain by Cretaceous sandstones and shales. Brief descriptions of the principal mapped units of the basement complex follow.

Pelona Schist. The pre-Cambrian (?) Pelona schist, as mapped by Wiese (1950, pp. 12-13), occurs only between the two branches of the Garlock fault in the Tehachapi Range where about 5,000 feet is exposed. The formation is highly foliated, with prominent cleavage, and is composed predominantly of dark greenish-gray mica-chlorite-albite-quartz schist which was probably metamorphosed from tuffaceous shale.

Biotite Gneiss. A large mass of gneiss of unknown but probable pre-Cambrian age is exposed on the north flank of the Tehachapi Mountains in the vicinity of El Paso Canyon. This formation is a complex of well banded biotite-hornblende-quartz-feldspar gneiss, and numerous injections of massive quartz diorite.

Pampa Schist. In the Cottonwood Canyon area of the western slope of the Sierra Nevada are several lenticular and linear pendants of mica schist within quartz diorite. The schist, of unknown age, mapped as the Pampa schist (Dibblee, 1953) and named after Pampa Peak, is dark gray and prominently foliated parallel to bedding. It is a biotite-quartz-feldspar schist similar to that of the Kernville series. The most southwesterly exposures of the schist in Cottonwood Canyon contain numerous large crystals of andalusite (chiastolite) elongated parallel to foliation planes. The Pampa schist is of sedimentary origin, having been metamorphosed from clay shale.

Kernville Series. The linear inclusions of metasediments exposed in the Sierra Nevada from Walker Basin southward to Keene and again on Bear Mountain ridge and Brite Valley were mapped as the Kernville series, because they are similar to the Kernville series mapped

* Consulting geologist. Manuscript submitted for publication June, 1953.

Figure 6. Mud volcanoes along cracks in water-saturated low terrace in lower Comanche Creek; apparently east of White Wolf fault. *Photo by Gordon B. Oakeshott.*

rately determined. According to St. Amand (oral communication, November 1952), one important epicenter was located almost directly under Bear Mountain at about 12 miles below sea level. Projecting this position up to the nearest surface trace would determine a dip of about 70° southeast.

From the foregoing it appears that the only surface fractures that represent the true dip of the White Wolf fault are those at and near the mouth of Little Sycamore Canyon. The low angle thrust feature at the base of Bear Mountain must then be a local flattening of the fault at the surface where the elevated mountain block partially overrode the San Joaquin Valley area. The north-trending left lateral fault cracks along the northeastern portion of the White Wolf fault probably branch off from the main fault below the surface and were produced by upward and northeastward movement of the southeastern block.

Type of Fault and Movement. The foregoing data indicate the White Wolf fault to be a high angle reverse fault dipping southeast along which the southeastern block was elevated to a maximum displacement of some 10,000 feet and displaced a much lesser distance to the northeast—relative to the stationary northwestern block. The low-dipping thrust fault rupture along the central portion of the fault indicates that the northwestern or footwall block is stationary and that the southeastern block was actively elevated and thrust northwestward. This is further suggested by the intensity of the earthquake of July 21, 1952, which was more violent in the area southeast of the White Wolf fault than in the area to the northwest.

Possible Northeastward Extension. There is neither physiographic nor geologic evidence that the White Wolf fault extends northeast of Tehachapi Canyon and there is no evidence that the White Wolf fault ties to the Breckenridge Mountain fault. However, between the Tehachapi and Caliente Canyons several isolated ruptures trending nearly northward did develop in shattered quartz diorite. These may have formed along one or several north-trending branches of the White Wolf fault that might extend at depth as far northward as Caliente Canyon.

Possible Southwest Extension. The extent of the White Wolf fault southwesterly from Comanche Point is unknown as there is no direct surface indication of this fault beyond that point, and no surface ruptures were formed during the earthquake of July 21, 1952. The White Wolf fault apparently does not reach the surface anywhere southwest of Comanche Point. However, stratigraphic, structural, subsurface, geophysical and seismic evidence indicate or suggest that the White Wolf fault does extend southwestward across the San Joaquin Valley and at depth under Wheeler Ridge and the San Emigdio foothills, possibly to the San Andreas fault. The exact location of this buried portion of the White Wolf fault is as yet unknown, but available evidence indicates it to maintain the same S 50° W trend as does the exposed portion between Tehachapi Canyon and Comanche Point.

Evidence that the White Wolf fault extends southwest from Comanche Point across the southeastern San Joaquin Valley to Wheeler Ridge is—(1) the 10,000 foot displacement at Comanche Point, indicating the fault to extend far beyond that point; (2) the abrupt change of the water table at the supposed trace of the fault across the valley; (3) differences in depth of geophysical reflections on either side of this buried fault; and, (4) the much greater depth to the base of the Plio-Pleistocene continental sediments in the valley area on the northwest side of the buried fault as encountered in deep wells in which the maximum drilled depth to this horizon is 14,000 feet on the northwest side of the fault and 4,000 feet on the southeast side. Although no well has reached the basement complex in the deeper portion of the valley area on either side of the fault, the marine formations underlying the continental Pliocene strata are consequently much more deeply buried under the valley area on the northwest side of the supposed extension of the White Wolf fault than on the southeast side. The great difference in thickness of the

Appendix D.2

Davis et al. (1959)

Ground-Water Conditions and Storage Capacity in the San Joaquin Valley California

By G. H. DAVIS, J. H. GREEN, F. H. OLMSTED, *and* D. W. BROWN

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1469

Prepared in cooperation with the California Department of Water Resources

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1959

EDISON-MARICOPA FRONT UNIT

SOURCES AND MOVEMENT

The major sources of replenishment to the ground-water reservoir in the Edison-Maricopa Front unit are as follows: Seepage from streams that discharge upon the valley floor, chiefly Caliente Creek; seepage losses from the Eastside Canal (pl. 3), which diverts water from the Kern River upstream from Bakersfield and serves the western part of the area as far south as Arvin; application of imported irrigation water in excess of plant requirements in the Eastside Canal's service area; and subsurface flow of ground water from the adjoining Kern River unit.

The mean annual flow of the streams that enter the unit from Caliente Creek on the northeast to Grapevine Creek on the south is estimated to be on the order of 71,000 acre-feet (California State Water Resources Board, 1951, p. 407). Additional water runs off in several small streams west of Wheeler Ridge. Most of this runoff percolates to the ground-water reservoir. The mean annual water supply imported from the Kern River via the Eastside Canal is about 20,000 acre-feet (Trowbridge, 1950, p. 19), of which as much as 7,000 to 10,000 acre-feet probably finds its way to the ground water as a result of canal and irrigation losses. The Bureau of Reclamation (Frink and Summers, 1954, p. 24) estimated that the average subsurface flow of ground water to the area east of the Eastside Canal service area was 47,000 acre-feet a year from 1946 to 1952, including eastward movement of water from the Eastside Canal and subsurface movement from the Kern River unit.

Considering these estimates, it appears that the mean annual recharge to ground water in the part of the Edison-Maricopa Front unit east of U. S. Highway 99 may be on the order of 100,000 acre-feet. For many years this recharge, although substantial, has been less than the ground-water draft in the unit; consequently, water levels have declined and the direction of movement and hydraulic gradient have been greatly modified from initial conditions.

In most places in the Edison-Maricopa Front unit there are two distinct ground-water bodies: (a) a body of unconfined and semiconfined water in the upper part of the saturated deposits, and (b) the principal body of confined water, tapped by wells deeper than about 400 feet. As shown by the water-level contour map (pl. 15), the two bodies differ greatly in head and in direction of movement of the contained ground water. Furthermore, fault barriers that border the area on the northeast and southeast impede or prevent the movement of ground water and thus break up the area into several blocks, each having a different hydraulic system. Three such barriers are shown on plate 15. One extends southeast from a point about 2 miles southeast of Edison across Caliente Creek to a point about 4 miles east of DiGiorgio. A second extends northeast toward Tejon Creek from a point on U. S. Highway 99 about 2 miles north of Wheeler Ridge. This second barrier is shown as abutting against a third barrier which trends approximately normal to the second, and appears to have offset the northeast-trending barrier about 1½ miles to the north, from which place the second barrier continues northeast toward the edge of the valley. These two principal barriers are approximately parallel to known faults, and presumably they result from offsetting of aquifers against impermeable beds and possibly in part from cementation along the fault zones. The northeastern barrier appears to be an expression of one of several north-northwest-trending faults in the basement rocks, mapped by Beach (1948, fig. 5); the southern barrier appears to be the result of offset along the White Wolf fault zone (Dibblee and Oakeshott, 1953).

The slope of the water table and direction of movement of the water in the unconfined and semiconfined deposits are shown by the water-level contours on plate 15. Ground water moves in the direction of the hydraulic gradient from areas of recharge to areas of discharge. Before irrigation development the direction of movement probably was generally from recharge areas along the edges of valley toward areas of natural discharge in the beds of Kern and Buena Vista Lakes. Importation of surface water and development of ground water for irrigation have greatly modified the natural regimen, however, and the direction of movement likewise has been modified.

In the eastern part of the unit north of Arvin, ground water in the unconfined and semiconfined deposits as of the spring of 1952 was moving generally toward a depression extending from Edison southward to a few miles south of Arvin. This depression is the site of intensive irrigation development wholly dependent upon ground-water supply. Thus, all discharge of ground water in this eastern area is by pumping. Recharge is largely from the west, from lands irrigated with surface supplies from the Kern River. East of the barrier crossing Caliente Creek, the contours indicate that water was moving generally westward and was passing through or around the barrier, probably chiefly at the northwest end near U. S. Highway 466. Control on the water table is poor in the area east of DiGiorgio and Arvin, and it was impossible to determine the direction of movement and hydraulic gradient of ground water in the unconfined and semiconfined deposits in that area.

In the southeastern part of the unit the unconfined water moves generally northward to the depression near Arvin and northwestward toward Kern Lake bed; west of Wheeler Ridge it moves generally northward toward areas of natural discharge in Kern Lake bed. The

White Wolf fault zone apparently acts as a barrier to movement of the unconfined and semiconfined ground water only in the southern part of T. 32 S., R. 29 E., east of the offset by the transverse barrier. In the small separate basin between these barriers the hydraulic gradient is toward the southwest. However, the contours indicate that no water moves out of the basin; any movement across the bordering faults probably is into the basin. Southwest of the transverse barrier, according to the contours, the offset extension of the fault zone does not impede movement of the unconfined water, although it does act as a barrier to the movement of water in the confined deposits.

Water-level control was sufficient to define the hydraulic gradient and the direction of movement of confined water in most of the Edison-Maricopa Front unit. The only extensive areas where control was lacking are in the extreme west, south of Buena Vista Lake bed, and south of Lamont and Weed Patch. The available information on the small basins formed by the fault barriers southeast of Edison and northeast of Wheeler Ridge suggests that there is no separation of water bodies, at least in the zone tapped by water wells, and for that reason the water surface measured in wells was considered to be the water table. In effect, then, the fault barriers form the boundary of the artesian basin, probably as a result of the vertical offset of the aquifers along the faults.

The confinement of ground water at depth in the Edison-Maricopa Front unit seems to be related to a thick section of generally poorly sorted fine-grained deposits, rather than a single blanket of lacustrine clay as in the western part of the valley. Thus, the confinement appears to be similar to that in the eastern part of the White–Poso unit. Data presently available are not sufficient to define the depth of the confinement specifically, although wells shallower than 300 feet generally register the water table, whereas wells deeper than 400 feet generally register a piezometric surface.

The contours on the piezometric surface (pl. 15) indicate that water in the confined deposits was moving toward closed pumping depressions northeast of DiGiorgio, southwest of Arvin, and an elongate trough south of Kern Lake bed, extending east-west from about 3 miles east to about 14 miles west of U. S. Highway 99. These depressions are in irrigated areas where ground water is the sole irrigation supply and evidently are the result of local heavy withdrawals. The location of the two depressions northeast of DiGiorgio and southwest of Arvin, close to the margin of the valley and to the edge of the irrigated area, indicates that there is little recharge to the confined aquifers along the eastern border of the unit, which is not surprising, because the area to the east is underlain by dense, impervious granitic rock at shallow depth. West of DiGiorgio, the gentle eastward hydraulic gradient

Appendix D.3

Wood and Dale (1964)

Geology and Ground-Water Features of the Edison-Maricopa Area Kern County, California

By P. R. WOOD *and* R. H. DALE

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1656

Prepared in cooperation with the California Department of Water Resources

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1964

Tertiary age, as well as the steeply dipping beds, suggests thrust faulting here and to the east. Eastward from Pastoria Creek, the structure is comparatively simple. Here the nonmarine beds and volcanic rocks become more abundant, and the Tertiary rocks dip north-northwestward at an angle that becomes progressively smaller until, near the Tejon Ranch Co. (11N/18W–24), they dip only 10° to 15° (Hoots, 1929, pl. 31).

The middle segment, east of the Tejon Hills, trends northwestward from the mouth of the canyon of Tejon Creek to the White Wolf fault (pl. 3). Although structural evidence is lacking, the boldness of the scarp and the sharp topographic boundaries between Cummings Valley and the Tejon Valley, 2,000 to 2,500 feet below, suggest a major fault, or series of faults, which Hoots (1929, p. 315) called the Tejon Canyon fault. The broadness, shallowness, and orientation of Tejon Valley suggest that, before displacement along the Tejon Canyon fault, it was genetically related to the Cummings Valley, which is part of an old physiographic surface characterized by broad valleys and comparatively low, subdued ridges.

In the Tejon Hills, north of Tejon Valley, deformed Miocene marine and Pliocene nonmarine strata rest unconformably on the basement rocks and dip toward the valley at angles ranging from less than 10° to 55°.

The northeast segment, which extends 15 miles northeastward from the Tejon Hills to points beyond Caliente and Tehachapi Creeks, is controlled in large part by the White Wolf fault. Extensive geologic, seismologic, and geodetic studies made in connection with the Arvin-Tehachapi earthquake, which originated on the fault in 1952, indicate that it is a high-angle reverse fault dipping southeastward at a probable angle near the surface of 45°±15° (Buwalda, 1954, p. 137). East of Arvin, the fault is bounded on both sides by crystalline basement rocks; it continues toward the southwest to Wheeler Ridge or beyond but is concealed throughout most of its length beneath the alluvium of the San Joaquin Valley (pl. 3). Although the surface trace of the fault in the valley area is unknown, its approximate trace on the surface of the crystalline basement is shown on plate 3 (Buwalda and St. Amand, 1955, p. 42, pl. 2). As the fault plane dips steeply southeastward, the fault line shown on plate 3 indicates the uplifted, overhanging edge of the granitic block southeast of the fault. Buwalda and St. Amand (1955, p. 42, pl. 2) reported that the edge of the uplifted, overhanging granitic block is nearly 8,000 feet below sea level 3.5 miles southwest of Comanche Point, but that it rises to 3,000 feet below sea level near Wheeler Ridge. North of the fault, the altitude of the granitic basement ranges from 6,000 feet below sea level south of Arvin to more than 22,000 feet below sea level north of Wheeler Ridge. The base of the Pliocene and Quaternary continental deposits in the valley north of the fault is reported to be more than 14,000 feet below the land surface, whereas south of the fault the depth to this horizon is about 4,000 feet (Dibblee, 1955, p. 31).

Water levels in wells north and south of the fault show that it forms a northeastward-trending barrier that impedes the movement of ground water along a line extending from Wheeler Ridge to Comanche Point. This barrier probably results from offsetting of permeable units against poorly permeable units in the Quaternary deposits and possibly in part from cementation along the concealed fault zone.

Between the Tejon Hills and the vicinity of Caliente, no Tertiary formations crop out along the western base of the Tehachapi Mountains. The mountains west of Caliente and south of Caliente Creek, however, are composed of Tertiary continental deposits, which dip toward the San Joaquin Valley at an angle of about 20°. These deposits, which are 3,000 feet thick, are brought into contact with the crystalline basement rocks on the south by the Edison fault, which has a maximum displacement of more than 5,000 feet near the edge of the valley (Dibblee and Chesterman, 1953, p. 44, 50).

Beach (1948, fig. 5) reported a wide northwestward-trending fault zone in the crystalline basement rocks beneath the Edison oil field. This fault zone, generally referred to as the Edison fault, has a displacement of 1,500 feet in upper Miocene and older sediments, but, according to Beach (1948, p. 69), has little recognizable displacement in the overlying Pliocene and Quaternary continental deposits. Water-level measurements in wells adjacent to the fault indicate, however, that water-bearing deposits have been displaced along a line approximately coinciding with the Edison fault zone. Reports of damage to installations in the vicinity of the Edison oil field and cracks in the land surface indicate displacement of the near-surface deposits during the Arvin-Tehachapi earthquake of 1952. The reported damage probably resulted from adjustment of an elevated fault block to stresses in the basement rocks.

COAST RANGES

The Temblor Range and San Emigdio Mountains, which form the western and southern borders of the southern San Joaquin Valley, are underlain in the Edison-Maricopa area by marine and continental deposits of Tertiary age dipping generally toward the valley floor.

Appendix D.4

Anderson et al. (1979)

TECHNICAL INFORMATION RECORD
STUDY CODE NO. 1610-4-J-1

File

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
Southern District
Water Projects Branch

PRELIMINARY EVALUATION OF STATE WATER PROJECT GROUND WATER STORAGE PROGRAM: WHITE WOLF BASIN

-by-

Stephen C. Anderson
Associate Engineer

Diane K. Sanchez
Water Resources Engineering Associate

Arvey A. Swanson
Senior Engineering Geologist

This Technical Information Record (TIR) was prepared to document information developed during a reconnaissance-level investigation of the White Wolf Ground ᐧᐧᐧᐧter Basin to determine if inclusion of this basin in the State Water Project ᐧᐧᐧe Supply Program is feasible. Therefore, it should be considered as ᐧᐧᐧminary and subject to revision. This is primarily an internal office ᐧᐧᐧment with distribution limited to the cooperating agencies only.

September 1979

of the basin have total dissolved solids (TDS) concentrations ranging from 500 to 800 milligrams per litre (mg/l). Ground water on the west side of the basin has an electrical conductivity (EC) of more than 2 000 microsiemens (2,000 micromhos) per centimetre, TDS concentrations greater than 1 000 mg/l, and contains less than 0.9 mg/l of boron. This water which increases in salinity to the west, probably originates as recharge from Salt and Tecuya Creeks. It has TDS concentrations up to 2 400 mg/l and is associated with marine sediments.

Ground water moves toward a pumping depression near the northeast corner of the basin. Just east of the pumping depression is an area where in 1977 one well had a TDS concentration of more than 1 000 mg/l, while chloride concentrations were less than 100 mg/l. In other parts of the basin, the EC ranges from 400 to 1 600 microsiemens (400 to 1,600 micromhos) per centimetre. In 1977, water from 24 wells had nitrate concentrations averaging 14 mg/l (with 5 wells having concentrations greater than 45 mg/l); and boron concentrations averaging 0.34 mg/l. Most of these wells are in the northeast corner of the basin.

Between spring 1975 and spring 1977, a number of wells in the western areas that have poor quality ground water showed a rise in water levels up to 12 metres (40 feet). These changes probably reflect semi-confined aquifier conditions due to their being located on the fringes of the basin. In the central half of the basin, water levels showed a decline of up to 1.5 metres (5 feet) for the same period. Therefore, present operating methods have steepened the gradient that moves the poor quality water toward the center of the basin.

A steep gradient exists across the White Wolf fault, and some subsurface outflow probably occurs. In the Kern County ground water model study, annual subsurface outflows range from 5.4 cubic hectometres

(4,400 acre-feet) in 1961 to 1.5 cubic hectometres (1,200 acre-feet) in the early 1970's. Reductions in outflow from the White Wolf Basin resulted from the recovery of artesian heads north of the fault due to use of SWP water on the north side of the fault. Also, recharging ground water outside of White Wolf Basin by Arvin-Edison WSD may have been a contributing factor.

Appendix D.5

Hagan (2001)

THE EFFECTS OF THE WHITE WOLF FAULT ON GROUNDWATER HYDROLOGY

IN THE SOUTHERN SAN JOAQUIN VALLEY, CALIFORNIA

THESIS

Presented to the Faculty of the School of Arts and Sciences

of California State University, Bakersfield

in Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Geology

Karin Hagan

B.S. 1997, California State University, Bakersfield

December 2001

suggested that the White Wolf and the Garlock faults moved similarly and therefore the White Wolf fault probably influenced the San Andreas fault (Dibblee and Oakeshott, 1953; Buwalda, 1954; Buwalda and St. Amand, 1955; Dibblee, 1955). Dibblee (1955) also noted a discrepancy in water levels across the assumed trace of the fault.

A USGS Water-Supply Paper (Davis et al., 1959) reported that, based on groundwater level measurements, the White Wolf fault created a hydrologic barrier for the unconfined and semi-confined aquifers only in the southern part of T. 32 S, R. 29 E, Mount Diablo Meridian; farther southwest the fault was only a barrier for the confined aquifers and not to the movement of the unconfined groundwater. The California Department of Water Resources (1959) also stated that the fault had some influence on groundwater movement, but gave no details concerning either the manner in which the fault influenced groundwater or the methods used to determine this influence. A later USGS Water-Supply Paper (Wood and Dale, 1964) stated that the fault created a barrier to groundwater flow along its entire length in the SJV, extending from Wheeler Ridge to Comanche Point. The proposed cause of the barrier was the offsetting of aquifers across the fault and possible mineral cementation within the fault zone, although no supporting data were included in the report.

In the late 1970s, California Department of Water Resources evaluations of the White Wolf groundwater basin (Swanson, 1977; Anderson et al., 1979) reported that the fault formed a hydrologic barrier for the basin, based on a steep hydraulic gradient across the fault. They also suggested the existence of subsurface outflow from the basin to the main SJV groundwater basin and noted that the effectiveness of the barrier at shallow depths was not known. A similar report by WRMWSD (Jaspar et al., 1977) stated that it could be assumed that there was no appreciable groundwater flow across the White Wolf fault, presumably based upon water level measurements made during the winter of 1976-1977.

A 1975 USGS study of subsidence in the southern SJV (Lofgren, 1975) noted that, on a contour map of lines of equal subsidence for the period 1953 to 1962, two of the contours crossed the assumed trace of the fault without interruption. This suggests that equal volumes of groundwater were removed from both sides of the fault.

Hitchcock (1993) studied fluid inclusions in an exposed portion of the White Wolf fault zone near Bealville, where it is bounded on both sides by crystalline rocks. He determined that the fault displayed "fault-valve behavior" (discussed under "Related Studies of Faults as Barriers") and that fluids migrated across the fault zone, later (re-)sealing it with calcite precipitation. He also noted that there was no evidence for or against the hypothesis that fluids migrating from depth along the fault plane were expelled into the aquifer system, as water chemistry analyses were scarce.

Related Studies of Faults as Barriers

The hydrogeologic properties of fault zones can cause faults to act as barriers, partial barriers, or conduits for groundwater flow, or to have no effect. Factors that influence the effect that faults have on groundwater flow include the hydraulic conductivity, transmissivity and permeability of the fault zone itself and the hydraulic conductivity, transmissivity and permeability of the strata juxtaposed on either side of the fault. Due to the anisotropic fluid flow that may be created by a fault zone, and the varying hydrologic properties of a fault as discussed in the following paragraphs, one fault may act simultaneously as a barrier and a conduit to groundwater flow, varying along its length and with depth (Logan, 1992).

Depending on the permeability of the surrounding materials, the groundwater path may follow the natural gradient despite the presence of the fault or may preferentially move along the fault plane either parallel to the trend of the fault through the fracture halo (Logan, 1992; Logan and Decker, 1993; Scholz and Anders, 1994) or vertically, connecting aquifers or creating springs. The crushing of compacted or cemented sedimentary or crystalline materials within the fault zone can create an area of high permeability that acts as a conduit for groundwater flow within the faulted aquifer. However, this granulation of materials may form a groundwater barrier if they are compacted tightly, thereby decreasing pore space and increasing the tortuosity of the flow path, or if

Conclusions

Contour maps of groundwater elevations across the fault suggest that the White Wolf fault zone does act as a partial barrier to groundwater movement, but only when the aquifer is stressed by pumping. Hydrographs also show that differing groundwater elevations across the fault may persist over several years but are more prominent in drought years. The fault zone does not appear to block the movement of groundwater, it only slows the flow of groundwater across it as shown by the historical groundwater elevation records. This slowing of groundwater movement is probably due to decreased transmissivity within the fault zone relative to the surrounding aquifer, and is only apparent when the aquifer is stressed by increased groundwater pumping.

The fault may exhibit "fault-valve behavior" further east in the mountains where Hitchcock (1993) found calcite inclusions cementing the fault zone. However, within the valley there is no evidence of calcite within the fault zone although historical carbonate records were sparse. The geochemical compositions of groundwater on either side of the fault are similar and do not support the designation of the fault as a groundwater barrier.

The pumping test indicated that the aquifer is semi-confined to confined, with an approximate transmissivity of 970 ft^2/day (88 m^2/day) (7,300 gal/day/ft). A barrier boundary was reached ten minutes into the pumping test and probably represents the intersection of the cone of depression with the fault zone.

Appendix D.6

AEWSD (2003)

Arvin-Edison Water Storage District Groundwater Management Plan

6/5/03

1801 21st Street, Suite 6
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Office Phone (661) 327-1985

Formation consists of coarse to fine grained sand and sandy clay with lenses of gravels and cobbles. The Chanac Formation consists of continental conglomerate deposits with lenses of coarse sand and clays.

In addition, two faults, or “fault zones” that traverse the District are the White Wolf and Edison Faults. These faults are believed to impede groundwater flow and affect the movement from one side of the fault to the other. A small portion of the District lies north of the Edison Fault. Another relatively large area lies south of the White Wolf Fault. A major portion of the District lies between the two faults and comprises the majority of the District area.

While these faults do appear to provide some impediment to groundwater flow across these faults, this is a subject that may merit additional study in the future. In this regard, there has been some more recent work done in this area, such as a thesis prepared by Karin Hagan[1]. This thesis studied the White Wolf fault zone, and concluded that groundwater elevation data indicate that the fault is a “partial barrier” to groundwater flow. An analysis of groundwater quality data found little difference in water quality on either side of the fault.

In many portions of the San Joaquin Valley, the Corcoran Clay separates a generally unconfined aquifer system above and a confined aquifer system below. However, the District area and immediately neighboring areas are believed to be situated too far south for this regional confining layer to be present. However, there are other relatively fine-grained materials beneath the District that cause varying levels of confinement within different locations in the District. This confinement tends to be more pronounced towards the more central portions of the basin.

The aquifer underlying the District yields substantial amounts of water to wells. USGS Water Supply Paper 1618 tabulated average well yields by township. For the townships underlying the District, these yields range from approximately 622 gallons per minute (gpm) to1,786 gpm, and averaged 1,191 gpm.

Yields from District-owned wells vary with the depth to water. For example, early in the recent drought of the late 1980s and early 1990s, District wells produced an average of about 1,800 gpm per well. By the end of the drought, the wells yielded approximately 1,400 gpm per well. Higher well yields returned after the drought ended, with a series of wetter-than-average years and significant groundwater recharge through District recharge operations.

[1] “The Effects of the White Wolf Fault on Groundwater Hydrology in the Southern San Joaquin Valley, California” Thesis dated December 2001 for California State University Bakersfield - Masters of Science in Geology Degree

Appendix D.7

WRMWSD (2007)

FINAL

AB3030
Groundwater Management Plan

Prepared for

Wheeler Ridge-Maricopa
Water Storage District

November 2007

Todd Engineers
with Kennedy/Jenks Consultants

consist of up to 150 feet of interstratified and discontinuous beds of clay, silt, sand, and gravel. Permeability within the alluvium tends to decrease from east to west, associated with the change in lithology and depositional environment from the Tehachapi Mountains to the San Emigdio Mountains. The permeability of the alluvial sediments also decreases northward across the District and is particularly low beneath the beds of Buena Vista and Kern Lakes (Figure 4) (BE, 1995).

Subsurface correlations and regional mapping with seismic data by Pacific Geotechnical (1990) were reviewed for the GWMP. Using geophysical logs provided by the District, Todd Engineers confirmed several of the subsurface units mapped by Pacific Geotechnical and identified at least three alluvial fan packages to a depth of approximately 1,500 feet beneath the central and western portions of the District (north of Wheeler Ridge and west to the western District boundary). Logs indicate numerous discontinuous layers and unconformities in both the Tulare formation and Pleistocene/Holocene alluvial sediments. Most clay layers cannot be correlated across the District and groundwater is expected to be unconfined to semiconfined to depths of 1,000 feet or more beneath the central portion of the District. More continuous confining layers have been noted in the western portion of the District (Maricopa Subarea, Figure 4) (BE, 1995).

Faults that act as barriers to groundwater within the Kern County Subbasin include the Edison, Pond-Pose, White Wolf, and Springs faults. Only the White Wolf Fault and Springs Fault occur within District boundaries (Figure 4). The White Wolf fault separates a southeastern alluvial subarea from the remainder of the Kern County Subbasin (referred to in this report as the White Wolf Subarea and defined in the following section). A study on groundwater flow in the vicinity of the fault indicates that groundwater levels are disrupted and groundwater flows across the fault only in certain areas and only during conditions of relatively high water levels (Hagan, 2001). Groundwater flow is also impeded across the Springs fault. Here, groundwater flowing northward from recharge areas in the Tehachapi Mountains rises along the fault trace and surfaces as springs, providing the fault with its name.

