4 Corners
Coal

Exhibit 1

Data From a Study of Produced Water Disposal at Ten Gas Wells in San Juan County, New Mexico

An Exhibit for the April 9, 1992, New Mexico Oil Conservation Commission Hearing on Case Number 10436

Revised

April 8, 1992

Prepared for:

The Four Corners Gas Producers Association

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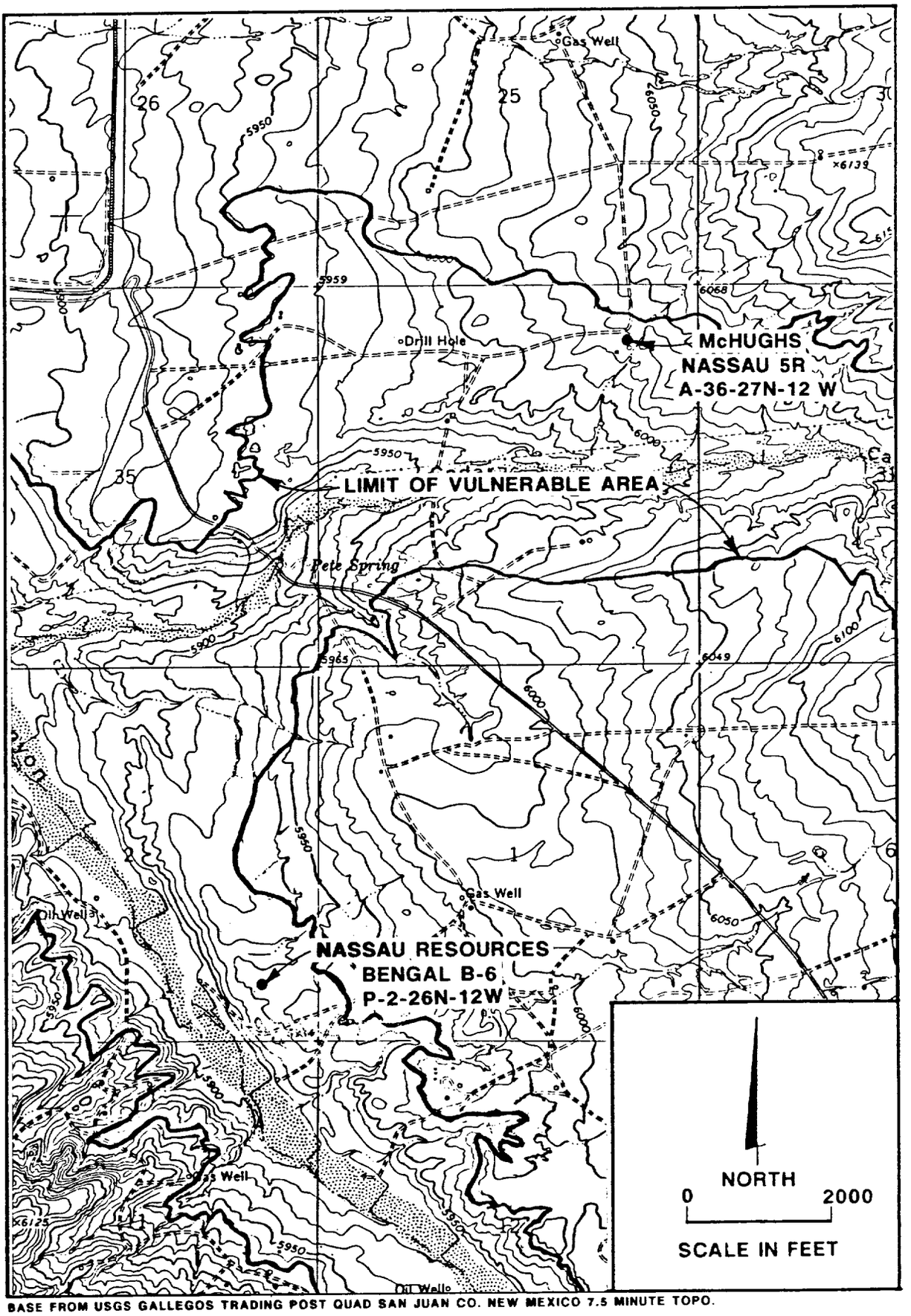
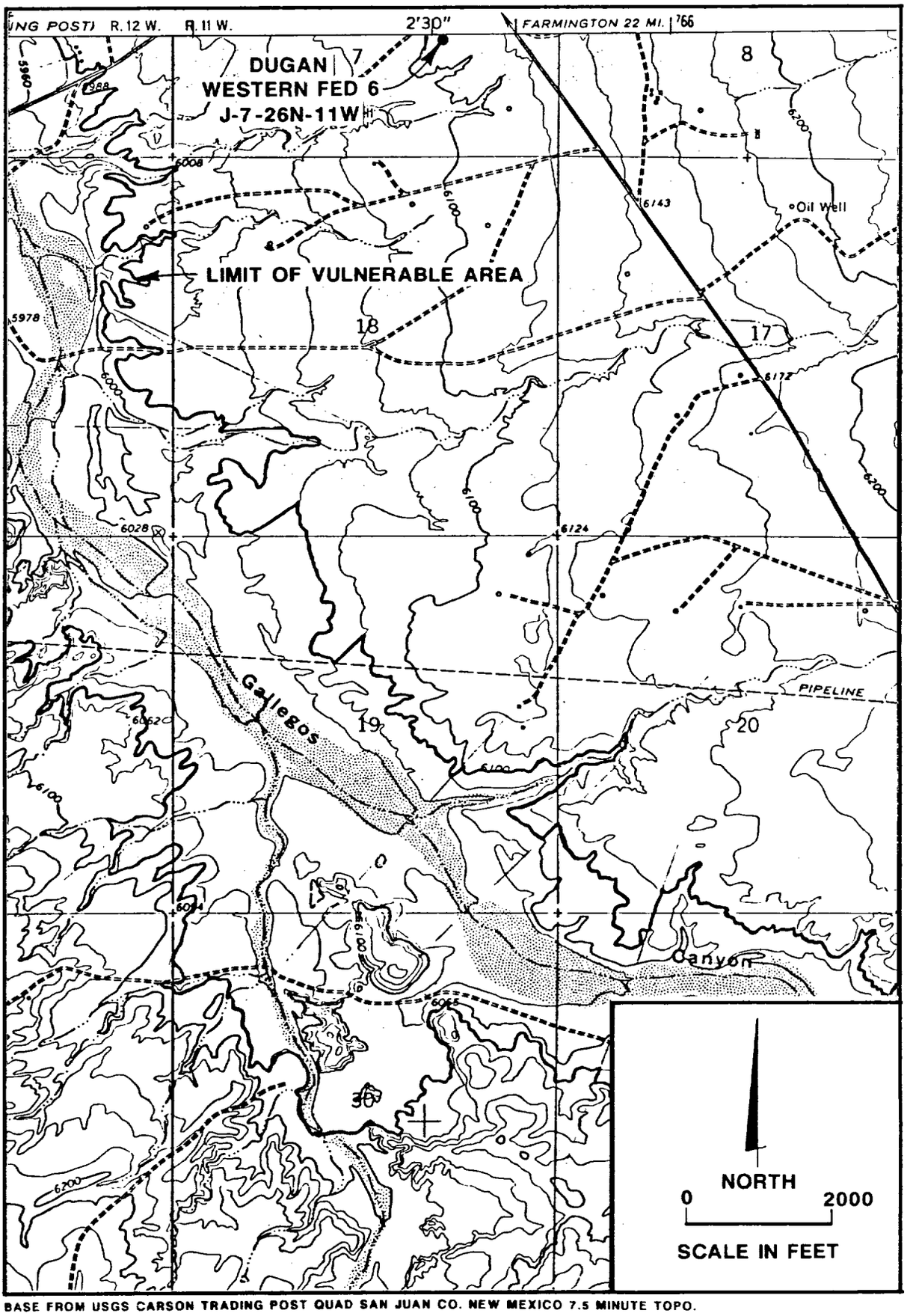
Section 1.0

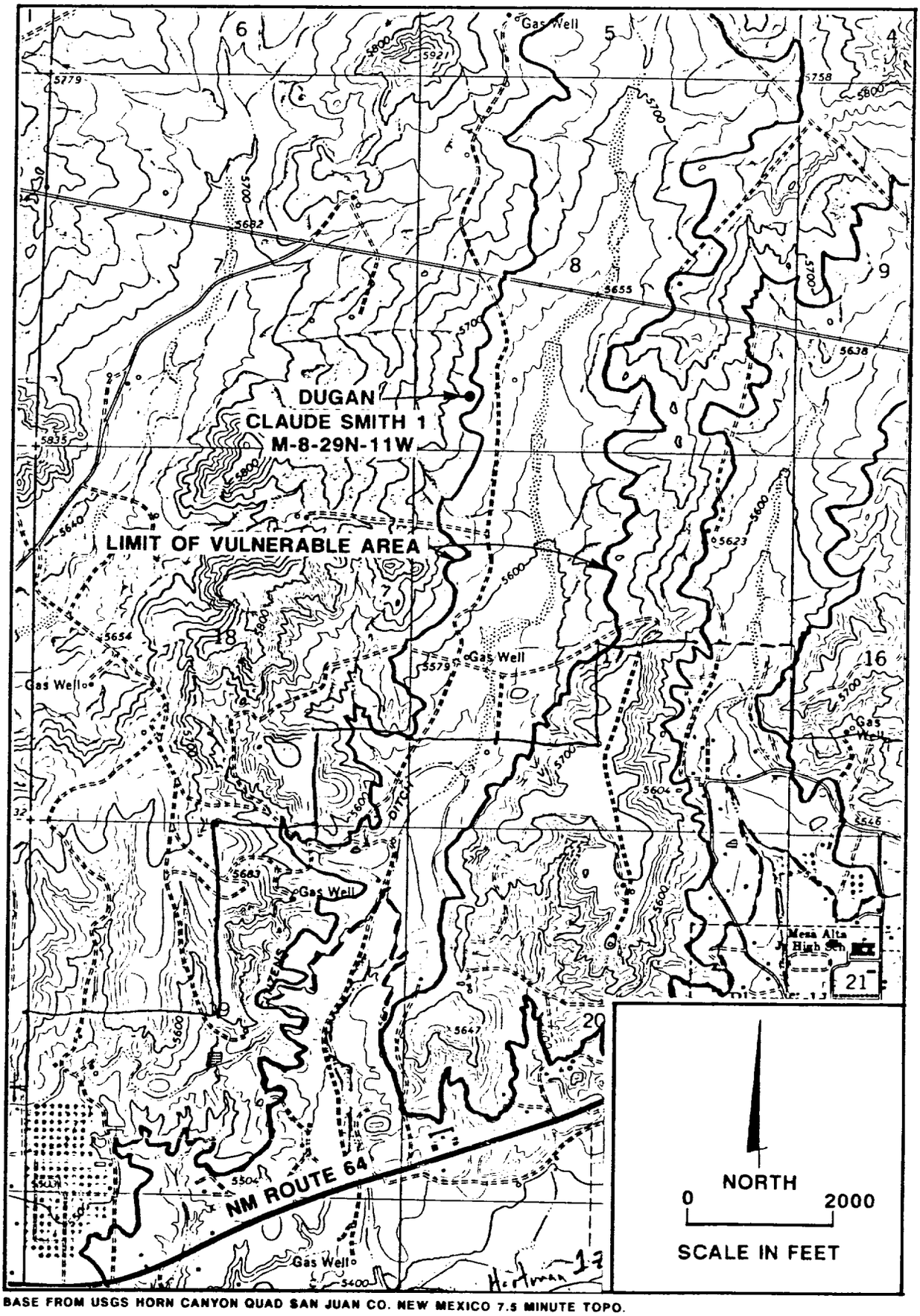
Maps Showing Locations of Well Sites Sampled in this Study



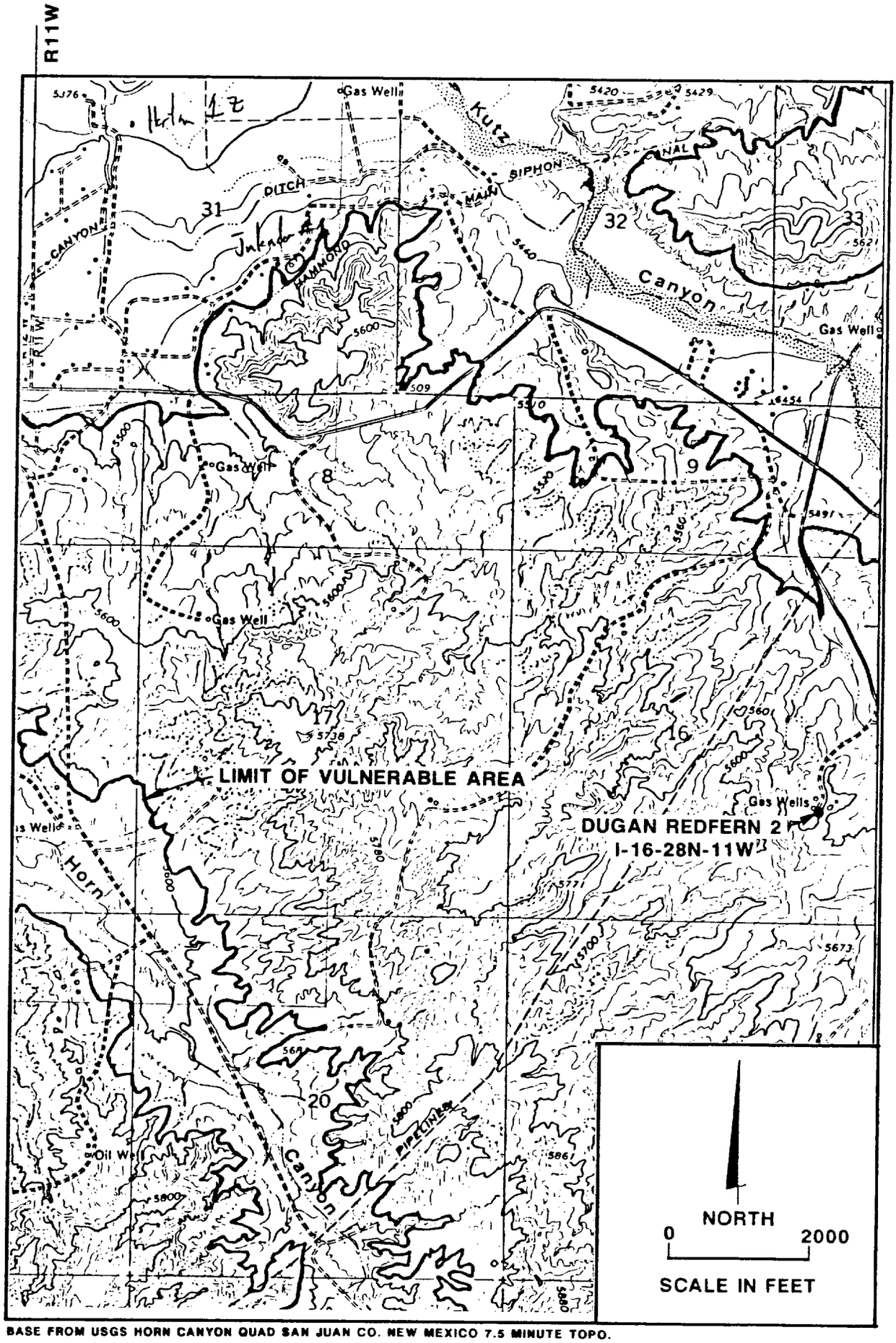
BASE FROM USGS GALLEGOS TRADING POST QUAD SAN JUAN CO. NEW MEXICO 7.5 MINUTE TOPO.



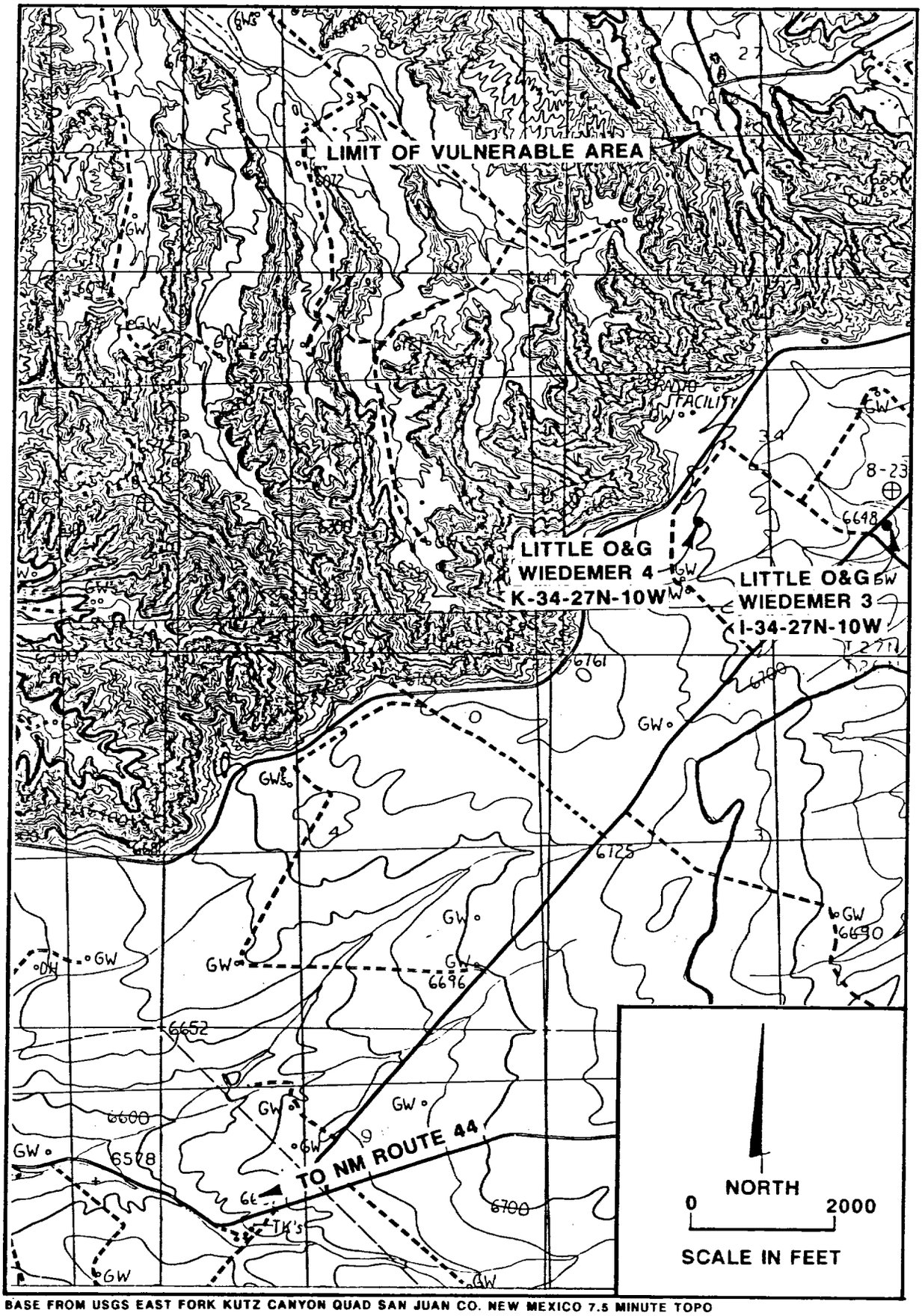
BASE FROM USGS CARSON TRADING POST QUAD SAN JUAN CO. NEW MEXICO 7.5 MINUTE TOPO.



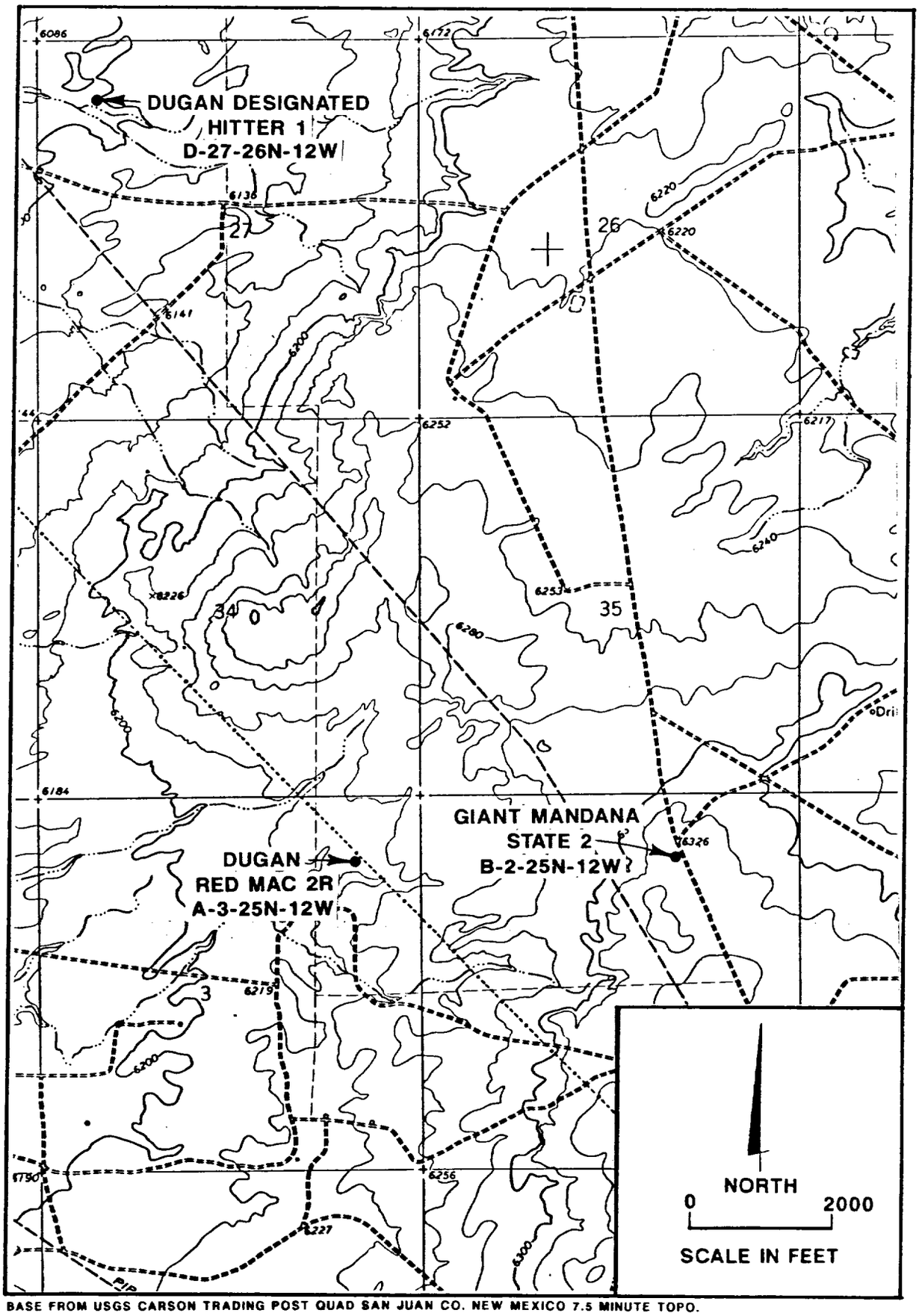
BASE FROM USGS HORN CANYON QUAD SAN JUAN CO. NEW MEXICO 7.5 MINUTE TOPO.



BASE FROM USGS HORN CANYON QUAD SAN JUAN CO. NEW MEXICO 7.5 MINUTE TOPO.



BASE FROM USGS EAST FORK KUTZ CANYON QUAD SAN JUAN CO. NEW MEXICO 7.5 MINUTE TOPO



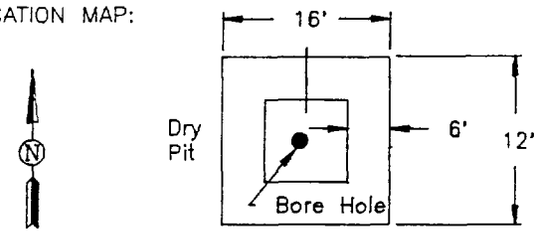
BASE FROM USGS CARSON TRADING POST QUAD SAN JUAN CO. NEW MEXICO 7.5 MINUTE TOPO.

Section 2.0

Lithologic Logs of Soil Borings Used to Obtain Soil Samples

Nassau 5R Lithologic Log

LOCATION MAP:



Not To Scale

___1/4 ___1/4 ___1/4 ___1/4 S 36 T 27N R 12W

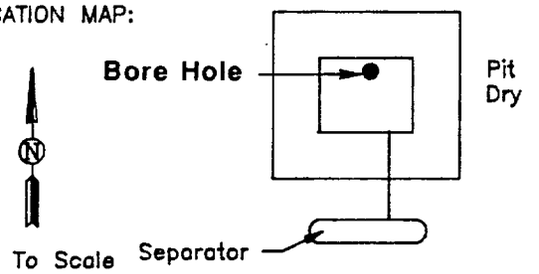
SITE ID: McHughs LOCATION ID: Nassau 5R
SITE COORDINATES (ft.):
N ____ E ____
GROUND ELEVATION (ft. MSL):
STATE: N.M. COUNTY: San Juan
DRILLING METHOD: Hand Auger
DRILLING CONTR.:
DATE STARTED: 3-4-92 DATE COMPLETED: 3-4-92
FIELD REP.: M. Mohorcich
COMMENTS: Dry Pit, Moist Soil, * HNU Not Working Properly

LOCATION DESCRIPTION: NAPI, Off Hammond County Rd. 5510

DEPTH (ft.)	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
					1.6'	2.2'	HNU=175ppm*			0-1.9' Clayey Sand: moderate yellowish brown 10 YR 5/4 very moist, moderately plastic.
										1.9-2.5' Sand: light olive gray 5 Y 5/2, medium to coarse grain moist, unconsolidated.
5					4.9'	5.2'	HNU=125ppm*			2.5-5.6' Sand: dusky yellow 5 Y 6/4, primarily medium grain, fine to coarse. Semi consolidated, slow drilling at 3.5. 3.5-5.6' moderate to consolidated, cemented.
					4.9'	5.6'	9203040915			
										5.6' T.D. 5.6' sandstone.
10										
15										
20										
25										
30										

Bengal B#6 Lithologic Log

LOCATION MAP:



__1/4 __1/4 __1/4 __1/4 S 2 T 26N R 12W

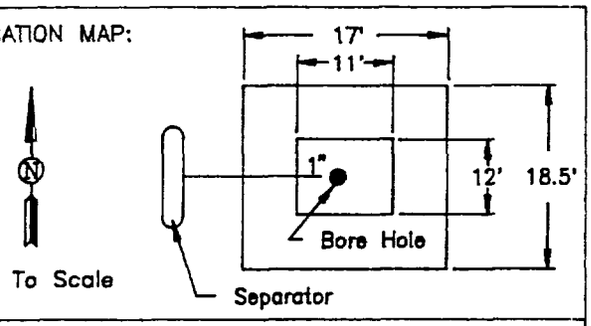
SITE ID: Jerome P. McHugh LOCATION ID: Bengal B#6
SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL):
STATE: N.M. COUNTY: San Juan
DRILLING METHOD: Hand Auger
DRILLING CONTR.:
DATE STARTED: 3-4-92 DATE COMPLETED: 3-4-92
FIELD REP.: M. Mohorcich
COMMENTS: Sampled Gallegos Wash For TOS

LOCATION DESCRIPTION: NAPI Off Hammond County Road 5510

DEPTH (ft.)	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
				1.8'	2.5'		HNU=27ppm			0–1' Sand: dusky yellow 5 Y 6/4, very fine to fine grain, unconsolidated.
										2–3.7' Clayey Sand: dark yellowish brown 10 YR 4/2, semi consolidated, moist.
5				5.1'	5.5'		HNU=13ppm			3.7–4.9' Sandy Clay: pale yellowish brown 10 Yr 6/2. 60–40 fine grain sand with laminations, moderately plastic.
				5.2'	5.5'		9203041022			4.9–5.67' Sand: pale yellowish brown 10 YR 6/2 saturated at 5.2'. Fine to medium grain moderate to well sorted, unconsolidated.
10										5.67' T.D. 5.67' due to hole slough below water table.
15										
20										
25										
30										

Western Federal #6

LOCATION MAP:



Not To Scale

___1/4 ___1/4 ___1/4 ___1/4 S 7 T 26N R 11W

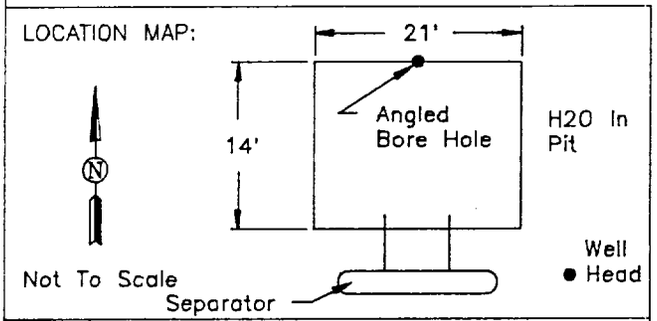
SITE ID: Dugan LOCATION ID: Western Federal #6
SITE COORDINATES (ft.):
N ____ E ____
GROUND ELEVATION (ft. MSL):
STATE: N.M. COUNTY: San Juan
DRILLING METHOD: Hand Auger
DRILLING CONTR.:
DATE STARTED: 3-4-92 DATE COMPLETED: 3-4-92
FIELD REP.: M. Mohorcich
COMMENTS: Pit Bottom Is Approx. 2' Below Grade. T.D. 20.1'. No Visible Stain Or Odor. Very Small Separator, Little H20 Discharge, Low Producer Of A Well. * HNU Not Reading Properly

LOCATION DESCRIPTION:

DEPTH (ft.)	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
					2.1'	2.7'	HNU=10ppm*			0–2.4' Sand: dark yellowish brown fine to medium, moderately sorted, unconsolidated.
						4.8'	HNU=10ppm*			2.4–3.2' Sand: moderate yellowish brown fine to medium, unconsolidated, moderate sorting.
5					4.9'	5.2'	9203041126			3.2–3.8' Silty Sand: moderate yellowish brown 10 YR 5/4, moist, very fine to fine grain 70% silt well sorted.
										3.8–4.9' Sand: moderate yellowish brown 10 YR 5/4 to grayish orange, 10 YR 7/4 fine to medium grain well sorted, unconsolidated.
10					9.9'	10.1'	HNU=8ppm*			4.9–6.0' Silty Sand: moderate yellowish brown 10 YR 5/4, very fine and fine sand approximately 70% with 30% silt. White clay smears from 5 to approximately 5.5', unconsolidated.
15					15.1'	15.6'	HNU=8ppm*			6.0–9.5' Sand: moderate yellowish brown to 10 YR 7/4, fine to medium grain, unconsolidated.
						19.8'	HNU <4ppm*			9.5–10.5' Gravel Sand: as above with appearance of 1/4" subrounded gravel.
20					19.8'	20.1'	9203041237			10.5–11.0' Silty Sand: as from 4.9–6' with white clay smears.
										11.0–21.1' Sand: moderate yellowish brn 10 YR 5/4 to grayish orange 10 YR 7/4. Fine to medium, moderate to well sorted, unconsolidated.
25										20.1' T.D. 20.1'.
30										

Claude-Smith #1 Lithologic Log

LOCATION MAP:



