AQUIFER STORAGE RECOVERY FEASIBILITY INVESTIGATION

PHASE IIA MONITORING WELL PZ-1

VOLUME II -- APPENDIXES

PREPARED FOR

Upper Guadalupe River Authority
Kerrville, Texas

December 1989

CH2M HILL

AQUIFER STORAGE RECOVERY FEASIBILITY INVESTIGATION

PHASE IIA: MONITORING WELL PZ-1

Prepared for:

Upper Guadalupe River Authority
Kerrville, Texas

By:

CH2M HILL
AUSTIN, TEXAS

John S. McLeod
Dec. 1, 1989

TEX24486.A1

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Volume I of II - Technical Report

Appendix A
GEOLOGIC LOGS

PROJECT NUMBER TEX24486.A1

ROCK CORE LOG

PROJECT Aquifer Storage and Recovery LOCATION UGRA WTP

DRILLING METHOD Mud Rotary DRILLERS & EQUIPMENT TWDB-Failing 1500

ELEVATION _____ ORIENTATION Vertical BORE HOLE: Well PZ-1

WATER LEVEL _____ DATE: 7/17/89 START: 845 AM FINISH: 1605 INSPECTOR Petrus

DEPTH	COMMENTS: TESTS, INSTRUMENTATION, CORING RATE AND SMOOTHNESS, CORING FLUID LOSS	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES: RQD	FRACTURES PER FOOT	DESCRIPTION: TIGHTNESS, PLANARITY, SMOOTHNESS, FILLING, STAINING, ORIENTATION	LITHOLOGY: MINERALOGY, CLASSIFICATION, COLOR, GRAIN SIZE, ALTERATION; CEMENTATION, HARDNESS, WEATHERED STATE	GRAPHIC LOG
	USE 11 INCH ROLLERBIT (MUD ROTARY) TO 37' REAM WITH 14 3/4" ROLLER BIT TO 39' SET 10 3/4" OD. STEEL PIPE TO 39' PIPE WAS TWO JOINTS AND ONE COUPLING. GROUT ANNULUS USING 19 BAGS OF PORTLAND I AND 1/2 BAG of BENTONITE							0-1.5 OLIVE GRAY (5Y 4/1) SILT, TRACE CLAY, DRY, MEDIUM SOFT VERY CALCAREOUS (ML) 1.5-7.0 DARK REDDISH BROWN (10YR 4/2) SILT, SOME FINE GRAINED SAND, MOIST TO DRY, MEDIUM SOFT. OCCASIONAL SANDY ZONE WITH TRACE GRAVEL (ML) 7.0-20.' DARK REDDISH BROWN (10 YR 4/2) GRAVEL, SOME SILT, LOOSE, GRAVEL IS MOSTLY A MICRITIC LIMESTONE WITH LESSER FINE GRAINED SANDS. ANGULAR TO SUBROUND. OCCASSIONAL SILT AND V. FINE GRAINED SAND MATRIX (GW)	
10									
	DRILLING EASY 0-23'								
20									
								20-23.0 GRAVEL AND WEATHERED LIMESTONE, —CONTACT—	
	23 HARD DRILLING ALSO LOSING CIRCULATION						FRACTURED	23-26' LIMESTONE, — PALE YELLOWISH BROWN ( ) MICRITIC MOD HARD TO HARD, FRESH	
	26-28 EASY DRILLING							26-28' CLAYEY SHALE, — Light GRAY ( ) to MEDIUM GRAY ( ), CALCAREOUS, NOT WELL LITHIFIED.	
30								28-30 See next page	

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ELEVATION _____ ORIENTATION Vertical BORE HOLE: Well PZ-1

WATER LEVEL _____ DATE: 7/18-7/20 START: 0845 FINISH: 1600 INSPECTOR Petrus

DEPTH	COMMENTS: TESTS, INSTRUMENTATION, CORING RATE AND SMOOTHNESS, CORING FLUID LOSS	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES: ROD	FRACTURES PER FOOT	DESCRIPTION: TIGHTNESS, PLANARITY, SMOOTHNESS, FILLING, STAINING, ORIENTATION	LITHOLOGY: MINERALOGY, CLASSIFICATION, COLOR, GRAIN SIZE, ALTERATION; CEMENTATION, HARDNESS, WEATHERED STATE	GRAPHIC LOG
	Drilled to 38' from 0845-1010hr						Good return few fractures?	28-39 Limestone, light gray (N7) soft to medium hard, argillaceous, fresh	
	1235-1345 Ream hole to 14 3/4"						Thinly laminated		
	Grout 10 3/4"								
	pipe w couplings to 40'								
	Finish grouting at 1605 on 7/18							Stop @ 39' on 7-15-89 then ream to 40'	
40	Let grout cure for 4 days Start drilling again on 7-26-89						40'	Mudstone lt gray (N7), soft, laminated, calcareous fresh	
	Drill rate 2 min/ft								
	Rollerbit Drilling								
50							50'		
								Limestone, lt gray (N7) and grayish orange (10YR 7/4) finely crystalline	
	8 min/5 feet							soft to med hard, argillaceous seams, trace chert, slight weathering	
60									

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	ROLLER BIT							LIMESTONE lt brown, (5YR 5/6) to LT GRAY (N7), FINELY CRYSTALLINE, SOFT TO	
	DRILLING 2 MIN PER FOOT, NO MUD LOSS							MED. HARD, SL. WEATHERED PELYCYPOD FOSSILS.	
70							70'		
	NOT MAKING WATER							LIMESTONE, LIGHT GRAY (N7) SOFT, FINELY CRYSTALLINE, ARGILLACEOUS, TRACE FOSSILS	
								THINLY LAMINATED TO LAMINATED, SLIGHTLY weathered to fresh	
	DRILLING RATE: 8 MIN/5 FT						75'	SANDSTONE v.f. GRAINED lt GRAY (N7) v. CALCAREOUS, SOFT TO MEDIUM HARD,	
								TRACE FOSSILS, THINLY BEDDED	
80									
	POOR CUTTING RETURN						80'	MUDSTONE, LT GRAY (N7) SOFT, CALCAREOUS, THINLY LAMINATED, MARL.	
	7 MIN/5 FT.								
							85'	SAME AS ABOVE	
	6 MIN/5 FT.								
90									

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	MUD ROTARY ROLLER BIT							MUDSTONE LT GRAY (N7), SOFT TO MED. HARD, V. CALCAREOUS POSSIBLE CLAY SEAMS, TRACE V. F. GRAINED SAND. FOSSIL CASTS. MICRO TO THINLY LAMINATED	
	GETTING HARDER TO CUT 17MIN/5FT.								
100							100	SILTSTONE, LT GRAY (N7) TO OLIVE GRAY (5Y 4/1) SOFT TO MEDIUM HARD, SLIGHTLY WEATHERED, CEMENTED WITH CALCITE, INTERBEDDED WITH V. F. GRAINED SANDSTONE, HEITIC, SUBROUND, TRACE FOSSIL CASTS. THINLY TO LAMINATED.	
	108-10 9 VERY SOFT. 20 SEC. TO DRILL								
110							110'		
								MUDSTONE, LT GRAY (N7) TO OLIVE GRAY (5Y 4/1) SOME V. FINE GRAINED SANDSTONE SOFT TO MEDIUM HARD. CALCAREOUS	
								FRESH TO SLIGHTLY WEATHERED, THINLY LAMINATED TO LAMINATED,	
120									

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	MUD ROTARY ROLLER BIT DRILLING						120'	SANDSTONE (?) WITH SOME ANHYDRITE CRYSTALS, ROUNDED & ELONGATE HABITS	
	GEOPHYSICS NOTES 10' ANHYDRITE BED							LT GRAY (N7) TO MEDIUM OLIVE GRAY (5Y 4/4)	
	DRILLING RATE = 2 MIN/FT								
130									
							130'	MUDSTONE, LT GRAY (N7) TO MEDIUM GRAY (N6) SOFT, V. CALCAREOUS,	
							VERY BROKEN	ABUNDANT FOSSIL CASTS.	
	DRILL RATE = 2 MIN/FT.								
140									
	MORE RIG CHATTER						140'	MUDSTONE/SILTSTONE, LT. GRAY (N7) LAMINATED SLIGHTLY CALCAREOUS TO	
	SOME CLAY BUT MAY BE FROM PIT, 140-144 SOFT ZONE							CALCAREOUS, TRACE V.F. GRAINED SAND. FRESH FOSSILS.	
150									

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	Drills @ 1'/min.							Interbedded Claystone lt. gray (N7) soft to v. soft, slightly calc. to calcareous, intbd. w/ light olive gray (5Y 6/1) sands.	
160	Cuts easily							Same as above, but more claystone.	
	Drills 15 min/10 ft								
170								Siltstone interbedded with v. fine grained sandstone light gray	
	14 min/10 ft.							(N7) thinly laminated qtz sands are cemented with calcite, sands are subrounded.	
180									

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	Stop drilling on 7/20 @ 180'						180'	SAME AS ABOVE WITH A FEW THINLY LAMINATED LIMESTONE FRAGMENTS. LIGHT GRAY	
190							190'	SILTY SANDSTONE, LT GRAY (N7) to MED. LT GRAY (N6) V. FINE GRAINED QTZITIC, SUBROUND, SLIGHTLY CALCAREOUS, SOFT, THINLY TO LAMINATED.	
	15 MIN/10 FT.								
200							200'	INTERBEDDED, LT. GRAY CALCAREOUS MUDSTONE AND ARGILLACEOUS LIMESTONE, SOFT, PREDOMINANTLY MUDSTONE	
	200-207 DRILLER NOTES								
	ALT. HARD & SOFT ZONES								
	V. HARD @ 208'								
210									

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							210'	PREDOMINANTLY MUDSTONE LIGHT GRAY (N7), SOFT, WITH SOME CLAY, LT GRAY,	
	Drills easy 10 feet in 5 minutes							AND OCCASIONAL LIMESTONE, GRAYISH ORANGE (10YR 7/4) LIMESTONE IS MEDIUM	
								HARD.	
	Driller notes some hard zones								
220	Poor Sample Recovery						220	CLAYSTONE, LIGHT GRAY, (N7) SOFT, TRACE	
								LIMESTONE GRAYISH ORANGE (10YR 7/4) CLAY HAS FOSSIL CASTS,	
	Driller notes SOFT ZONES								
	w/ THIN INTERBEDDED HARDER ZONES								
230							230	POOR SAMPLE (?) MAY CONTAIN CAVE FROM ABOVE	
								CLAYSTONE, LIGHT GRAY, (N7) SOFT, INTERBEDDED	
								WITH ARGILLACEOUS LT. GRAY LIMESTONE, AND	
	STOP DRILLING ON 7/21/89							MEDIUM LIGHT GRAY (N6) SILTSTONE, SOFT	
	AT 230 FEET							SLIGHTLY CALCAREOUS	
240									

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	Mud Rotary Rollerbit						240'	Limestone, multicolored Mod. brown (5YR 3/4), lt gray (N7) and olive
								gray, some chert, inter-bedded with fine grained sandstone,
	13 min/10 ft							soft to medium hard Some return of
								conglomerate with calcite matrix.
250								
							250'	Siltstone, sandy, lt gray (N7) soft, slightly
	Drilling smoothly with							calcareous to very calcareous, slightly fossiliferous, trace
	a little chatter							limestone and clay
	caused by							
	alternating							
	hard & soft units							
260								
	Clay zone @ 259'						260'	Mudstone, reddish brown, soft to very
								soft, thinly laminated calcareous
	13 minutes/10 ft.							
270								

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	Mud Rotary Rollerbit						270'	Siltstone and v. fine to fine grained sandstone soft to medium hard.
	15 min to cut 10'							Fe Ox stained. Medium reddish brown to light gray, thinly lam-inated. Slightly cal-carcous, sands are quartzitic and sub round
280								
	17 min to drill 10'						280'	Same as above but slightly more siltstone
	Driller notes soft between							
	283 & 285							
290								
	Hard @ 290' 5 min / foot						290'	Siltstone, Grayish red (10 R 4/2) and
	292' out of hard zone 1'/min							med. lt. gray (N6) soft to medium hard, dolomitic in places
	297 hard							
300	Drilling Limestone Return							

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							300'	SANDSTONE, V. LT GRAY (N8) FINE TO MEDIUM GRAINED MED. HARD, CEMENTED WITH CALCITE. SANDS ARE QUARTZITIC & SUBROUND, OCCASIONAL LIMESTONE CHIP.	
310							310	GRANULE CONGLOMERATE, GRANULES ARE LIMESTONE, QUARTZ, AND FELDSPAR, ANGULAR TO SUBROUND, SOFT, CEMENTED WITH CALCITE	
320	END DAY 7/21/89 @ 320'						320'	SILTSTONE, LIGHT GRAY AND REDDISH BROWN, SOFT TO MEDIUM HARD, LIMEY IN PLACES,	
330									

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	MUD ROTARY Rollerbit						330	LIMESTONE, VERY FINELY CRYSTALLINE, AND CALCAREOUS MARL, PALE REDDISH BROWN (10R5/4) AND VERY LIGHT GRAY (N8) MED. HARD, THINLY LAMINATED.	
	At 336 it cuts @ 4-5 MIN/FT.								
340									
	@ 340' quit for day (7/24/89)						340	LIMESTONE, V. LT GRAY (N8) FINELY CRYSTALLINE, AND CALCAREOUS SILTSTONE, (MOSTLY LIMESTONE) MEDIUM HARD, THINLY LAMINATED.	
350							350	LIMESTONE, VERY LT. GRAY MEDIUM HARD, FINELY CRYSTALLINE, SLIGHTLY CLAYEY,	
	358-355 took 10 MIN TO CUT.								
360									

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	MUD ROTARY DRILLING.						360'	LIMESTONE LT GRAY (N7) TO VERY LT. GRAY (N8), CHALKY IN PLACES, MED.
	18 MIN TO CUT 361-362'							HARD TO HARD, TRACE SMALL FOSSILS, SOME PINK STAINING, FRESH, COAL STRINGERS IN RETURN
	367' PALE RED SHALE IN RETURN							D 361 DOLOMITE IN RETURN
								D 367' PALE RED SHALE
370							370'	MUDSTONE, LT. OLIVE GRAY (5Y 6/1) AND FINELY CRYSTALLINE
								LIMESTONE, TRACES OF V.F GRAINED SANDSTONE CEMENTED W/ CALCITE
380	2-3'/MIN						380'	CLAYEY SHALE, PALE RED (10 R 6/2), SOFT,
	383-387 CUTS AT 5MIN/FT							THINLY LAMINATED NON TO SLIGHTLY CALCAREOUS
390								

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	Mud Rotary Roller bit to 400'							390-400 feet, return is a mixture, indiscernable can't be sure of log, Decide to switch to coring	
400	End day @ 400' on 7/25/89							Move to Sheet 15	

FORM D 2113A 5/78

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401	Core w/ 4" barrel 6 MIN/FT					2	Rough fractures, FeOx stains, moderate	400 - 400.5 Sandstone, v. fine grained, pale reddish brown & lt. olive gray yt2. subround siliceous cement, clasts
402	6 MIN/FT			1		2	weatherings on fractures (horizontal) vesicles	400.5 - 401.6 S.S. v. f.g. to f. grained, occ. gravel, conglomeritic at base, sl.
403	5 MIN/FT					1	mottled, sl. broken	calc., mostly siliceous, med. bedded. 401.6 - 403.2 Sandstone, fine
404	5 MIN/FT	Run #1				0		grained, occ. coarse grains, qtzitic subround, honey-combed, convoluted bedding
405	5 MIN/FT (smooth cutting)	85% Recovery		2	7%	0	unbroken w/ planar bedding	siliceous, sl. calc. hard 403.2 - 403.7 As above but cross bedded
406	5 MIN/FT					0		403.7 - 405.5 Sandstone, qtzitic, pale reddish orange staining lithology same as above
407	5 MIN/FT					1	Slightly broken w/ planar massive	405.5 - 408. - Sandstone, qtzitic, lt gray (N7) w/ 10% FeOx staining, slightly
408	4 MIN/FT			3		0	Bedding clay filling on fracture	honey combed. very fine to medium grained, siliceous cement, sl. calc. argillaceous, hard clayey
409	8 MIN/FT					0		408 - 408.5 Sandstone, very fine grained, qtzitic, hard pale reddish brown,
410	6 MIN/FT		Loss			0		slightly weathered, siliceous, argillaceous low porosity
411	8 MIN/FT					0	massive	410 - 413.6 Same as above.
412	2 MIN/FT	Run	4		70	0		485'
413	1 MIN/FT	#2				0		413.6 - Sandstone, silty, v. fine grained, greenish gray (5GY6/1)
414	2 MIN/FT					0	413.6 weathered fracture	with some moderate red brown staining, occasional gravel up to 3 cm in Ø, arkosic
415	1 MIN/FT		5			2	414.4 weathered fracture	subangular to subrounded, qtz & calcite regrowths, slightly micaceous conglomeritic zone 414-414.6

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ROCK CORE LOG

PROJECT Aquifer Storage and Recovery LOCATION UGRA WTP

DRILLING METHOD Mud Rotary DRILLERS & EQUIPMENT TWDB-Failing 1500

ELEVATION _____ ORIENTATION Vertical BORE HOLE: Well PZ-1

WATER LEVEL _____ DATE: _____ START: _____ FINISH: _____ INSPECTOR Petrus

DEPTH	COMMENTS: TESTS, INSTRUMENTATION, CORING RATE AND SMOOTHNESS, CORING FLUID LOSS	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES: RQD	FRACTURES PER FOOT	DESCRIPTION: TIGHTNESS, PLANARITY, SMOOTHNESS, FILLING, STAINING, ORIENTATION	LITHOLOGY: MINERALOGY, CLASSIFICATION, COLOR, GRAIN SIZE, ALTERATION; CEMENTATION, HARDNESS, WEATHERED STATE	GRAPHIC LOG
415								415 – 415.4 Conglomerate, pebbly matrix of med. grained sand, sands are subrounded pebbles are qtz and rock	
416				5		3	WEATHERED		
417		Run 2		6		1	416.5 – Coarse	FRAGMENTS Greenish Gray 415.4–417.3 SILTSTONE w/ occassional fine grain	
418		70%	LOSS		70%	2	Grained sand lens	SANDSTONE, grayish green (5G 5/2) to greenish gray (5GY 6/1)	
419							2 vuggy calcite or dissolution growths	Occ. bedding plane with pebble cng'l. FeOx stain near base	
420	Poor recovery.								
421	Decide to Ream hole								
422	to 430' to clean it out	Run 3							
423		58%			40%		CLAY FILLING ON JOINTS, WEATHERED	423.6–425.4 MUDSTONE, moderate reddish brown (10R 4/6) Clasts of limestone and claystone,	
424							Ancaled high angle joints	weathered, very broken, slightly calcareous to non calcareous, med hard.	
425	Rock is "weathered"						@ 425.5 & 426.5'	425.4–429.5 – MUDSTONE, moderate reddish brown w/ dark yellow brown clasts,	
426	By coring						erosional lower contact @ 429.5	hard, sl. calcareous, massive	
427	Cuts at ~15 min/ ft.								
428							FRACTURES ARE VERY WEATHERED	429.5–430 Sandstone, very fine grained, yellowish gray (5Y 8/1) and Greenish gray (5GY 6/1)	
429								Claystone, broken, highly weathered, med hard to hard, very calcareous	
430									

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431	2 MIN/FT		LOST CORE			1	HORIZONTAL FLASER TYPE BEDDING, VUGGY	430-432.7' INTERBEDDED SILTSTONE LT. GRAY GREEN, AND LT GREEN GRAY V. FINE GRAINED SANDSTONE, SUBROUND, ?, SILICEOUS, SL. CALCAREOUS HARD, BROKEN, FRESH	
432	2 MIN/FT			8		?	WEATHERED OR CORE LOSS		
433	3 MIN/FT	RUN #4			79	3	VUGGY & POROUS	432.9-434 SANDSTONE, V. FINE GRAINED, SL. SILTY, MOSTLY QTZ, LT GRAY TO PALE YELLOWISH BROWN, HARD TO VERY HARD, CALCAREOUS	
434	4 MIN/FT	85%		9	%	1	MASSIVE CALCITE JOINT FILLING		
435	5 MIN/FT					0	MODRATELY WEATHERED,	434-435.5 - SANDSTONE, V. FINE GRAINED, WITH CLAY ZONES, VARIGATED PALE BROWN AND	
436	6 MIN/FT					1	VUGGY & POROUS MASSIVE,	LT OLIVE GRAY, & PALE REDDISH BROWN, VUGGY W/ QTZ & CALCITE FILLING, INTERBEDDED	
437	6 MIN/FT			10		0	UNBROKEN	435.5-438.3 SILTSTONE VARIGATED, PALE REDDISH BROWN & LT. OLIVE GRAY, VERY FINE	
438	6 MIN/FT					0		GRAINED, SUBROUND, SL. SANDY IN PLACES, DOLOMITIC (?) TRACE CLAY (BROWN) ZONES.	
439	9 MIN/FT					0		438.3-440 SANDY SILTSTONE - LT OLIVE GRAY TO MOD. YELLOW BROWN, CALCAREOUS, WEATHERED	
440	3 MIN/FT			11		0		TRACE PEBBLES, (GREYWACKE) 440-441.4 SILTSTONE AND ?THIC	
441						0	LOWER GRADATIONAL	SILTY SANDSTONE V. FINE TO FINE GRAINED. GRAYISH GREEN (10 GY 5/2) SL. CALCAREOUS, HARD, SL.	
442		RUN				1	CONTACT	WEATHERED W/ CLAY FILLING. 441.4-447.5 SILTY SANDSTONE LT GREENISH GRAY (5G 8/1) TO	
443	5 FT/MIN AVG	#5		12		6		LT OLIVE GRAY (5Y 6/1) V. FOSSILIFEROUS CALCARENITE, HARD, VUGGY, CALCITE IN	
444		100			97 %	1	FOSSILS WEATHER & FORM VUGS THAT INCREASE	VUGS, WHOLE & PARTIAL FOSSILS 447.5-449.2 SANDSTONE, FINE	
445						1	POROSITY MOD WEATHERED	& MED. GRAINED, ?THIC, WITH SOME CALCITE CEMENT, HARD, OCC GRAVEL, INC. SILT & ORGANICS TOWARDS BASE LT GRAY TO LT OLIVE GRAY.	

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446	4" Core 5-7 min/ft			13		1			
447		Run 5				1			
448		100%			97 %	3'	Broken		
449	Last 2 feet drilled in 2 minutes			14		2	Broken w/ sharp basal	449.2 – 450.0 Carbonaceous Sandstone, qtz-feldspar v.f.	
450						1	contact @ 449.2 weathered joints	grained, Olive Black (5Y2/1) argillaceous, hard, sl. calcareous, subangular to	
451	3 min/ft					0		subround, occ. pebble. 450 – 452.7 Sandstone, Grayish Black (N2) to olive gray	
452	2 min/ft			15		0	moderately weathered	(5Y 4/1) very fine to fine grain, quartzitic, subround to sub angular, thinly laminated	
453	3 min/ft	Rec 80%			80 %	1	Coal Stringers @	Carbonaceous streaks, sl calcareous, hard, trace pebbles and fossils	
454	5 min/ft	Run 6		16		1	453 – 451.5' Erosional surface @	452.7 – 453.1 Convoluted clasts of argillaceous Limestone & v. fine gr. Sandstone,	
455	6 min/ft		Loss			1	452.7-453.1 secondary calcite crystals	hard, sl. weathered, v. calc., sl carbonaceous Olive gray & greenish black.	
456	4 min/ft					0	massive bed sl vuggy-frack	453.1-454 Sandstone, Lt gray, v. fine grained, qtzitic, very hard, calcite cement, subround	
457	6 min/ft	Run		17		0	fossils are casts Carbonaceous –	fossiliferous, calc. Arenite 455-455.9 Sandstone, v.f.g, very lt gray @ top olive gray	
458	7 min/ft	#7 105			105	1	micaceous towards base.	@ base, qtzitic, subround, calcite cement 455.9 – 457.7 Very fossiliferous	
459	9 min/ft			18		0		Limestone, Arenaceous in places, fossils, Dolomitized, Upper 0.1 ft is glauconitic	
460	11					1	vuggy w/ calcite crystals	sand, trace glauconite elsewhere. 457.7-458 As above, no dolomite	

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	12 MIN			18		0		458.4-460 - Limestone, very fossiliferous, sparry, sl. arenaceous, lt gray, very hard	?
462	9 MIN					0	vuggy	460 - 463.4 Limestone, marbled olive gray & lt gray, sl fossil, hard, arenaceous	
	12 MIN	Run 7		19	15 %	2		(in places) 463.4 - 465.2 Limestone, olive gray to light gray, argill-	
464	11 MIN	105%				1		aceous, very fossiliferous, sl. carbonaceous coral @ 465'	
	12 MIN			20		1		465.2 - 468.5 Sandstone v.f. grained and intbd. siltstone very fossiliferous, sl. vuggy	
466	7 MIN					0	fresh trace Fe ox staining	Lots of secondary calcite v. Lt gray (N8) to olive gray (5Y 4/1) hard	
	8 MIN					2		468.5-468.9 Transition Zone 468.9-471.7 - Sandstone, fine-grained, quartzitic, subrounded,	
468	9 MIN			21		1	gradational/ lower contact	calcareous @ top slightly @ base, porous, sl. fossil. thinly laminated to	
	4 MIN					1	sl. weathered	thin bedded med hard pale brown to olive gray	
470	1 MIN	Run 8 98 %			57 %	4	very broken & porous		
				22		3		471.7 - 475.0 Interbedded Claystone &	
472						4		fine grained silty sandstone thinly laminations & carbonaceous stringers	
						2	Fe ox stains	non calcareous, trace fossils, med hard	
474				23		2			
						3			

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								475.6 – 476.6 Convoluted v. lt gray Limestone	
476	3 MIN/FT			24				(Argillaceous) and siltstone dolomitic, med hard, fossiliferous, sl. arenaceous & carbonaceous	
	8 MIN/FT					2	— Pine Island	476.6 – 478.5 Interbedded Dark greenish gray (5GY 4/1)	
478	8 MIN/FT			—		3	SHALE slightly	and greenish gray (5GY 6/1) very fine grained gteitic SANDSTONE and clayey shale	
	7 MIN/FT	RUN 9		25		1	weathered	dolomitic, slightly micaceous, carbonaceous stringers,	
480	8 MIN/FT	77 %			69 %	3		478.5 – 479.3 = same as 475.6 – 476.6	
	6 MIN/FT 481.1 – 481.8 LAB SAMPLE			—		1	Drilling erodes unit	479.3 – 482.3 Mudstone, Dark green gray, med hard dolomitic, slightly carbonac.	
482	10 MIN/FT					4		trace fossils, thinly laminated, occ. sand lens, gteitic Lt gray	
	9 MIN/FT			26		2	sharp upper contact	(N7) hard w/ calcite cement, slightly pyritic 482.3 – 482.7 Sandstone,	
484	11 MIN/FT		LOSS			?	weathered	fine to med. grained, Dark olive gray, 40% mafic & carbon, 60% gtz.	
	11 MIN/FT					?		calcareous cement, subrnd. coal fragements 485 – 487.5 Interlaminated	
486	3 MIN/FT			—		0		Siltstone, and fine grained sand stone, Dk olive gray	
	5 MIN/FT	RUN 10			67 %	2	weathered	to black, med hard lots of lignite, 2-4 mm beds, clasts to 3 cm	
	6 MIN/FT	83 %		27		0		in Ø, porous v. calcareous 487.5 – 488.3 Interbd. Silt-	
488	13 MIN/FT			—		0	FRIABLE – POROUS	stone and silty fine grained SANDSTONE thinly laminated, calcareous, olive gr.	
				28				Sands are mafic & gtzitic	

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490						1	UNDULATORY BASAL CONTACT	488.3 – 489.8 Conglomeratic Siltstone, up to 1.5cm in Ø, Olive gray to	
		83%		28		2	Vuggy @ 490.2'	olive black very calc and carbonaceous, Lignite & plant fragments	
492		Run 10			67	3	2" Ø w/ calcite filling.	489.8 – 492.3 Irregularly Bedded Argillaceous, fine	
						2		grained Sandstone, friable, medium gray to	
494			Loss	29			Porous	brownish black sand is subangular to sub-round Abundant carbon	
								very vuggy, dolomitic and calcareous	
496									
498									
500									
502									
504									

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500	497-503 = 3 MIN 503-507 = 12 MIN	Run 11					502.3	502.3 - 505.8 Sandstone Greenish Gray (5G 6/1) fine grained, med. hard calcareous	
	upper 3.3 feet of run was	47%			23		Calcite reported in vugs	At 503.2 Grades downward into a siltstone.	
	probably disturbed during grouting				8	1	vugs up to 5cm in ø slightly	Trace glauconite. Sands are glauconitic. Slightly conglomeritic @ 503.2	
	Reaming			30		2	weathered on joints.	up to 2cm. Slightly pyritic (euhedral, fresh) Limestone inplaces. very vuggy	
505						0		505.8 - 508.5 Siltstone,	
						3	Calcite filling very	Greenish gray (5GY 6/1) and dark reddish brown (10R 3/4) dolomitic	
				31		2	weathered FeOx stains Hi Angle	soft, very broken, lots of clay weathering products high secondary porosity	
	3 min/ft					1	Fracture @ 506.8	508.5 - 509.4 Sandstone, light gray to dark reddish brown, fine grained,	
	3 min/ft					1	FeOx stained low porosity	thinly laminated & irregularly bedded, calcareous, med. hard,	
510	2 min/ft	Run		32		1		509.4 - 512 Sandstone dolomitic grayish red, to lt olive	
	2 min/ft	12				3	vugs open up to 3 in. in ø	gray, med. grained, glauconitic subround, Hi porosity (40%) med hard. irreg.	
	511.5-512 = Lab test. 2 min/ft	99%			71%	1	weathered 512 -	bedding, secondary dolomite xtals 515.8 Sandstone - v.f. grain	
	2 min/ft			33		1	massive LT	med. hard to hard, mostly mod. brown (5 YR 4/4) 20% olive gray, glauconitic,	
	2 min/ft					1	slightly vuggy mod. porosity	dolomitic, 5-10% mafics. intbd. w/ sandy dolomite.	
515	2 min/ft					1	Crystals on bedding planes	Conglomeritic @ 514.2	

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	2 MIN/FT	RUN 12 99%			71	1	515.8 – VERY VUGGY W DRUSY CALCITE	518.7 SANDSTONE, V. FINE TO FINE GRAINED, VERY DOLOMITIC ARGILLACEOUS SOME	
	2 MIN/FT			34	%	2	FeOx STAINS,	4 MM Ø ROCK FRAGMENTS. VERY CALCAREOUS (ARENACEOUS DOLOMITE IN PLACES)	
	2 MIN/FT					0		REDDISH BROWN TO LIGHT GRAY	
				35		1	CLAY AREAS HAVE FeOx STAIN 518.7	– 520.3 SANDY DOLOMITE, DARK REDDISH BROWN (10 R 3/4) TO LT. OLIVE GRAY (5Y6/1) VERY	
520						1	SLIGHT VUGGY VUGS HAVE qtz + CALCITE	FINE GRAINED, CLAYEY IN PLACES, HARD, LOTS OF DOLOMITE TO CALCAREOUS FEW GRAVEL	
		RUN 13			85 %	3	VERY VUGGY	520.3–521.5 SAME AS ABOVE Highly porous	
		97 %		36		3	2-3 cm Ø VUGS W/ CALCITE FILLING	521.5–527 DOLOMITE, SANDY INTERMIXED WITH SOME SANDSTONE	
						2	VERY BROKEN	FINE GRAINED, OCCASIONAL MED. GRAINED, GRAY TO BROWN (5YR 5/1) TO MOSTLY	
	1 MIN/FT					2	MASSIVE, SLIGHTLY BROKEN	LT OLIVE GRAY, qtzitic, SUBROUND, NOT VERY POROUS. CALCITE CEMENT INCREASES	
525	1 MIN/FT			37		2		WITH DEPTH. MATRIX MATERIAL CONTAINS WEATHERED CLAY OR FELDSPAR	
	Tungsten Bit 1 MIN/FT					1		527 – 528.7 SANDSTONE, yellowish	
	1 MIN/FT					1	CALCAREOUS	GRAY (5Y7/2) FINE GRAINED, qtzitic, SUBROUND, MED HARD, MODERATE POROSITY	
	2 MIN/FT			38		1	VUGGY Ø 528.5 528.7	OCCASSIONAL CLAY LENSES. – 533.3 DOLOMITIC SANDSTONE, lt OLIVE GRAY (5Y5/2) MEDIUM	
	1 MIN/FT	RUN 14				3	MASSIVE BEDDED but	GRAINED, VERY POROUS, 90 % qtz. SOME FELDSPAR AND MAFICS, CLAYEY at	
530	1 MIN/FT	98 %		39	66 %	2	BROKEN	BASE, MED HARD, SUBROUND TO SUBANGULAR MORE CALCAREOUS @ BASE	

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	1 MIN/FT TUNGSTEN BIT	RUN		39		4		531.7-531.9 Conglomeritic CLAYSTONE CLAST ZONE	
	1 MIN/FT	14 98%			6%	3			
	1 MIN/FT					1	533.3 WEATHERED FOX STAINS	533.3-535.4 SANDSTONE, very fine GRAINED, SILTY, LIGHT BROWN TO LIGHT OLIVE GRAY,	
	2 MIN/FT			40		3	MASSIVE 41° ANGLE FRACTURE @	QUARTZITIC, CALCAREOUS CEMENT, MOD HARD SLIGHTLY VUGGY	
535	2 MIN/FT					1	533.1 NON POROUS except for fracture	DOLOMITIC IN PLACES,	
	3 MIN/FT					1		535.4-537 - SANDY DOLOMITE, MOD. REDDISH BROWN, HARD, CLAYEY @ BASE	
	3 MIN/FT			41		2		537-537.9 SANDY DOLOMITE, SPOTTED	
	3 MIN/FT					0		LT OLIVE GRAY (5Y 6/1) to MODERATE REDDISH BROWN (10R4/6) QTZITIC, SUB	
	2 MIN/FT					1	FRESH, UNBROKEN	ROUND, MODERATE to low POROSITY, SLIGHTLY ARGILLACEOUS, HARD	
540	2 MIN/FT	RUN 15	X	42	41	1	539- VERY WEATHERED	539.9 - VERY COARSE GRAINED SANDY DOLOMITE AND CONGLOMERATE (Cup to 4 cm in Ø)	
	2 MIN/FT	88 %			7%	3	CLOSED UPPER & LOWER CONTACT	CEMENTED WITH CLAY AND CALCITE, MODERATE RED BROWN, MED HARD VERY POROUS.	
	2 MIN/FT					2	539.9 - VERY STAINED	542, SANDY DOLOMITE M. YELLOW BROWN, LT OLIVE GRAY, &	
	2 MIN/FT		X			3	BROKEN & SLIGHTLY WEATHERED	MOD RED BROWN, FINE GR CONVOLUTE BEDS, occ. ROCK FRAGMENT 542-542.2	
	2 MIN/FT			43		5	SL. ARGILLACEOUS 542.2	CONGLOMERITIC ZONE - 544.8 INTERBEDDED SILTY V. FINE GRAINED SAND	
545	2 MIN/FT					1	VERY BROKEN VERY ARGILLACEOUS IN PLACES, FOX	STONE & FINE to MED GRAIN SANDSTONE, VARIGATED color mostly qtz, occ GRAVEL HIGH SECONDARY POROSITY	

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	2 MIN/FT	Run 15			41	4	546.8- WEATHERED	546.8 Conglomerate (Cgm 8) with matrix of fine to coarse grain, [illegible]	
	3 MIN/FT	88 %		44	%	2	GRADATIONAL UPPER CONTACT	[illegible] second [illegible] MOD. HARD, DOLOMITIC?	
	7 MIN/FT					0	546.8- SLIGHTLY WEATHERED, FRIABLE	547 SANDSTONE, REDDISH BROWN & LT. GRAY, VERY FINE GRAINED, DOLOMITIC SILTY, QTZITIC, LOW POROSITY	
	4 MIN/FT					0	547 -	556.1 SANDSTONE, VERY FINE TO FINE GRAINED, MOSTLY	
	3 MIN/FT	Run 16		45	93 %	0	UNFRACTURED	MOD. REDDISH BROWN (10R4/6) SLIGHTLY GREENISH GRAY	
550	4 MIN/FT	93%				0	@ FRESH MASSIVE STRUCTURE	(5GY 6/1) MED HARD, QTZITIC, DOLOMITIC CEMENT, LOW POROSITY	
	5 MIN/FT					0		YELLOWISH BROWN TO GRAY SILTY DOLOMITE LAMINAE @ 547.2, 552.6	
	6 MIN/FT			46		0		@ 554.4, CONVOLUTED & THINLY BEDDED	
	5 MIN/FT					0			
	5 MIN/FT					0			
555							556.1-	Conglomeratic med grained	
	2 MIN/FT					0	556.3 FRIABLE,	SANDSTONE, quartzitic SUBROUND, SOFT, MATRIX of silty qtz, very calcareous	
	1 MIN/FT			47		1		pebbles up to 1.5 cm.	
	5 MIN/10 FT	Run					557-	560 Little return	
		17 <5%			0 %	N A		Includes cobbles up to 3 inches in Ø SUBROUND to ROUND. GRAVELS ARE fine grained SANDSTONE	
560									