2.4.5.2. Subareas

USGS and others have noted gradational changes in aquifers, well yields, and groundwater quality from east to west within the District boundaries and have subdivided this portion of the groundwater subbasin into subareas based on source rocks, permeability, and water quality (Wood and Dale, 1964). These subareas were adopted and modified by Bookman-Edmonston (1995) and serve as a useful framework within which to evaluate changes in the GWMP study area over time. As such, these subareas are often referenced in this GWMP and are shown on Figure 7, along with wells used in the groundwater basin assessment. From west to east, subareas are referred to as Maricopa, Wheeler West, Wheeler East, and White Wolf subareas.

The Maricopa Subarea covers the western portion of the District and is surrounded by fine-grain marine source rocks of the Coast Ranges. The subarea is fed by relatively small ephemeral streams of poor water quality from the west and southwest.

APPENDIX E

Selected Groundwater Models Including the White Wolf Fault
as a Significant Impediment to Groundwater Flow

Appendix E.1

Williamson et al (1989)

GROUND-WATER FLOW IN THE CENTRAL VALLEY, CALIFORNIA

REGIONAL AQUIFER-SYSTEM ANALYSIS

U.S. GEOLOGICAL SURVEY PROFESSIONAL PAPER 1401-D ties from block to block and (2) averaging values to represent the aggregate of the heterogeneity within each block.

Dividing the Aquifer System Into Finite-Difference Blocks

The aquifer system was divided into blocks by superimposing a grid over a map of the study area and orienting it such that a minimum number of the blocks were outside the study area. A uniform planimetric grid spacing of 6 mi by 6 mi was used in the study (fig. 12). The vertical dimensions of the blocks vary and are incorporated into several terms that quantify the aquifer properties. For example, the horizontal transmissivity term for each node equals the product of the thickness of the block and the average horizontal hydraulic conductivity of the sediments. Similarly, the leakance (*Tk*) term, which affects vertical flow between layers, equals the equivalent vertical hydraulic conductivity divided by the thickness between nodes (one-half of each adjacent block thickness).

The valley was also subdivided by grouping model blocks into areas and subareas for analysis (see fig. 27). In the San Joaquin Valley, subarea boundaries approximate the ground-water-management boundaries outlined by the California Department of Water Resources (1980).

Four model layers were used to simulate the three-dimensional flow in the Central Valley aquifer system. The lowest model layer (layer 1 in fig. 11*B*) consists of the continental deposits below the depth penetrated by any production wells in the area. Most of the pumpage comes from layers 3 and 4. The division between the water table (layer 4) and the lower pumped zone (layer 3) was determined on the basis of the following criteria:

1. In areas where there was a large amount of well-construction data, the division between the shallow and the deep zones (model layers 3 and 4) was based on the vertical zonation of perforation intervals. A depth near which the majority of wells had no perforation was chosen as the boundary between the two zones.

2. In most of the area where the E-clay, which includes the Corcoran Clay Member of the Tulare Formation (Croft, 1972, p. 18), has been mapped, the division made by the criteria coincided with the depth above the E-clay. In the Westside subarea, the division based on criterion 1 was above the Corcoran Clay Member. The E-clay underlies more than half of the San Joaquin Valley (Croft, 1972, pl. 4).

3. In the remaining areas, the division was interpolated and extrapolated from adjacent areas.

Layer 2 extends to the depth of the deepest wells in the area. In model blocks where the wells are not as deep as they are in the adjacent general area, layer 3 extends to the deepest wells in the block. This layer definition reduces the effect of well leakage between nonadjacent layers (model layers 2 and 4) and allows for a simple adjustment of the *Tk* term between adjacent layers to account for well leakage during transient analyses (Bennett and others, 1982, p. 338).

Transmissivities were assumed constant in all model layers, including the uppermost layer, which incorporated the water table. Commonly, the transmissivity of the uppermost layer is allowed to vary depending on the saturated thickness in the layer, which can change during a simulation period owing to pumping or recharge. However, unless the changes in the water table are large compared with the thickness of the uppermost model layer, the change in the transmissivity is small and assigning a constant value makes little difference. In simulating the Central Valley aquifer from 1961 to 1977, the water table in a few model nodes in the uppermost layer changed about 60 ft but the initial saturated thickness was more than 500 ft. The maximum error in assuming a constant transmissivity was 12 percent, which is within the limits of this large-scale study.

Boundaries

The modeled aquifer system is surrounded by impermeable (no flow) boundaries except at Suisun Bay (fig. 12). Generally, the boundaries along the west side of the valley and beneath the aquifer system represent less permeable marine deposits; along the east side, the boundary is represented by less permeable igneous or metamorphic rocks. At the south end of the Central Valley, the boundary of the modeled aquifer system is the White Wolf fault, which acts as a barrier to flow (Wood and Dale, 1964). At the north end, the boundary is the Red Bluff arch, which is a series of low-lying hills consisting of northeast-trending anticlines and synclines. The series of hills acts as a barrier to ground-water flow (California Department of Water Resources, 1978, p. 39). In addition, both the Sutter Buttes and the Kettleman Hills within the valley restrict ground-water flow and were assumed virtually impermeable (Page, 1986, fig. 2 and p. C19).

Along the three model blocks that coincide with the discharge point (Suisun Bay) of the San Joaquin and Sacramento Rivers (fig. 12), constant hydraulic heads were specified in all model runs in the uppermost model layer (layer 4 in fig. 11*B*). During steady-state (predevelopment) simulations, the hydraulic head in the entire model layer 4 was held constant to aid in estimating recharge and discharge.

SIMULATION OF LAND SUBSIDENCE

The computer program of Trescott (1975) was modified to account for the release of water from the inelastic (irreversible) compaction of clay beds in the aquifer system. In general, the ratio of subsidence to head decline in an aquifer system, which is related to the irreversible compaction of the clayey beds, is small until after the head

FIGURE 12.—Model grid and boundaries.

Appendix E.2

Bookman-Edmonston (2007)

Bookman-Edmonston
A Division of GEI Consultants

Geotechnical
Environmental and
Water Resources
Engineering

Groundwater Storage and Recovery Pilot Project in White Wolf Basin

Final Pilot Project Report

Submitted to:
Wheeler Ridge-Maricopa Water Storage District
12109 Highway 166
Bakersfield, CA 93313-9630

Prepared By:
Bookman-Edmonston, a division of GEI Consultants, Inc.
225 West Broadway, Suite 400
Glendale, CA 91204

Revised January 26, 2007

The material along the White Wolf Fault on the model north boundary is very tight. The White Wolf Fault is believed to act as a barrier to groundwater flow. The study and investigation on the hydrogeological conditions of White Wolf Fault are limited. Studies performed by Karin Hagan (Karin Hagan, 1997), as part of a Master's thesis shows that there was a pair of wells which lie on opposite sides of the fault. The pumping test data from these wells indicated the transmissivity of the White Wolf Fault ranges from 560 feet $(ft)^2$ /day to 1,100 ft^2/day. The bottom elevation of the alluvial layer (layer 1) along the fault was interpolated based on the limited information is about -400 to -770 feet (see Figure 3). The average groundwater elevation along the fault is about 230 feet resulting in a saturated thickness of about 630 feet near the margins of the basin to 1000 feet near the center of the basin along the length of the fault. Therefore, a hydraulic conductivity of 1.0 feet/day along the fault was used in the model.

Recharge and pumpage

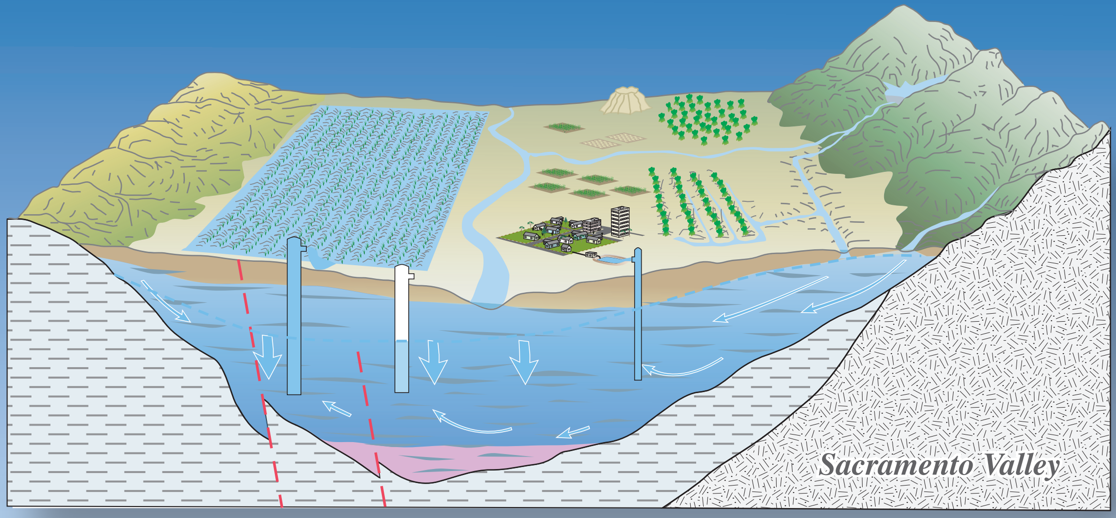
Local surface runoff is caused by rainfall in the surrounding mountainous area. The rainfall is characterized by relatively high intensity, short duration storms. Local runoff contributes to groundwater recharge and is one of the sources of natural water supply. The White Wolf Basin receives surface water inflow from several creeks as shown on Figure 9. These supplies generally percolate to the groundwater within the basin, although some surface water does escape the basin during periods of exceptionally high flows. Average annual precipitation was based on a review of long-term isohyetal maps. The watershed areas of the major streams that discharge into the White Wolf Basin, include El Paso, Grapevine, Pastoria, Tunis, Tecuya and Tejon creeks. Utilizing established methods of analysis, a relationship and the average annual precipitation, the average annual surface water inflow into White Wolf Basin was 7,600 acre-foot per year (ac-ft/yr)

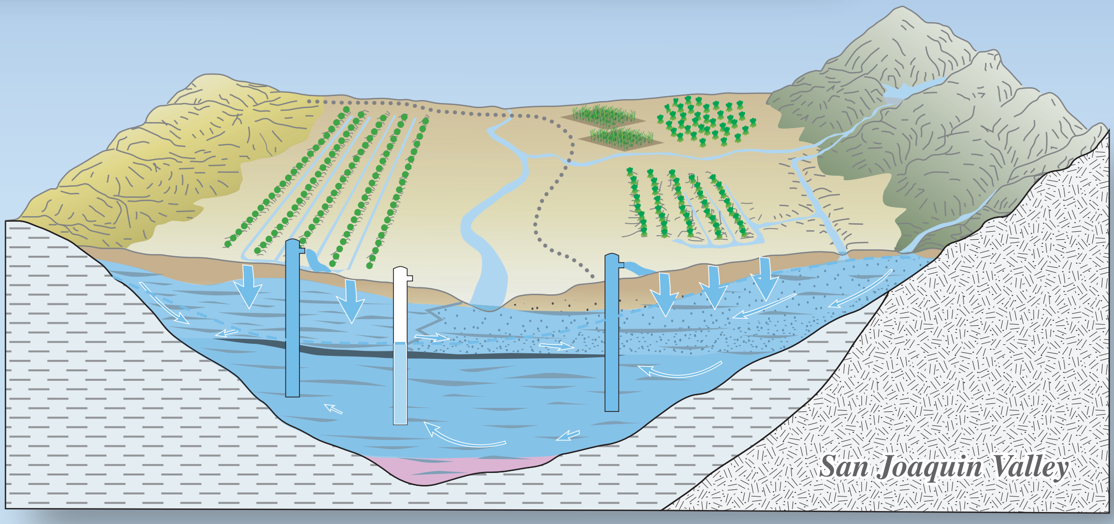
Appendix E.3

Faunt et al. (2009)

GROUNDWATER RESOURCES PROGRAM

Groundwater Availability of the Central Valley Aquifer, California





Professional Paper 1766

U.S. Department of the Interior
U.S. Geological Survey

most sensitive to this parameter, and cell-by-cell parameter values were estimated during calibration.

Critical head is another parameter used by the SUB package that strongly affects storage changes, particularly the timing of those changes (*fig. B18*). Critical head is the equivalent head at which effective or intergranular stress is equal to the pre-consolidation stress. The equivalent critical head or preconsolidation stress represents the threshold stress that determines whether changes in stress deform the granular skeleton elastically or inelastically. For head changes (whether positive or negative) in the range of heads greater than the critical head, the skeleton deforms elastically. For head changes in the range of heads less than the critical head, the mode of skeletal deformation depends on the sense of the head change—a positive change (head increase) causes elastic deformation, and a negative change (head decrease) causes inelastic deformation and re-establishes a new critical head. In the upper three model layers, specified initial critical-head values were equal to the water levels estimated for the spring of 1961 (starting head values used in CVHM). In the lower seven model layers, the initial critical heads initially were derived from those estimated by Williamson and others (1989). These heads are approximate and were interpolated from the minimum historical head values simulated in the CV-RASA model. In the final calibration, specified initial critical heads were equal to the head simulated in CVHM in September 1961. These values approximate the minimum historical head value in 1961.

Hydrogeologic Units

Because the 3D configuration of regionally extensive hydrogeologic units generally is unavailable for the Central Valley, only two stratigraphically defined units and the crystalline bedrock of the Sierra Nevada complex are explicitly incorporated in the CVHM. As described in *Chapter A*, the extent and thickness of the Corcoran Clay defined by Page (1986) and later modified by Burow and others (2004) was used to define model layers 4 and 5 (*fig. A8*). Where the San Joaquin Formation (Allegra Hosford Scheirer, U.S. Geological Survey, written commun., 2004) is present in the model domain, model cells within its mapped extent were identified. Similarly, model cells that coincide with the mapped extents of crystalline rocks of the Sierra Nevada complex also were identified. The uppermost model cell in each applicable column intersecting these crystalline rocks is zoned as upper bedrock and all lower cells were inactived. This bedrock intersection occurs only on the eastern edge of the model domain and leaves the bulk of the domain undefined by specific formations (*fig. C1*). The contribution of groundwater from the bedrock was assumed negligible.

Hydrogeologic Structures

As delineated in *Chapter A*, the basin is traversed by two cross-valley faults, the Stockton Fault and White Wolf Fault (Hackel, 1966) (*fig. C1*). In addition, several smaller structures also were identified as possibly affecting groundwater-flow during an examination of water levels throughout the valley (*fig. C1*). The Horizontal Flow Barrier package (Hsieh and Freckelton, 1993) was used to simulate resistance to flow across these two major structures and several smaller structures (*fig. C1*). Although the model solution is relatively insensitive to these features, the effectiveness of these barriers was evaluated through model calibration by estimating parameters representing the hydraulic conductance across the features. The only other prominent structure in the Central Valley is the Sutter Buttes, a Pliocene and Pleistocene volcanic plug that rises abruptly to an altitude of 2,000 ft (600 m) above the flat valley floor (*fig. C1*). The Sutter Buttes is about 9 mi in diameter and the area is represented by inactive cells within the model domain (*fig. C1*).

Initial Conditions

For transient models, initial conditions define the system state at the beginning of the simulation. There is a long history of groundwater development and irrigation in the study area. Despite the fact that the system has been under stress since the late 1800s, sufficient historical water levels and data for estimating stresses were not available until about the 1960s. The combined effects of irrigation and groundwater pumpage have greatly increased the vertical head gradients, particularly in the southwestern part of the CVHM (WBS 14, *fig. A4* and *B13*). The hydrologic system was in a transient state during the early 1960s owing to the changing vertical head gradients and the continued recovery of the potentiometric surface. As a result of these and possibly other conditions, steady-state simulations using 1961 stresses and water-level altitude constraints fail to capture the ongoing transient responses to pre-1961 stresses. Therefore, there is little choice but to begin the simulation with initial conditions derived from a combination of historical water-level-altitude data and model-derived initial water levels. Like CV-RASA, the groundwater-flow simulation starts in April 1961, for which there are sufficient data to map both the altitude of the water table and the groundwater levels in the confined part of the aquifer system (Williamson and others, 1989). Although the specified initial state of the system generally is inconsistent, to some degree, with the conservation equations and properties of the CVHM, it is considered an adequate starting point.

The initial heads for the transient simulation were specified using the approach employed for previous studies in the San Joaquin Valley (Belitz and others, 1993; C. Brush, U.S. Geological Survey, written commun., 2006). The 1961

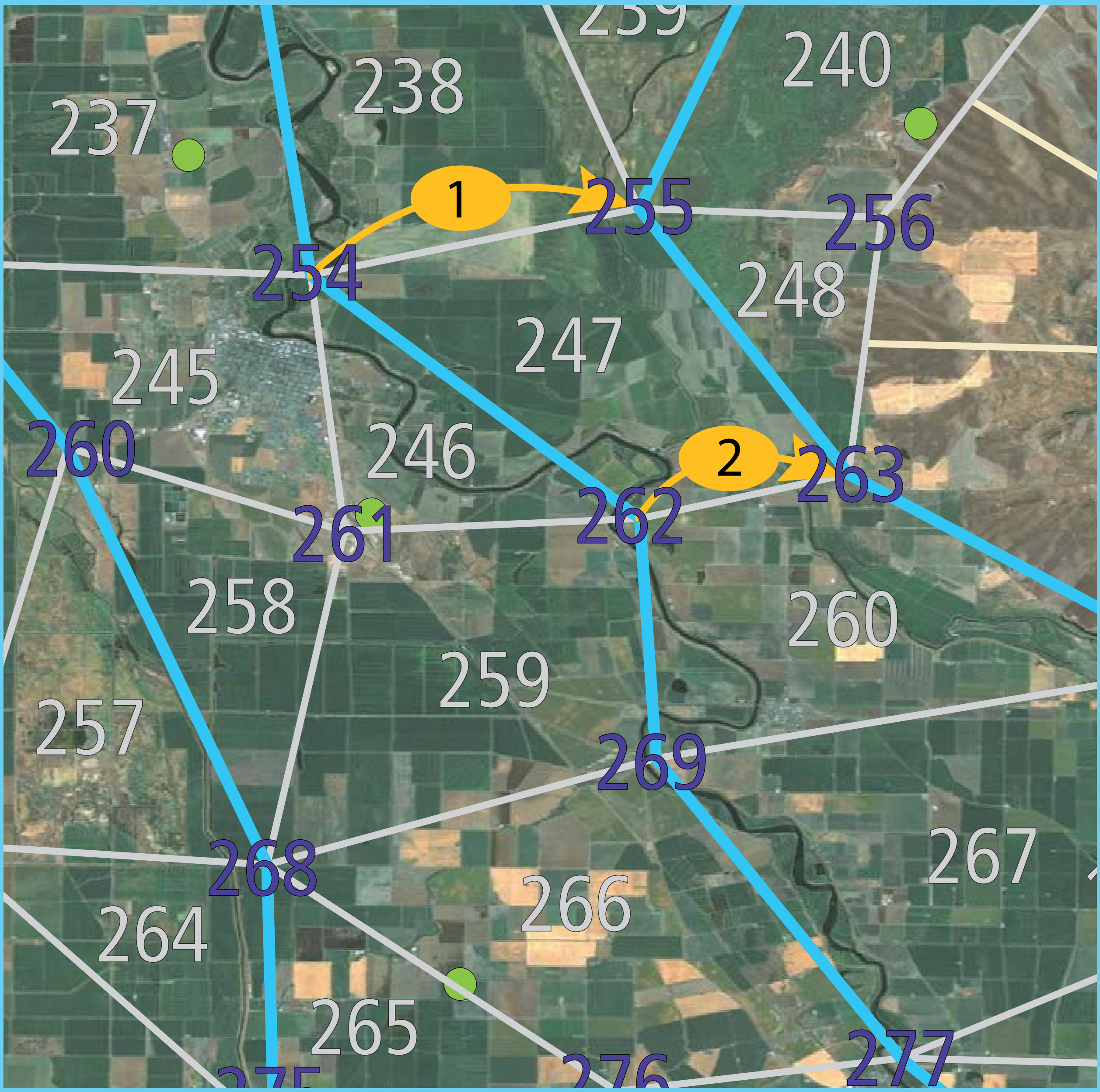
Appendix E.4

Brush et al. (2013)

DWR Technical Memorandum

Development and Calibration of the California Central Valley Groundwater-Surface Water Simulation Model (C2VSim), Version 3.02-CG

Charles F. Brush, Emin C. Dogrul and Tariq N. Kadir



Bay-Delta Office, California Department of Water Resources, 1416 Ninth Street, Sacramento, CA 95814

C2VSim-CG Version R374, released June 2013

Geologic structures within the Central Valley influence surface water and groundwater movement (Page, 1986). The Sutter Buttes, a small mountain range located in the central part of the Sacramento Valley, obstructs surface water flow and affect the groundwater flow system (Springhorn, 2008). The irregular spatial and temporal pattern of basement subsidence and sediment accumulation reveals numerous structural basins and arches superimposed on the major northwest-trending valley axis (Lettis and Unruh, 1991). The major structural basins in the southern San Joaquin Valley are the Buena Vista and Tulare Basins. The basins are smaller in the northern San Joaquin Valley and Sacramento Valley, with an amplitude of 5 to 40 miles. A series of anticlines are present along the western margin of the Central Valley along the Coast Ranges-Great Valley margin. Prominent anticlines include the Corning Domes, Dunnigan Hills anticline and associated Plainfield Ridge, Montezuma Hills, Panoche Hills, Anticline Ridge, Guijarral Hills, Kettleman Hills, Lost Hills, Elk Hills, Buena Vista Hills and Wheeler Ridge. These anticlines affect the east-west movement of surface water and groundwater, and are associated with faults that may act as barriers to groundwater flow (Olmsted and Davis, 1961; DWR, 1978; Harwood and Helley, 1982; Page, 1986; Faunt et al., 2009).

Faults extending upward from the basement rocks into the alluvium may also act as horizontal barriers to groundwater flow (Page, 1986). The Red Bluff Arch at the northern end of the Sacramento Valley is a group of faults that act as a groundwater flow barrier (Page, 1986). The White Wolf and Edison faults in Kern County also act as horizontal barriers to groundwater flow (Wood and Dale, 1964). Other faults which may act as horizontal barriers to groundwater flow include the Battle Creek Fault, the Corning Fault, and the Willows Fault Zone extending southeast from the Orland Buttes to Sacramento in the Sacramento Valley; the Rio Vista Fault, the Midland Fault, and the roughly collinear Vaca, Potrero Hills, Kirby Hills and Pittsburgh faults extending across the Sacramento-San Joaquin Delta; and the Stockton Fault, Vernalis Fault, Visalia Fault, and Pond-Poso Creek Fault in the San Joaquin Valley.

The Central Valley groundwater flow system comprises a regional aquifer that can be divided into local groundwater basins along geographic and political boundaries to facilitate water management and planning (DWR, 2003). The Central Valley is divided into two large groundwater basins (see Figure 5), the Sacramento Valley Groundwater Basin (5-21), and the San Joaquin Valley Groundwater Basin (5-22). The C2VSim model also covers the Redding Area Basin (5-6) and the Suisun-Fairfield Valley Basin (2-3). These groundwater basins are further divided into sub-basins. These sub-basins are delineated based on political, administrative and surface water boundaries, and may not reflect physical characteristics of the aquifer. The C2VSim model area covers 15 sub-basins of the San Joaquin Valley Groundwater Basin, 15 sub-basins of the Sacramento Valley Groundwater Basin, and five sub-basins of the Redding Area Basin.

Climate

The climate of California's Central Valley varies dramatically both geographically and from month to month and year to year. Precipitation rates are significantly greater fraction of field capacity, and the crop efficiency. These values were derived from the DWR Consumptive Use model (DWR, 1979).

Calibration Methodology

The C2VSim model is a highly parameterized integrated hydrologic model, and thus a specialized approach must be used to calibrate the model parameters. A simple model with few parameters can be calibrated by adjusting individual parameter values up and down until the model produces simulated output that corresponds reasonably well with observed values. However, for a highly parameterized model like C2VSim, this approach is impractical. Instead, a mathematical approach such as regularized inversion can be used to combine many observations into an objective function and then adjust many parameters at one time (Doherty and Hunt, 2010).

The C2VSim model's hydrogeologic parameters were calibrated using Parameter ESTimation (PEST) tool, a model-independent software suite for parameter estimation and uncertainty analysis for complex and highly parameterized models (Doherty, 2004). PEST was used to automate some aspects of model calibration, running the C2VSim model many thousands of times with slightly different sets of input parameters, analyzing the model results after each run, and adjusting parameter values to achieve a slightly better fit to observed values. The C2VSim model parameters calibrated using PEST included the hydraulic conductivities and storage parameters at each groundwater node, the curve numbers and soil conductivities for each subregion, river-bed conductances for each river node, and horizontal hydraulic conductances for the White Wolf Fault and the Red Bluff Arch. During calibration, all parameters were bounded within reasonable ranges. In all, more than 25,000 individual parameters were calibrated.

The first step in model calibration was the development of a set of computer programs to link IWFM with the PEST programs (CH_2M Hill, Inc., and S.S. Papadopoulos and Associates, 2005). These programs write PEST instruction files, run the C2VSim model, and convert C2VSim output into a format that can be read and used by PEST. The C2VSim model was then calibrated in three phases. The first two calibration phases used pilot points to estimate parameter values at a reduced number of locations within the model domain, and spatial interpolation to assign values to model nodes (Doherty, 2003).

In the first phase, the model framework was thoroughly reviewed, values for estimated parameters were selected, and an initial observation data set was developed. 137 pilot points in the top two model layers (Figure 24A) and 40 pilot points in the bottom model layer (Figure 24B) were chosen in the interior of the model domain for calibrating aquifer parameters, 19 pilot points were chosen for calibrating the vertical hydraulic conductivity of the Corcoran Clay (Figure 24C), and parameter values were transferred from pilot points to model nodes using kriging (CH_2M Hill, Inc., and S.S. Papadopoulos and Associates, 2006).