___1/4 ___1/4 ___1/4 ___1/4 S 8 T 29N R 11W

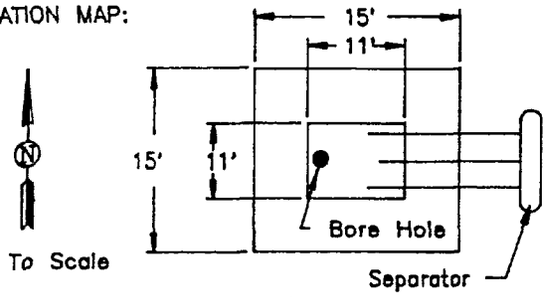
SITE ID: Dugan LOCATION ID: Claude-Smith #1
SITE COORDINATES (ft.):
N E
GROUND ELEVATION (ft. MSL):
STATE: N.M. COUNTY: San Juan
DRILLING METHOD: Hand Auger
DRILLING CONTR.:
DATE STARTED: 3-5-92 DATE COMPLETED: 3-5-92
FIELD REP.: M. Mohorcich
COMMENTS: H20 In Pit, Angle Hole To Get Under Pit

LOCATION DESCRIPTION: Dirt County Road 5117, Road East Of Salmon Ruins, North Of 64

DEPTH (ft.)	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
						2'	HNU=170ppm			0-6' Sand: black, strong HC stain and odor from start of hole to 3.5', very moist, fine grain 3.5-5 sand is mottled gray and black clearing, decrease in HC stain. 5-6' pale yellowish brown 10 YR 6/2 very fine to fine grain, well sorted, semi to moderately consolidated, cemented.
					4.2'	4.6'	HNU=300ppm			
					4.8'	5.1'	9203051542			
5					5.9'	6.0'	9203051617			
										6.0' T.D. at 6.0' auger refusal.
10										
15										
20										
25										
30										

Red Fern #2 Lithologic Log

LOCATION MAP:



___1/4 ___1/4 ___1/4 ___1/4 S 16 T 28N R 11W

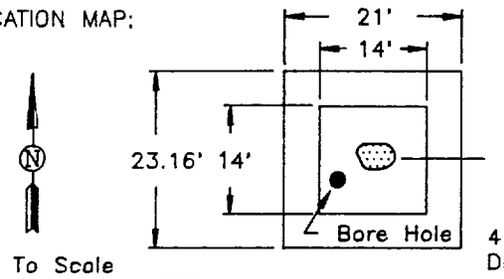
SITE ID: Dugan LOCATION ID: Redfern #2
SITE COORDINATES (ft.):
N ____ E ____
GROUND ELEVATION (ft. MSL):
STATE: N.M. COUNTY: San Juan
DRILLING METHOD: Hand Auger
DRILLING CONTR.:
DATE STARTED: 3-6-92 DATE COMPLETED: 3-6-92
FIELD REP.: M. Mohorcich
COMMENTS: Pit Muddy

LOCATION DESCRIPTION: Off County Rd. 5500, 1st Right East Of Thriftway Refinery

DEPTH (ft.)	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
						1.0'	HNU=1ppm			0–0.8' Mud:
						1.5'	9203060810			0.8–1.5' Sand: pale yellowish brown 10 YR 6/2 to dusky yellow 5 Y 6/4. Consolidated, cemented fine to medium grain sand with some clay.
5										1.5' T.D. at 1.5' auger refusal.
10										
15										
20										
25										
30										

Wiedemer #4 Lithologic Log

LOCATION MAP:



SITE ID: Curtis J. Little LOCATION ID: Wiedemer #4
SITE COORDINATES (ft.):
N E
GROUND ELEVATION (ft. MSL):
STATE: N.M. COUNTY: San Juan
DRILLING METHOD:
DRILLING CONTR.:
DATE STARTED: DATE COMPLETED:
FIELD REP.:
COMMENTS: H2O Standing In Pit, T.D. 3.6' In Possible Cement

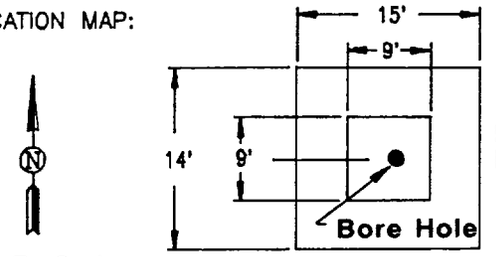
__1/4 __1/4 __1/4 __1/4 S 34 T 27N R 10W

LOCATION DESCRIPTION: Angel Peak Area, County Road 7175

DEPTH (ft.)	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
										0–3.0' Silty Sand: muddy, dark yellowish brown 10 YR 4/2, very fine grain sand and 20–30% silt, unconsolidated.
						3.6'	9203061045			3.0–3.6' Silty Sand: olive gray 5 Y 4/1, very fine grain sand and silt, very consolidated, possibly cement?
5						3.6'	HNU=0ppm			3.6' T.D. hole at 3.6'.
10										
15										
20										
25										
30										

Wiedemer #3 Lithologic Log

LOCATION MAP:



Not To Scale

1850' FSL 790' FEL

__1/4 __1/4 __1/4 __1/4 S 34 T 27N R 10W

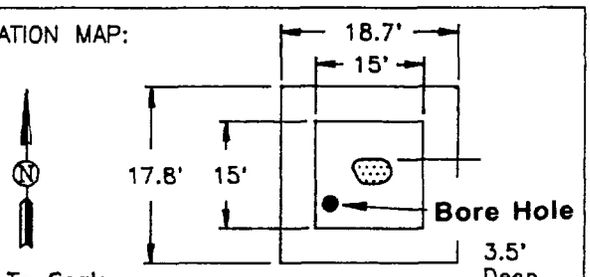
SITE ID: Curtis J. Little LOCATION ID: Wiedemer #3
SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): 6644 G.L.
STATE: N.M. COUNTY: San Juan
DRILLING METHOD: Hand Auger
DRILLING CONTR.:
DATE STARTED: 3-6-92 DATE COMPLETED: 3-6-92
FIELD REP.: M. Mohorcich
COMMENTS: Dry Pit. P&A With Bentonite, Cuttings, Sand.

LOCATION DESCRIPTION: Angel Peak Area, County Rd. 7175

DEPTH (ft.)	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
					1.8'	2.3'	HNU=0ppm			0–8.25' Silty Sand: moderate brown 5 Yr 3/4, moist very fine to fine grain sand with approximately 20% silt, well sorted, unconsolidated. 3.8–8.25 moderate brown 5 YR 4/4.
5					5.0'	5.35'	9203061145			
					5.35'	5.6'	HNU=0ppm			8.25–20.45' Sand: 8.25–9 dark yellowish orange 10 YR 6/6, fine to medium grain, unconsolidated, well sorted. At 9.2 rust pervasive, 10–19' light olive gray 5 Y 5/2 to dusky yellow 5 Y 6/4.
10					9.8'	10.25'	HNU=0ppm			
15					14.7'	14.95'	HNU=0ppm			
					19.75'	20.25'	9203061330			
20					20.25'	20.40'	HNU=0ppm			20.25' T.D. 20.25'.
25										
30										

Designated Hitter #1 Lithologic Log

LOCATION MAP:



___1/4 ___1/4 ___1/4 ___1/4 S 27 T 26N R 12W

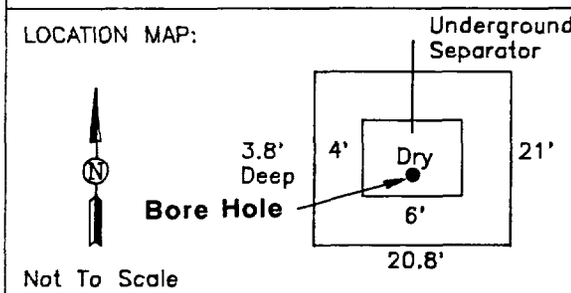
SITE ID: Dugan LOCATION ID: Designated Hitter #1
SITE COORDINATES (ft.):
N E
GROUND ELEVATION (ft. MSL):
STATE: N.M. COUNTY: San Juan
DRILLING METHOD: Hand Auger
DRILLING CONTR.:
DATE STARTED: 3-6-92 DATE COMPLETED: 3-6-92
FIELD REP.: M. Mohorcich
COMMENTS: H20 In Pit, Drainage To West Running N/S.

LOCATION DESCRIPTION:

DEPTH (ft.)	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
					1.6'	2.3'	HNU=0ppm			0-7.5' Sand: moderate yellowish brown 10 YR 5/4, well sorted, fine to medium grain sand, unconsolidated moist.
5					4.9'	5.3'	9203061447			7.5-8.0' Clayey Sand: dark yellowish brown 10 YR 4/2, semi to moderate clay consolidated, approximately 70% very fine grain sand with moderately plastic clay in matrix. Water saturation below 8'.
					5.3'	5.6'	HNU=0ppm			
										8.0-14.9' Sand: moderate yellowish brown 10 YR 5/4, saturated, very fine grain sands, well sorted.
10					10'		9203061520			
					10'		HNU=0ppm			
15										14.9' T.D. at 14.9' due to sloughing of saturated borehole and very compacted clay lens.
20										
25										
30										

Redmac #2R Lithologic Log

LOCATION MAP:



Not To Scale

910' FNL 910' FEL

__1/4 __1/4 __1/4 __1/4 S 3 T 25N R 12W

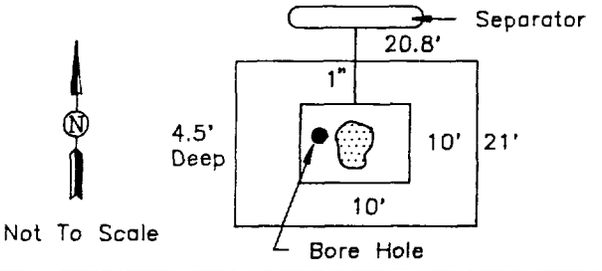
SITE ID: Dugan LOCATION ID: **Red Mac #2R**
SITE COORDINATES (ft.):
N E
GROUND ELEVATION (ft. MSL):
STATE: N.M. COUNTY: San Juan
DRILLING METHOD: Hand Auger
DRILLING CONTR.:
DATE STARTED: 3-7-92 DATE COMPLETED: 3-7-92
FIELD REP.: M. Mohorcich
COMMENTS: Dry Pit, 3.8' Deep, P&A With Ben Powder, Cuttings Surface Runoff To West With Irrigated Field To East

LOCATION DESCRIPTION:

DEPTH (ft.)	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
					1.9'	2.5'	HNU=0ppm			0–14.9' Sand: moderate yellowish brown 10 YR 5/4 to moderate brown 5 YR 4/4 very fine grain sand, well sorted, unconsolidated, moist.
5					5.1'	5.5'	9203071110			
					5.5'	5.7'	HNU=0ppm			
10					10.0'	10.4'	HNU=0ppm			
					14.9'	15.4'	HNU=0ppm			14.9–19' Clayey Sand: pale brown 5 YR 5/2, dusky yellow 5 Y 6/4 and light olive gray 5 Y 5/2, laminated clayey approximately (30%) in very fine grain sands, moderately plastic, well sorted, semi consolidated.
15										
					19.7'	19.9'	9203071230			19–19.9' Clayey Silt: dark yellowish brown 10 YR 4/2 to brownish gray 5 YR 4/1. Moderately consolidated, very slightly plastic (10%) clay.
					19.9'		HNU=.2ppm			
20										19.9' T.D. at 19.9'.
25										
30										

Mandana #2 Lithologic Log

LOCATION MAP:



___1/4 ___1/4 ___1/4 ___1/4 S 26 T 25N R 12W

SITE ID: Giant LOCATION ID: Mandana #2
SITE COORDINATES (ft.):
N E
GROUND ELEVATION (ft. MSL):
STATE: N.M. COUNTY: San Juan
DRILLING METHOD: Hand Auger
DRILLING CONTR.:
DATE STARTED: 3-7-92 DATE COMPLETED: 3-7-92
FIELD REP.: M. Mohorcich
COMMENTS: H2O in Pit, Pit Approx. 4.5' Deep, 10' x 10' P&A, Ben Powder, Cuttings, Sand

LOCATION DESCRIPTION:

DEPTH (ft.)	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
					1.7'	2'	HNU=0ppm			0-7.3' Sand: moderate yellowish brown 10 YR 5/4, moist very fine grain at top of hole and well sorted, unconsolidated. 5-7' medium to coarse grain, moderately sorted, moderately consolidated.
5					5.0'	5.5'	9203071340			
					5.7'	6.0'	HNU=NA			7.3' T.D. at 7.3' in a gravel zone, auger refusal.
					7.3'		9203071415			
10										
15										
20										
25										
30										

Section 3.0

Chemical Analyses of Soils

Chemical Data of Soils at
Dry Gas Well Water Disposal Pits

Well Name	BBLS/Day Water	Sample Number	Depth of Sample Below Base of Pit	Benzene ug/kg	Toluene ug/kg	Ethylbenzene ug/kg	Total Xylenes ug/kg	TPH mg/kg	Method	
Nassau #5R	TSTM		1.6- 2.2'					175 ppm(1)	PID	
Nassau #5R		9203040915	4.9- 5.2'	ND	ND	ND	ND	125 ppm(1) ND	PID LAB	(2)
Bengal B #6	TSTM		1.8- 2.7'					27 ppm(1)	PID	
Bengal B #6		9203041022	5.2- 5.5'	ND	ND	ND	55.1	13 ppm(1) ND	PID LAB	(2)
Western Federal #6	TSTM		2.1- 2.7'					10 ppm(1)	PID	
Western Federal #6		9203041126	4.9- 5.3'	ND	20.1	ND	58.5	10 ppm(1) ND	PID LAB	(2)
Western Federal #6			9.9-10.1'					8 ppm(1)	PID	
Western Federal #6			15.1-15.6'					8 ppm(1)	PID	
Western Federal #6		9203041237	19.8-20.1'	ND	22.5	ND	59.1	4 ppm(1) ND	PID LAB	(2)
Claude-Smith #1	0.5		2'					170 ppm	PID	
Claude-Smith #1			4.2- 4.6'					300 ppm	PID	(1)
Claude-Smith #1		9203051542	4.8- 5.1'	ND	ND	970	4,523	NA 220	PID LAB	(3)
Claude-Smith #1		9203051617	5.9- 6.0'	ND	ND	98	2,232	NA 164	PID LAB	(3)

Chemical Data of Soils at
Dry Gas Well Water Disposal Pits (cont'd)

Well Name	BBLS/Day Water	Sample Number	Depth of Sample Below Base of Pit	Benzene ug/kg	Toluene ug/kg	Ethylbenzene ug/kg	Total Xylenes ug/kg	TPH mg/kg	Method	
Red Fern #2	0.5		1.5'					1 ppm	PID	
Red Fern #2		9203060817	1.5'	ND	ND	11.0	94.9	1.6	LAB	(3)
Weidemer #4	TSTM		2'					0	PID	
Weidemer #4		9203061050	3.6'	ND	25.8	ND	76.4	3.7	LAB	(3)
Weidemer #3			1.8- 2.3'					0	PID	
Weidemer #3		9203061145	5.0- 5.3'	ND	ND	ND	66.5	ND	LAB	(3)
Weidemer #3			5.3- 5.6'					0	PID	
Weidemer #3			9.8-10.3'					0	PID	
Weidemer #3			14.7-14.9'					0	PID	
Weidemer #3		9203061330	19.7-20.2'	ND	ND	ND	47.3	ND	LAB	(4)
Weidemer #3			20.2-20.4'					0	PID	

Chemical Data of Soils at
Dry Gas Well Water Disposal Pits (cont'd)

Well Name	BBLS/Day Water	Sample Number	Depth of Sample Below Base of Pit	Benzene ug/kg	Toluene ug/kg	Ethylbenzene ug/kg	Total Xylenes ug/kg	TPH mg/kg	Method	
Designated Hitter #1	TSTM		1.6- 2.3'					0	PID	
Designated Hitter #1		9203061447	4.9- 5.3'	ND	33.9	23.1	193.5	1 ppm 4.6	PID LAB	(3)
Designated Hitter #1		9203061530	14.9'	ND	28.8	17.2	151.9	2.9	LAB	(3)
RedMac #2	1.0		1.9- 2.5'					0	PID	
RedMac #2		9203071110	5.0- 5.4'	ND	20.8	ND	58.5	ND	LAB	(4)
RedMac #2			5.5- 5.7'					0	PID	
RedMac #2			10.0-10.4'					0	PID	
RedMac #2			14.9-15.4'					0	PID	
RedMac #2		9203071230	19.7-19.9	ND	ND	ND	49.1	ND	LAB	(4)
RedMac #2			19.9'					0 ppm	PID	

Chemical Data of Soils at
Dry Gas Well Water Disposal Pits (cont'd)

Well Name	BBLS/Day Water	Sample Number	Depth of Sample Below Base of Pit	Benzene ug/kg	Toluene ug/kg	Ethylbenzene ug/kg	Total Xylenes ug/kg	TPH mg/kg	Method	
Mandana #2	TSTM		1.9- 2.1'					0	PID	
Mandana #2		9203071340	5.0- 5.7'	ND	ND	ND	52.9	ND	LAB	(4)
Mandana #2			5.7- 6.0'					0	PID	
Mandana #2		9203071415	7.3'	ND	ND	ND	56.9	ND	LAB	(4)

(1) PID not functioning properly.

Detection Limits:

(2) B = 20 ug/kg
T = 20 ug/kg
E = 20 ug/kg
PMX = 55 ug/kg
OX = 20 ug/kg
TPH = 1.2 mg/kg

(3) B = 10 ug/kg
T = 25 ug/kg
E = 10 ug/kg
PMX = 50 ug/kg
OX = 15 ug/kg
TPH = 1.3 mg/kg

(4) B = 10 ug/kg
T = 20 ug/kg
E = 10 ug/kg
PMX = 32 ug/kg
OX = 10 ug/kg
TPH = 1.3 mg/kg

TSTM = Too small to measure.
ND = Not detected.
PID = Photo Ionization Detector.
NA = Not analyzed.

Exh. 2

OUTLINE OF THE PRESENTATION

- A DISCUSSION OF PREVIOUS FIELD WORK AT PRODUCED WATER SITES

- A STUDY OF SOIL CONTAMINATION AT 10 "DRY GAS" WELL PRODUCED WATER DISPOSAL SITES

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PREVIOUS FIELD WORK

- 1985 HEARING DATA
- OPEN FILE REPORT 89-9 (1987)
- TENNECO GROUNDWATER STUDIES (1988-89)

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PREVIOUS FIELD WORK (cont'd)

- AMOCO GALLEGOS CANYON UNIT 153E (1987)
- MOBIL THOMAS #1 (1990)
- PIT CLOSURE DATA FROM VARIOUS OPERATORS (1990-91)

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1985 HEARING

- DOCUMENTED CONTAMINATION AT PRODUCED WATER SITES
- NATURAL REMEDIATION OF SITES
- FIELD STUDIES OF THREE SITES SHOWED LIMITED CONTAMINATION LIMITED TO THE AREA OF THE WELL PAD

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1985 HEARING (cont'd)

- AQUIFER SIMULATION MODELS OF VARIOUS "TYPES" OF WELL SITES PREDICTED LIMITED CONTAMINATION

- CONCLUDED THAT MORE STUDY WAS REQUIRED

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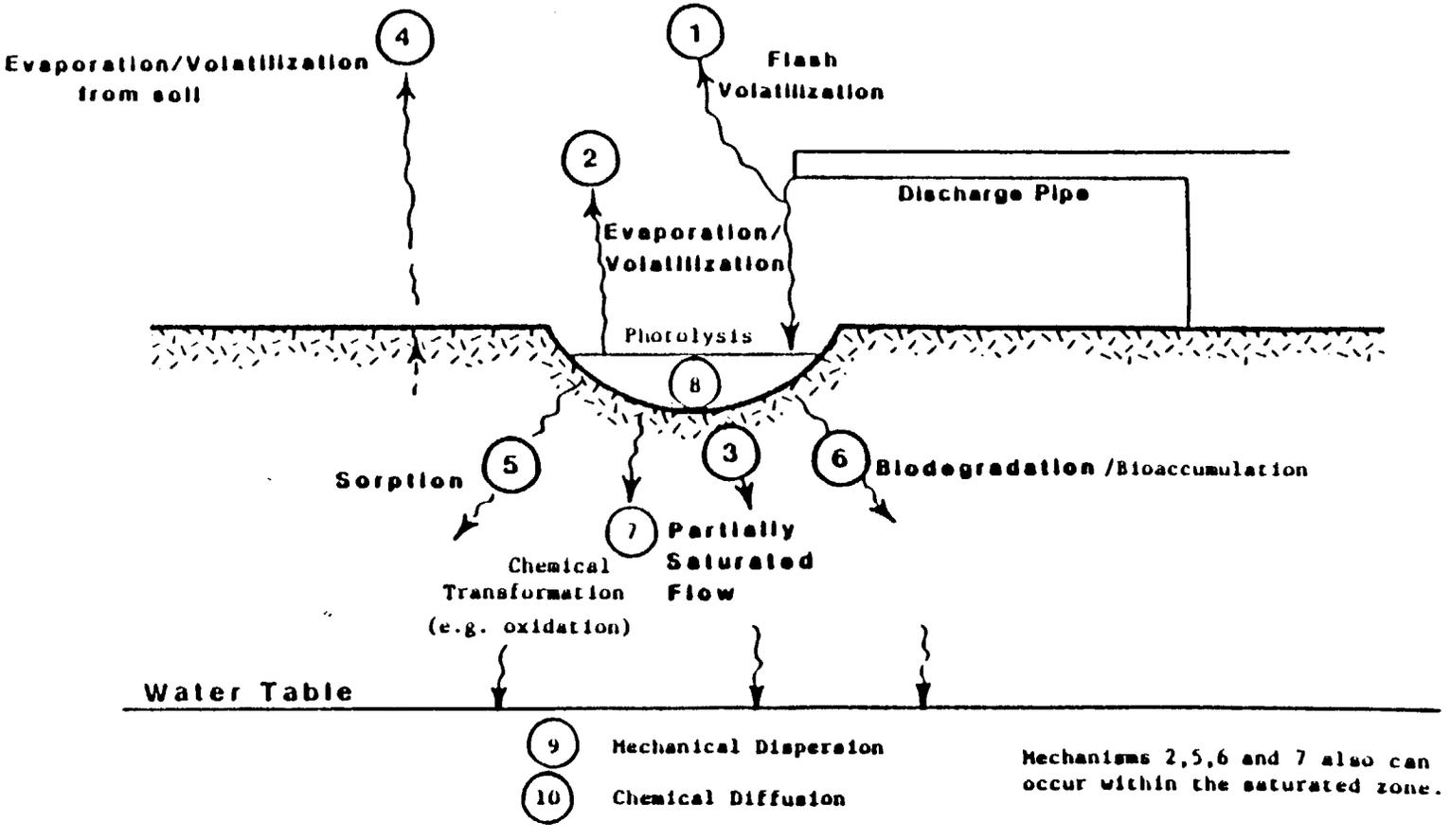

Figure 4 - Potential Attenuation Mechanisms of Volatile Organics (McQuillan, 1986).

OPEN FILE REPORT 89-9

- HYDROCARBONS IN GROUND WATER WERE OBSERVED AT NINE SITES

- LIMITS OF CONTAMINATION WERE NOT DEFINED

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OPEN FILE REPORT 89-9 (cont'd)

- SOPHISTICATION OF THE STUDY WAS LIMITED BY RESOURCES

- THIS REPORT IS THE BASIS FOR THE APPLICATION BY NMOCD TO EXPAND THE VULNERABLE AREA AND TO ELIMINATE SMALL VOLUME DISCHARGES

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GROUND-WATER STUDIES BY INDUSTRY

- STANDARD METHODS WERE GENERALLY EMPLOYED

- CONTAMINATION WAS LIMITED TO THE AREA OF THE WELL PAD AT FOUR OF FIVE SITES

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GROUND-WATER STUDIES BY INDUSTRY

- LESS THAN 35 FEET TO GROUND WATER
- CONCLUDED THAT CONTAMINATION BEYOND THE WELL PAD ONLY WHERE FREE-PHASE HYDROCARBONS WERE OBSERVED

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PIT CLOSURE AND DISCHARGE ELIMINATION DATA

- SOME DATA ARE NOT PUBLICLY AVAILABLE
- SOIL CONTAMINATION WAS LIMITED TO 35 FEET DEPTH OR LESS

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PIT CLOSURE AND DISCHARGE ELIMINATION DATA (cont'd)

- CONDUCTED ON MANY TYPES OF WELLS AT DIFFERENT LOCATIONS

- CONCLUDED THAT NATURAL PROCESS MAY ELIMINATE THREAT TO GROUND WATER

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A STUDY OF SOIL CONTAMINATION AT 10 "DRY GAS" WELL PRODUCED WATER DISPOSAL SITES

. DEFINITION OF "DRY GAS" WELLS

. OBJECTIVES OF THE STUDY

. METHODS OF INVESTIGATION

. RESULTS

. CONCLUSIONS

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DEFINITION OF "DRY GAS" WELLS

- GAS TO OIL RATIO IS GREATER THAN 100,000 (MCFD/BD)
- LIQUID HYDROCARBONS ARE NOT RECOVERED AT THE WELL
- LESS THAN 1 BARREL OF WATER IS DISCHARGED PER DAY

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OBJECTIVES OF THE STUDY

- DETERMINE DEPTH OF HYDROCARBONS IN SOILS AT DRY GAS WELL SITES
- DETERMINE TYPE OF HYDROCARBONS OBSERVED IN SOILS

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OBJECTIVES OF THE STUDY (cont'd)

. TEST THE NMOCD HYPOTHESIS:

THE DISCHARGE TO UNLINED PITS OF LOW VOLUMES OF WATER PRODUCED FROM GAS WELLS REPRESENTS A THREAT TO HUMAN HEALTH AND THE ENVIRONMENT WITHIN THE PROPOSED VULNERABLE AREA

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METHODS OF INVESTIGATION

10 SITES WERE SELECTED BASED UPON THE FOLLOWING CRITERIA:

- FIT DEFINITION OF "DRY GAS" WELL
- PRODUCED WATER WAS CURRENTLY DISCHARGED TO UNLINED PITS
- SURFACE SOIL/GEOLOGY ARE REPRESENTATIVE OF THE PROPOSED VULNERABLE AREAS

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METHODS OF INVESTIGATION

10 SITES WERE SELECTED BASED UPON THE FOLLOWING CRITERIA: (cont'd)

- DIFFERENT FORMATIONS WHICH FIT DEFINITION
- RELATIVELY CLOSE TO FARMINGTON WITH REASONABLE ACCESS
- DIFFERENT OPERATORS

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METHODS OF INVESTIGATION

- COLLECT SOIL SAMPLES IN CENTER OF PIT OR AT EDGE OF SATURATED SOILS
- USE HAND AUGER TO PENETRATE TO SELECTED SAMPLE INTERVAL
- USE SLIDE HAMMER SOIL SAMPLER TO COLLECT SAMPLE IN BRASS SLEEVE

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METHODS OF INVESTIGATION (cont'd)

- COLLECT SAMPLES AT 2 FEET, 5 FEET, 10 FEET, 15 FEET OR TO AUGER REFUSAL

- EVALUATE SAMPLES IN THE FIELD FOR TOTAL VOLATILE HYDROCARBONS USING HEADSPACE METHOD AND PHOTO IONIZATION DETECTOR

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METHODS OF INVESTIGATION (cont'd)

- SEND DEEPEST SAMPLE TO INTERMOUNTAIN ANALYTICAL LABORATORIES FOR EPA METHOD ANALYSIS

- LOG BOREHOLE/CONSTRUCT SITE MAP/SEAL BORING

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METHODS OF INVESTIGATION (cont'd)

- 34 SAMPLES WERE EVALUATED
- 16 SAMPLES WERE ANALYZED BY THE LABORATORY

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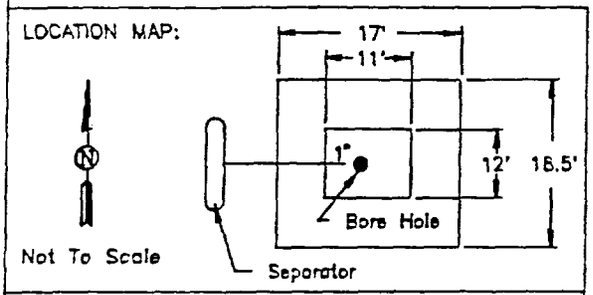
Western Federal #8

LOCATION MAP:



___1/4 ___1/4 ___1/4 ___1/4 S 7 T 26N R 11W

SITE ID: Dugan LOCATION ID: Western Federal #6
SITE COORDINATES (ft.):
N E
GROUND ELEVATION (ft. MSL):
STATE: N.M. COUNTY: San Juan
DRILLING METHOD: Hand Auger
DRILLING CONTR.:
DATE STARTED: 3-4-92 DATE COMPLETED: 3-4-92
FIELD REP.: M. Mohorcich
COMMENTS: Pit Bottom Is Approx. 2' Below Grade. T.D. 20.1'. No Visible Stain Or Odor. Very Small Separator. Little H2O Discharge, Low Producer Of A Well. * HNU Not Reading Properly

LOCATION DESCRIPTION:

DEPTH (ft.)	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
					2.1'	2.7'	HNU=10ppm*			0-2.4' Sand: dark yellowish brown fine to medium, moderately sorted, unconsolidated.
						4.8'	HNU=10ppm*			2.4-3.2' Sand: moderate yellowish brown fine to medium, unconsolidated, moderate sorting.
5					4.9'	5.2'	9203041126			3.2-3.8' Silty Sand: moderate yellowish brown 10 YR 5/4, moist, very fine to fine grain 70% silt well sorted.
										3.8-4.9' Sand: moderate yellowish brown 10 YR 5/4 to grayish orange, 10 YR 7/4 fine to medium grain well sorted, unconsolidated.
10					9.9'	10.1'	HNU=8ppm*			4.9-6.0' Silty Sand: moderate yellowish brown 10 YR 5/4, very fine and fine sand approximately 70% with 30% silt. White clay smears from 5 to approximately 5.5', unconsolidated.
15					15.1'	15.6'	HNU=8ppm*			6.0-9.5' Sand: moderate yellowish brown to 10 YR 7/4, fine to medium grain, unconsolidated.
						19.8'	HNU <4ppm*			9.5-10.5' Gravel Sand: as above with appearance of 1/4" subrounded gravel.
20					19.8'	20.1'	9203041237			10.5-11.0' Silty Sand: as from 4.9-6' with white clay smears.
										11.0-21.1' Sand: moderate yellowish brn 10 YR 5/4 to grayish orange 10 YR 7/4. Fine to medium, moderate to well sorted, unconsolidated.
25										20.1' T.D. 20.1'.
30										

Chemical Data of Soils at
Dry Gas Well Water Disposal Pits

Well Name	BBLS/Day Water	Sample Number	Depth of Sample Below Base of Pit	Benzene ug/kg	Toluene ug/kg	Ethylbenzene ug/kg	Total Xylenes ug/kg	TPH mg/kg	Method	
Nassau #5R	TSTM		1.6- 2.2'					175 ppm(1)	PID	
Nassau #5R		9203040915	4.9- 5.2'	ND	ND	ND	ND	125 ppm(1) ND	PID LAB	(2)
Bengal B #6	TSTM		1.8- 2.7'					27 ppm(1)	PID	
Bengal B #6		9203041022	5.2- 5.5'	ND	ND	ND	55.1	13 ppm(1) ND	PID LAB	(2)
Western Federal #6	TSTM		2.1- 2.7'					10 ppm(1)	PID	
Western Federal #6		9203041126	4.9- 5.3'	ND	20.1	ND	58.5	10 ppm(1) ND	PID LAB	(2)
Western Federal #6			9.9-10.1'					8 ppm(1)	PID	
Western Federal #6			15.1-15.6'					8 ppm(1)	PID	
Western Federal #6		9203041237	19.8-20.1'	ND	22.5	ND	59.1	4 ppm(1) ND	PID LAB	(2)
Claude-Smith #1	0.5		2'					170 ppm	PID	
Claude-Smith #1			4.2- 4.6'					300 ppm	PID	(1)
Claude-Smith #1		9203051542	4.8- 5.1'	ND	ND	970	4,523	NA 220	PID LAB	(3)
Claude-Smith #1		9203051617	5.9- 6.0'	ND	ND	98	2,232	NA 164	PID LAB	(3)

Chemical Data of Soils at
Dry Gas Well Water Disposal Pits (cont'd)

Well Name	BBLS/Day Water	Sample Number	Depth of Sample Below Base of Pit	Benzene ug/kg	Toluene ug/kg	Ethylbenzene ug/kg	Total Xylenes ug/kg	TPH mg/kg	Method	
Red Fern #2	0.5		1.5'					1 ppm	PID	
Red Fern #2		9203060817	1.5'	ND	ND	11.0	94.9	1.6	LAB	(3)
Weidemer #4	TSTM		2'					0	PID	
Weidemer #4		9203061050	3.6'	ND	25.8	ND	76.4	3.7	LAB	(3)
Weidemer #3	TSTM		1.8- 2.3'					0	PID	
Weidemer #3		9203061145	5.0- 5.3'	ND	ND	ND	66.5	ND	LAB	(3)
Weidemer #3			5.3- 5.6'					0	PID	
Weidemer #3			9.8-10.3'					0	PID	
Weidemer #3			14.7-14.9'					0	PID	
Weidemer #3		9203061330	19.7-20.2'	ND	ND	ND	47.3	ND	LAB	(4)
Weidemer #3			20.2-20.4'					0	PID	

Chemical Data of Soils at
Dry Gas Well Water Disposal Pits (cont'd)

Well Name	BBLS/Day Water	Sample Number	Depth of Sample Below Base of Pit	Benzene ug/kg	Toluene ug/kg	Ethylbenzene ug/kg	Total Xylenes ug/kg	TPH mg/kg	Method	
Designated Hitter #1	TSTM		1.6- 2.3'					0	PID	
Designated Hitter #1		9203061447	4.9- 5.3'	ND	33.9	23.1	193.5	1 ppm 4.6	PID LAB	(3)
Designated Hitter #1		9203061530	14.9'	ND	28.8	17.2	151.9	2.9	LAB	(3)
RedMac #2	1.0		1.9- 2.5'					0	PID	
RedMac #2		9203071110	5.0- 5.4'	ND	20.8	ND	58.5	ND	LAB	(4)
RedMac #2			5.5- 5.7'					0	PID	
RedMac #2			10.0-10.4'					0	PID	
RedMac #2			14.9-15.4'					0	PID	
RedMac #2		9203071230	19.7-19.9	ND	ND	ND	49.1	ND	LAB	(4)
RedMac #2			19.9'					0 ppm	PID	

Chemical Data of Soils at
Dry Gas Well Water Disposal Pits (cont'd)

Well Name	BBLS/Day Water	Sample Number	Depth of Sample Below Base of Pit	Benzene ug/kg	Toluene ug/kg	Ethylbenzene ug/kg	Total Xylenes ug/kg	TPH mg/kg	Method	
Mandana #2	TSTM		1.9- 2.1'					0	PID	
Mandana #2		9203071340	5.0- 5.7'	ND	ND	ND	52.9	ND	LAB	(4)
Mandana #2			5.7- 6.0'					0	PID	
Mandana #2		9203071415	7.3'	ND	ND	ND	56.9	ND	LAB	(4)

(1) PID not functioning properly.