CH2MHILL

PROJECT NUMBER TEX24486.A1

ROCK CORE LOG

PROJECT Aquifer Storage and Recovery LOCATION UGRA WTP

DRILLING METHOD Mud Rotary DRILLERS & EQUIPMENT TWDB-Failing 1500

ELEVATION _____ ORIENTATION Vertical BORE HOLE: Well PZ-1

WATER LEVEL _____ DATE: _____ START: _____ FINISH: _____ INSPECTOR Petrus

DEPTH	COMMENTS: TESTS, INSTRUMENTATION, CORING RATE AND SMOOTHNESS, CORING FLUID LOSS	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES: RQD	DISCONTINUITIES: FRACTURES PER FOOT	DISCONTINUITIES: DESCRIPTION (TIGHTNESS, PLANARITY, SMOOTHNESS, FILLING, STAINING, ORIENTATION)	LITHOLOGY: MINERALOGY, CLASSIFICATION, COLOR, GRAIN SIZE, ALTERATION; CEMENTATION, HARDNESS, WEATHERED STATE	GRAPHIC LOG
	5min/10 FT							Included in return is a reddish disturbed silty sandstone. Can't tell if it is cave in material	
	Core loss uncertain	Run 17							
	Hit gravel zone estimate	<5%			0 %	NA			
	3' thick			47					
565									
	HARD DRILLING FEELS LIKE	Run				N		Probably hard sandstone but gravel in hole prohibited recovery	
	SITTING ON A BOULDER AS	18 0%		NA	0 %	A			
	BIT IS WORN COMPLETELY IN 3 FEET								
570	Use 6" Rollerbit to CLEAN AND							Cutting returns are tan v fine grained to fine grained sandstone, hard, cemented with calcite	
	CONDITION HOLE FROM 570 to 575 FEET								
575									

FORM D 2113A 5/78

CH2MHILL

PROJECT NUMBER TEX24486.A1

ROCK CORE LOG

PROJECT Aquifer Storage and Recovery LOCATION UGRA WTP

DRILLING METHOD Mud Rotary DRILLERS & EQUIPMENT TWDB-Failing 1500

ELEVATION _____ ORIENTATION Vertical BORE HOLE: Well PZ-1

WATER LEVEL _____ DATE: _____ START: _____ FINISH: _____ INSPECTOR Petrus

DEPTH	COMMENTS: TESTS, INSTRUMENTATION, CORING RATE AND SMOOTHNESS, CORING FLUID LOSS	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES: ROD	DISCONTINUITIES: FRACTURES PER FOOT	DISCONTINUITIES: DESCRIPTION (TIGHTNESS, PLANARITY, SMOOTHNESS, FILLING, STAINING, ORIENTATION)	LITHOLOGY: MINERALOGY, CLASSIFICATION, COLOR, GRAIN SIZE, ALTERATION; CEMENTATION, HARDNESS, WEATHERED STATE	GRAPHIC LOG
	Collar above core barrel twisted off							Unknown, no recovery	
	during run. Fished out	Run 19		NA	0%	?			
	but no core in barrel.	0%							
	↓							↓	
	Diamond bit								
580									
	Twisted off again. This							No recovery. Drilling was hard. Probably	
	time 200'							a well cemented sandstone	
	When fishing out, barrel								
	dropped 30' free fall with 350' of	Run		NA	0	?			
	pipe	20			0%				
585	Could have	0%							
	caused core loss.								
	581-582 (5min) 582-583 (5min) 583-585 (9min)							Drilled the cored interval later with rotary bit. Chips were mixture of clay, chert, &	
	585-588 hard took 25 min 588-589 10min							fine grained Sandstone. Probably in a conglomerate	
	589-590 11min							cemented w/ calcite. Buff colored	
590									

FORM D 2113A 5/78

CH2M HILL

PROJECT NUMBER TEX24486.A1

ROCK CORE LOG

PROJECT Aquifer Storage and Recovery LOCATION UGRA WTP

DRILLING METHOD Mud Rotary DRILLERS & EQUIPMENT TWDB-Failing 1500

ELEVATION _____ ORIENTATION Vertical BORE HOLE: Well PZ-1

WATER LEVEL _____ DATE: _____ START: _____ FINISH: _____ INSPECTOR Petrus

DEPTH	COMMENTS: TESTS, INSTRUMENTATION, CORING RATE AND SMOOTHNESS, CORING FLUID LOSS	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES: ROD	DISCONTINUITIES: FRACTURES PER FOOT	DISCONTINUITIES: DESCRIPTION (TIGHTNESS, PLANARITY, SMOOTHNESS, FILLING, STAINING, ORIENTATION)	LITHOLOGY: MINERALOGY, CLASSIFICATION, COLOR, GRAIN SIZE, ALTERATION; CEMENTATION, HARDNESS, WEATHERED STATE	GRAPHIC LOG
	7min Alt. hard and easy zones							No recovery in something very hard (chert?)	
	20min Loud chatter	Run 21		NA	0	NA			
	25min Very hard	0%							
	16min								
595	32min Ruined Diamond Bit in 5 feet								
	Rollerbit to 606'						Chip	Returns are medium reddish brown & tan very fine grained sand, slightly calcareous Also lots of chert chips some with calcareous sand matrix Probably Conglomerate	
	Alternating hard & soft zones								
600									
	602 Cuts smoothly							Returns are soft to med hard v. fine grained Sandstone	
								At 604' we get some soft dark reddish brown	
605								Mudstone Decide to core	

PROJECT NUMBER TEX24486.A1

ROCK CORE LOG

PROJECT Aquifer Storage and Recovery LOCATION UGRA WTP

DRILLING METHOD Mud Rotary DRILLERS & EQUIPMENT TWDB-Failing 1500

ELEVATION _____ ORIENTATION Vertical BORE HOLE: Well PZ-1

WATER LEVEL _____ DATE: _____ START: _____ FINISH: _____ INSPECTOR Petrus

DEPTH	COMMENTS: TESTS, INSTRUMENTATION, CORING RATE AND SMOOTHNESS, CORING FLUID LOSS	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES: ROD	DISCONTINUITIES: FRACTURES PER FOOT	DISCONTINUITIES: DESCRIPTION (TIGHTNESS, PLANARITY, SMOOTHNESS, FILLING, STAINING, ORIENTATION)	LITHOLOGY: MINERALOGY, CLASSIFICATION, COLOR, GRAIN SIZE, ALTERATION	LITHOLOGY: CEMENTATION, HARDNESS, WEATHERED STATE
				—					
	5min						Extremely broken or	Mostly Boulder conglomerate boulders > 4 inches in ø	
	7min gets hard						unconsol, fated Can't tell	well rounded, mostly fine grained sands MATRIX where present is mod.	
	5min.	Run 22					if drilling has washed	REDDISH BROWN SANDSTONE fine grained comprised of	
	4min	0%			0%	N	AWAY MATRIX	qtz, feldspar, mica, and TRACE PYRITE, Friable AND poorly cemented	
610									
	17min lots of chatter			4 8		A			
	5min								
	17min								
	28 min								
	19min								
615	Can't Drill			—					
	PAST 615 w/ RUN Rollerbit to							Rollerbit, hard drilling Cuttings are, sandstone and chert.	
	625' 617-620 = 2/min							Probably still in Conglomerate	
	hard drilling								
620									

PROJECT NUMBER TEX24486.A1

ROCK CORE LOG

PROJECT Aquifer Storage and Recovery LOCATION UGRA WTP

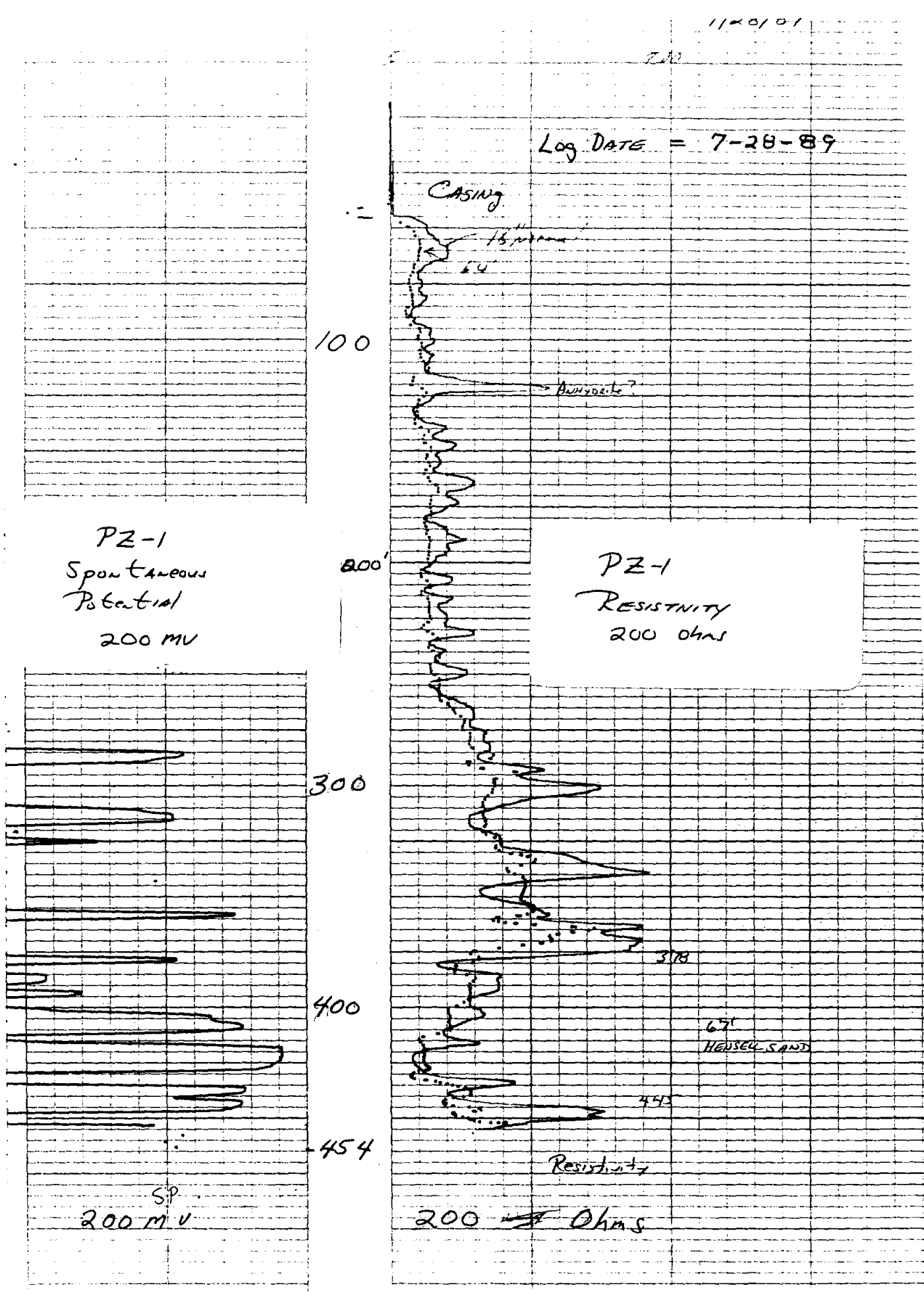
DRILLING METHOD Mud Rotary DRILLERS & EQUIPMENT TWDB-Failing 1500

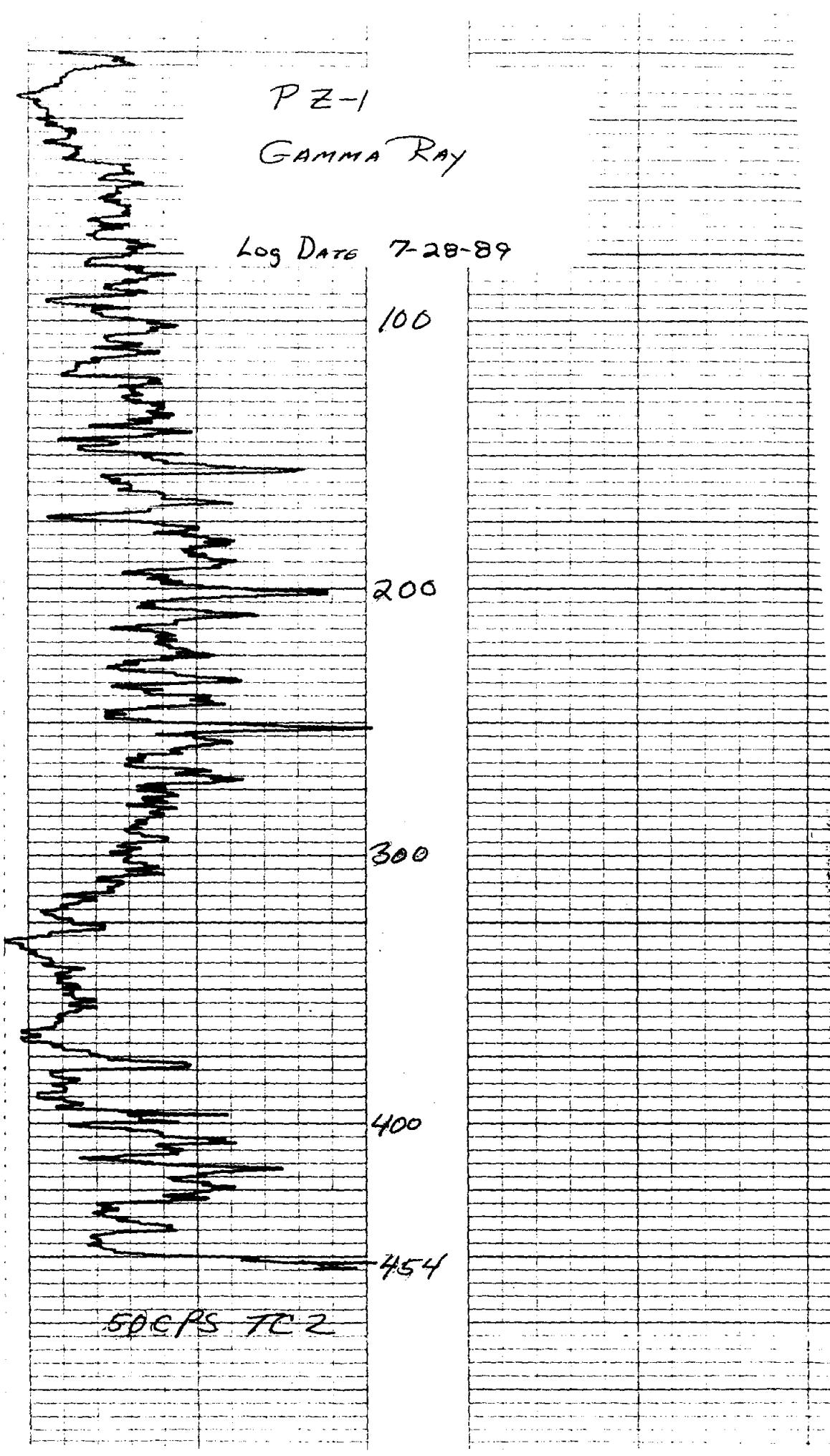
ELEVATION _____ ORIENTATION Vertical BORE HOLE: Well PZ-1

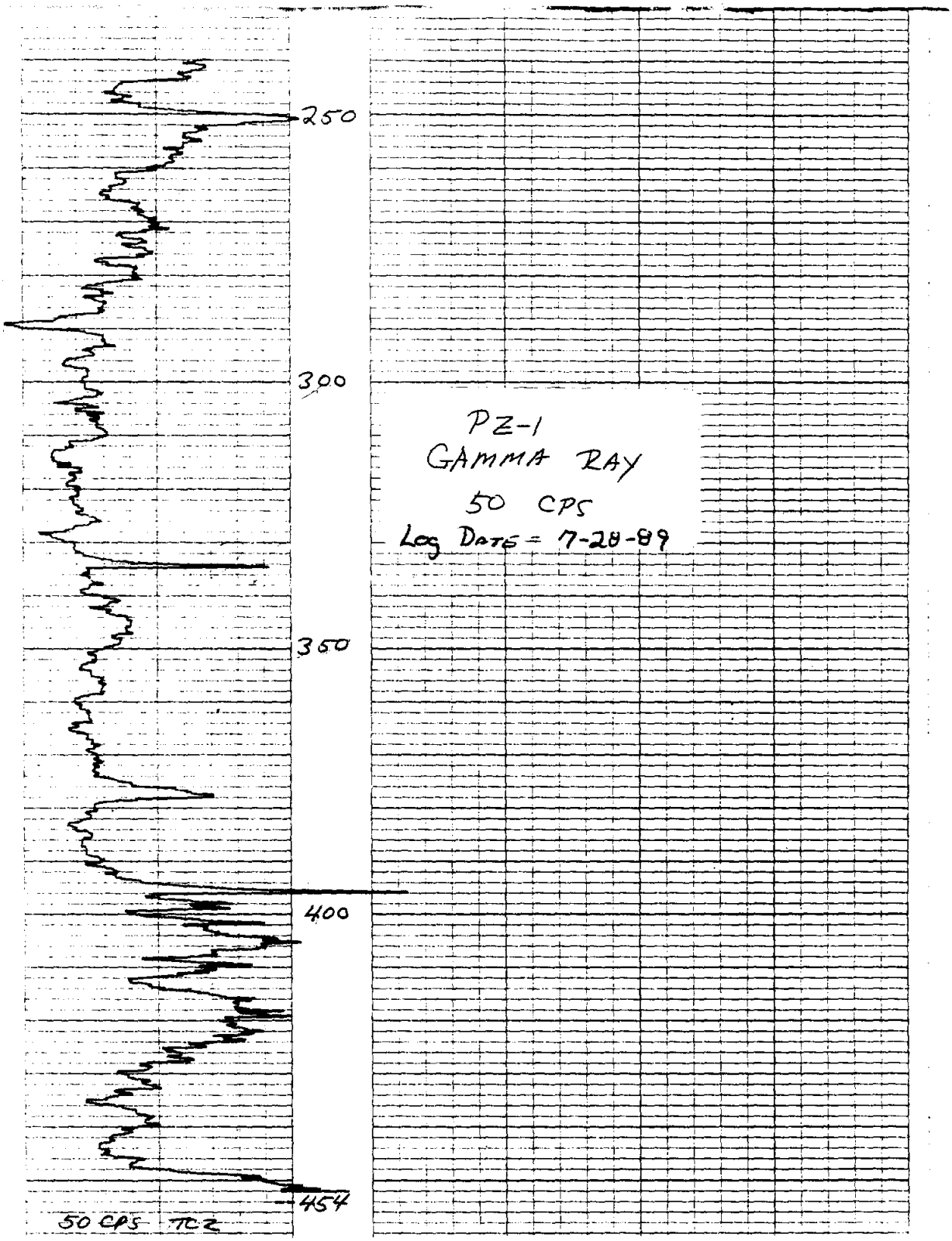
WATER LEVEL _____ DATE: _____ START: _____ FINISH: _____ INSPECTOR Petrus

DEPTH	COMMENTS: TESTS, INSTRUMENTATION, CORING RATE AND SMOOTHNESS, CORING FLUID LOSS	CORE RUN LENGTH AND RECOVERY (%)	CORE LOSS ZONE	BOX NUMBER	DISCONTINUITIES: ROD	FRACTURES PER FOOT	DESCRIPTION: TIGHTNESS, PLANARITY, SMOOTHNESS, FILLING, STAINING, ORIENTATION	LITHOLOGY: MINERALOGY, CLASSIFICATION, COLOR, GRAIN SIZE, ALTERATION; CEMENTATION, HARDNESS, WEATHERED STATE	GRAPHIC LOG
	Drilling to 625' Smooth Drilling IN clay? 620-25' = 19min							@ 620' Drilling is smooth Out of Cngl. Returns Are minimal probably a shale or claystone	
625	4" core ↓								
	7MIN/FT							No recovery but inside of barrel contains Clay,	
	8 MIN/FT							Light gray (N7) slightly sandy, very sticky, soft.	
	10MIN/FT							slightly calcareous	
	7MIN/FT	Run 24				N/A		Need to run geophysics for confirmation	
630	6MIN/FT	0%		N/A	0%				
	5MIN/FT								
	7MIN/FT								
	6MIN/FT								
	7MIN/FT								
635	7MIN/FT							TD 635'	

Appendix B
GEOPHYSICAL LOGS


11-01-01
Log Date = 7-28-89
Casing
16" Normal
64
100
Anhydrite?
200'
PZ-1
Spontaneous
Potential
200 MV
PZ-1
Resistivity
200 Ohms
300
318
400
67'
Hensel Sand
443
454
Resistivity
SP
200 mV
200 Ohms


PZ-1
GAMMA RAY
Log Date 7-28-89
100
200
300
400
454
50 CPS FC 2


250
300
350
400
454
50 CPS TC2
PZ-1
GAMMA RAY
50 CPS
Log Date = 7-28-89

TEXAS WATER DEVELOPMENT BOARD
WATER AVAILABILITY DATA AND STUDIES SECTION
AUSTIN, TEXAS

STATE WELL NUMBER _____
FILE NUMBER 89-26
PROJECT 3206

NOTE: THESE LOGS CANNOT BE USED TO FULFILL CONTRACTURAL OBLIGATIONS.

TYPES OF LOGS THIS DATE: 8-2-89 : E-log : _____ : _____ : _____ : _____ : _____ : _____ .

OPERATOR (S) Crew . LOCATION: _____

COUNTY: Kerr NEAREST TOWN: Kerrville DRILLER: TWDB, McCurdy

OWNER: U.G.R.A ADDRESS: _____

TYPE OF DRILL: Air Cored BIT SIZE: 9 7/8" to 400', 6" to 495'

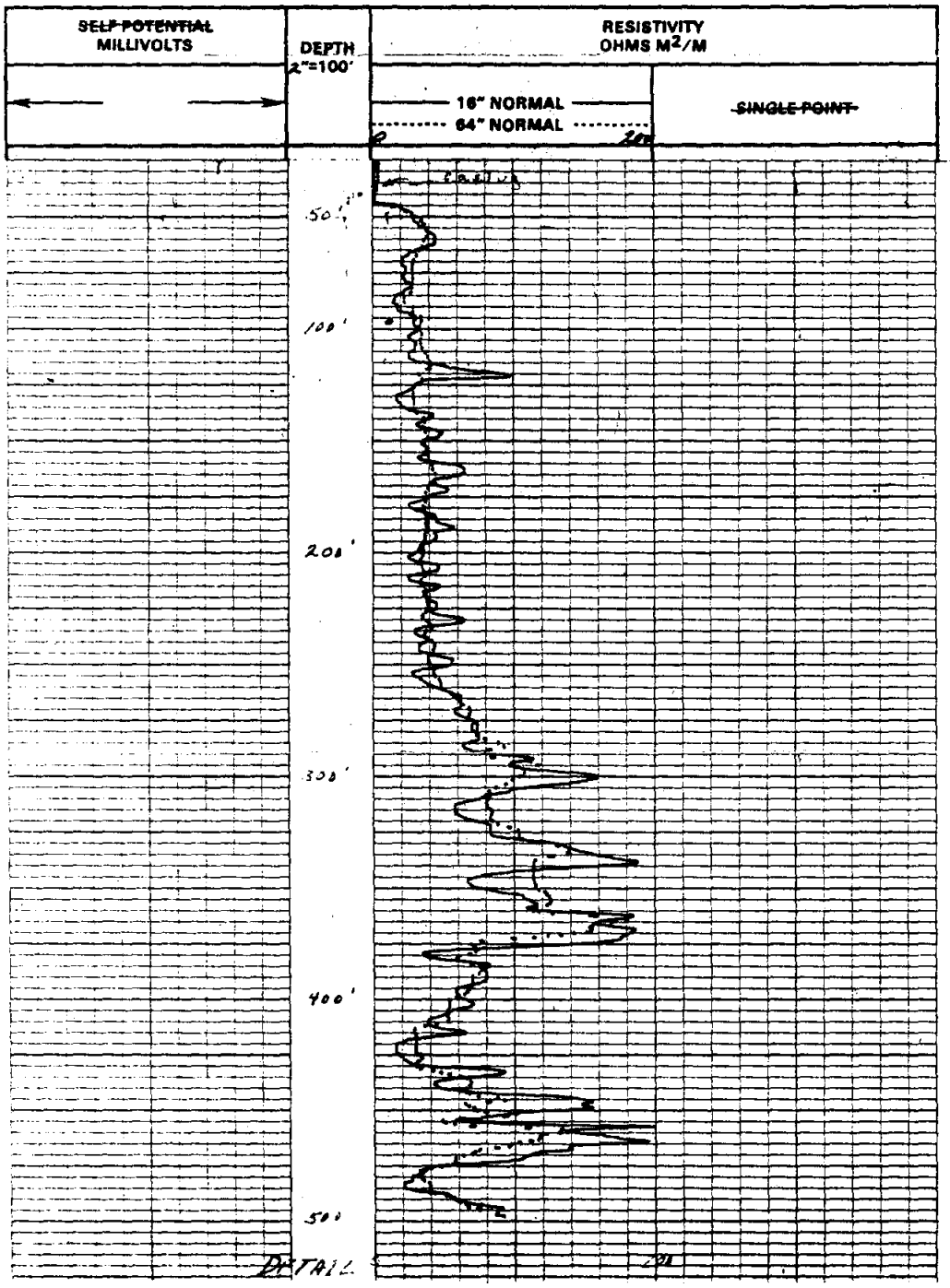
ALTITUDE OF LAND SURFACE: 1635' LOGGED DEPTH: 497' DRILLED DEPTH: 495'

FLUID LEVEL: _____ FLUID TYPE: Fresh Mud LOG REFERENCE POINT: Ground level

CASING DATA: 10 3/4" to 39' OPEN HOLE DIA.: 6"

CEMENTED FROM: Surf TO 39' SCREEN: Open Hole TO _____ AQUIFER: _____

FLUID RESISTIVITY: _____ OHMS AT _____ °F. REMARKS: _____



OPERATOR (S) CBRA . LOCATION:

COUNTY: Kerr NEAREST TOWN: Kerrville DRILLER: TWDB, McCarty

OWNER: U.G.R.A ADDRESS:

TYPE OF DRILL: ~~Rotary~~ Cored BIT SIZE: 9 7/8" to 400', 6" to 495'

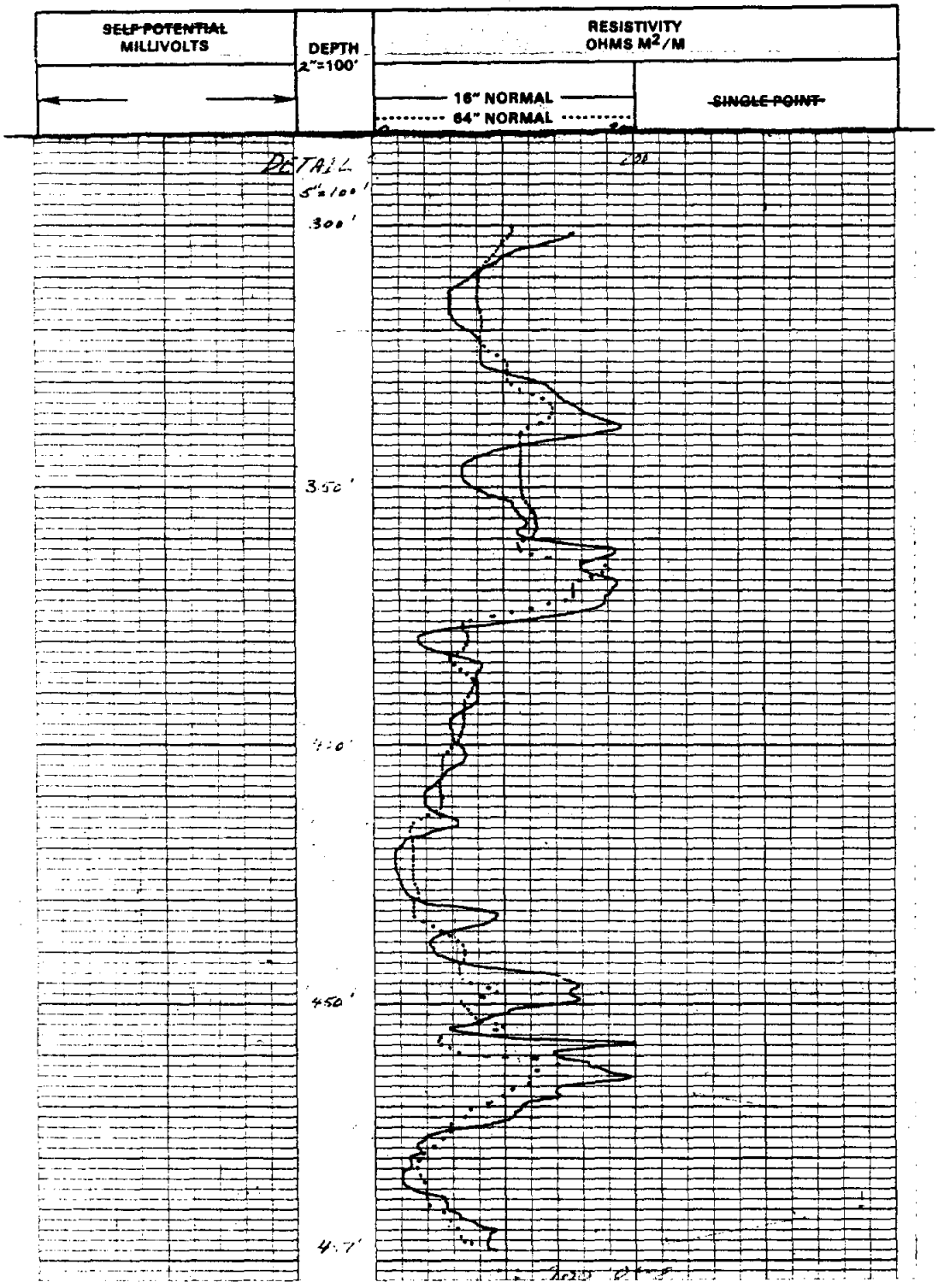
ALTITUDE OF LAND SURFACE: 1635' LOGGED DEPTH: 497' DRILLED DEPTH: 495'

FLUID LEVEL: FLUID TYPE: Fresh Mud LOG REFERENCE POINT: Ground level

CASING DATA: 10 3/4" to 39' OPEN HOLE DIA.: 6"

CEMENTED FROM: Surf TO 39' SCREEN: ~~None~~ N/A TO AQUIFER:

FLUID RESISTIVITY: OHMS AT °F. REMARKS:



TWDB-0272A

TEXAS WATER DEVELOPMENT BOARD
WATER AVAILABILITY DATA AND STUDIES SECTION
AUSTIN, TEXAS

STATE WELL NUMBER _____
FILE NUMBER 89-26
PROJECT 3206

NOTE: THESE LOGS CANNOT BE USED TO FULFILL CONTRACTURAL OBLIGATIONS.

TYPES OF LOGS THIS DATE: 8-2-89 : _____ : _____ : _____ : _____ : _____ : _____ : _____ : _____

OPERATOR (S) C Bin . LOCATION: _____

COUNTY: Kerr NEAREST TOWN: Kerrville DRILLER: _____

OWNER: U. G. R. A. ADDRESS: _____

TYPE OF DRILL: Core BIT SIZE: 9 7/8" - 400', 6" 400' to 497'

ALTITUDE OF LAND SURFACE: 1635' LOGGED DEPTH: 497' DRILLED DEPTH: 495'

FLUID LEVEL: _____ FLUID TYPE: Fresh Water LOG REFERENCE POINT: Ground Level

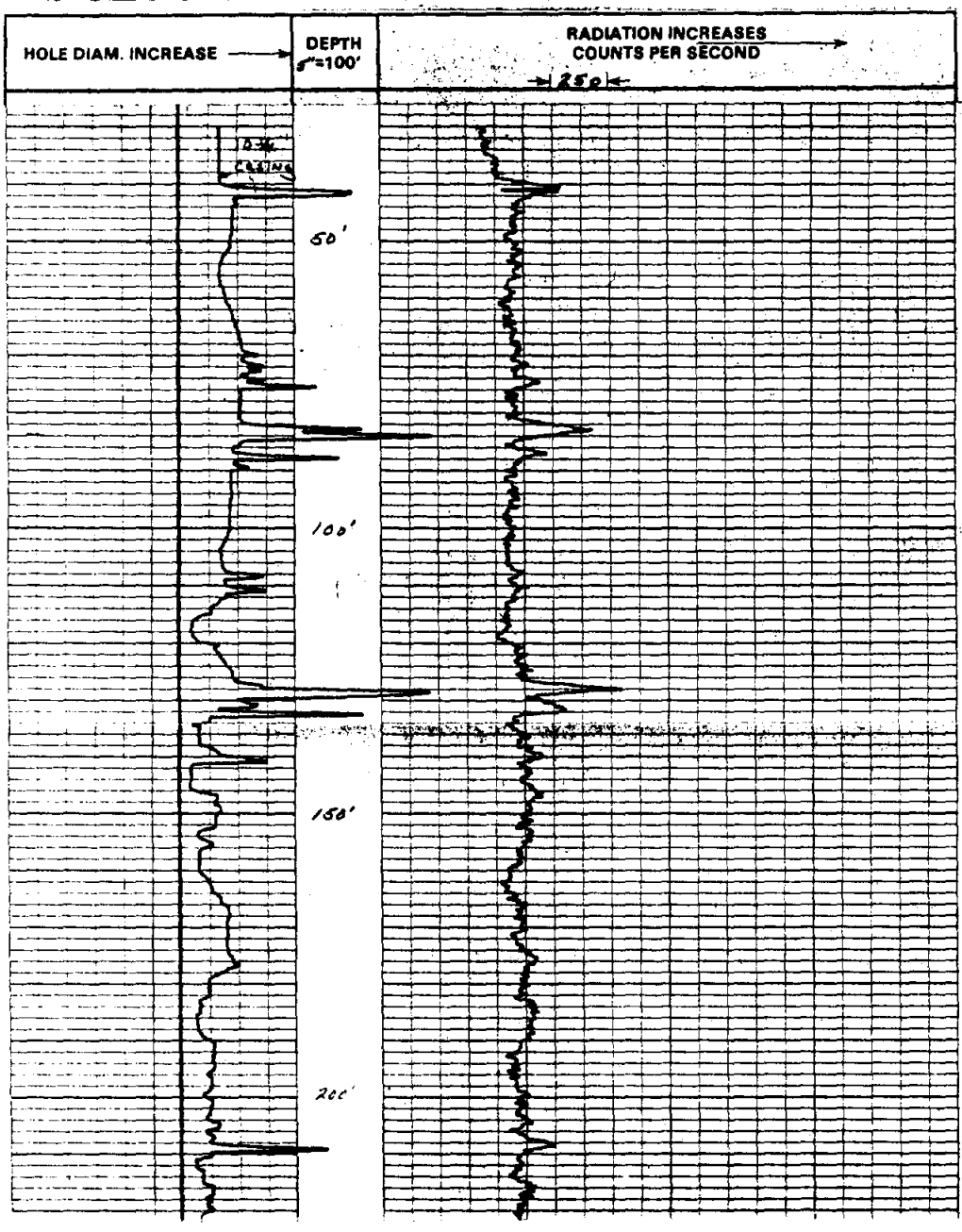
CASING DATA: 10 3/4" Surf - 39' OPEN HOLE DIA.: 6"

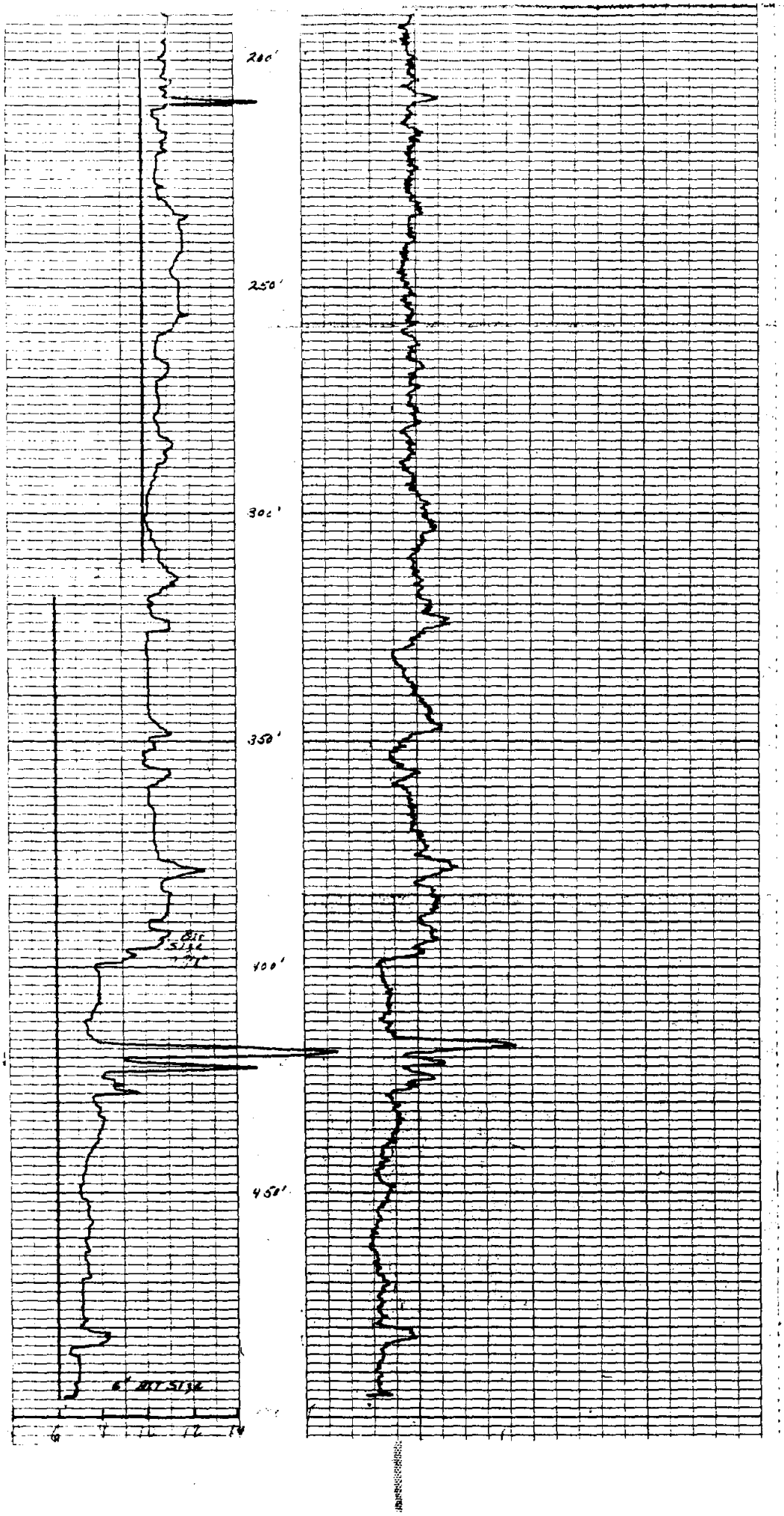
CEMENTED FROM: Surf TO 39' SCREEN: Open hole TO _____ AQUIFER: _____