In the second phase, the model framework was improved, a more extensive observation data set was developed, 394 pilot points coinciding with model nodes

APPENDIX F

Water Quality Data and Maps

Appendix F.1

Wood and Dale (1964)

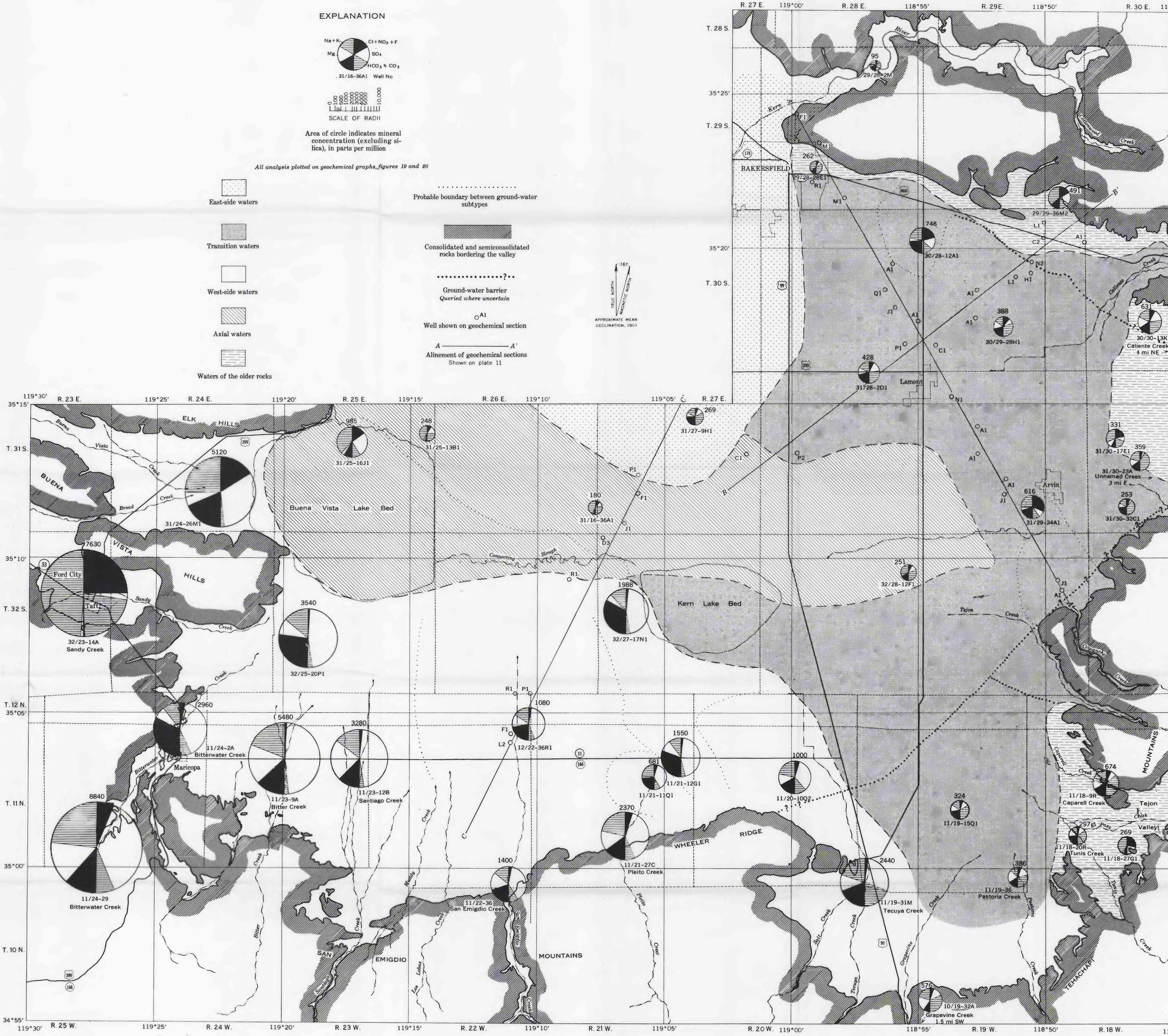
Geology and Ground-Water Features of the Edison-Maricopa Area Kern County, California

By P. R. WOOD *and* R. H. DALE

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1656

Prepared in cooperation with the California Department of Water Resources

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1964



MAP OF THE EDISON-MARICOPA AREA, CALIFORNIA, SHOWING CHEMICAL QUALITY OF TYPICAL SURFACE AND GROUND WATERS

2 0 2 4 6 MILES

714-848 O - 64 (In pocket)

Appendix F.2

WRMWSD (2007)

FINAL

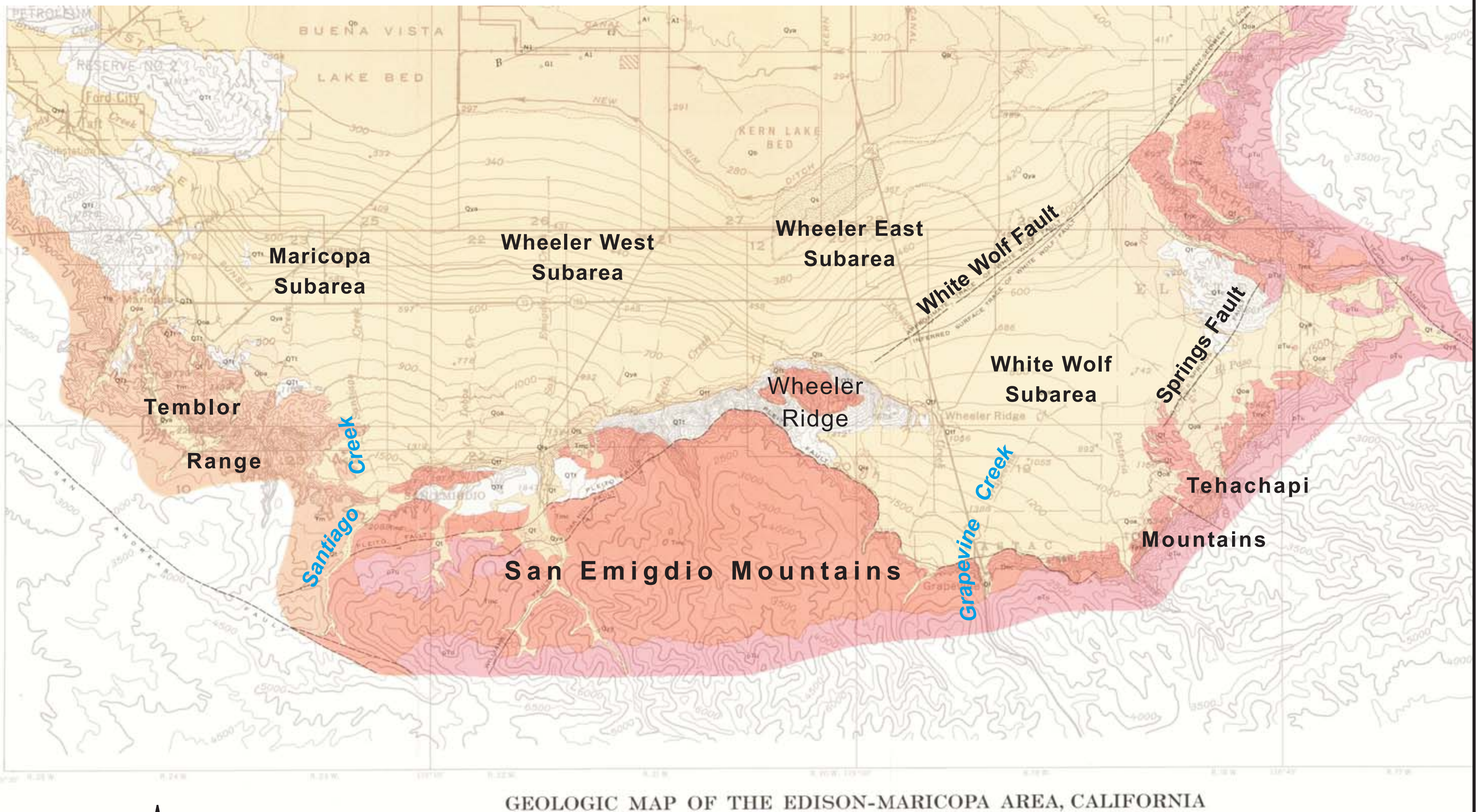
AB3030
Groundwater Management Plan

Prepared for

Wheeler Ridge-Maricopa Water Storage District

November 2007

Todd Engineers with Kennedy/Jenks Consultants

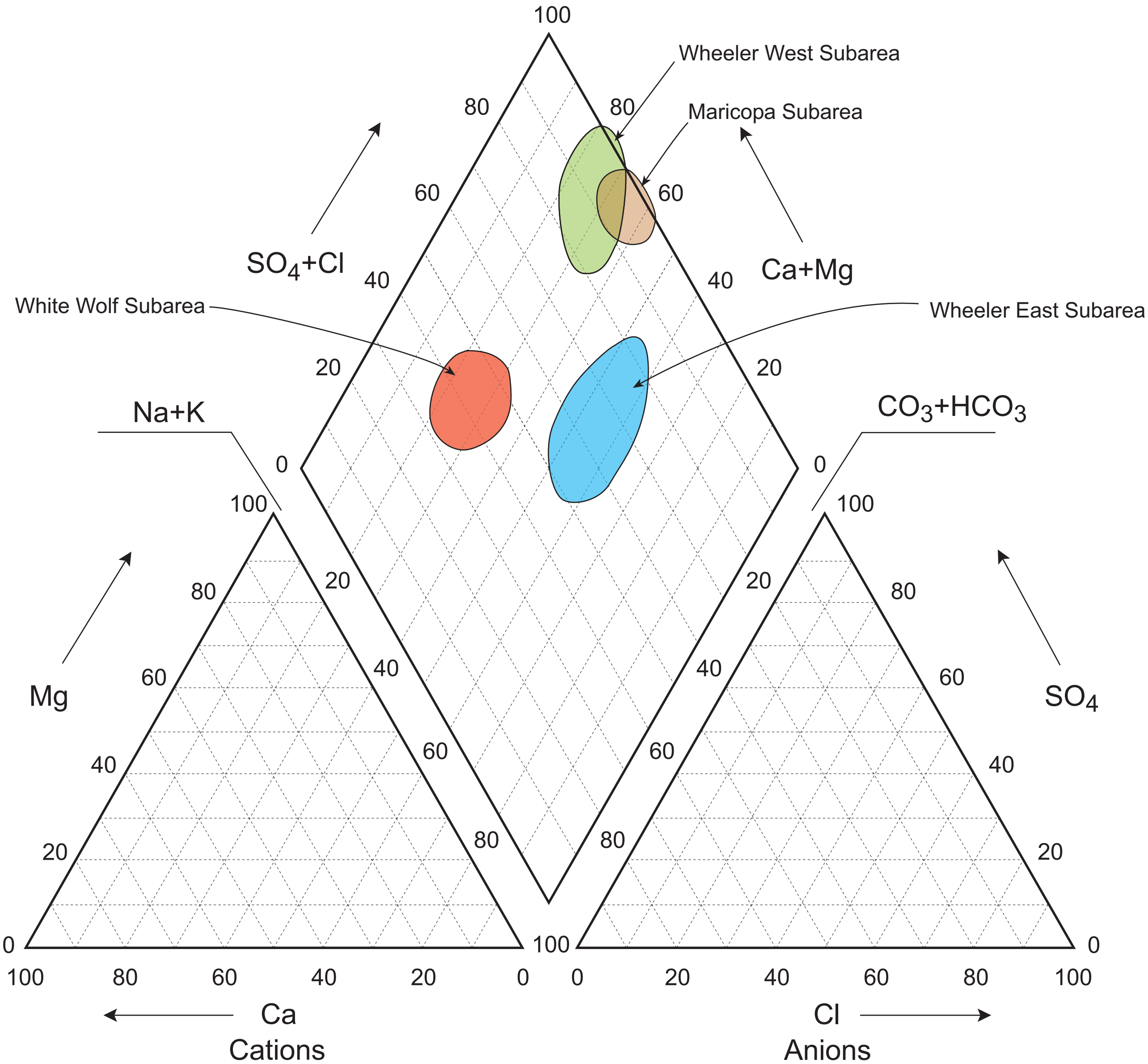


Source: Wood and Dale, 1964.

November 2007

TODD ENGINEERS
Emeryville, California

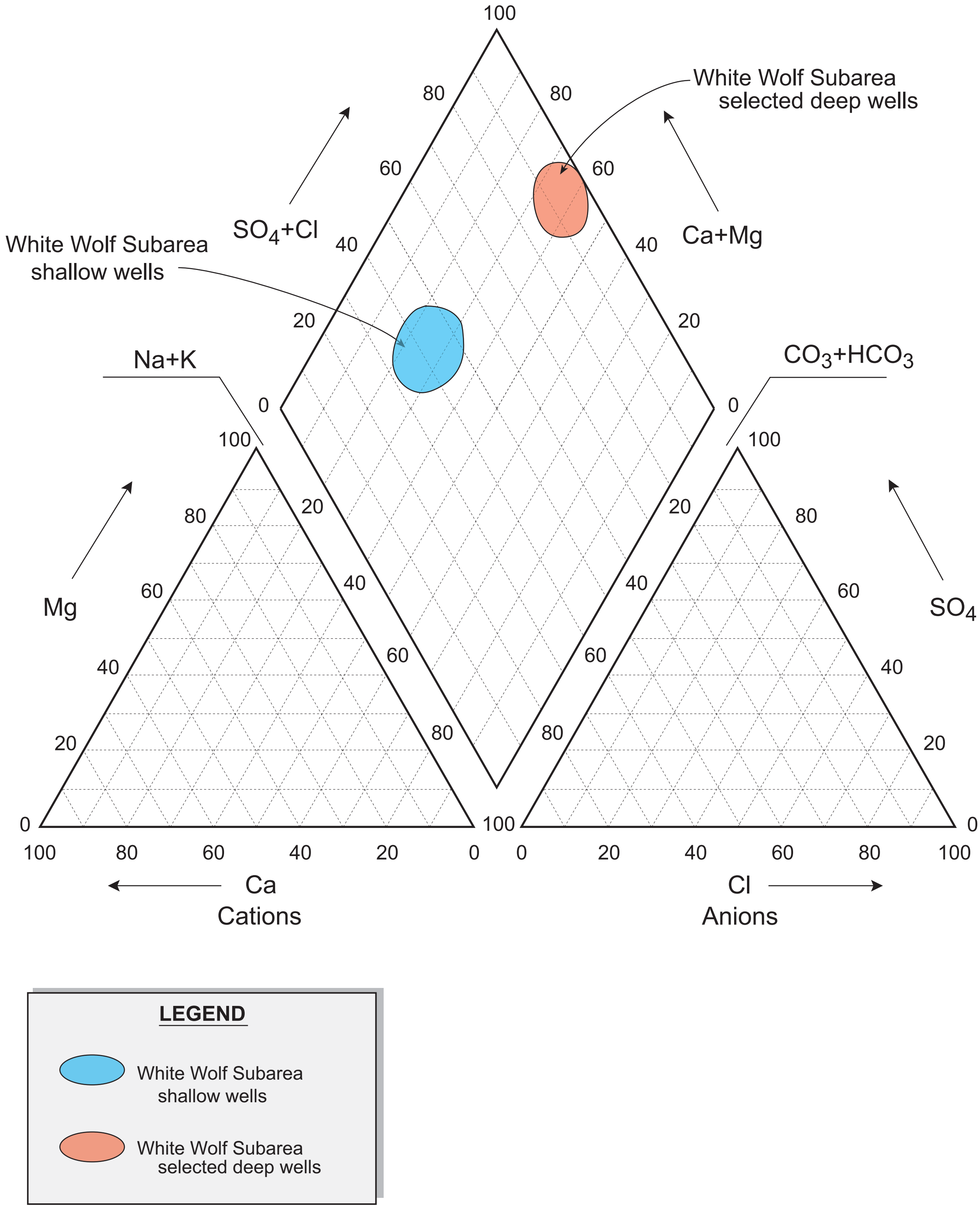
Figure 4
Geologic Map



LEGEND

- Maricopa Subarea
- Wheeler West Subarea
- Wheeler East Subarea
- White Wolf Subarea

November 2007	Figure 12
TODD ENGINEERS Emeryville, California	**Trilinear Diagram** **Groundwater Quality by Subarea**



November 2007	**Figure 13**
TODD ENGINEERS Emeryville, California	**Trilinear Diagram Groundwater Variability in White Wolf Subarea**

Appendix F.3

USGS

USGS
science for a changing world

CALIFORNIA
Water Boards

Prepared in cooperation with the California State Water Resources Control Board
A product of the California Groundwater Ambient Monitoring and Assessment (GAMA) Program

Status and Understanding of Groundwater Quality in the Two Southern San Joaquin Valley Study Units, 2005–2006: California GAMA Priority Basin Project

Scientific Investigations Report 2011–5218

U.S. Department of the Interior
U.S. Geological Survey

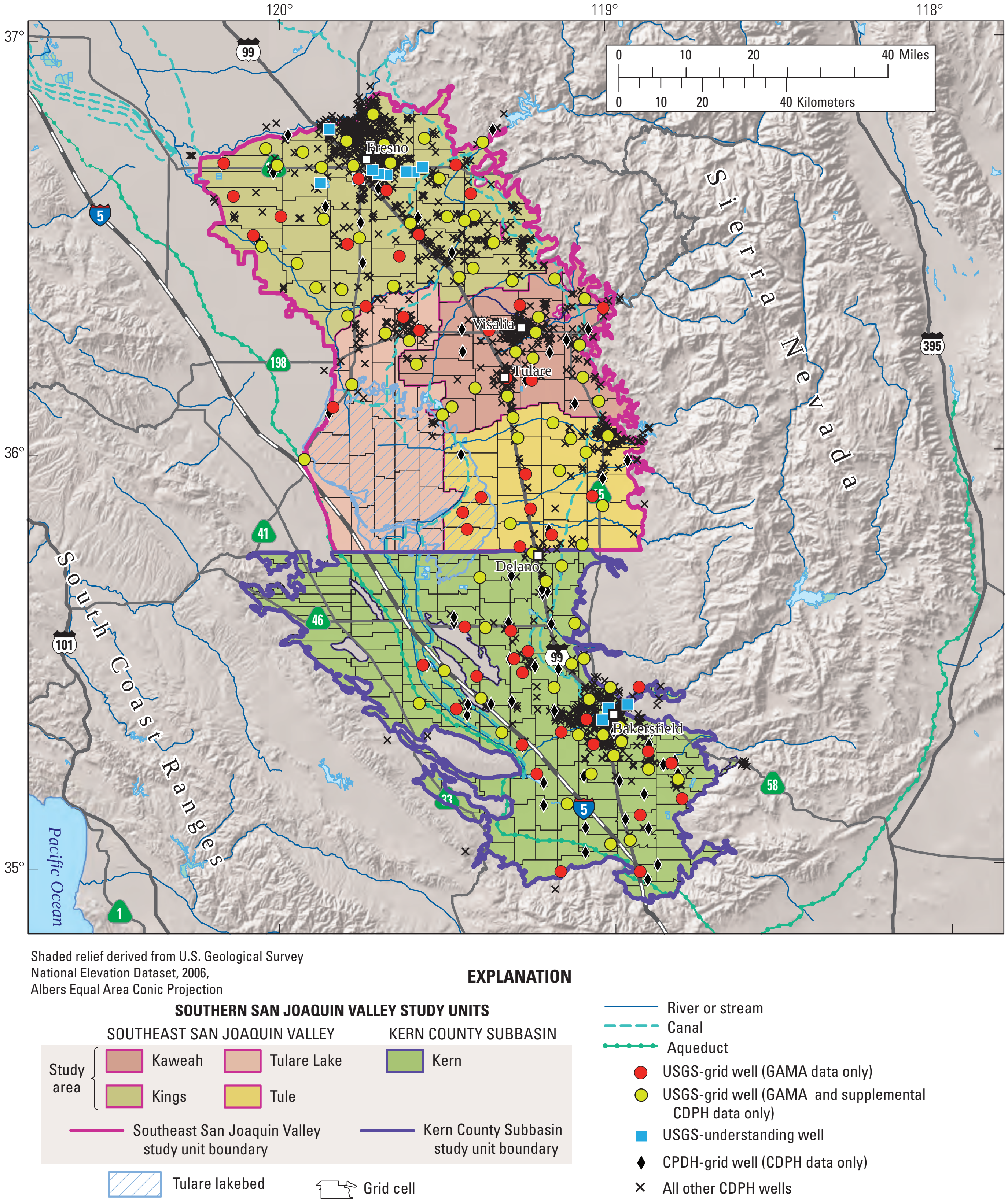
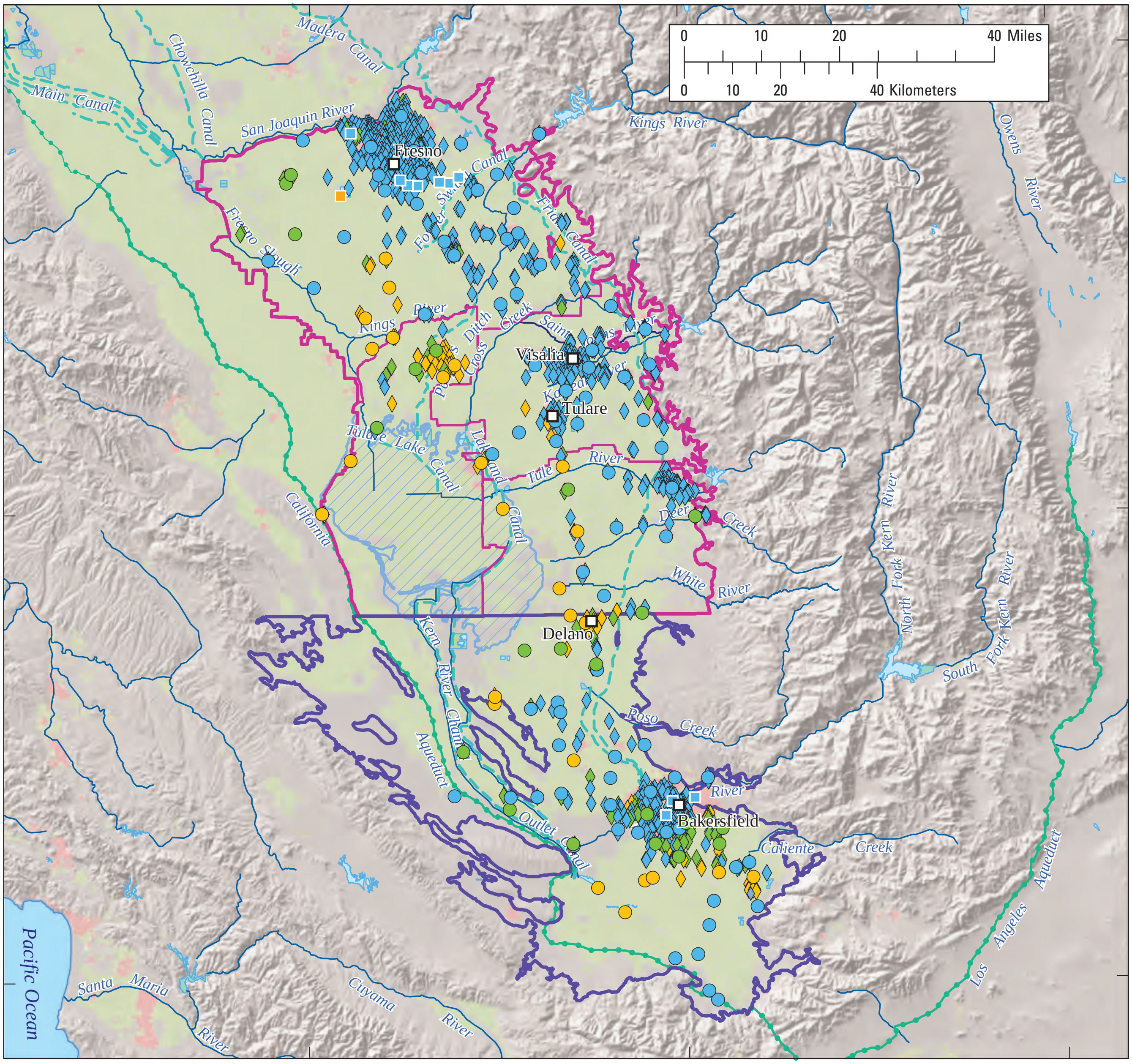


Figure 6. Locations of grid cells, USGS-grid, and USGS-understanding wells sampled during October 2005–March 2006, and California Department of Public Health (CDPH)-grid wells for inorganic constituents, for the two southern San Joaquin Valley study units, California GAMA Priority Basin Project.



Shaded relief derived from U.S. Geological Survey National Elevation Dataset, 2006, Albers Equal Area Conic Projection

Land use from Nakagaki and others, 2007

EXPLANATION

A. Arsenic

LAND-USE CLASSIFICATION

- Urban
- Agricultural
- Natural
- Tulare lakebed

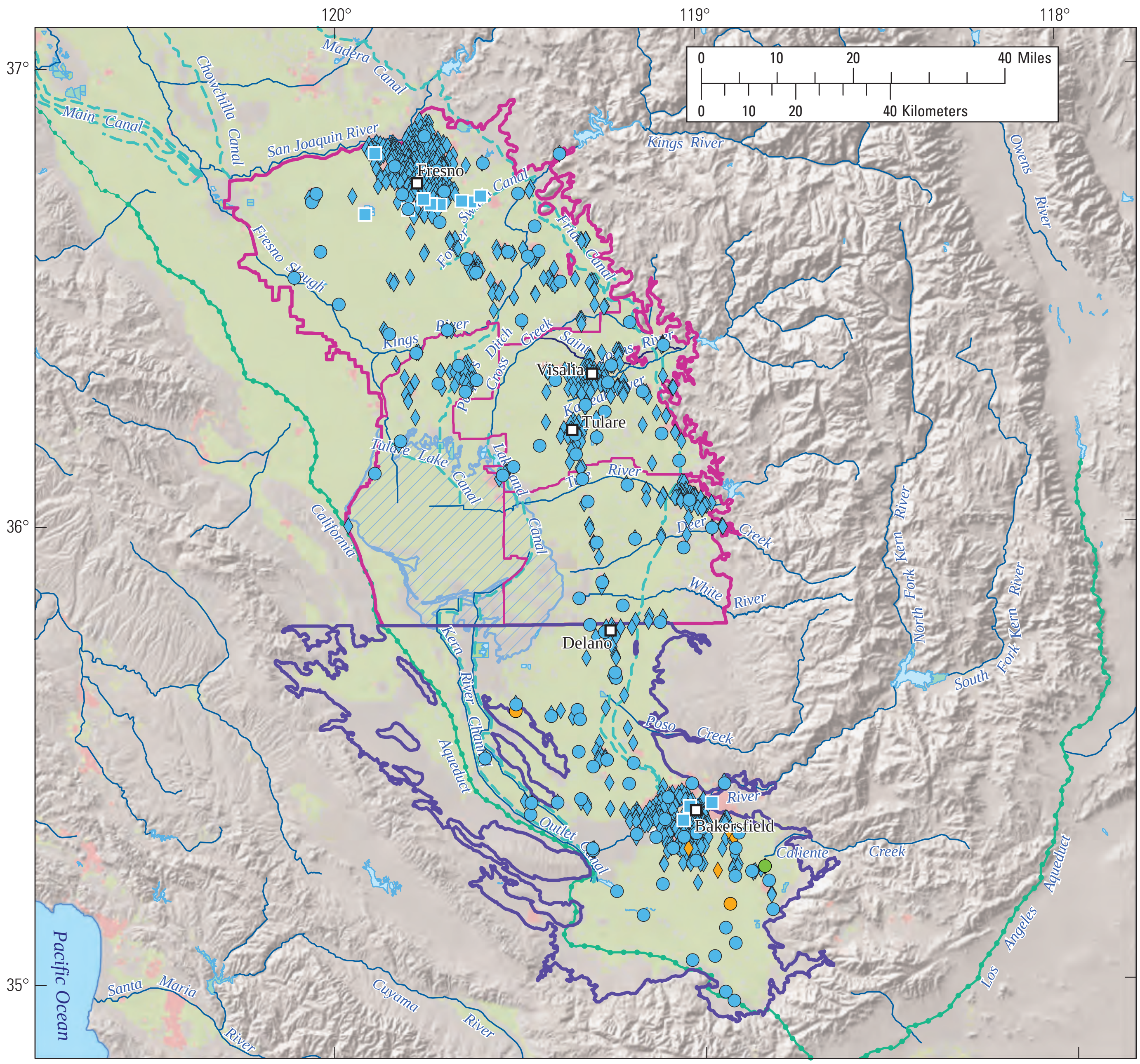
- Southeast San Joaquin Valley study unit boundary
- Kern County Subbasin study unit boundary
- Southeast San Joaquin Valley study area boundary
- River or stream
- Canal
- Aqueduct

ARSENIC, IN MICROGRAMS PER LITER

	USGS- and CDPH-grid well	USGS-understanding well	CDPH-other well
Low	0–5	0–5	0–5
Moderate	5.1–10	5.1–10	5.1–10
High	> 10	> 10	> 10

(> is greater than)

Figure 17. (*A–K*) Relative-concentrations of selected inorganic constituents with human-health-based and aesthetic benchmarks in USGS-grid, CDPH-grid, USGS-understanding wells, and CDPH-other wells in the two southern San Joaquin Valley study units, California GAMA Priority Basin Project.