Detection Limits:

(2) B = 20 ug/kg
T = 20 ug/kg
E = 20 ug/kg
PMX = 55 ug/kg
OX = 20 ug/kg
TPH = 1.2 mg/kg

(3) B = 10 ug/kg
T = 25 ug/kg
E = 10 ug/kg
PMX = 50 ug/kg
OX = 15 ug/kg
TPH = 1.3 mg/kg

(4) B = 10 ug/kg
T = 20 ug/kg
E = 10 ug/kg
PMX = 32 ug/kg
OX = 10 ug/kg
TPH = 1.3 mg/kg

TSTM = Too small to measure.
ND = Not detected.
PID = Photo Ionization Detector.
NA = Not analyzed.

RESULTS

BENZENE

- NOT DETECTED IN ANY SAMPLES

TOLUENE

- DETECTED IN 6 SAMPLES
- DETECTED AT A MAXIMUM DEPTH OF 20.1 FEET (22.5 PPB)
- THE MAXIMUM CONCENTRATION OF 33.9 PPB OBSERVED AT 4.9 FEET

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RESULTS (cont'd)

ETHYLBENZENE

- DETECTED IN 5 SAMPLES
- DETECTED AT A MAXIMUM DEPTH OF 14.9 FEET (17.2 PPB)
- MAXIMUM CONCENTRATIONS OBSERVED AT CLAUDE SMITH WELL (970 PPB AT 4.8 FEET AND 98 PPB AT 5.9 FEET)
- NEXT HIGHEST CONCENTRATION WAS 23.1 PPB AT 4.9 FEET

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RESULTS (cont'd)

TOTAL XYLENES

- DETECTED IN 15 SAMPLES
- DETECTED AT A MAXIMUM DEPTH OF 19.8 FEET (59.1 PPB)
- MAXIMUM CONCENTRATIONS OBSERVED AT CLAUDE SMITH WELL (4,523 PPB AT 4.8 FEET AND 2,232 PPB AT 5.9 FEET)
- NEXT HIGHEST CONCENTRATION WAS 193 PPB AT 4.9 FEET

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RESULTS (cont'd)

TOTAL PETROLEUM HYDROCARBONS

- DETECTED IN 7 SAMPLES BY LABORATORY METHODS
- DETECTED AT A MAXIMUM DEPTH OF 14.9 FEET (2.9 PPM)
- MAXIMUM CONCENTRATIONS OBSERVED AT CLAUDE SMITH WELL (220 PPM AT 4.8 FEET AND 164 PPM AT 5.9 FEET)
- NEXT HIGHEST CONCENTRATION WAS 4.6 PPM AT 4.9 FEET

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RESULTS (cont'd)

- ALLUVIAL SEDIMENTS, SOILS AND BEDROCK WERE ENCOUNTERED
- ALL PITS SHOWED EVIDENCE OF RECENT DISCHARGES
- SOME PITS EXHIBITED STANDING WATER
- SOME BORINGS ENCOUNTERED SATURATED SEDIMENTS
- MOST SAMPLES WERE NOT MOIST AT TOTAL DEPTH

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STANDARDS

	NMUST SOIL*	WQCC GW**
B	<10 PPM WHEN MEASURED USING AN APPROPRIATE LABORATORY TEST AND THE TOTAL AROMATIC HYDROCARBON VALUE TO BE LESS THAN 50 PPM	0.01 mg/L
T		0.75 mg/L
E		0.75 mg/L
X		0.62 mg/L
TPH	TOTAL TPH IS <100 PPM USING AN APPROPRIATE LABORATORY TEST	NONE

REFERENCES:

*WQCC 82-1, Amendment No. 4, Page 21, Amended through Dec. 24, 1982
**NMUST Regulations §1209, XII-14

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CONCLUSIONS

- NO SITES SHOWED BTEX CONCENTRATION ABOVE ACCEPTABLE LEVELS

- ONLY ONE SITE SHOWED TPH CONCENTRATIONS ABOVE NMUST STANDARDS

- DEEPER SAMPLES MAY BE CONTAMINATED BY "UP HOLE" MATERIAL

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CONCLUSIONS (cont'd)

THE NMOCD HYPOTHESIS:

. THE DISCHARGE TO UNLINED PITS OF LOW VOLUMES OF WATER PRODUCED FROM GAS WELLS REPRESENTS A THREAT TO HUMAN HEALTH AND THE ENVIRONMENT WITHIN THE VULNERABLE AREA

IS NOT SUPPORTED BY THESE DATA

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Soil Properties of Dry Gas Well Sites Presented in FCGPA Exhibit 1

FCGPA Exhibit 7 for the May 21, 1992 Continuation of the April 9, 1992, New Mexico Oil Conservation Commission Hearing on Case Number 10436

May 21, 1992

Prepared for:

The Four Corners Gas Producers Association

Prepared by:

H+GCL

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Section 1.0

Soil Conservation Service Maps of Selected Dry Gas Well Sites

SAN JUAN COUNTY, NEW MEXICO, EASTERN PART — SHEET NUMBER 60

(Joins sheet 55)

(Joins sheet 59)

(Joins sheet 61)

(Joins sheet 64)

McHUGHS NASSAU 5R

LIMIT OF VULNERABLE AREA

NASSAU RESOURCES BENGAL B-6

Gallegos Canyon

Gallegos West Fork

Pete Spring

Scale 1:24000

2 Miles

10000 Feet

5000

0

1000

2000

3000

4000

5000

T 26 N R 11 W

SAN JUAN COUNTY, NEW MEXICO, EASTERN PART — SHEET NUMBER 65

R 12 W | R 11 W

T 26 N

DUGAN WESTERN FED 6

LIMIT OF VULNERABLE AREA

(Joins sheet 64)

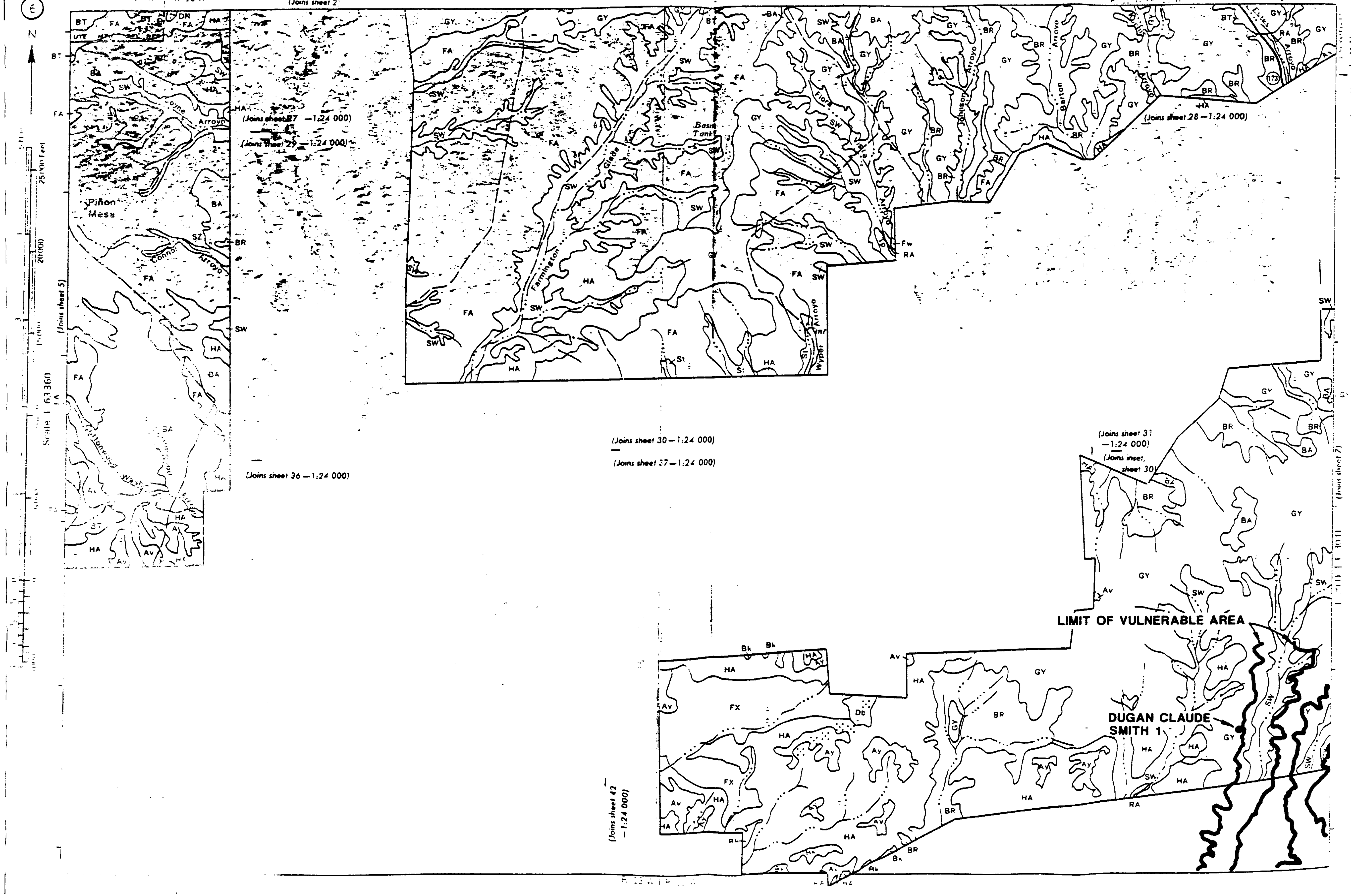
(Joins sheet 12 — 1:63 360) | (Joins sheet 13 — 1:63 360)

Gallegos Canyon

Scale 1:24000

5000 0 1000 2000 3000 4000 5000

SAN JUAN COUNTY, NEW MEXICO: EASTERN PART – SHEET NUMBER 6



50

R 12 W, R 11 W

N

(Joins sheet 43)

(Joins sheet 49)

T 28 N.

DUGAN REDFERN 2

LIMIT OF VULNERABLE AREA

Horn Canyon

Kutz Canyon

(Joins sheet 10 — 1:63 360)

(Joins inset, sheet 38)

(Joins inset, sheet 56)

(Joins sheet 65)

T. 26 N.

(Joins sheet 13 — 1:63 360)

R. 11 W. | R. 10 W.

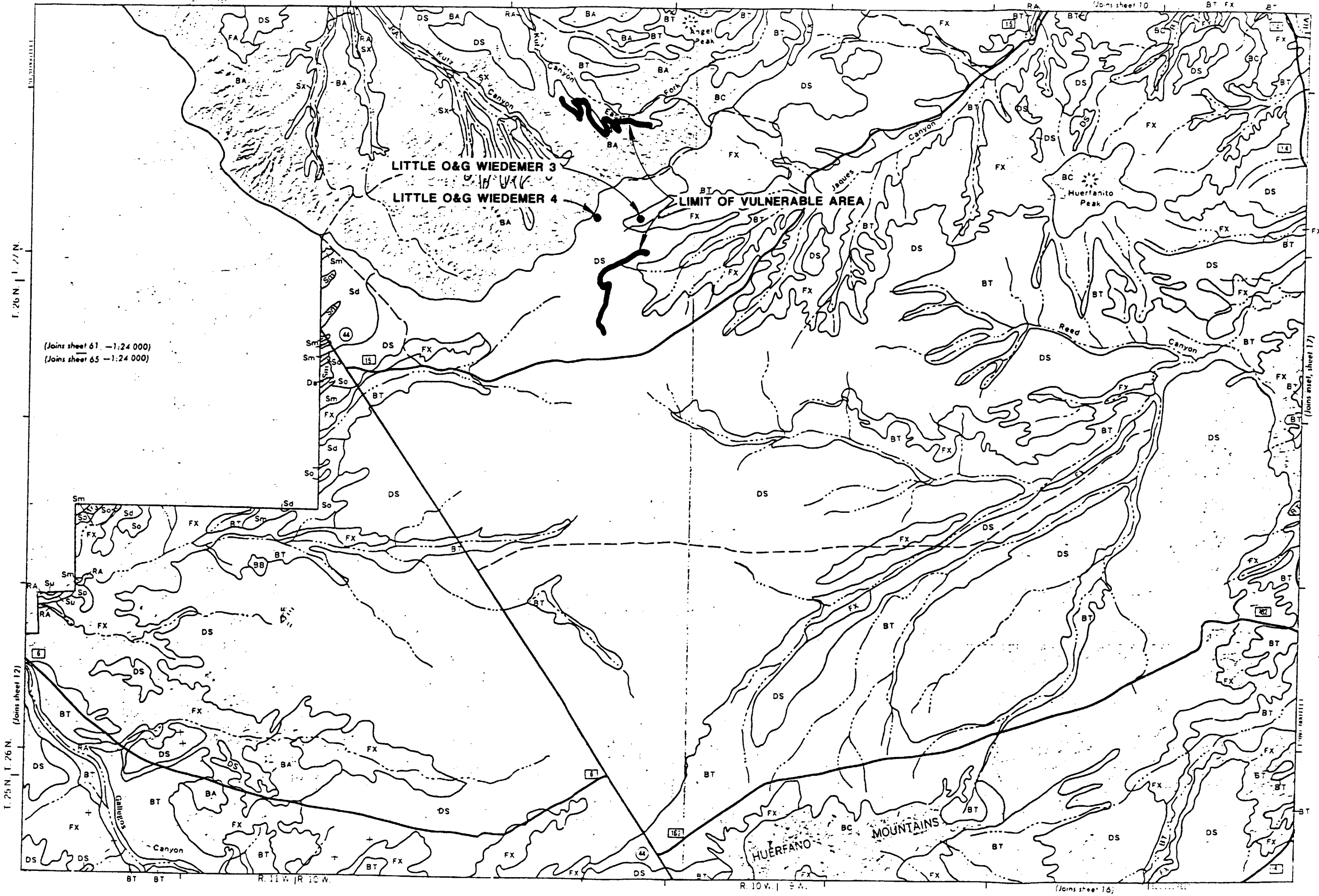
(Joins sheet 56)

2 Miles

10000 Feet

Scale 1:24000

SAN JUAN COUNTY, NEW MEXICO, EASTERN PART — SHEET NUMBER 13



SAN JUAN COUNTY NEW MEXICO EASTERN PART – SHEET NUMBER 64

SAN JUAN COUNTY, NEW MEXICO, EASTERN PART — SHEET NUMBER 62

(62)

N

2 Miles

10000 Feet

5000

Scale 1:24000

0

1000

2000

3000

4000 (Feet)

R. 14 W. | R. 13 W.

(Joins sheet 58)

NAVAJO INDIAN RESERVATION

AZ

NM

FX

MO

(Joins sheet 63)

T. 26 N.

(Joins sheet 11 — 1:63 360)

(Joins sheet 12 — 1:63 360)

(Joins sheet 64)

(Joins sheet 12 — 1:63 360)

(Joins sheet 61)

Fork West Gallegos Canyon

DUGAN REDMAC 2R

T. 25 N.

R. 12 W.

12

N

Scale 1:63 360

INSET A

R. 16 W.

T. 24 N.

(Joins inset, sheet 15)

(Joins sheet 14)

INSET B

(Joins inset 8, sheet 8)

(Joins sheet 14)

T. 24 N. | T. 25 N.

R. 16 W.

INSET C

R. 16 W.

(Joins inset 8, sheet 8)

(Joins sheet 9)

T. 27 N. | T. 28 N.

INSET D

T. 28 N.

R. 11 W.

(Joins sheet 10)

(Joins sheet 62 —1:24 000)

(Joins sheet 63—1:24 000)

(Joins sheet 67 —1:24 000)

(Joins sheet 64—1:24 000)

(Joins sheet 65—1:24 000)

(Joins sheet 13)

(Joins inset, sheet 71 —1:24 000)

GIANT MANDANA STATE 2

NAVAJO INDIAN RESERVATION

(Joins sheet 11)

(Joins sheet 15)

T. 24 N. | R. 13 W.

R. 13 W. | R. 12 W.

R. 12 W. | R. 11 W.

Chaco River

Chaco Soil Survey

Chaco Soil Survey Limit

AZ BA BB BT DS DZ FX HU MO RA SC Sd So St SZ TV

Section 2.0

Soil Associations at Selected Dry Gas Well Sites

Soil Associations at Selected Dry Natural Gas Sites

Ds

Wiedemer 4
Mandana State 2

Du

Red Mac 2R

Fx

Redfern 2
Wiedemer 4

Gy

Claude Smith 1

Sc

Designated Hitter 1
Nassau 5R

Sd

Bengal B-6

Sm

Western Federal 6

TABLE 3.--ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS

Map symbol	Soil name	Acres	Percent
Ap	Apishapa clay loam	576	*
As	Apishapa clay	1,045	*
AT	Atrac-Florita-Travessilla association, hilly	6,782	0.3
Av	Avalon sandy loam, 2 to 5 percent slopes	14,267	0.7
Ax	Avalon sandy loam, 5 to 8 percent slopes	2,016	0.1
Ay	Avalon loam, 0 to 3 percent slopes	5,550	0.3
AZ	Avalon-Sheppard-Shiprock association, gently sloping	19,581	0.9
BA	Badland	231,889	10.6
BB	Badland-Monierco-Rock outcrop complex, moderately steep	86,629	4.0
BC	Badland-Rock outcrop-Persayo complex, extremely steep	44,283	2.0
Be	Beebe loamy sand	2,482	0.1
Bf	Beebe Variant loamy sand	1,800	0.1
Bk	Blackston loam, 0 to 3 percent slopes	1,888	0.1
Bm	Blackston gravelly loam, 3 to 8 percent slopes	1,225	0.1
BP	Blackston-Farb complex, moderately steep	3,106	0.1
BR	Blancot-Fruitland association, gently sloping	17,614	0.8
BT	Blancot-Notal association, gently sloping	214,713	9.8
BU	Buckle silt loam, gently sloping	6,467	0.3
Da	Doak loam, 0 to 1 percent slopes	8,538	0.4
Db	Doak loam, 1 to 3 percent slopes	12,573	0.6
Dc	Doak loam, 3 to 5 percent slopes	1,343	0.1
Dd	Doak clay loam, 0 to 2 percent slopes	3,706	0.2
DN	Doak-Avalon association, gently sloping	38,944	1.8
DS	Doak-Sheppard-Shiprock association, rolling	157,315	7.2
Du	Doak-Uffens complex, 0 to 3 percent slopes	18,817	0.9
Dw	Doak-Uffens complex, 3 to 8 percent slopes	1,448	0.1
DZ	Dune land	3,881	0.2
FA	Farb-Persayo-Rock outcrop complex, moderately steep	81,390	3.7
FP	Fluvaquents, ponded	1,607	0.1
Fr	Fruitland sandy loam, 0 to 2 percent slopes	2,776	0.1
Fs	Fruitland sandy loam, 2 to 5 percent slopes	5,271	0.2
Ft	Fruitland sandy loam, wet, 0 to 2 percent slopes	2,072	0.1
Fu	Fruitland loam, 1 to 3 percent slopes	4,621	0.2
Fw	Fruitland loam, 5 to 8 percent slopes	2,096	0.1
FX	Fruitland-Persayo-Sheppard complex, hilly	171,613	7.9
Fy	Fruitland-Slickspots complex, 0 to 3 percent slopes	4,848	0.2
Ga	Garland loam	4,017	0.2
Gr	Green River fine sandy loam	1,190	0.1
GY	Gypsiorthids-Badland-Stumble complex, moderately steep	48,685	2.2
HA	Haplargids-Blackston-Torriorthents complex, very steep	61,763	2.8
HU	Huerfano-Muff-Uffens complex, gently sloping	43,121	2.0
Ma	Mayqueen loamy fine sand	1,628	0.1
MO	Monierco fine sandy loam, gently sloping	4,145	0.2
PO	Penistaja loam, gently sloping	13,803	0.6
PP	Penistaja-Buckle association, gently sloping	22,610	1.0
PT	Penistaja-Travessilla association, moderately sloping	21,932	1.0
PX	Pits	894	*
RA	Riverwash	29,514	1.4
RO	Rock outcrop	38,257	1.8
RT	Rock outcrop-Travessilla-Weska complex, extremely steep	187,184	8.6
SB	Sheppard-Badland complex, very steep	4,979	0.2
SC	Sheppard-Huerfano-Notal complex, gently sloping	184,339	8.4
Sd	Sheppard-Mayqueen-Shiprock complex, 0 to 8 percent slopes	98,028	4.5
Sn	Shiprock loamy fine sand, 0 to 2 percent slopes	534	*
Sk	Shiprock loamy fine sand, 2 to 5 percent slopes	720	*
Sm	Shiprock fine sandy loam, 0 to 2 percent slopes	25,830	1.2
So	Shiprock fine sandy loam, 2 to 5 percent slopes	42,392	1.9
Sp	Shiprock fine sandy loam, 5 to 8 percent slopes	1,940	0.1
Sr	Shiprock Variant fine sandy loam	1,336	0.1
St	Stumble loamy sand, 0 to 3 percent slopes	4,299	0.2
Su	Stumble loamy sand, 3 to 8 percent slopes	3,086	0.1
SV	Stumble sandy clay loam, gently sloping	969	*
SW	Stumble-Fruitland association, gently sloping	22,073	1.0
SX	Stumble-Notal complex, gently sloping	11,088	0.5
SZ	Stumble-Slickspots complex, gently sloping	3,603	0.2
TA	Travessilla-Weska-Rock outcrop complex, moderately steep	70,024	3.2
Tp	Turley clay loam, 0 to 1 percent slopes	1,544	0.1
Tr	Turley clay loam, 1 to 3 percent slopes	4,637	0.2
Ts	Turley clay loam, 3 to 5 percent slopes	485	*
Tt	Turley clay loam, wet, 0 to 2 percent slopes	3,185	0.1

See footnote at end of table.

TABLE 3.--ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS--Continued

Map symbol	Soil name	Acres	Percent
Tv	Turley-Slickspots complex, 0 to 3 percent slopes	1,566	0.1
TW	Twick-Silver association, moderately sloping	7,853	0.4
Wa	Walrees loam	4,112	0.2
Wr	Werlog loam	4,515	0.2
Ws	Werlog loam, saline	1,984	0.1
Yo	Youngston clay loam	918	*
	Lakes, rivers, reservoirs	12,966	0.6
	Total	2,182,520	100.0

* Less than 0.1 percent.

Section 3.0

Engineering Tables Showing
Soil Properties of Selected Dry Gas Well Sites

TABLE 13.--ENGINEERING INDEX PROPERTIES

[The symbol < means less than; > means more than. Absence of an entry indicates that data were not estimated]

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
Ap---------- Apishapa	0-5	Clay loam--------	CL	A-6	0	95-100	95-100	90-100	70-85	30-40	15-25
	5-81	Clay, silty clay, clay loam.	CL, CH	A-7	0	95-100	95-100	90-100	75-95	40-60	20-40
As---------- Apishapa	0-6	Clay------------	CL, CH	A-7	0	95-100	95-100	90-100	75-95	40-60	20-40
	6-81	Clay, silty clay, clay loam.	CL, CH	A-7	0	95-100	95-100	90-100	75-95	40-60	20-40
AT*:											
Atrac----------	0-3	Loam------------	CL-ML, ML	A-4	0	100	100	85-95	60-80	25-35	5-10
	3-44	Sandy clay loam, loam, clay loam.	CL, CL-ML, SC, SM-SC	A-4, A-6	0	100	100	80-100	35-80	20-40	5-20
	44-60	Sandy loam, sandy clay loam, loam.	SM-SC, CL-ML, SM, ML	A-2, A-4, A-6	0	100	100	60-95	30-75	20-40	NP-15
Florita----------	0-4	Sandy loam------	SM	A-2, A-4	0	100	100	60-70	30-40	---	NP
	4-12	Loamy coarse sand.	SM, SP-SM	A-1	0	100	100	30-40	0-10	---	NP
	12-43	Sandy loam, coarse sandy loam.	SM	A-2, A-1	0	100	100	45-65	15-35	---	NP
	43-60	Coarse sand-----	SM, SP-SM	A-1	0	100	100	30-40	0-10	---	NP
Travessilla-------	0-2	Sandy loam------	SM-SC	A-4	0	100	100	65-75	35-50	20-30	5-10
	2-12	Loam, very fine sandy loam, fine sandy loam	CL-ML, SM-SC	A-4	0	100	100	70-85	35-55	20-30	5-10
	12	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Av---------- Avalon	0-14	Sandy loam------	SM	A-4	0	100	90-100	60-80	35-50	15-25	NP-5
	14-53	Loam, sandy clay loam, clay loam	CL-ML, CL	A-4, A-6	0	85-95	80-90	65-85	50-70	20-35	5-15
	53-72	Gravelly sandy loam, gravelly loam, gravelly sandy clay loam	SM, SM-SC, GM, GM-GC	A-2, A-4	0	55-75	50-70	35-60	25-40	15-25	NP-10
Ax---------- Avalon	0-2	Sandy loam------	SM	A-4	0	100	90-100	60-80	35-50	15-25	NP-5
	2-80	Loam, clay loam, sandy clay loam	CL-ML, CL	A-4, A-6	0	85-95	80-90	65-85	50-70	20-35	5-15
Ay---------- Avalon	0-18	Loam------------	CL-ML	A-4	0	100	90-100	70-80	50-70	20-30	5-10
	18-60	Loam, clay loam.	CL-ML, CL	A-4, A-6	0	85-95	80-90	65-85	50-70	20-35	5-15
AZ*:											
Avalon------------	0-3	Sandy loam------	SM	A-4	0	100	90-100	60-80	35-50	15-25	NP-5
	3-60	Loam, clay loam.	CL-ML, CL	A-4, A-6	0	85-95	80-90	65-85	50-70	20-35	5-15
Sheppard----------	0-3	Loamy fine sand	SM	A-2	0	100	100	65-85	15-30	15-20	NP-5
	3-60	Loamy fine sand, loamy sand, fine sand.	SM	A-2	0	100	100	65-85	15-30	15-20	NP-5
Shiprock----------	0-3	Sandy loam------	SM, SM-SC	A-2, A-4	0	100	100	75-90	30-50	20-30	NP-10
	3-60	Sandy loam, fine sandy loam.	SM, SM-SC	A-2, A-4	0	100	100	75-90	30-50	20-30	NP-10
BA*. Badland											

See footnote at end of table.