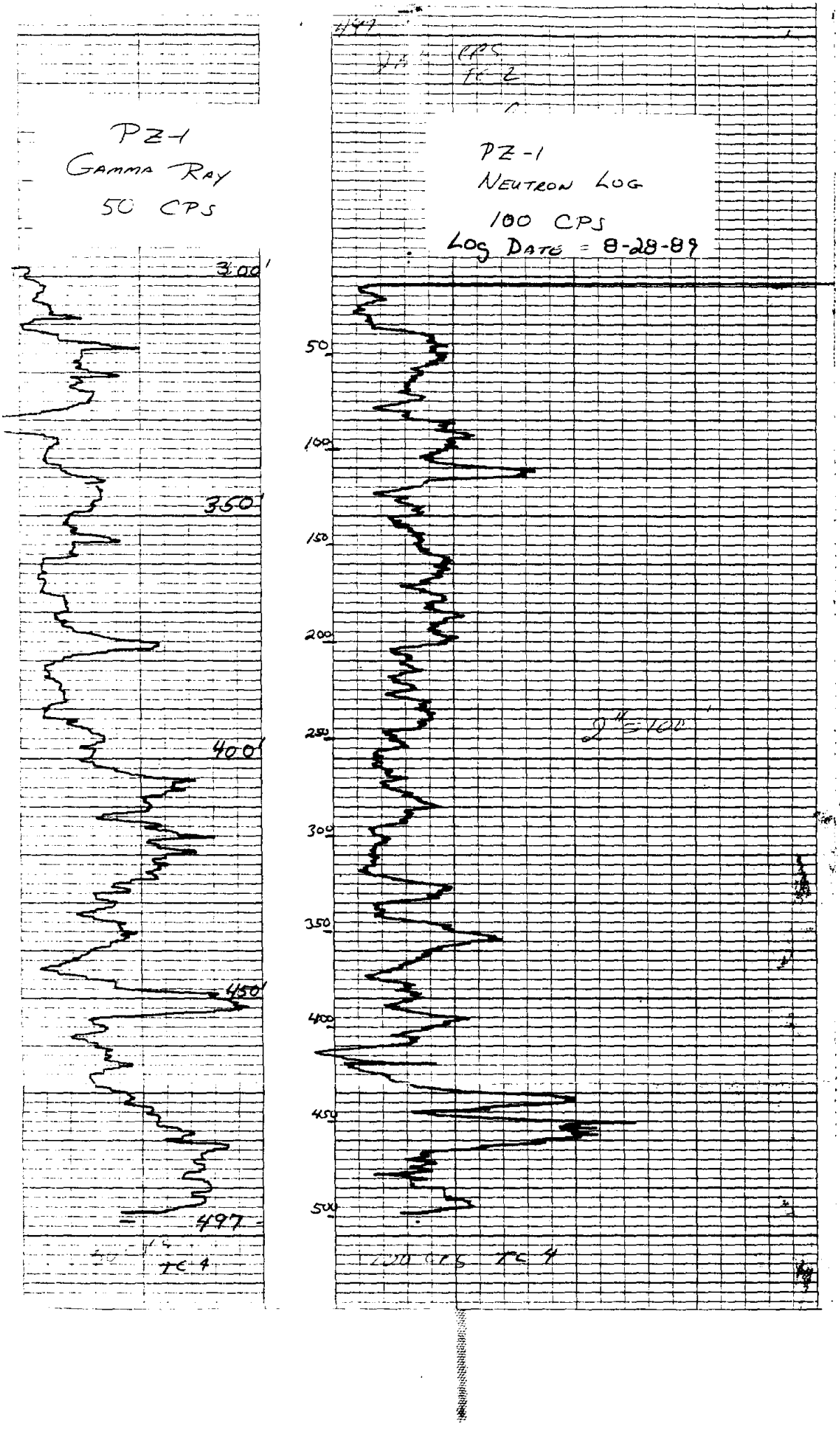
FLUID RESISTIVITY: _____ OHMS AT _____ ° F. REMARKS: _____

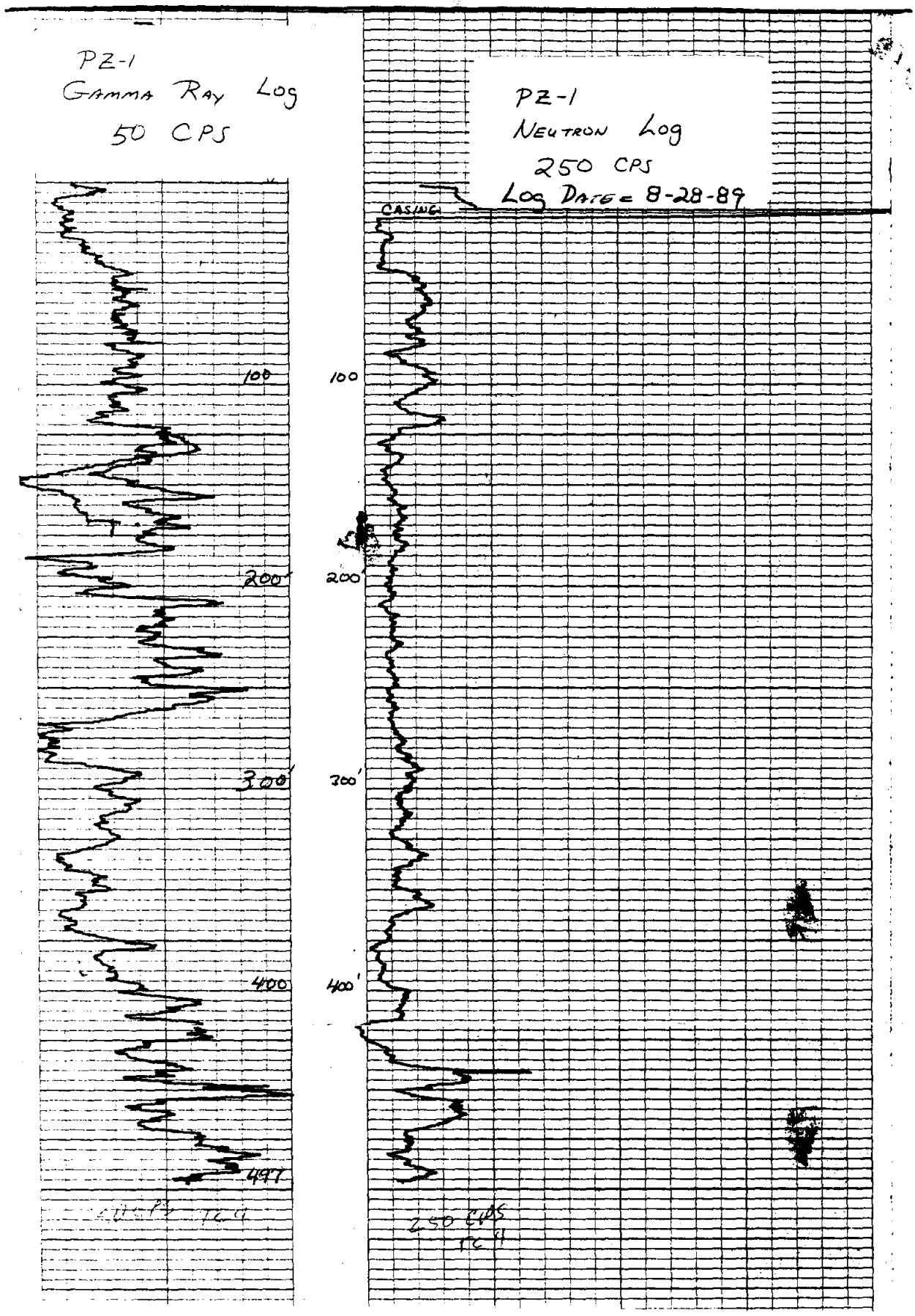
CALIPER
HOLE DIAMETER IN INCHES
FROM 4 " TO 14 "

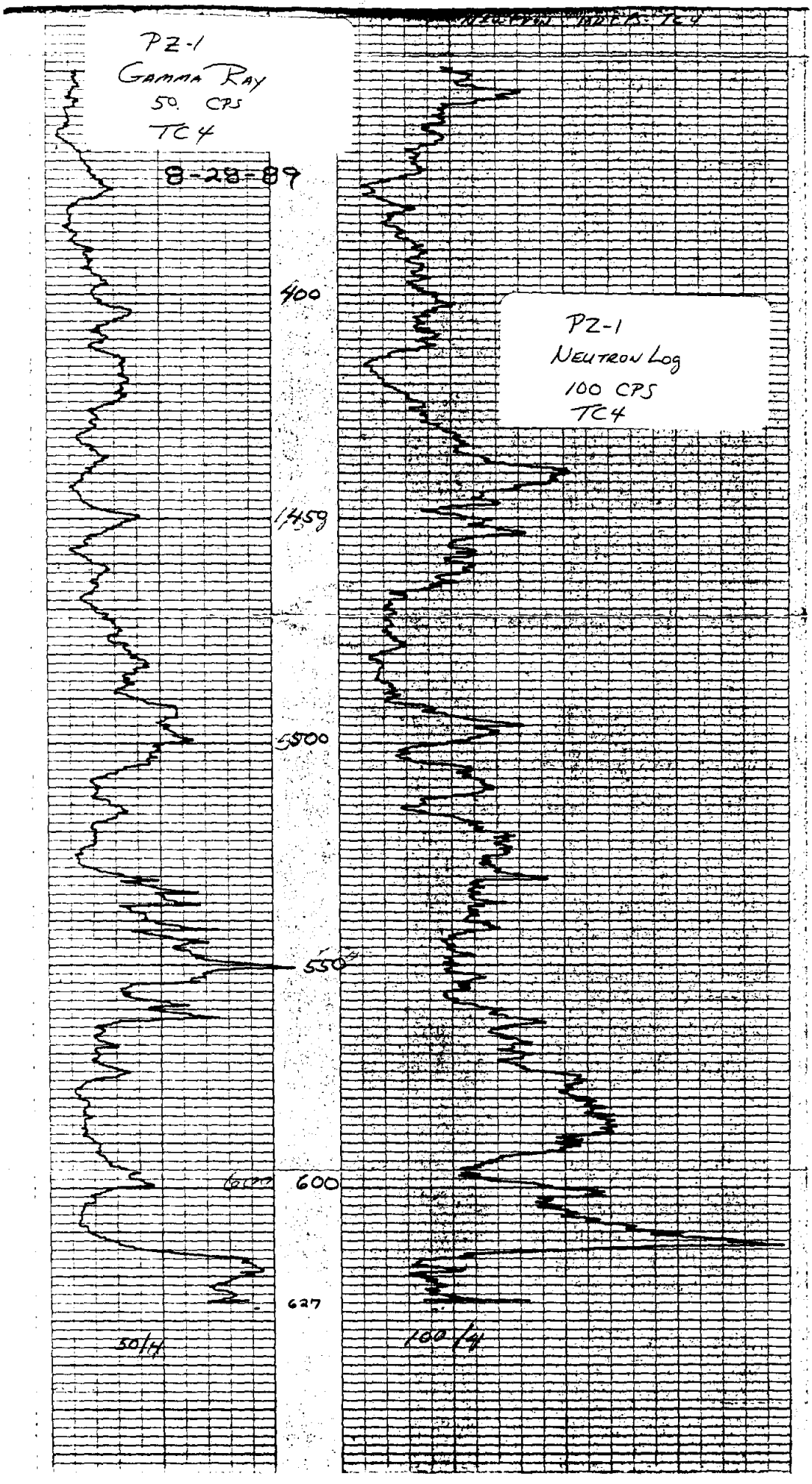
GAMMA GAMMA
COUNTS PER SECOND 25000
TIME CONSTANT 1 SPACING 21 "

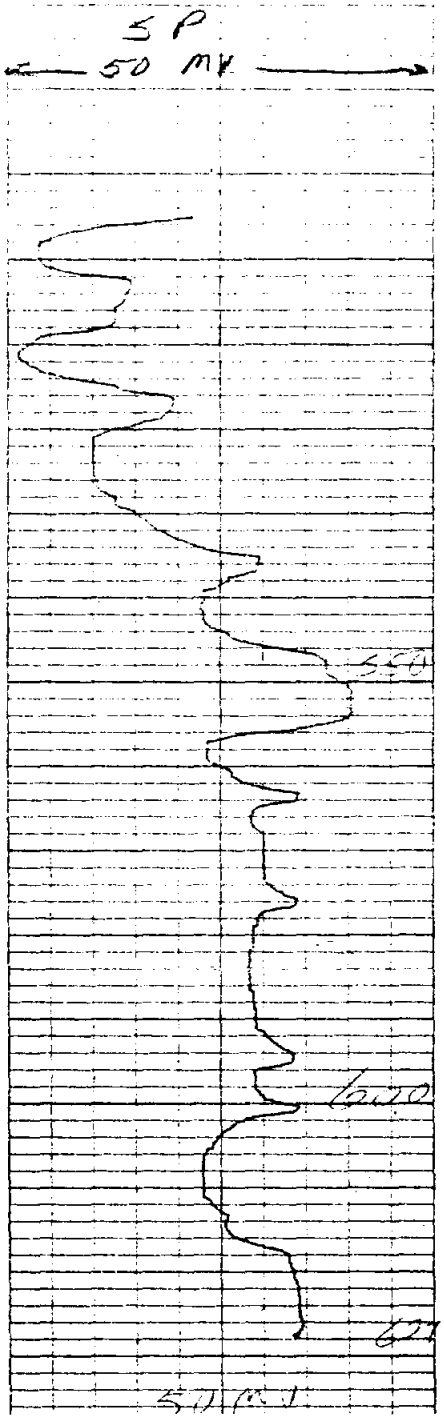



200'
250'
300'
350'
400'
450'
Bit Size
6" Bit Size

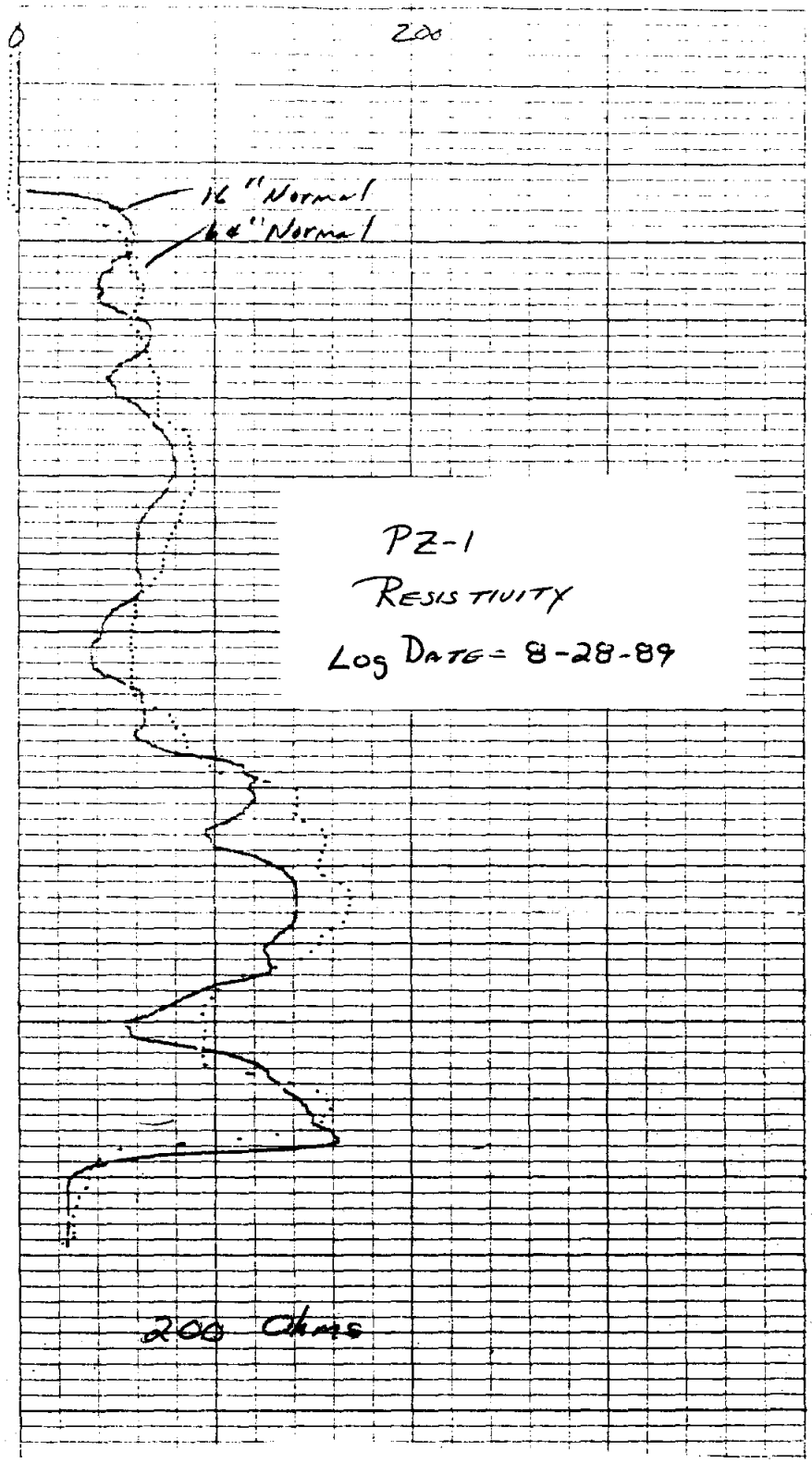

PZ-1
GAMMA RAY
50 CPS
300'
350'
400'
450'
497'
PZ-1
NEUTRON LOG
100 CPS
LOG DATE = 8-28-89
50
100
150
200
250
300
350
400
450
500
2" = 100'

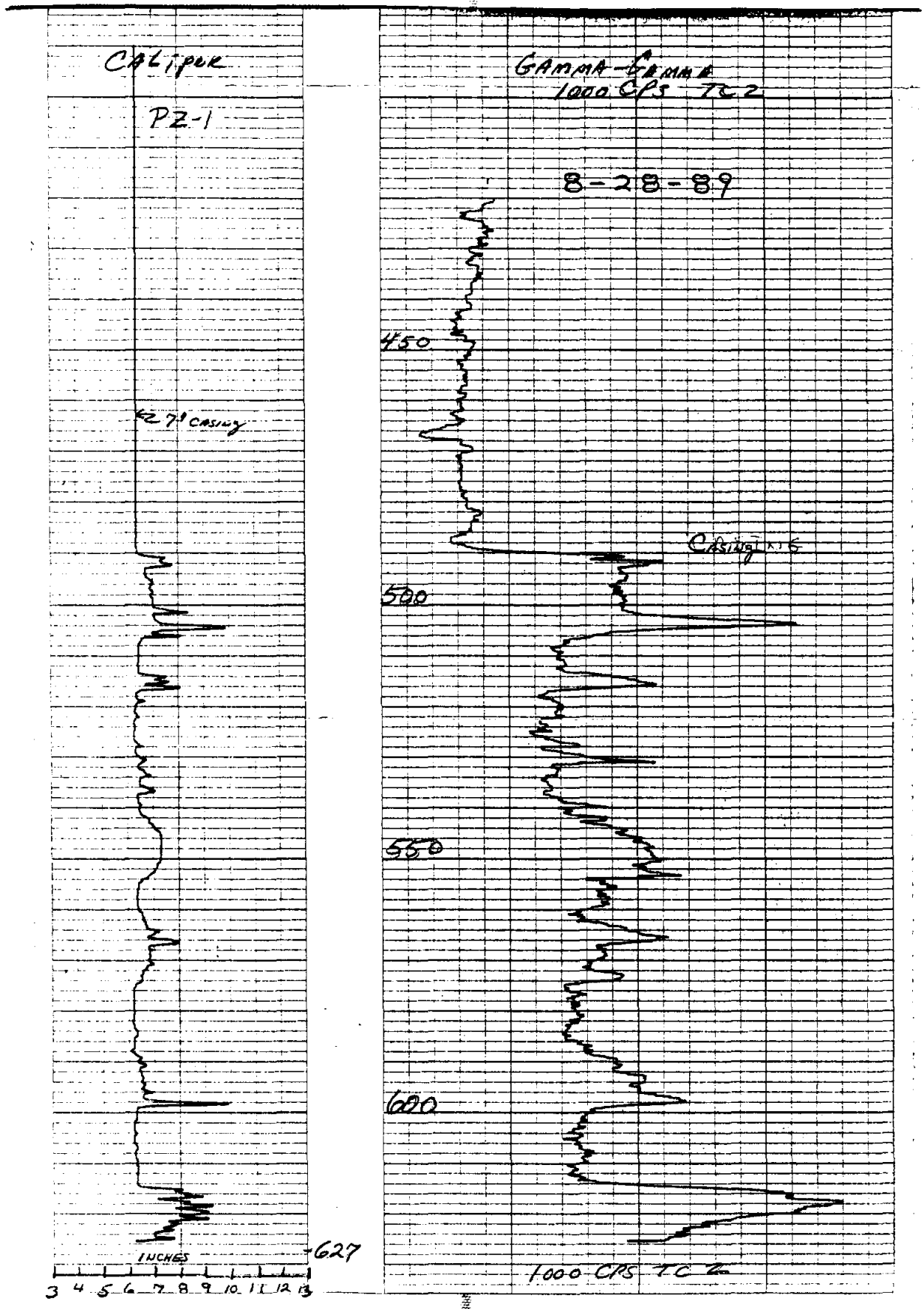

PZ-1
GAMMA RAY LOG
50 CPS
100
200'
300'
400
497
PZ-1
NEUTRON LOG
250 CPS
LOG DATE = 8-28-89
CASING
100
200'
300'
400'
250 CPS

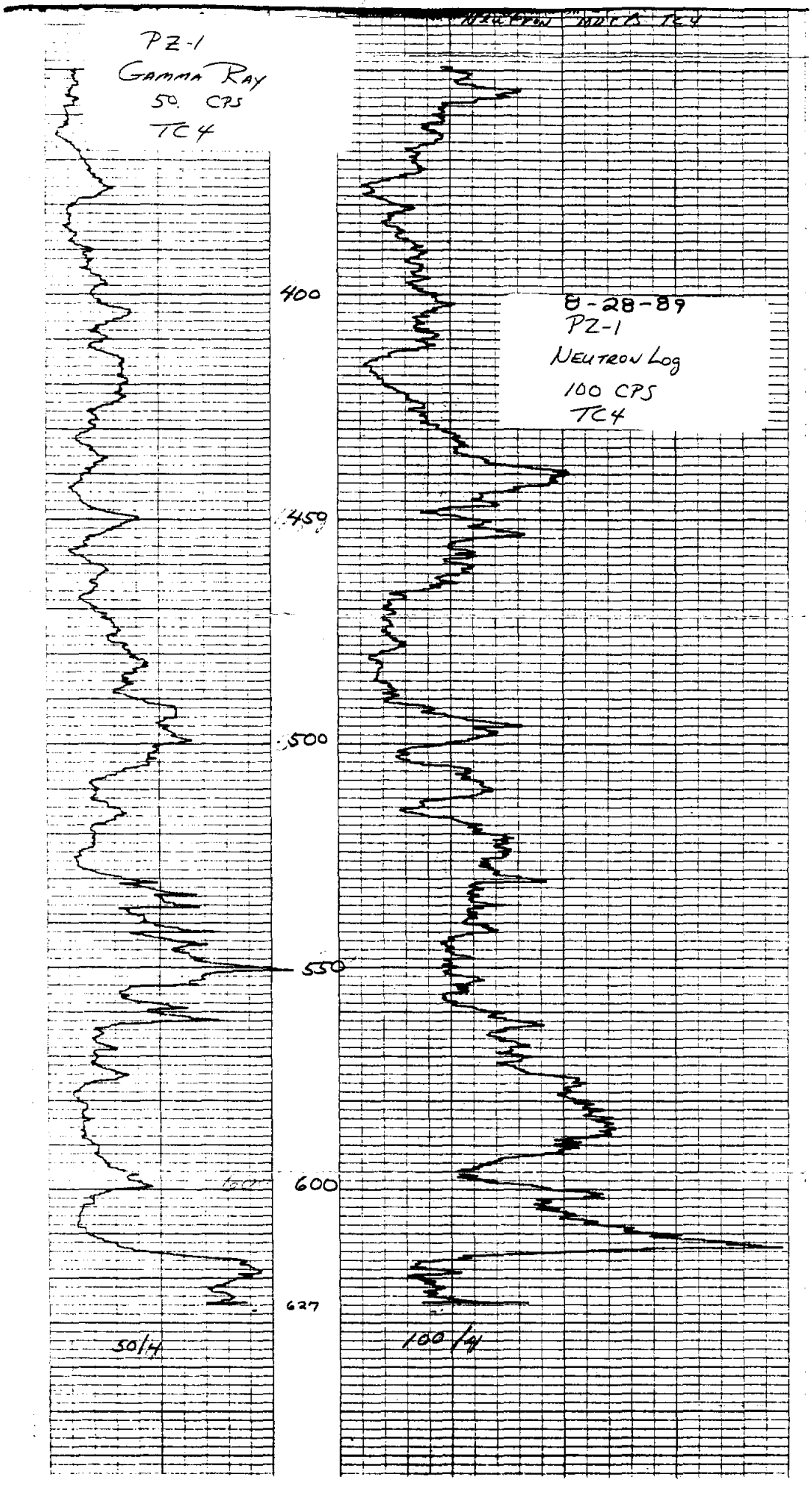

PZ-1
GAMMA RAY
50. CPS
TC4
8-28-89
400
1459
5500
550
600
627
50/4
PZ-1
NEUTRON LOG
100 CPS
TC4
100/4

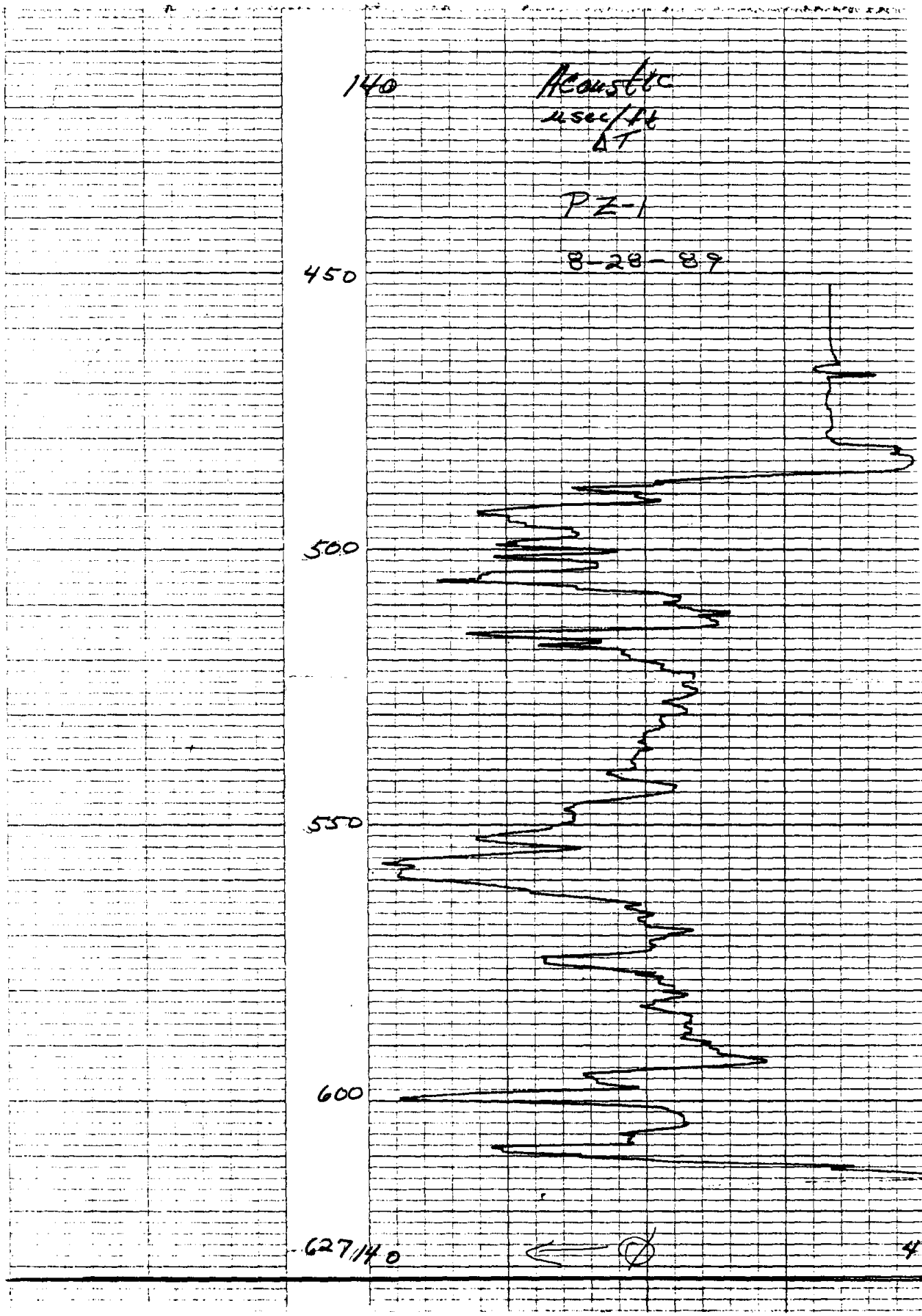


PZ-1
SPONTANEOUS
POTENTIAL




CALIPER
PZ-1
GAMMA-GAMMA
1000 CPS TC 2
8-28-89
450
500
550
600
627
INCHES
3 4 5 6 7 8 9 10 11 12 13
1000 CPS TC 2


PZ-1
GAMMA RAY
50 CPS
TC4
400
450
500
550
600
627
50/4
8-28-89
PZ-1
NEUTRON LOG
100 CPS
TC4
100/4


140
Acoustic
μsec/ft
Δ T
PZ-1
8-28-89
450
500
550
600
627/140

TWDB-0270A

TEXAS WATER DEVELOPMENT BOARD
WATER AVAILABILITY DATA AND STUDIES SECTION
AUSTIN, TEXAS

STATE WELL NUMBER _____
FILE NUMBER 89-26
PROJECT 3245

NOTE: THESE LOGS CANNOT BE USED TO FULFILL CONTRACTURAL OBLIGATIONS.

TYPES OF LOGS THIS DATE: 9/25/89 : E-LOG : GR : N : GG : CAL : SONIC : _____.

OPERATOR (S) CRIM . **LOCATION:** UGRA TEST WELL # 1

COUNTY: KERR **NEAREST TOWN:** KERRVILLE **DRILLER:** TWDB, McCARTY

OWNER: UGRA **ADDRESS:** _____

TYPE OF DRILL: CORED **BIT SIZE:** 6"

ALTITUDE OF LAND SURFACE: 1635' **LOGGED DEPTH:** 603' **DRILLED DEPTH:** 627'

FLUID LEVEL: 197' ± **FLUID TYPE:** FRESH WATER **LOG REFERENCE POINT:** GROUND LEVEL

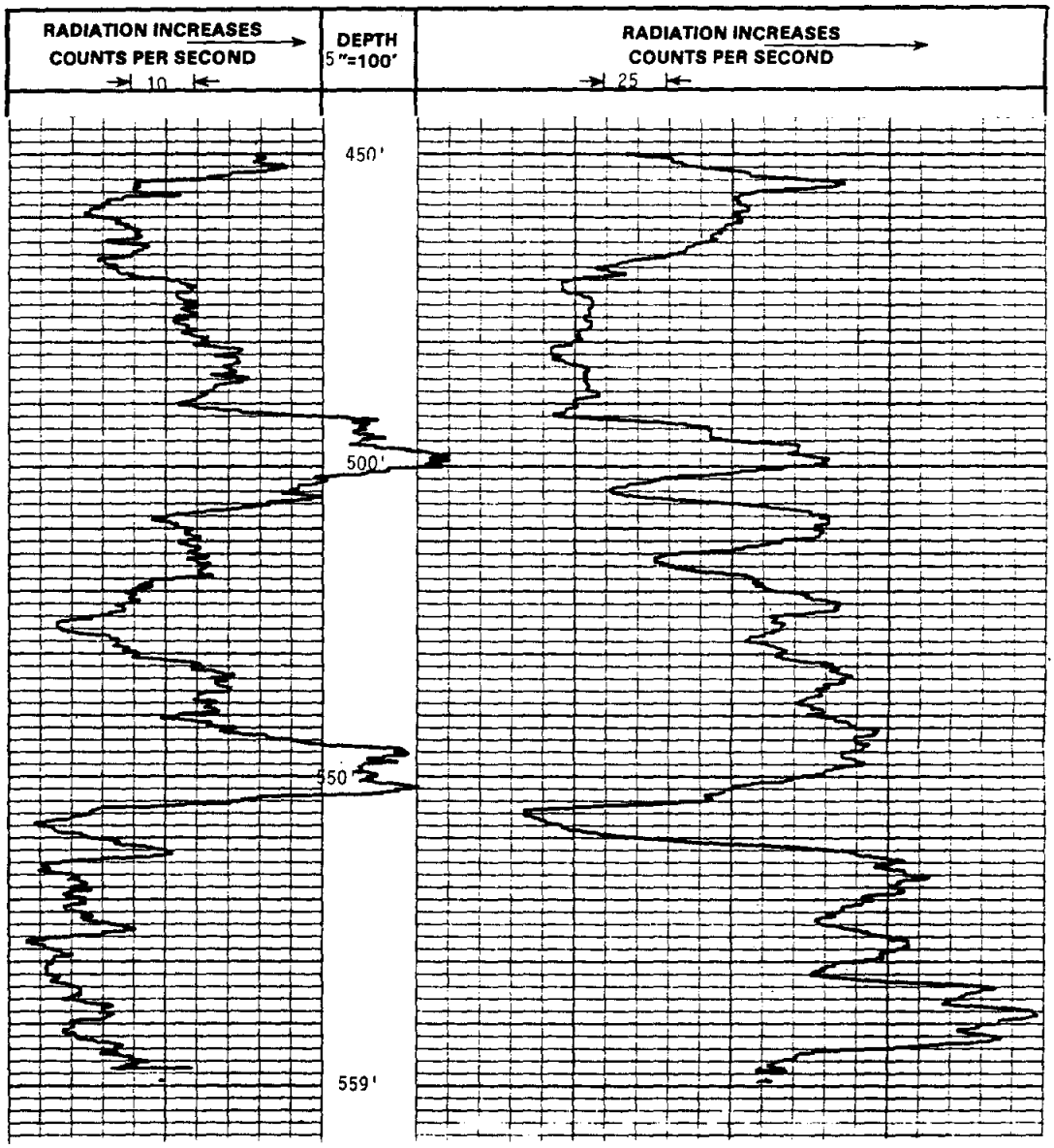
CASING DATA: 7" STEEL **OPEN HOLE DIA.:** 6"

CEMENTED FROM: SURF. **TO** 490' **SCREEN:** OPEN HOLE **TO** _____ **AQUIFER:** HOSSTON

FLUID RESISTIVITY: _____ **OHMS AT** _____ **° F. REMARKS:** _____

GAMMA RAY
COUNTS PER SECOND 50
TIME CONSTANT 4

NEUTRON
COUNTS PER SECOND 250
TIME CONSTANT 4 **SPACING** 21 "



#DB-0271

TEXAS WATER DEVELOPMENT BOARD
WATER AVAILABILITY DATA AND STUDIES SECTION
AUSTIN, TEXAS

STATE WELL NUMBER _____
FILE NUMBER 89-26 3245
PROJECT _____

NOTE: THESE LOGS CANNOT BE USED TO FULFILL CONTRACTURAL OBLIGATIONS.

TYPES OF LOGS THIS DATE: 9/25/89 : E-LOG : GR : N : GG : CAL : SONIC : _____.

OPERATOR (S) CRIM . LOCATION: UGRA TEST WELL # 1

COUNTY: KERR NEAREST TOWN: KERRVILLE DRILLER: TWDB, McCARTY

OWNER: UGRA ADDRESS: _____

TYPE OF DRILL: MUD ROTARY CORED BIT SIZE: 9 7/8" - 400' 6" 400-627-ft.