Shaded relief derived from U.S. Geological Survey National Elevation Dataset, 2006, Albers Equal Area Conic Projection

Land use from Nakagaki and others, 2007

EXPLANATION

B. Antimony

LAND-USE CLASSIFICATION

- Urban
- Agricultural
- Natural
- Tulare lakebed

- Southeast San Joaquin Valley study unit boundary
- Kern County Subbasin study unit boundary
- Southeast San Joaquin Valley study area boundary
- River or stream
- Canal
- Aqueduct

ANTIMONY, IN MICROGRAMS PER LITER

	USGS- and CDPH-grid well	USGS-understanding well	CDPH-other well
Low	0–3.0	0–3.0	0–3.0
Moderate	3.1–6.0	3.1–6.0	3.1–6.0
High	> 6.0	> 6.0	> 6.0

(> is greater than)

Figure 17.—Continued

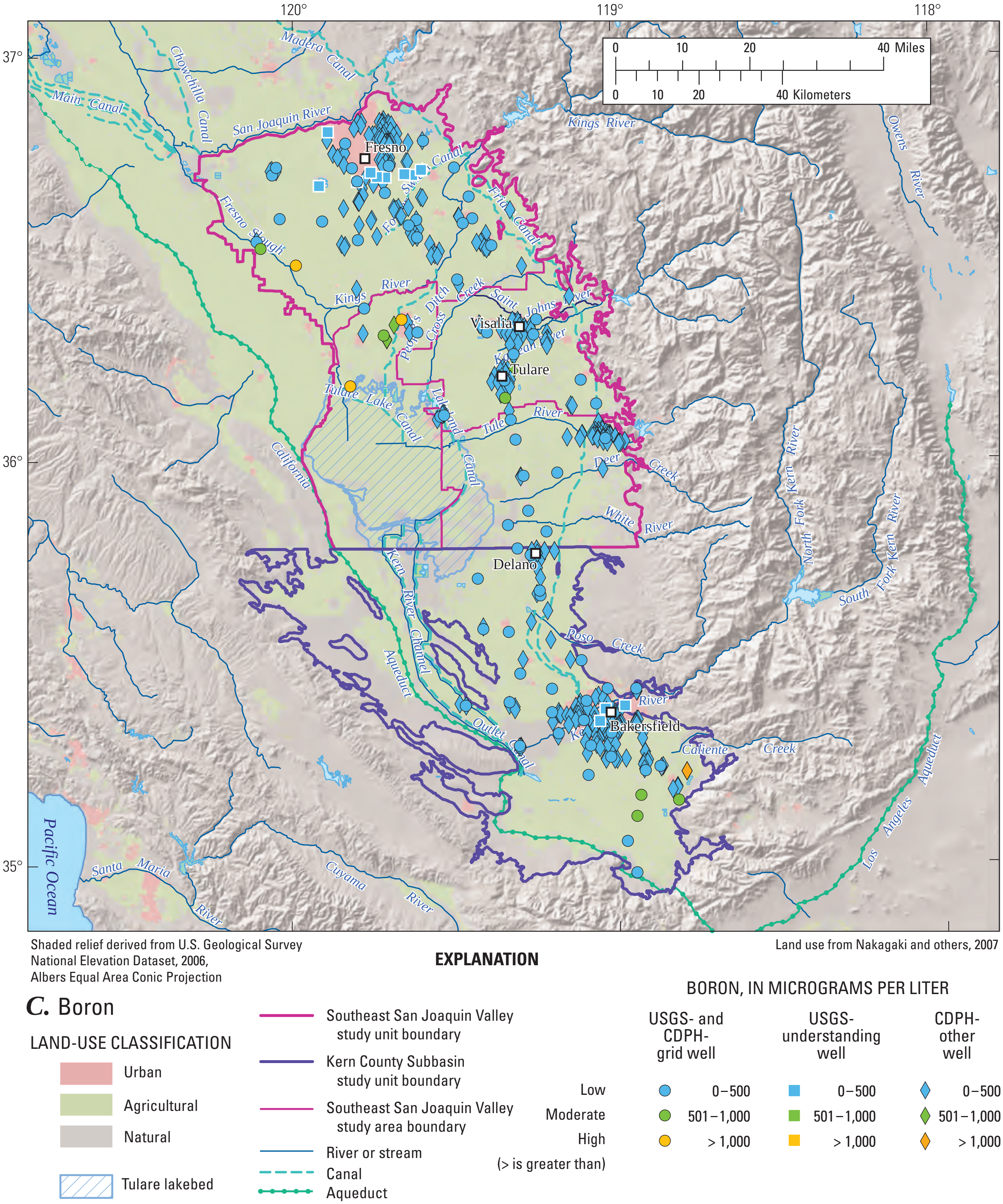
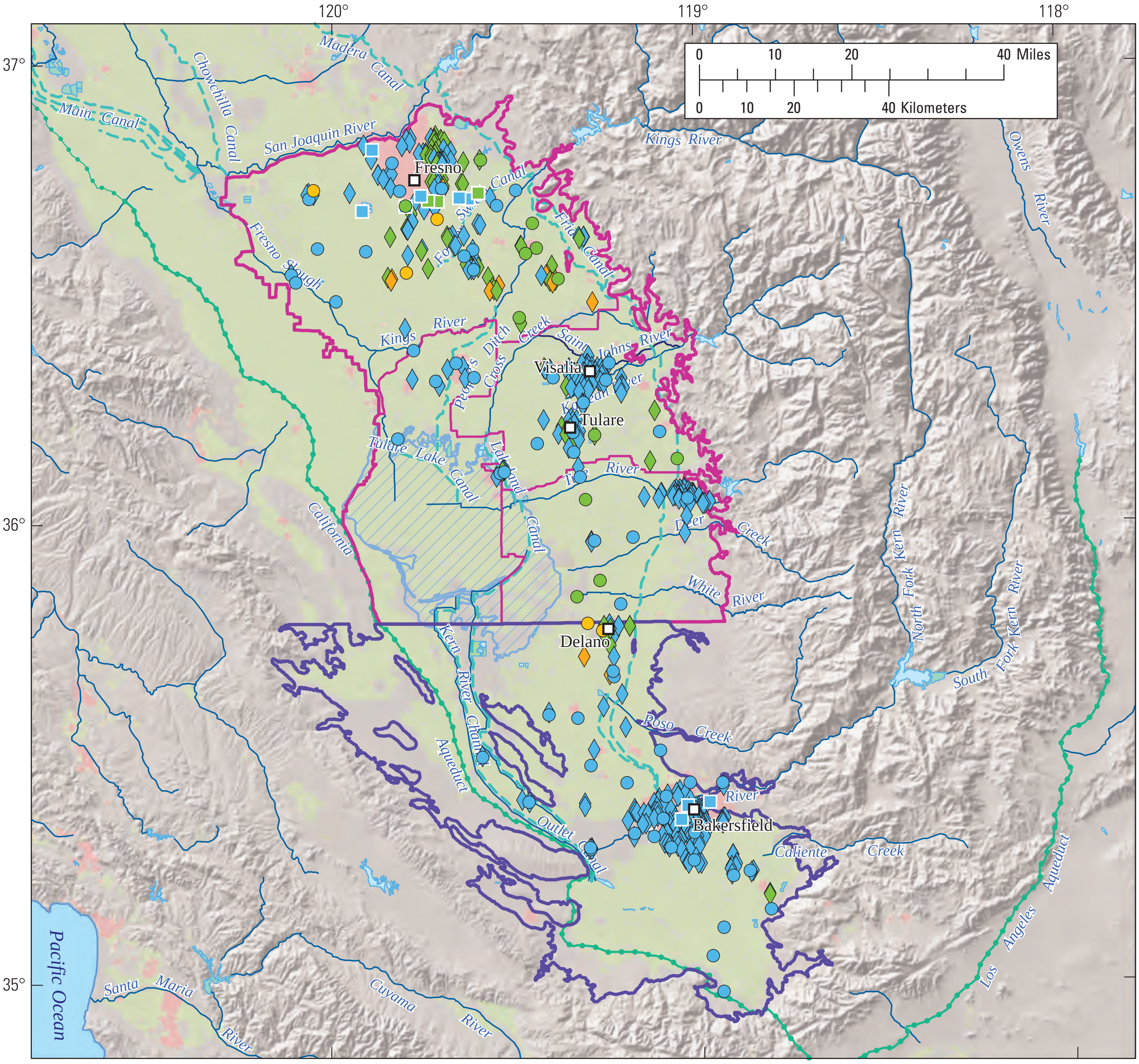


Figure 17.—Continued



Shaded relief derived from U.S. Geological Survey National Elevation Dataset, 2006, Albers Equal Area Conic Projection

Land use from Nakagaki and others, 2007

EXPLANATION

D. Vanadium

LAND-USE CLASSIFICATION

- Urban
- Agricultural
- Natural
- Tulare lakebed

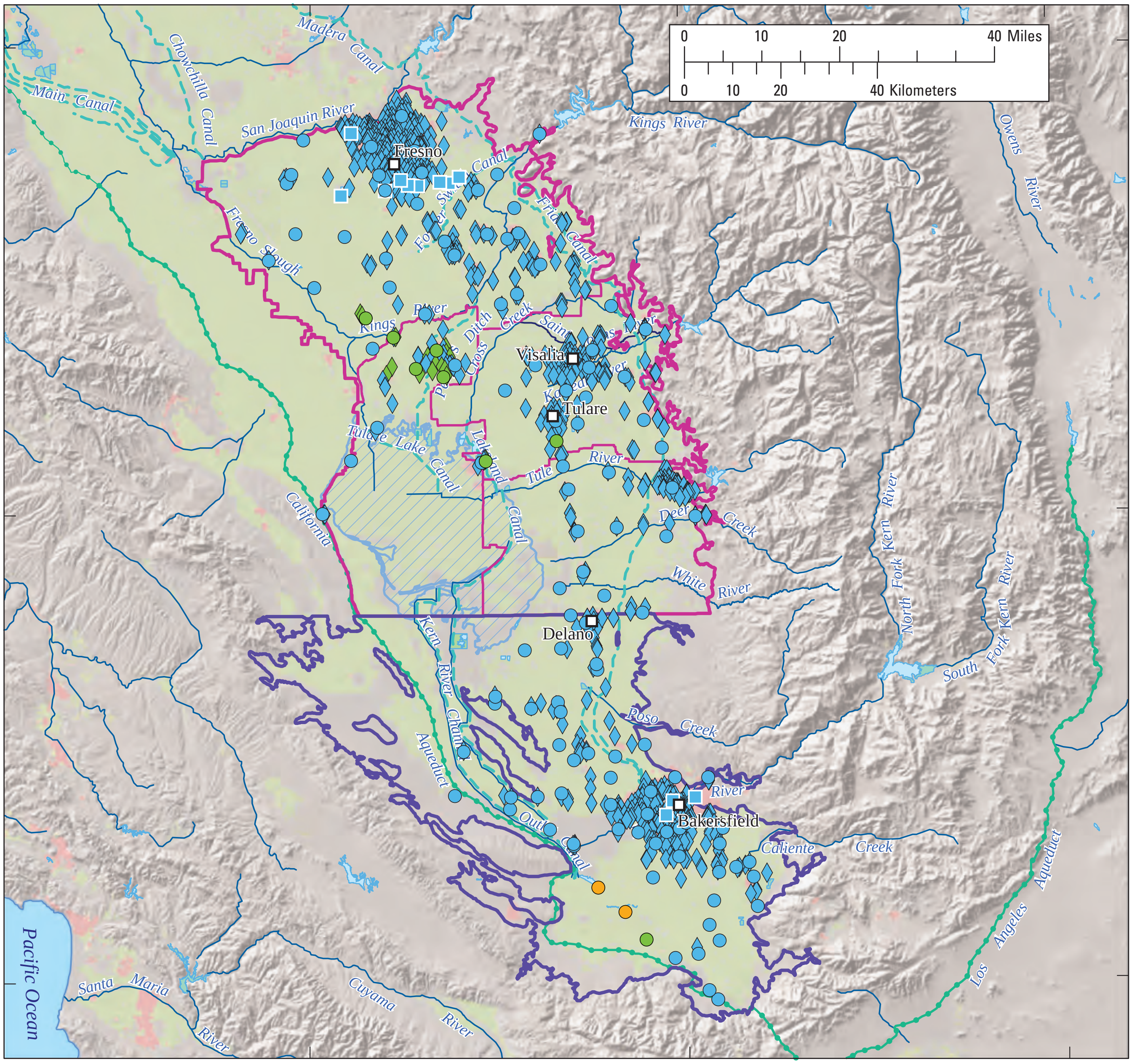
- Southeast San Joaquin Valley study unit boundary
- Kern County Subbasin study unit boundary
- Southeast San Joaquin Valley study area boundary
- River or stream
- Canal
- Aqueduct

VANADIUM, IN MICROGRAMS PER LITER

	USGS- and CDPH-grid well	USGS-understanding well	CDPH-other well
Low	0–25	0–25	0–25
Moderate	25.1–50	25.1–50	25.1–50
High	> 50	> 50	> 50

(> is greater than)

Figure 17.—Continued



Shaded relief derived from U.S. Geological Survey National Elevation Dataset, 2006, Albers Equal Area Conic Projection

Land use from Nakagaki and others, 2007

EXPLANATION

E. Fluoride

LAND-USE CLASSIFICATION

- Urban
- Agricultural
- Natural
- Tulare lakebed

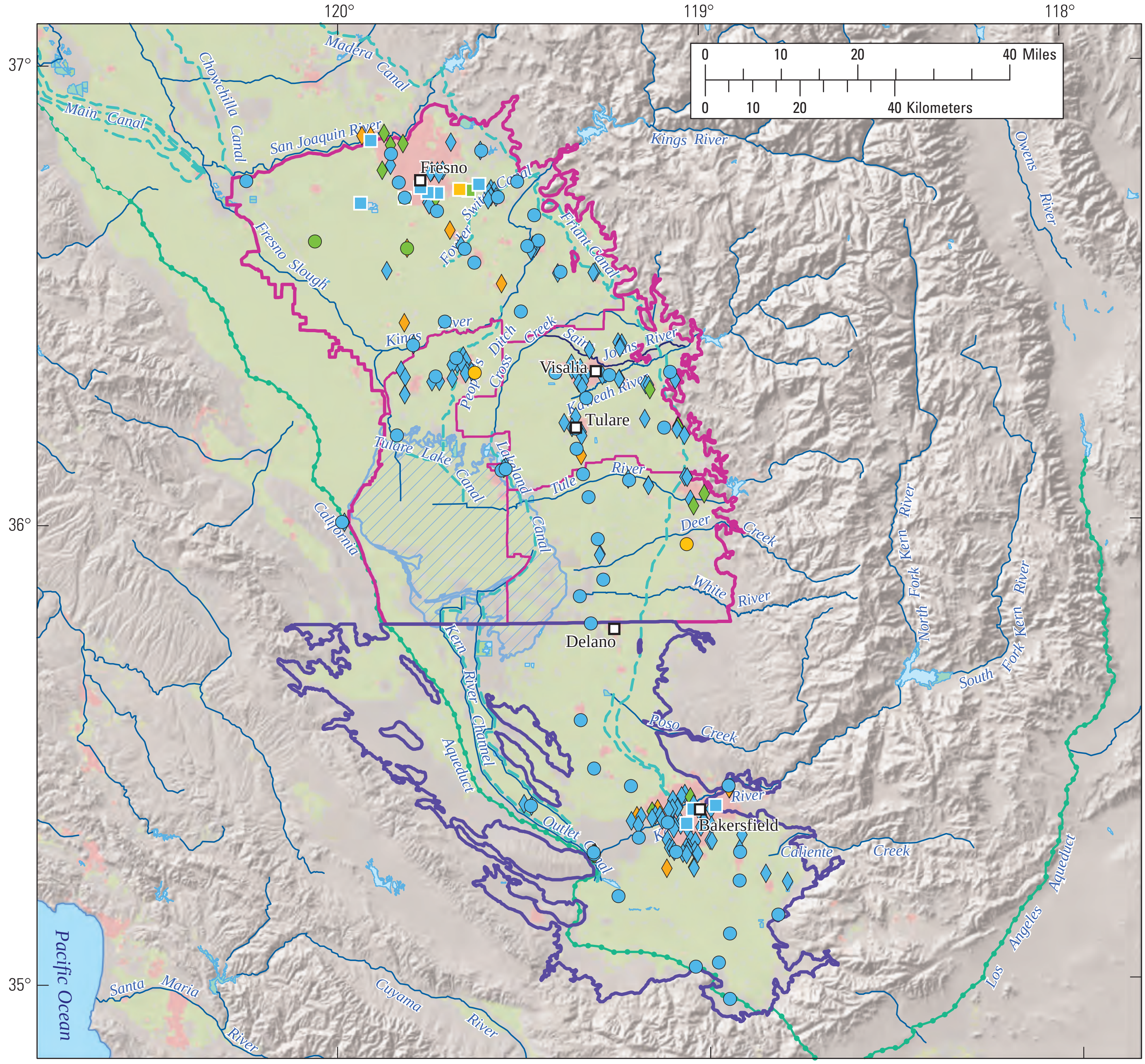
- Southeast San Joaquin Valley study unit boundary
- Kern County Subbasin study unit boundary
- Southeast San Joaquin Valley study area boundary
- River or stream
- Canal
- Aqueduct

FLUORIDE, IN MILLIGRAMS PER LITER

	USGS- and CDPH-grid well	USGS-understanding well	CDPH-other well
Low	0–1.0	0–1.0	0–1.0
Moderate	>1–2.0	>1–2.0	>1–2.0
High	> 2.0	> 2.0	> 2.0

(> is greater than)

Figure 17.—Continued



Shaded relief derived from U.S. Geological Survey National Elevation Dataset, 2006, Albers Equal Area Conic Projection

Land use from Nakagaki and others, 2007

EXPLANATION

F. Uranium

LAND-USE CLASSIFICATION

- Urban
- Agricultural
- Natural
- Tulare lakebed

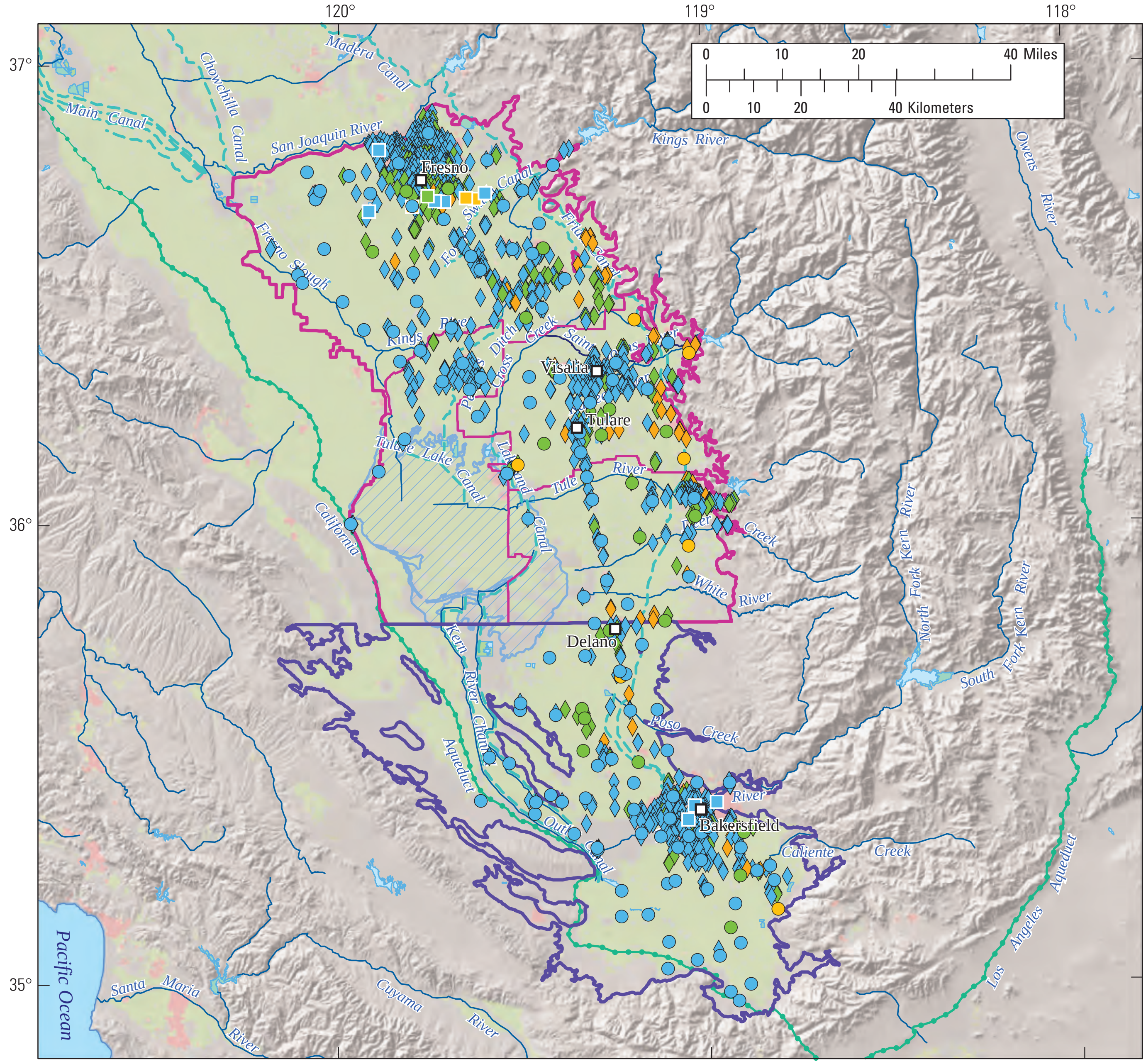
- Southeast San Joaquin Valley study unit boundary
- Kern County Subbasin study unit boundary
- Southeast San Joaquin Valley study area boundary
- River or stream
- Canal
- Aqueduct

URANIUM, IN MICROGRAMS PER LITER

	USGS- and CDPH- grid well	USGS- understanding well	CDPH- other well
Low	0–15	0–15	0–15
Moderate	15.1–30	15.1–30	15.1–30
High	> 30	> 30	> 30

(> is greater than)

Figure 17.—Continued



Shaded relief derived from U.S. Geological Survey National Elevation Dataset, 2006, Albers Equal Area Conic Projection

Land use from Nakagaki and others, 2007

EXPLANATION

G. Nitrate as nitrogen

LAND-USE CLASSIFICATION

- Urban
- Agricultural
- Natural
- Tulare lakebed

- Southeast San Joaquin Valley study unit boundary
- Kern County Subbasin study unit boundary
- Southeast San Joaquin Valley study area boundary
- River or stream
- Canal
- Aqueduct

NITRATE AS NITROGEN, IN MILLIGRAMS PER LITER

	USGS- and CDPH-grid well	USGS-understanding well	CDPH-other well
Low	0–5	0–5	0–5
Moderate	5.1–10	5.1–10	5.1–10
High	> 10	> 10	> 10

(> is greater than)

Figure 17.—Continued

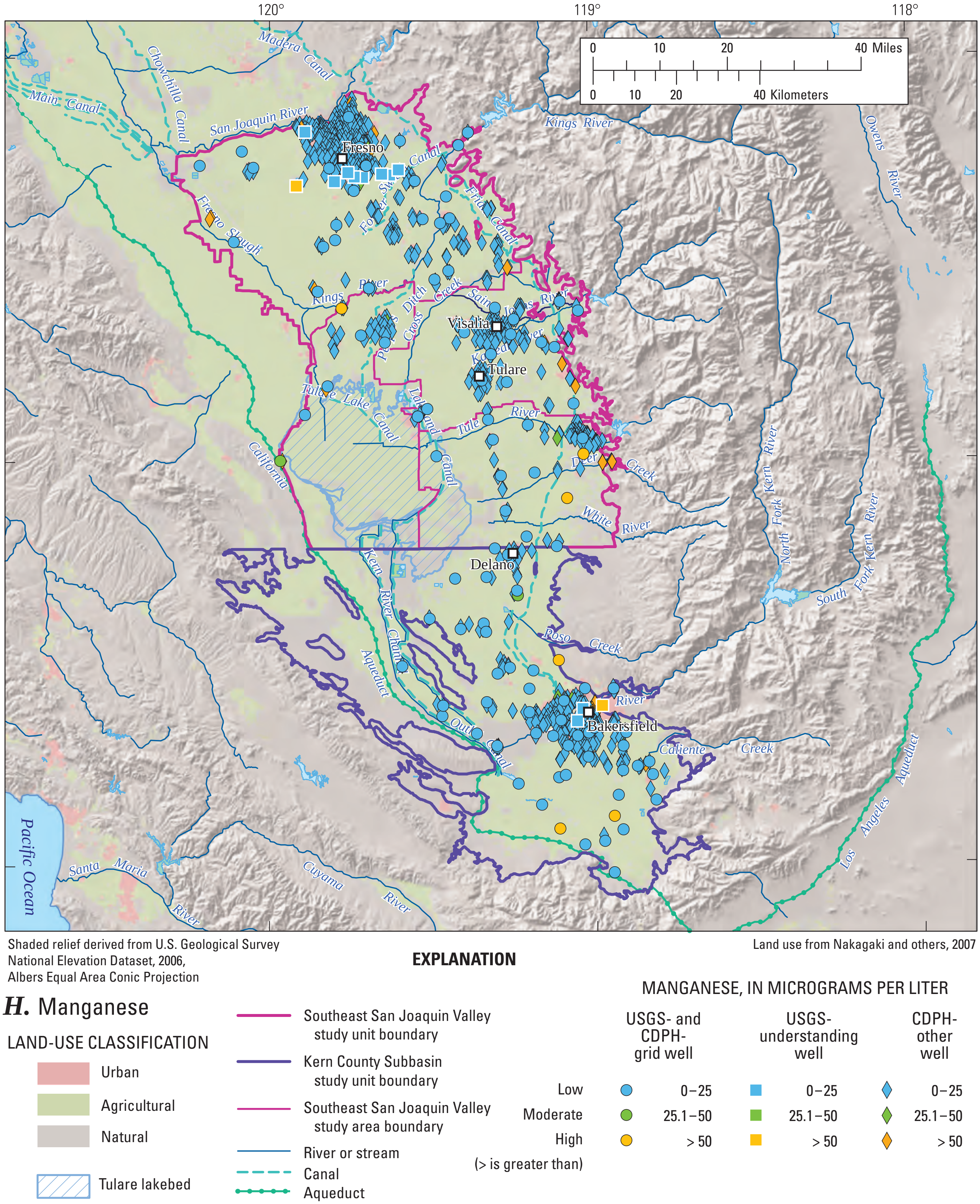
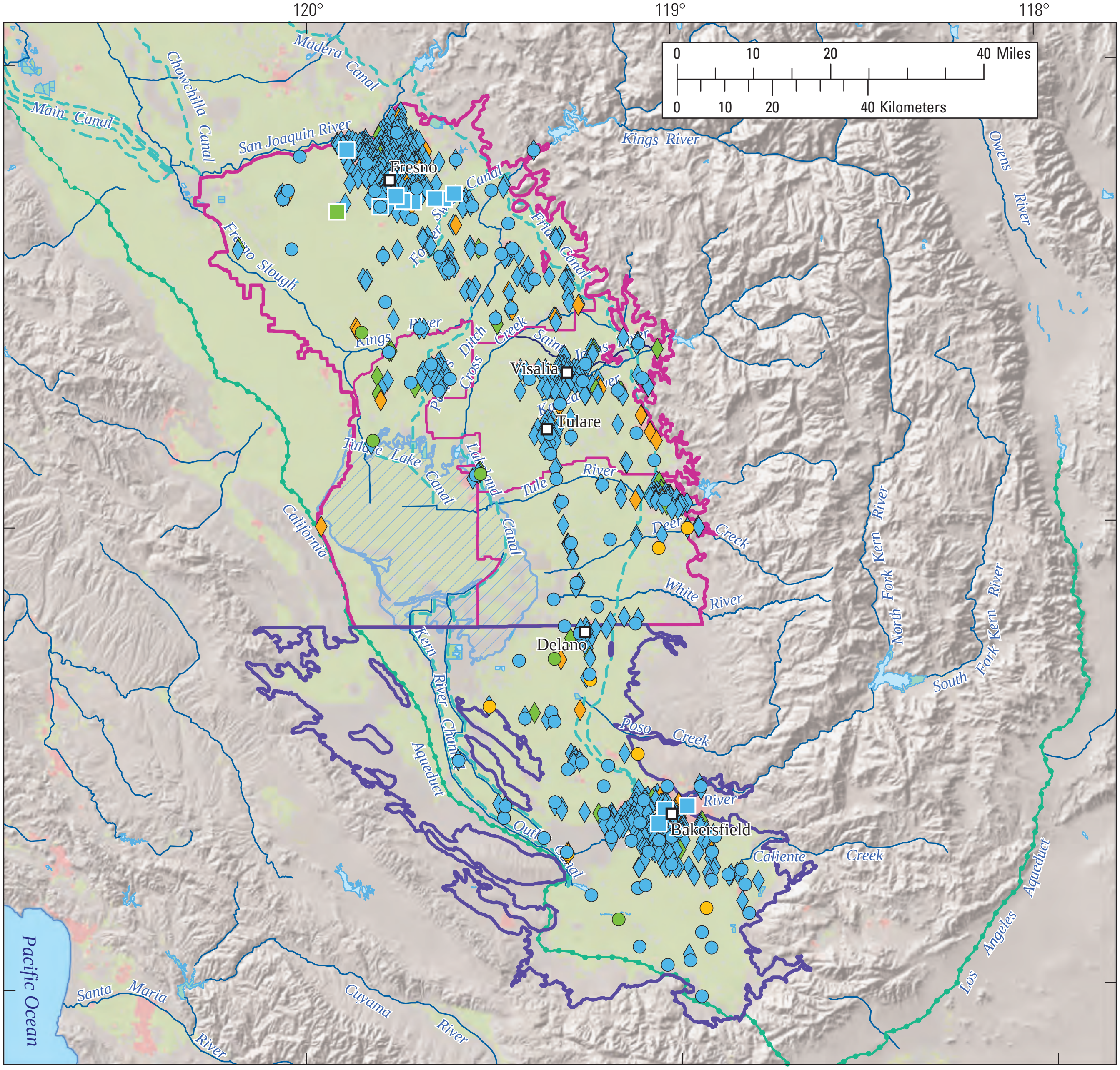


Figure 17.—Continued



Shaded relief derived from U.S. Geological Survey National Elevation Dataset, 2006, Albers Equal Area Conic Projection