TABLE 13.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Frag-ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas-ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
BB*:											
Badland.											
Monierco	0-2	Fine sandy loam	SM	A-4, A-2	0	100	100	60-85	30-50	15-25	NP-5
	2-14	Sandy clay loam, clay loam, loam.	CL, CL-ML	A-4, A-6	0	100	100	80-100	50-80	20-35	5-15
	14	Weathered bedrock.	---	---	---	---	---	---	---	---	---
Rock outcrop.											
BC*:											
Badland.											
Rock outcrop.											
Persayo	0-2	Clay loam	CL	A-6	0-10	80-100	75-100	75-95	60-85	25-40	10-20
	2-12	Clay loam, silty clay loam.	CL	A-6	0-10	80-100	75-100	75-95	60-85	25-40	10-20
	12	Weathered bedrock.	---	---	---	---	---	---	---	---	---
Be	0-6	Loamy sand	SM	A-2, A-1	0	100	100	50-75	15-30	---	NP
Beebe	6-67	Sand, loamy sand.	SP-SM, SM	A-2, A-3, A-1	0	100	80-100	50-70	5-25	---	NP
	67-81	Very gravelly sand.	SM, SP-SM, GM, GP-GM	A-1	0	50-60	40-50	20-45	0-15	---	NP
Bf	0-8	Loamy sand	SM, SM-SC	A-2	0	100	100	50-75	15-35	15-25	NP-5
Beebe Variant	8-67	Sand, coarse sand, loamy sand.	SM, SW-SM	A-3, A-2	0	100	100	50-70	5-25	---	NP
	67-81	Very gravelly sand.	SM, SP-SM, GM, GP-GM	A-1	0	50-70	40-50	30-45	0-15	---	NP
Bk	0-11	Loam	ML, CL-ML	A-4	0	75-100	75-100	65-85	50-70	20-30	NP-10
Blackston	11-27	Very gravelly loam, very gravelly clay loam.	GM, GM-GC	A-1, A-2	25-35	30-50	20-45	20-40	15-30	20-30	NP-10
	27-80	Very gravelly sand.	GP-GM, SP-SM	A-1	25-35	30-60	15-50	10-35	5-10	---	NP
Bm	0-9	Gravelly loam	ML, CL-ML	A-4	0	80-100	70-100	65-85	50-70	20-30	NP-10
Blackston	9-25	Very gravelly loam, very gravelly clay loam.	GM, GM-GC	A-1, A-2	25-35	30-50	20-45	20-40	15-30	20-30	NP-10
	25-60	Very gravelly sand, very gravelly clay loam.	GP-GM, GM, SP-SM, SM	A-1	25-35	30-60	15-50	10-35	5-20	---	NP
BP*:											
Blackston	0-12	Loam	ML, CL-ML	A-4	0	75-100	75-100	65-85	50-70	20-30	NP-10
	12-30	Very gravelly loam, very gravelly clay loam.	GM, GM-GC	A-1, A-2	25-35	30-50	20-45	20-40	15-30	20-30	NP-10
	30-60	Very gravelly sand, very gravelly sandy loam.	GP-GM, GM, SP-SM, SM	A-1	25-35	30-60	15-50	10-35	5-20	---	NP

See footnote at end of table.

TABLE 13.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
BP*:											
Farb	0-7	Sandy loam	SM	A-4	0	100	100	65-80	35-50	20-25	NP-5
	7-10	Loamy sand, sandy loam, fine sandy loam.	SM	A-2, A-4	0	100	100	50-80	15-50	15-25	NP-5
	10	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Br*:											
Blancot	0-6	Loam	CL-ML, ML, CL	A-4	0	100	100	75-95	50-80	25-35	5-10
	6-60	Clay loam, sandy clay loam,	CL-ML, CL	A-4, A-6	0	100	100	80-100	50-80	25-40	5-20
Fruitland	0-8	Sandy loam	SM	A-2, A-4	0	100	100	60-75	30-45	15-25	NP-5
	8-60	Fine sandy loam, sandy loam.	SM	A-4, A-2	0	100	100	60-75	30-45	15-25	NP-5
BT*:											
Blancot	0-2	Loam	CL-ML, ML	A-4	0	100	100	75-95	50-80	25-35	5-10
	2-60	Clay loam, sandy clay loam, loam.	CL-ML, CL	A-4, A-6	0	100	100	80-100	50-80	25-40	5-20
Notal	0-3	Silty clay loam	CL, ML	A-6, A-7	0	100	100	90-100	70-80	35-45	10-20
	3-60	Silty clay, clay	CL, CH	A-7	0	100	100	90-100	80-95	40-60	15-30
Bu	0-5	Silt loam	CL-ML	A-4	0	100	100	85-95	65-85	20-30	5-10
Buckle	5-44	Clay loam, silty clay loam, silt loam.	CL	A-6, A-7	0	100	100	90-100	70-85	25-45	10-20
	44-66	Silt loam, clay loam, silty clay loam.	CL, CL-ML	A-6, A-7, A-4	0	100	100	85-100	70-90	20-45	5-20
Da	0-6	Loam	ML	A-4	0	100	100	80-95	60-75	20-30	NP-5
Doak	6-60	Clay loam, silty clay loam, loam.	CL, CL-ML	A-6, A-4	0	100	100	80-100	60-80	25-40	5-20
Db	0-4	Loam	ML	A-4	0	100	100	80-95	60-75	20-30	NP-5
Doak	4-60	Clay loam, silty clay loam, loam.	CL, CL-ML	A-6, A-4	0	100	100	80-100	60-80	25-40	5-20
Dc	0-3	Loam	ML	A-4	0	100	100	80-95	60-75	20-30	NP-5
Doak	3-60	Clay loam, silty clay loam, loam.	CL, CL-ML	A-6, A-4	0	100	100	80-100	60-80	25-40	5-20
Dd	0-5	Clay loam	CL, CL-ML	A-6, A-4	0	100	100	90-100	65-80	25-40	5-20
Doak	5-60	Clay loam, silty clay loam, loam.	CL, CL-ML	A-6, A-4	0	100	100	80-100	60-80	25-40	5-20
DN*:											
Doak	0-5	Loam	ML	A-4	0	100	100	80-95	60-75	20-30	NP-5
	5-69	Clay loam, silty clay loam, loam.	CL, CL-ML	A-6, A-4	0	100	100	80-100	60-80	25-40	5-20
Avalon	0-14	Loam	CL-ML	A-4	0	100	90-100	70-80	50-70	20-30	5-10
	14-60	Loam	CL-ML	A-4	0	85-95	80-90	65-85	50-70	20-30	5-10

See footnote at end of table.

TABLE 13.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
DS*:											
Doak	0-3	Loam	ML	A-4	0	100	100	80-95	60-75	20-30	NP-5
	3-60	Clay loam, silty clay loam, loam.	CL, CL-ML	A-6, A-4	0	100	100	80-100	60-80	25-40	5-20
Sheppard	0-3	Loamy fine sand	SM	A-2	0	100	100	65-85	15-30	15-20	NP-5
	3-60	Loamy fine sand, loamy sand, fine sand.	SM	A-2	0	100	100	65-85	15-30	15-20	NP-5
Shiprock	0-3	Fine sandy loam	SM, SM-SC	A-2, A-4	0	100	100	75-90	30-50	20-30	NP-10
	3-60	Sandy loam, fine sandy loam.	SM, SM-SC	A-2, A-4	0	100	100	75-90	30-50	20-30	NP-10
Du*:											
Doak	0-5	Very fine sandy loam.	CL-ML	A-4	0	100	100	85-95	50-75	20-30	5-10
	5-19	Loam, sandy clay loam, clay loam.	CL, SM-SC, SC, CL-ML	A-4, A-6	0	100	100	80-100	40-80	25-40	5-20
	19-60	Loam, sandy clay loam, clay loam.	CL, SM-SC, SC, CL-ML	A-4, A-6	0	100	100	80-100	40-80	25-40	5-20
Uffens	0-6	Fine sandy loam	SM, ML, CL-ML, SM-SC	A-4	0	100	100	80-90	45-55	20-30	NP-10
	6-18	Sandy clay loam, clay loam, silty clay loam.	CL	A-6	0	100	100	85-95	65-85	30-40	10-20
	18-60	Sandy clay loam, loam, clay loam.	CL	A-6	0	100	100	85-95	55-75	30-40	10-15
Dw*:											
Doak	0-3	Very fine sandy loam.	CL-ML	A-4	0	100	100	85-95	50-75	20-30	5-10
	3-15	Loam, sandy clay loam, clay loam.	CL, SM-SC, SC, CL-ML	A-4, A-6	0	100	100	80-100	40-80	25-40	5-20
	15-60	Loam, sandy clay loam, clay loam.	CL, SM-SC, SC, CL-ML	A-4, A-6	0	100	100	80-100	40-80	25-40	5-20
Uffens	0-4	Fine sandy loam	SM, ML, CL-ML, SM-SC	A-4	0	100	100	80-90	45-55	20-30	NP-10
	4-22	Sandy clay loam, clay loam, silty clay loam.	CL	A-6	0	100	100	85-95	65-85	30-40	10-20
	22-60	Sandy clay loam, loam, clay loam.	CL	A-6	0	100	100	85-95	55-75	30-40	10-15
DZ*.											
Dune land											

See footnote at end of table.

TABLE 13.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
FA*:											
Farb	0-7	Fine sandy loam	SM	A-4	0	100	100	65-80	35-50	20-25	NP-5
	7-10	Loamy sand, sandy loam, fine sandy loam.	SM	A-2, A-4	0	100	100	50-80	15-50	15-25	NP-5
	10	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Persayo	0-2	Clay loam	CL	A-6	0-10	80-100	75-100	75-95	60-85	25-40	10-20
	2-15	Clay loam, silty clay loam.	CL	A-6	0-10	80-100	75-100	75-95	60-85	25-40	10-20
	15	Weathered bedrock.	---	---	---	---	---	---	---	---	---
Rock outcrop.											
FP*. Fluvaquents											
Fr	0-7	Sandy loam	SM	A-2, A-4	0	100	100	60-75	30-45	15-25	NP-5
Fruitland	7-60	Fine sandy loam, sandy loam.	SM	A-4, A-2	0	100	100	60-75	30-45	15-25	NP-5
Fs	0-6	Sandy loam	SM	A-2, A-4	0	100	100	60-75	30-45	15-25	NP-5
Fruitland	6-60	Fine sandy loam, sandy loam.	SM	A-4, A-2	0	100	100	60-75	30-50	15-25	NP-5
Ft	0-6	Sandy loam	SM	A-2, A-4	0	100	100	60-75	30-45	15-25	NP-5
Fruitland	6-60	Fine sandy loam, sandy loam.	SM	A-2, A-4	0	100	100	60-75	30-50	15-25	NP-5
Fu	0-8	Loam	SM-SC, SC, CL, CL-ML	A-6, A-4	0	100	100	80-90	40-60	20-30	5-15
Fruitland	8-60	Fine sandy loam, sandy loam.	SM	A-4, A-2	0	100	100	60-75	30-50	15-25	NP-5
Fw	0-3	Loam	SM-SC, SC, CL, CL-ML	A-6, A-4	0	100	100	80-90	40-60	20-30	5-15
Fruitland	3-60	Fine sandy loam, sandy loam.	SM	A-4, A-2	0	100	100	60-75	30-50	15-25	NP-5
FX*:											
Fruitland	0-4	Sandy loam	SM	A-2, A-4	0	100	100	60-75	30-45	15-25	NP-5
	4-60	Fine sandy loam, sandy loam.	SM	A-4, A-2	0	100	100	60-75	30-50	15-25	NP-5
Persayo	0-2	Clay loam	CL	A-6	0-10	80-100	75-100	75-95	60-85	25-40	10-20
	2-18	Clay loam, silty clay loam.	CL	A-6	0-10	80-100	75-100	75-95	60-85	25-40	10-20
	18	Weathered bedrock.	---	---	---	---	---	---	---	---	---
Sheppard	0-4	Loamy fine sand	SM	A-2	0	100	100	65-85	15-30	15-20	NP-5
	4-60	Loamy fine sand, loamy sand, fine sand.	SM	A-2	0	100	100	65-85	15-30	15-20	NP-5
Fy*:											
Fruitland	0-9	Sandy loam	SM	A-2, A-4	0	100	100	60-75	30-45	15-25	NP-5
	9-60	Fine sandy loam, sandy loam.	SM	A-4, A-2	0	100	100	60-75	30-45	15-25	NP-5
Slickspots.											

See footnote at end of table.

TABLE 13.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
Ga---------- Garland	0-4	Loam----------	CL-ML	A-4	0-10	80-100	75-100	65-90	50-75	25-30	5-10
	4-24	Clay loam, sandy clay loam, loam	CL, CL-ML	A-6, A-4	0-10	80-100	75-100	65-95	50-65	25-35	5-15
	24-60	Very gravelly loamy sand, very gravelly sand.	GP, GP-GM	A-1	15-25	20-50	20-50	15-25	0-10	---	NP
Gr---------- Green River	0-6	Fine sandy loam	SM, SM-SC	A-2, A-4	0	100	100	60-85	30-50	20-30	NP-10
	6-60	Stratified sandy loam to loam.	SM-SC	A-2, A-4	0	100	100	75-90	30-50	20-30	5-10
GY*: Gypsiorthids. Badland.											
Stumble----------	0-8	Loamy sand------	SM	A-2	0	100	100	50-75	15-25	15-20	NP-5
	8-60	Loamy coarse sand, loamy sand, sand.	SM, SP-SM	A-2, A-1, A-3	0	100	100	40-75	5-25	15-20	NP-5
HA*: Haplargids.											
Blackston---------	0-11	Gravelly loam---	SM, SM-SC	A-4, A-2	0-5	70-90	60-80	45-70	25-50	20-30	NP-10
	11-28	Very gravelly sandy loam, very gravelly loam, very gravelly clay loam.	GM, GM-GC	A-1, A-2	35-55	20-50	15-40	10-30	5-25	20-30	NP-10
	28-60	Very gravelly sand, very gravelly sandy loam.	GP	A-1	35-55	15-45	10-40	5-20	0-5	---	NP
Torriorthents.											
HU*: Huerfano----------	0-1	Sandy clay loam	CL, SC	A-6	0	100	100	85-95	40-70	25-35	10-15
	1-15	Clay loam, sandy clay loam.	CL, SC	A-7, A-6	0	100	100	85-95	45-60	35-45	15-20
	15	Weathered bedrock.	---	---	---	---	---	---	---	---	---
Muff----------	0-4	Very fine sandy loam.	ML, CL-ML	A-4	0	95-100	90-100	85-95	50-10	20-30	NP-10
	4-24	Sandy clay loam, clay loam.	SC, SM-SC	A-6, A-4	0	90-100	75-100	65-90	35-50	25-35	5-15
	24	Weathered bedrock.	---	---	---	---	---	---	---	---	---
Uffens----------	0-9	Fine sandy loam	SM, ML, CL-ML, SM-SC	A-4	0	100	100	80-90	45-55	20-30	NP-10
	9-20	Sandy clay loam, clay loam, silty clay loam.	CL	A-6	0	100	100	85-95	65-85	30-40	10-20
	20-60	Sandy clay loam, loam, clay loam.	CL	A-6	0	100	100	85-95	55-75	30-40	10-15

See footnote at end of table.

TABLE 13.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
Ma----------	0-4	Loamy fine sand	SM	A-2	0	100	100	50-75	15-35	15-20	NP-5
Mayqueen	4-16	Fine sandy loam, sandy loam.	SM, SM-SC	A-4	0	100	100	65-80	35-50	20-25	NP-10
	16-60	Loamy sand, loamy fine sand, fine sand.	SM	A-2	0	100	100	55-80	15-35	15-20	NP-5
MO----------	0-5	Fine sandy loam	SM	A-4, A-2	0	100	100	60-85	30-50	15-25	NP-5
Monierco	5-16	Sandy clay loam, clay loam, loam.	CL, CL-ML	A-4, A-6	0	100	100	80-100	50-80	20-35	5-15
	16	Weathered bedrock.	---	---	---	---	---	---	---	---	---
PO----------	0-2	Loam----------	ML	A-4	0	100	100	90-100	50-60	20-25	NP-5
Penistaja	2-67	Sandy clay loam, clay loam.	CL-ML, CL, SC, SM-SC	A-4, A-6	0	100	100	95-100	45-75	25-35	5-15
PP*:											
Penistaja---------	0-3	Loam----------	ML	A-4	0	100	100	90-100	50-60	20-25	NP-5
	3-60	Sandy clay loam, clay loam.	CL-ML, CL, SC, SM-SC	A-4, A-6	0	100	100	95-100	45-75	25-35	5-15
Buckle----------	0-13	Silt loam-------	CL-ML	A-4	0	100	100	85-95	65-85	20-30	5-10
	13-47	Clay loam, silty clay loam.	CL	A-6, A-7	0	100	100	90-100	70-85	25-45	10-20
	47-66	Silt loam, clay loam, silty clay loam.	CL, CL-ML	A-6, A-7, A-4	0	100	100	85-100	70-90	20-45	5-20
PT*:											
Penistaja---------	0-3	Loam----------	ML	A-4	0	100	100	90-100	50-60	20-25	NP-5
	3-60	Sandy clay loam, clay loam.	CL-ML, CL, SC, SM-SC	A-4, A-6	0	100	100	95-100	45-75	25-35	5-15
Travessilla-------	0-2	Very fine sandy loam.	CL-ML	A-4	0	100	100	85-95	55-65	20-30	5-10
	2-12	Loam, very fine sandy loam, fine sandy loam	CL-ML, SM-SC	A-4	0	100	100	70-85	35-55	20-30	5-10
	12	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
PX*.											
Pits											
RA*.											
Riverwash											
RO*.											
Rock outcrop											
RT*:											
Rock outcrop.											
Travessilla-------	0-1	Sandy loam------	SM-SC	A-4	0	100	100	65-75	35-50	20-30	5-10
	1-9	Loam, sandy loam, fine sandy loam.	CL-ML, SM-SC	A-4	0	100	100	70-85	35-55	20-30	5-10
	9	Unweathered bedrock.	---	---	---	---	---	---	---	---	---

See footnote at end of table.

TABLE 13.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
RT*:											
Weska	0-1	Silty clay loam	CL	A-6	0	100	100	90-100	75-90	35-40	15-20
	1-7	Silty clay loam, clay loam.	CL	A-6	0	100	100	90-100	75-90	35-40	15-20
	7	Weathered bedrock.	---	---	---	---	---	---	---	---	---
SB*:											
Sheppard	0-2	Loamy fine sand	SM	A-2	0	100	100	65-85	15-30	15-20	NP-5
	2-60	Loamy fine sand, loamy sand, fine sand.	SM	A-2	0	100	100	65-85	15-30	15-20	NP-5
Badland.											
SC*:											
Sheppard	0-5	Loamy fine sand	SM	A-2	0	100	100	65-85	15-30	15-20	NP-5
	5-60	Loamy fine sand, fine sand.	SM	A-2	0	100	100	65-85	15-30	15-20	NP-5
Huerfano	0-1	Sandy clay loam	CL, SC	A-6	0	100	100	85-95	40-70	25-35	10-15
	1-15	Clay loam, sandy clay loam.	CL, SC	A-7, A-6	0	100	100	85-95	45-60	35-45	15-20
	15	Weathered bedrock.	---	---	---	---	---	---	---	---	---
Notal	0-3	Clay loam	CL, ML	A-6, A-7	0	100	100	90-100	70-80	35-45	10-20
	3-60	Silty clay, clay	CL, CH	A-7	0	100	100	90-100	80-95	40-60	15-30
Sd*:											
Sheppard	0-1	Loamy fine sand	SM	A-2	0	100	100	65-85	15-30	15-20	NP-5
	1-62	Loamy fine sand, loamy sand, fine sand.	SM	A-2	0	100	100	65-85	15-30	15-20	NP-5
Mayqueen	0-3	Loamy fine sand	SM	A-2	0	100	100	50-75	15-35	15-20	NP-5
	3-12	Fine sandy loam, sandy loam.	SM, SM-SC	A-4	0	100	100	65-80	35-50	20-25	NP-10
	12-60	Loamy sand, loamy fine sand, fine sand.	SM	A-2	0	100	100	55-80	15-35	15-20	NP-5
Shiprock	0-1	Fine sandy loam	SM, SM-SC	A-2, A-4	0	100	100	75-90	30-50	20-30	NP-10
	1-60	Sandy loam, fine sandy loam.	SM, SM-SC	A-2, A-4	0	100	100	75-90	30-50	20-30	NP-10
Sh	0-10	Loamy fine sand	SM, SP-SM	A-2, A-3	0	100	100	65-85	5-30	15-25	NP-5
Shiprock	10-60	Sandy loam, fine sandy loam.	SM, SM-SC	A-2, A-4	0	100	100	75-90	30-50	20-30	NP-10
Sk	0-9	Loamy fine sand	SM, SP-SM	A-2, A-3	0	100	100	65-85	5-30	15-25	NP-5
Shiprock	9-60	Sandy loam, fine sandy loam.	SM, SM-SC	A-2, A-4	0	100	100	75-90	30-50	20-30	NP-10
Sm	0-2	Fine sandy loam	SM, SM-SC	A-2, A-4	0	100	100	75-90	30-50	20-30	NP-10
Shiprock	2-60	Sandy loam, fine sandy loam.	SM, SM-SC	A-2, A-4	0	100	100	75-90	30-50	20-30	NP-10
So	0-4	Fine sandy loam	SM, SM-SC	A-2, A-4	0	100	100	75-90	30-50	20-30	NP-10
Shiprock	4-60	Sandy loam, fine sandy loam.	SM, SM-SC	A-2, A-4	0	100	100	75-90	30-50	20-30	NP-10
Sp	0-3	Fine sandy loam	SM, SM-SC	A-2, A-4	0	100	100	75-90	30-50	20-30	NP-10
Shiprock	3-60	Sandy loam, fine sandy loam.	SM, SM-SC	A-2, A-4	0	100	100	75-90	30-50	20-30	NP-10

See footnote at end of table.

TABLE 13.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
Sr----------	0-8	Fine sandy loam	SM, ML	A-4	0	100	100	70-85	40-55	20-30	NP-5
Shiprock Variant	8-24	Fine sandy loam, sandy clay loam, sandy loam.	SM, SM-SC, SC, ML	A-4, A-6, A-2	0	100	100	60-90	30-55	20-35	NP-15
	24-48	Loam, sandy clay loam, fine sandy loam.	SM, ML	A-4	0	100	100	70-95	35-75	20-35	NP-10
	48-68	Loamy sand, sandy loam, fine sandy loam.	SM	A-2, A-4	0	100	100	50-85	15-50	20-25	NP-5
St----------	0-5	Loamy sand------	SM	A-2	0	100	100	50-75	15-25	15-20	NP-5
Stumble	5-29	Loamy coarse sand, loamy sand, sand.	SM, SP-SM	A-2, A-1, A-3	0	100	100	40-75	5-25	15-20	NP-5
	29-49	Gravelly sand, gravelly loamy sand.	SP, SP-SM	A-1, A-2	0	65-85	50-65	20-50	0-10	---	NP
	49-81	Loamy coarse sand, loamy sand, sand.	SM, SP-SM	A-2, A-1, A-3	0	100	100	40-75	5-25	15-20	NP-5
Su----------	0-5	Loamy sand------	SM	A-2	0	100	100	50-75	15-25	15-20	NP-5
Stumble	5-81	Gravelly sand, loamy sand, sand.	SM, SP-SM	A-2, A-1, A-3	0	75-100	60-100	30-75	0-15	15-20	NP-5
SV----------	0-7	Sandy clay loam	CL, CL-ML	A-4, A-6	0	100	100	80-95	50-75	20-30	5-15
Stumble	7-60	Loamy coarse sand, loamy sand, sand.	SM, SP-SM	A-2, A-1, A-3	0	100	100	40-75	5-25	15-20	NP-5
Sw*:											
Stumble----------	0-6	Loamy sand------	SM	A-2	0	100	100	50-75	15-25	15-20	NP-5
	6-29	Loamy coarse sand, loamy sand, sand.	SM, SP-SM	A-2, A-1, A-3	0	100	100	40-75	5-25	15-20	NP-5
	29-60	Gravelly sand, gravelly loamy sand.	SP, SP-SM	A-1, A-2	0	65-85	50-65	20-50	0-10	---	NP
Fruitland----------	0-7	Sandy loam------	SM	A-2, A-4	0	100	100	60-75	30-45	15-25	NP-5
	7-60	Fine sandy loam, sandy loam.	SM	A-4, A-2	0	100	100	60-75	30-45	15-25	NP-5
Sx*:											
Stumble----------	0-3	Loamy sand------	SM	A-2	0	100	100	50-75	15-25	15-20	NP-5
	3-60	Loamy coarse sand, loamy sand, sand.	SM, SP-SM	A-2, A-1, A-3	0	100	100	40-75	5-25	15-20	NP-5
Notal----------	0-24	Clay loam-------	CL, ML	A-6, A-7	0	100	100	90-100	70-80	35-45	10-20
	24-60	Silty clay, clay	CL, CH	A-7	0	100	100	90-100	80-95	40-60	15-30
Sz*:											
Stumble----------	0-4	Loamy sand------	SM	A-2	0	100	100	50-75	15-25	15-20	NP-5
	4-60	Loamy coarse sand, loamy sand, sand.	SM, SP-SM	A-2, A-1, A-3	0	100	100	40-75	5-25	15-20	NP-5
Slickspots.											

See footnote at end of table.

TABLE 13.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Frag-ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas-ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
TA*:											
Travessilla-------	0-2	Sandy loam------	SM-SC	A-4	0	100	100	65-75	35-50	20-30	5-10
	2-12	Loam, sandy loam, fine sandy loam.	CL-ML, SM-SC	A-4	0	100	100	70-85	35-55	20-30	5-10
	12	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Weska-------------	0-1	Clay loam-------	CL	A-6	0	100	100	90-100	75-90	35-40	15-20
	1-9	Silty clay loam, clay loam.	CL	A-6	0	100	100	90-100	75-90	35-40	15-20
	9	Weathered bedrock.	---	---	---	---	---	---	---	---	---
Rock outcrop.											
Tp-----------------	0-3	Clay loam-------	CL	A-6	0	100	100	85-100	65-80	30-40	10-20
Turley	3-80	Clay loam, silty clay loam, loam.	CL	A-6	0	100	100	85-100	65-80	30-40	10-20
Tr-----------------	0-9	Clay loam-------	CL	A-6	0	100	100	85-100	65-80	30-40	10-20
Turley	9-60	Clay loam, silty clay loam, loam.	CL	A-6	0	100	100	85-100	65-80	30-40	10-20
Ts-----------------	0-4	Clay loam-------	CL	A-6	0	100	100	85-100	65-80	30-40	10-20
Turley	4-60	Clay loam, silty clay loam, loam.	CL	A-6	0	100	100	85-100	65-80	30-40	10-20
Tt-----------------	0-9	Clay loam-------	CL	A-6	0	100	100	90-100	70-80	30-40	10-20
Turley	9-60	Clay loam, silty clay loam, loam	CL	A-6	0	100	100	90-100	60-80	30-40	10-20
Tv*:											
Turley------------	0-8	Clay loam-------	CL	A-6	0	100	100	85-100	65-80	30-40	10-20
	8-60	Clay loam, silty clay loam, loam.	CL	A-6	0	100	100	85-100	65-80	30-40	10-20
Slickspots.											
Tw*:											
Twick-------------	0-4	Cobbly silty clay loam.	CL, ML	A-6	15-50	95-100	90-100	80-100	70-90	35-40	10-20
	4-17	Clay loam, silty clay loam, clay.	MH, CL	A-7	0	100	100	95-100	70-95	40-65	20-30
	17	Weathered bedrock.	---	---	---	---	---	---	---	---	---
Silver------------	0-4	Cobbly silty clay loam.	CL	A-6, A-7	35-45	100	100	90-100	75-90	35-45	15-20
	4-60	Clay, silty clay	CL, CH	A-7	0	100	100	90-100	75-95	45-55	20-30
Wa-----------------	0-6	Loam------------	CL-ML	A-4	0	100	100	85-95	60-75	20-30	5-10
Walrees	6-30	Very fine sandy loam, loam, clay loam.	CL-ML, CL	A-4, A-6	0	100	100	85-100	50-80	25-40	5-15
	30-81	Stratified sand to cobble.	GP-GM, GM	A-1	20-45	30-40	25-40	20-30	5-15	---	NP

See footnote at end of table.

TABLE 13.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
Wr	0-6	Loam	ML	A-4	0	100	100	85-95	50-75	20-25	NP-5
Werlog	6-60	Loam, clay loam, silty clay loam	CL, CL-ML	A-4, A-6	0	100	100	85-100	60-80	20-40	5-15
	60-81	Stratified sand, gravel and cobbles.	GM, GP-GM	A-1	20-45	30-40	25-40	20-30	0-15	---	NP
Ws	0-5	Loam	CL-ML, ML	A-4	0	100	100	85-95	50-75	20-25	NP-10
Werlog	5-60	Loam, clay loam, silty clay loam.	CL, CL-ML	A-4, A-6	0	100	100	85-100	60-80	20-40	5-15
Yo	0-10	Clay loam	CL	A-6	0	100	100	90-100	75-90	35-40	15-20
Youngston	10-66	Silt loam, loam, silty clay loam.	CL, CL-ML	A-4, A-6	0	100	100	85-100	60-85	25-40	5-20

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 14.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS

[The symbol < means less than; > means more than. Entries under "Erosion factors--T" apply to the entire profile. Entries under "Wind erodibility group" and "Organic matter" apply only to the surface layer. Absence of an entry indicates that data were not available or were not estimated]

Soil name and map symbol	Depth	Clay <2mm	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Erosion factors		Wind erodibility group	Organic matter
								K	T		
	In	Pct	In/hr	In/in	pH	Mmhos/cm					Pct
Ap	0-5	30-40	0.2-0.6	0.14-0.18	7.4-8.4	2-16	Moderate	0.17	5	4	1-2
Apishapa	5-81	35-60	0.06-0.2	0.10-0.14	7.9-9.0	4-16	High	0.17			
As	0-6	40-60	0.06-0.2	0.10-0.14	7.4-8.4	2-16	High	0.17	5	4	1-2
Apishapa	6-81	35-60	0.06-0.2	0.10-0.14	7.9-9.0	4-16	High	0.17			
AT*:											
Atrac	0-3	18-27	0.2-2.0	0.13-0.19	7.4-7.8	<2	Low	0.32	5	6	---
	3-44	18-35	0.6-2.0	0.13-0.19	7.4-9.0	<2	Moderate	0.17			
	44-60	15-30	0.6-6.0	0.08-0.17	7.4-9.0	<2	Low	0.15			
Florita	0-4	15-20	2.0-6.0	0.08-0.13	7.4-7.8	<2	Low	0.24	5	3	---
	4-12	3-8	2.0-6.0	0.03-0.05	7.4-7.8	<2	Low	0.10			
	12-43	10-18	2.0-20	0.08-0.13	7.4-7.8	<2	Low	0.17			
	43-60	3-8	>20	0.03-0.05	7.4-7.8	<2	Low	0.10			
Travessilla	0-2	15-20	2.0-6.0	0.08-0.13	7.4-8.4	<2	Low	0.17	1	3	---
	2-12	15-27	2.0-6.0	0.08-0.17	7.4-8.4	<2	Low	0.20			
	12	---	---	---	---	<2	---	---			
Av	0-14	12-17	2.0-6.0	0.11-0.13	7.9-8.4	2-8	Low	0.37	3	3	.5-.8
Avalon	14-53	20-30	0.6-2.0	0.15-0.17	7.9-8.4	2-8	Low	0.43			
	53-72	15-25	2.0-6.0	0.10-0.12	7.9-8.4	2-8	Low	0.32			
Ax	0-2	12-17	2.0-6.0	0.11-0.13	7.9-8.4	2-8	Low	0.37	3	3	.5-.8
Avalon	2-80	20-30	0.6-2.0	0.15-0.17	7.9-8.4	2-8	Low	0.43			
Ay	0-18	15-25	0.6-2.0	0.16-0.18	7.9-8.4	2-8	Low	0.43	3	4L	.5-.8
Avalon	18-60	20-30	0.6-2.0	0.15-0.17	7.9-8.4	2-8	Low	0.43			
AZ*:											
Avalon	0-3	12-17	2.0-6.0	0.11-0.13	7.9-8.4	2-8	Low	0.37	3	3	---
	3-60	20-30	0.6-2.0	0.15-0.17	7.9-8.4	2-8	Low	0.43			
Sheppard	0-3	5-15	6.0-20	0.06-0.08	7.9-8.4	<2	Low	0.15	5	2	---
	3-60	5-10	6.0-20	0.06-0.08	7.9-8.4	<2	Low	0.15			
Shiprock	0-3	10-20	2.0-6.0	0.09-0.12	7.4-8.4	<2	Low	0.24	5	3	.5-.6
	3-60	10-18	2.0-6.0	0.09-0.12	7.4-9.0	<4	Low	0.24			
BA*.											
Badland											
BB*:											
Badland.											
Monierco	0-2	10-15	2.0-6.0	0.08-0.13	7.4-8.4	<2	Low	0.24	1	3	---
	2-14	18-35	0.2-0.6	0.13-0.19	7.4-9.0	<2	Moderate	0.32			
	14	---	---	---	---	---	---	---			
Rock outcrop.											
BC*:											
Badland.											
Rock outcrop.											
Persayo	0-2	27-35	0.2-0.6	0.15-0.19	7.9-9.0	<8	Moderate	0.37	1	4L	.5-1
	2-12	27-35	0.2-0.6	0.15-0.19	7.9-9.0	<8	Moderate	0.37			
	12	---	---	---	---	---	---	---			
Be	0-6	5-10	6.0-20	0.06-0.08	7.4-8.4	2-4	Low	0.20	5	2	.5-.8
Beebe	6-67	5-10	>20	0.03-0.08	7.4-8.4	2-4	Low	0.17			
	67-81	5-10	>20	0.02-0.04	7.4-8.4	2-4	Low	0.15			

See footnote at end of table.