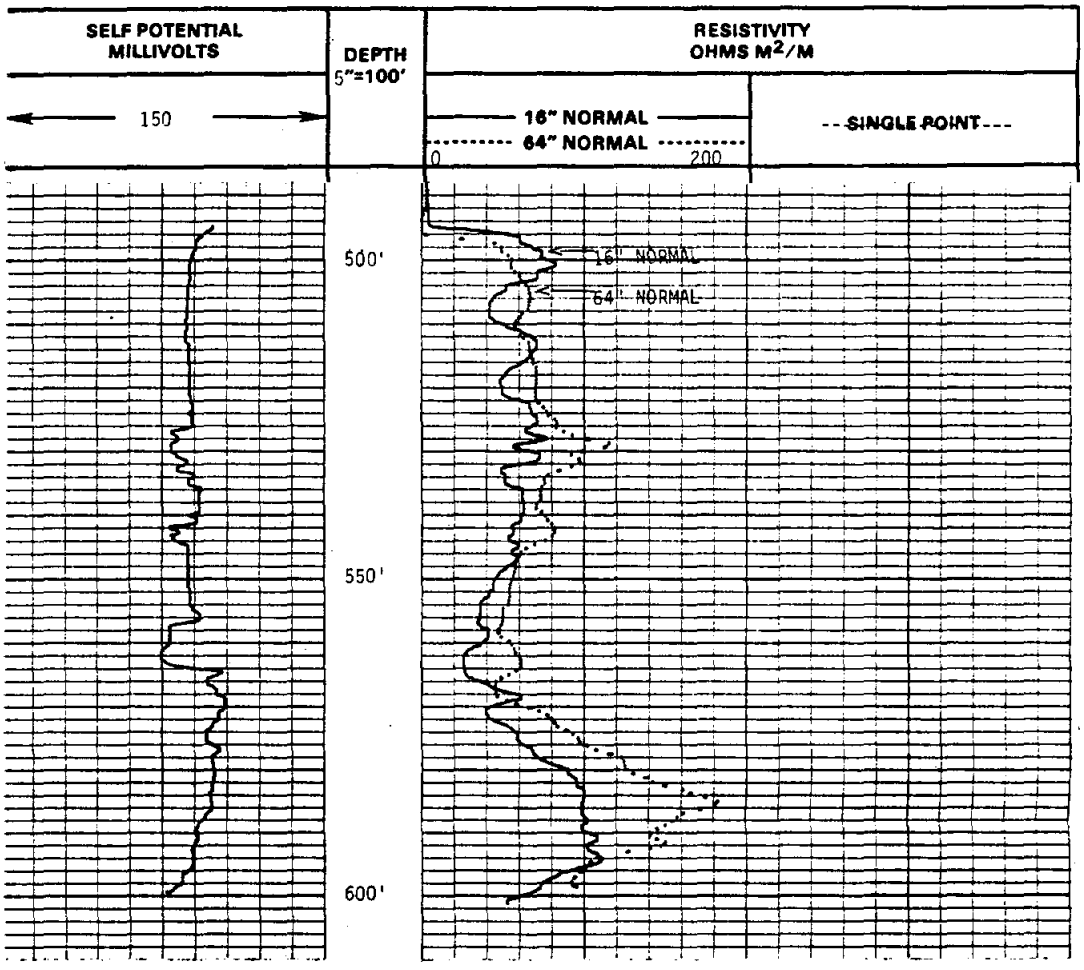
ALTITUDE OF LAND SURFACE: 1635' LOGGED DEPTH: ~~627'~~ 603' DRILLED DEPTH: ~~603'~~ 627'

FLUID LEVEL: 197' * FLUID TYPE: FRESH WATER LOG REFERENCE POINT: GROUND LEVEL

CASING DATA: 7" STEEL OPEN HOLE DIA.: 6"

CEMENTED FROM: SURF. TO 490' SCREEN: OPEN HOLE TO _____ AQUIFER: HOSSTON

FLUID RESISTIVITY: _____ OHMS AT _____° F. REMARKS: _____



TWDB-0272A

TEXAS WATER DEVELOPMENT BOARD
WATER AVAILABILITY DATA AND STUDIES SECTION
AUSTIN, TEXAS

STATE WELL NUMBER _____
FILE NUMBER 89-26
PROJECT 3245

NOTE: THESE LOGS CANNOT BE USED TO FULFILL CONTRACTURAL OBLIGATIONS.

TYPES OF LOGS THIS DATE: 9/25/89 : E-LOG : GR : N : GG : CAL : SONIC : _____.

OPERATOR (S) CRIM . **LOCATION:** UGRA TEST WELL # 1

COUNTY: KERR **NEAREST TOWN:** KERRVILLE **DRILLER:** TWDB, McCARTY

OWNER: UGRA **ADDRESS:** _____

TYPE OF DRILL: CORED **BIT SIZE:** 6"

ALTITUDE OF LAND SURFACE: 1635' **LOGGED DEPTH:** 603' **DRILLED DEPTH:** 627'

FLUID LEVEL: 197' ± **FLUID TYPE:** FRESH WATER **LOG REFERENCE POINT:** GROUND LEVEL

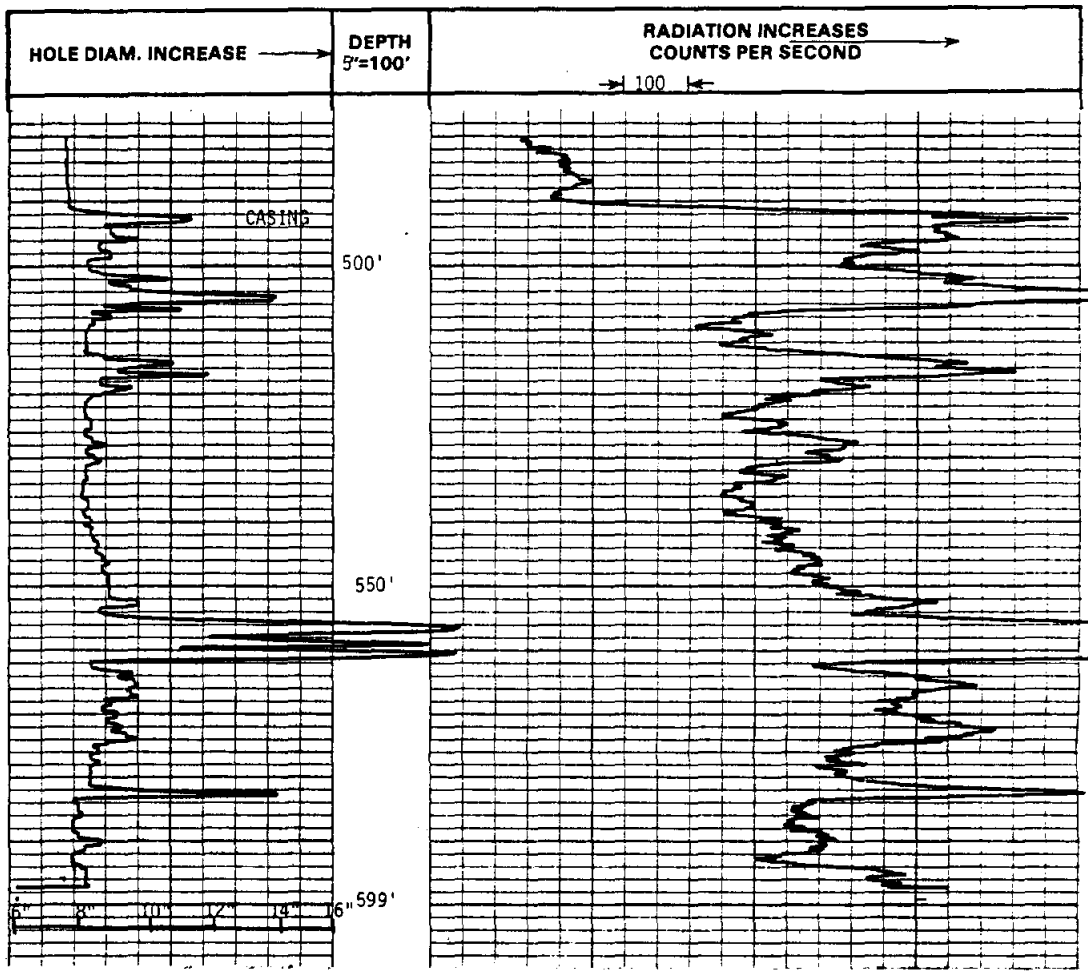
CASING DATA: 7" STEEL **OPEN HOLE DIA.:** 6"

CEMENTED FROM: SURF. **TO** 490' **SCREEN:** OPEN HOLE **TO** _____ **AQUIFER:** HOSSTON

FLUID RESISTIVITY: _____ **OHMS AT** _____ **° F. REMARKS:** CALIPER TOOL IS OFF APPROXIMATELY ONE DIVISION----SEE CASING SIZE ON LOG.

CALIPER
HOLE DIAMETER IN INCHES
FROM 6 **" TO** 16 **"**

GAMMA GAMMA
COUNTS PER SECOND 1000
TIME CONSTANT 2 **SPACING** 21 **"**



TWDB-0751

TEXAS WATER DEVELOPMENT BOARD
WATER AVAILABILITY DATA AND STUDIES SECTION
AUSTIN, TEXAS

STATE WELL NUMBER _____
FILE NUMBER 89-26
PROJECT 3245

NOTE: THESE LOGS CANNOT BE USED TO FULFILL CONTRACTURAL OBLIGATIONS.

TYPES OF LOGS THIS DATE: 9/25/89 : E-LOG : GR : N : GG : CAL : SONIC : _____

OPERATOR (S) CRIM . LOCATION: UGRA TEST WELL #1

COUNTY: KERR NEAREST TOWN: KERRVILLE DRILLER: TWDB, McCARTY

OWNER: UGRA ADDRESS: _____

TYPE OF DRILL: CORED BIT SIZE: 6"

ALTITUDE OF LAND SURFACE: 1635' LOGGED DEPTH: 603' DRILLED DEPTH: 627'

FLUID LEVEL: 197' ± FLUID TYPE: FRESH WATER LOG REFERENCE POINT: GROUND LEVEL

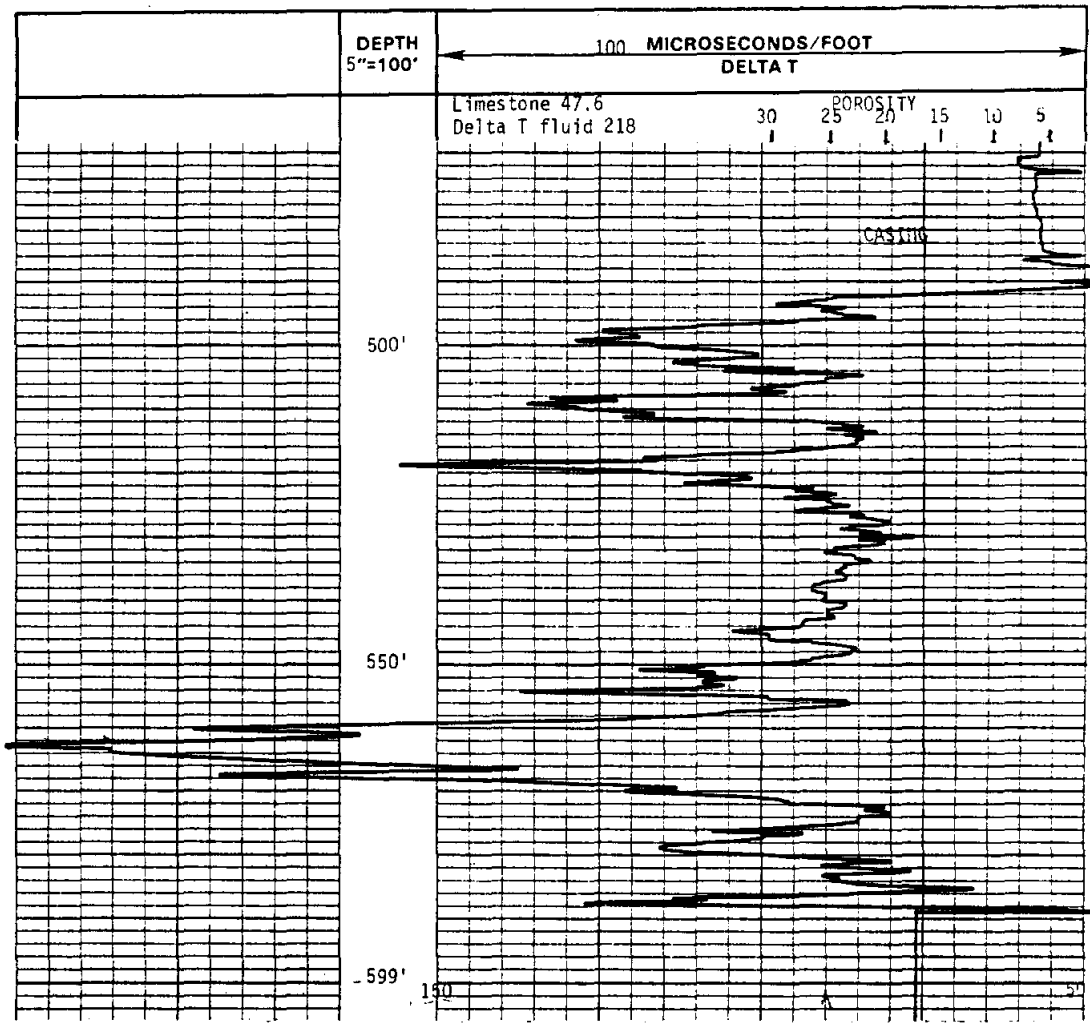
CASING DATA: 7" STEEL OPEN HOLE DIA.: 6"

CEMENTED FROM: SURF. TO 490' SCREEN: OPEN HOLE TO _____ AQUIFER: HOSSTON

FLUID RESISTIVITY: _____ OHMS AT _____ ° F. REMARKS: WELL HAS BEEN ACIDIZED.

--CALIPER--
HOLE DIAMETER IN INCHES
FROM _____ TO _____

BOREHOLE COMPENSATED SONIC VELOCITY
CALIBRATED FROM 50 TO 150 MICROSECONDS PER FOOT



P. O. Box 541332 — TEJAS Well Logging Service — Dallas, Texas 75354-1332

Caliper Survey

COMPANY UPPER GUADALUPE RIVER AUTHORITY

WELL A.S.R. WELL PROJECT MONITOR WELL PZ-1

FIELD WATER WELL

COUNTY KERR STATE TEXAS

Location	Type Log
	CALIPER

Permanent Datum	G.L.	Elev. 1630'	Elev.K.B.
Log Measured From	G.L.	Ft. Above Perm. Datum	D.F.
Drilling Measured From	G.L.		G.L.

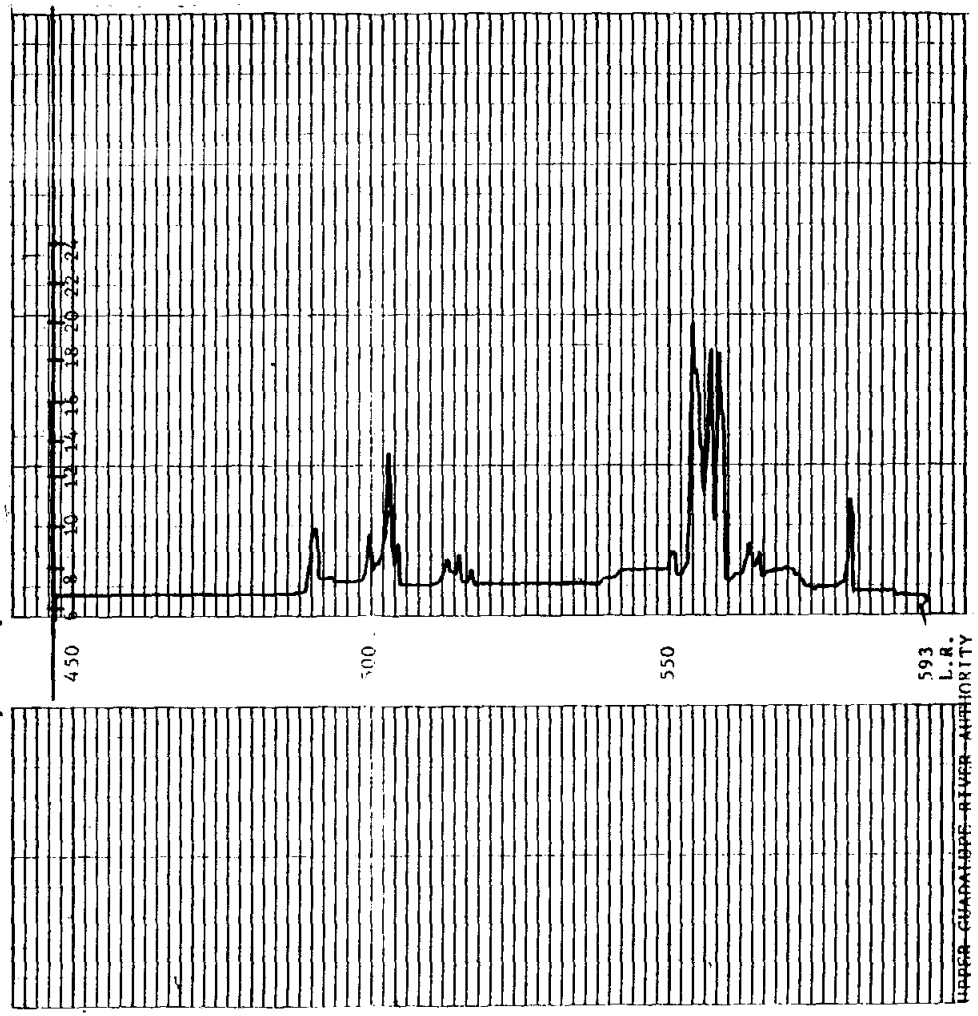
Date	9-20-89
Run No.	ONE
Depth Driller	603'
Depth Logger	593'
Btm. Log Interval	593'
Top Logged Interval	450'
Casing Driller	7"
Casing Logger	7"
Bit Size	6-1/8"
Type Fluid in Hole	WATER
Time Since Circ.	
Recorded By	M.A. LARGENT
Witnessed By	R. PETRUS

BORE HOLE RECORD			CASING RECORD		
Bit Size	From	To	Size	From	To
6-1/8"	495'	620'	7"	SURFCAE	495'

REMARKS

CALIPER
HOLE DIAM. IN INCHES

6 12 18 24



P. O. Box 29300 — Dallas, Texas 75229

TEJAS Well Logging Service

Radioactivity Log

COUNTY — STATE

LOCATION

WELL

COMPANY

COMPANY UPPER GUADALUPE RIVER

WELL A.S.R. WELL PROJECT

MONITOR WELL PZ-1

FIELD WATER WELL

LOCATION

COUNTY KERR.

STATE TEXAS

LOCATION

Elev. D.F.

K.B.

Grd.

Log. Meas. From G.L. Elev. 1630'

Drlg. Meas. From g.l. Elev.

Perm. Datum g.l. Elev.

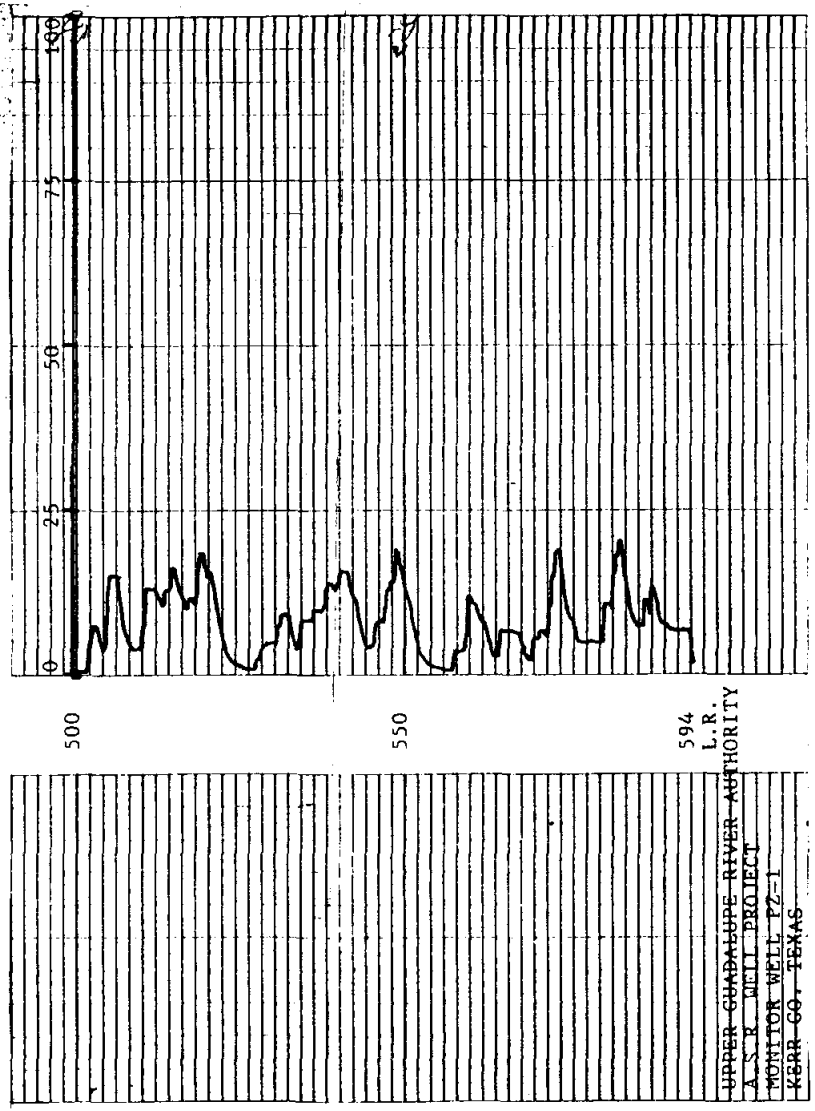
Type of Log	FLOWMETER			
Run No.	ONE	TWO		
Date	9-20-89	9-20-89		
Total Depth Reached	594'	594'		
Total Depth Logged	594'	594'		
Footage Logged	194'	194'		
Fluid Level	206'	206'		
Type of Fluid in Hole	water	water		
Maximum Temp °F				
O.D. of Instrument	1-7/16"	1-7/16"		
Length Meas Device-In	42"	42"		
Time Constant-Sec.	1	1		
Logging Speed Ft/Min.	100'	50'		
Source Strength				
Source Spacing-In				
Sensitivity	100 cts	100 cts		
Truck No.				
Opr Rig Time				
Recorded By	M.A. LARGENT			
Witness	R. PETRUS			

OPEN HOLE RECORD — Bit Size-in. 6-1/8" — Interval 620' to

CASING RECORD — Run No. ONE — Size-in. 7" — Wt.-Lb. — Interval SURFACE to 495'

Remarks FLOWMETER RUN IN OPEN HOLE WHILE BEING PRODUCED BY AIR INJECTION

RUN NO. 2



P. O. Box 28306 — TEXAS Well Logging Service — Dallas, Texas 75228

Radioactivity Log

COMPANY UPPER GUADALUPE RIVER

WELL A.S.R. WELL PROJECT

MONITOR WELL PZ-1

FIELD WATER WELL

LOCATION

COUNTY KERR.

STATE TEXAS

LOCATION

Elev. D.F.

K.B.

Grd.

COUNTY — STATE

LOCATION

WELL

COMPANY

Log Meas. From G. L. Elev. 1630'

Drlg. Meas. From G. L. Elev.

Perm. Datum G. L. Elev.

Type of Log	FLOWMETER			
Run No.	ONE	TWO		
Date	9-20-89	9-20-89		
Total Depth Reached	594'	594'		
Total Depth Logged	594'	594'		
Footage Logged	194'	194'		
Fluid Level	206'	206'		
Type of Fluid in Hole	water	water		
Maximum Temp °F				
O.D. of Instrument	1-7/16"	1-7/16"		
Length Meas. Device-In.	42"	42"		
Time Constant-Sec.	1	1		
Logging Speed Ft/Min	100'	50'		
Source Strength				
Source Spacing-In.				
Sensitivity	100 cts	100 cts		
Truck No.				
Opr. Rig Time				
Recorded By	M.A. LARGENT			
Witness	R. PETRUS			

OPEN HOLE RECORD
Bit Size-In. 6-1/8" Interval 620' to
to
to
to

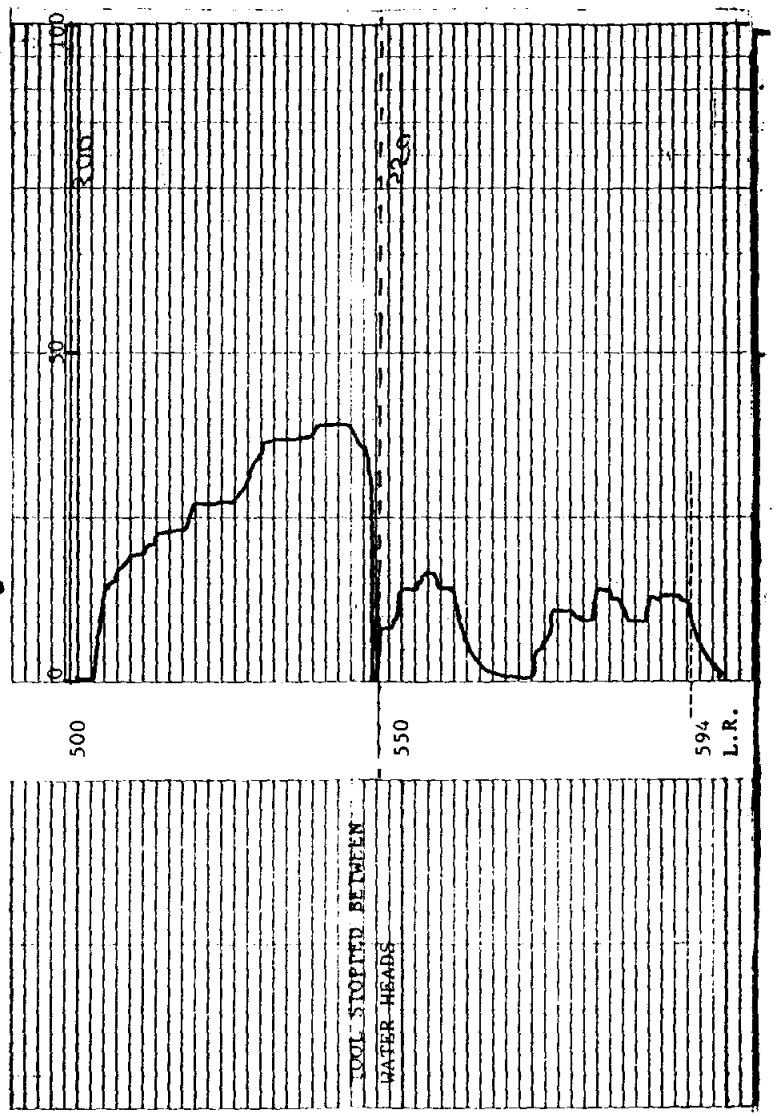
CASING RECORD
Run No. ONE Size-In. 7" Wt.-Lb. Interval SURFACE 495' to
to
to
to

Remarks FLOWMETER RUN IN OPEN HOLE WHILE BEING PRODUCED BY AIR INJECTION

DEPTH AND CASING COLLARS

100
50
0

Flow Log



Appendix C
MINERALOGY, INC. REPORT

MINERALOGY
INCORPORATED

3228 East 15th Street/Tulsa, Oklahoma 74104/(918) 744-8284

Where Science Gets Down to Earth

xc: R. Petrus/DFW
D. Pyne/GNV
J. McLeod/AUS
ORIG: D. Glanzman/I

August 20, 1989

B. W. Bruns, P.E.
Upper Guadalupe River Authority
215 West Water Street
Kerrville, TX 78029

SUBJECT

X-ray diffraction mineralogy, acid insoluble residue analysis, sieve analysis, porosity, permeability, grain density, specific gravity, cation exchange capacity, SEM, thin section, energy dispursive chemical analysis, and core photographs with descriptions of five (5) samples from four (4) cores from the Kerrville ASR Project.

CONCLUSIONS

The samples from four cores were:

481.1'-481.8' A gray dolomitic shale with good porosity (24.3%) but little or no permeability. The shale contained silty, sandy, dolomite streaks and burrows with some scattered glauconite grains. Some of the fine micro shell fragments in the shale were removed by dissolution leaving scattered minor fine dissolution porosity.

511.5'-512.0' A mottled fractured reddish to brownish, silty, sandy dolomite. The fractures were healed by a fine crystalline grayish dolomite. The porosity was good at 19.2%, but the permeability was low at 4.48 md. vertical permeability and 38.2 md. horizontal permeability.

539.6'-540.3' A fine sandy dolomite grading abruptly into a dolomite-cemented conglomerate. The conglomerate had 29.8% porosity and 1505.0 md. horizontal permeability. The vertical permeability was only 24.7 md. The good permeability follows horizontal bedding planes containing high variable porosity. The fine

sandy dolomite with the conglomerate had 24.7% porosity and 91.6 md. vertical permeability and 95.3 md. horizontal permeability. The low permeability in the crystalline dolomite is due to the fine pore size. Most of the porosity in the dolomites is micro intercrystalline porosity.

552.5'-553.4' A reddish, very fine crystalline, silty dolomite, with light gray to tan irregualr inclusions and streaks. At 552.5'-552.7' the dolomite was tannish with grayish mottles. The porosity was 18.3%. The permeability was very low at 0.32 md. vertical and 1.71 md. horizontal permeability.

The dolomite samples were originally deposited as sandy, silty limestone containing shell fragments and scattered glauconite grains. Dissolution of some shell fragments created vuggy porosity in some core examined. The limestone was recrystallized as fine crystalline dolomite with intercrystalline micro porosity.

The clay in these samples is primarily allogenic and was deposited with the fine silt and sand. Some of the illite and mixed-layer illite/smectite is glauconite. Glauconite is the physical form, a greenish pellet and not a mineral.

DISCUSSION OF RESULTS

1. X-RAY MINERALOGY (Table 1)

Four of the samples were sandy dolomites to dolomitic, silty, sands. One sample was a dolomitic shale. Most of the illite and mixed-layer illite/smectite shown in x-ray results is glauconite with the exception of the shale sample at 481'6"-481'7", where most of the reported illite and mixed-layer illite/smectite is not mostly glauconite pellets. The feldspar in the samples is K-feldspar.

2. ACID RESIDUE ANALYSIS (Table 2)

The acid residues reflect the amount of carbonate present, primarily dolomite.

3. GRAIN SIZE DISTRIBUTION SIEVE ANALYSIS (Table 3)

These samples were fine to very fine-grained with the exception of the conglomerate at 539.6'. The particle size of the authigenic dolomite in the samples was very fine. This was also reflected in the high porosities with low permeabilities.

4. POROSITY, PERMEABILITY AND GRAIN DENSITY (Table 4)

The porosities were high but permeabilities were generally low due to dolomite crystal size. The horizontal permeability in the conglomerate was excellent, but due to porosity variations from thin bed to thin bed and to pore size changes, the vertical permeabilities were very low. The grain densities were generally high due to the predominance of dolomite in the samples.

5. SPECIFIC GRAVITY (Table 5)

The specific gravity was lowest in the shale (2.42) and was highest in the conglomerate and the sandy dolomite associated with the conglomerate. The sandy dolomite was 2.63.

6. CATION EXCHANGE CAPACITY (Table 6)

The cation exchange capacity was greatest in the shale (11.1) but was low in other samples, ranging from 0.7 to 4.5 meg/100 grams. The low cation exchange reflects the low clay percentages, particularily the small amounts of the illite/smectite mixed-layering. Smectite is the clay mineral with the high CEC.

7. SCANNING ELECTRON MICROSCOPE-SEM (Figures 1-5)

The results primarily show the dolomite with fine micro intercrystalline porosity. Figure 2 (511'11"-512'0") shows dolomite with fine intercrystalline porosity in the left side of photograph "A" at 50X and on the right-hand side of the photograph, a very fine crystalline vuggy dolomite. Associated with the vugs is very fine intercrystalline porosity.

8. THIN SECTION PHOTOGRAPHS WITH DESCRIPTIONS (Figures 6-10)

The thin section results show the fine crystal size of the dolomite. Figure 6 shows a burrow infilled with silt and carbonate in the left side of the photograph. The burrow is perpendicular to the black organic, thin parallel bedding streaks. The porosity is in streaks parallel to bedding planes and varies from thin bed to thin bed.

9. ENERGY DISPURSIVE-CHEMICAL ANALYSIS (Figures 11-15)

The energy dispursive analysis reflects the mineralogy which is primarily dolomite, a calcium magnesium carbonate, and quartz, which is silica. Energy dispursive analysis does not detect light elements well. A small magnesium peak is indicative of a considerable amount of magnesium. Aluminum reflects feldspar and clay. Iron is associated with clay, dolomite, and primarily as red iron oxide staining samples. Potassium reflects the K-feldspar and illite.

10. THIN SLAB PHOTOGRAPHS AND DESCRIPTIONS (Figure 16-4 pages)

These results show the general physical appearance of the core with descriptions of the core. Most of the core analyized was a fine, sandy, silty, dolomite. The physical appearance and rock properties varied from thin bed to thin bed within each core.

If there are any questions, please call.

A. Jack Nash

AJN/mcj

cc: John S. McLeod

TABLE OF CONTENTS

Upper Guadalupe River Authority
CH2M Hill

TABLE 1.

MINERALOGY, INC.

3228 E. 15th St.
Tulsa, Oklahoma 74104

B.W. Bruns

Page 1 of 1

X-RAY DIFFRACTION MINERAL PERCENTAGES

Job 89-336

SAMPLE IDENTIFICATION NUMBER KERRVILLE ASR PROJECT TEX24486.A1	QUARTZ	FELDSPAR	CALCITE	DOLOMITE	PYRITE	KAOLINITE	CHLORITE	ILLITE/MICA	MIXED-LAYER ILLITE/SMECTITE									Plagioclase Feldspar	Feldspar K	TOTAL
481'6"-481'7"	57	5	4	12	4	6		10	2									trc	5	
511'11"-512'0"	28	4		65		1	trc	2	trc										4	
539'11"	35	4		56		1		3	1										4	
540'½"-540'1½"	38	4	1	52		1		3	1										4	
552'7"-552'8"	49	4	trc	40		2		3	2										4	

*there is scattered minor glauconite in all samples, reported by XRD as illite/mica and mixed-layer illite/smectite

TABLE 2

ACID INSOLUBLE RESIDUE ANALYSIS

DEPTH	PERCENT ACID SOLUBLE
481'6"-481'7"	14.0%
511'11"-512'0"	71.4%
539'11"	63.7%
540'½"-540'1½"	54.7%
552'7"-552'8"	34.5%

KERRVILLE ASR PROJECT TEX24486.A1

GRAIN SIZE DISTRIBUTION-SIEVE ANALYSIS

TABLE 3

(3 pages)

SIEVE ANALYSIS

Sample: 481.8' Well: Kerrville ASR Project

Sieve Size (in microns)			Weight Percent
> 2000		Pebbles	
< 2000	> 1000	Very coarse grained sandstone	
< 1000	> 500	Coarse grained sandstone	
< 500	> 250	Medium grained sandstone	
< 250	> 125	Fine grained sandstone	.7%
< 125	> 62	Very fine grained sandstone	2.2%
< 62	(pan)	Silt and clay	97.1%

Sample: 512.0' Well: Kerrville ASR Project

Sieve Size (in microns)			Weight Percent
> 2000		Pebbles	
< 2000	> 1000	Very coarse grained sandstone	
< 1000	> 500	Coarse grained sandstone	
< 500	> 250	Medium grained sandstone	.1%
< 250	> 125	Fine grained sandstone	.2%
< 125	> 62	Very fine grained sandstone	31.3%
< 62	(pan)	Silt and clay	68.4%

SIEVE ANALYSIS

Sample: 539.6' Well: Kerrville ASR Project

Sieve Size (in microns)			Weight Percent
> 2000		Pebbles	4.9%
< 2000	> 1000	Very coarse grained sandstone	29.1%
< 1000	> 500	Coarse grained sandstone	25.1%
< 500	> 250	Medium grained sandstone	15.6%
< 250	> 125	Fine grained sandstone	4.4%
< 125	> 62	Very fine grained sandstone	6.4%
< 62	(pan)	Silt and clay	14.5%

Sample: 540.5' Well: Kerrville ASR Project

Sieve Size (in microns)			Weight Percent
> 2000		Pebbles	
< 2000	> 1000	Very coarse grained sandstone	trace
< 1000	> 500	Coarse grained sandstone	trace
< 500	> 250	Medium grained sandstone	.3%
< 250	> 125	Fine grained sandstone	10.7%
< 125	> 62	Very fine grained sandstone	54.4%
< 62	(pan)	Silt and clay	34.6%

SIEVE ANALYSIS

Sample: 552.6' Well: Kerrville ASR Project

Sieve Size (in microns)			Weight Percent
> 2000		Pebbles	
< 2000	> 1000	Very coarse grained sandstone	trace
< 1000	> 500	Coarse grained sandstone	trace
< 500	> 250	Medium grained sandstone	.1%
< 250	> 125	Fine grained sandstone	1.5%
< 125	> 62	Very fine grained sandstone	16.0%
< 62	(pan)	Silt and clay	82.4%

Sample: _____ Well: _____

Sieve Size (in microns)			Weight Percent
> 2000		Pebbles	
< 2000	> 1000	Very coarse grained sandstone	
< 1000	> 500	Coarse grained sandstone	
< 500	> 250	Medium grained sandstone	
< 250	> 125	Fine grained sandstone	
< 125	> 62	Very fine grained sandstone	
< 62	(pan)	Silt and clay	

3228 E 15th St.
Tulsa, Oklahoma 74104

M. I.
MINERALOGY, INC.

918-744-8284

TABLE 4

Lab No. 89-336
Date

Well KERRVILLE ASR PROJECT Field TEX24486.A1 State UGRA

Sample Number	Depth	Description	Permeability-md		Porosity %	Saturation - % PV		Grain Density gm/cc
			Horiz.	Vert.		Oil	Water	
1.	481'6"-7"	Fr.	1.91	.002	24.3			2.80
2.	511'11"-512'		38.2	4.48	19.2			2.77
3.	539'11"	Fr.	1505.	24.7	29.8			2.79
4.	540'½"-1½"		95.3	91.6	24.7			2.75
5.	552'7"-8"		1.71	.32	18.3			2.75

TABLE 5

SPECIFIC GRAVITY

DEPTH		SPECIFIC GRAVITY
481'6"-481'7"	Gray shale with silty dolomitic streaks	2.42
511'11"-512'0"	Silty dolomitic sandstone to sandy dolomite	2.46
539'11"	Conglomerate sandstone with silty dolomitic matrix	2.58
540'½"-540'1½"	Silty dolomitic sandstone to sandy dolomite	2.63
552'7"-552'8"	Silty dolomitic sandstone to sandy dolomite	2.54

KERRVILLE ASR PROJECT

TEX24486.A1

TABLE 6

CATION EXCHANGE CAPACITY

DEPTH	CEC (meg/100 grams of core)
481'2"	11.1
512'0"	1.2
539'6"	0.7
540'½"	2.6
552'7"	4.5

KERRVILLE ASR PROJECT

TEX24486.A1

SEM ANALYSIS

FIGURES 1-5

FIGURE 1

UPPER GUADALUPE RIVER AUTHORITY

KERRVILLE ASR PROJECT
TEX24486.A1

481'6"-481'7"

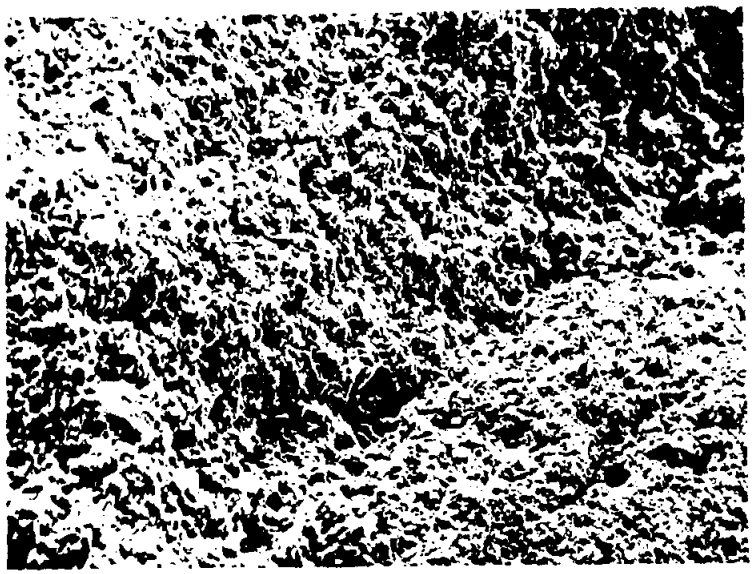
A&B Black, thin-bedded shale. Small fossil shell fragments. No visible porosity.