Land use from Nakagaki and others, 2007

EXPLANATION

I. Iron

LAND-USE CLASSIFICATION

- Urban
- Agricultural
- Natural
- Tulare lakebed

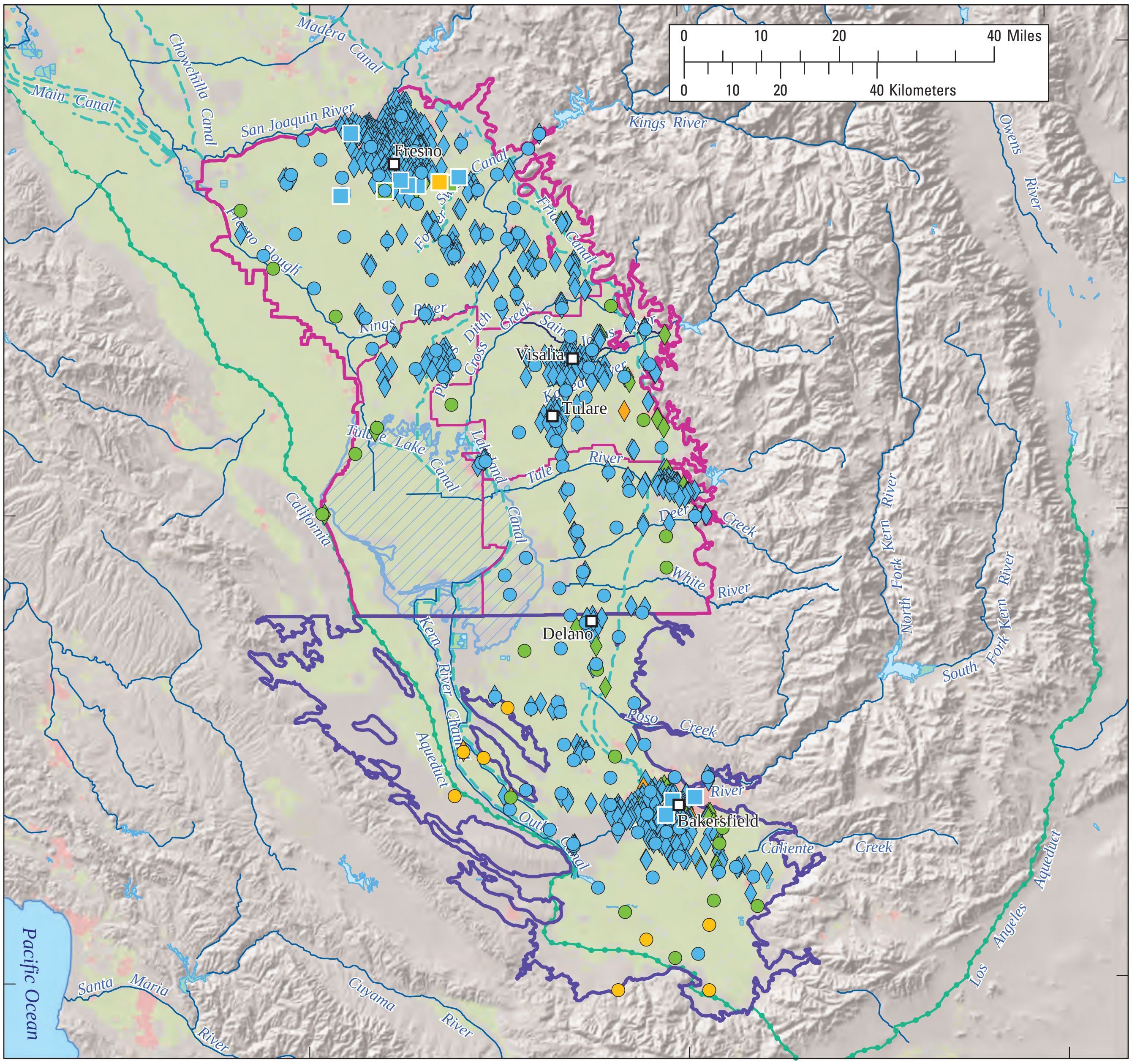
- Southeast San Joaquin Valley study unit boundary
- Kern County Subbasin study unit boundary
- Southeast San Joaquin Valley study area boundary
- River or stream
- Canal
- Aqueduct

IRON, IN MICROGRAMS PER LITER

	USGS- and CDPH-grid well	USGS-understanding well	CDPH-other well
Low	0–150	0–150	0–150
Moderate	151–300	151–300	151–300
High	> 300	> 300	> 300

(> is greater than)

Figure 17.—Continued



Shaded relief derived from U.S. Geological Survey National Elevation Dataset, 2006, Albers Equal Area Conic Projection

Land use from Nakagaki and others, 2007

EXPLANATION

J. Total dissolved solids

LAND-USE CLASSIFICATION

- Urban
- Agricultural
- Natural
- Tulare lakebed

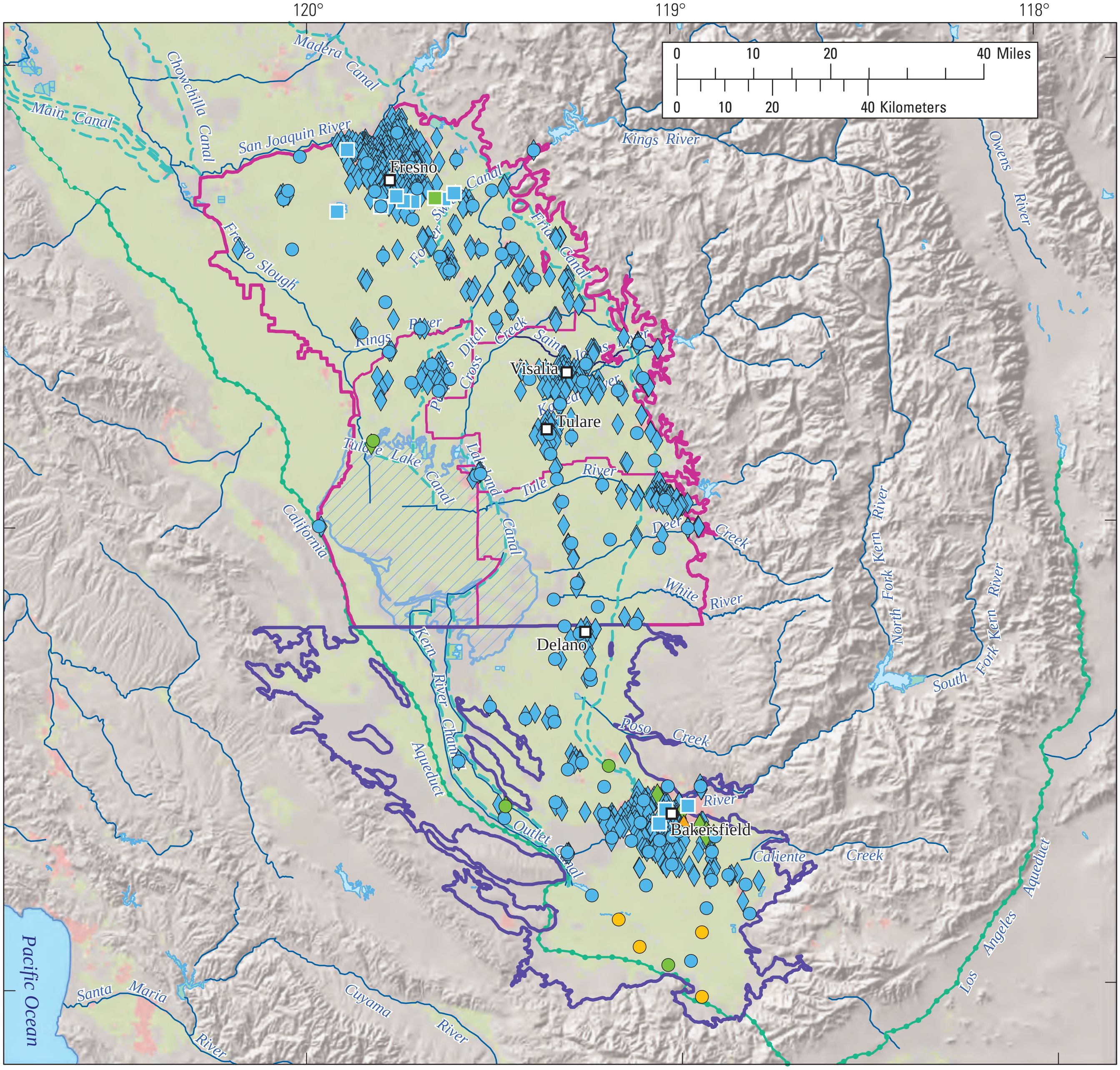
- Southeast San Joaquin Valley study unit boundary
- Kern County Subbasin study unit boundary
- Southeast San Joaquin Valley study area boundary
- River or stream
- Canal
- Aqueduct

TOTAL DISSOLVED SOLIDS (TDS), IN MILLIGRAMS PER LITER

	USGS- and CDPH-grid well	USGS-understanding well	CDPH-other well
Low	0–500	0–500	0–500
Moderate	501–1,000	501–1,000	501–1,000
High	> 1,000	> 1,000	> 1,000

(> is greater than)

Figure 17.—Continued



Shaded relief derived from U.S. Geological Survey National Elevation Dataset, 2006, Albers Equal Area Conic Projection

Land use from Nakagaki and others, 2007

EXPLANATION

K. Sulfate

LAND-USE CLASSIFICATION

- Urban
- Agricultural
- Natural
- Tulare lakebed

- Southeast San Joaquin Valley study unit boundary
- Kern County Subbasin study unit boundary
- Southeast San Joaquin Valley study area boundary
- River or stream
- Canal
- Aqueduct

SULFATE, IN MILLIGRAMS PER LITER

	USGS- and CDPH-grid well	USGS-understanding well	CDPH-other well
Low	0–250	0–250	0–250
Moderate	251–500	251–500	251–500
High	> 500	> 500	> 500

(> is greater than)

Figure 17.—Continued

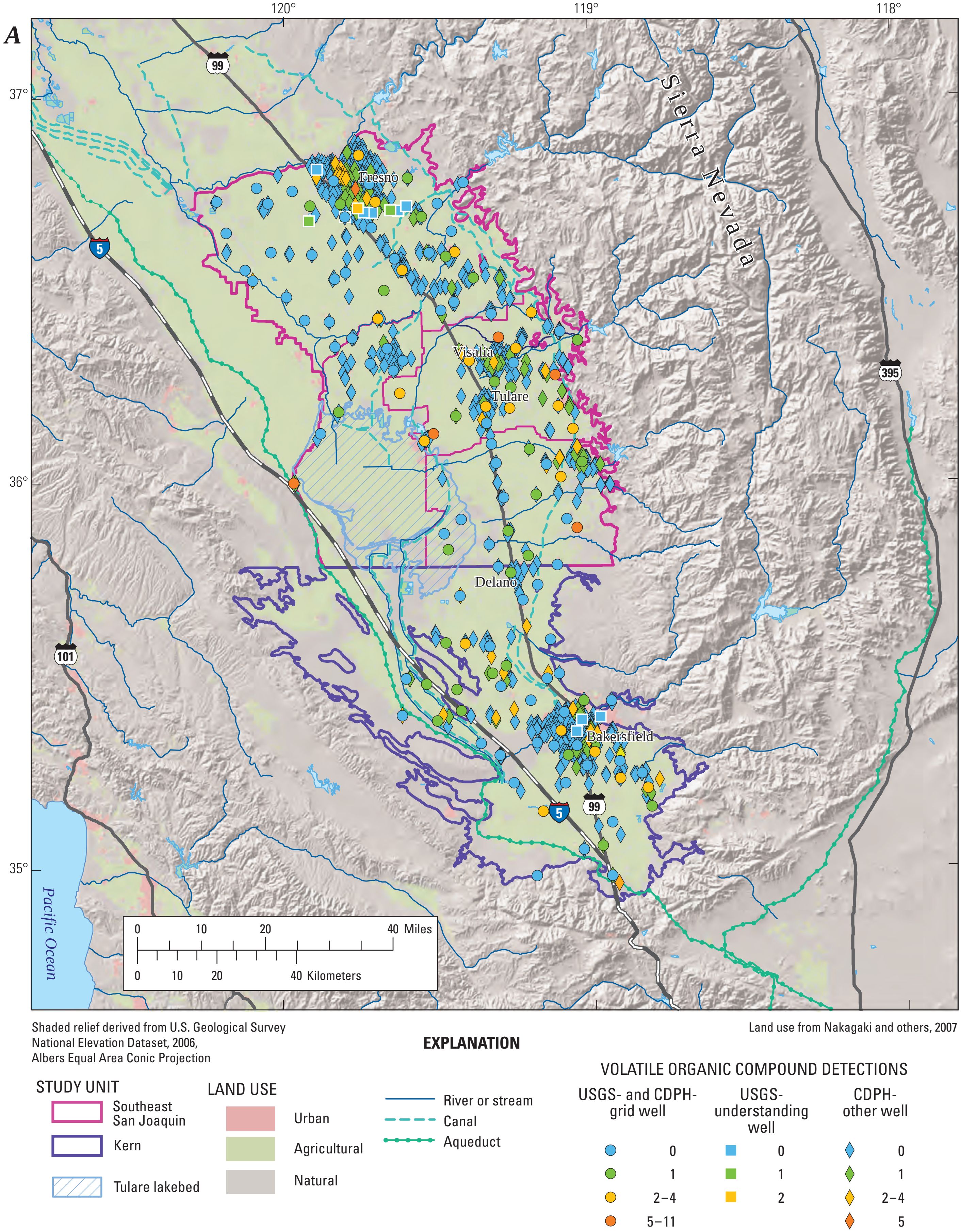


Figure 24. *(A)* Number of volatile organic compound (VOC) detections, (*B*) relative-concentrations of DBCP, (*C*) number of pesticide detections, and (*D*) relative-concentration of perchlorate in USGS-grid wells, USGS-understanding wells, and CDPH-other wells in the two southern San Joaquin Valley study units, California GAMA Priority Basin Project.

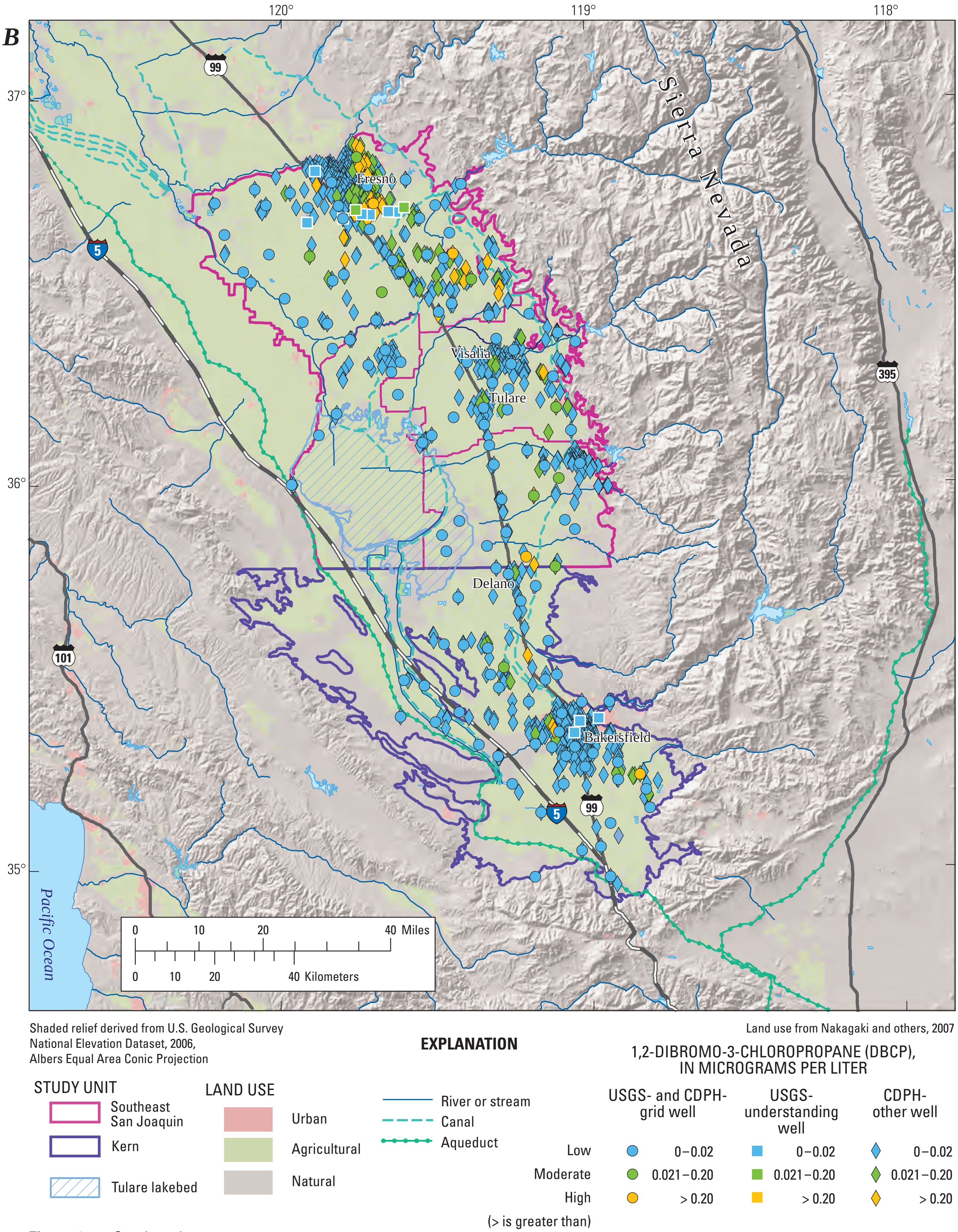


Figure 24.—Continued

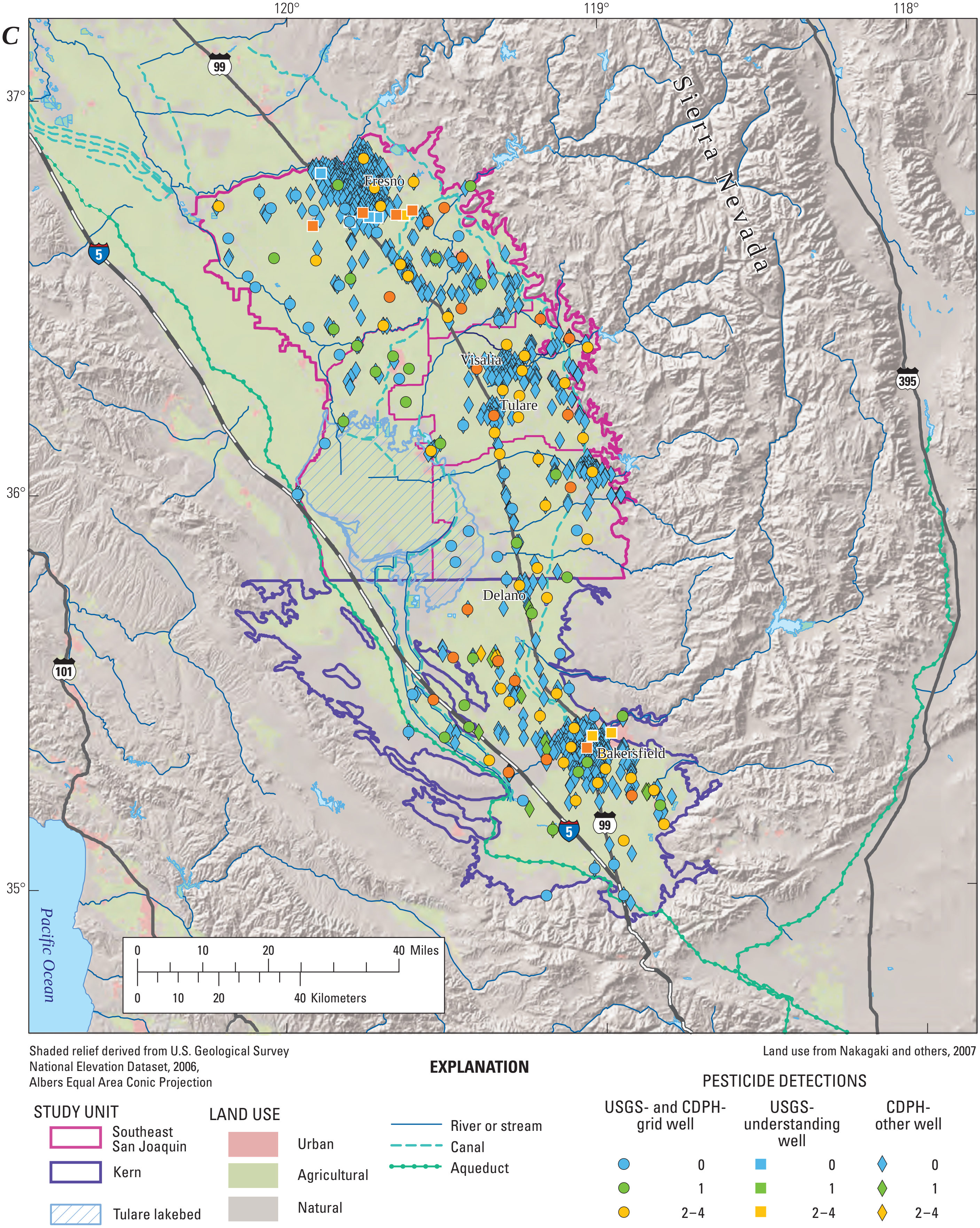


Figure 24.—Continued

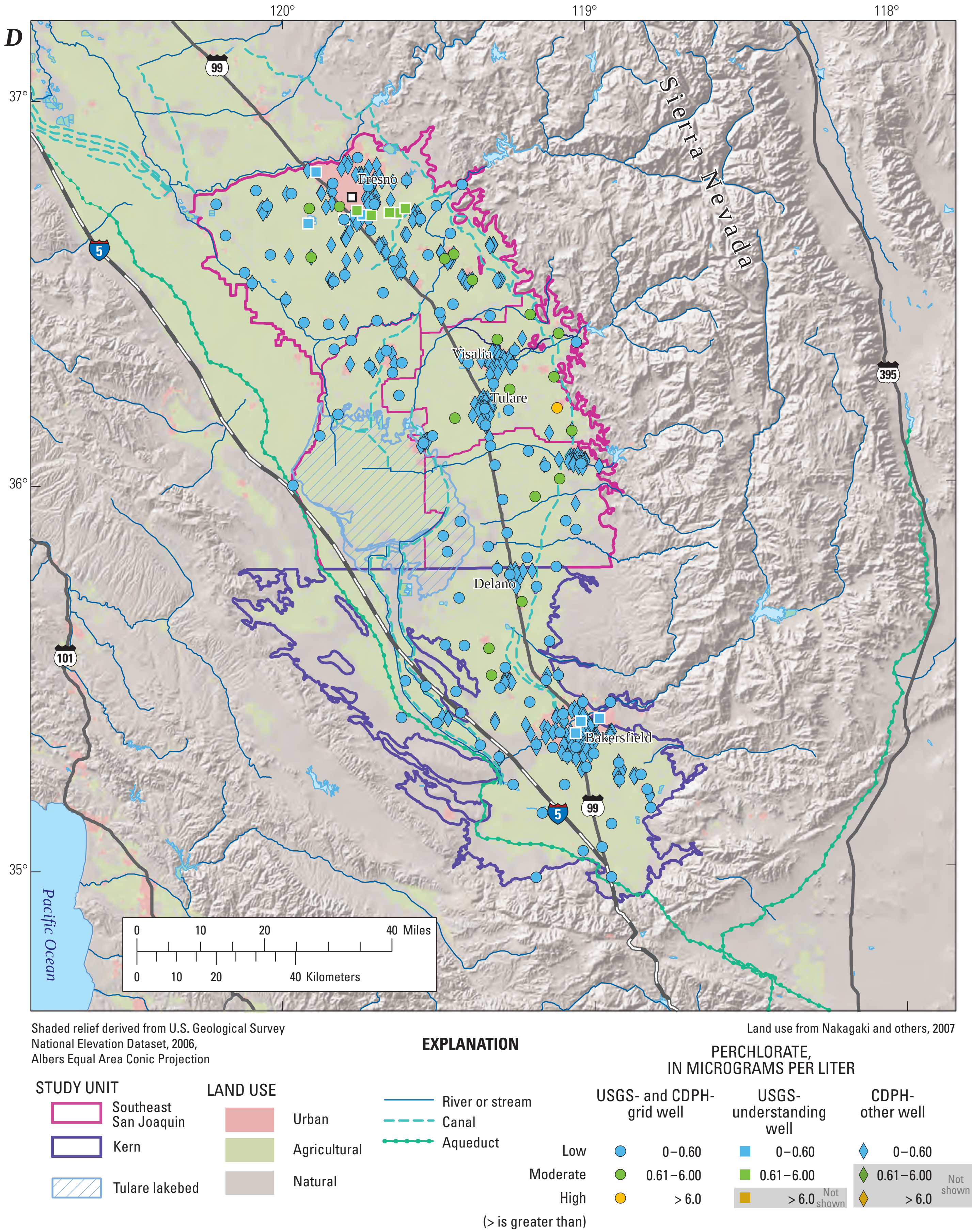


Figure 24.—Continued

Appendix F.4

Hagan (2001)

THE EFFECTS OF THE WHITE WOLF FAULT ON GROUNDWATER HYDROLOGY IN THE SOUTHERN SAN JOAQUIN VALLEY, CALIFORNIA

THESIS

Presented to the Faculty of the School of Arts and Sciences

of California State University, Bakersfield

in Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Geology

Karin Hagan

B.S. 1997, California State University, Bakersfield

December 2001

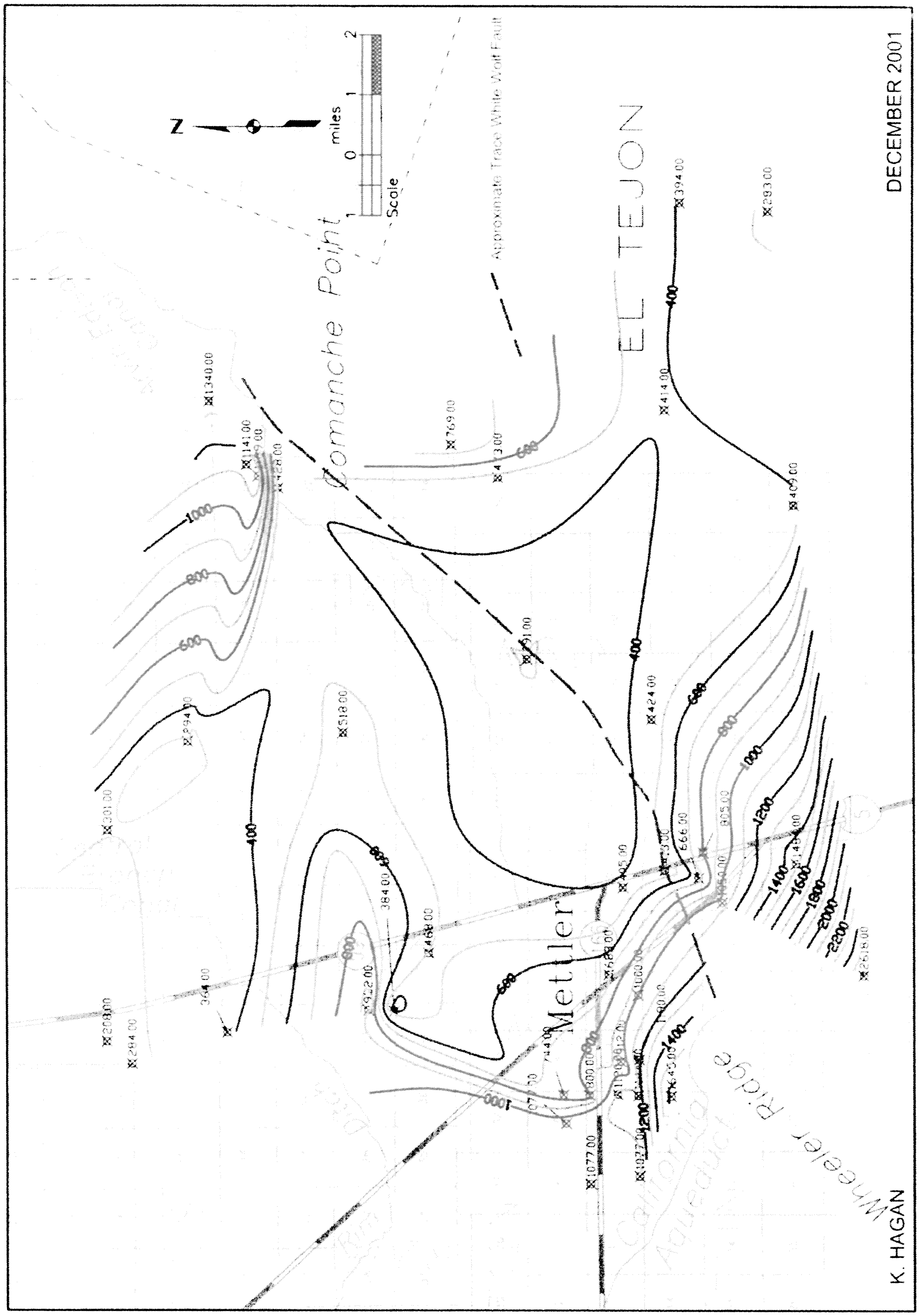


Figure 37. Total Dissolved Solids contour map for 1950-1959. Contour Interval is 100 mg/L.