TABLE 14.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS--Continued

Soil name and map symbol	Depth	Clay <2mm	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Erosion factors		Wind erodibility group	Organic matter
								K	T		
	In	Pct	In/hr	In/in	pH	Mmhos/cm					Pct
Bf	0-8	5-15	6.0-20	0.06-0.12	7.4-8.4	2-4	Low	0.20	5	2	.5-1
Beebe Variant	8-67	5-10	6.0-20	0.05-0.08	7.4-8.4	2-4	Low	0.20			
	67-81	5-10	6.0-20	0.03-0.06	7.4-8.4	2-4	Low	0.15			
Bk	0-11	15-25	0.6-2.0	0.14-0.17	7.9-8.4	<2	Low	0.28	3	5	.5-1
Blackston	11-27	15-30	0.6-2.0	0.07-0.10	7.9-9.0	4-8	Low	0.10			
	27-80	0-5	6.0-20	0.03-0.06	7.9-8.4	4-8	Low	0.10			
Bm	0-9	15-25	0.6-2.0	0.14-0.17	7.9-8.4	<2	Low	0.28	3	5	.5-1
Blackston	9-25	15-30	0.6-2.0	0.07-0.10	7.9-9.0	4-8	Low	0.10			
	25-60	0-10	6.0-20	0.03-0.06	7.9-8.4	4-8	Low	0.10			
BP*:											
Blackston	0-12	15-25	0.6-2.0	0.14-0.17	7.9-8.4	<2	Low	0.28	3	5	.5-1
	12-30	15-30	0.6-2.0	0.07-0.10	7.9-9.0	4-8	Low	0.10			
	30-60	0-10	6.0-20	0.03-0.06	7.9-8.4	4-8	Low	0.10			
Farb	0-7	15-20	2.0-6.0	0.08-0.13	7.4-8.4	<2	Low	0.32	1	3	---
	7-10	10-20	2.0-6.0	0.06-0.13	7.4-8.4	<2	Low	0.28			
	10	---	---	---	---	---	---	---			
BR*:											
Blancot	0-6	15-26	0.2-2.0	0.13-0.19	7.9-8.4	<2	Low	0.32	5	6	---
	6-60	20-35	0.6-2.0	0.13-0.19	7.9-9.0	<4	Moderate	0.28			
Fruitland	0-8	5-10	2.0-6.0	0.11-0.13	7.4-8.4	<4	Low	0.24	5	3	.6-.8
	8-60	5-18	2.0-6.0	0.11-0.13	7.4-8.4	<4	Low	0.28			
BT*:											
Blancot	0-2	15-26	0.2-2.0	0.13-0.19	7.9-8.4	<2	Low	0.32	5	6	---
	2-60	20-35	0.6-2.0	0.13-0.19	7.9-9.0	<4	Moderate	0.28			
Notal	0-3	28-35	0.2-0.6	0.15-0.19	7.9-9.0	4-8	Moderate	0.32	5	4L	---
	3-60	40-50	<0.06	0.13-0.19	7.9-9.0	4-8	High	0.43			
BU	0-5	18-27	0.6-2.0	0.13-0.19	7.4-8.4	<2	Low	0.37	5	6	---
Buckle	5-44	25-35	0.2-0.6	0.15-0.19	7.9-9.0	<2	Moderate	0.37			
	44-66	20-35	0.6-2.0	0.13-0.19	7.9-9.0	<2	Moderate	0.37			
Da	0-6	15-27	0.6-2.0	0.15-0.17	7.4-8.4	<2	Low	0.37	5	5	.5-.6
Doak	6-60	25-35	0.2-0.6	0.15-0.18	7.4-9.0	2-4	Moderate	0.37			
Db	0-4	15-27	0.6-2.0	0.15-0.17	7.4-8.4	<2	Low	0.37	5	5	.5-.6
Doak	4-60	25-35	0.2-0.6	0.15-0.18	7.4-9.0	2-4	Moderate	0.37			
Dc	0-3	15-27	0.6-2.0	0.15-0.17	7.4-8.4	<2	Low	0.37	5	5	.5-.6
Doak	3-60	25-35	0.2-0.6	0.15-0.18	7.4-9.0	2-4	Moderate	0.37			
Dd	0-5	27-30	0.2-0.6	0.15-0.18	7.4-8.4	<2	Moderate	0.32	5	6	.5-.6
Doak	5-60	25-35	0.2-0.6	0.15-0.18	7.4-9.0	2-4	Moderate	0.37			
DN*:											
Doak	0-5	15-27	0.6-2.0	0.15-0.17	7.4-8.4	<2	Low	0.37	5	5	.5-.6
	5-69	25-35	0.2-0.6	0.15-0.18	7.4-9.0	2-4	Moderate	0.37			
Avalon	0-14	20-27	0.6-2.0	0.16-0.18	7.9-8.4	2-8	Low	0.43	3	4L	---
	14-60	20-27	0.6-2.0	0.15-0.17	7.9-8.4	2-8	Low	0.43			
DS*:											
Doak	0-3	15-27	0.6-2.0	0.15-0.17	7.4-8.4	<2	Low	0.37	5	5	.5-.6
	3-60	25-35	0.2-0.6	0.15-0.18	7.4-9.0	2-4	Moderate	0.37			
Sheppard	0-3	5-10	6.0-20	0.06-0.08	7.9-8.4	<2	Low	0.15	5	2	---
	3-60	5-10	6.0-20	0.06-0.08	7.9-8.4	<2	Low	0.15			
Shiprock	0-3	10-20	2.0-6.0	0.09-0.12	7.4-8.4	<2	Low	0.24	5	3	.5-.6
	3-60	10-18	2.0-6.0	0.09-0.12	7.4-9.0	<4	Low	0.24			

See footnote at end of table.

TABLE 14.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS--Continued

Soil name and map symbol	Depth	Clay <2mm	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Erosion factors		Wind erodibility group	Organic matter
								K	T		
	In	Pct	In/hr	In/in	pH	Mmhos/cm					Pct
Du*:											
Doak----------	0-5	18-20	0.6-2.0	0.13-0.17	7.4-8.4	<2	Low--------	0.37	5	3	.5-.6
	5-19	18-35	0.2-0.6	0.13-0.19	7.4-9.0	<2	Moderate	0.32			
	19-60	18-35	0.2-0.6	0.13-0.19	7.9-9.0	2-4	Moderate	0.37			
Uffens----------	0-6	10-20	0.6-6.0	0.08-0.14	7.4-8.4	4-8	Low--------	0.20	1	3	---
	6-18	25-35	0.2-0.6	0.05-0.10	>7.8	>16	Moderate	0.32			
	18-60	20-30	0.2-0.6	0.05-0.10	>7.8	>16	Moderate	0.28			
Dw*:											
Doak----------	0-3	18-20	0.6-2.0	0.13-0.17	7.4-8.4	<2	Low--------	0.37	5	3	.5-.6
	3-15	18-35	0.2-0.6	0.13-0.19	7.4-9.0	<2	Moderate	0.32			
	15-60	18-35	0.2-0.6	0.13-0.19	7.9-9.0	2-4	Moderate	0.37			
Uffens----------	0-4	10-20	0.6-6.0	0.08-0.14	7.4-8.4	4-8	Low--------	0.20	1	3	---
	4-22	25-35	0.2-0.6	0.05-0.10	>7.8	>16	Moderate	0.32			
	22-60	20-30	0.2-0.6	0.05-0.10	>7.8	>16	Moderate	0.28			
DZ*.											
Dune land											
FA*:											
Faro----------	0-7	15-20	2.0-6.0	0.08-0.13	7.4-8.4	<2	Low--------	0.32	1	3	---
	7-10	10-20	2.0-6.0	0.06-0.13	7.4-8.4	<2	Low--------	0.28			
	10	---	---	---	---	---	----------	----			
Persayo---------	0-2	28-35	0.2-0.6	0.15-0.19	7.9-9.0	<8	Moderate	0.37	1	4L	.5-1
	2-15	28-35	0.2-0.6	0.15-0.19	7.9-9.0	<8	Moderate	0.37			
	15	---	---	---	---	---	----------	----			
Rock outcrop.											
FP*.											
Fluvaquents											
Fr----------	0-7	5-10	2.0-6.0	0.11-0.13	7.4-8.4	<4	Low--------	0.24	5	3	.6-.8
Fruitland	7-60	5-18	2.0-6.0	0.11-0.13	7.4-8.4	<4	Low--------	0.28			
Fs----------	0-6	5-10	2.0-6.0	0.11-0.13	7.4-8.4	<4	Low--------	0.24	5	3	.6-.8
Fruitland	6-60	5-18	2.0-6.0	0.11-0.13	7.4-8.4	<4	Low--------	0.28			
Ft----------	0-6	10-18	2.0-6.0	0.08-0.13	7.4-8.4	2-4	Low--------	0.24	5	3	.5-.8
Fruitland	6-60	10-20	2.0-6.0	0.08-0.13	7.4-8.4	2-4	Low--------	0.28			
Fu----------	0-8	10-25	0.6-2.0	0.15-0.17	7.4-8.4	<4	Low--------	0.28	5	5	.6-.8
Fruitland	8-60	5-18	2.0-6.0	0.11-0.13	7.4-8.4	<4	Low--------	0.28			
Fw----------	0-3	10-25	0.6-2.0	0.15-0.17	7.4-8.4	<4	Low--------	0.28	5	5	.6-.8
Fruitland	3-60	5-18	2.0-6.0	0.11-0.13	7.4-8.4	<4	Low--------	0.28			
FX*:											
Fruitland-------	0-4	5-10	2.0-6.0	0.11-0.13	7.4-8.4	<4	Low--------	0.24	5	3	.6-.8
	4-60	5-18	2.0-6.0	0.11-0.13	7.4-8.4	<4	Low--------	0.28			
Persayo---------	0-2	28-35	0.2-0.6	0.15-0.19	7.9-9.0	<8	Moderate	0.37	1	4L	.5-1
	2-18	18-35	0.2-0.6	0.15-0.19	7.9-9.0	<8	Moderate	0.37			
	18	---	---	---	---	---	----------	----			
Sheppard--------	0-4	5-10	6.0-20	0.06-0.08	7.9-8.4	<2	Low--------	0.15	5	2	---
	4-60	5-10	6.0-20	0.06-0.08	7.9-8.4	<2	Low--------	0.15			
Fy*:											
Fruitland-------	0-9	5-10	2.0-6.0	0.11-0.13	7.4-8.4	<4	Low--------	0.24	5	3	.6-.8
	9-60	5-18	2.0-6.0	0.11-0.13	7.4-8.4	<4	Low--------	0.28			
Slickspots.											

See footnote at end of table.

TABLE 14.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS--Continued

Soil name and map symbol	Depth	Clay <2mm	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Erosion factors		Wind erodibility group	Organic matter
								K	T		
	In	Pct	In/hr	In/in	pH	Mmhos/cm					Pct
Ga	0-4	18-25	0.6-2.0	0.16-0.18	7.4-8.4	2-4	Low	0.32	4	6	.5-.8
Garland	4-24	20-30	0.6-2.0	0.19-0.21	7.4-9.0	2-4	Moderate	0.28			
	24-60	5-15	>6.0	0.03-0.05	7.9-8.4	<2	Low	0.10			
Gr	0-6	10-18	2.0-6.0	0.08-0.12	7.9-8.4	2-8	Low	0.24	5	3	.5-.8
Green River	6-60	15-18	0.6-2.0	0.09-0.12	7.9-8.4	2-8	Low	0.28			
GY*:											
Gypsiorthids.											
Badland.											
Stumble	0-8	0-10	6.0-20	0.06-0.08	7.9-8.4	<2	Low	0.17	5	2	---
	8-60	0-10	6.0-20	0.06-0.08	7.9-9.0	<4	Low	0.15			
HA*:											
Haplargids.											
Blackston	0-11	18-27	2.0-6.0	0.07-0.13	7.9-8.4	2-4	Low	0.17	1	5	---
	11-28	15-30	0.2-0.6	0.08-0.13	8.5-9.0	<2	Low	0.17			
	28-60	5-15	6.0-20	0.05-0.07	7.9-8.4	<2	Low	0.15			
Torriorthents.											
HU*:											
Huerfano	0-1	20-25	0.6-2.0	0.15-0.17	7.9-9.0	>4	Moderate	0.32	1	4L	---
	1-15	20-35	0.2-0.6	0.15-0.19	>7.8	>4	Moderate	0.32			
	15	---	---	---	---	---	---	---			
Muff	0-4	10-20	0.6-2.0	0.15-0.17	7.4-8.4	2-4	Low	0.28	3	3	---
	4-24	25-30	0.06-0.2	0.14-0.16	>7.8	4-8	Moderate	0.24			
	24	---	---	---	---	---	---	---			
Uffens	0-9	10-20	0.6-6.0	0.08-0.14	7.4-8.4	4-8	Low	0.20	1	3	---
	9-20	25-35	0.2-0.6	0.05-0.10	>7.9	>16	Moderate	0.32			
	20-60	20-30	0.2-0.6	0.05-0.10	>7.9	>16	Moderate	0.28			
Ma	0-4	5-10	6.0-20.0	0.06-0.10	7.9-8.4	<2	Low	0.24	5	2	<.5
Mayqueen	4-16	7-17	2.0-6.0	0.10-0.14	7.9-8.4	<2	Low	0.28			
	16-60	5-10	6.0-20.0	0.07-0.10	7.9-8.4	<2	Low	0.24			
MO	0-5	10-20	2.0-6.0	0.08-0.13	7.4-8.4	<2	Low	0.24	1	3	---
Monierco	5-16	18-35	0.2-0.6	0.13-0.19	7.4-9.0	<2	Moderate	0.32			
	16	---	---	---	---	---	---	---			
PO	0-2	10-20	0.6-2.0	0.13-0.15	6.6-8.4	<2	Low	0.24	5	3	.5-.9
Penistaja	2-67	20-30	0.6-2.0	0.15-0.18	6.6-8.4	<2	Moderate	0.32			
PP*:											
Penistaja	0-3	10-20	0.6-2.0	0.13-0.15	6.6-8.4	<2	Low	0.24	5	3	.5-.9
	3-60	20-30	0.6-2.0	0.15-0.18	6.6-8.4	<2	Moderate	0.32			
Buckle	0-13	18-27	0.6-2.0	0.13-0.19	7.4-8.4	<2	Low	0.37	5	6	---
	13-47	27-35	0.2-0.6	0.15-0.19	7.9-9.0	<2	Moderate	0.37			
	47-66	20-35	0.6-2.0	0.13-0.19	7.9-9.0	<2	Moderate	0.37			
PT*:											
Penistaja	0-3	10-20	0.6-2.0	0.13-0.15	6.6-8.4	<2	Low	0.24	5	3	.5-.9
	3-60	20-30	0.6-2.0	0.15-0.18	6.6-8.4	<2	Moderate	0.32			
Travessilla	0-2	15-20	0.6-2.0	0.13-0.17	7.4-8.4	<2	Low	0.24	1	3	---
	2-12	15-27	2.0-6.0	0.08-0.17	7.4-8.4	<2	Low	0.20			
	12	---	---	---	---	<2	---	---			
PX*.											
Pits											

See footnote at end of table.

TABLE 14.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS--Continued

Soil name and map symbol	Deptn	Clay <2mm	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Erosion factors		Wind erodibility group	Organic matter
								K	T		
	In	Pct	In/hr	In/in	pH	Mmhos/cm					Pct
RA*. Riverwash											
RO*. Rock outcrop											
RT*: Rock outcrop.											
Travessilla-----	0-1	15-20	2.0-6.0	0.08-0.13	7.4-8.4	<2	Low--------	0.17	1	3	---
	1-9	15-27	2.0-6.0	0.08-0.17	7.4-8.4	<2	Low--------	0.20			
	9	---	---	---	---	<2	----------	----			
Weska-----------	0-1	28-35	0.2-0.6	0.19-0.21	7.9-8.4	<2	Moderate	0.32	1	6	---
	1-7	28-35	0.2-0.6	0.19-0.21	7.9-8.4	<2	Moderate	0.32			
	7	---	---	---	---	---	----------	----			
SB*:											
Sheppard--------	0-2	5-10	6.0-20	0.06-0.08	7.9-8.4	<2	Low--------	0.15	5	2	---
	2-60	5-10	6.0-20	0.06-0.08	7.9-8.4	<2	Low--------	0.15			
Badland.											
SC*:											
Sheppard--------	0-5	5-10	6.0-20	0.06-0.08	7.9-8.4	<2	Low--------	0.15	5	2	---
	5-60	5-10	6.0-20	0.06-0.08	7.9-8.4	<2	Low--------	0.15			
Huerfano--------	0-1	20-25	0.6-2.0	0.15-0.17	7.9-9.0	>4	Moderate	0.32	1	4L	---
	1-15	20-35	0.2-0.6	0.15-0.19	>7.8	>4	Moderate	0.32			
	15	---	---	---	---	---	----------	----			
Total-----------	0-3	28-35	0.2-0.6	0.15-0.19	7.9-9.0	4-8	Moderate	0.32	5	4L	---
	3-60	40-50	<0.06	0.13-0.19	7.9-9.0	4-8	High-------	0.43			
Sc*:											
Sheppard--------	0-1	5-10	6.0-20	0.06-0.08	7.9-8.4	<2	Low--------	0.15	5	2	<.5
	1-62	5-10	6.0-20	0.06-0.08	7.9-8.4	<2	Low--------	0.15			
Mayqueen--------	0-3	5-10	6.0-20.0	0.06-0.10	7.9-8.4	<2	Low--------	0.24	5	2	<.5
	3-12	7-17	2.0-6.0	0.10-0.14	7.9-8.4	<2	Low--------	0.28			
	12-60	5-10	6.0-20.0	0.07-0.10	7.9-8.4	<2	Low--------	0.24			
Shiprock--------	0-1	10-20	2.0-6.0	0.09-0.12	7.4-8.4	<2	Low--------	0.24	5	3	.5-.6
	1-60	10-18	2.0-6.0	0.09-0.12	7.4-9.0	<4	Low--------	0.24			
Sh----------	0-10	10-15	6.0-20	0.06-0.09	7.4-8.4	<2	Low--------	0.15	5	2	.5-.6
Shiprock	10-60	10-18	2.0-6.0	0.09-0.12	7.4-9.0	<4	Low--------	0.24			
Sk----------	0-9	10-15	6.0-20	0.06-0.09	7.4-8.4	<2	Low--------	0.15	5	2	.5-.6
Shiprock	9-60	10-18	2.0-6.0	0.09-0.12	7.4-9.0	<4	Low--------	0.24			
Sm----------	0-2	10-20	2.0-6.0	0.09-0.12	7.4-8.4	<2	Low--------	0.24	5	3	.5-.6
Shiprock	2-60	10-18	2.0-6.0	0.09-0.12	7.4-9.0	<4	Low--------	0.24			
So----------	0-4	10-20	2.0-6.0	0.09-0.12	7.4-8.4	<2	Low--------	0.24	5	3	.5-.6
Shiprock	4-60	10-18	2.0-6.0	0.09-0.12	7.4-9.0	<4	Low--------	0.24			
Sp----------	0-3	10-20	2.0-6.0	0.09-0.12	7.4-8.4	<2	Low--------	0.24	5	3	.5-.6
Shiprock	3-60	10-18	2.0-6.0	0.09-0.12	7.4-9.0	<4	Low--------	0.24			
Sr----------	0-8	10-18	2.0-6.0	0.08-0.13	7.9-8.4	<2	Low--------	0.24	5	3	<.5
Shiprock	8-24	18-28	2.0-6.0	0.12-0.17	7.9-9.0	<2	Low--------	0.28			
Variant	24-48	15-28	0.6-2.0	0.08-0.17	7.9-9.0	<4	Low--------	0.24			
	48-68	10-18	2.0-6.0	0.06-0.13	7.9-9.0	<4	Low--------	0.20			

See footnote at end of table.

TABLE 14.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS--Continued

Soil name and map symbol	Depth	Clay <2mm	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Erosion factors		Wind erodibility group	Organic matter
								K	T		
	In	Pct	In/hr	In/in	pH	Mmhos/cm					Pct
St	0-5	0-10	6.0-20	0.06-0.08	7.9-8.4	<2	Low	0.17	5	2	<.5
Stumble	5-29	0-10	6.0-20	0.06-0.08	7.9-9.0	<4	Low	0.15			
	29-49	0-5	6.0-20	0.04-0.06	7.9-9.0	<4	Low	0.10			
	49-81	0-10	6.0-20	0.06-0.06	7.9-9.0	<4	Low	0.15			
Su	0-5	0-10	6.0-20	0.06-0.08	7.9-8.4	<2	Low	0.17	5	2	<.5
Stumble	5-81	0-10	6.0-20	0.06-0.08	7.9-9.0	<4	Low	0.15			
SV	0-7	20-27	0.6-2.0	0.13-0.17	7.9-8.4	<2	Low	0.24	5	5	<.5
Stumble	7-60	0-10	6.0-20	0.06-0.08	7.9-9.0	<4	Low	0.15			
SW*:											
Stumble	0-6	0-10	6.0-20	0.06-0.08	7.9-8.4	<2	Low	0.17	5	2	---
	6-29	0-10	6.0-20	0.06-0.08	7.9-9.0	<4	Low	0.15			
	29-60	0-5	6.0-20	0.04-0.06	7.9-9.0	<4	Low	0.10			
Fruitland	0-7	5-10	2.0-6.0	0.11-0.13	7.4-8.4	<4	Low	0.24	5	3	.6-.8
	7-60	5-18	2.0-6.0	0.11-0.13	7.4-8.4	<4	Low	0.28			
SX*:											
Stumble	0-3	0-10	6.0-20	0.06-0.08	7.9-8.4	<2	Low	0.17	5	2	---
	3-60	0-10	6.0-20	0.06-0.08	7.9-9.0	<4	Low	0.15			
Notal	0-24	28-35	0.2-0.6	0.15-0.19	7.9-9.0	4-8	Moderate	0.32	5	4L	---
	24-60	40-50	<0.06	0.13-0.19	7.9-9.0	4-8	High	0.43			
SZ*:											
Stumble	0-4	0-10	6.0-20	0.06-0.08	7.9-8.4	<2	Low	0.17	5	2	<.5
	4-60	0-10	6.0-20	0.06-0.08	7.9-9.0	<4	Low	0.15			
Slickspots.											
TA*:											
Travessilla	0-2	15-20	2.0-6.0	0.08-0.13	7.4-8.4	<2	Low	0.17	1	3	---
	2-12	15-27	2.0-6.0	0.08-0.17	7.4-8.4	<2	Low	0.20			
	12	---	---	---	---	<2	---	---			
Weska	0-1	28-35	0.2-0.6	0.19-0.21	7.9-8.4	<2	Moderate	0.32	1	6	---
	1-9	28-35	0.2-0.6	0.19-0.21	7.9-8.4	<2	Moderate	0.32			
	9	---	---	---	---	---	---	---			
Rock outcrop.											
Tp	0-3	28-35	0.2-0.6	0.18-0.20	7.4-9.0	2-4	Moderate	0.28	5	4L	.5-.8
Turley	3-80	25-35	0.2-0.6	0.18-0.20	7.4-9.0	2-4	Moderate	0.28			
Tr	0-9	28-35	0.2-0.6	0.18-0.20	7.4-9.0	2-4	Moderate	0.28	5	4L	.5-.8
Turley	9-60	25-35	0.2-0.6	0.18-0.20	7.4-9.0	2-4	Moderate	0.28			
Ts	0-4	28-35	0.2-0.6	0.18-0.20	7.4-9.0	2-4	Moderate	0.28	5	4L	.5-.8
Turley	4-60	25-35	0.2-0.6	0.18-0.20	7.4-9.0	2-4	Moderate	0.28			
Tt	0-9	28-35	0.2-0.6	0.15-0.19	7.4-8.4	2-4	Moderate	0.28	5	4L	.5-.8
Turley	9-60	25-35	0.2-0.6	0.15-0.19	7.4-9.0	2-4	Moderate	0.28			
Tv*:											
Turley	0-8	28-35	0.2-0.6	0.18-0.20	7.4-9.0	2-4	Moderate	0.28	5	4L	.5-.8
	8-60	25-35	0.2-0.6	0.18-0.20	7.4-9.0	2-4	Moderate	0.28			
Slickspots.											
Tw*:											
Twick	0-4	28-35	0.2-0.6	0.15-0.19	7.4-8.4	2-4	Low	0.20	1	8	---
	4-17	35-60	0.06-0.2	0.13-0.17	7.4-8.4	2-4	High	0.28			
	17	---	---	---	---	---	---	---			
Silver	0-4	30-40	0.2-0.6	0.14-0.16	7.9-8.4	<2	Moderate	0.28	5	8	---
	4-60	40-50	0.06-0.2	0.14-0.17	7.9-8.4	<2	High	0.28			

See footnote at end of table.

TABLE 14.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS--Continued

Soil name and map symbol	Depth	Clay <2mm	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Erosion factors		Wind erodibility group	Organic matter
								K	T		
	In	Pct	In/hr	In/in	pH	Mmhos/cm					Pct
Wa	0-6	18-27	0.6-2.0	0.13-0.17	7.9-9.0	2-8	Low	0.24	2	4L	1-2
Walrees	6-30	15-35	0.2-0.6	0.13-0.19	7.9-9.0	2-8	Low	0.15			
	30-81	0-10	>20	0.07-0.13	7.9-9.0	<2	Low	----			
Wr	0-6	18-27	0.6-2.0	0.13-0.17	7.9-9.0	2-4	Low	0.37	5	8	.9-1
Werlog	6-60	18-35	0.2-0.6	0.15-0.19	7.9-9.0	2-4	Moderate	0.32			
	60-81	0-10	>20	0.03-0.06	7.9-9.0	2-4	Low	0.10			
Ws	0-6	10-20	0.6-2.0	0.13-0.17	7.9-9.0	4-8	Low	0.37	5	5	.7-.9
Werlog	6-60	25-35	0.2-0.6	0.15-0.19	7.9-9.0	4-8	Low	0.32			
Yo	0-10	28-35	0.2-0.6	0.19-0.21	7.9-8.4	2-4	Moderate	0.32	5	4L	.6-.9
Youngston	10-66	18-35	0.2-0.6	0.16-0.19	7.9-8.4	2-4	Moderate	0.32			

* See description of the map unit for composition and behavior characteristics of the map unit.