C&D Carbonate fragment with pinhole dissolution. Thin-bedded shale platelet shown in photograph at 2000X.

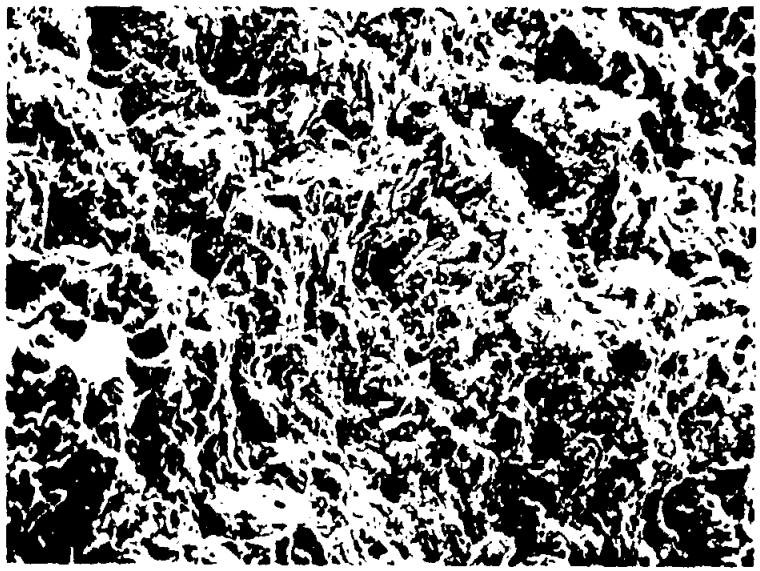
UPPER GUADALUPE RIVER AUTHORITY

KERRVILLE ASR PROJECT
TEX24486.A1

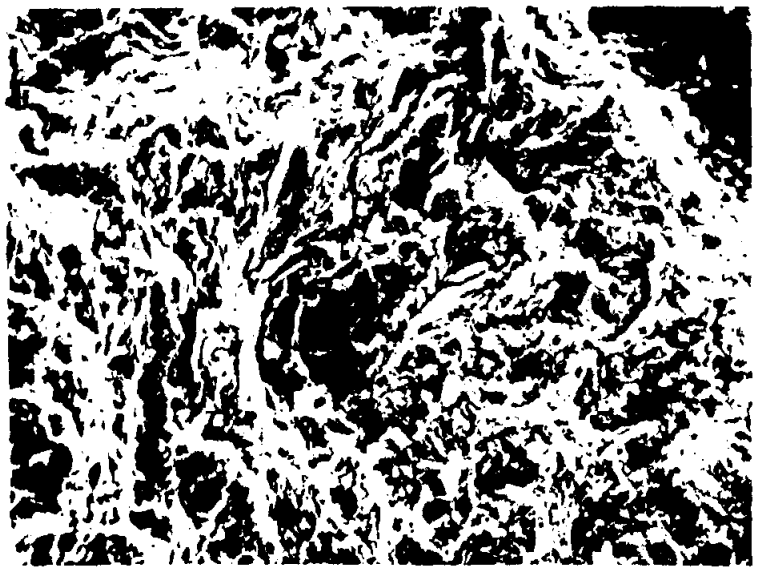
481'6"-481'7"



A. 50X 200 μ



B. 200X 50 μ



C. 500X 20 μ

D. 2000X 5 μ

TS. NO. DATE FIGURE 1.

FIGURE 2

UPPER GUADALUPE RIVER AUTHORITY

KERRVILLE ASR PROJECT
TEX24486.A1

511'11"-512'0"

A&B Sandy dolomite with well-rounded fine sand and silt grains. Intercrystalline porosity and dissolution of scattered grains on the left side of the photograph at 50X. On the right side of the photograph at 50X is finer crystalline dolomite with vuggy and fine dissolution pores.

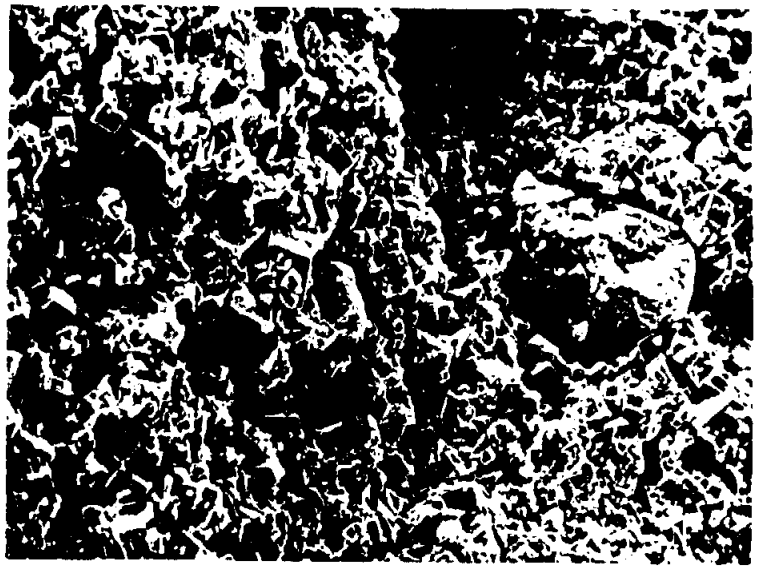
C&D Dolomite crystals with intercrystalline porosity. Dolomite crystals and a rounded fine sand grain in photograph at 500X.

UPPER GUADALUPE RIVER AUTHORITY

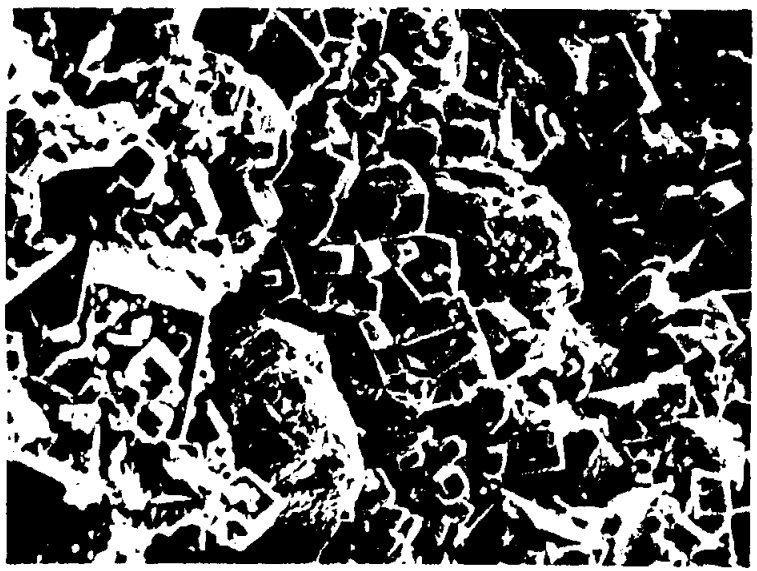
KERRVILLE ASR PROJECT
TEX24486.A1

511'11"-512'0"

A. 50X 200 μ



B. 200X 50 μ



C. 500X 20 μ

D. 2000X 5 μ

TS. NO. DATE

FIGURE 2.

FIGURE 3

UPPER GUADALUPE RIVER AUTHORITY

KERRVILLE ASR PROJECT
TEX24486.A1

539'11"

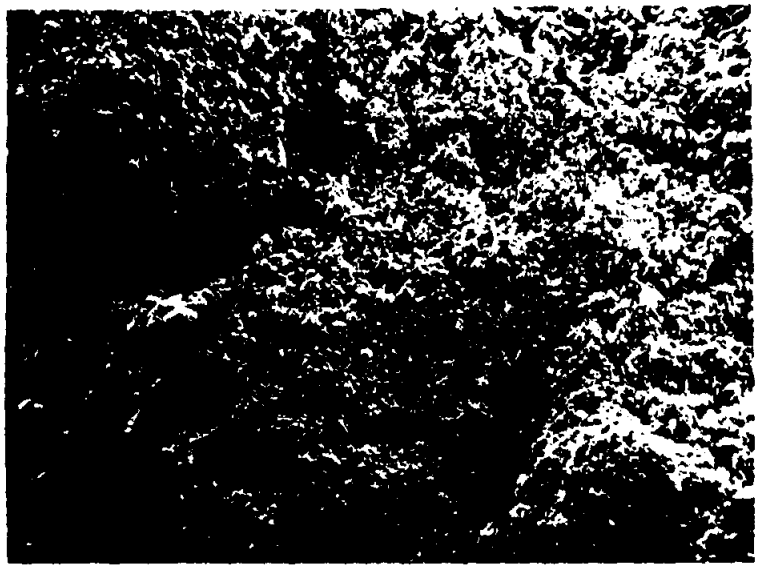
A&B Dolomite cemented congolomerate pebble in upper left side of photograph at 50X.

C&D Dolomite crystals cementing congolomerate grains. Intercrystalline porosity between dolomite crystals.

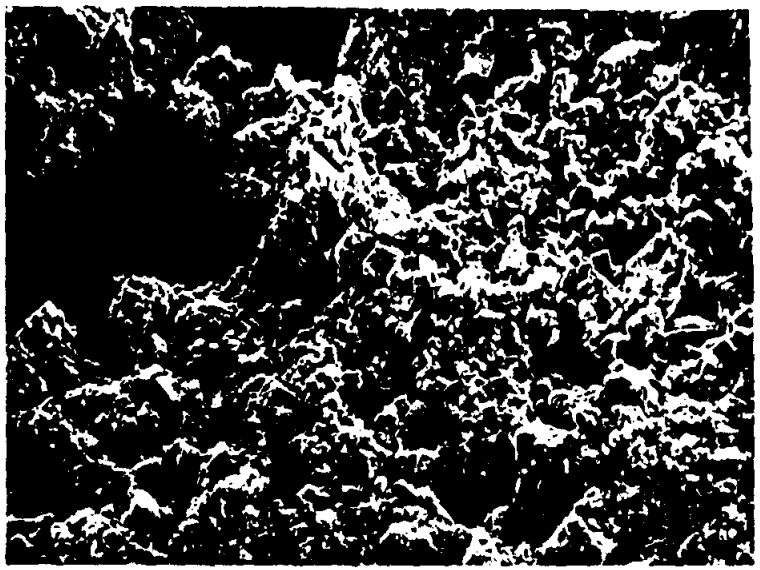
UPPER GUADALUPE RIVER AUTHORITY

KERRVILLE ASR PROJECT
TEX24486.A1

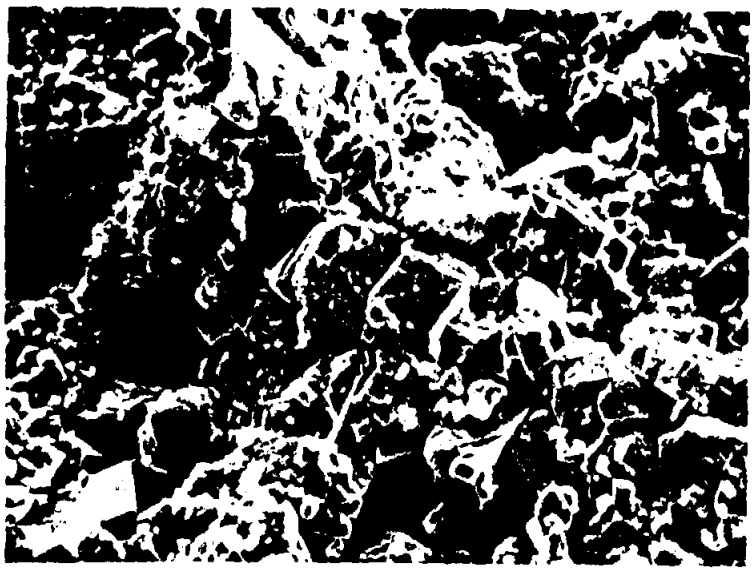
539'11"



A. 50X 200 µ



B. 200X 50 µ



C. 500X 20 µ

D. 2000X 5 µ

TS. NO.

DATE

FIGURE 3.

FIGURE 4

UPPER GUADALUPE RIVER AUTHORITY

KERRVILLE ASR PROJECT
TEX24486.A1

540'½"-540'1½"

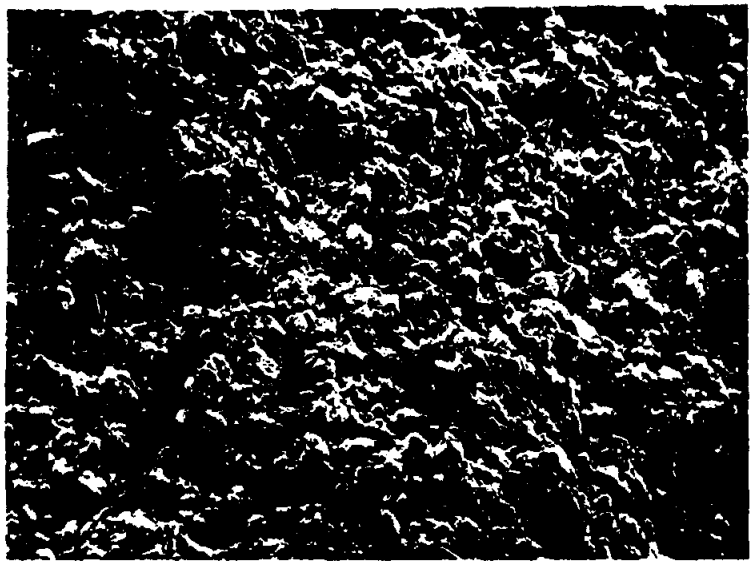
A&B Sandy, fine crystalline dolomite. Well-rounded fine sand grains.

C&D Intercrystalline porosity between dolomite grains.

UPPER GUADALUPE RIVER AUTHORITY

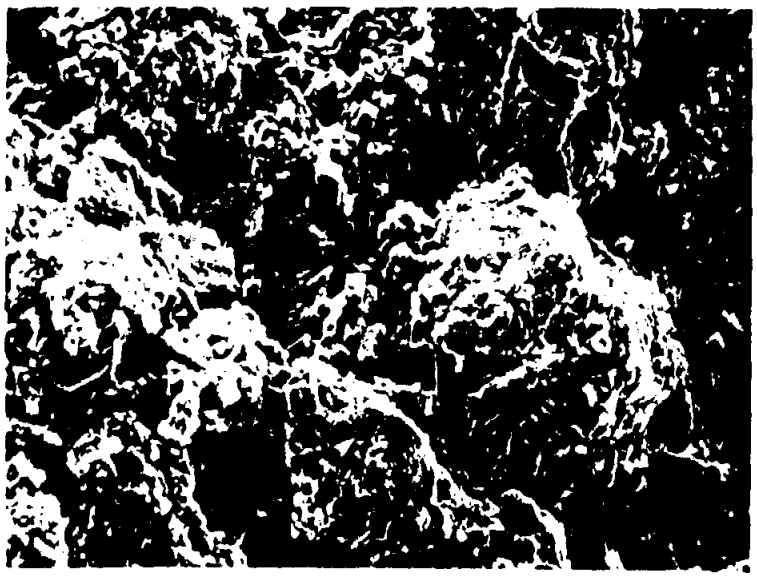
KERRVILLE ASR PROJECT
TEX24486.A1

540'½"-540'1½"



A. 50X 200 μ

B. 200X 50 μ



C. 500X 20 μ

D. 2000X 5 μ

TS. NO. DATE FIGURE 4.

FIGURE 5

UPPER GUADALUPE RIVER AUTHORITY

KERRVILLE ASR PROJECT
TEX24486.A1

552'7"-552'8"

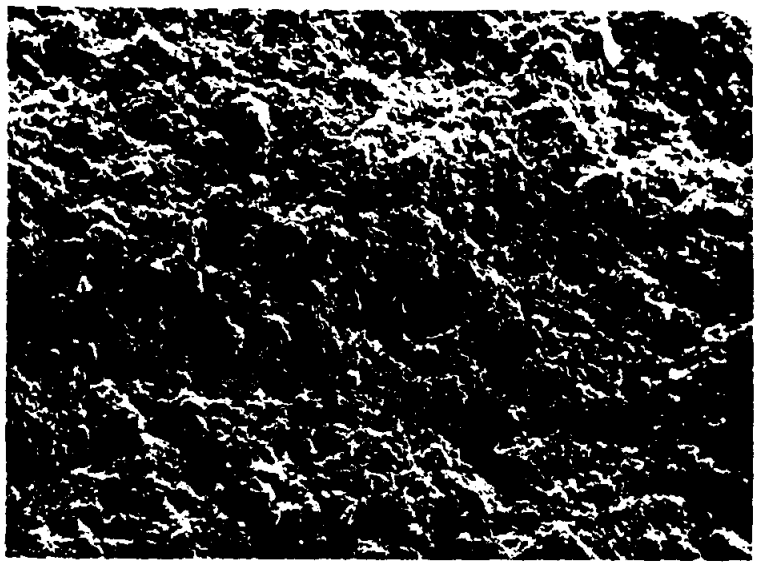
A&B Very fine-grained, silty dolomitic sandstone to sandy fine crystalline dolomite. No visible macro porosity.

C&D Small dissolution pore with authigenic koalinite crystals and scattered fine dolomite crystals attached to the surface of the pore.

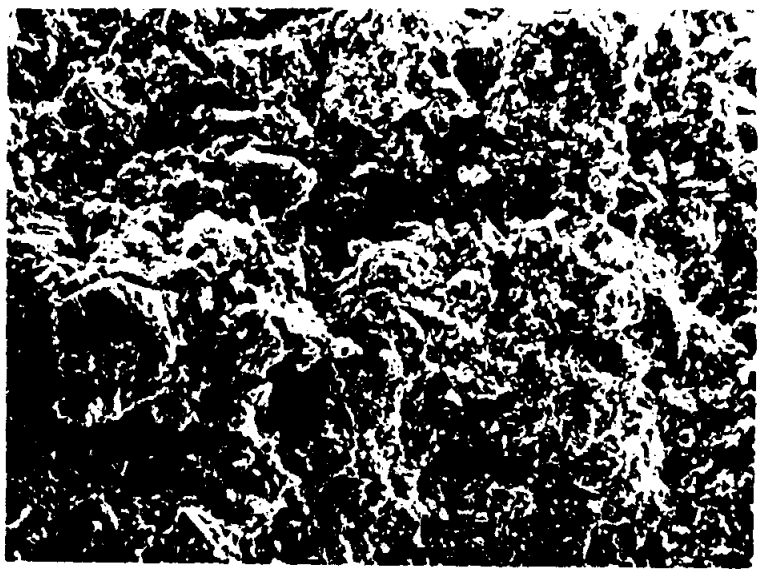
UPPER GUADALUPE RIVER AUTHORITY

KERRVILLE ASR PROJECT
TEX24486.A1

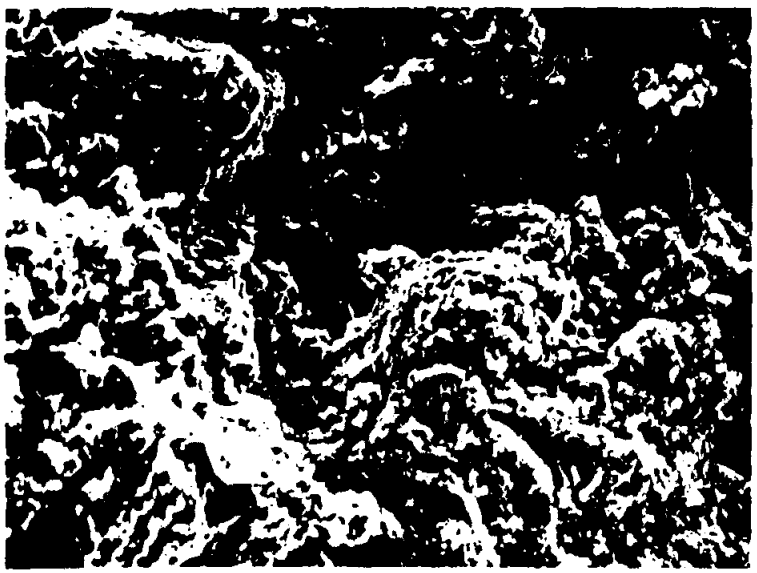
552'7"-552'8"



A. 50X 200 µ



B. 200X 50 µ



C. 500X 20 µ

D. 2000X 5 µ

TS. NO. DATE FIGURE 5

THIN SECTION PHOTOGRAPHS AND DESCRIPTIONS

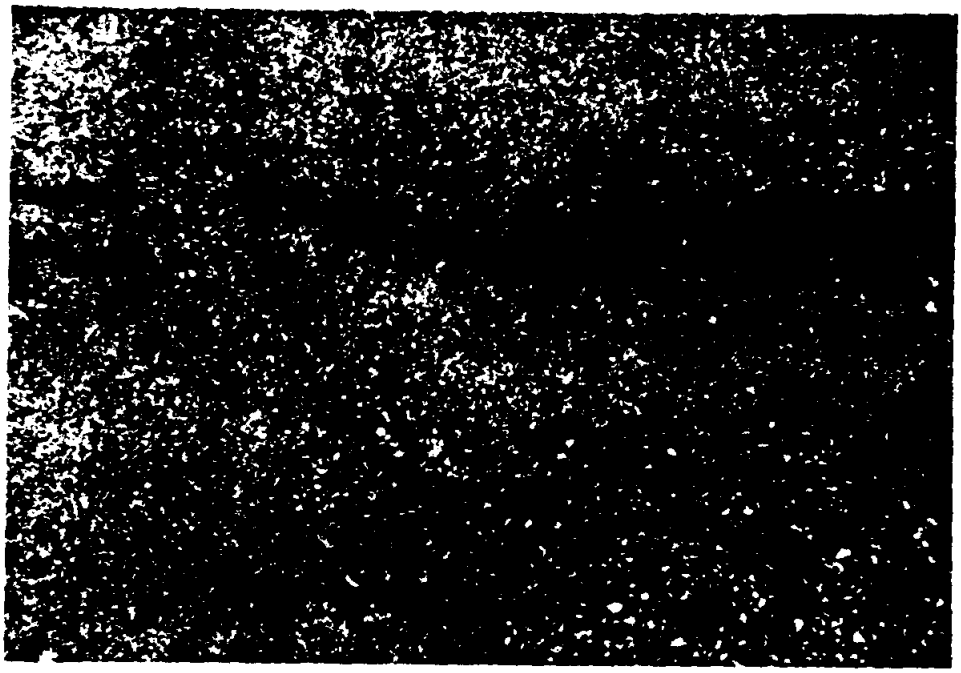
FIGURES 6 - 10

FIGURE 6

UPPER GUADALUPE RIVER AUTHORITY

KERRVILLE ASR PROJECT
TEX24486.A1

481'6"-481'7"



THIN SECTION PHOTO
40X

THIN SECTION DESCRIPTION

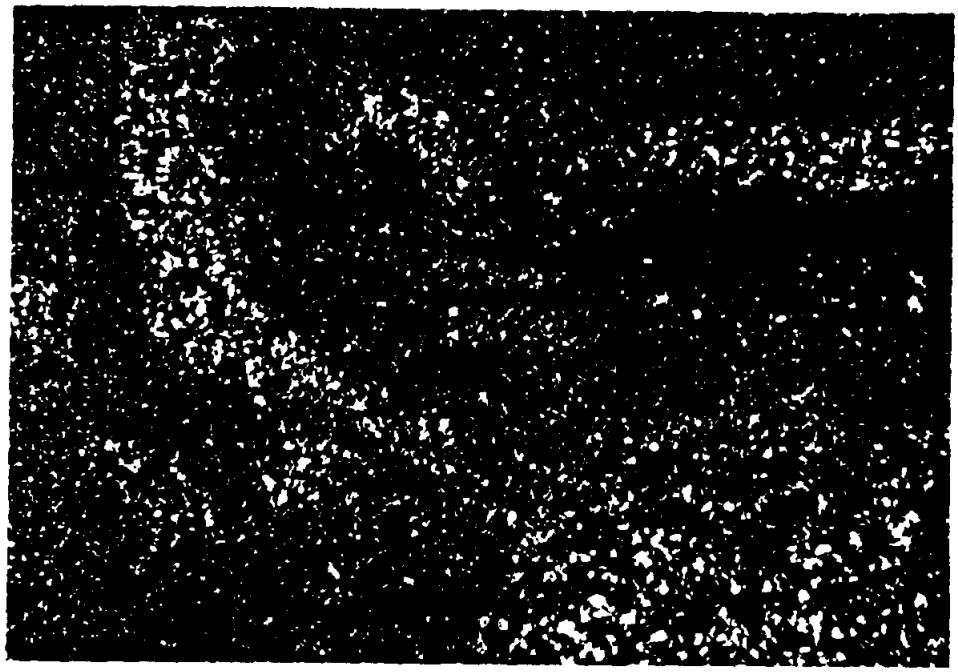
Gray shale, silty dolomitic streaks. Burrows, some containing pyrite as scattered inclusions. Scattered silt-size to very fine sand-size glauconite grains. Dolomite occurs as fine to very fine grains and crystals in the silty streaks. The silty streaks contain scattered minor dissolution porosity. No visible porosity except for minor to trace amounts of dissolution porosity associated with the dolomitic silt and very fine dolomitic sand.

FIGURE 6

UPPER GUADALUPE RIVER AUTHORITY

KERRVILLE ASR PROJECT
TEX24486.A1

481'6"-481'7"



THIN SECTION PHOTO
40X
x-nicols
THIN SECTION DESCRIPTION

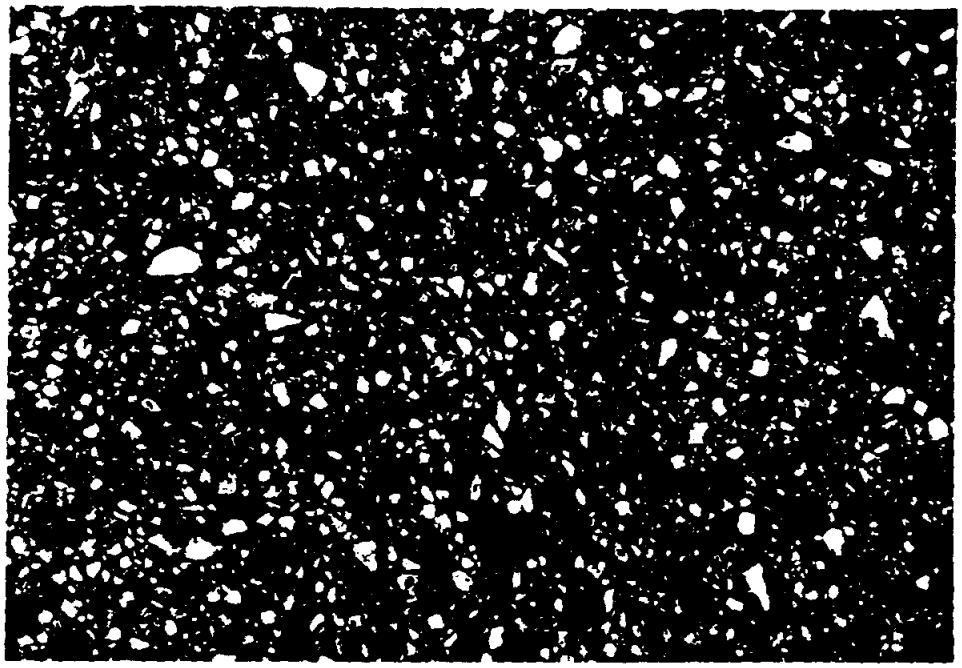
Gray shale, silty dolomitic streaks. Burrows, some containing pyrite as scattered inclusions. Scattered silt-size to very fine sand-size glauconite grains. Dolomite occurs as fine to very fine grains and crystals in the silty streaks. The silty streaks contain scattered minor dissolution porosity. No visible porosity except for minor to trace amounts of dissolution porosity associated with the dolomitic silt and very fine dolomitic sand.

FIGURE 7

UPPER GUADALUPE RIVER AUTHORITY

KERRVILLE ASR PROJECT
TEX24486.A1

511'11"-512'0"



THIN SECTION PHOTO
40X

THIN SECTION DESCRIPTION

Very fine, silty dolomitic sandstone to sandy dolomite. Sand grains are subrounded. Scattered glauconite grains. Scattered visible fine dissolution pores in half of the sample with pink hematite staining. The grayish-colored part of the sample has vuggy dissolution porosity. The pores are much larger than in the pink part of the sample.

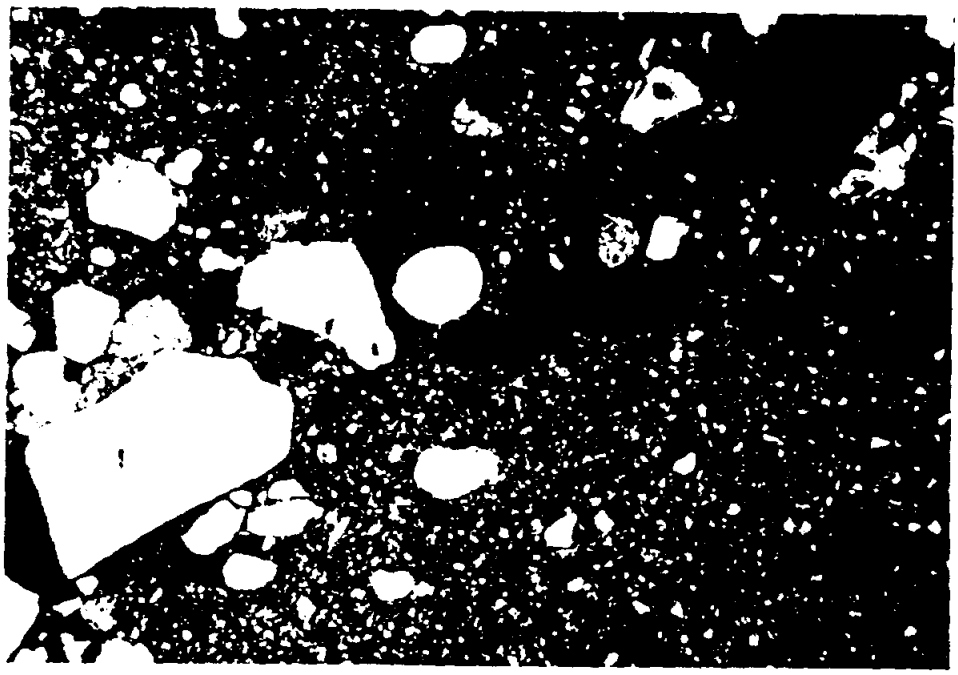
Porosity in the thin section photograph is shown in blue.

FIGURE 8

UPPER GUADALUPE RIVER AUTHORITY

KERRVILLE ASR PROJECT
TEX24486.A1

539'11"



THIN SECTION PHOTO
40X

THIN SECTION DESCRIPTION

This thin section shows the contact between a very fine dolomitic sand to siltstone and a conglomerate sandstone made up of rounded quartz and rock fragment grains up to pebble size, cemented by fine crystalline, silty, sandy dolomite. One or two well-rounded dolomite pebble grains. Scattered macro and micro dissolution porosity in the conglomerate matrix. Some fractured pebbles and grains with inherited healed fractures. Some grains show undulatory extinction due to metamorphic strain. The finer dolomitic sand to siltstone has scattered minor dissolution porosity, and is cemented with red hematite-stained dolomite. There are a few scattered fine glauconite grains. The contact between the fine sand to siltstone and the conglomerate is irregular with scattered coarse grains scattered into the fine siltstone to sandstone. The conglomerate has fair visible macro porosity.

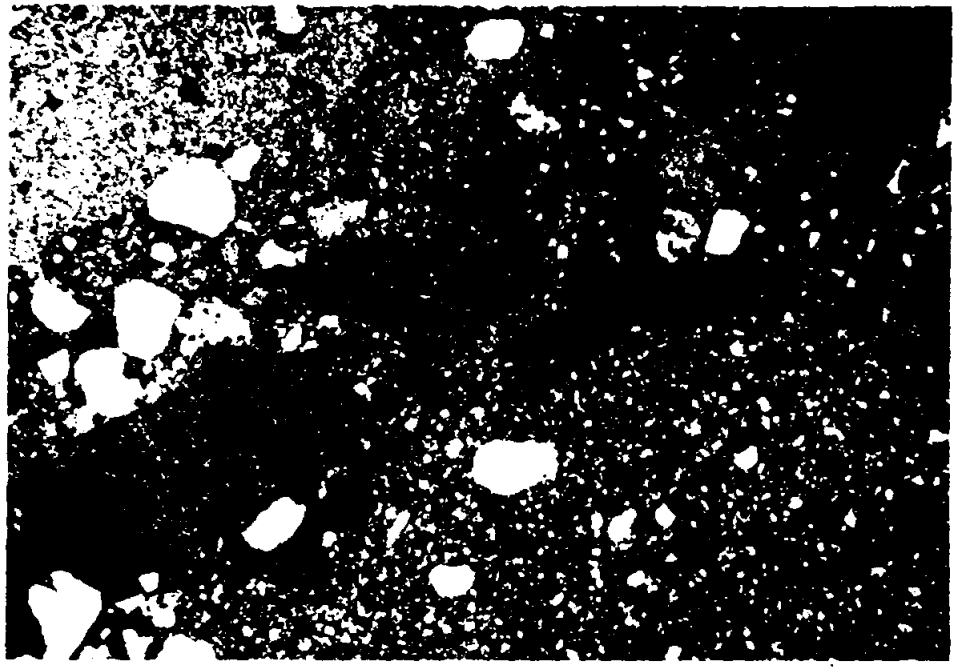
Porosity in the thin section photograph is shown in blue.

FIGURE 8

UPPER GUADALUPE RIVER AUTHORITY

KERRVILLE ASR PROJECT
TEX24486.A1

539'11"



THIN SECTION PHOTO
40X
x-nicols

THIN SECTION DESCRIPTION

This thin section shows the contact between a very fine dolomitic sand to siltstone and a conglomerate sandstone made up of rounded quartz and rock fragment grains up to pebble size, cemented by fine crystalline, silty, sandy dolomite. One or two well-rounded dolomite pebble grains. Scattered macro and micro dissolution porosity in the conglomerate matrix. Some fractured pebbles and grains with inherited healed fractures. Some grains show undulatory extinction due to metamorphic strain. The finer dolomitic sand to siltstone has scattered minor dissolution porosity, and is cemented with red hematite-stained dolomite. There are a few scattered fine glauconite grains. The contact between the fine sand to siltstone and the conglomerate is irregular with scattered coarse grains scattered into the fine siltstone to sandstone. The conglomerate has fair visible macro porosity.

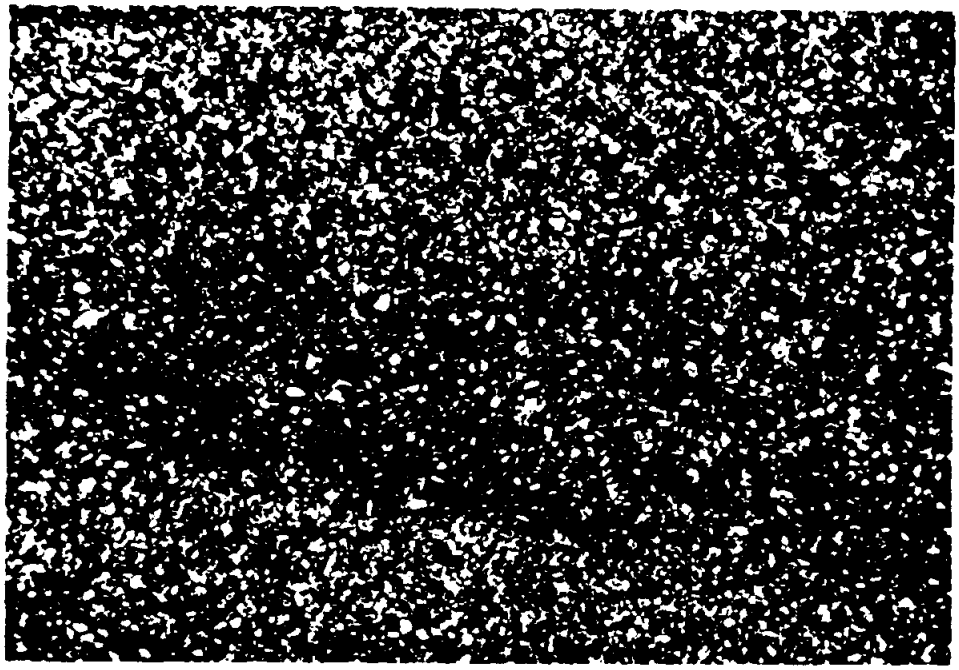
Porosity in the thin section photograph is shown in blue.