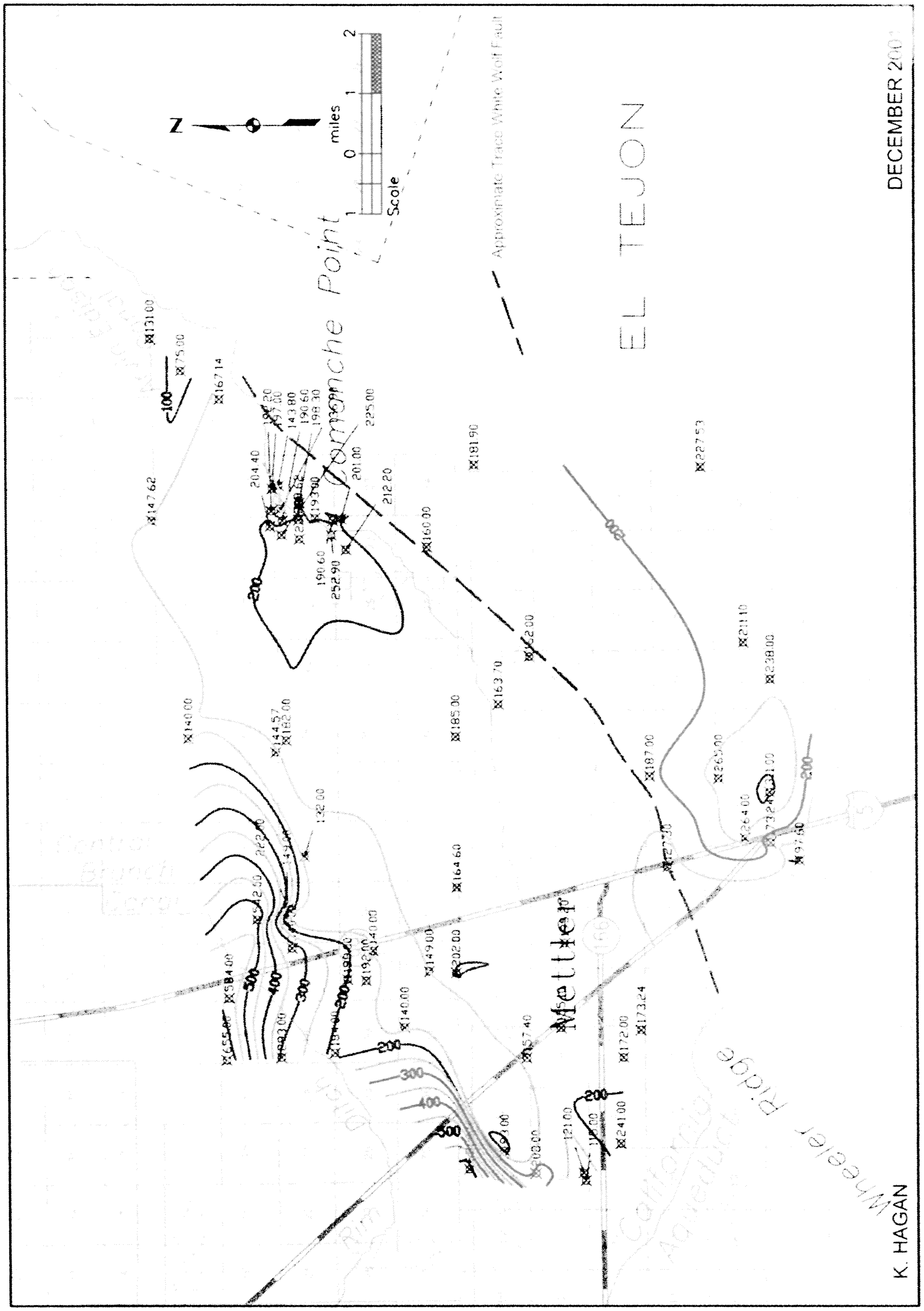


Figure 39. Bicarbonate concentrations contour map for 1970-1979. Contour Interval is 50 mg/L.

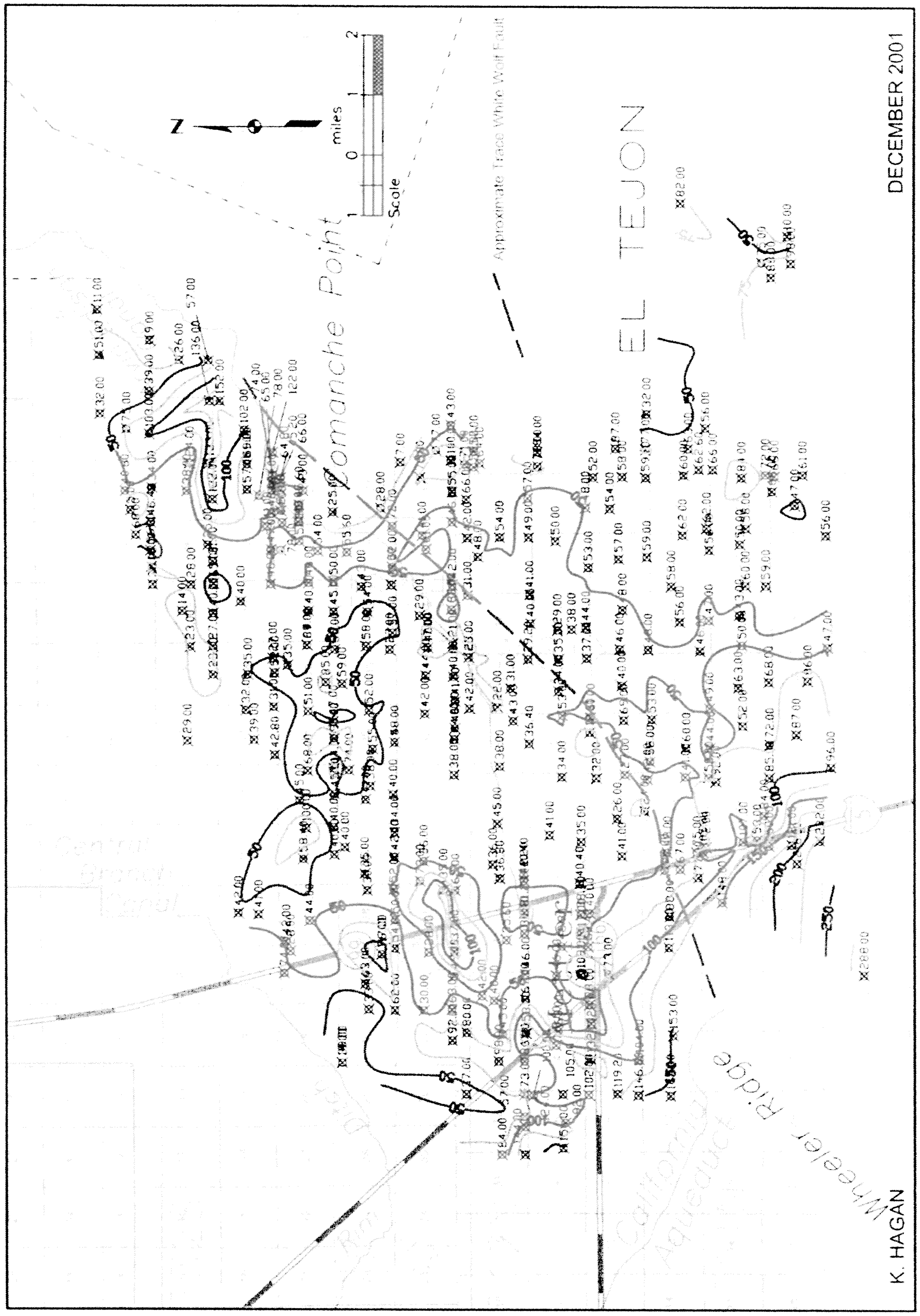


Figure 40. Calcium concentration contour map for 1960-1969. Contour Interval is 25 mg/L.

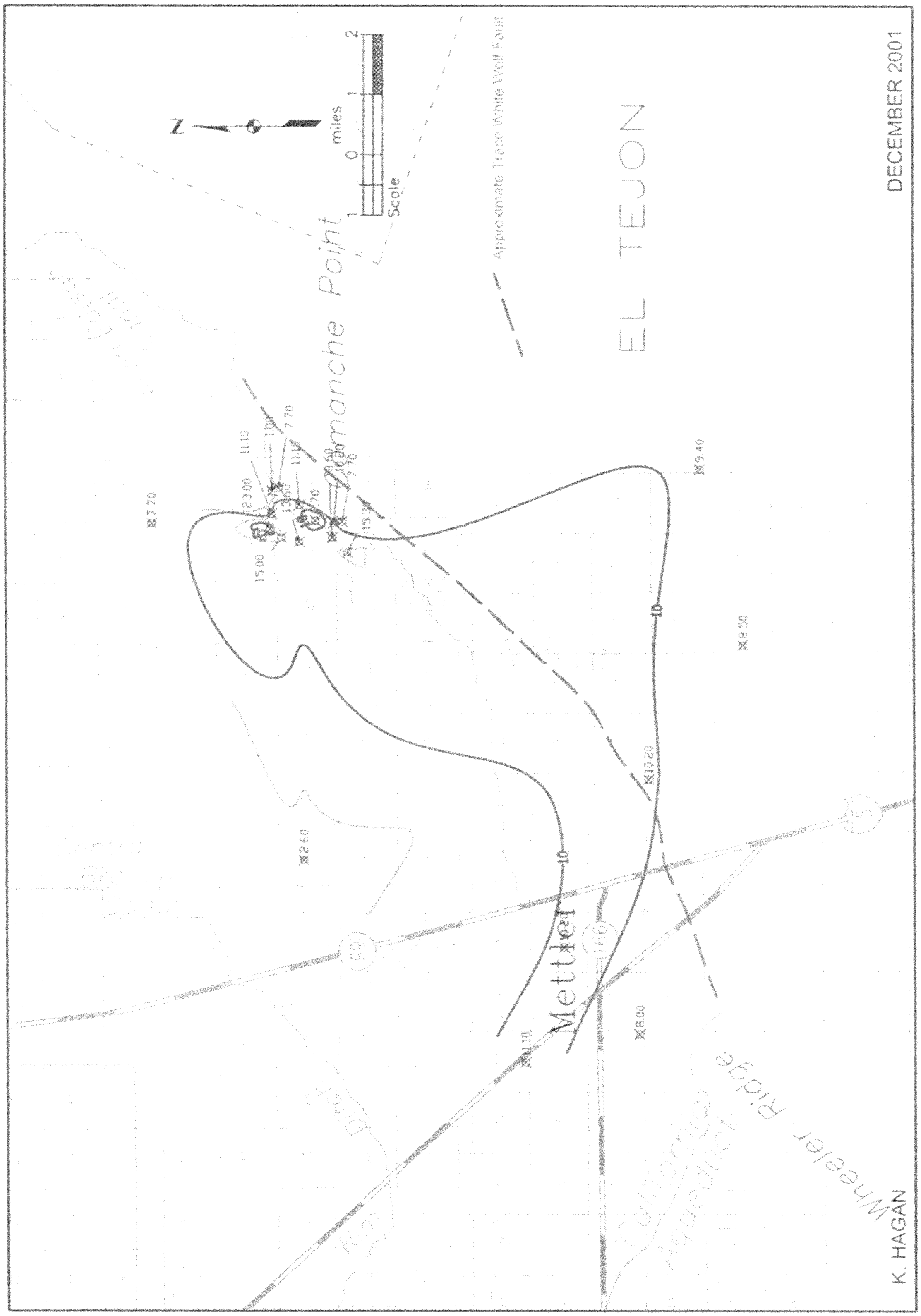


Figure 41. Carbonate concentration contour map for 1970-1979. Contour Interval is 5 mg/L.

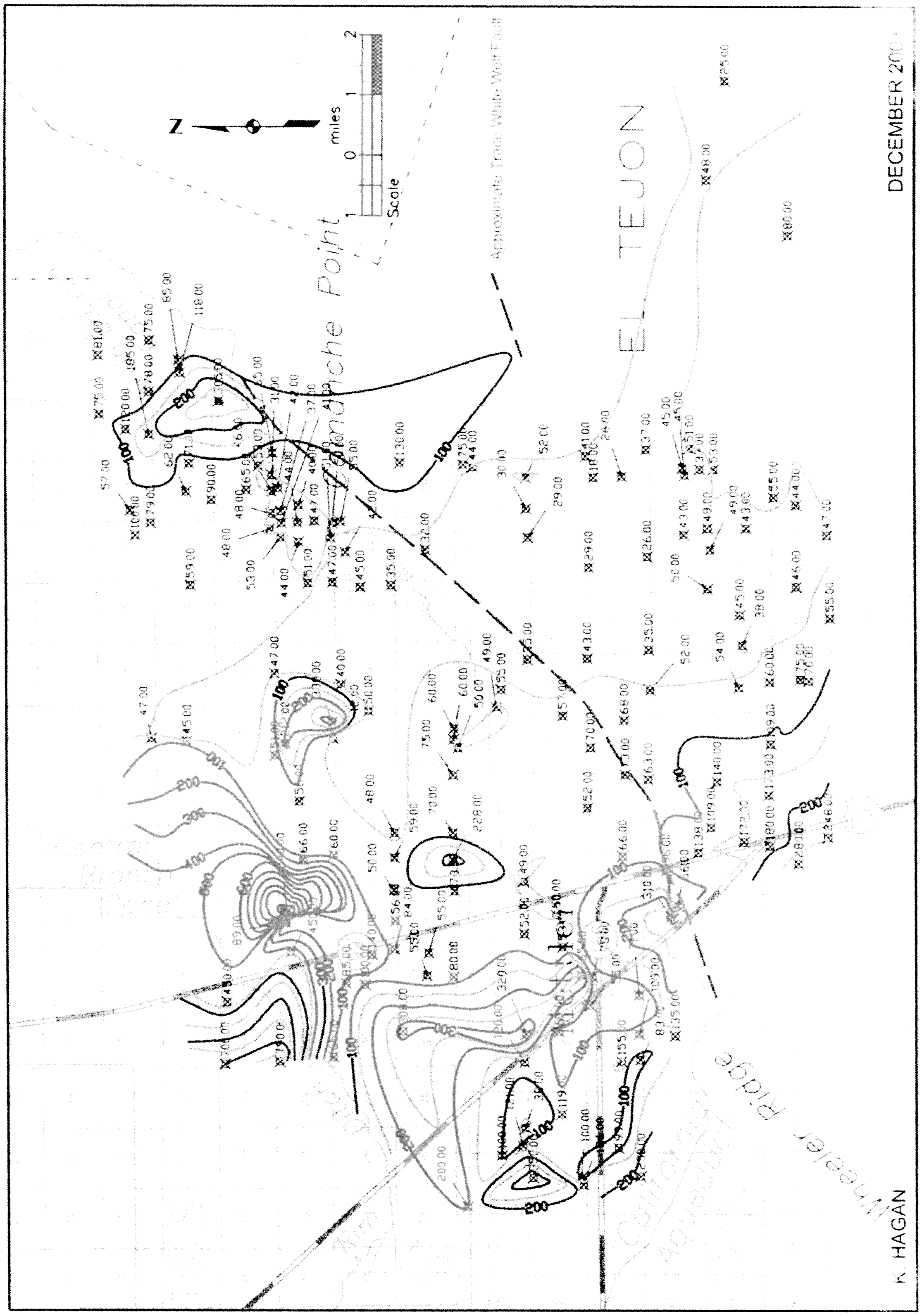


Figure 42. Sodium concentration contour map for 1970-1979. Contour Interval is 50 mg/L.

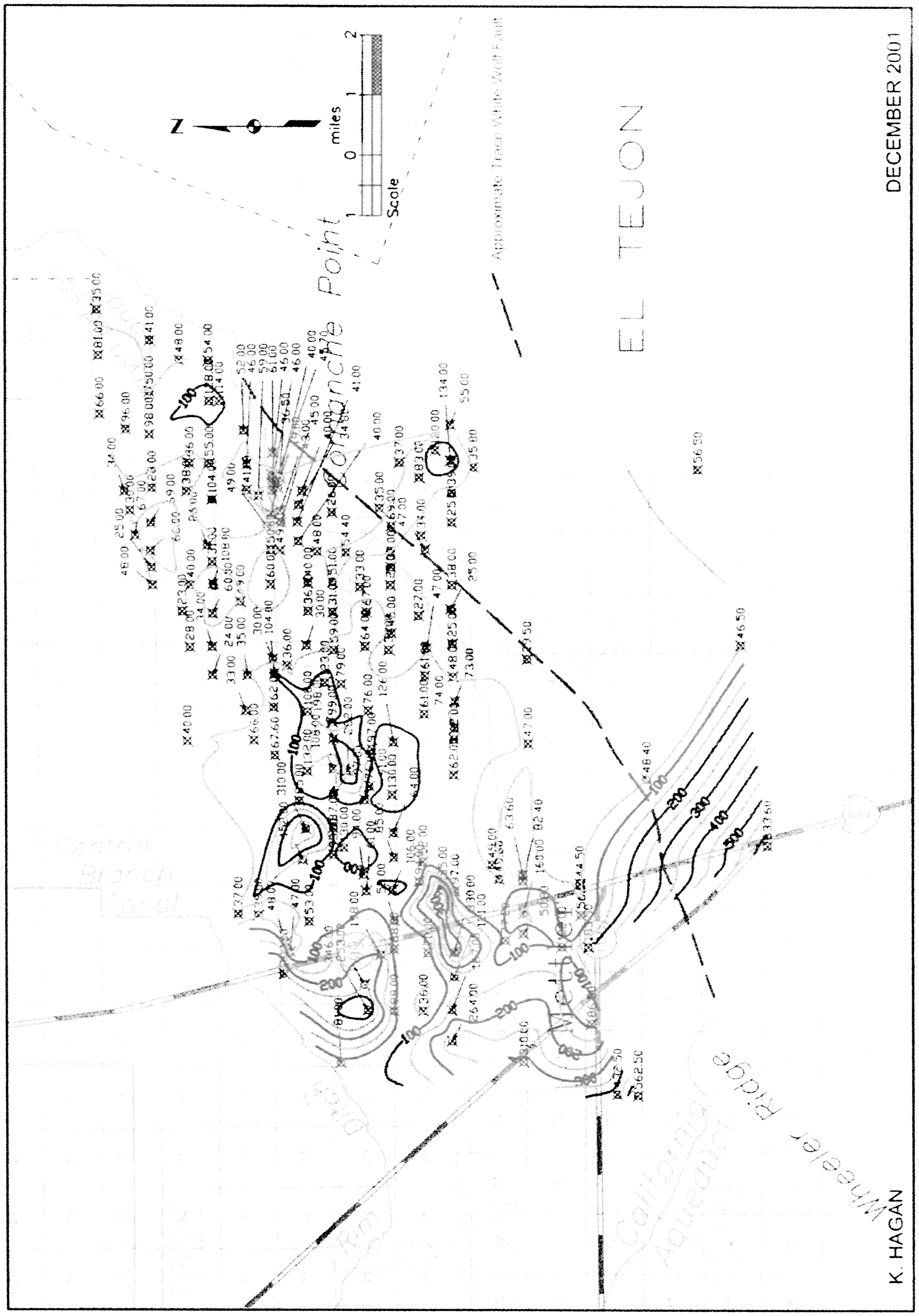


Figure 43. Sulfate concentration contour map for 1960-1969. Contour Interval is 50 mg/L.

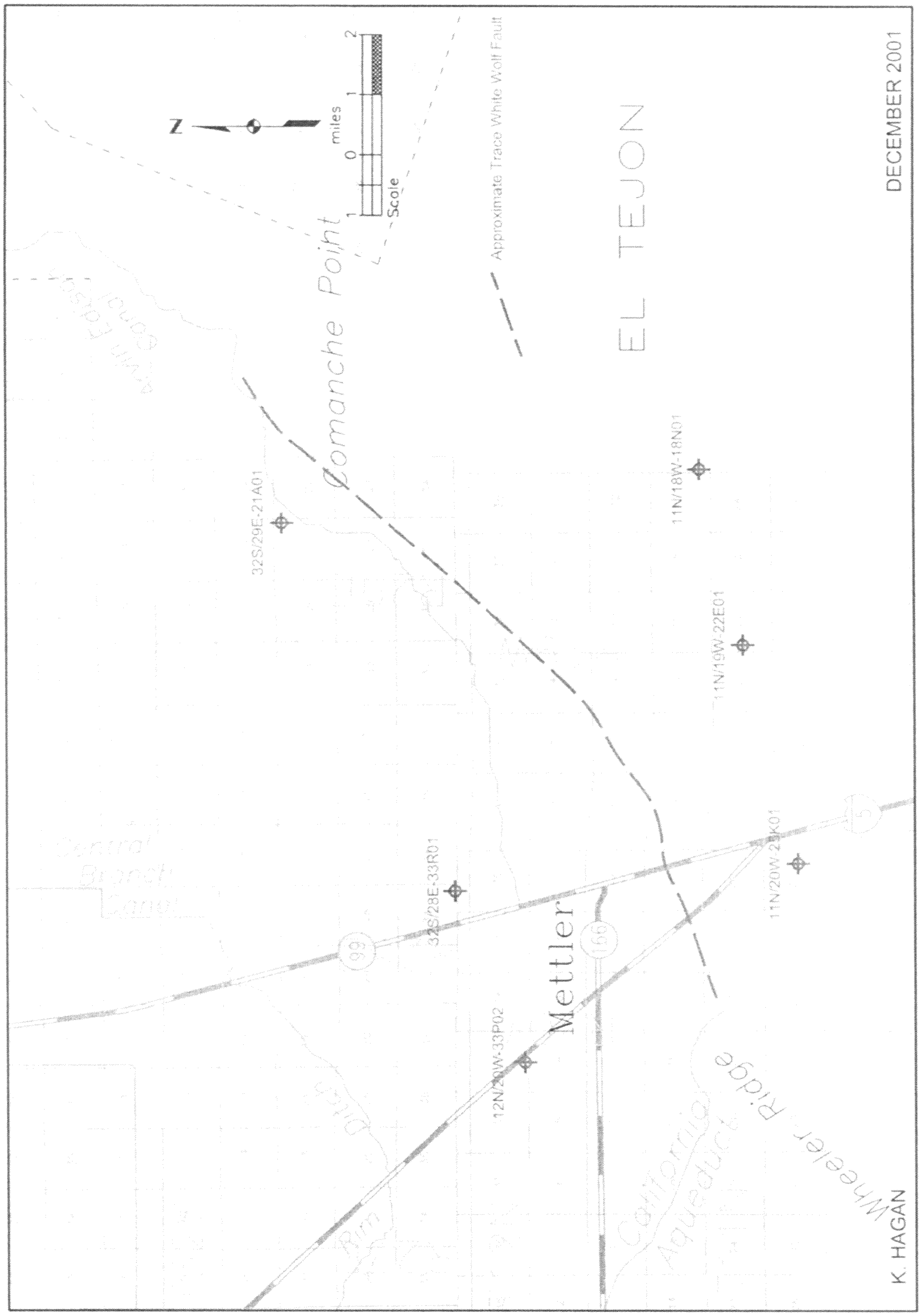
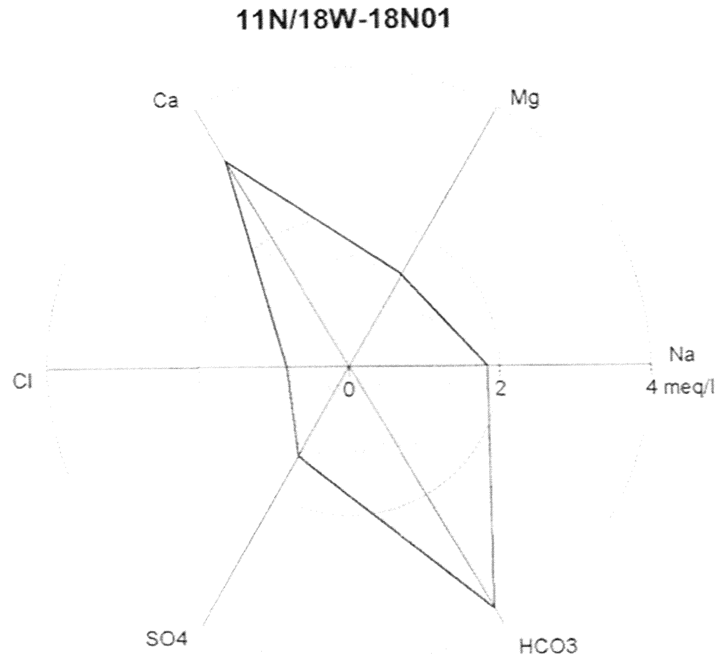


Figure 44. Location of wells selected for in-depth water quality analysis.

1979



1986

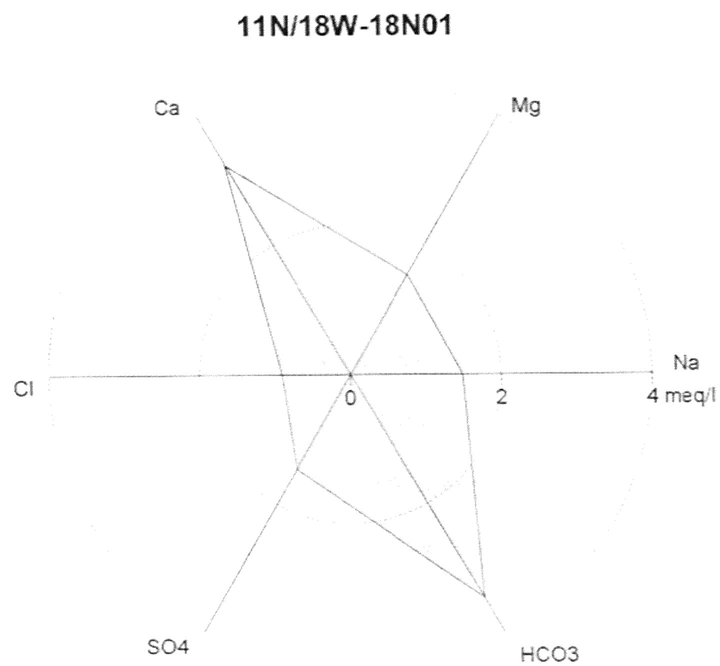


Figure 45. Radial plots of groundwater quality in well T11N/R18W-18N01 on July 5, 1979 and July 23, 1986.

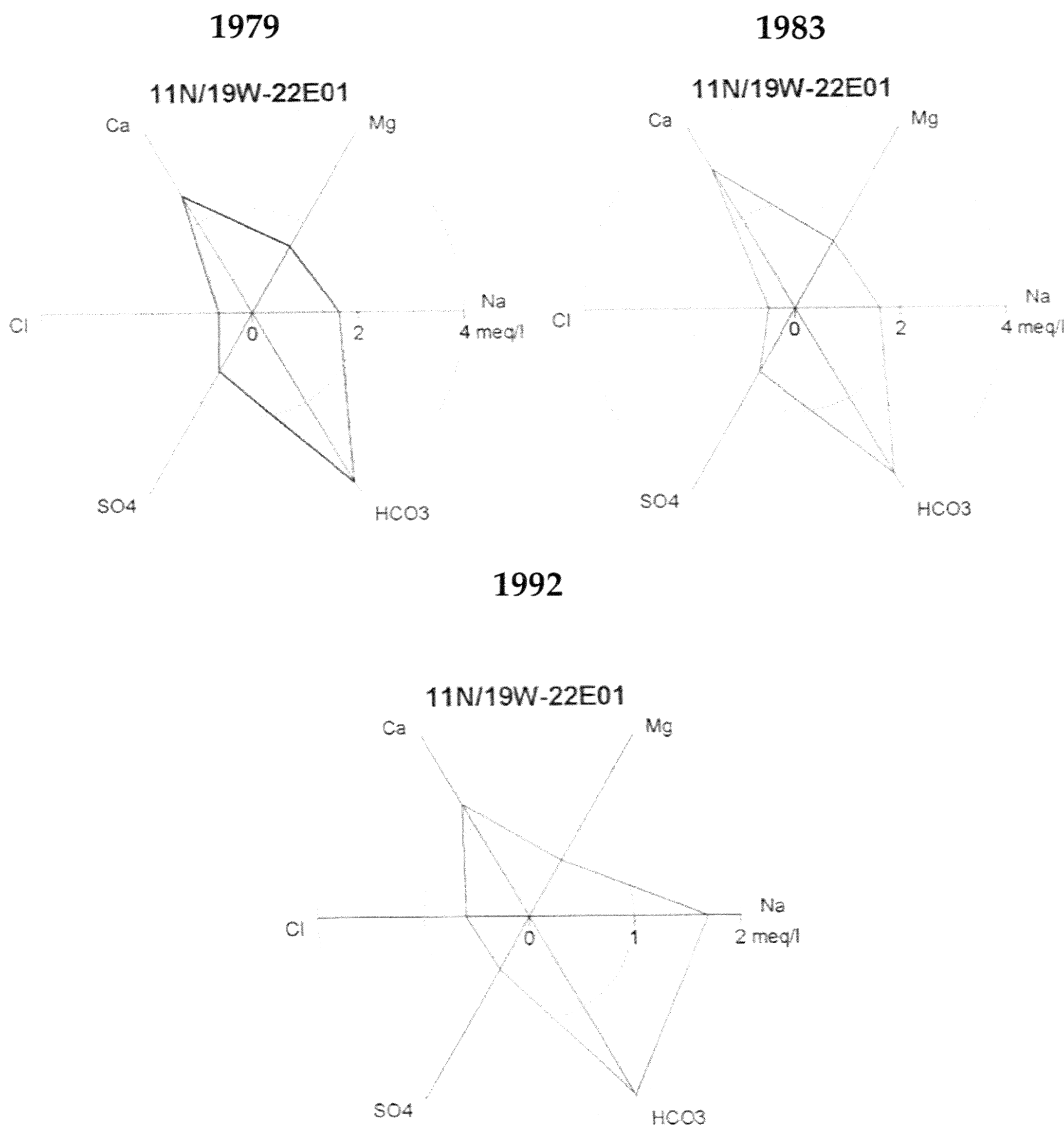


Figure 46. Radial plots of groundwater quality in well T11N/R19W-22E01 on July 12, 1979, August 17, 1983 and August 14, 1992.