Groundwater Chemistry of Two Dry Gas Well Sites

FCGPA Exhibit 8 for the May 21, 1992 Continuation of the April 9, 1992, New Mexico Oil Conservation Commission Hearing on Case Number 10436

May 21, 1992

Prepared for:

The Four Corners Gas Producers Association

Prepared by:

H^+GCL

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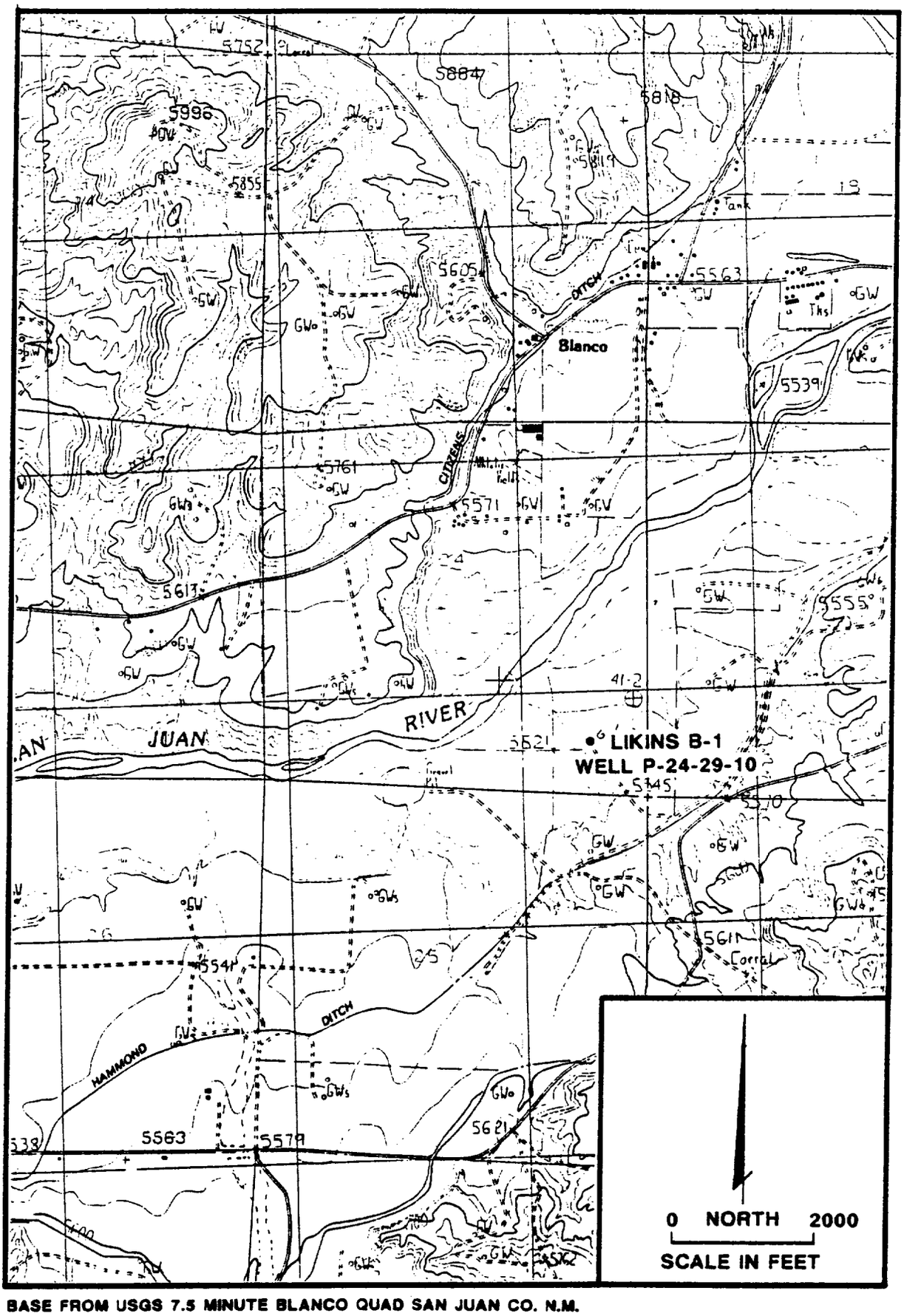
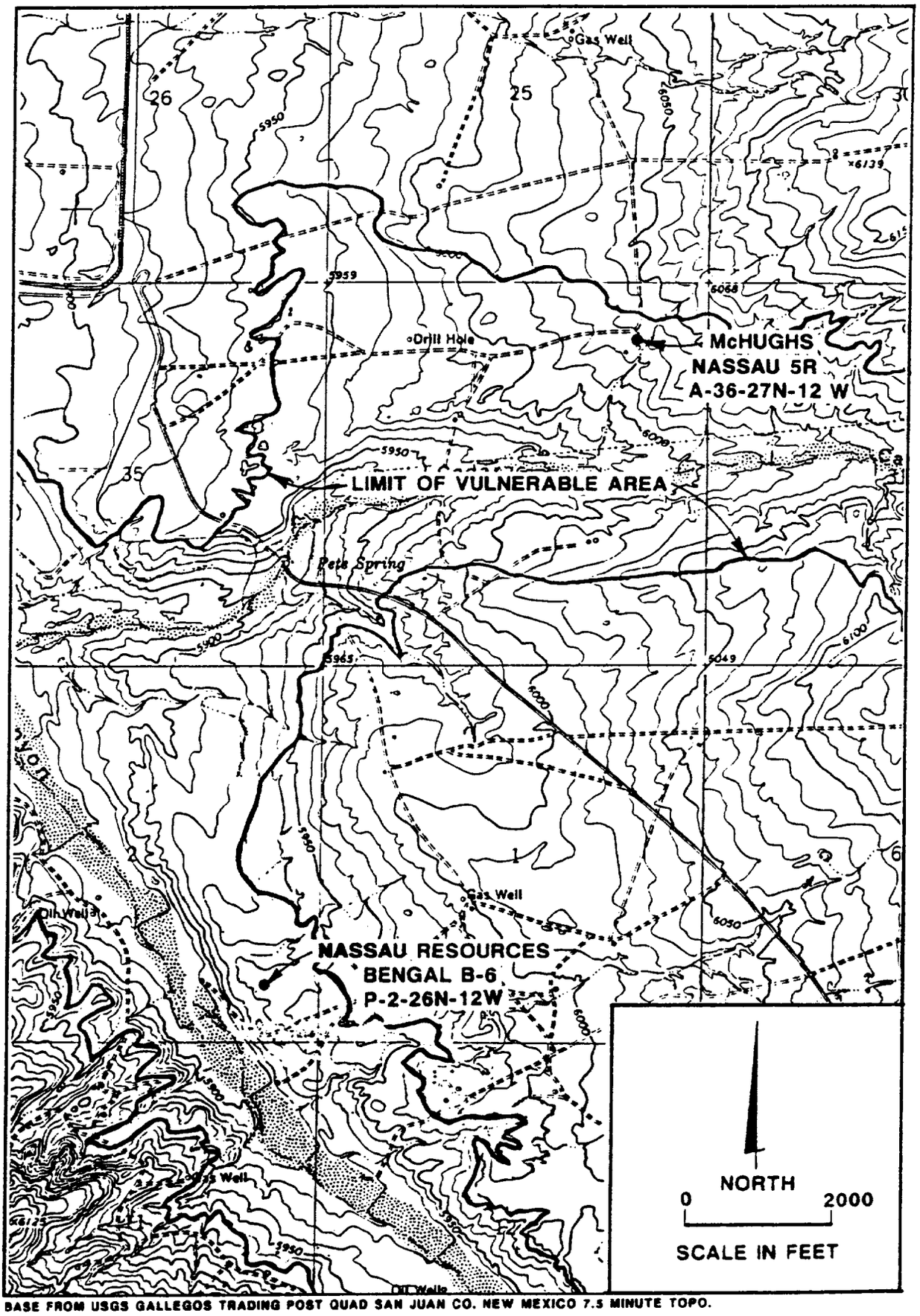
Groundwater Chemistry of
Two Dry Gas Well Sites

Well Name	Sample Number	Benzene ug/kg	Toluene ug/kg	Ethylbenzene ug/kg	Total Xylenes ug/kg
Likins B-1	9205070915	ND	ND	ND	ND
Bengal #6	9205131710	ND	1.4	ND	ND

54101/EXHIBIT8.WQ1



BASE FROM USGS 7.5 MINUTE BLANCO QUAD SAN JUAN CO. N.M.



BASE FROM USGS GALLEGOS TRADING POST QUAD SAN JUAN CO. NEW MEXICO 7.5 MINUTE TOPO.

FCGPA Exhibit 9 and Exhibit 10 for the May 21, 1992 Continuation of the April 9, 1992, New Mexico Oil Conservation Commission Hearing on Case Number 10436

May 21, 1992

Prepared for:

The Four Corners Gas Producers Association

Prepared by:

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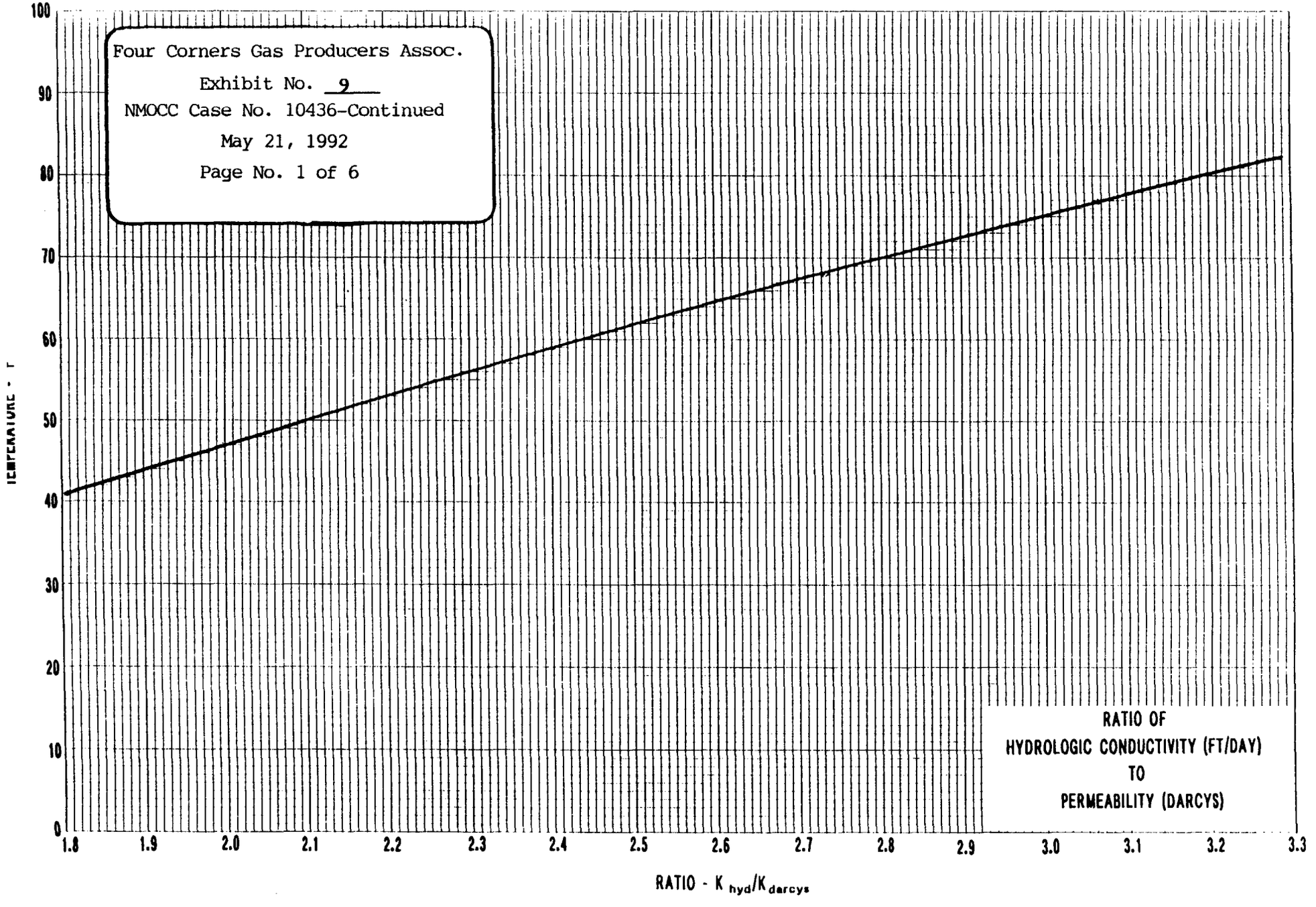

Four Corners Gas Producers Assoc.
Exhibit No. 9
NMOCC Case No. 10436-Continued
May 21, 1992
Page No. 1 of 6
100
90
80
70
60
50
40
30
20
10
0
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
3.0
3.1
3.2
3.3
RATIO - K hyd/K darcys
RATIO OF
HYDROLOGIC CONDUCTIVITY (FT/DAY)
TO
PERMEABILITY (DARCYS)

COMPARISON OF CONDUCTIVITY IN FEET/DAY WITH PERMEABILITY IN DARCYS

By definition:

Permeability or conductivity = $\frac{Q}{A}\ \frac{L}{\Delta P}$ (1)

Where Q = Volume rate per time
A = Area
L = Distance
ΔP = Differential pressure

For conductivity in feet/day (at the viscosity and density of the flowing fluid):

Q must be cf/day
A must be square feet
ΔP is in hydraulic head, H
L is in units consistent with H

which gives the following dimensions:

Hydrologic conductivity, $K_{H\ CON} = Ft^3/day \div Ft^2 \times Ft/Ft = Ft/day$

For permeability in darcys and using oil field units:

$$K = \frac{Q\ \mu\ L}{1.127\ A\ \Delta\ P} \quad (2)$$

(Reference Craft and Hawkins attached)

Where K = darcys
Q = barrels/day
A = square feet
L = feet
ΔP = psi
μ = viscosity, cp

In Equation (2), at temperature of 68° (viscosity = 1 cp) and substituting:

$\frac{Ft^3}{5.6146}$ for Q & .4328 H for psi, where H is fluid "head" in feet

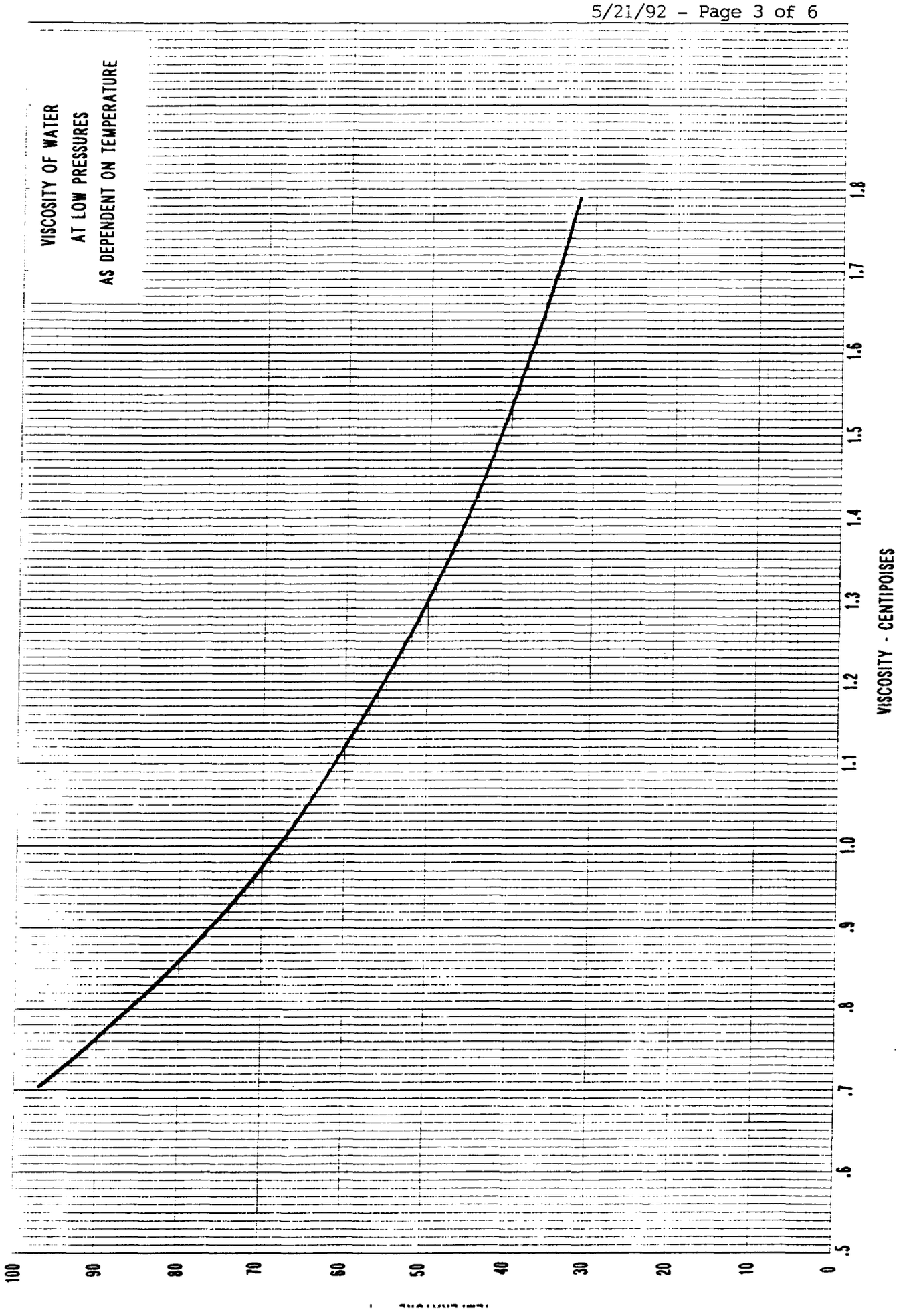
Then $K_{darcys} = 2.7328\ \frac{Q}{A}\ \frac{L}{H}$ (3)

and ratio of Equation (2) to Equation (3):

$$\frac{K_{H\ CON}}{K_{darcys}} = 2.7328 \text{ (at } 68^\circ \text{ F)}$$

For ratio at another temperature, T:

$$\frac{K_{H\ CON}}{K_{darcys}} = 2.7328 \times \frac{\text{Viscosity at } 68^\circ}{\text{Viscosity at T}} \times \frac{\text{Density at T}}{\text{Density at } 68^\circ}$$


VISCOSITY OF WATER
AT LOW PRESSURES
AS DEPENDENT ON TEMPERATURE
VISCOSITY - CENTIPOISES
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
.9
.8
.7
.6
.5
100
90
80
70
60
50
40
30
20
10
0

THE VISCOSITY OF WATER 0°C TO 100°C

Contribution from the National Bureau of Standards, not subject to copyright.

°C	η(cp)	°C	η(cp)	°C	η(cp)	°C	η(cp)
0	1.787	26	0.8705	52	0.5290	78	0.3638
1	1.728	27	.8513	53	.5204	79	.3592
2	1.671	28	.8327	54	.5121	80	.3547
3	1.618	29	.8148	55	.5040	81	.3503
4	1.567	30	.7975	56	.4961	82	.3460
5	1.519	31	.7808	57	.4884	83	.3418
6	1.472	32	.7647	58	.4809	84	.3377
7	1.428	33	.7491	59	.4736	85	.3337
8	1.386	34	.7340	60	.4665	86	.3297
9	1.346	35	.7194	61	.4596	87	.3259
10	1.307	36	.7052	62	.4528	88	.3221
11	1.271	37	.6915	63	.4462	89	.3184
12	1.235	38	.6783	64	.4398	90	.3147
13	1.202	39	.6654	65	.4335	91	.3111
14	1.169	40	.6529	66	.4273	92	.3076
15	1.139	41	.6408	67	.4213	93	.3042
16	1.109	42	.6291	68	.4155	94	.3008
17	1.081	43	.6178	69	.4098	95	.2975
18	1.053	44	.6067	70	.4042	96	.2942
19	1.027	45	.5960	71	.3987	97	.2911
20	1.002	46	.5856	72	.3934	98	.2879
21	0.9779	47	.5755	73	.3882	99	.2848
22	.9548	48	.5656	74	.3831	100	.2818
23	.9325	49	.5561	75	.3781		
24	.9111	50	.5468	76	.3732		
25	.8904	51	.5378	77	.3684		

The above table was calculated from the following empirical relationships derived from measurements in viscometers calibrated with water at 20°C (and one atmosphere), modified to agree with the currently accepted value for the viscosity at 20° of 1.002 cp:

$$0° \text{ to } 20°C: \log_{10} \eta_T = \frac{1301}{998.333 + 8.1855(T-20) + 0.00585(T-20)^2} - 3.30233$$

(R. C. Hardy and R. L. Cottington, J.Res.NBS 42, 573 (1949).)

$$20° \text{ to } 100°C: \log_{10} \frac{\eta_T}{\eta_{20}} = \frac{1.3272(20-T) - 0.001053(T-20)^2}{T + 105}$$

(J. F. Swindells, NBS, unpublished results.)

TAKEN FROM CRC HANDBOOK OF CHEMISTRY AND PHYSICS,

BY ROBERT C. WEAST, 58TH EDITION, 1977-1978, PAGE F-51

Specific Gravity and Density of Water at Atmospheric Pressure
(Weights are in vacuo)

Temp, °C	Specific gravity	Density, lb/ft³	Density, kg/m³	Temp, °C	Specific gravity	Density, lb/ft³	Density, kg/m³
0	0.99987	62.4183	999.845	40	0.99224	61.9428	992.228
2	0.99997	62.4246	999.946	42	0.99147	61.894	991.447
4	1.00000	62.4266	999.955	44	0.99066	61.844	990.647
6	0.99997	62.4246	999.946	46	0.98982	61.791	989.797
8	0.99988	62.4189	999.854	48	0.98896	61.737	988.931
10	0.99973	62.4096	999.706	50	0.98807	61.682	988.050
12	0.99952	62.3969	999.502	52	0.98715	61.624	987.121
14	0.99927	62.3811	999.272	54	0.98621	61.566	986.192
16	0.99897	62.3623	998.948	56	0.98524	61.505	985.215
18	0.99862	62.3407	998.602	58	0.98425	61.443	984.222
20	0.99823	62.3164	998.213	60	0.98324	61.380	983.213
22	0.99780	62.2894	997.780	62	0.98220	61.315	982.172
24	0.99732	62.2598	997.304	64	0.98113	61.249	981.113
26	0.99681	62.2278	996.793	66	0.98005	61.181	980.025
28	0.99626	62.1934	996.242	68	0.97894	61.112	978.920
30	0.99567	62.1568	995.656	70	0.97781	61.041	977.783
32	0.99505	62.1179	995.033	72	0.97666	60.970	976.645
34	0.99440	62.0770	994.378	74	0.97548	60.896	975.460
36	0.99371	62.0341	993.691	76	0.97428	60.821	974.259
38	0.99299	61.9893	992.973	78	0.97307	60.745	973.041

TAKEN FROM STANDARD HANDBOOK FOR MECHANICAL ENGINEERS,

BY BAUMEISTER, AVILONE, BAUMEISTER, EIGHTH EDITION, PAGE 6-10.

necessary. In general, then, steady-state mechanics will suffice where the readjustment time is small compared with the time between substantial changes in the flow rate, or, in the case of reservoirs, small compared with the total producing life(time) of the reservoir.

5. Linear Flow of Incompressible Fluids, Steady-State. Figure 6.12 represents linear flow through a body of constant cross section, where both ends are entirely open to flow, and where no flow crosses the sides, top

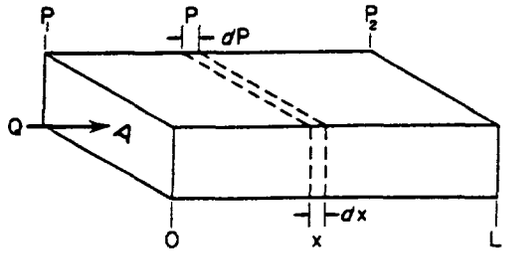


Fig. 6.12.

or bottom. If the fluid is incompressible, or essentially so for all engineering purposes, then the velocity is the same at all points, as is the total flow rate across any cross section, so that,

$$v = \frac{q}{A} = -1.127 \frac{k}{\mu} \frac{dp}{dx}$$

Separating variables and integrating over the length of the porous body,

$$\frac{q}{A} \int_0^L dx = -1.127 \frac{k}{\mu} \int_{p_1}^{p_2} dp$$

$$q = \frac{1.127\, kA(p_1 - p_2)}{\mu L} \tag{6.14}$$

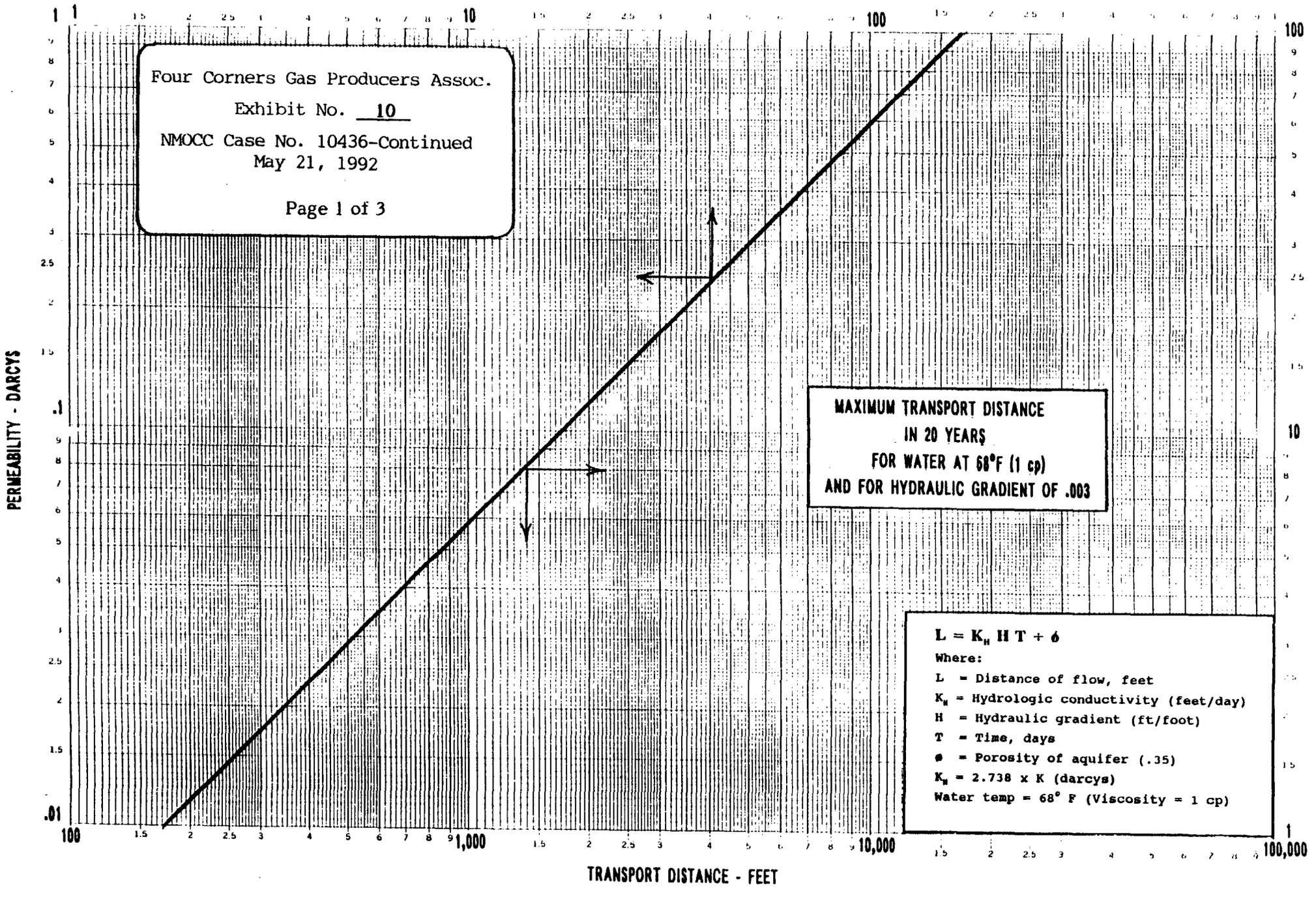
For example, under a pressure differential of 100 psi for a permeability of 250 md, a fluid viscosity of 2.5 cp, a length of 450 feet, and a cross-sectional area of 45 square feet, the flow rate will be

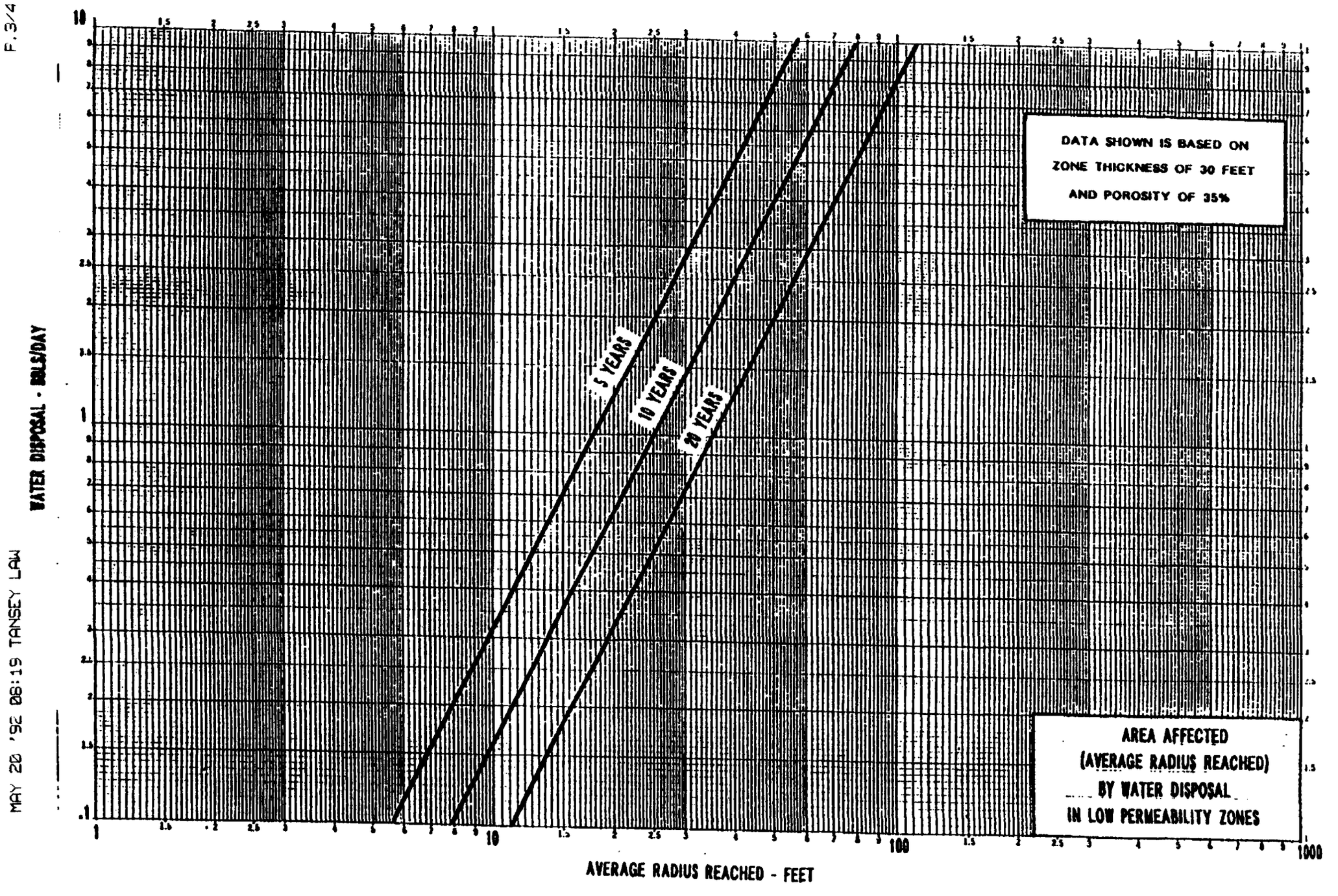
$$q = \frac{1.127 \times 0.25 \times 45 \times 100}{2.5 \times 450} = 1.127 \text{ bbl/day}$$

In this integration q, μ, and k have been removed from the integral sign, assuming they are invariant with pressure. Actually, for flow above the bubble point, the volume, and hence the rate of flow, will vary with the pressure as expressed by Eq. (6.6). The viscosity of the oil also varies with pressure as explained in Sec. 2. Fatt and Davis[6] have shown a variation in permeability with net overburden pressure for several sandstones. As the

TAKEN FROM APPLIED PETROLEUM RESERVOIR ENGINEERING,

B.C. CRAFT AND M.F. HAWKINS, 1959


Four Corners Gas Producers Assoc.
Exhibit No. 10
NMOCC Case No. 10436-Continued
May 21, 1992
Page 1 of 3
MAXIMUM TRANSPORT DISTANCE
IN 20 YEARS
FOR WATER AT 68°F (1 cp)
AND FOR HYDRAULIC GRADIENT OF .003
$L = K_H H T + \phi$
Where:
L = Distance of flow, feet
K_H = Hydrologic conductivity (feet/day)
H = Hydraulic gradient (ft/foot)
T = Time, days
ϕ = Porosity of aquifer (.35)
K_H = 2.738 x K (darcys)
Water temp = 68° F (Viscosity = 1 cp)
PERMEABILITY - DARCYS
TRANSPORT DISTANCE - FEET
1
.1
.01
100
1,000
10,000
100,000


WATER DISPOSAL - BBLS/DAY
AVERAGE RADIUS REACHED - FEET
5 YEARS
10 YEARS
20 YEARS
DATA SHOWN IS BASED ON
ZONE THICKNESS OF 30 FEET
AND POROSITY OF 35%
AREA AFFECTED
(AVERAGE RADIUS REACHED)
BY WATER DISPOSAL
IN LOW PERMEABILITY ZONES

CALCULATION OF AVERAGE RADIUS REACHED FOR WATER DISPOSED IN A 30' ZONE (FUNCTION OF DISPOSAL RATE AND TIME)

V = Injected Volume = Rd (1)

Where:

R = disposal rate, BWPD

d = time of disposal, days

Also:

$$V = \frac{\pi r^2 T \phi}{5.6146} \quad (2)$$

Where:

r = average radius reached

T = aquifer thickness (30 feet)