FIGURE 9

UPPER GUADALUPE RIVER AUTHORITY

KERRVILLE ASR PROJECT
TEX24486.A1

540'½"-540'1½"



THIN SECTION PHOTO
40X

THIN SECTION DESCRIPTION

Very fine crystalline, sandy, silty, dolomite. Scattered dissolution porosity. Scattered green glauconite grains. Thin-bedded streaks of pink iron-staining, marking thin bedding planes. Some quartz grains are partially replaced by dolomite along grain edges. Minor intercrystalline porosity.

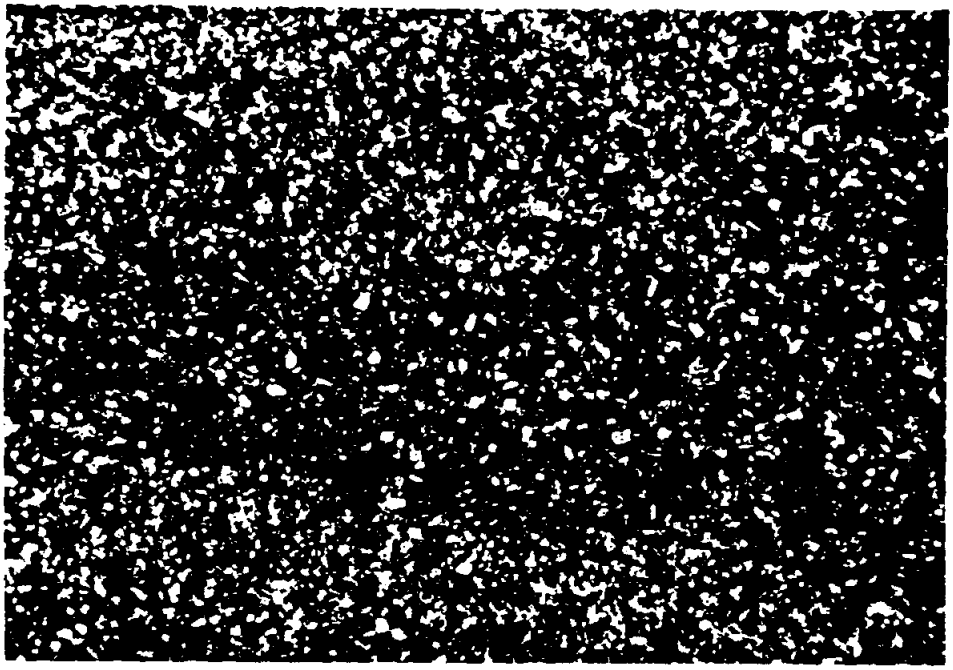
Porosity in the thin section photograph is shown in blue.

FIGURE 9

UPPER GUADALUPE RIVER AUTHORITY

KERRVILLE ASR PROJECT
TEX24486.A1

540'½"-540'1½"



THIN SECTION PHOTO
40X
x-nicols

THIN SECTION DESCRIPTION

Very fine crystalline, sandy, silty, dolomite. Scattered dissolution porosity. Scattered green glauconite grains. Thin-bedded streaks of pink iron-staining, marking thin bedding planes. Some quartz grains are partially replaced by dolomite along grain edges. Minor intercrystalline porosity.

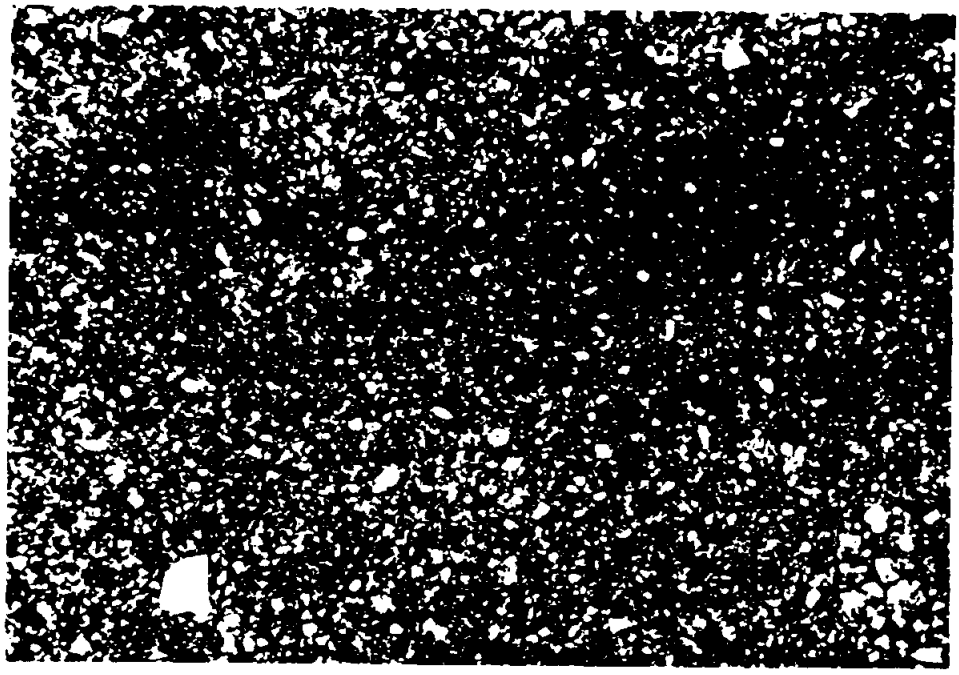
Porosity in the thin section photograph is shown in blue.

FIGURE 10

UPPER GUADALUPE RIVER AUTHORITY

KERRVILLE ASR PROJECT
TEX24486.A1

552'7"-552'8"



THIN SECTION PHOTO
40X

THIN SECTION DESCRIPTION

Thin-bedded, very fine silty dolomitic sand to sandy dolomite. Pink staining from oxidized iron. Scattered thin argillaceous beds. Brownish color in some thin beds may be organic streaks. A few scattered fine sand grains. Scattered fine particle-sized green glauconite grains. Minor amounts of very fine dissolution porosity. Some quartz grains are angular and other grains are well rounded.

Porosity in the thin section photograph is shown in blue.

ENERGY DISPURSIVE CHEMICAL ANALYSIS

Figures 11-15

FIGURE 11

UPPER GUADALUPE RIVER AUTHORITY

KERRVILLE ASR PROJECT
TEX24486.A1

481'6"-481'7"

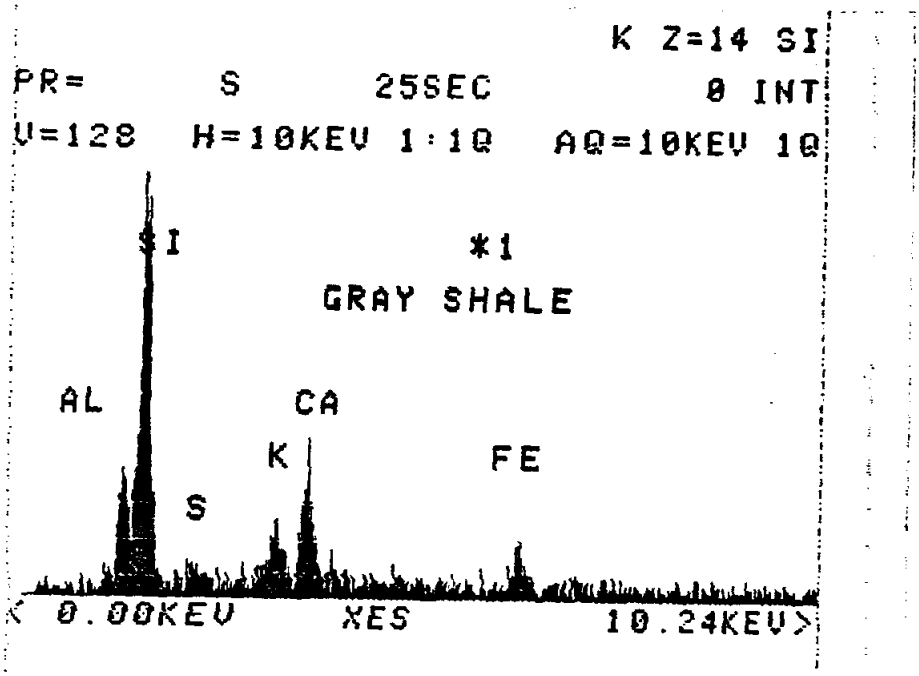


FIGURE 12

UPPER GUADALUPE RIVER AUTHORITY

KERRVILLE ASR PROJECT
TEX24486.A1

5-1'11"-512'0"

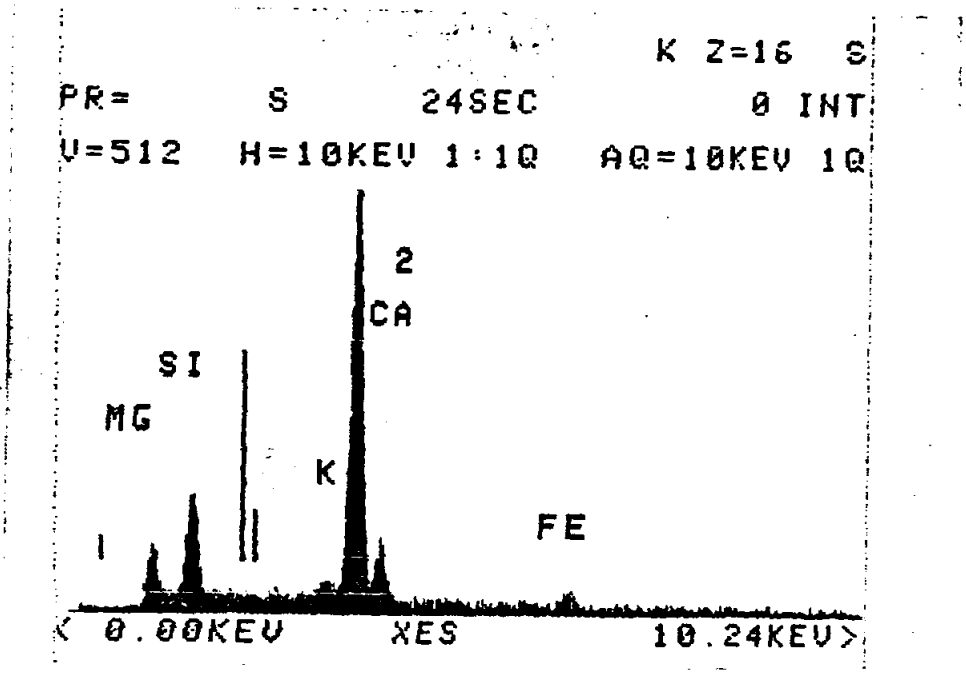


FIGURE 13

UPPER GUADALUPE RIVER AUTHORITY

KERRVILLE ASR PROJECT
TEX24486.A1

539'11"

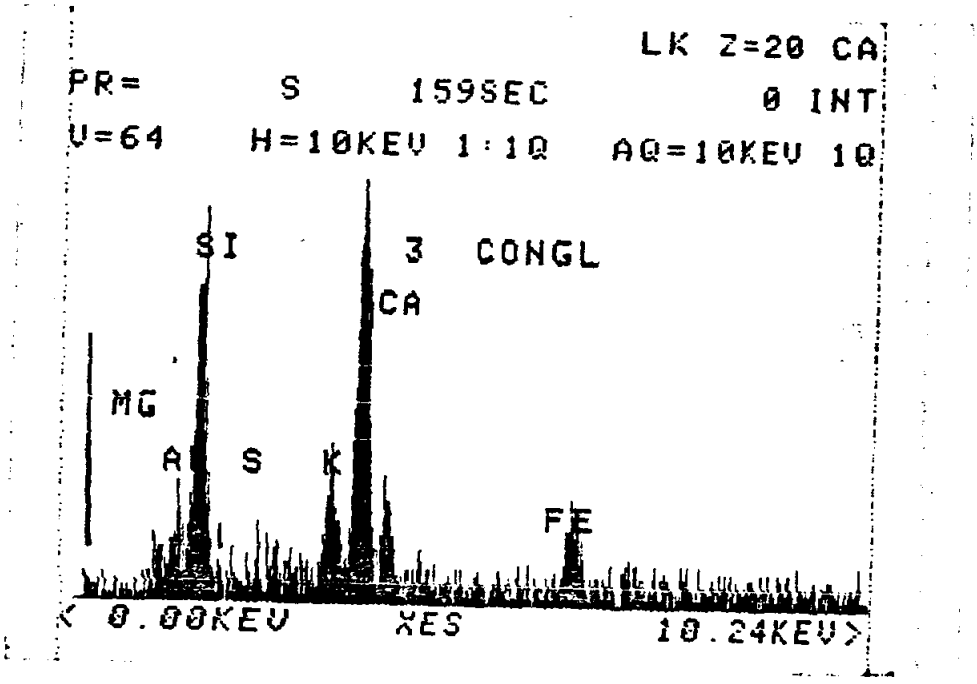


FIGURE 14

UPPER GUADALUPE RIVER AUTHORITY

KERRVILLE ASR PROJECT
TEX24486.A1

540'½"-540'1½"

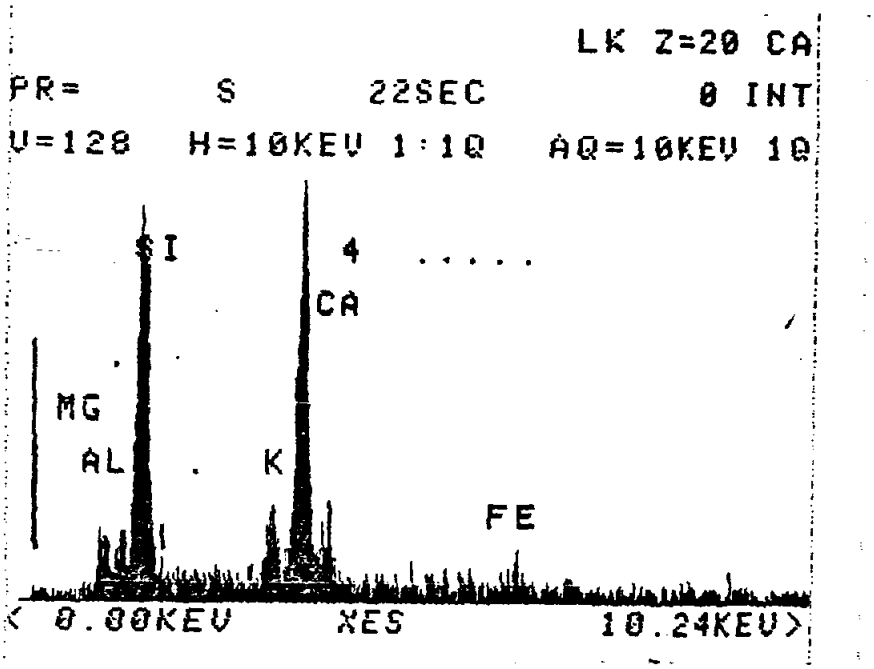
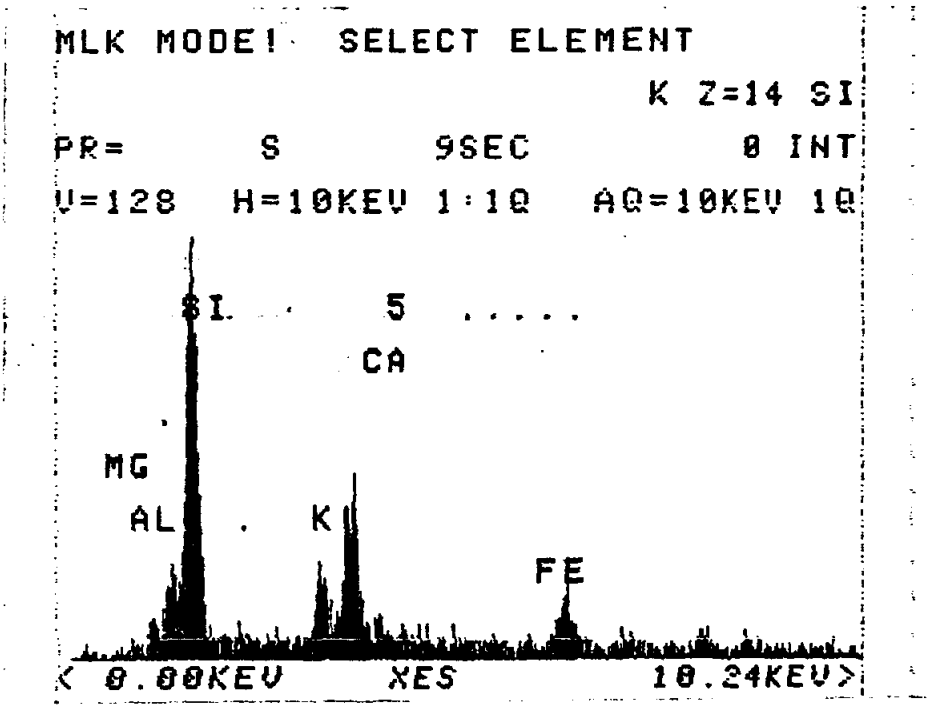


FIGURE 15

UPPER GUADALUPE RIVER AUTHORITY

KERRVILLE ASR PROJECT
TEX24486.A1

552'7"-552'8"

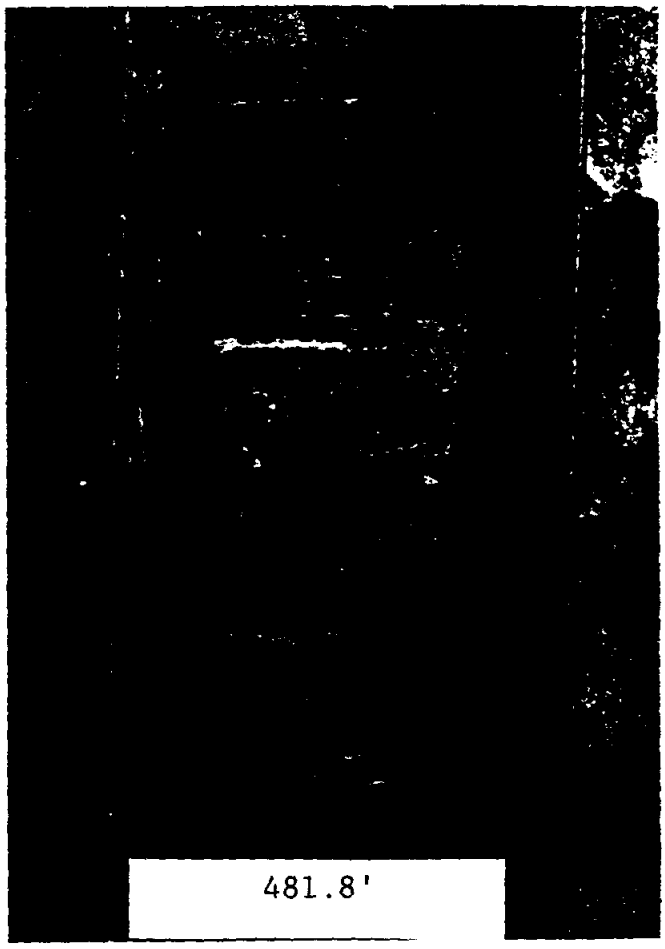


DESCRIPTION OF CORE

Figure 16

(4 pages)

481.1'

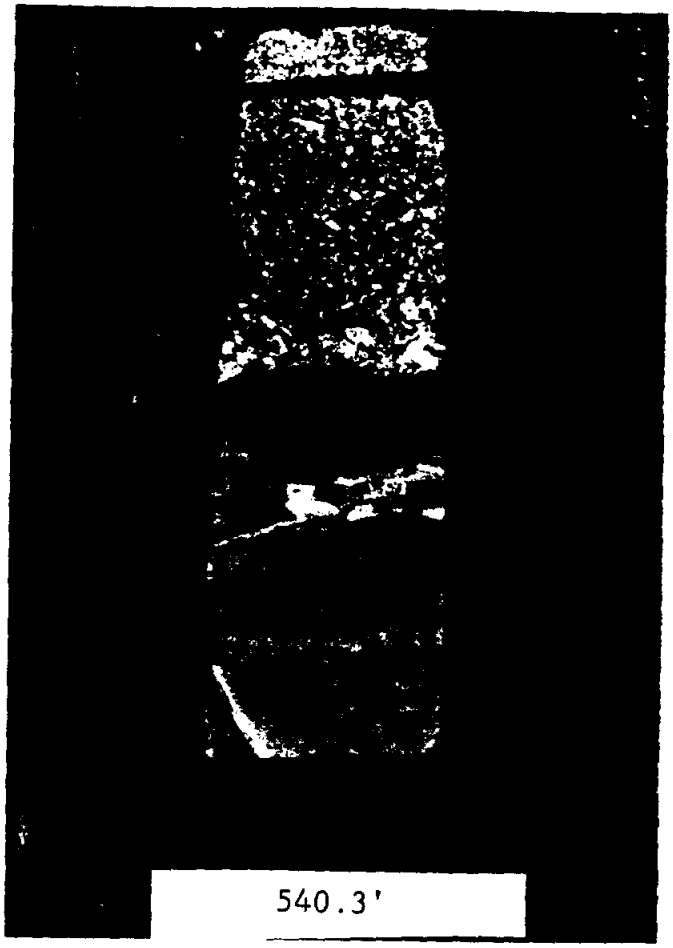


481.8'

481.1'-481.8'

Gray, Thin-bedded shale. Light tannish gray-colored dolomite streaks and inclusions. Scattered calcareous micro fossil inclusions. Scattered burrows infilled with fine sand.

539.6'



539.6'-539.10'

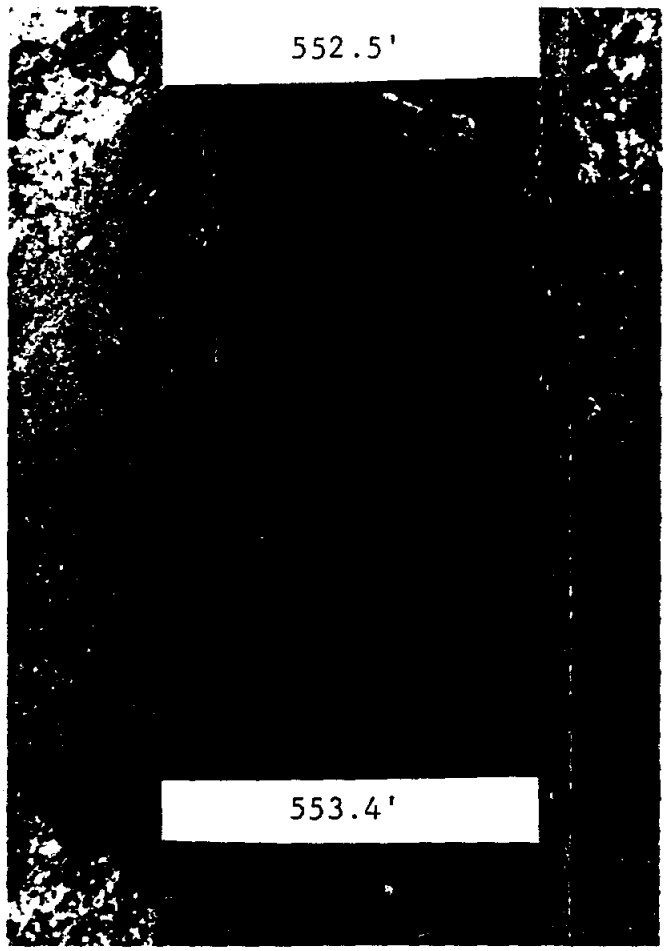
Tan to pinkish; coarse-grained well-rounded, dolomite-cemented conglomerate sand. There is a coarsening upward in particle s from coarse sand to conglomerat sand with pebbles, changing to fine sand at 539.10'.

539.10'-540.0'

A fine-grained dolomitic sandsto to sandy dolomite with mottled gray streaks and inclusions. So grayish, very thin streaks of fi cross bedding.

540.0'-540.3'

Tan to gray, fine-grained dolo-mite-cemented sandstone to sandy fine crystalline dolomite.



552.5'-552.7'

Mottled gray and yellowish fine grained dolomite-cemented sandstone to sandy fine crystalline dolomite. Some very thin parallel bedding.

552.7'-553.2'

Red to pink, very fine-grained dolomitic sandstone to sandy fin crystalline dolomite showing slight undulated bedding with white to grayish inclusions.

553.2'-553.4'

Red and pink fine-grained dolomitic sandstone to sandy fine crystalline dolomite with tannis grayish-white irregularly shaped blob-like inclusions.

Appendix D
PUMP TEST RESULTS

PUMP TEST 2 - DRAWDOWN
UGRA SITE WELL PZ-1

TIME (MIN)	DRAW-DOWN (FT)	FLOW (GPM)	DEPTH TO WATER (FT)
0	0	0	204.2
0.1	20	196	224.2
4	43	150	247.2
15	92	150	296.2
30	85.5	148	289.7
65	80.8	150	285
90	85.5	150	289.7
120	80.8	150	285
150	83	150	287.2
185	67	150	271.2
210	83	150	287.2
240	81	150	285.2

PUMP TEST 2 - RECOVERY
UGRA SITE WELL PZ-1

TIME (MIN)	T' RECOV. TIME	DEPTH TO WATER (FT	T/T'	RECOVERY FEET	RESIDUAL FEET
240.50	0.00	285.20	ERR	204.20	81.00
242.00	1.50	223.00	161.33	142.00	18.80
242.30	1.80	221.00	134.61	140.00	16.80
242.60	2.10	220.00	115.52	139.00	15.80
243.50	3.00	218.00	81.17	137.00	13.80
245.00	4.50	216.00	54.44	135.00	11.80
249.00	8.50	214.00	29.29	133.00	9.80
261.00	20.50	212.00	12.73	131.00	7.80
275.00	34.50	211.00	7.97	130.00	6.80
295.00	54.50	210.00	5.41	129.00	5.80
310.00	69.50	209.50	4.46	128.50	5.30

PUMP TEST 3 - DRAWDOWN POST ACIDIFICATION
UGRA SITE WELL PZ-1 9-21-89

TIME (MIN)	DRAW-DOWN (FT)	FLOW (GPM)	DEPTH TO WATER (FT)
0	0	0	201
0.03	5	155	206
0.3	15	155	216
0.6	12.8	155	213.8
1	13.1	155	214.1
1.5	13.3	155	214.3
2	13.4	155	214.4
2.5	13.55	155	214.55
5	14.1	155	215.1
10	15.3	155	216.3
15	15.7	155	216.7
30	16.4	155	217.4
60	18.2	155	219.2
90	19.25	155	220.25
105	19.6	155	220.6
120	19.95	155	220.95
120.5	21.5	175	222.5
121	21.6	175	222.6
122	21.7	175	222.7
125	21.9	175	222.9
127.5	22	175	223
130	22.15	175	223.15
135	22.3	175	223.3
150	22.8	175	223.8
165	23.15	175	224.15
180	23.5	175	224.5
181	25.3	195	226.3
182	25.4	195	226.4
183	25.6	195	226.6
185	25.75	195	226.75
190	26	195	227
195	26.25	195	227.25
210	26.7	195	227.7
211	28.1	210	229.1
212	28.2	210	229.2
213	28.3	210	229.3
215	28.4	210	229.4
225	28.8	210	229.8
230	29	210	230
240	29.25	210	230.25

TOTAL Q (GALLONS) = 41250

PUMP TEST 3 POST ACID - RECOVERY
UGRA SITE WELL PZ-1 9-21-89

TIME (MIN)	T' RECOV. TIME	T/T'	DEPTH TO WATER (FT)	RECOVERY (FEET)	RESIDUAL (FEET)
240	0	ERR	230.25	0	29.25
240.1	0.1	2401	225	5.25	24
240.2	0.2	1201	221	9.25	20
240.5	0.5	481	217	13.25	16
241.2	1.2	201	215	15.25	14
242.3	2.3	105	214	16.25	13
244.5	4.5	54	213	17.25	12
248.5	8.5	29	212	18.25	11
255.6	15.6	16	211	19.25	10
266.9	26.9	10	210	20.25	9

PUMP TEST NO. 4
8 HOUR DURATION
200 GPM FLOW VOLUME
UGRA WTP PZ-1
SEPTEMBER 22, 1989

TIME (MIN)	DRAWDOWN (FEET)	WATER LEVEL
0	0	202.4
0.05	5	207.4
0.06	9.6	212
0.33	12.6	215
0.75	14.6	217
1.16	15.6	218
1.6	16.6	219
2.3	17.6	220
3	18.1	220.5
5	17.8	220.2
8.5	18.6	221
10	18.9	221.3
12	19.25	221.65
15	19.66	222.06
30	21.5	223.9
45	22.58	224.98
60	23.46	225.86
75	24.12	226.52
95	25.02	227.42
105	25.35	227.75
120	25.86	228.26
135	26.33	228.73
150	26.8	229.2
165	27.18	229.58
180	27.55	229.95
195	27.87	230.27
210	28.36	230.76
225	28.76	231.16
240	29	231.4
270	29.55	231.95
300	30.04	232.44
365	30.72	233.12
390	31.24	233.64
420	31.56	233.96
450	31.94	234.34
480	32.22	234.62

PUMP TEST NO.4 - RECOVERY
UGRA SITE WELL PZ-1
SEPTEMBER 22, 1989

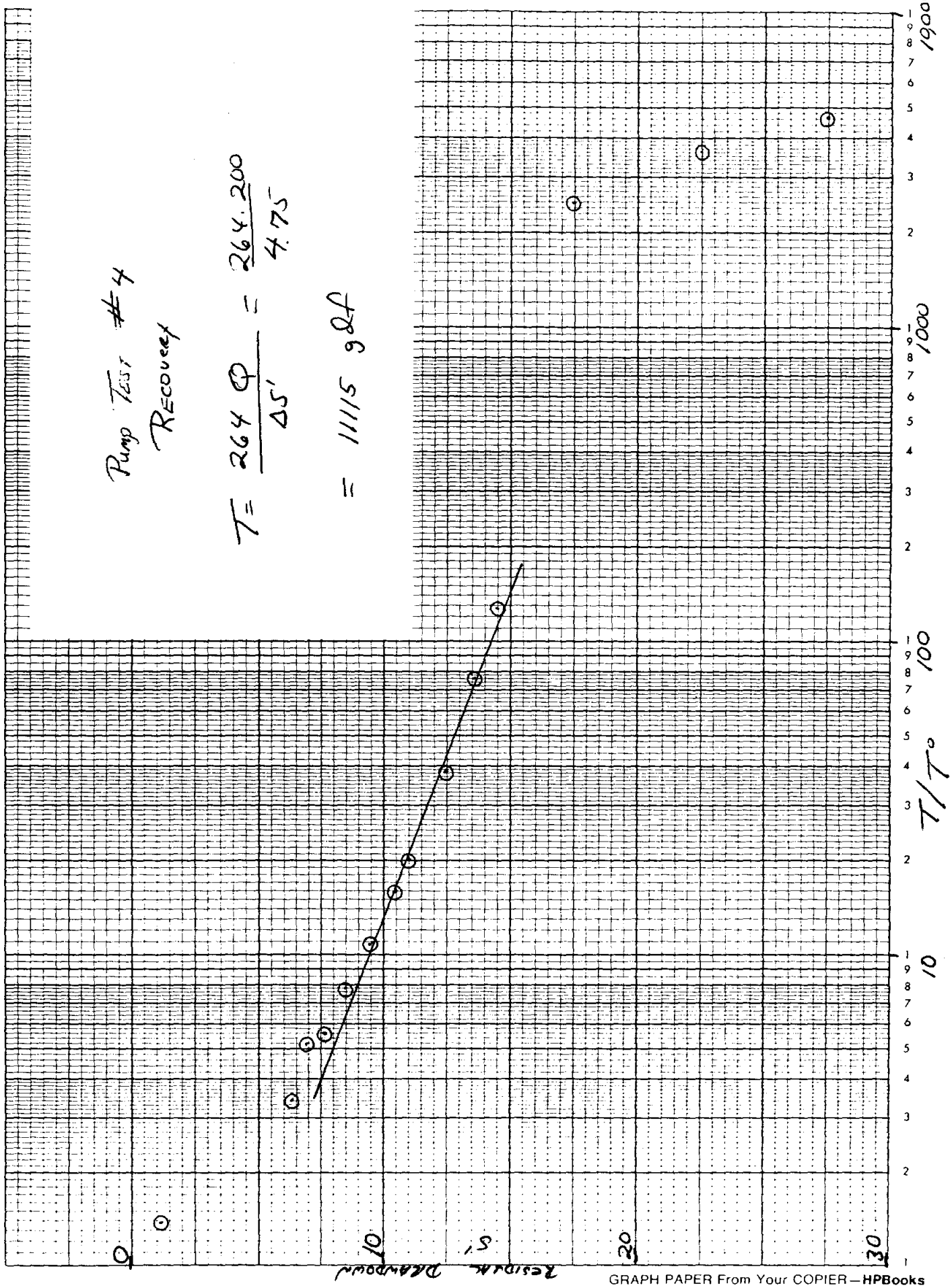
TIME (MIN)	T' RECOV. TIME	T/T'	DEPTH TO WATER (FT)	RECOVERY (FEET)	RESIDUAL (FEET)
480	0	ERR	234.62	0	32.22
480.1	0.1	4801	230	4.62	27.6
480.13	0.13	3693.307	225	9.62	22.6
480.2	0.2	2401	220	14.62	17.6
483.75	3.75	129	217	17.62	14.6
487.2	7.2	67.66666	216	18.62	13.6
492.5	12.5	39.4	215	19.62	12.6
500.5	20.5	24.41463	214	20.62	11.6
511.7	31.7	16.14195	213	21.62	10.6
527.5	47.5	11.10526	212	22.62	9.6
549.5	69.5	7.906474	211	23.62	8.6
584.5	104.5	5.593301	210	24.62	7.6
591.25	111.25	5.314606	209.5	25.12	7.1
617	137	4.503649	208.8	25.82	6.4
1650	1170	1.410256	203.65	30.97	1.25