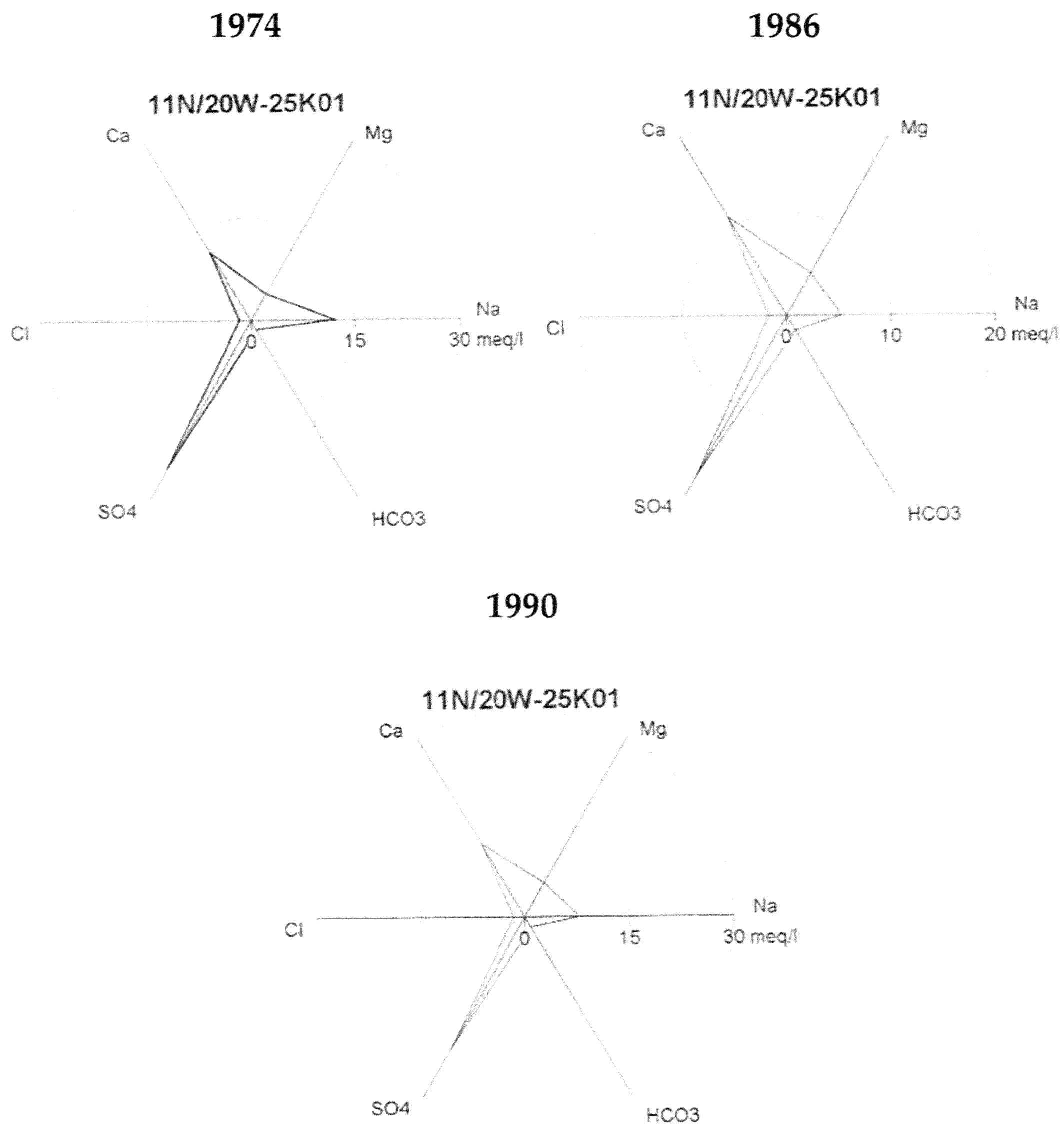


Figure 47. Radial plots of groundwater quality in well T11N/R20W-25K01 on August 1, 1974, August 14, 1986 and July 19, 1990.

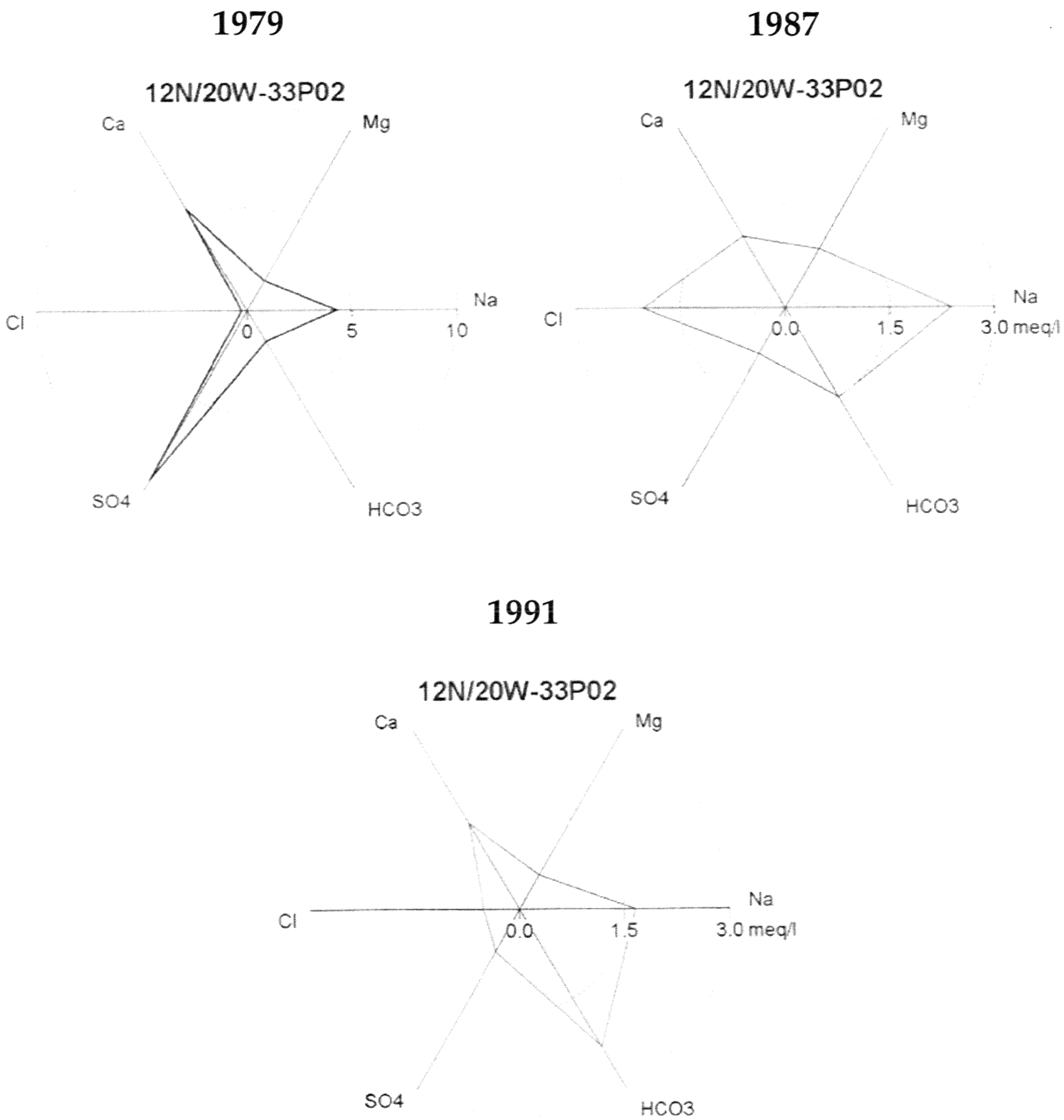
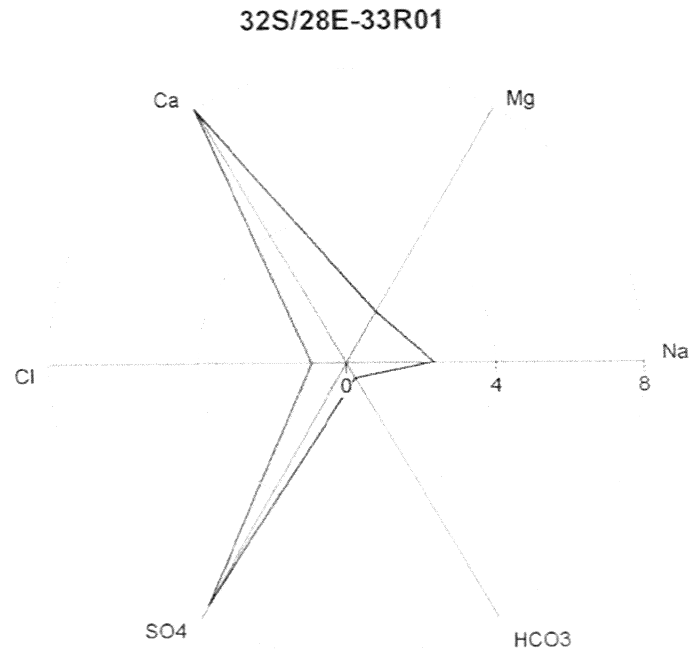


Figure 48. Radial plots of groundwater quality in well T12N/R20W-33P02 on June 28, 1979, August 12, 1987 and September 13, 1991.

1979



1987

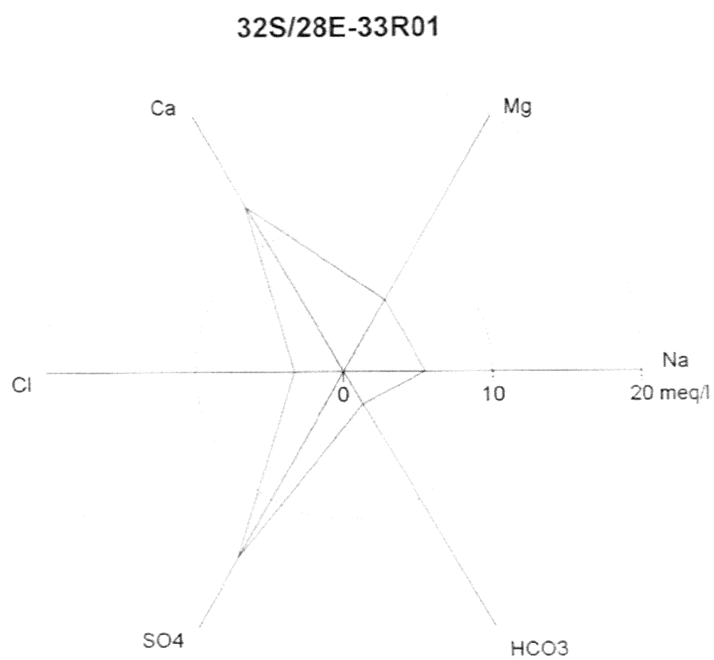
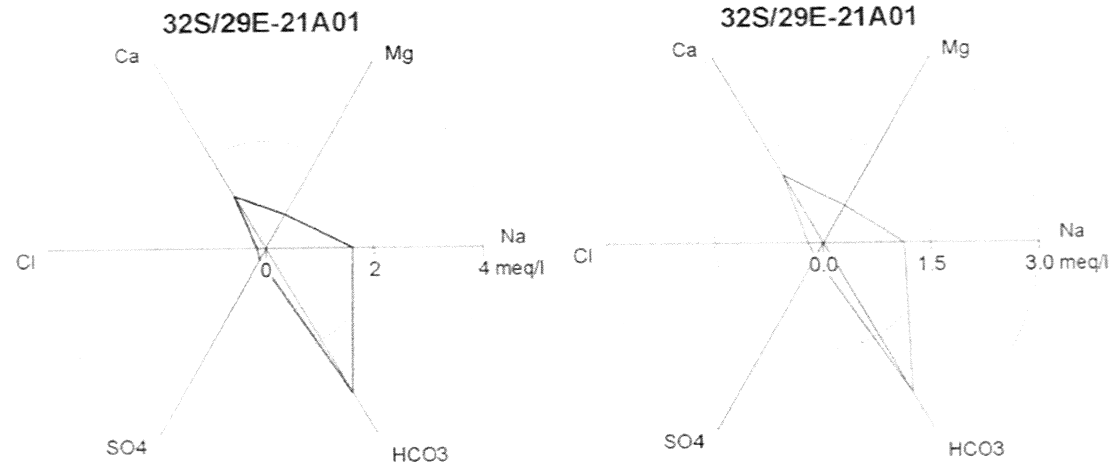


Figure 49. Radial plots of groundwater quality in well T32S/R28E-33R01 on June 28, 1979 and August 6, 1987.

1979

1986



1994

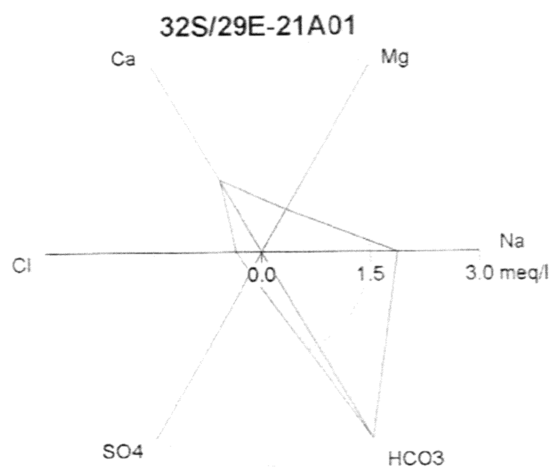


Figure 50. Radial plots of groundwater quality in well T32S/R29E-21A01 on August 9, 1979, July 29, 1986 and August 8, 1994.

APPENDIX G

Land Subsidence

Appendix G.1

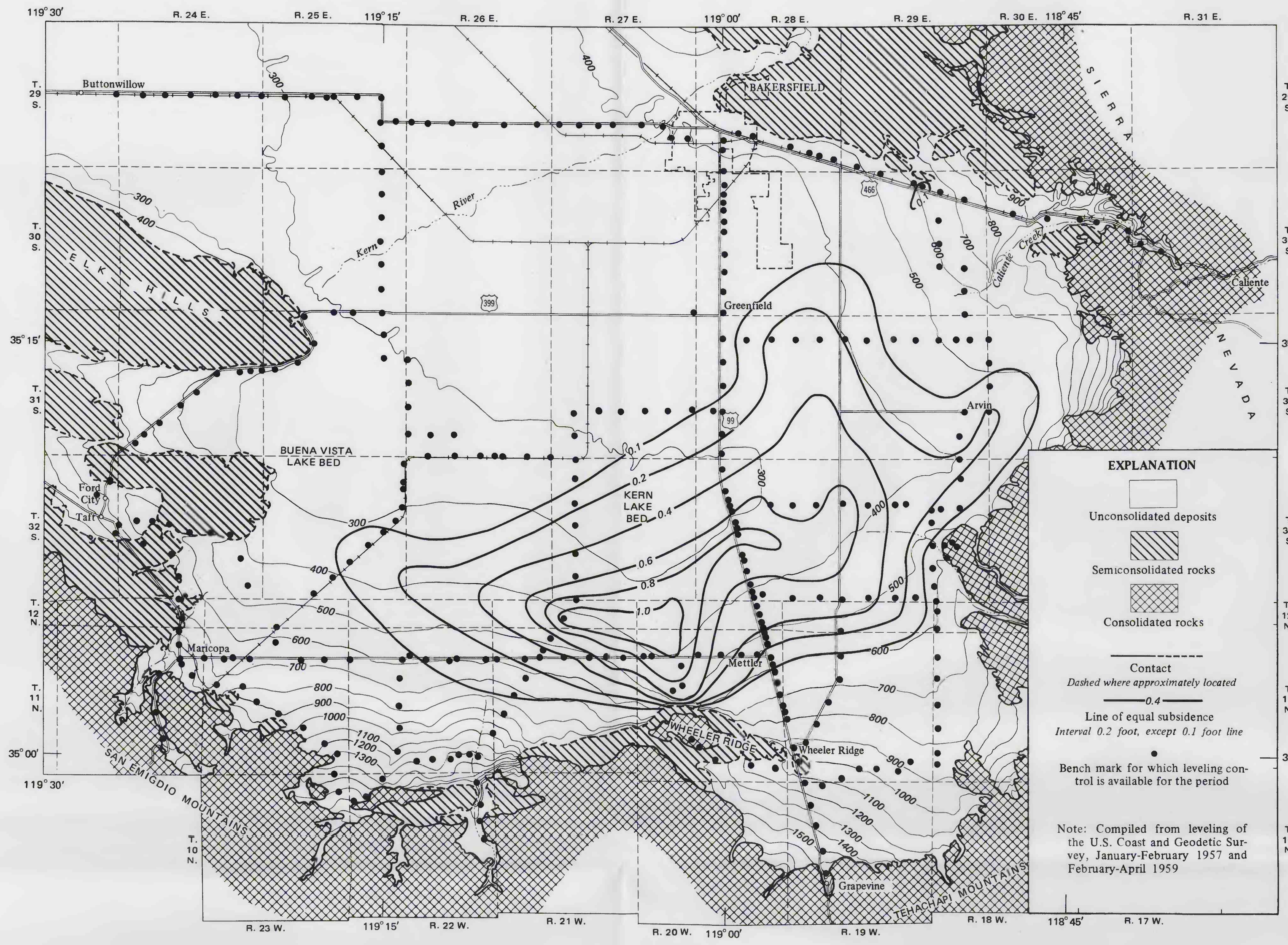
Lofgren (1975)

Land Subsidence Due to Ground-Water Withdrawal, Arvin-Maricopa Area, California

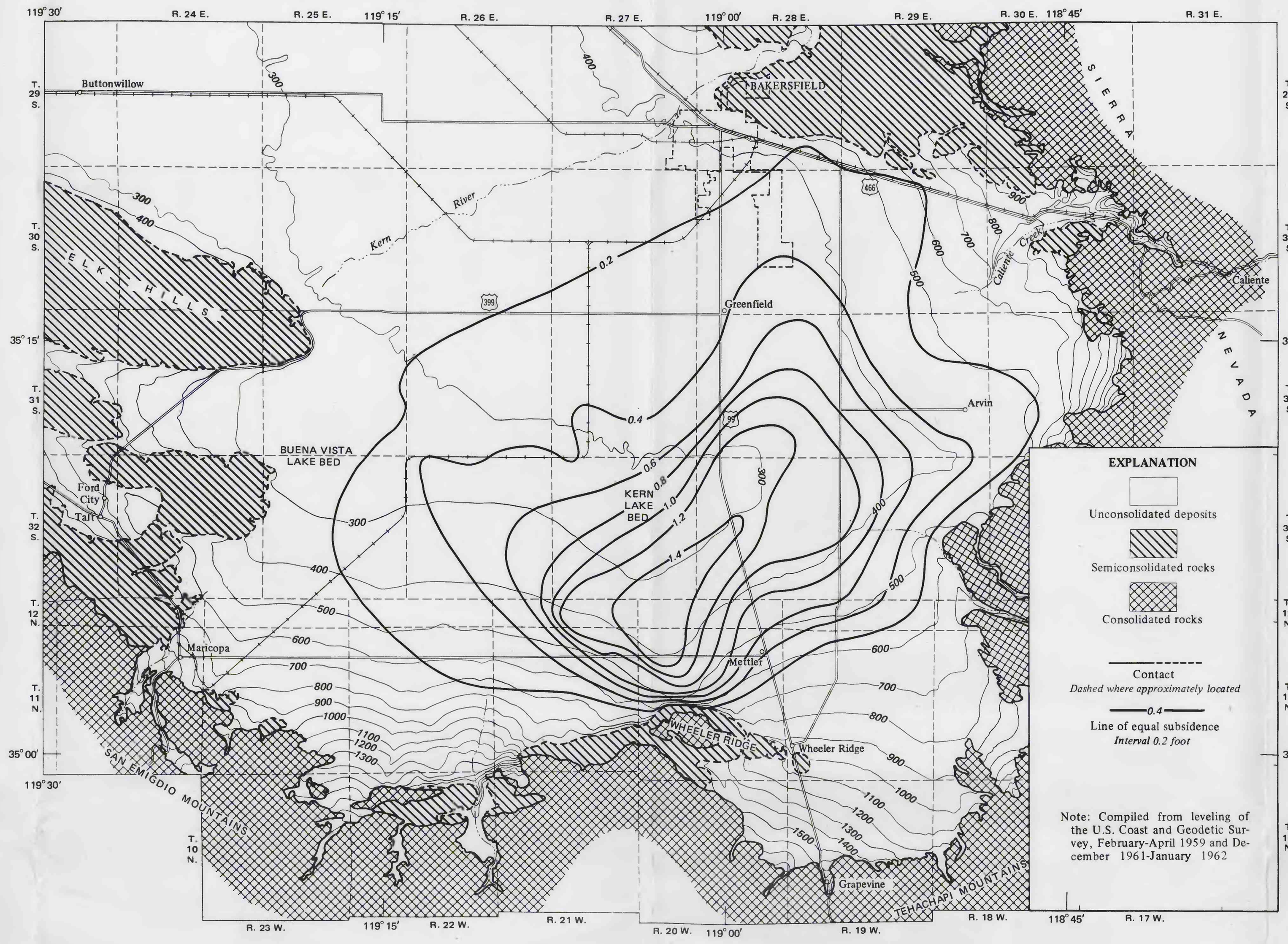
GEOLOGICAL SURVEY PROFESSIONAL PAPER 437-D

Prepared in cooperation with the California Department of Water Resources

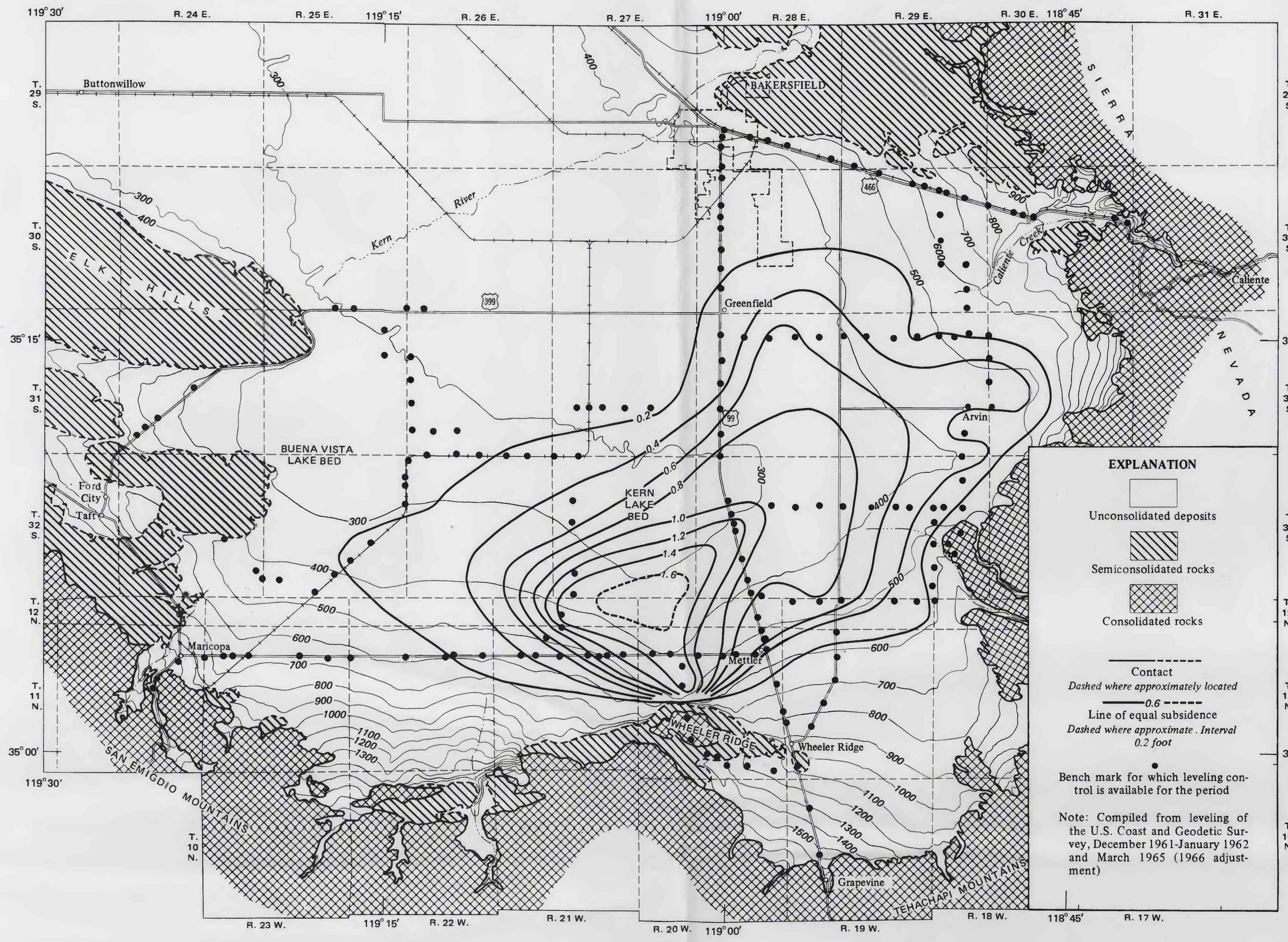
Prepared in cooperation with the
CALIFORNIA DEPARTMENT OF WATER RESOURCES