ϕ = porosity (.35)

5.6146 = cf/bbl

Combining (1) and (2):

$$V = Rd = \frac{\pi r^2 T \phi}{5.6146} \quad (3)$$

From which:

r = square root of $(5.6146\ R\ d) \div (\pi\ T\ \phi)$ (4)

(which is form of equation $Y = X^n$; and will be straight line on log-log paper)

Material Balance Calculations Based on SRIC Simulation Results

FCGPA Exhibit 11 for the May 21, 1992 Continuation of the April 9, 1992, New Mexico Oil Conservation Commission Hearing on Case Number 10436

May 21, 1992

Prepared for:

The Four Corners Gas Producers Association

Prepared by:

H⁺GCL

ALBUQUERQUE OFFICE
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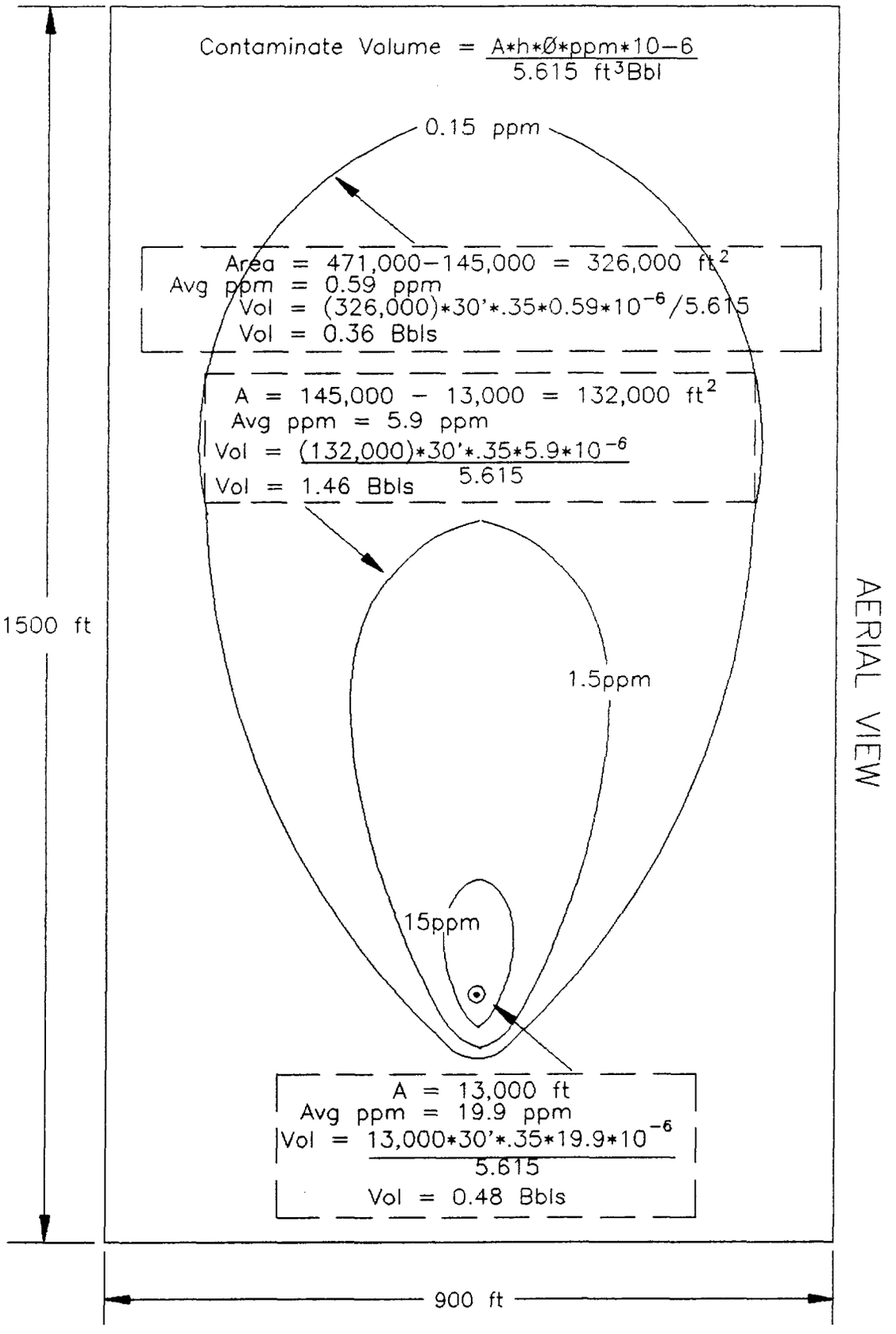
Albuquerque, New Mexico 87102
(505) 842-0001
FAX (505) 842-0595

MATERIAL BALANCE CALCULATIONS
BASED ON SRIC SIMULATION RESULTS



Total Vol Mapped = 0.36+1.46+0.48 = 2.30 Bbls
Source = 2.5 BPD*365day*5yr*30*10^{-6} = 0.14 Bbls

MATERIAL BALANCE CALCULATION PROCEDURE

$$Vol = \frac{A * h * \emptyset * ppm * 10^{-6}}{5.615}$$

Where:

Vol = contaminant volume within contour lines (Bbls)

A = planimetered area between contour lines (ft^2)

h = aquifer thickness (ft)

$\emptyset$ = aquifer porosity (fraction)

ppm = average contaminant concentration between contour lines based on a logarithimic distribution (ppm)

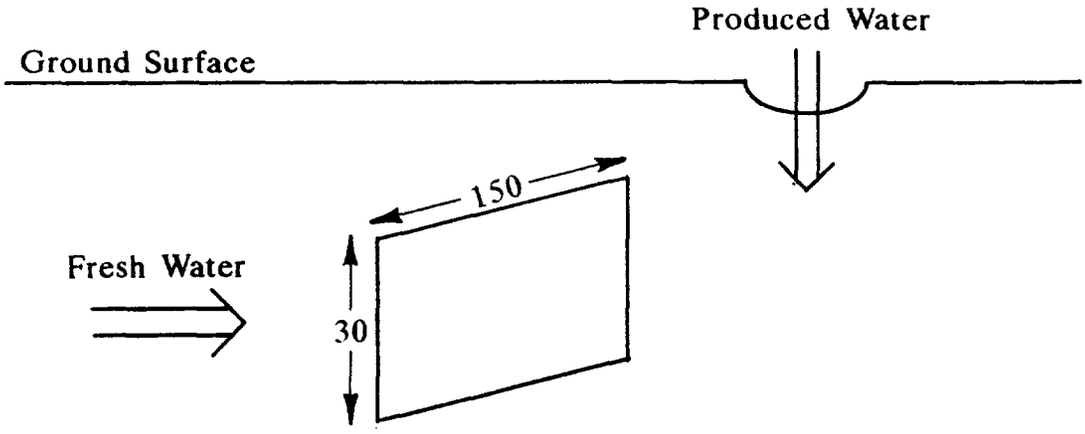
5.615 = ft^3/Bbl

Note: For a full cycle change in ppm, the average ppm is calculated as follows:

$$\text{Avg ppm} = \frac{(ppm_1 - ppm_2)}{Ln(10)}$$

For the area between the 15 and 1.5 ppm contours:

$$\text{Avg ppm} = \frac{(15 - 1.5)}{Ln(10)} = 5.9 \text{ ppm}$$



Q = KA dh/dl

= 250 feet/day x 150 feet x 30 feet x 0.003

= 3,375 cubic feet/day

= 601 barrels/day

In order to maintain a concentrtaion of 30 ppm in the 150 x 150 foot node beneath the pit, a discharge of 601 barrels per day of produced water (30 ppm) must enter the pit and the underlying aquifer.

Comparison of Available Groundwater Chemistry Data with SUTRA Model Predictions of SRIC Exhibit 11

FCGPA Exhibit 12 for the May 21, 1992 Continuation of the April 9, 1992, New Mexico Oil Conservation Commission Hearing on Case Number 10436

May 21, 1992

Prepared for:

The Four Corners Gas Producers Association

Prepared by:

H⁺GCL

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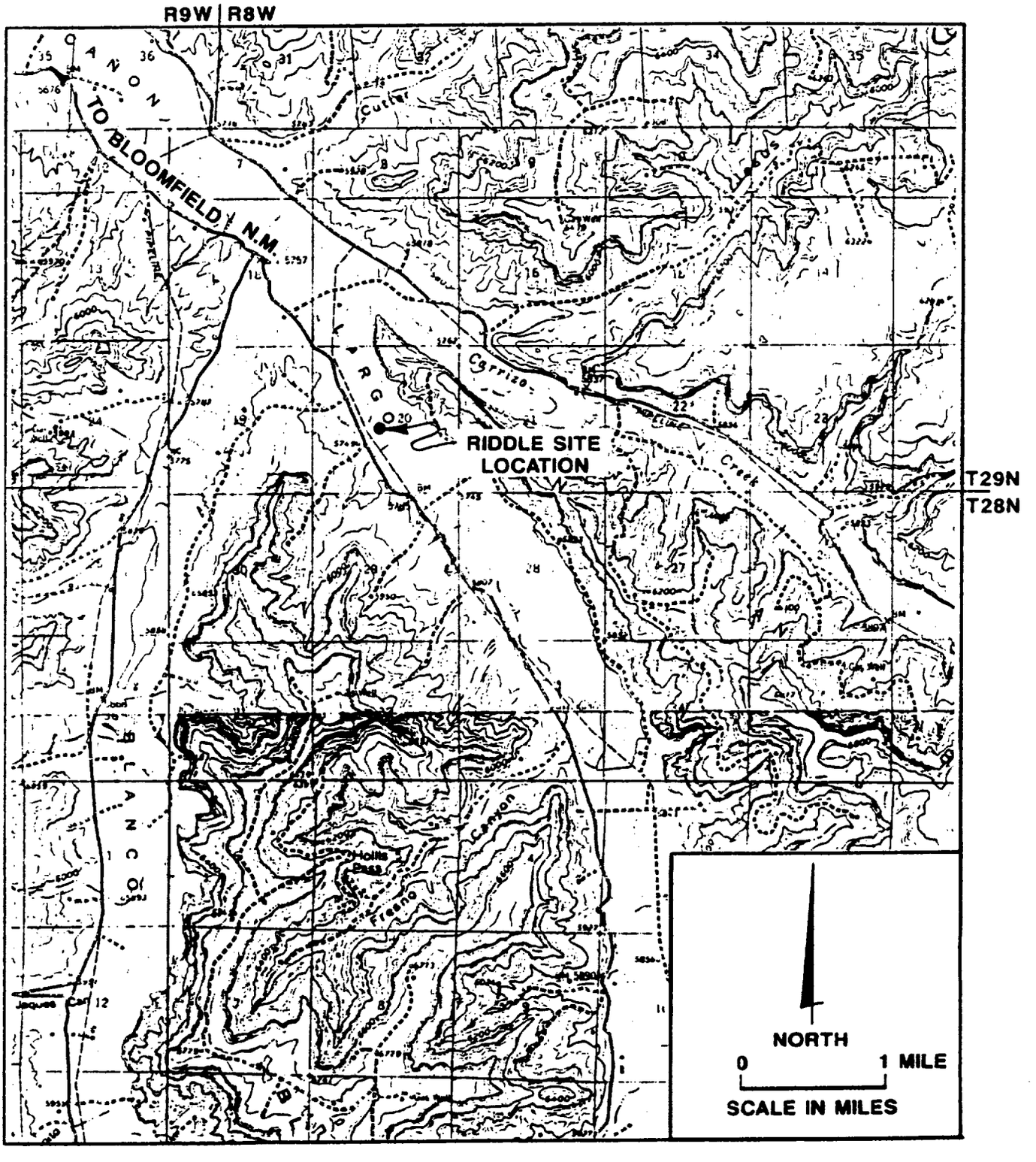
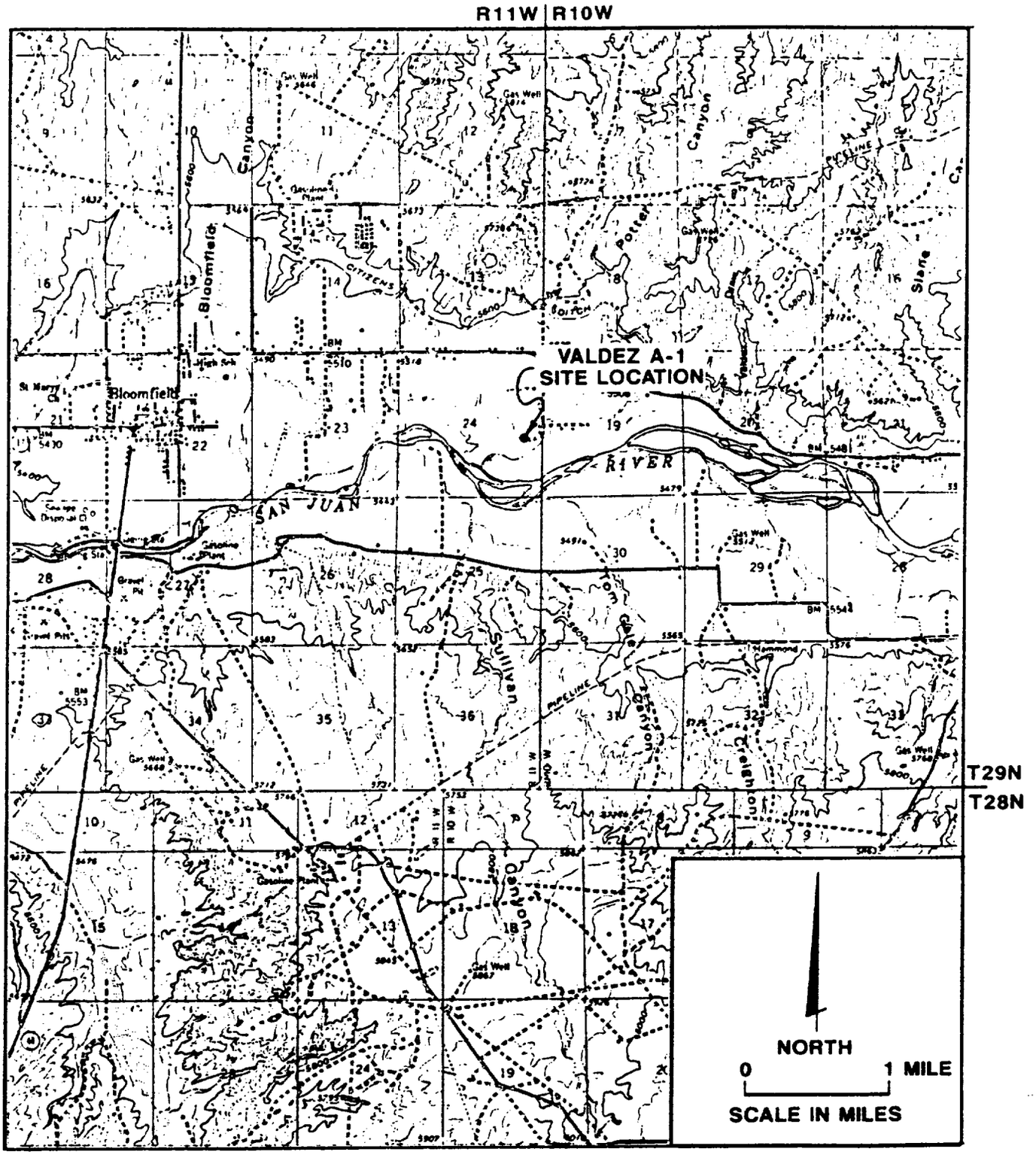
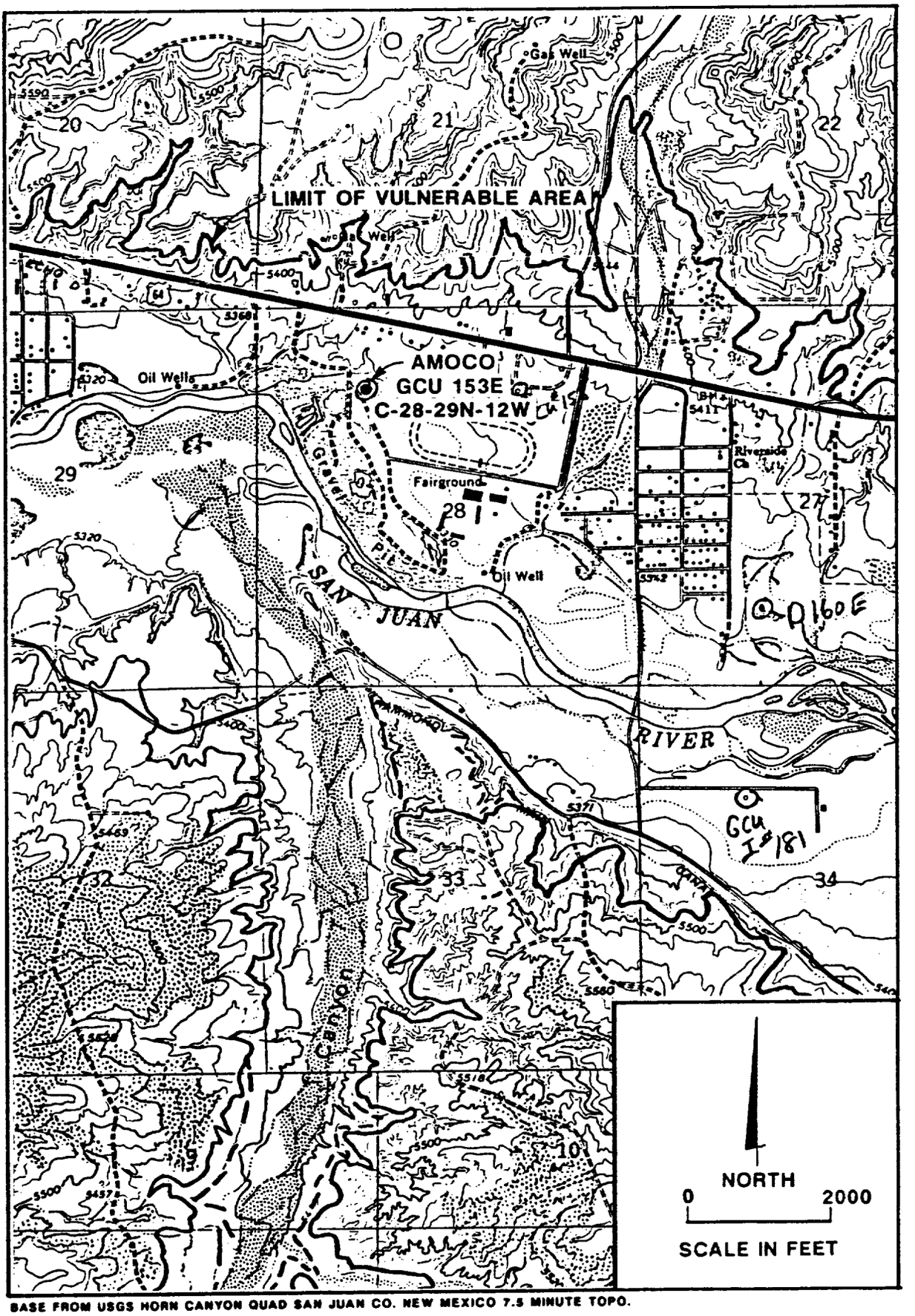
LOCATION MAP OF THE TENNECO RIDDLE FLS-3A SITE



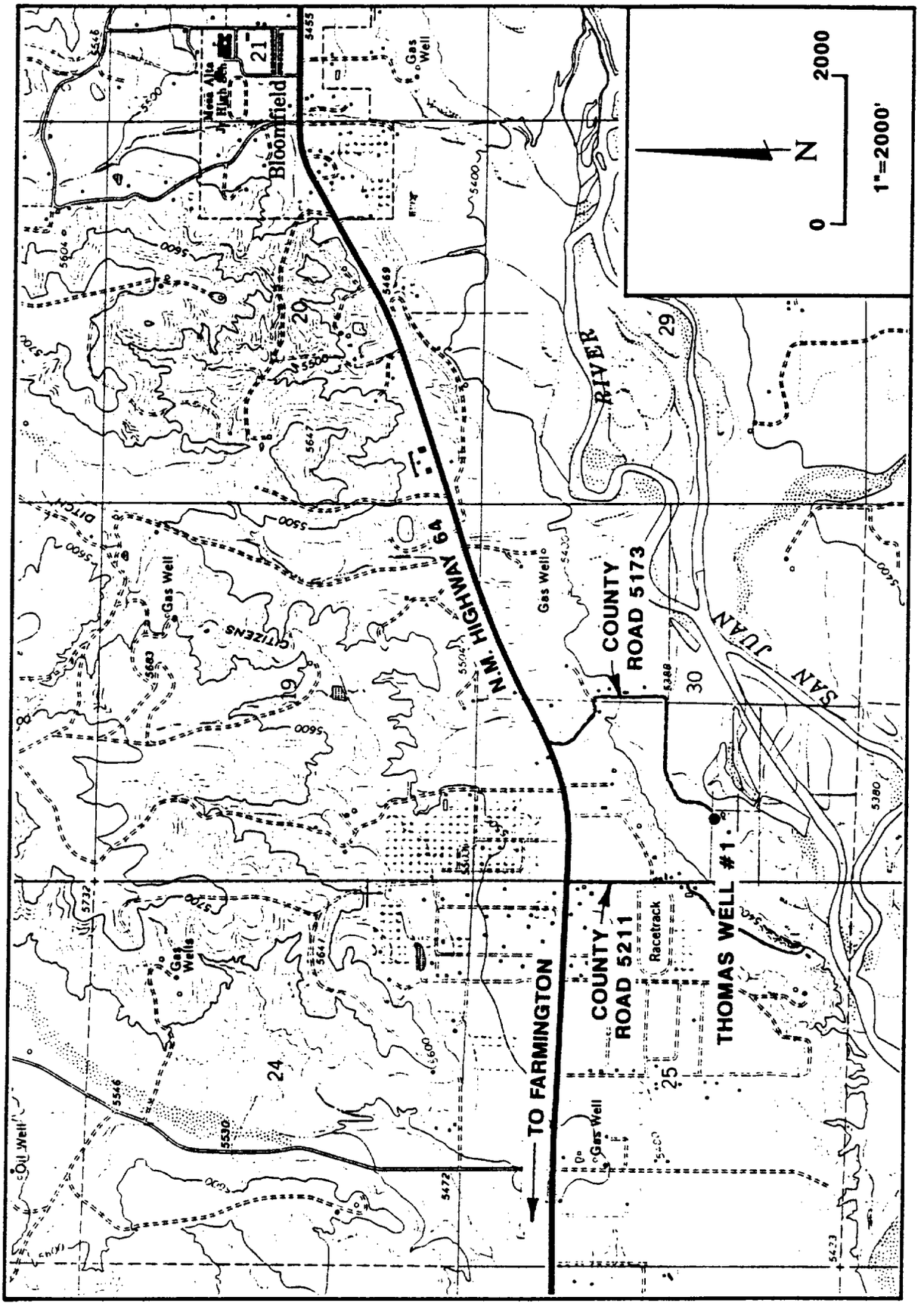
LOCATION MAP OF THE TENNECO VALDEZ A-1 SITE



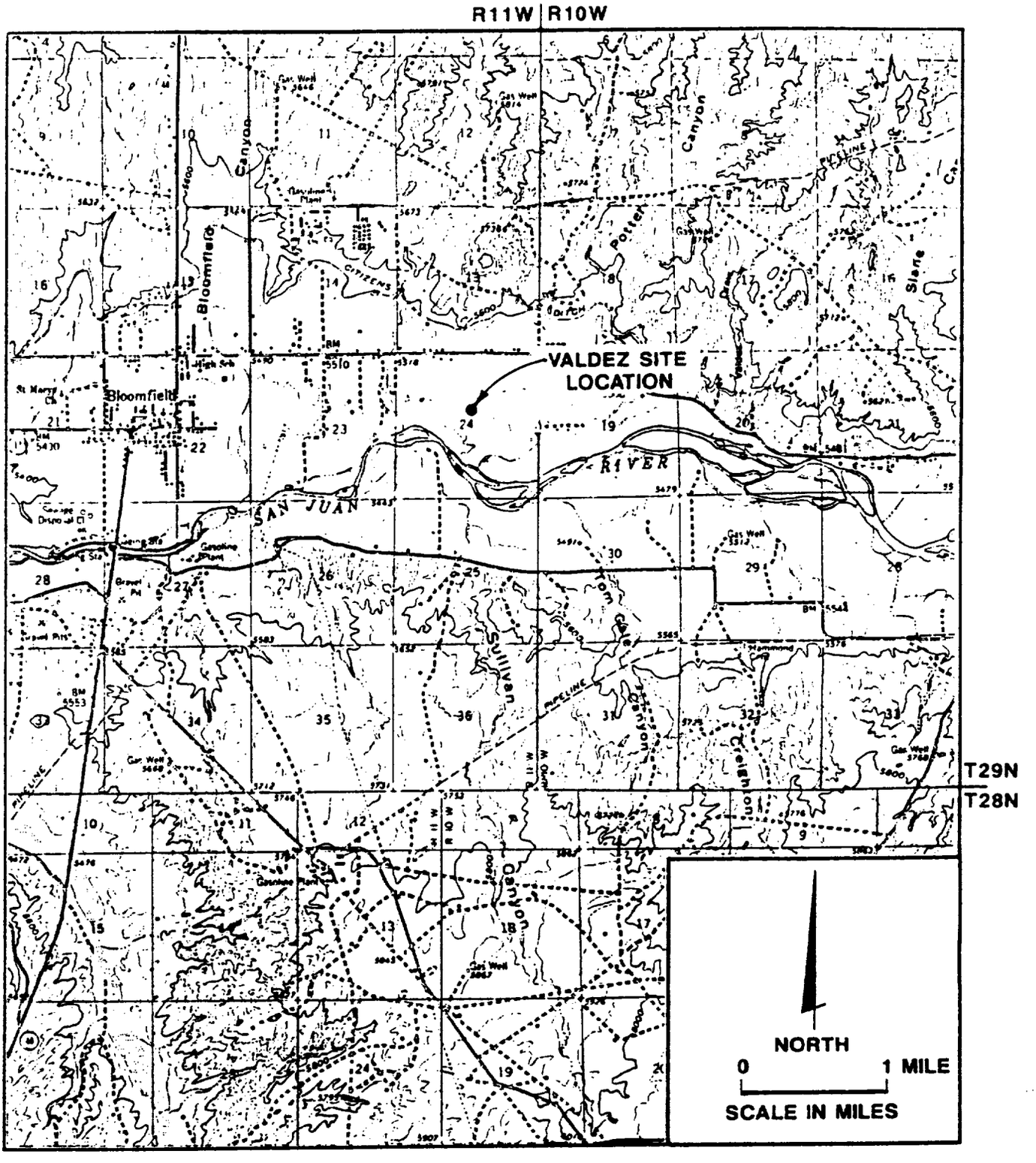


BASE FROM USGS HORN CANYON QUAD SAN JUAN CO. NEW MEXICO 7.5 MINUTE TOPO.

LOCATION MAP OF THOMAS WELL #1
SAN JUAN COUNTY, NEW MEXICO.