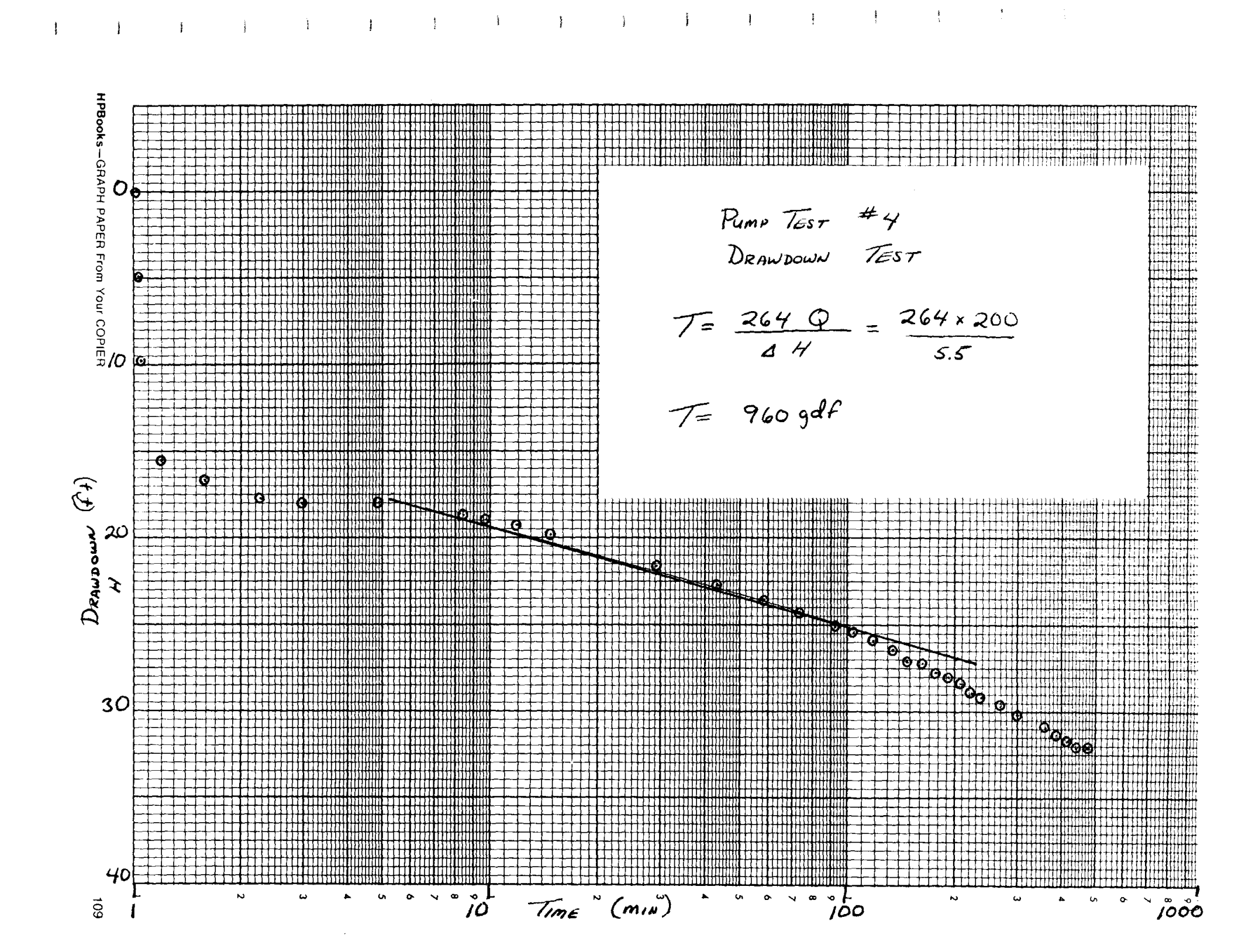
```
NUMBER OF KNOWN POINTS= 34
POINT NUMBER= 1
X (TIME)-COORDINATE OF POINT (MIN)= 5.0000D-02
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 5.0000D+00
POINT NUMBER= 2
X (TIME)-COORDINATE OF POINT (MIN)= 6.0000D-02
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 9.6000D+00
POINT NUMBER= 3
X (TIME)-COORDINATE OF POINT (MIN)= 3.3000D-01
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 1.2600D+01
POINT NUMBER= 4
X (TIME)-COORDINATE OF POINT (MIN)= 7.5000D-01
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 1.4600D+01
POINT NUMBER= 5
X (TIME)-COORDINATE OF POINT (MIN)= 1.1600D+00
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 1.5600D+01
POINT NUMBER= 6
X (TIME)-COORDINATE OF POINT (MIN)= 1.6000D+00
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 1.6600D+01
POINT NUMBER= 7
X (TIME)-COORDINATE OF POINT (MIN)= 2.3000D+00
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 1.7600D+01
POINT NUMBER= 8
X (TIME)-COORDINATE OF POINT (MIN)= 3.0000D+00
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 1.8100D+01
POINT NUMBER= 9
X (TIME)-COORDINATE OF POINT (MIN)= 8.5000D+00
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 1.8600D+01
POINT NUMBER= 10
X (TIME)-COORDINATE OF POINT (MIN)= 1.0000D+01
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 1.8900D+01
POINT NUMBER= 11
X (TIME)-COORDINATE OF POINT (MIN)= 1.2000D+01
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 1.9250D+01
POINT NUMBER= 12
X (TIME)-COORDINATE OF POINT (MIN)= 1.5000D+01
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 1.9660D+01
POINT NUMBER= 13
X (TIME)-COORDINATE OF POINT (MIN)= 3.0000D+01
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 2.1500D+01
POINT NUMBER= 14
X (TIME)-COORDINATE OF POINT (MIN)= 4.5000D+01
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 2.2580D+01
POINT NUMBER= 15
X (TIME)-COORDINATE OF POINT (MIN)= 6.0000D+01
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 2.3460D+01
POINT NUMBER= 16
X (TIME)-COORDINATE OF POINT (MIN)= 7.5000D+01
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 2.4120D+01
POINT NUMBER= 17
X (TIME)-COORDINATE OF POINT (MIN)= 9.5000D+01
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 2.5020D+01
POINT NUMBER= 18
X (TIME)-COORDINATE OF POINT (MIN)= 1.0500D+02
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 2.5350D+01
POINT NUMBER= 19
X (TIME)-COORDINATE OF POINT (MIN)= 1.2000D+02
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 2.5860D+01
POINT NUMBER= 20
X (TIME)-COORDINATE OF POINT (MIN)= 1.3500D+02
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 2.6330D+01
POINT NUMBER= 21
X (TIME)-COORDINATE OF POINT (MIN)= 1.5000D+02
```

```
POINT NUMBER= 22
X (TIME)-COORDINATE OF POINT (MIN)= 1.6500D+02
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 2.7180D+01
POINT NUMBER= 23
X (TIME)-COORDINATE OF POINT (MIN)= 1.8000D+02
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 2.7550D+01
POINT NUMBER= 24
X (TIME)-COORDINATE OF POINT (MIN)= 1.9500D+02
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 2.7870D+01
POINT NUMBER= 25
X (TIME)-COORDINATE OF POINT (MIN)= 2.1000D+02
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 2.8360D+01
POINT NUMBER= 26
X (TIME)-COORDINATE OF POINT (MIN)= 2.2500D+02
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 2.8760D+01
POINT NUMBER= 27
X (TIME)-COORDINATE OF POINT (MIN)= 2.4000D+02
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 2.9000D+01
POINT NUMBER= 28
X (TIME)-COORDINATE OF POINT (MIN)= 2.7000D+02
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 2.9550D+01
POINT NUMBER= 29
X (TIME)-COORDINATE OF POINT (MIN)= 3.0000D+02
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 3.0040D+01
POINT NUMBER= 30
X (TIME)-COORDINATE OF POINT (MIN)= 3.6500D+02
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 3.0720D+01
POINT NUMBER= 31
X (TIME)-COORDINATE OF POINT (MIN)= 3.9000D+02
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 3.1240D+01
POINT NUMBER= 32
X (TIME)-COORDINATE OF POINT (MIN)= 4.2000D+02
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 3.1560D+01
POINT NUMBER= 33
X (TIME)-COORDINATE OF POINT (MIN)= 4.5000D+02
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 3.1940D+01
POINT NUMBER= 34
X (TIME)-COORDINATE OF POINT (MIN)= 4.8000D+02
Y (DRAWDOWN)-COORDINATE OF POINT (FT)= 3.2220D+01
PRODUCTION WELL DISCHARGE RATE (GPM)= 2.5000D+02
DISTANCE FROM PRODUCTION WELL (FT)= 1.0000D+00

COMPUTATION RESULTS:

AQUIFER TRANSMISSIVITY (GPD/FT)=  11128.00
AQUIFER STORATIVITY (DIM)= 8.668E-03
```





Appendix E
CHEMICAL DATA

SAN ANTONIO TESTING LABORATORY

4733 RITTIMAN ROAD
201 E. SPRING ST.
SAN ANTONIO, TEXAS 78218
BRACKETTVILLE, TEXAS 78832
(512) 599-7670
(512) 563-2124

REPORT OF CHEMICAL ANALYSIS

REPORT NO. 1648
Page 1

Upper Guadalupe River Authority
P.O. Box 1278
Kerrville, TX 78029

Date Reported: 10-05-89
Date Received: 9-22-89
Sample: Water

ATTN: Mr. Charlie Wiedenfeld

PARAMETER	ASR WEST WELL FILTERED RESULTS		UGRA WTP FINISHED H2O RESULTS	
Silica	3.3	mg/L	4.9	mg/L
Mg	48	mg/L	19	mg/L
K	7.5	mg/L	1.3	mg/L
Al	0.1	mg/L	0.2	mg/L
Cu	<0.02	mg/L	<0.02	mg/L
Mn	0.07	mg/L	<0.01	mg/L
Zn	0.04	mg/L	0.05	mg/L
Cd	<0.01	mg/L	<0.01	mg/L
Se	<0.01	mg/L	<0.01	mg/L
Na	37	mg/L	11	mg/L
Color	39	Color Units	1	Color Units
Fluid Density	0.992	g/ml	0.991	g/ml
H2S	<1	mg/L	<1	mg/L

mg/L: Milligrams per Liter
g/ml: Grams per Milliliter
Test Method: Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, Revised March 1983
Standard Methods for the Examination of Water and Wastewater, 16th Edition, 1985

Test Conducted by: John D. Burch

Respectfully Submitted,

Richard Hawk
General Manager

CHEMICAL ANALYSIS BY OGRA LAB
09/17/89

Parameter		ASR TEST WELL Spl 1	Spl 2	Avg	OGRA WTP FINISHED WATER Spl 1	Spl 2	Avg
*pH	F	7.3	7.3	7.3	7.6	7.6	7.6
*Turb.	U	2.8	2.8	2.8	0.22	0.22	0.22
*Spec Cond	F	942	942	942	398	399	399
*Temp (C°)	U	23.0	22.9	23.0	24.9	25.0	25.0
*D.O.	U	4.14	4.01	4.08	7.69	7.69	7.69
*Ttl Colj	U	0-0	0-0	0	0	0	0
*C Alkalinty	F	0	0	0	0	0	0
*Ttl Alkalinty	F	334	328	331	172	166	169
Bi Alkalinty	F	334	328	331	172	166	169
TDS	F	559	607	583	262	-	262
TSS	U	4.4	4.4	4.4	0.20	0.22	0.21
Cl	F	97	96	96	23	24	23
Fl	F	1.0	1.0	1.0	0.9	0.9	0.9
SO4	F	23	25	24	11	-	11
Calcium	F	60	57	58	28	26	27
Sodium	F						
*Iron	F	1.35	1.37	1.36	0.05	0.05	0.05
Ttl Hardness	F	416	416	416	206	206	206
Non-Car Hard	F	82	88	85	34	40	37
Ca Hardness	F	150	142	146	70	65	68
Nitrate	F	0.1	0.1	0.1	0.1	0.1	0.1
O-PO4	F	0.030	0.051		0.012	0.010	0.011
Ammonia	F	0.068	0.070	0.069	0.049	-	0.049
TOC	U	1.4	1.4	1.4	2.3	2.3	2.3

* On-site Determination

SAN ANTONIO TESTING LABORATORY

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BRACKETTVILLE, TEXAS 78832
(512) 599-7670
(512) 563-2124

UPPER GUADALUPTE RIVER AUTHORITY

SAMPLE I.D.: UGRA WTP
FINISHED H2O

HALOGENATED AND AROMATIC VOLATILE ORGANICS

PARAMETERS	METHOD	RESULTS ug/L	DETECTION LIMITug/L	ANALYST
Bromoform	EPA 624	<5	5	DM
Carbon Tetrachloride	EPA 624	<5	5	DM
Chlorobenzene	EPA 624	<5	5	DM
Chlorodibromomethane	EPA 624	<5	5	DM
Chloroethane	EPA 624	<5	5	DM
2-Chloroethylvinyl Ether	EPA 624	<5	5	DM
Chloroform	EPA 624	35	5	DM
Dichlorobromomethane	EPA 624	23	5	DM
Dichlorodifluoromethane	EPA 624	<5	5	DM
1,1-Dichloroethane	EPA 624	<5	5	DM
1,2-Dichloroethane	EPA 624	<5	5	DM
1,1-Dichloroethylene	EPA 624	<5	5	DM
1,2-Dichloropropane	EPA 624	<5	5	DM
trans-1,3-Dichloropropylene	EPA 624	<5	5	DM
1,1,2,2-Tetrachloroethane	EPA 624	<5	5	DM
Tetrachloroethylene	EPA 624	<5	5	DM
trans-1,2-Dichloroethylene	EPA 624	<5	5	DM
1,1,1-Trichloroethane	EPA 624	<5	5	DM
1,1,2-Trichloroethane	EPA 624	<5	5	DM
Trichloroethylene	EPA 624	<5	5	DM
Trichlorofluoromethane	EPA 624	<5	5	DM

SAN ANTONIO TESTING LABORATORY

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SAN ANTONIO, TEXAS 78218
BRACKETTVILLE, TEXAS 78832
(512) 599-7670
(512) 563-2124

UPPER GUADALUPE RIVER AUTHORITY

SAMPLE I.D.: ASR WEST WELL FILTERED

PARAMETERS	METHOD	RESULTS ug/L	DETECTION LIMITug/L	ANALYST
Vinyl Chloride	EPA 624	<5	5	DM
Bis(2-chloroethoxy)methane	EPA 624	<10	10	DM
Bis(2-chloroisopropyl)ether	EPA 624	<10	10	DM
1,2-Dichlorobenzene	EPA 624	<5	5	DM
1,3-Dichlorobenzene	EPA 624	<5	5	DM
1,4-Dichlorobenzene	EPA 624	<5	5	DM
Benzyl chloride	EPA 624	<5	5	DM
Bromobenzene	EPA 624	<5	5	DM
Bromomethane	EPA 624	<5	5	DM
Chloroacetaldehyde	EPA 624	<5	5	DM
1-Chlorohexane	EPA 624	<5	5	DM
Chloromethane	EPA 624	<5	5	DM
Chloromethylmethyl ether	EPA 624	<5	5	DM
Chlorotoluene	EPA 624	<5	5	DM
Dibromomethane	EPA 624	<5	5	DM
Dichloromethane	EPA 624	<5	5	DM
1,1,1,2-Tetrachloroethane	EPA 624	<5	5	DM
Trichloropropane	EPA 624	<5	5	DM
Benzene	EPA 624	<5	5	DM
Ethyl Benzene	EPA 624	<5	5	DM
Toluene	EPA 624	<5	5	DM
Xylenes	EPA 624	<5	5	DM

SAN ANTONIO TESTING LABORATORY

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SAN ANTONIO, TEXAS 78218
BRACKETTVILLE, TEXAS 78832
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(512) 563-2124

UPPER GUADALUPE RIVER AUTHORITY

SAMPLE I.D.: UGRA WTP
FINISHED H2O

PARAMETERS	METHOD	RESULTS ug/L	DETECTION LIMITug/L	ANALYST
Vinyl Chloride	EPA 624	<5	5	DM
Bis(2-chloroethoxy)methane	EPA 624	<10	10	DM
Bis(2-chloroisopropyl)ether	EPA 624	<10	10	DM
1,2-Dichlorobenzene	EPA 624	<5	5	DM
1,3-Dichlorobenzene	EPA 624	<5	5	DM
1,4-Dichlorobenzene	EPA 624	<5	5	DM
Benzyl chloride	EPA 624	<5	5	DM
Bromobenzene	EPA 624	<5	5	DM
Bromomethane	EPA 624	<5	5	DM
Chloroacetaldehyde	EPA 624	<5	5	DM
1-Chlorohexane	EPA 624	<5	5	DM
Chloromethane	EPA 624	<5	5	DM
Chloromethylmethyl ether	EPA 624	<5	5	DM
Chlorotoluene	EPA 624	<5	5	DM
Dibromomethane	EPA 624	<5	5	DM
Dichloromethane	EPA 624	<5	5	DM
1,1,1,2-Tetrachloroethane	EPA 624	<5	5	DM
Trichloropropane	EPA 624	<5	5	DM
Benzene	EPA 624	<5	5	DM
Ethyl Benzene	EPA 624	<5	5	DM
Toluene	EPA 624	<5	5	DM
Xylenes	EPA 624	<5	5	DM

SAN ANTONIO TESTING LABORATORY

4733 RITTIMAN ROAD
201 E. SPRING ST.
SAN ANTONIO, TEXAS 78218
BRACKETTVILLE, TEXAS 78832
(512) 599-7670
(512) 563-2124

UPPER GUADALUPE RIVER AUTHORITY

SAMPLE I.D.: ASR WEST WELL FILTERED

HALOGENATED AND AROMATIC VOLATILE ORGANICS

PARAMETERS	METHOD	RESULTS ug/L	DETECTION LIMITug/L	ANALYST
Bromoform	EPA 624	<5	5	DM
Carbon Tetrachloride	EPA 624	<5	5	DM
Chlorobenzene	EPA 624	<5	5	DM
Chlorodibromomethane	EPA 624	<5	5	DM
Chloroethane	EPA 624	<5	5	DM
2-Chloroethylvinyl Ether	EPA 624	<5	5	DM
Chloroform	EPA 624	<5	5	DM
Dichlorobromomethane	EPA 624	<5	5	DM
Dichlorodifluoromethane	EPA 624	<5	5	DM
1,1-Dichloroethane	EPA 624	<5	5	DM
1,2-Dichloroethane	EPA 624	<5	5	DM
1,1-Dichloroethylene	EPA 624	<5	5	DM
1,2-Dichloropropane	EPA 624	<5	5	DM
trans-1,3-Dichloropropylene	EPA 624	<5	5	DM
1,1,2,2-Tetrachloroethane	EPA 624	<5	5	DM
Tetrachloroethylene	EPA 624	<5	5	DM
trans-1,2-Dichloroethylene	EPA 624	<5	5	DM
1,1,1-Trichloroethane	EPA 624	<5	5	DM
1,1,2-Trichloroethane	EPA 624	<5	5	DM
Trichloroethylene	EPA 624	<5	5	DM

Texas Water Development Board

Chemical Water Analysis Report

BOTTLE 5
BOTTLE 5

~~MISC~~ UGRA . ARTW. 89-9-1

TOTAL ORGANICS FORM

TWDB Use Only
Work No. 3202
IAC No. _____

Send Reply To:
Ground Water Unit
Texas Water Development Board
P.O. Box 13231
Austin, Texas 78711

Attention: BOB BLUNTZER / ERIC ADIDAS
State Well Number: _____

County: KERR
Date & Time: 9/22/89

Owner: UPPER GUADALUPE RIVER AUTHORITY
☑ Send Copy To Owner

Address: _____
Sampled After Pumping: _____ Hours

Date Drilled: _____ Depth: _____
Yield: 200 GPM ☑ Measured ☐ Estimated

Collection Point: DISCHARGE PIPE pH _____
Use: TEST WELL Temperature: 22.7 °C

By: ERIC ADIDAS
Specific Conductance: 927

Requested Chemical Analysis

Laboratory No.: EB10 19
Date Received: [illegible]
Date Reported: NOV 9 1989

Total Organic Carbon < 1 mg/l

890091-A

Texas Water Development Board

Chemical Water Analysis Report

Bottle #1

GWR-UGRA - ARTW. 89-9-1
(Anions)

TWDB Use Only
Work No. 3202
IAC No. _____

Send Reply To:
Ground Water Unit
Texas Water Development Board
P.O. Box 13231
Austin, Texas 78711

Attention: BOB BUNTZER/ERIC ADIDAS
State Well Number: _____

County: KERR
Date & Time: 9/22/89

Owner: UPPER GUADALUPE RIVER AUTHORITY (UGRA) ☑ Send Copy To Owner

Address: KERVILLE
Sampled After Pumping: _____ Hours

Date Drilled: _____ Depth: _____
Yield: _____ GPM ☐ Measured ☐ Estimated

Collection Point: DISCHARGE PINT pH 7.45
Use: TEST WELL FOR ARTIFICIAL RECHARGE
Temperature: 22.7 °C

By: ERIC ADIDAS
Specific Conductance: 927 micromhos/cm @ 22.7°C

Requested Chemical Analysis

Laboratory No. E80 15
Date Received: SEP 25 [illegible]
Date Reported: OCT 31 1989

		me/l	mg/l
Sulfate	(00946)	~~3~~ 0.65	~~0.653~~
Chloride	(00941)	~~97~~ 2.57	~~2.57~~ 91
Flouride	(00950)	0.06	1.1
Nitrate NO_3-N		0.01	0.0
Nitrite NO_2-N		<0.01	0.0

		mg/l			µg/l
Silica	(00955)	11	~~Boron~~	(01020)	
Phenol Alkalinity (Carbonate)	(00415)	0	~~Bromide~~	(82298)	
Total Alkalinity	(00410)	320			
Iodide	(71865)	< 0.10			
Orthophosphate		0.15			
Bicarbonate Alkalinity		390			

NOTE * FILTER AND ANALYSE

890091-C

Typewrite (Black ribbon) or Print Plainly
(soft pencil or black ink)
Do not use ball point pen

Texas Department of Health Laboratories
1100 West 49th Street
Austin, Texas 78756

TWDB ONLY
Organization No. 3202 Lab No.
Work No.

Bottles #8 and #9

CHEMICAL WATER ANALYSIS REPORT

Sample # UGRA-ARTW-89-9-1

Send report to:

Data Collection and Evaluation Section
Texas Water Development Board
P.O. Box 13231
Austin, Texas 78711-3231

County KERR
State Well No. - -
Well No.
Date Collected 09-22-89

Owner UPPER GUADALUPE RIVER AUTHORITY (UGRA) Send copy to owner Sample No. By
Address KERVILLE Well Location
Date Drilled Depth ft. WBF Source (type of well)
Producing intervals Water level ft. Sample depth ft.
Sampled after pumping Several days hrs. Yield 200 GPM meas. est. Temperature °F 22 °C
Point of collection DISCHARGE POINT Appearance ☑ clear ☐ turbid ☐ colored ☐ other
Use TEST WELL Remarks

(FOR LABORATORY USE ONLY)
Laboratory EB 0 20

CHEMICAL ANALYSIS

Date Received

OCT 31 1989
Date Reported

		MG/L	ME/L
Silica	00955	11	
Calcium	00915	80	4.02
Magnesium	00925	47	3.86
Sodium	00930	41	1.78
Total			9.66
☐ Potassium	00935		
[3] ☐ Manganese	01055		%Na
☐ Boron	01020		SAR
[3] ☐ Total Iron	01045		RSC
☐ (other)		MG/L	

Specific Conductance (micromhos/cm^3) 00095 868
Diluted Conductance (micromhos/cm^3):
7 x 149 = 1043

		MG/L	ME/L
Carbonate	00445	0	0.00
Bicarbonate	00440	401	6.58
Sulfate	00946	33	0.69
Chloride	00940	93	2.62
Fluoride	00950	1.1	0.06
Nitrate	71851	0.04	0.00
pH	00403	7.8	Total 9.95
[1] Dissolved Solids (~~residue at 180° C~~)	70300		511
Phenolphthalein Alkalinity as C aCO$_3$	00415		0
Total Alkalinity as C aCO$_3$	00410		329
Total Hardness as C aCO$_3$	00900		394
[2] Nitrogen Cycle			
~~Ammonia~~ - N	00610		
Nitrite - N	00615	<0.01	
Nitrate - N	00620	0.01	
~~Organic Nitrogen~~	00605		

" ☐ " items will be analyzed if checked.

[1] The bicarbonate reported in this analysis can be converted by computation (multiplying by 0.4917) to an equivalent amount of carbonate, and the carbonate figure used in the computation of dissolved solids.
[2] Nitrogen cycle requires separate sample.
[3] Total Iron and Manganese require separate sample.

Analyst Checked By

TWDB-0148 (Rev.08-03-87)

Appendix F
GEOCHEMICAL MODELING RESULTS

```
EQ3NR, version 3245R111

  Copyright (c) 1987 The Regents of the University of California,
  Lawrence Livermore National Laboratory. All rights reserved.

Supported by EQLIB, version 3245R136

  Copyright (c) 1987 The Regents of the University of California,
  Lawrence Livermore National Laboratory. All rights reserved.


Run  11:54:55  12-OCT89


--- reading the input file ---
input file name= kerr2.3i revised=10/11/89     revisor= rg
Kerrville, Texas - ASR Project;  Charge No.: TEX24486.a1

Basic data for EQ3 modeling of Kerrville project received
from Dick Glanzman/DEN on October 10, 1989.


This is one of four scenarios.
   1)  Equilibrium for ASR groundwater at a pH of 8.2
   2)  Equilibrium for ASR groundwater at a pH of 7.3
   3)  Equilibrium for ASR Water Treatment Plant (WTP) recharge water
   4)  Equilibrium of a 50-50 mixture of one of the above ASR
       groundwaters and the WTP water.

This run is for the ~~second~~ first scenario with pH 8.2.




endit.
      tempc=  0.23000E+02
        rho=  0.10000E+01     tdspkg=  0.00000E+00     tdspl=  0.00000E+00
        fep= -0.10000E+00     uredox=
      tolbt=  0.00000E+00      toldl=  0.00000E+00     tolsat=  0.00000E+00
    itermx=  0
                1    2    3    4    5    6    7    8    9   10
  iopt1-10=    -1    0    0    0    0    0    0    0    0    0
  iopg1-10=     0    0    0    0    0    0    0    0    0    0
  iopr1-10=     0    0    0    0    0    0    0    0    0    0
 iopr11-20=     0    0    0    0    0    0    0    0    0    0
  iodb1-10=     0    0    0    0    0    0    0    0    0    0
     uebal= none
    uacion= cl-
     nxmod=  0
data file master species= na+
   switch with species=
   jflag=  2   csp=  0.37000E+02
```

aqueous species accounting for 99% or more of o2(aq)

species	molal conc	per cent
o2(aq)	0.4375E-04	100.00
total		100.00

aqueous species accounting for 99% or more of ch3coo-

species	molal conc	per cent
ch3coo-	0.4297E-03	97.58
mgch3coo+	0.9796E-05	2.22
total		99.80

aqueous species accounting for 99% or more of nh4+

species	molal conc	per cent
nh4+	0.7198E-05	90.17
nh3	0.4672E-06	5.85
cu(nh3)2+	0.1571E-06	3.94
total		99.95

----- summary of aqueous redox reactions -----

couple		eh, volts	pe-	log fo2	ah, kcal
default		-0.100	-0.1702E+01	-57.696	-2.306
o2(aq)	/h2o	0.726	0.1235E+02	-1.473	16.741
h2(aq)	/h2o	-0.100	-0.1702E+01	-57.696	-2.306
ch3coo-	/hco3-	-0.364	-0.6200E+01	-75.687	-8.401
cu++	/cu+	-0.100	-0.1702E+01	-57.696	-2.306
fe+++	/fe++	-0.100	-0.1702E+01	-57.696	-2.306
hs-	/so4--	-0.100	-0.1702E+01	-57.696	-2.306
nh4+	/no3-	0.160	0.2723E+01	-39.997	3.690
no2-	/no3-	-0.100	-0.1702E+01	-57.696	-2.306

----- summary of aqueous non-equilibrium non-redox reactions -----

couple	affinity, kcal
none	

----- summary of stoichiometric mineral saturation states -----

(minerals with affinities .lt. -10 kcal are not listed)

mineral	log q/k	aff, kcal	state	mineral	log q/k	aff, kcal	state

albite	-1.704	-2.309	
albite low	-1.704	-2.309	
amrph.silica	-1.538	-2.084	
analcime	-1.652	-2.238	
andradite	2.724	3.692	ssatd
annite	3.302	4.475	ssatd
antigorite	6.928	9.388	ssatd
artinite	-3.624	-4.911	
bassanite	-3.693	-5.004	
beidellit-k	0.345	0.468	satd
beidellit-na	0.314	0.425	satd
boehmite	-0.820	-1.111	
brucite	-3.092	-4.190	
calcite	1.095	1.484	ssatd
caso4.1/2h2o	-3.864	-5.236	
chalcedony	-0.509	-0.690	
chamosite-7a	1.615	2.189	ssatd
clinochl-14a	3.149	4.267	ssatd
clinoptil-ca	-2.445	-3.313	
clinoptil-mg	-6.564	-8.895	
clinozoisite	-3.852	-5.220	
corundum	-3.855	-5.223	
crist.beta.a	-1.236	-1.675	
cufeo2(c)	9.411	12.753	ssatd
dachiardite-	-1.781	-2.413	
daphnite-7a	2.960	4.012	ssatd
diaspore	0.035	0.047	satd
dolomite	3.242	4.393	ssatd
dolomite-ord	3.242	4.393	ssatd
epidote	2.363	3.203	ssatd
epistilbite	-0.193	-0.262	satd
erionite-ca	-0.899	-1.219	
faujasite-na	-4.067	-5.511	
fe(oh)2(ppd)	-2.018	-2.734	
feo(c)	-0.532	-0.720	
ferrite-cu	0.384	0.520	ssatd
ferrite-zn	6.652	9.014	ssatd
fluorapatite	21.583	29.248	ssatd
forsterite	-5.700	-7.724	
gibbsite	0.844	1.144	ssatd
gmelinite-ca	0.447	0.606	ssatd
goethite	3.823	5.180	ssatd
gypsum	-2.869	-3.888	
hedenbergite	-3.873	-5.248	
hercynite	-1.063	-1.441	
heulandite-n	-5.013	-6.793	
huntite	0.865	1.173	ssatd
hydroxyapati	11.282	15.289	ssatd
jadeite	-3.092	-4.190	
kalicinite	-6.389	-8.658	
kaolinite	1.694	2.295	ssatd
kyanite	-2.991	-4.054	
laumontite	-0.287	-0.389	satd
leonhardtite	-6.337	-8.588	
magnesite	0.506	0.686	ssatd
margarite	-2.309	-3.129	
melanterite	-7.319	-9.919	
mesolite-ss	-2.146	-2.908	
minnesotaite	1.704	2.310	ssatd

albite high	-3.036	-4.114	
amesite-14a	1.438	1.949	ssatd
analc-dehydr	-6.395	-8.666	
andalusite	-3.271	-4.433	
anhydrite	-3.062	-4.149	
anorthite	-4.793	-6.496	
aragonite	0.930	1.260	ssatd
ashcroftite	-2.020	-2.738	
beidellit-ca	0.797	1.080	ssatd
beidellit-mg	0.838	1.136	ssatd
berlinite	-6.542	-8.865	
brewsterite-	-0.193	-0.262	satd
cahpo4.2h2o	-2.354	-3.190	
casi2o5.2h2o	-5.214	-7.066	
chabazite	0.447	0.606	ssatd
chalcocite	-7.265	-9.845	
chrysotile	0.090	0.123	satd
clinochl-7a	-0.240	-0.326	satd
clinoptil-k	-1.036	-1.404	
clinoptil-na	-6.275	-8.504	
copper	0.616	0.834	ssatd
cristobalite	-0.791	-1.072	
cronstedt.-7	9.973	13.515	ssatd
cuprite	-1.477	-2.002	
daphnite-14a	6.351	8.607	ssatd
dawsonite	-0.982	-1.331	
diopside	-2.870	-3.889	
dolomite-dis	1.683	2.281	ssatd
enstatite	-2.359	-3.197	
epidote-ord	2.363	3.203	ssatd
epsomite	-5.340	-7.236	
faujasite-ca	0.441	0.598	ssatd
fayalite	-1.626	-2.204	
fe(oh)3(ppd)	-0.590	-0.800	
ferrite-ca	0.252	0.342	satd
ferrite-mg	0.828	1.123	ssatd
ferrosilite	-0.820	-1.111	
fluorite	0.818	1.108	ssatd
garronite	-0.238	-0.323	satd
gismondine	1.101	1.491	ssatd
gmelinite-na	-4.046	-5.483	
greenalite	1.492	2.022	ssatd
halite	-7.057	-9.563	
hematite	8.598	11.651	ssatd
heulandite-c	-0.520	-0.704	
hexahydrite	-5.591	-7.577	
hydromagnesi	-6.454	-8.746	
illite	1.590	2.155	ssatd
k-feldspar	0.421	0.570	ssatd
kalsilite	-2.304	-3.122	
kieserite	-7.100	-9.622	
lansfordite	-1.936	-2.624	
lawsonite	-0.370	-0.501	
levyne	0.447	0.606	ssatd
magnetite	9.183	12.445	ssatd
maximum micr	0.421	0.571	ssatd
mesolite	2.840	3.848	ssatd
mgf2(c)	-1.847	-2.503	
mn(oh)2(am)	-6.013	-8.148	

mnhpo4(c)	0.120	0.162	satd	monohydrocal	0.103	0.140	satd
montmor-ca	1.273	1.726	ssatd	montmor-mg	1.385	1.876	ssatd
montmor-na	0.857	1.161	ssatd	montmor-k	0.892	1.209	ssatd
mordenite-k	-0.523	-0.708		mordenite-na	-3.142	-4.258	
muscovite	3.532	4.787	ssatd	nahcolite	-5.013	-6.793	
natrolite	-3.617	-4.902		nepheline	-4.289	-5.812	
nesquehonite	-2.190	-2.967		nontronit-ca	9.743	13.203	ssatd
nontronit-k	9.291	12.591	ssatd	nontronit-mg	9.784	13.258	ssatd
nontronit-na	9.259	12.548	ssatd	paragonite	0.506	0.686	ssatd
pd-oxyannite	13.893	18.827	ssatd	pentahydrite	-5.925	-8.029	
phengite	1.695	2.297	ssatd	phillipsite-	1.007	1.365	ssatd
phillipsite-	-3.953	-5.357		phillipsite-	-5.736	-7.774	
phlogopite	2.389	3.237	ssatd	prehnite	-1.968	-2.667	
pseudowollas	-5.062	-6.859		pyrophyllite	-0.428	-0.580	
quartz	-0.236	-0.320	satd	rhodochrosit	-0.866	-1.173	
rhodonite	-4.677	-6.338		ripidolit-14	4.710	6.383	ssatd
ripidolit-7a	1.321	1.790	ssatd	sanidine hig	-0.791	-1.072	
saponite-ca	2.835	3.842	ssatd	saponite-h	1.616	2.191	ssatd
saponite-k	2.383	3.230	ssatd	saponite-mg	2.876	3.898	ssatd
saponite-na	2.352	3.187	ssatd	scolecite	1.606	2.177	ssatd
sepiolite	-2.910	-3.943		siderite	0.637	0.864	ssatd
sillimanite	-3.634	-4.925		smectite-hig	1.598	2.166	ssatd
smectite-low	1.358	1.841	ssatd	smectite-rey	6.759	9.159	ssatd
smithsonite	-1.191	-1.614		stilbite-ca	-0.526	-0.713	
stilbite-k	-3.829	-5.188		stilbite-na	-5.020	-6.803	
strengite	-3.742	-5.072		sylvite	-7.331	-9.934	
talc	1.609	2.181	ssatd	tenorite	-5.641	-7.644	
tremolite	-2.288	-3.101		tridymite	-0.404	-0.548	
vivianite	-0.346	-0.469	satd	wairakite	-4.762	-6.453	
whitlockite	5.314	7.201	ssatd	wollastonite	-4.664	-6.320	
wustite	-2.833	-3.840		yugawaralite	0.134	0.181	satd
zincite	-1.472	-1.995		zn3(po4)2.4h	-4.144	-5.616	
zoisite	-3.898	-5.282					

15 approx. saturated pure minerals
0 approx. saturated end-members of specified solid solutions
0 saturated end-members of hypothetical solid solutions

72 supersaturated pure minerals
0 supersatd. end-members of specified solid solutions
0 supersatd. hypothetical solid solution phases

----- summary of gases -----

gas	fugacity	log fugacity
ch4(g)	0.221978E-31	-31.65369
co2(g)	0.208240E-02	-2.68144
h2(g)	0.906970E-13	-13.04241
h2s(g)	0.138269E-30	-30.85928
n2(g)	0.100000E+35	87.76520
o2(g)	0.000000E+00	-57.69581
s2(g)	0.000000E+00	-61.47081
steam	0.277603E-01	-1.55658

```
----- end of output -----
----- pickup file successfully written -----

--- reading the input file ---

--- no further input found ---

         start time = 11:54:55  12-OCT89
           end time = 11:55:31  12-OCT89
-------------------------------------------------------------------------------
  9 completed  11
normal exit
```

```
data file master species= (o-phth)--
   switch with species=
   jflag=  0   csp=  0.00000E+00
data file master species= clo4-
   switch with species=
   jflag= -1   csp=  0.00000E+00
ndit.

--- the input file has been successfuly read ---

--- reading the data1 file ---

--- the data1 file has been successfully read ---
```

```
eeee   qqq   33333  n   n  rrrr
e     q   q      3  nn  n  r   r
eeee  q   q    33   n n n  rrrr
e     q q q      3  n  nn  r  r
eeee   qqq   3333   n   n  r   r
          q
```

```
eq3nr.3245R111
 supported by eqlib.3245R136

input file name= kerr1.3i revised=10/11/89     revisor= rg
Kerrville, Texas - ASR Project;  Charge No.: TEX24486.a1

Basic data for EQ3 modeling of Kerrville project received
from Dick Glanzman/DEN on October 10, 1989.

This is one of four scenarios.
   1)  Equilibrium for ASR groundwater at a pH of 8.2
   2)  Equilibrium for ASR groundwater at a pH of 7.3
   3)  Equilibrium for ASR Water Treatment Plant (WTP) recharge water
   4)  Equilibrium of a 50-50 mixture of one of the above ASR
       groundwaters and the WTP water.

                    second
This run is for the ~~first~~ scenario.
```

```
data file data0.3245R54
         1 atm steam saturation curve data
last modified 18feb88   (da0r)
```

nh4+	0.4889E-05	99.08
total		99.08

----- summary of aqueous redox reactions -----

couple		eh, volts	pe-	log fo2	ah, kcal
default		-0.100	-0.1702E+01	-61.296	-2.306
o2(aq)	/h2o	0.786	0.1337E+02	-1.009	18.118
h2(aq)	/h2o	-0.100	-0.1702E+01	-61.296	-2.306
fe+++	/fe++	-0.100	-0.1702E+01	-61.296	-2.306
hs-	/so4--	-0.100	-0.1702E+01	-61.296	-2.306
nh4+	/no3-	0.223	0.3790E+01	-39.330	5.136
no2-	/no3-	-0.100	-0.1702E+01	-61.296	-2.306