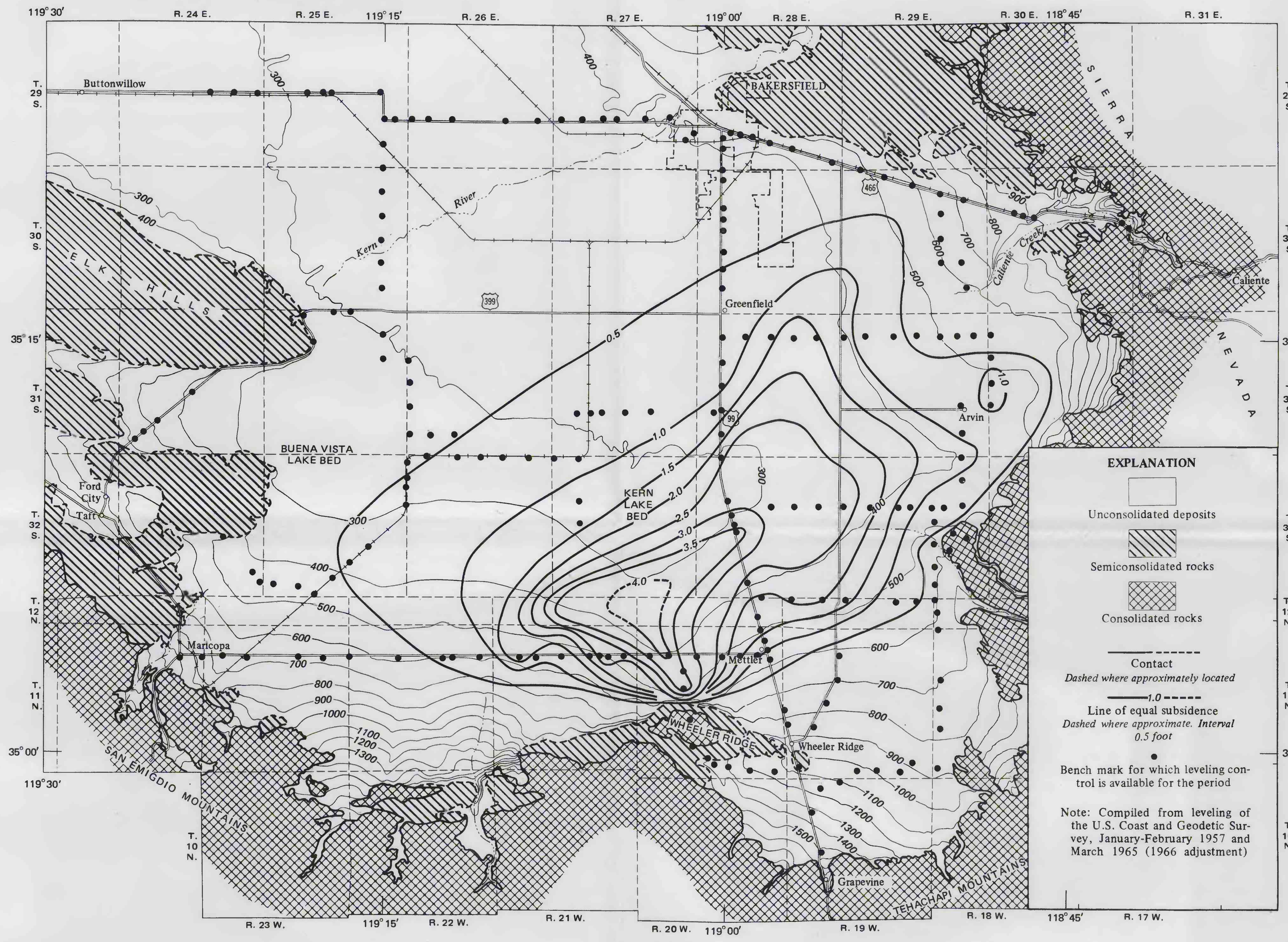
A—1957-59



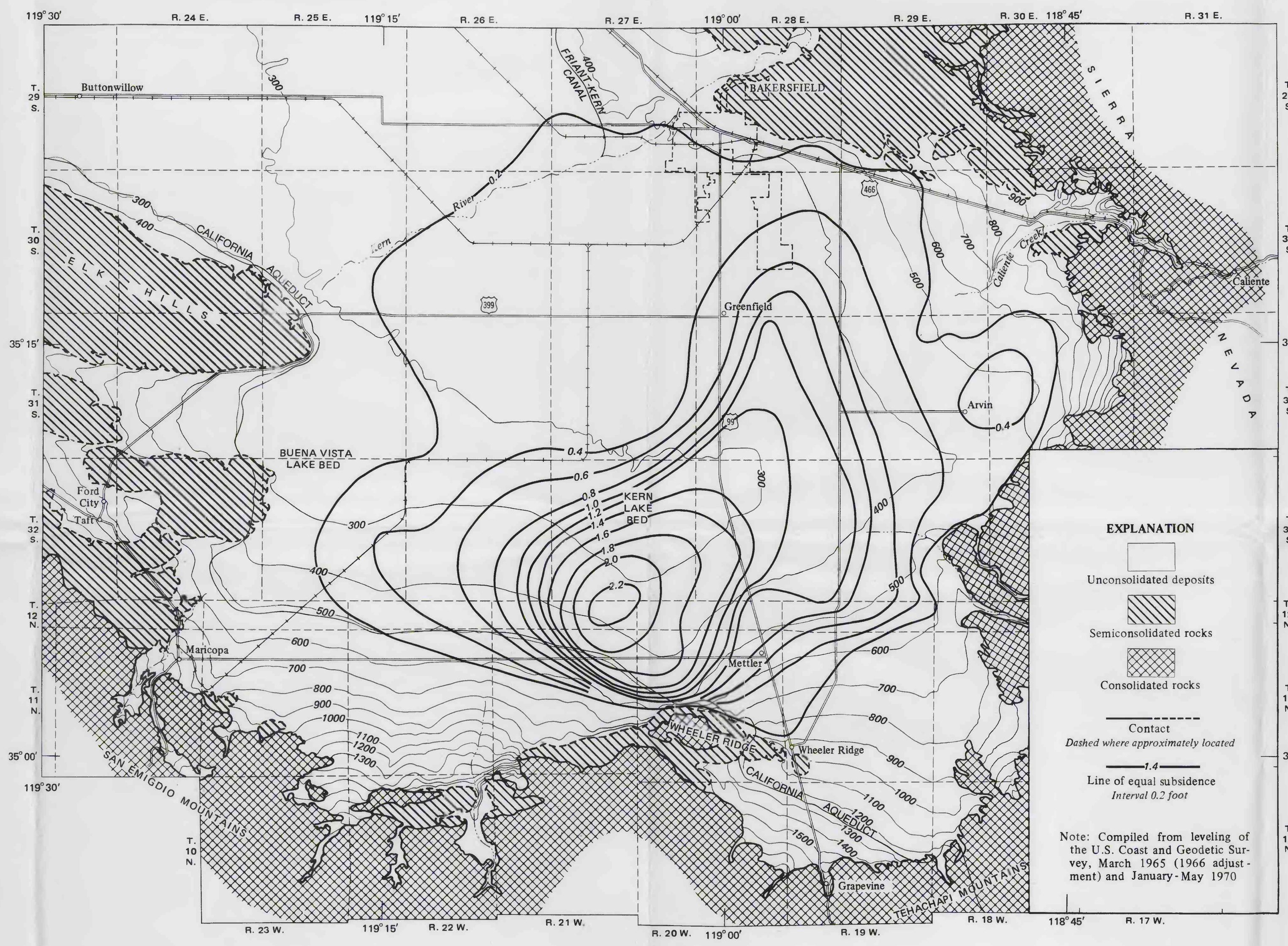
B—1959-62



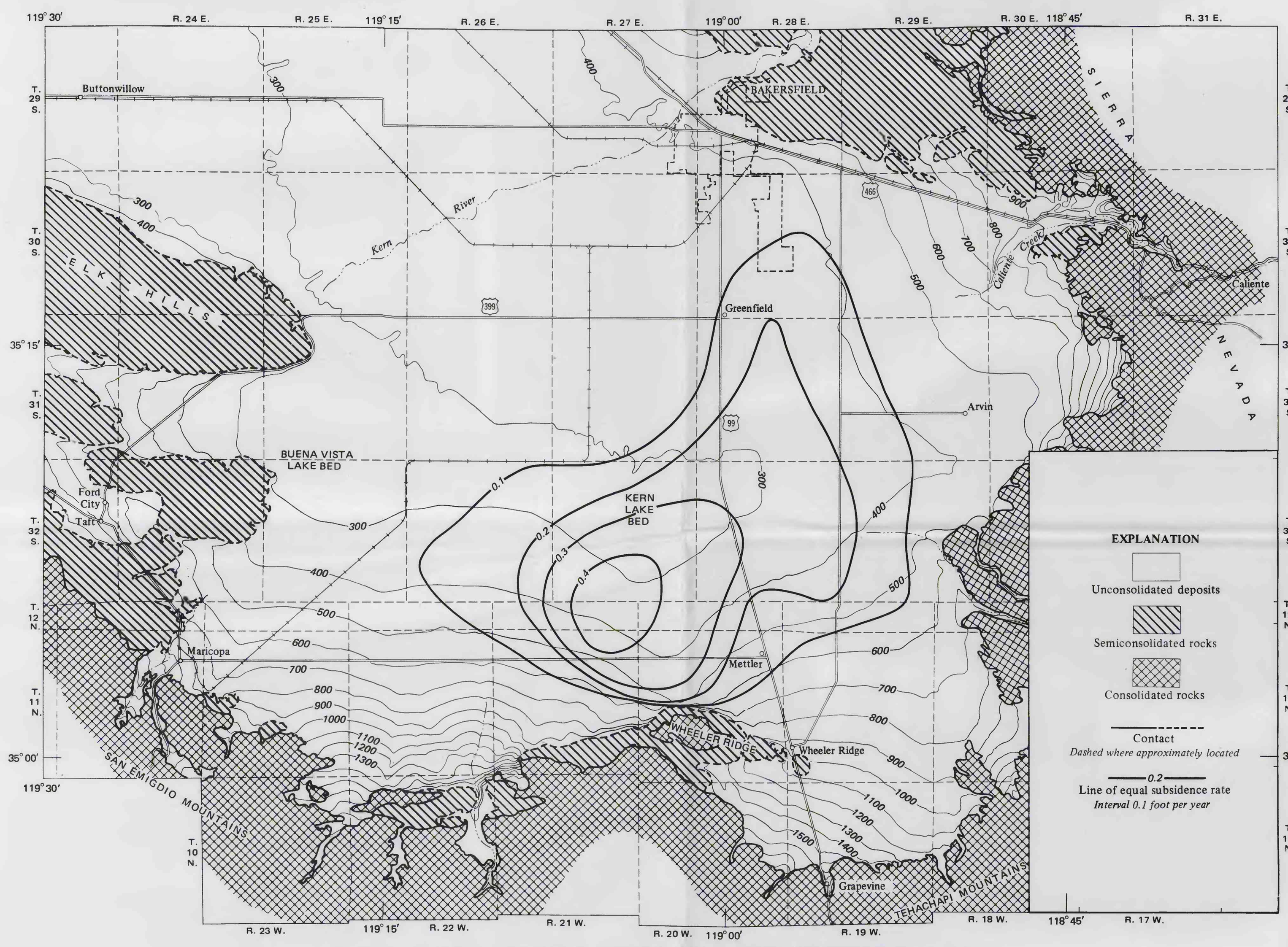
C—1962-65



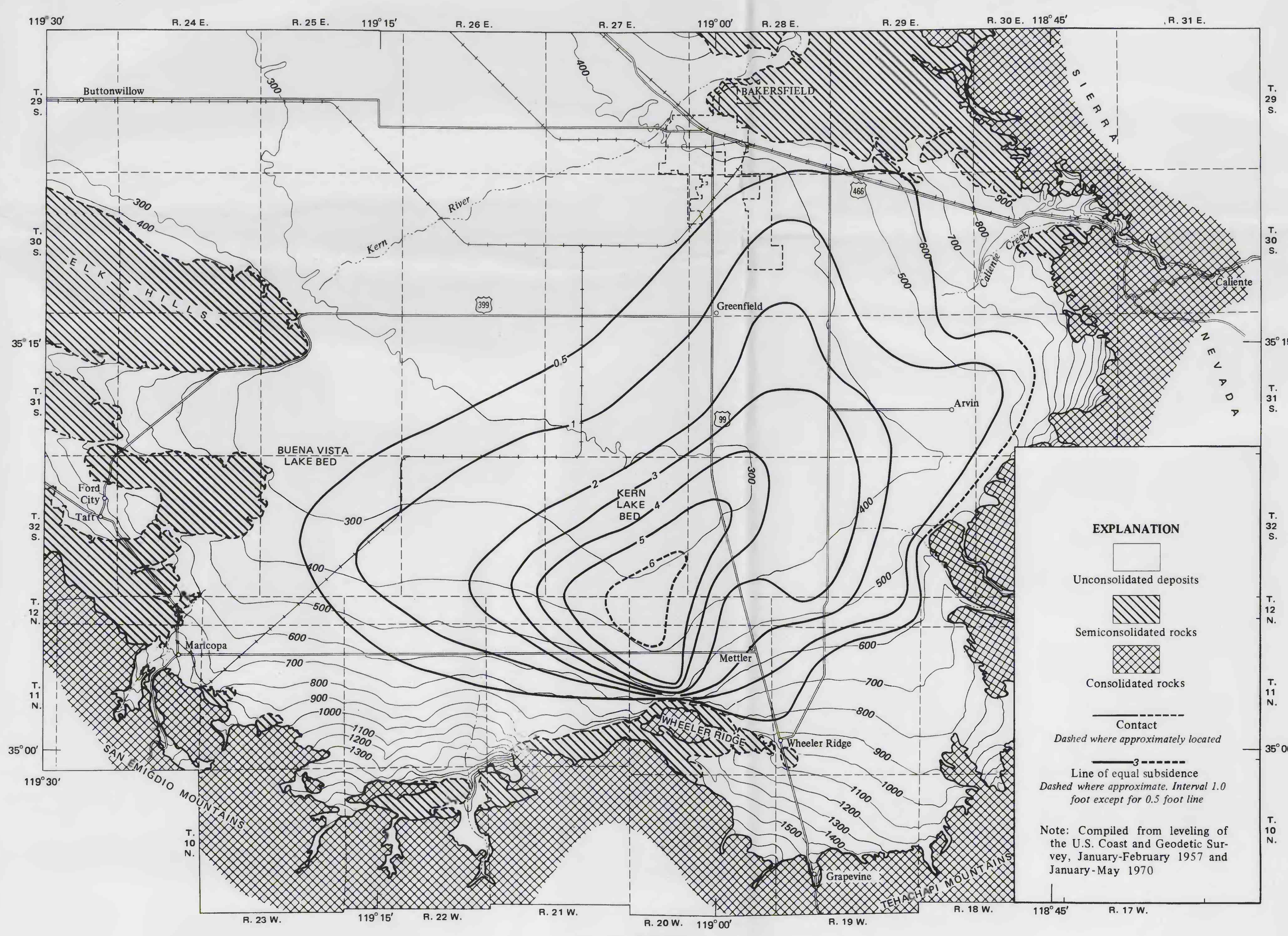
D—1957-65



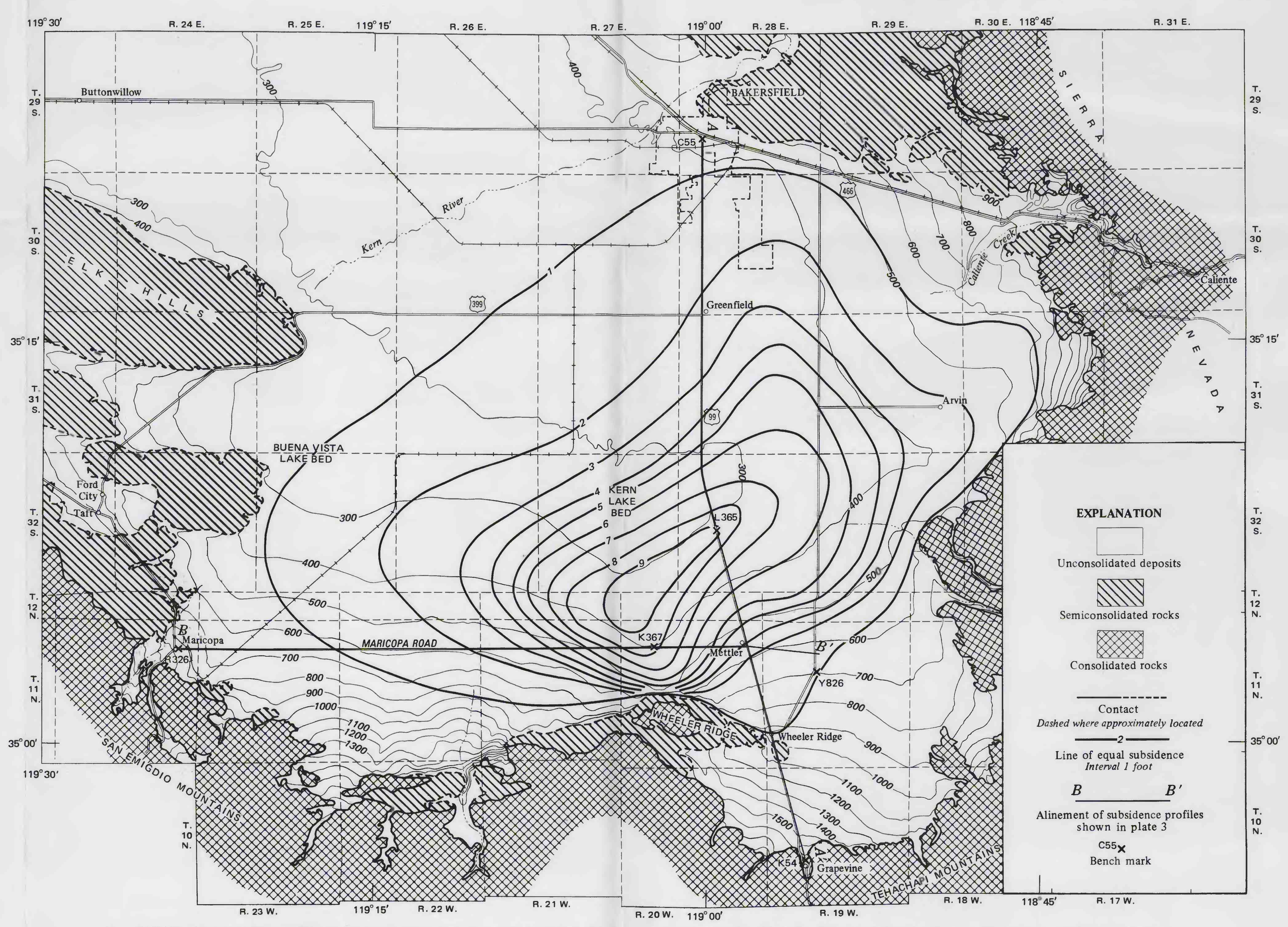
E—1965-70



F—AVERAGE ANNUAL RATE OF SUBSIDENCE, 1965-70, BASED ON DATA OF PLATE 4, E



G—1957-70



H—1926-70, COMPILED CHIEFLY AS THE SUM OF: (1) APPROXIMATED SUBSIDENCE FROM 1926 TO 1957 FROM LEVELING DATA OF THE U.S. COAST AND GEODETIC SURVEY ALONG U.S. HIGHWAY 99 AND ALONG MARICOPA ROAD, AND (2) 1957-70 SUBSIDENCE FROM PLATE 4, G

Base from U.S. Geological Survey Central Valley, California, South Area, 1958 1:250,000

MAPS SHOWING LAND SUBSIDENCE IN THE ARVIN-MARICOPA AREA, CALIFORNIA

[Leveling of 1957, 1959, 1962, and 1965 in financial cooperation with the California Department of Water Resources. Leveling of 1970 in financial cooperation with the California Department of Water Resources U.S. Bureau of Reclamation, and Kern County Water Agency]

CONTOUR INTERVAL 100 FEET
DATUM IS MEAN SEA LEVEL

Interior—Geological Survey, Reston, Va.—1975

☆ U.S. GOVERNMENT PRINTING OFFICE: 1975-0-

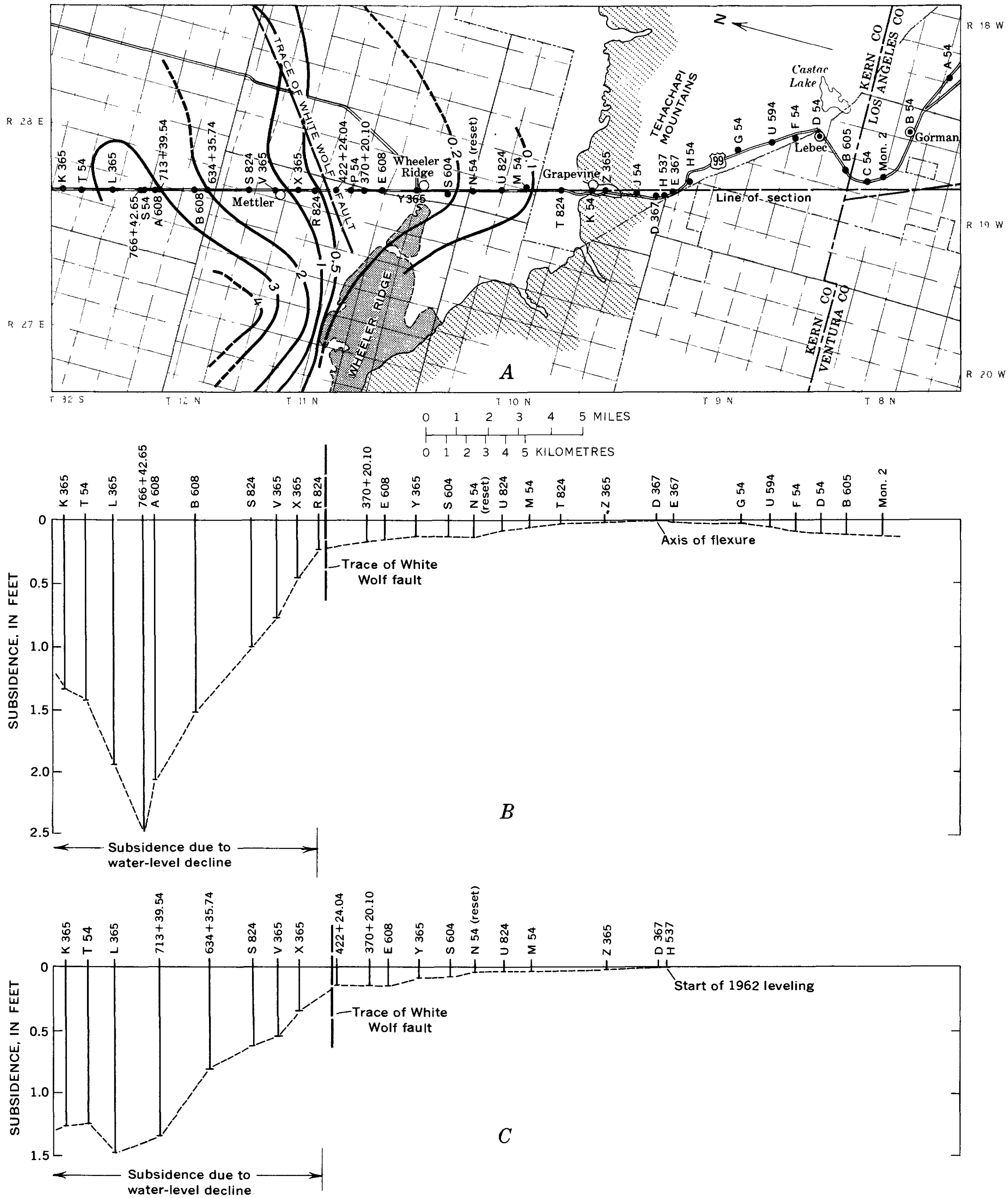


FIGURE 9.—Vertical movement of bench marks along U.S. Highway 99 in the Grapevine area, 1953–62. *A*, Lines of equal subsidence, in feet, 1953–62. *B*, Subsidence profile, 1953–59. *C*, Subsidence profile, 1959–62. The vertical movement of some bench marks in *A* is shown in figure 8.

Appendix G.2

WRMWSD (2007)

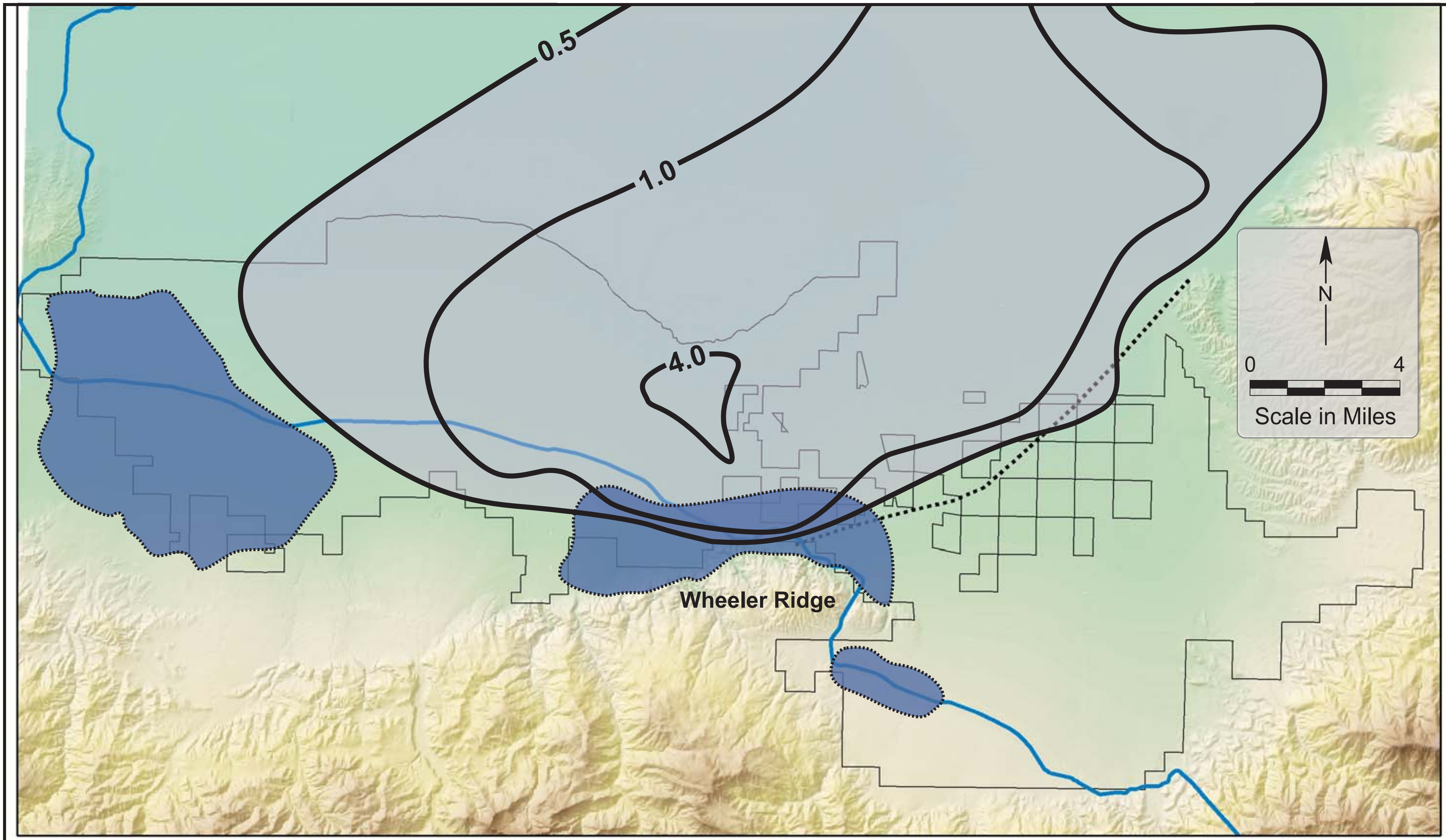
FINAL

AB3030
Groundwater Management Plan

Prepared for
Wheeler Ridge-Maricopa
Water Storage District

November 2007

Todd Engineers
with Kennedy/Jenks Consultants



—0.5— Lines of equal subsidence due to groundwater widthdrawal, in feet

Area of subsidence due to groundwater widthdrawal (approximate)

Area subject to hydrocompaction (approximate)

Source: Lofgren, 1975.

November 2007

TODD ENGINEERS
Emeryville, California

Figure 17
Areas of Subsidence and Hydrocompaction

APPENDIX H

Memorandum of Understanding Between AEWSD, WRMWSD, and TCWD Regarding the White Wolf Subbasin

Memorandum of Understanding

Between Arvin-Edison Water Storage District, Wheeler Ridge-Maricopa Water Storage District and Tejon–Castac Water District

Regarding the White Wolf Subbasin

THIS **MEMORANDUM OF UNDERSTANDING ("MOU")** in entered into by and between **Arvin-Edison Water Storage District ("Arvin-Edison"), Wheeler Ridge-Maricopa Water Storage District ("Wheeler Ridge") and Tejon-Castac Water District ("Tejon-Castac"),** collectively the "Parties", this 9th day of February, 2016.

WHEREAS, in 2014 the Sustainable Groundwater Management Act (Water Code Section 10720 et seq) ("SGMA") was enacted and each of the Parties is a "local agency" as therein defined and therefore eligible to form and/or be part of a Groundwater Sustainability Agency ("GSA"); and

WHEREAS, in has long been recognized and documented in various reports and studies that there exists the separate White Wolf Subbasin, located within a portion of each of the Parties, along with non-district areas of the County of Kern;

WHEREAS, the White Wolf Subbasin presently is classified under the Department of Water Resource's ("DWR") Bulletin 118 as being within the Kern County Subbasin and not separately identified as a basin or subbasin within Bulletin 118;

WHEREAS, as authorized by SGMA (Chapter 3) and Rules and Regulation promulgated by DWR (at Title 23, Division 2, Chapter 1.5, Subchapter 1 of the California Code of Regulation, "Basin Boundary Regulations"), local agencies may request that basin boundaries be modified;

WHEREAS, Erler & Kalinowski, Inc. has prepared for the Parties a draft Technical Study which concludes, among other things, that the White Wolf Fault provides a significant impediment to groundwater flow and that sustainable groundwater management can continue in the White Wolf Subbasin without impacting sustainable management of adjacent groundwater basins, which is consistent with the standards by which a scientific modification of a basin may be approved by DWR under the Basin Boundary Regulations; and

WHEREAS the Parties believe that a basin boundary modification to formally recognize that the White Wolf Subbasin is a separate basin under the Basin Boundary Regulations for purposes of SGMA compliance is appropriate to pursue, subject to the conditions of this MOU.

NOW, THEREFORE, the Parties agree as follows:

1. The Parties support the filing of a scientifically-based basin boundary modification to recognize the White Wolf Subbasin as a separate subbasin under the Basin Boundary Regulations.
2. Tejon-Castac shall act as the Requesting Agency in filing the basin boundary modification request with DWR, as provided in the Basin Boundary Regulations, and the other Parties will cooperate to provide information necessary and appropriate for such filing.
3. Each of the Parties will continue to evaluate the rationale for such filing, how it would affect and be implemented within its jurisdiction, and other considerations, and each Party reserves the

right to at any time withdraw its support for the filing if it determines doing so is in the best interest of itself and/or its landowners.

4. If the proposed basin boundary revision is approved by DWR following the process prescribed by the Basin Boundary Regulations, the Parties shall cooperate in the timely formation of a GSA and thereafter development of a Groundwater Sustainability Plan for the Subbasin, as provided by SGMA.

IN WITNESS WHEREOF, the Parties have executed this MOU.

Arvin-Edison Water Storage District

By__________________________

Wheeler Ridge-Maricopa Water Storage District

By__________________________

Tejon-Castac Water Storage District

By__________________________

right to at any time withdraw its support for the filing if it determines doing so is in the best interest of itself and/or its landowners.

4. If the proposed basin boundary revision is approved by DWR following the process prescribed by the Basin Boundary Regulations, the Parties shall cooperate in the timely formation of a GSA and thereafter development of a Groundwater Sustainability Plan for the Subbasin, as provided by SGMA.

IN WITNESS WHEREOF, the Parties have executed this MOU.

Arvin-Edison Water Storage District

By____________________________

Wheeler Ridge-Maricopa Water Storage District

By____________________________

Tejon-Castac Water Storage District

By____________________________

other Parties will cooperate to provide information necessary and appropriate for such filing.

3. Each of the Parties will continue to evaluate the rationale for such filing, how it would affect and be implemented within its jurisdiction, and other considerations, and each Party reserves the right to at any time withdraw its support for the filing if it determines doing so is in the best interest of itself and/or its landowners.

4. If the proposed basin boundary revision is approved by DWR following the process prescribed by the Basin Boundary Regulations, the Parties shall cooperate in the timely formation of a GSA and thereafter development of a Groundwater Sustainability Plan for the Subbasin, as provided by SGMA.

IN WITNESS WHEREOF, the Parties have executed this MOU.

Arvin-Edison Water Storage District

By___________________________

Wheeler Ridge-Maricopa Water Storage District

By Robert J. Kunde

Tejon-Castac Water Storage District

By___________________________

(Filename S:\Management\Shared_JF\Resolution and MOU for WW Subbasin Application.wpd)