----- summary of aqueous non-equilibrium non-redox reactions -----

couple	affinity, kcal
none	

----- summary of stoichiometric mineral saturation states -----

(minerals with affinities .lt. -10 kcal are not listed)

mineral	log q/k	aff, kcal	state	mineral	log q/k	aff, kcal	state
albite	-1.705	-2.311		albite high	-3.037	-4.115	
albite low	-1.705	-2.311		alunite	-5.022	-6.805	
amesite-14a	-0.400	-0.542		amrph.silica	-1.527	-2.070	
analc-dehydr	-6.407	-8.682		analcime	-1.663	-2.254	
andalusite	-1.524	-2.065		anhydrite	-2.720	-3.686	
annite	-1.350	-1.829		anorthite	-4.830	-6.546	
aragonite	0.082	0.111	satd	artinite	-6.263	-8.487	
ashcroftite	-2.091	-2.833		bassanite	-3.351	-4.541	
beidellit-ca	2.562	3.472	ssatd	beidellit-k	2.110	2.859	ssatd
beidellit-mg	2.604	3.528	ssatd	beidellit-na	2.078	2.816	ssatd
berlinite	-5.033	-6.821		boehmite	0.049	0.066	satd
brewsterite-	-0.189	-0.256	satd	brucite	-4.885	-6.620	
cahpo4.2h2o	-3.509	-4.755		calcite	0.247	0.334	satd
casi2o5.2h2o	-6.988	-9.470		caso4.1/2h2o	-3.522	-4.773	
chabazite	0.431	0.584	ssatd	chalcedony	-0.499	-0.676	
chamosite-7a	0.262	0.355	satd	chrysotile	-5.268	-7.139	
clinochl-14a	-4.048	-5.486		clinoptil-ca	-2.399	-3.252	
clinoptil-k	-0.997	-1.351		clinoptil-mg	-6.517	-8.831	
clinoptil-na	-6.236	-8.451		clinozoisite	-4.805	-6.512	
corundum	-2.118	-2.870		cristobalite	-0.781	-1.058	
crist.beta.a	-1.225	-1.661		cronstedt.-7	1.982	2.686	ssatd
dachiardite-	-1.729	-2.343		daphnite-14a	0.368	0.498	satd
daphnite-7a	-3.023	-4.096		dawsonite	-0.068	-0.092	satd
diaspore	0.903	1.224	ssatd	diopside	-6.437	-8.723	
dolomite	1.547	2.097	ssatd	dolomite-dis	-0.012	-0.016	satd
dolomite-ord	1.547	2.097	ssatd	enstatite	-4.142	-5.613	

epidote	-1.908	-2.586		epidote-ord	-1.908	-2.586	
epistilbite	-0.189	-0.256	satd	epsomite	-4.997	-6.771	
erionite-ca	-0.880	-1.193		faujasite-ca	0.425	0.575	ssatd
faujasite-na	-4.090	-5.543		fayalite	-4.716	-6.391	
fe(oh)2(ppd)	-3.568	-4.835		fe(oh)3(ppd)	-3.041	-4.120	
feo(c)	-2.082	-2.821		ferrite-ca	-6.443	-8.731	
ferrite-mg	-5.865	-7.948		ferrite-zn	0.104	0.140	satd
ferrosilite	-2.360	-3.198		fluorapatite	14.610	19.799	ssatd
fluorite	-0.815	-1.105		garronite	-0.311	-0.422	satd
gibbsite	1.712	2.321	ssatd	gismondine	1.064	1.441	ssatd
gmelinite-ca	0.431	0.584	ssatd	gmelinite-na	-4.069	-5.514	
goethite	1.372	1.860	ssatd	greenalite	-3.138	-4.252	
gypsum	-2.527	-3.425		halite	-7.058	-9.565	
hedenbergite	-7.197	-9.753		hematite	3.697	5.010	ssatd
hercynite	-0.876	-1.188		heulandite-c	-0.505	-0.685	
heulandite-n	-5.005	-6.783		hexahydrite	-5.248	-7.112	
huntite	-2.522	-3.418		hydroxyapati	4.229	5.731	ssatd
illite	2.635	3.571	ssatd	jadeite	-3.104	-4.206	
k-feldspar	0.420	0.569	ssatd	kalicinite	-6.343	-8.595	
kalsilite	-2.325	-3.151		kaolinite	3.451	4.677	ssatd
kieserite	-6.757	-9.156		kyanite	-1.244	-1.686	
lansfordite	-2.783	-3.771		laumontite	-0.304	-0.412	satd
lawsonite	-0.407	-0.551		leonhardtite	-5.994	-8.123	
levyne	0.431	0.584	ssatd	magnesite	-0.340	-0.461	satd
magnetite	2.733	3.703	ssatd	margarite	-0.609	-0.825	
maximum micr	0.420	0.569	ssatd	melanterite	-6.733	-9.124	
mesolite	2.811	3.810	ssatd	mesolite-ss	-2.233	-3.026	
mgf2(c)	-3.479	-4.714		minnesotaite	-2.905	-3.937	
mn(oh)2(am)	-6.946	-9.412		mnhpo4(c)	-0.173	-0.234	satd
monohydrocal	-0.745	-1.009		montmor-ca	1.877	2.544	ssatd
montmor-mg	1.989	2.695	ssatd	montmor-na	1.460	1.978	ssatd
montmor-k	1.495	2.026	ssatd	mordenite-k	-0.503	-0.682	
mordenite-na	-3.123	-4.232		muscovite	5.268	7.139	ssatd
nahcolite	-4.967	-6.731		natrolite	-3.651	-4.947	
nepheline	-4.311	-5.842		nesquehonite	-3.036	-4.114	
nontronit-ca	4.871	6.600	ssatd	nontronit-k	4.418	5.987	ssatd
nontronit-mg	4.912	6.656	ssatd	nontronit-na	4.386	5.944	ssatd
paragonite	2.242	3.038	ssatd	pd-oxyannite	6.541	8.864	ssatd
pentahydrite	-5.582	-7.564		phengite	-0.089	-0.121	satd
phillipsite-	0.973	1.318	ssatd	phillipsite-	-3.998	-5.418	
phillipsite-	-5.781	-7.834		phlogopite	-2.991	-4.053	
prehnite	-3.789	-5.135		pseudowollas	-6.846	-9.277	
pyrophyllite	1.350	1.830	ssatd	quartz	-0.226	-0.306	satd
rhodochrosit	-0.852	-1.154		rhodonite	-5.599	-7.588	
ripidolit-14	-2.001	-2.712		ripidolit-7a	-5.391	-7.305	
sanidine hig	-0.792	-1.074		saponite-ca	-2.515	-3.409	
saponite-h	-3.438	-4.659		saponite-k	-2.968	-4.023	
saponite-mg	-2.474	-3.353		saponite-na	-3.000	-4.065	
scolecite	1.580	2.141	ssatd	siderite	0.034	0.046	satd
sillimanite	-1.887	-2.557		smectite-hig	-0.922	-1.250	
smectite-low	-0.324	-0.439	satd	smectite-rey	2.555	3.463	ssatd
smithsonite	-1.893	-2.565		stilbite-ca	-0.512	-0.694	
stilbite-k	-3.821	-5.177		stilbite-na	-5.012	-6.792	
strengite	-5.553	-7.525		sylvite	-7.332	-9.935	
talc	-3.729	-5.053		tridymite	-0.394	-0.534	
vivianite	-3.717	-5.037		wairakite	-4.778	-6.475	
whitlockite	1.210	1.639	ssatd	wollastonite	-6.448	-8.738	
wustite	-4.397	-5.958		yugawaralite	0.128	0.173	satd
zincite	-3.120	-4.228		zoisite	-4.850	-6.573	

```
   19 approx. saturated pure minerals
    0 approx. saturated end-members of specified solid solutions
    0 saturated end-members of hypothetical solid solutions


   40 supersaturated pure minerals
    0 supersatd. end-members of specified solid solutions
    0 supersatd. hypothetical solid solution phases



                  ----- summary of gases -----


      gas                   fugacity     log fugacity

  ch4(g)                0.311068E-23     -23.50714
  co2(g)                0.184124E-01      -1.73489
  h2(g)                 0.572260E-11     -11.24241
  h2s(g)                0.299976E-21     -21.52291
  n2(g)                 0.100000E+35      97.29711
  o2(g)                 0.000000E+00     -61.29581
  s2(g)                 0.000000E+00     -46.39808
  steam                 0.277603E-01      -1.55658

----- end of output -----
----- pickup file successfully written -----

--- reading the input file ---

--- no further input found ---

         start time = 11:52:46  12-OCT89
           end time = 11:53:09  12-OCT89
-------------------------------------------------------------------------------
  9 completed  11
normal exit
```

```
EQ3NR, version 3245R111

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Supported by EQLIB, version 3245R136

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Run  11:58:45  12-OCT89


--- reading the input file ---
input file name= kerr3.3i revised=10/11/89     revisor= rg
Kerrville, Texas - WTP Project;  Charge No.: TEX24486.a1

Basic data for EQ3 modeling of Kerrville project received
from Dick Glanzman/DEN on October 10, 1989.


This is one of four scenarios.
   1)  Equilibrium for ASR groundwater at a pH of 8.2
   2)  Equilibrium for ASR groundwater at a pH of 7.3
   3)  Equilibrium for ASR Water Treatment Plant (WTP) recharge water
   4)  Equilibrium of a 50-50 mixture of one of the above ASR
       groundwaters and the WTP water.


This run is for the third scenario.




endit.
      tempc=  0.25000E+02
        rho=  0.10000E+01    tdspkg=  0.00000E+00     tdspl=  0.00000E+00
        fep= -0.10000E+00    uredox=
      tolbt=  0.00000E+00     toldl=  0.00000E+00    tolsat=  0.00000E+00
    itermx=  0
                1    2    3    4    5    6    7    8    9   10
  iopt1-10=    -1    0    0    0    0    0    0    0    0    0
  iopg1-10=     0    0    0    0    0    0    0    0    0    0
  iopr1-10=     0    0    0    0    0    0    0    0    0    0
 iopr11-20=     0    0    0    0    0    0    0    0    0    0
  iodb1-10=     0    0    0    0    0    0    0    0    0    0
     uebal= none
    uacion= cl-
     nxmod=  0
data file master species= na+
   switch with species=
   jflag=  2   csp=  0.11000E+02
```

h2(aq)	/h2o	-0.100	-0.1690E+01	-59.465	-2.306
fe+++	/fe++	-0.100	-0.1690E+01	-59.465	-2.306
hs-	/so4--	-0.100	-0.1690E+01	-59.465	-2.306
nh4+	/no3-	0.203	0.3440E+01	-38.943	4.693
no2-	/no3-	-0.100	-0.1690E+01	-59.465	-2.306

----- summary of aqueous non-equilibrium non-redox reactions -----

couple affinity, kcal

none

----- summary of stoichiometric mineral saturation states -----

(minerals with affinities .lt. -10 kcal are not listed)

mineral	log q/k	aff, kcal	state	mineral	log q/k	aff, kcal	state
albite	-1.529	-2.087		albite high	-2.848	-3.886	
albite low	-1.529	-2.087		amesite-14a	0.371	0.506	ssatd
amrph.silica	-1.377	-1.879		analc-dehydr	-6.329	-8.635	
analcime	-1.621	-2.212		andalusite	-1.467	-2.002	
andradite	-5.763	-7.862		anhydrite	-3.198	-4.363	
annite	-2.377	-3.243		anorthite	-4.179	-5.702	
aragonite	-0.124	-0.169	satd	artinite	-6.164	-8.410	
ashcroftite	-2.312	-3.154		bassanite	-3.828	-5.223	
beidellit-ca	2.988	4.076	ssatd	beidellit-k	2.319	3.163	ssatd
beidellit-mg	3.019	4.119	ssatd	beidellit-na	2.370	3.234	ssatd
berlinite	-6.084	-8.300		boehmite	0.001	0.001	satd
brewsterite-	0.791	1.079	ssatd	brucite	-4.493	-6.129	
cahpo4.2h2o	-4.133	-5.639		calcite	0.041	0.056	satd
casi2o5.2h2o	-6.279	-8.566		caso4.1/2h2o	-3.997	-5.453	
chabazite	1.072	1.462	ssatd	chalcedony	-0.363	-0.495	satd
chamosite-7a	-0.338	-0.461	satd	chrysotile	-3.881	-5.295	
clinochl-14a	-1.895	-2.586		clinochl-7a	-5.269	-7.188	
clinoptil-ca	-0.724	-0.988		clinoptil-k	-0.632	-0.863	
clinoptil-mg	-4.865	-6.638		clinoptil-na	-5.338	-7.282	
clinozoisite	-3.655	-4.986		corundum	-2.190	-2.988	
cristobalite	-0.642	-0.876		crist.beta.a	-1.081	-1.475	
cronstedt.-7	1.504	2.052	ssatd	dachiardite-	1.399	1.908	ssatd
daphnite-14a	-0.918	-1.252		daphnite-7a	-4.291	-5.854	
dawsonite	-0.960	-1.309		diaspore	0.845	1.153	ssatd
diopside	-5.331	-7.272		dolomite	1.066	1.455	ssatd
dolomite-dis	-0.478	-0.652		dolomite-ord	1.066	1.455	ssatd
enstatite	-3.610	-4.925		epidote	-0.711	-0.970	
epidote-ord	-0.711	-0.970		epistilbite	0.791	1.079	ssatd
epsomite	-5.589	-7.624		erionite-ca	3.529	4.815	ssatd
faujasite-ca	1.066	1.454	ssatd	faujasite-na	-4.209	-5.742	
fayalite	-5.172	-7.056		fe(oh)2(ppd)	-3.867	-5.275	
fe(oh)3(ppd)	-3.012	-4.109		feo(c)	-2.376	-3.241	
ferrite-ca	-5.919	-8.075		ferrite-mg	-5.405	-7.374	
ferrite-zn	-0.692	-0.944		ferrosilite	-2.523	-3.442	
fluorapatite	13.153	17.945	ssatd	fluorite	-1.121	-1.529	
garronite	0.892	1.218	ssatd	gibbsite	1.637	2.233	ssatd
gismondine	1.365	1.863	ssatd	gmelinite-ca	1.072	1.462	ssatd
gmelinite-na	-4.188	-5.713		goethite	1.380	1.883	ssatd
greenalite	-3.809	-5.197		gypsum	-3.025	-4.127	

hedenbergite	-6.767	-9.232		hematite	3.719	5.073	ssatd
hercynite	-1.267	-1.728		heulandite-c	0.644	0.879	ssatd
heulandite-n	-4.615	-6.297		hexahydrite	-5.823	-7.944	
huntite	-3.503	-4.778		hydroxyapati	3.205	4.373	ssatd
illite	2.791	3.807	ssatd	jadeite	-3.063	-4.179	
k-feldspar	0.327	0.447	satd	kalsilite	-2.665	-3.635	
kaolinite	3.583	4.888	ssatd	kieserite	-7.277	-9.928	
kyanite	-1.192	-1.627		lansfordite	-3.099	-4.228	
laumontite	0.554	0.756	ssatd	lawsonite	0.175	0.239	satd
leonhardtite	-6.547	-8.933		levyne	1.072	1.462	ssatd
magnesite	-0.604	-0.823		magnetite	2.452	3.345	ssatd
margarite	-0.094	-0.128	satd	maximum micr	0.327	0.447	satd
mesolite	3.237	4.416	ssatd	mesolite-ss	-1.578	-2.153	
mgf2(c)	-3.822	-5.215		minnesotaite	-3.301	-4.503	
mnhpo4(c)	-2.313	-3.155		monohydrocal	-0.955	-1.303	
montmor-ca	2.503	3.414	ssatd	montmor-mg	2.604	3.552	ssatd
montmor-na	1.952	2.663	ssatd	montmor-k	1.904	2.597	ssatd
mordenite-k	-0.321	-0.438	satd	mordenite-na	-2.674	-3.648	
muscovite	5.040	6.876	ssatd	nahcolite	-5.772	-7.875	
natrolite	-3.722	-5.077		nepheline	-4.384	-5.981	
nesquehonite	-3.309	-4.514		nontronit-ca	5.412	7.384	ssatd
nontronit-k	4.743	6.471	ssatd	nontronit-mg	5.444	7.427	ssatd
nontronit-na	4.795	6.542	ssatd	paragonite	2.287	3.120	ssatd
pd-oxyannite	6.469	8.825	ssatd	pentahydrite	-6.161	-8.406	
phengite	0.313	0.427	satd	phillipsite-	1.764	2.407	ssatd
phillipsite-	-5.050	-6.890		phillipsite-	-6.129	-8.361	
phlogopite	-1.963	-2.678		prehnite	-2.614	-3.567	
pseudowollas	-6.237	-8.509		pyrophyllite	1.770	2.415	ssatd
quartz	-0.092	-0.125	satd	rhodochrosit	-2.577	-3.516	
rhodonite	-6.523	-8.899		ripidolit-14	-1.226	-1.672	
ripidolit-7a	-4.599	-6.274		sanidine hig	-0.872	-1.189	
saponite-ca	-0.860	-1.173		saponite-h	-1.847	-2.520	
saponite-k	-1.529	-2.086		saponite-mg	-0.828	-1.130	
saponite-na	-1.477	-2.015		scolecite	2.290	3.124	ssatd
siderite	-0.909	-1.240		sillimanite	-1.826	-2.492	
smectite-hig	-0.342	-0.467	satd	smectite-low	0.245	0.334	satd
smectite-rey	3.475	4.741	ssatd	smithsonite	-3.365	-4.591	
spinel	-7.249	-9.890		stilbite-ca	0.637	0.870	ssatd
stilbite-k	-3.901	-5.321		stilbite-na	-4.622	-6.306	
strengite	-6.560	-8.950		talc	-2.077	-2.834	
tridymite	-0.257	-0.351	satd	vivianite	-6.796	-9.272	
wairakite	-3.857	-5.262		whitlockite	0.400	0.545	ssatd
wollastonite	-5.844	-7.973		wustite	-4.623	-6.307	
yugawaralite	0.938	1.279	ssatd	zincite	-3.947	-5.385	
zoisite	-3.700	-5.047					

15 approx. saturated pure minerals
 0 approx. saturated end-members of specified solid solutions
 0 saturated end-members of hypothetical solid solutions

48 supersaturated pure minerals
 0 supersatd. end-members of specified solid solutions
 0 supersatd. hypothetical solid solution phases

----- summary of gases -----

```
      gas                     fugacity     log fugacity

   ch4(g)                  0.209994E-26     -26.67779
   co2(g)                  0.502736E-02      -2.29866
   h2(g)                   0.151657E-11     -11.81914
   h2s(g)                  0.106547E-24     -24.97246
   n2(g)                   0.100000E+35      93.88885
   o2(g)                   0.000000E+00     -59.46454
   s2(g)                   0.000000E+00     -51.94284
   steam                   0.313105E-01      -1.50431

----- end of output -----
----- pickup file successfully written -----

--- reading the input file ---

--- no further input found ---

          start time = 11:58:45   12-OCT89
            end time = 11:59:06   12-OCT89
-------------------------------------------------------------------------------
  9 completed  11
normal exit
```

```
EQ3NR, version 3245R111

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Run  09:40:05  19-OC89


--- reading the input file ---
input file name= kerr3.3i revised 10/11/89     revisor= rg
Kerrville, Texas - WTP Project;  Charge No.: TEX24486.a1

Basic data for EQ3 modeling of Kerrville project received
from Dick Glanzman/DEN on October 10, 1989.


This is one of four scenarios.
   1)  Equilibrium for ASR groundwater at a pH of 8.2
   2)  Equilibrium for ASR groundwater at a pH of 7.3
   3)  Equilibrium for ASR Water Treatment Plant (WTP) recharge water
   4)  Equilibrium of a 50-50 mixture of one of the above ASR
       groundwaters and the WTP water.


This run is for the third scenario.




endit.
      tempc=  0.25000E+02
        rho=  0.10002E+01    tdspkg=  0.00000E+00     tdspl=  0.00000E+00
        fep=  0.30000E+00    uredox=
      tolbt=  0.00000E+00     toldl=  0.00000E+00    tolsat=  0.00000E+00
    itermx=  0
                 1    2    3    4    5    6    7    8    9   10
  iopt1-10=     -1    0    0    0    0    0    0    0    0    0
  iopg1-10=      0    0    0    0    0    0    0    0    0    0
  iopr1-10=      0    0    0    0    0    0    0    0    0    0
 iopr11-20=      0    0    0    0    0    0    0    0    0    0
  iodb1-10=      0    0    0    0    0    0    0    0    0    0
     uebal= none
    uacion= cl-
     nxmod=  0
data file master species= na+
   switch with species=
   jflag=  2   csp=  0.11000E+02
```

fe+++	/fe++	0.300	0.5071E+01	-32.418	6.919
hs-	/so4--	0.300	0.5071E+01	-32.418	6.919
nh4+	/no3-	0.303	0.5130E+01	-32.183	6.999
no2-	/no3-	0.300	0.5071E+01	-32.418	6.919

----- summary of aqueous non-equilibrium non-redox reactions -----

couple	affinity, kcal
none	

----- summary of stoichiometric mineral saturation states -----

(minerals with affinities .lt. -10 kcal are not listed)

mineral	log q/k	aff, kcal	state	mineral	log q/k	aff, kcal	state
albite	-1.530	-2.087		albite high	-2.849	-3.886	
albite low	-1.530	-2.087		amesite-14a	0.371	0.506	ssatd
amrph.silica	-1.377	-1.879		analc-dehydr	-6.330	-8.635	
analcime	-1.622	-2.212		andalusite	-1.467	-2.002	
andradite	2.389	3.260	ssatd	anhydrite	-3.198	-4.363	
anorthite	-4.180	-5.703		aragonite	-0.124	-0.169	satd
artinite	-6.164	-8.410		ashcroftite	-2.313	-3.155	
bassanite	-3.828	-5.223		beidellit-ca	2.987	4.076	ssatd
beidellit-k	2.318	3.162	ssatd	beidellit-mg	3.019	4.118	ssatd
beidellit-na	2.370	3.233	ssatd	berlinite	-6.083	-8.299	
boehmite	0.001	0.001	satd	brewsterite-	0.790	1.078	ssatd
brucite	-4.493	-6.129		cahpo4.2h2o	-4.133	-5.639	
calcite	0.041	0.056	satd	casi2o5.2h2o	-6.279	-8.567	
caso4.1/2h2o	-3.997	-5.453		chabazite	1.071	1.461	ssatd
chalcedony	-0.363	-0.495	satd	chamosite-7a	-5.709	-7.789	
chrysotile	-3.882	-5.296		clinochl-14a	-1.896	-2.587	
clinochl-7a	-5.269	-7.189		clinoptil-ca	-0.725	-0.989	
clinoptil-k	-0.633	-0.864		clinoptil-mg	-4.866	-6.639	
clinoptil-na	-5.339	-7.284		clinozoisite	-3.655	-4.987	
corundum	-2.190	-2.988		cristobalite	-0.642	-0.876	
crist.beta.a	-1.081	-1.475		cronstedt.-7	4.286	5.847	ssatd
dachiardite-	1.396	1.905	ssatd	dawsonite	-0.960	-1.310	
diaspore	0.845	1.153	ssatd	diopside	-5.331	-7.273	
dolomite	1.066	1.454	ssatd	dolomite-dis	-0.479	-0.653	
dolomite-ord	1.066	1.454	ssatd	enstatite	-3.610	-4.925	
epidote	3.365	4.591	ssatd	epidote-ord	3.365	4.591	ssatd
epistilbite	0.790	1.078	ssatd	epsomite	-5.589	-7.624	
erionite-ca	3.526	4.810	ssatd	faujasite-ca	1.065	1.453	ssatd
faujasite-na	-4.209	-5.743		fe(oh)2(ppd)	-6.552	-8.939	
fe(oh)3(ppd)	1.065	1.453	ssatd	feo(c)	-5.061	-6.905	
ferrite-ca	2.234	3.047	ssatd	ferrite-mg	2.748	3.749	ssatd
ferrite-zn	7.461	10.179	ssatd	ferrosilite	-5.209	-7.106	
fluorapatite	13.154	17.946	ssatd	fluorite	-1.121	-1.530	
garronite	0.891	1.215	ssatd	gibbsite	1.637	2.233	ssatd
gismondine	1.365	1.862	ssatd	gmelinite-ca	1.071	1.461	ssatd
gmelinite-na	-4.189	-5.714		goethite	5.456	7.444	ssatd
gypsum	-3.025	-4.127		hematite	11.871	16.196	ssatd
hercynite	-3.952	-5.392		heulandite-c	0.643	0.878	ssatd
heulandite-n	-4.616	-6.298		hexahydrite	-5.823	-7.944	
huntite	-3.504	-4.780		hydroxyapati	3.206	4.374	

illite	2.790	3.806	ssatd	jadeite	-3.063	-4.179	
k-feldspar	0.327	0.446	satd	kalsilite	-2.665	-3.636	
kaolinite	3.583	4.888	ssatd	kieserite	-7.277	-9.928	
kyanite	-1.193	-1.627		lansfordite	-3.099	-4.228	
laumontite	0.554	0.755	ssatd	lawsonite	0.175	0.239	satd
leonhardtite	-6.547	-8.933		levyne	1.071	1.461	ssatd
magnesite	-0.604	-0.824		magnetite	7.919	10.804	ssatd
margarite	-0.094	-0.128	satd	maximum micr	0.327	0.446	satd
mesolite	3.236	4.415	ssatd	mesolite-ss	-1.580	-2.155	
mgf2(c)	-3.823	-5.215		mnhpo4(c)	-2.312	-3.154	
monohydrocal	-0.955	-1.304		montmor-ca	2.502	3.413	ssatd
montmor-mg	2.603	3.551	ssatd	montmor-na	1.951	2.662	ssatd
montmor k	1.903	2.596	ssatd	mordenite-k	-0.322	-0.439	satd
mordenite-na	-2.675	-3.649		muscovite	5.040	6.875	ssatd
nahcolite	-5.772	-7.875		natrolite	-3.722	-5.078	
nepheline	-4.384	-5.981		nesquehonite	-3.309	-4.515	
nontronit-ca	13.565	18.506	ssatd	nontronit-k	12.895	17.593	ssatd
nontronit-mg	13.596	18.549	ssatd	nontronit-na	12.947	17.664	ssatd
paragonite	2.286	3.119	ssatd	pd-oxyannite	18.697	25.509	ssatd
pentahydrite	-6.161	-8.406		phengite	0.312	0.426	satd
phillipsite-	1.764	2.406	ssatd	phillipsite-	-5.051	-6.891	
phillipsite-	-6.130	-8.363		phlogopite	-1.964	-2.679	
prehnite	-2.615	-3.567		pseudowollas	-6.237	-8.509	
pyrophyllite	1.770	2.415	ssatd	quartz	-0.092	-0.125	satd
rhodochrosit	-2.578	-3.517		rhodonite	-6.523	-8.899	
ripidolit-14	-6.597	-9.000		sanidine hig	-0.872	-1.190	
saponite-ca	-0.860	-1.174		saponite-h	-1.848	-2.521	
saponite-k	-1.530	-2.087		saponite-mg	-0.829	-1.131	
saponite-na	-1.478	-2.016		scolecite	2.289	3.123	ssatd
siderite	-3.595	-4.904		sillimanite	-1.827	-2.492	
smectite-hig	-0.870	-1.187		smectite-low	0.118	0.161	satd
smectite-rey	4.015	5.478	ssatd	smithsonite	-3.365	-4.591	
spinel	-7.249	-9.890		stilbite-ca	0.637	0.869	ssatd
stilbite-k	-3.901	-5.323		stilbite-na	-4.623	-6.307	
strengite	-2.483	-3.388		talc	-2.078	-2.834	
tridymite	-0.257	-0.351	satd	wairakite	-3.858	-5.263	
whitlockite	0.400	0.546	ssatd	wollastonite	-5.844	-7.973	
wustite	-6.449	-8.799		yugawaralite	0.937	1.279	ssatd
zincite	-3.947	-5.385		zoisite	-3.700	-5.048	

13 approx. saturated pure minerals
0 approx. saturated end-members of specified solid solutions
0 saturated end-members of hypothetical solid solutions

55 supersaturated pure minerals
0 supersatd. end-members of specified solid solutions
0 supersatd. hypothetical solid solution phases

----- summary of gases -----

gas	fugacity	log fugacity
ch4(g)	0.000000E+00	-80.77179
co2(g)	0.502497E-02	-2.29887

```
  h2(g)                    0.454375E-25    -25.34259
  h2s(g)                   0.000000E+00    -79.06627
  n2(g)                    0.100000E+35     53.31442
  o2(g)                    0.382253E-32    -32.41765
  s2(g)                    0.000000E+00   -133.08357
  steam                    0.313105E-01     -1.50431

----- end of output -----
----- pickup file successfully written -----

--- reading the input file ---

--- no further input found ---

         start time - 09:40:05  19-OCT-89
           end time - 09:40:30  19-OCT-89
------------------------------------------------------------------------------
  9 completed  01
normal exit
```

```
EQ3NR, version 3245R111

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Run  09:54:19  19-OC89


--- reading the input file ---
input file name- kerr4.3i revised-10/18/89     revisor- rg
Kerrville, Texas - ASR Project;  Charge No.: TEX24486.a1

Basic data for EQ3 modeling of Kerrville project received
from Dick Glanzman/DEN on October 10, 1989.


This is one of four scenarios.
   1)  Equilibrium for ASR groundwater at a pH of 8.2
   2)  Equilibrium for ASR groundwater at a pH of 7.3
   3)  Equilibrium for ASR Water Treatment Plant (WTP) recharge water
   4)  Equilibrium of a 50-50 mixture of one of the above ASR
       groundwaters and the WTP water (as an approximation av. value
       of asr and wtp used)

This run is for the fourth scenario.




endit.
      tempc-  0.24000E+02
        rho-  0.10004E+01    tdspkg-  0.00000E+00     tdspl-  0.00000E+00
        fep-  0.10000E+00    uredox-
      tolbt-  0.00000E+00     toldl-  0.00000E+00    tolsat-  0.00000E+00
    itermx-  0
                1    2    3    4    5    6    7    8    9   10
  iopt1-10-    -1    0    0    0    0    0    0    0    0    0
  iopg1-10-     0    0    0    0    0    0    0    0    0    0
  iopr1-10-     0    0    0    0    0    0    0    0    0    0
 iopr11-20-     0    0    0    0    0    0    0    0    0    0
  iodb1-10-     0    0    0    0    0    0    0    0    0    0
     uebal- none
    uacion- cl-
     nxmod-  0
data file master species- na+
   switch with species-
   jflag-  2   csp-  0.24000E+02
```

couple		eh, volts	pe-	log fo2	ah, kcal
default		0.100	0.1696E+01	-46.810	2.306
o2(aq)	/h2o	0.778	0.1319E+02	-0.839	17.933
h2(aq)	/h2o	0.100	0.1696E+01	-46.810	2.306
fe+++	/fe++	0.100	0.1696E+01	-46.810	2.306
hs-	/so4--	0.100	0.1696E+01	-46.810	2.306
nh4+	/no3-	0.263	0.4462E+01	-35.747	6.067
no2-	/no3-	0.100	0.1696E+01	-46.810	2.306

----- summary of aqueous non-equilibrium non-redox reactions -----

couple	affinity, kcal
none	

----- summary of stoichiometric mineral saturation states -----

(minerals with affinities .lt. -10 kcal are not listed)

mineral	log q/k	aff, kcal	state	mineral	log q/k	aff, kcal	state
albite	-1.491	-2.028		albite high	-2.817	-3.830	
albite low	-1.491	-2.028		alunite	-6.071	-8.255	
amesite-14a	0.130	0.177	satd	amrph.silica	-1.444	-1.963	
analc-dehydr	-6.250	-8.499		analcime	-1.525	-2.073	
andalusite	-1.434	-1.950		andradite	0.736	1.001	ssatd
anhydrite	-2.960	-4.024		annite	-0.928	-1.261	
anorthite	-4.408	-5.993		aragonite	0.029	0.040	satd
artinite	-6.107	-8.304		ashcroftite	-1.805	-2.454	
bassanite	-3.590	-4.881		beidellit-ca	2.872	3.905	ssatd
beidellit-k	2.355	3.202	ssatd	beidellit-mg	2.911	3.958	ssatd
beidellit-na	2.341	3.183	ssatd	berlinite	-5.449	-7.409	
boehmite	0.051	0.070	satd	brewsterite-	0.431	0.586	ssatd
brucite	-4.647	-6.319		cahpo4.2h2o	-3.711	-5.046	
calcite	0.194	0.264	satd	casi2o5.2h2o	-6.590	-8.960	
caso4.1/2h2o	-3.760	-5.112		chabazite	0.865	1.176	ssatd
chalcedony	-0.423	-0.575		chamosite-7a	0.515	0.700	ssatd
chrysotile	-4.433	-6.028		clinochl-14a	-2.686	-3.652	
clinochl-7a	-6.067	-8.249		clinoptil-ca	-1.399	-1.902	
clinoptil-k	-0.383	-0.521		clinoptil-mg	-5.513	-7.497	
clinoptil-na	-5.502	-7.482		clinozoisite	-4.071	-5.535	
corundum	-2.100	-2.856		cristobalite	-0.703	-0.956	
crist.beta.a	-1.145	-1.557		cronstedt.-7	9.518	12.942	ssatd
dachiardite-	0.193	0.263	satd	daphnite-14a	1.031	1.402	ssatd
daphnite-7a	-2.351	-3.197		dawsonite	-0.389	-0.530	
diaspore	0.901	1.225	ssatd	diopside	-5.798	-7.884	
dolomite	1.422	1.933	ssatd	dolomite-dis	-0.130	-0.176	satd
dolomite-ord	1.422	1.933	ssatd	enstatite	-3.826	-5.202	
epidote	2.461	3.346	ssatd	epidote-ord	2.461	3.346	ssatd
epistilbite	0.431	0.586	ssatd	epsomite	-5.279	-7.177	
erionite-ca	1.910	2.597	ssatd	faujasite-ca	0.858	1.167	ssatd
faujasite-na	-3.915	-5.323		fayalite	-4.445	-6.044	
fe(oh)2(ppd)	-3.472	-4.721		fe(oh)3(ppd)	0.612	0.832	ssatd
feo(c)	-1.983	-2.697		ferrite-ca	1.122	1.526	ssatd
ferrite-mg	1.682	2.288	ssatd	ferrite-zn	7.500	10.198	ssatd

ferrosilite	-2.188	-2.975		fluorapatite	14.264	19.394	ssatd
fluorite	-0.944	-1.283		garronite	0.674	0.917	ssatd
gibbsite	1.701	2.313	ssatd	gismondine	1.311	1.783	ssatd
gmelinite-ca	0.865	1.176	ssatd	gmelinite-na	-3.894	-5.294	
goethite	5.014	6.818	ssatd	greenalite	-2.720	-3.699	
gypsum	-2.777	-3.775		hedenbergite	-6.693	-9.100	
hematite	10.984	14.935	ssatd	hercynite	-0.773	-1.051	
heulandite-c	0.208	0.283	satd	heulandite-n	-4.550	-6.187	
hexahydrite	-5.521	-7.508		huntite	-2.768	-3.763	
hydroxyapati	4.100	5.575	ssatd	illite	2.902	3.946	ssatd
jadeite	-2.966	-4.033		k-feldspar	0.573	0.779	ssatd
kalicinite	-6.682	-9.085		kalsilite	-2.312	-3.144	
kaolinite	3.587	4.877	ssatd	kieserite	-7.003	-9.522	
kyanite	-1.157	-1.573		lansfordite	-2.876	-3.911	
laumontite	0.239	0.325	satd	lawsonite	-0.019	-0.025	satd
leonhardtite	-6.257	-8.507		levyne	0.865	1.176	ssatd
magnesite	-0.407	-0.554		magnetite	10.114	13.752	ssatd
margarite	-0.201	-0.273	satd	maximum micr	0.573	0.779	ssatd
melanterite	-7.145	-9.715		mesolite	3.170	4.311	ssatd
mesolite-ss	-1.469	-1.998		mgf2(c)	-3.612	-4.911	
minnesotaite	-2.333	-3.172		mn(oh)2(am)	-6.845	-9.307	
mnhpo4(c)	-0.530	-0.721		monohydrocal	-0.800	-1.087	
montmor-ca	2.286	3.108	ssatd	montmor-mg	2.394	3.255	ssatd
montmor-na	1.822	2.477	ssatd	montmor-k	1.839	2.501	ssatd
mordenite-k	-0.196	-0.267	satd	mordenite-na	-2.756	-3.748	
muscovite	5.407	7.351	ssatd	nahcolite	-5.272	-7.168	
natrolite	-3.459	-4.704		nepheline	-4.238	-5.763	
nesquehonite	-3.108	-4.226		nontronit-ca	12.461	16.943	ssatd
nontronit-k	11.944	16.240	ssatd	nontronit-mg	12.499	16.996	ssatd
nontronit-na	11.930	16.221	ssatd	paragonite	2.443	3.322	ssatd
pd-oxyannite	17.618	23.955	ssatd	pentahydrite	-5.857	-7.964	
phengite	0.361	0.491	satd	phillipsite-	1.530	2.080	ssatd
phillipsite-	-3.959	-5.384		phillipsite-	-5.611	-7.630	
phlogopite	-2.153	-2.928		prehnite	-3.069	-4.173	
pseudowollas	-6.506	-8.846		pyrophyllite	1.647	2.239	ssatd
quartz	-0.151	-0.205	satd	rhodochrosit	-1.062	-1.444	
rhodonite	-5.423	-7.374		ripidolit-14	-0.919	-1.250	
ripidolit-7a	-4.301	-5.848		sanidine hig	-0.633	-0.860	
saponite-ca	-1.519	-2.066		saponite-h	-2.479	-3.371	
saponite-k	-2.036	-2.769		saponite-mg	-1.480	-2.013	
saponite-na	-2.050	-2.788		scolecite	2.040	2.774	ssatd
siderite	-0.169	-0.230	satd	sillimanite	-1.795	-2.441	
smectite-hig	0.366	0.497	satd	smectite-low	0.757	1.029	ssatd
smectite-rey	4.532	6.162	ssatd	smithsonite	-2.087	-2.838	
spinel	-7.322	-9.956		stilbite-ca	0.201	0.274	satd
stilbite-k	-3.454	-4.696		stilbite-na	-4.557	-6.197	
strengite	-2.336	-3.176		talc	-2.745	-3.732	
tridymite	-0.317	-0.431	satd	vivianite	-4.355	-5.921	
wairakite	-4.204	-5.716		whitlockite	1.051	1.429	ssatd
wollastonite	-6.110	-8.308		wustite	-3.918	-5.327	
yugawaralite	0.654	0.890	ssatd	zincite	-3.015	-4.100	
zoisite	-4.116	-5.596					

17 approx. saturated pure minerals
 0 approx. saturated end-members of specified solid solutions
 0 saturated end-members of hypothetical solid solutions

55 supersaturated pure minerals

```
     0 supersatd. end-members of specified solid solutions
     0 supersatd. hypothetical solid solution phases


                    ----- summary of gases -----

       gas                    fugacity    log fugacity

   ch4(g)                  0.000000E+00     -52.20749
   co2(g)                  0.101511E-01      -1.99348
   h2(g)                   0.483926E-18     -18.31522
   h2s(g)                  0.000000E+00     -50.41362
   n2(g)                   0.100000E+35      75.23532
   o2(g)                   0.000000E+00     -46.81012
   s2(g)                   0.000000E+00     -89.93310
   steam                   0.294888E-01      -1.53034

----- end of output -----
----- pickup file successfully written -----

--- reading the input file ---

--- no further input found ---

          start time - 09:54:19  19-OCT89
            end time - 09:54:46  19-OCT89
------------------------------------------------------------------------------
  9 completed  01
normal exit
```