LOCATION MAP OF THE TENNECO VALDEZ A1E SITE



Chemical Data of Groundwater at
Dry Gas Well Water Disposal Pits

Well Name	Sample Number	Benzene ug/l	Toluene ug/l	Ethylbenze ug/l	Total Xylenes ug/l
Riddle FLS-3A R-1	88070008	ND	1.2	ND	3.1
Riddle FLS-3A R-2	88070009	ND	ND	ND	ND
Riddle FLS-3A R-3	88070010	2.5	0.5	ND	ND
Riddle FLS-3A R-4	8807091	ND	1.1	ND	1.9
Riddle FLS-3A R-1	880831	ND	ND	ND	ND
Riddle FLS-3A R-2	880831	300	0.3	37	0.9
Riddle FLS-3A R-3	880831	1.2	ND	ND	ND
Riddle FLS-3A R-4	880831	ND	2.1	ND	1.8

Chemical Data of Groundwater at
Dry Gas Well Water Disposal Pits

Well Name	Sample Number	Benzene ug/l	Toluene ug/l	Ethylbenze ug/l	Total Xylenes ug/l
Valdez A-1 1	87040012	ND	ND	ND	ND
Valdez A-1 2	87040013	87	ND	62	750
Valdez A-1 3	87040014	600	ND	82	1,000
Valdez A-1 4	87040015	ND	ND	ND	ND
Valdez A-1 5	870402xxx	ND	ND	110	1,260
Valdez A-1 6	870402xxx	ND	ND	ND	570
Valdez A-1 7	870505xxx	ND	ND	ND	600
Valdez A-1 8	870505xxx	380	1,100	ND	3,400
Valdez A-1 9	870505xxx	ND	ND	ND	ND
Valdez A-1 10	870505xxx	ND	ND	ND	ND
Valdez A-1 11	871110xxx	ND	ND	ND	ND
Valdez A-1 12	871110xxx	ND	0.58	0.56	ND
Valdez A-1 13	871110xxx	ND	8.1	ND	ND
Valdez A-1 14	871110xxx	ND	0.61	ND	0.96

Chemical Data of Groundwater at
Dry Gas Well Water Disposal Pits

Well Name	Sample Number	Benzene ug/l	Toluene ug/l	Ethylbenze ug/l	Total Xylenes ug/l
Valdez A-1 Surface Water	871110xxx				
Valdez A-1 11	880628xxx	ND	ND	ND	ND
Valdez A-1 12	880628xxx	ND	ND	ND	ND
Valdez A-1 13	880628xxx	ND	ND	ND	ND
Valdez A-1 14	880628xxx	ND	ND	ND	ND
Valdez A-1 Surface Water	880628xxx				
Valdez A-1 11	880628xxx	ND	ND	ND	ND
Valdez A-1 12	880628xxx	ND	ND	ND	ND
Valdez A-1 13	880628xxx	ND	9.8	ND	ND
Valdez A-1 14	880628xxx	ND	MD	ND	3.5

GCU 153E Ground Water Results
March 6, 1992

Well Name	Sample Number	Benzene ug/L	Toluene ug/L	Ethylbenze ug/L	Total Xylenes ug/l
# 1 *	9203060950	ND	ND	ND	0.5
# 2 **	9203061210	ND	24.2	ND	37.8
(1) # 2d ***	9203061230	1.3	5.9	1.8	6.1
# 3 *****	9203061530	3,900	2,230	1,040	4,390
# 4 *	9203061035	ND	ND	ND	0.5
# 5 *	9203061115	ND	ND	ND	ND
# 7 ***	9203061315	ND	ND	ND	ND
#11 ****	9203061445	23.2	22.3	6.0	39.5
#12 ****	9203061350	0.2	1.9	0.2	2.6

*	**	***	****
B = 0.2 ug/L	B = 10.0 ug/L	B = 0.2 ug/L	B = 0.2 ug/L
T = 0.4 ug/L	T = 20.0 ug/L	T = 0.4 ug/L	T = 0.3 ug/L
E = 0.2 ug/L	E = 10.0 ug/L	E = 0.2 ug/L	E = 0.2 ug/L
PM,X = 0.5 ug/L	]	PM,X = 0.6 ug/L	PM,X = 0.5 ug/L
O,X = 0.2 ug/L	O,X = 15.0 ug/L	O,X = 0.3 ug/L	O,X = 0.2 ug/L

Notes:
ND = Note detected.
(1) = Duplicate

54101/EXHBT12.WQ1

Chemical Data of Groundwater at
Dry Gas Well Water Disposal Pits

Well Name	Sample Number	Benzene ug/l	Toluene ug/l	Ethylbenze ug/l	Total Xylenes ug/l
Thomas #1 MW-1	9108311600				
Thomas #1 MW-2	9108311820				
Thomas #1 MW-3	9108311910				
Thomas #1 MW-4	9108311455				
Thomas #1 MW-4 (Dup)	9108311457				
Thomas #1 MW-5	9108311715				

54101/ATBL.WQ1

Chemical Data of Groundwater at
Dry Gas Well Water Disposal Pits

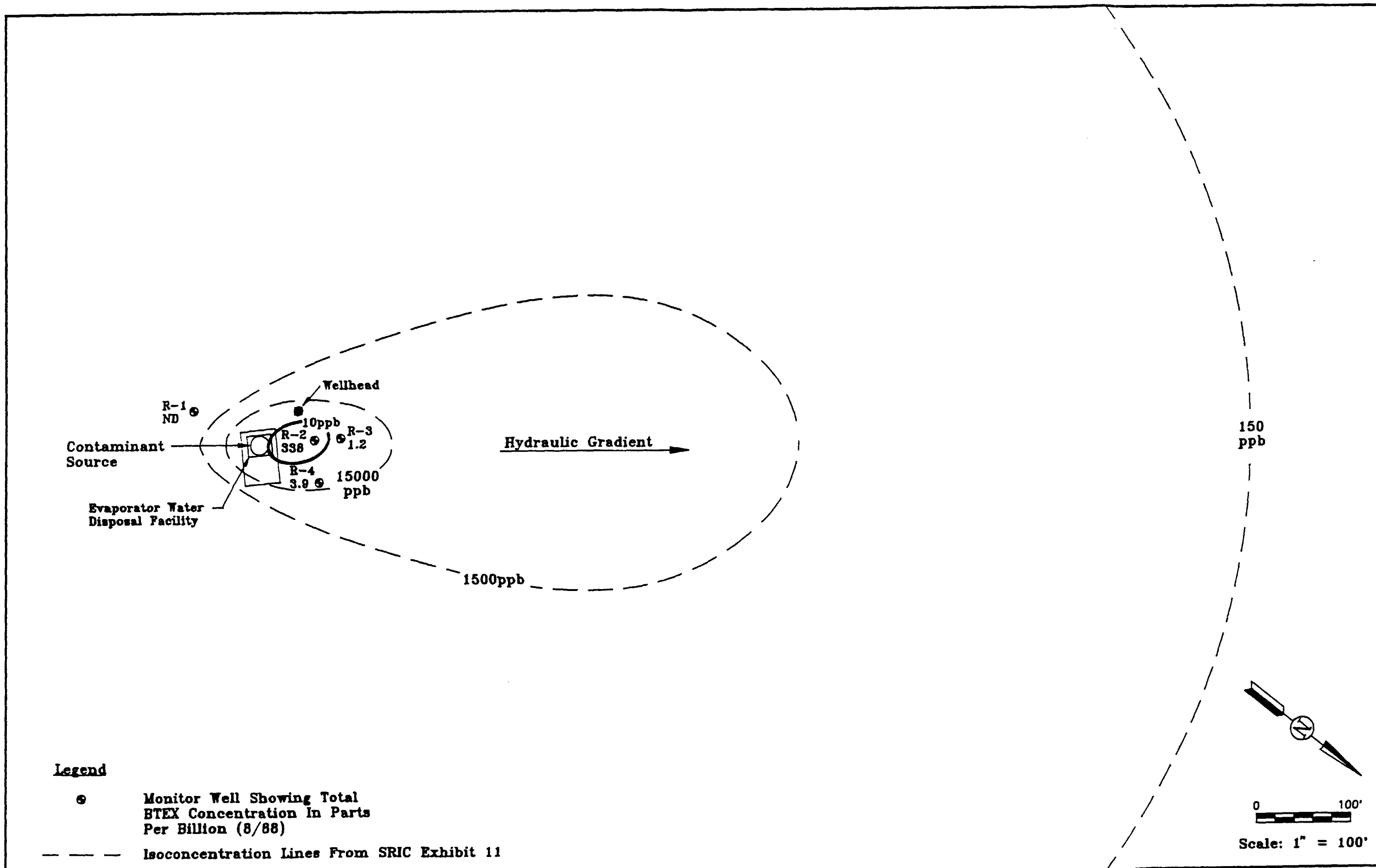
Well Name	Sample Number	Benzene ug/l	Toluene ug/l	Ethylbenze ug/l	Total Xylenes ug/l
Valdez A-1-E V-1	88070001	ND	ND	ND	ND
Valdez A-1-E V-2	88070002	ND	ND	ND	ND
Valdez A-1-E V-3	88070003	ND	ND	ND	ND
Valdez A-1-E V-4	88070004	NA	NA	NA	NA
Valdez A-1-E V-5	88070005	ND	0.5	ND	0.3
Valdez A-1-E V-6	88070006	1,500	3,300	550	4,560
Valdez A-1-E V-1	880831	ND	ND	ND	ND
Valdez A-1-E V-2	880831	ND	ND	ND	ND
Valdez A-1-E V-3	880831	ND	ND	ND	ND
Valdez A-1-E V-4	880831	110	730	230	1,560
Valdez A-1-E V-5	880831	ND	0.4	ND	ND
Valdez A-1-E V-6	880831	1,700	1,600	340	1,300
Domestic Well	88070007	ND	ND	ND	ND

Chemical Data of Groundwater at
Dry Gas Well Water Disposal Pits

Well Name	Sample Number	Benzene ug/l	Toluene ug/l	Ethylbenzene ug/l	Total Xylenes ug/l
Valdez A-1-E 1	9203051030	ND	ND	ND	0.5
Valdez A-1-E 2	9203051140	ND	ND	ND	ND
Valdez A-1-E 6	9203051250	65	44.1	20.3	82.7
Valdez A-1-E 3	9203051340	3.0	6.9	0.3	7.8
Valdez A-1-E 4	9203051445	0.4	5.3	0.6	3.1
Valdez A-1-E 5	9203051550	ND	0.5	ND	1.0
Valdez A-1-E 7	9203051620	1,160	1,110	302	1,972
Valdez A-1-E 8	9203051645	2,160	1,770	830	2,920
Valdez A-1-E 9	9203241310	PA	PA	PA	PA
Valdez A-1-E 10	9203241616	PA	PA	PA	PA
Valdez A-1-E 11	9203271533	PA	PA	PA	PA

AMOCOSMP.WQ1

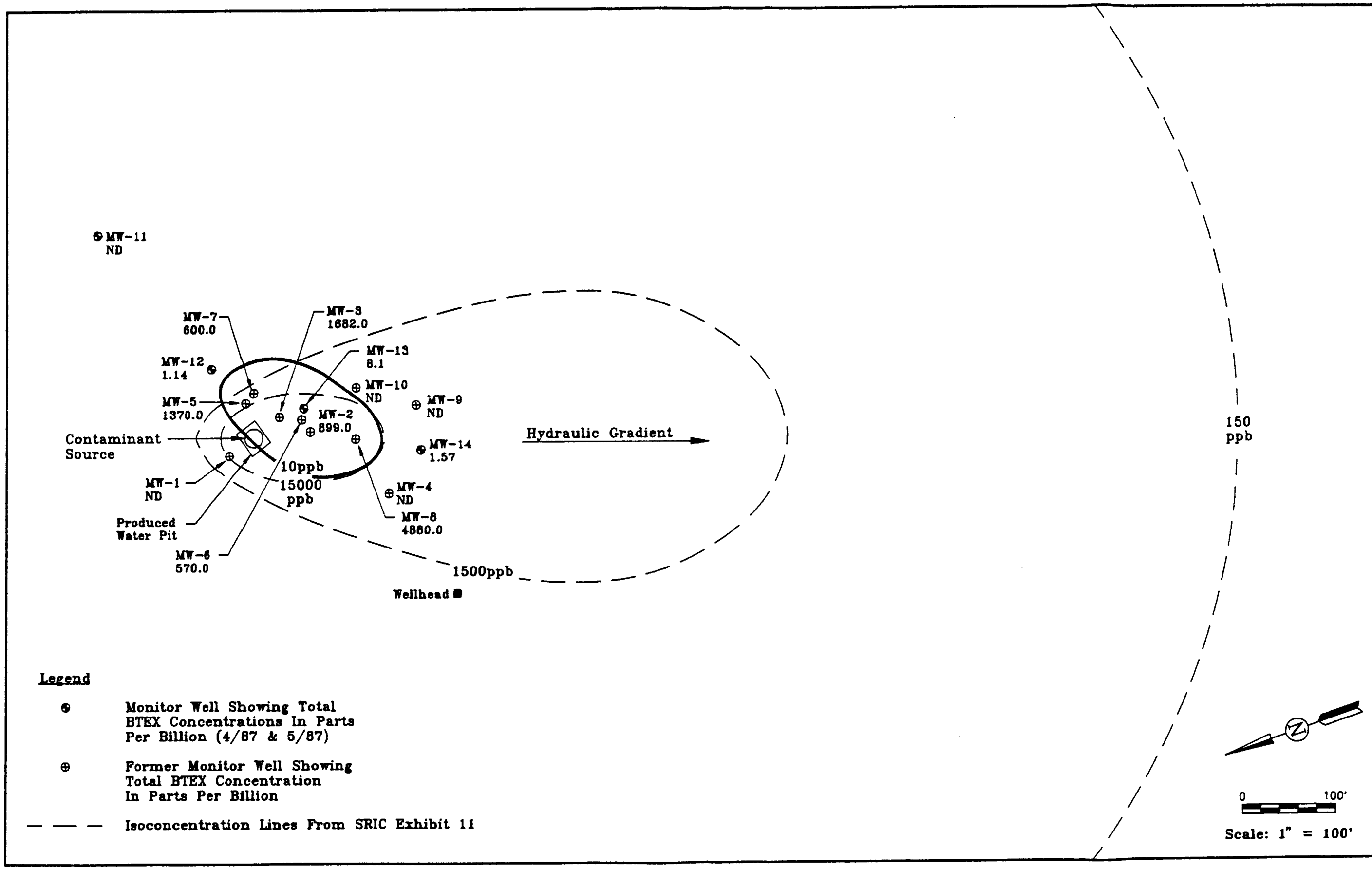
Riddle FLS-3A

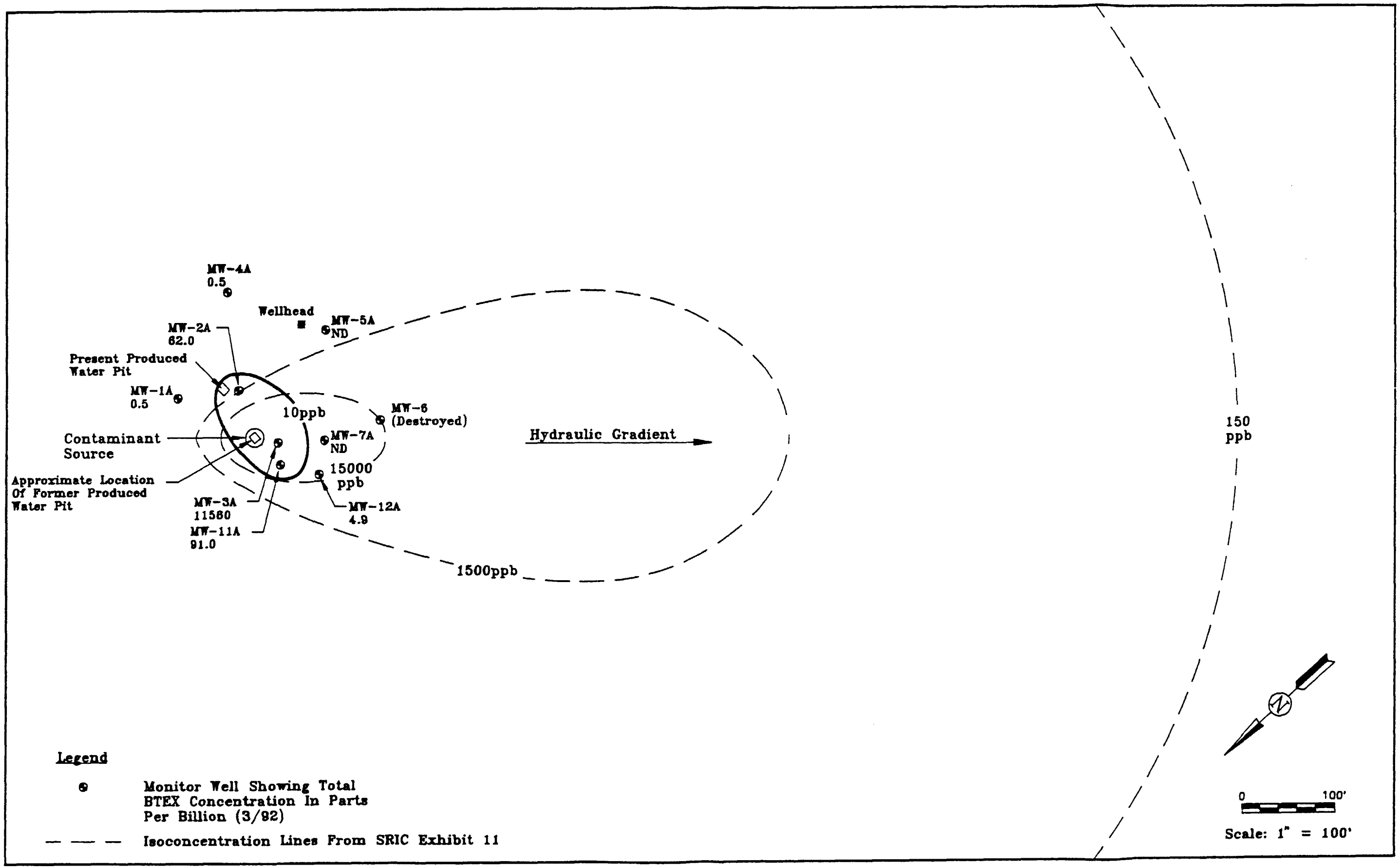


Legend

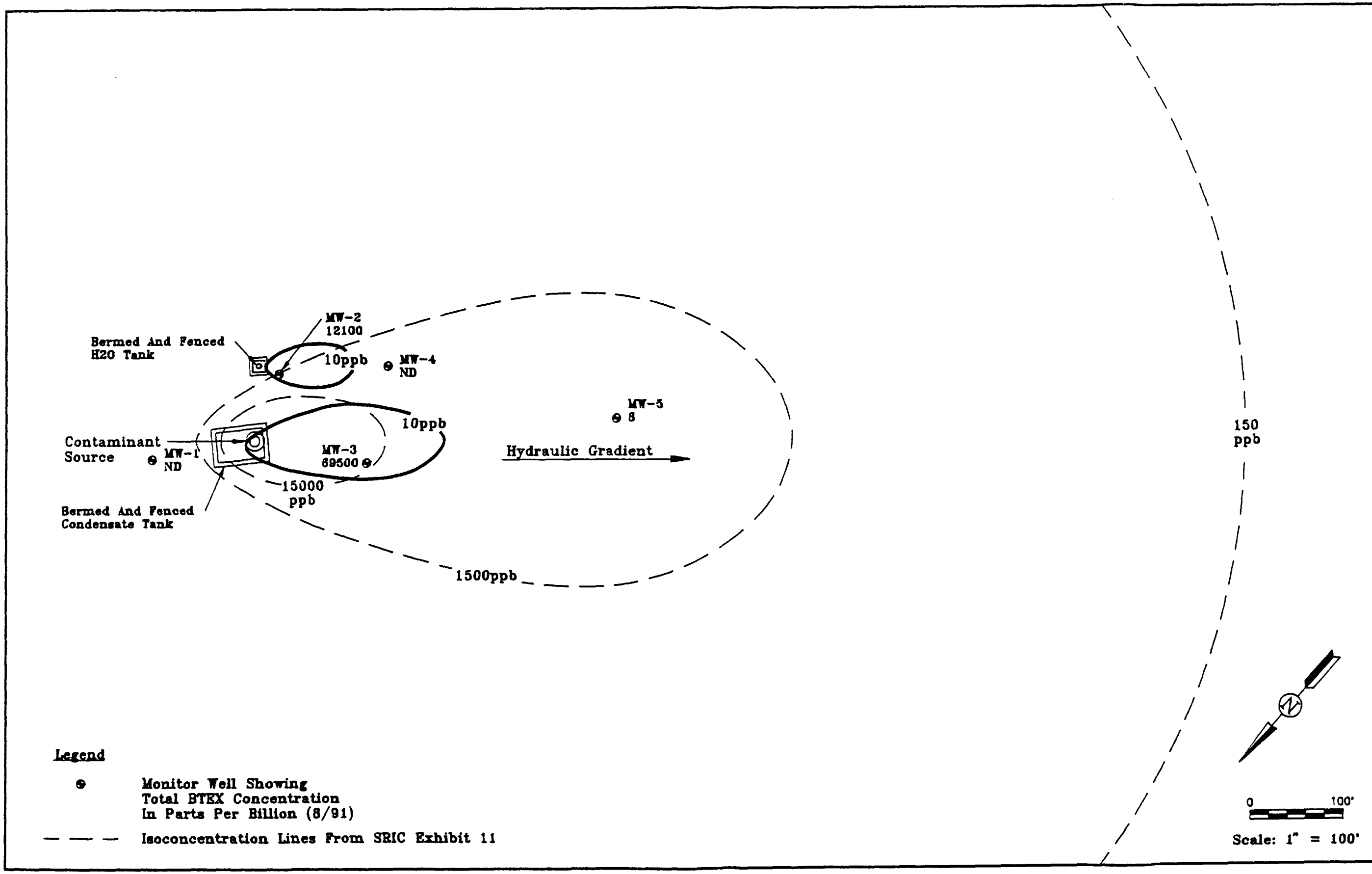
- Monitor Well Showing Total BTEX Concentration In Parts Per Billion (8/88)
- Isoconcentration Lines From SRIC Exhibit 11

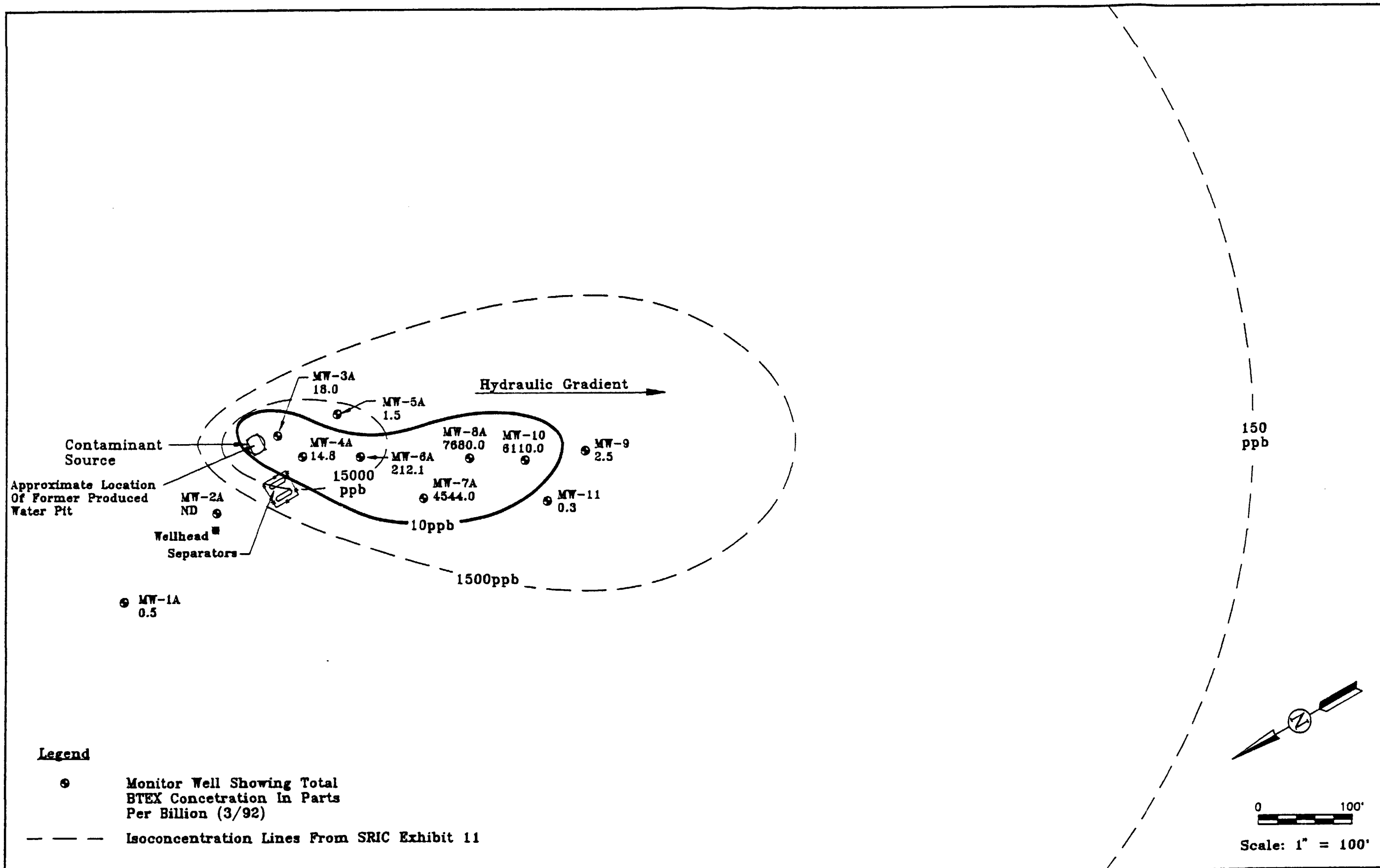
Valdez A-1


MW-11
ND
MW-7
600.0
MW-3
1682.0
MW-13
8.1
MW-12
1.14
MW-10
ND
MW-9
ND
MW-5
1370.0
MW-2
899.0
Contaminant
Source
MW-14
1.57
Hydraulic Gradient
10ppb
15000
ppb
MW-1
ND
MW-4
ND
MW-8
4880.0
Produced
Water Pit
MW-6
570.0
1500ppb
Wellhead
150
ppb
Legend
Monitor Well Showing Total BTEX Concentrations In Parts Per Billion (4/87 & 5/87)
Former Monitor Well Showing Total BTEX Concentration In Parts Per Billion
Isoconcentration Lines From SRIC Exhibit 11
N
0
100'
Scale: 1" = 100'


MW-4A
0.5
Wellhead
MW-5A
ND
MW-2A
62.0
Present Produced
Water Pit
MW-1A
0.5
10ppb
MW-6
(Destroyed)
Contaminant
Source
MW-7A
ND
Hydraulic Gradient
15000
ppb
Approximate Location
Of Former Produced
Water Pit
MW-3A
11560
MW-12A
4.9
MW-11A
91.0
1500ppb
150
ppb
Legend
Monitor Well Showing Total
BTEX Concentration In Parts
Per Billion (3/92)
Isoconcentration Lines From SRIC Exhibit 11
0
100'
Scale: 1" = 100'

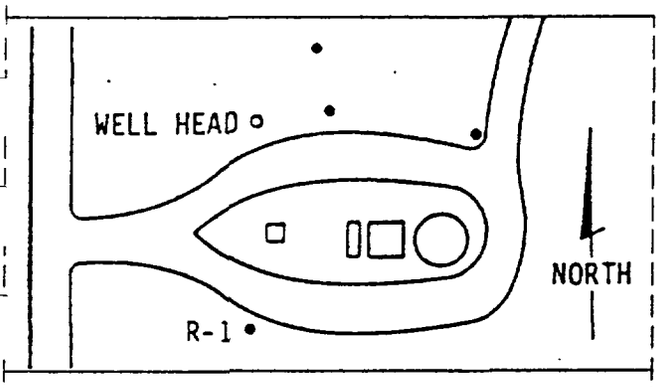
Mobil Thomas Well #1




MW-3A
18.0
MW-5A
1.5
Hydraulic Gradient
Contaminant
Source
MW-4A
14.8
MW-6A
212.1
MW-8A
7680.0
MW-10
6110.0
MW-9
2.5
15000
ppb
MW-7A
4544.0
MW-11
0.3
Approximate Location
Of Former Produced
Water Pit
MW-2A
ND
10ppb
Wellhead
Separators
1500ppb
MW-1A
0.5
150
ppb
Legend
Monitor Well Showing Total
BTEX Concetration In Parts
Per Billion (3/92)
Isoconcentration Lines From SRIC Exhibit 11
N
0
100'
Scale: 1" = 100'

Available Borehole Logs

BOREHOLE LOG (SOIL)



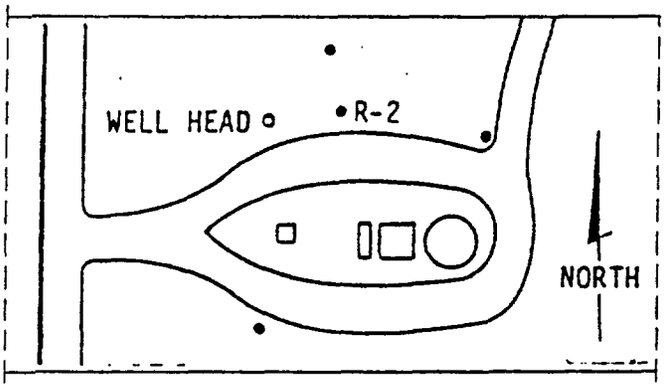
___1/4 ___1/4 ___1/4 ___1/4 S 20 T 28N R 8W

SITE ID: Riddle LOCATION ID: R-1
SITE COORDINATES (ft.): 1825 FNL, 1625 FWL
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
STATE: New Mexico COUNTY: San Juan
DRILLING METHOD: HSA
DRILLING CONTR.: Western Technologies
DATE STARTED: 6/29/88 DATE COMPLETED: 6/29/88
FIELD REP.: W.S. Dubyk, P. Linley
COMMENTS: Cored w/continuous sampler.

LOCATION DESCRIPTION: _____

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE REC.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
0				1	0'	3'	25%		SM	0'-3' Sand - pale brn 5 YR 5/2 minor org material, poorly srt, v fn to crs, qtz rich, uncons. Damp 5 YR 5/2
5				2	3'	7.5'	20%			3'-7.5' - Sand. As above, damp.
				3	7.5'	12.5'	20%		SM	7.5'-12.5' Sand - v fn to v crs, qtz rich w/lithic & feldspar grains, pale brn 5 YR 5/2 to dk ylsh org 10 YR 6/6. Minor clay layers, damp.
10										
				4	12.5'	17.5'	50%		SC	12.5'-17.5' Sand - v fn to v crs qtz rich, as above, no clay layers but some admixed clay. Wet.
15										
				5	17.5'	22.5'	75%		SL	17.5'-22.5' Sand, Silt and Clay: mixed sample - flowing sand. Grain size from mud to small gravel.
20										
25				6	22.5'	27.5'	0%		SC	22.5'-27.5' Sand - No sample - sampler stuck in auger. Abundant water in sand, flowing. Small amount of sample is light brown gray, 5 YR 6/1, medium to coarse grained quartz-rich sand.
	TD 27.5'									
30										

BOREHOLE LOG (SOIL)



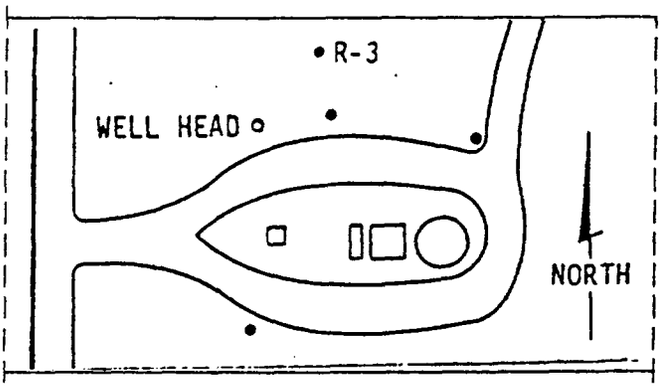
SITE ID: Riddle LOCATION ID: R-2
SITE COORDINATES (ft.): 1825 FNL, 1625 FWL
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
STATE: New Mexico COUNTY: San Juan
DRILLING METHOD: HSA
DRILLING CONTR.: Western Technologies
DATE STARTED: 6/27/88 DATE COMPLETED: 6/27/88
FIELD REP.: W.S. Dubyk
COMMENTS: _____

___1/4 ___1/4 ___1/4 ___1/4 S 20 T 28N R 8W

LOCATION DESCRIPTION: _____

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE REC.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
0									SC	0'-11' Sand - w/minor clay (8') - pale to medium brown 5 YR 5/2 to 5 YR 3/4 fine to coarse grained, uncemented, no odor.
5										
10										
									CH	12'-13' - Clay very fine grained pale brown 5 YR 5/2 laminated, plastic; no odor.
										13'-18' Sand & Clay - poorly sorted pale brown 5 YR 5/2.
15									SC	H_2O at -18', odor noted, at -18'.
									SC	18'-28' Sand - as above, flowing, T. D. at 28'.
20										
25										
30	TD 27.0'									

BOREHOLE LOG (SOIL)



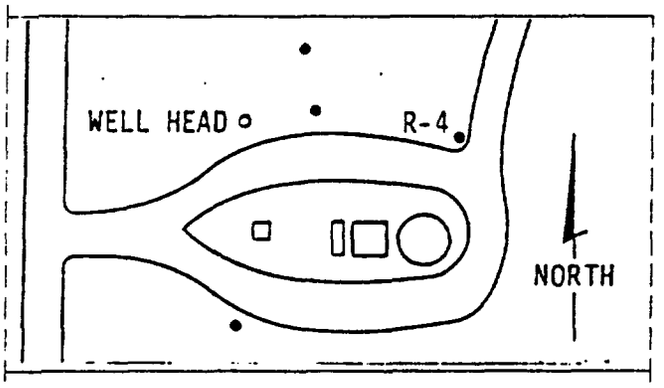
___1/4 ___1/4 ___1/4 ___1/4 S 20 T 28N R 8W

SITE ID: Riddle LOCATION ID: R-3
SITE COORDINATES (ft.): 1825 FNL, 1625 FWL
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
STATE: New Mexico COUNTY: San Juan
DRILLING METHOD: HSA
DRILLING CONTR.: Western Technologies
DATE STARTED: 6/27/88 DATE COMPLETED: 6/27/88
FIELD REP.: W.S. Dubyk, P. Linley
COMMENTS: _____

LOCATION DESCRIPTION: _____

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE REC.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
0									SW	0'-12' Recent Dune Sand and alluvium; no odor.
5										
10									CH	12'-13' - Clay light brown 5 YR 6/4 plastic, no odor.
									SC	13'-22' - Clay & Sand - light brown, 5 YR 6/4 saturated at -14', H_2O -17'. No odor.
15										
20										
									SC	22'-28' Sand - minor clay, poorly sorted, uncemented, fine to medium grained, clayey, flowing. T.D. at 28'. No odor.
25										
	TD 28.0'									
30										

BOREHOLE LOG (SOIL)



___1/4 ___1/4 ___1/4 ___1/4 S 20 T 28N R 8W

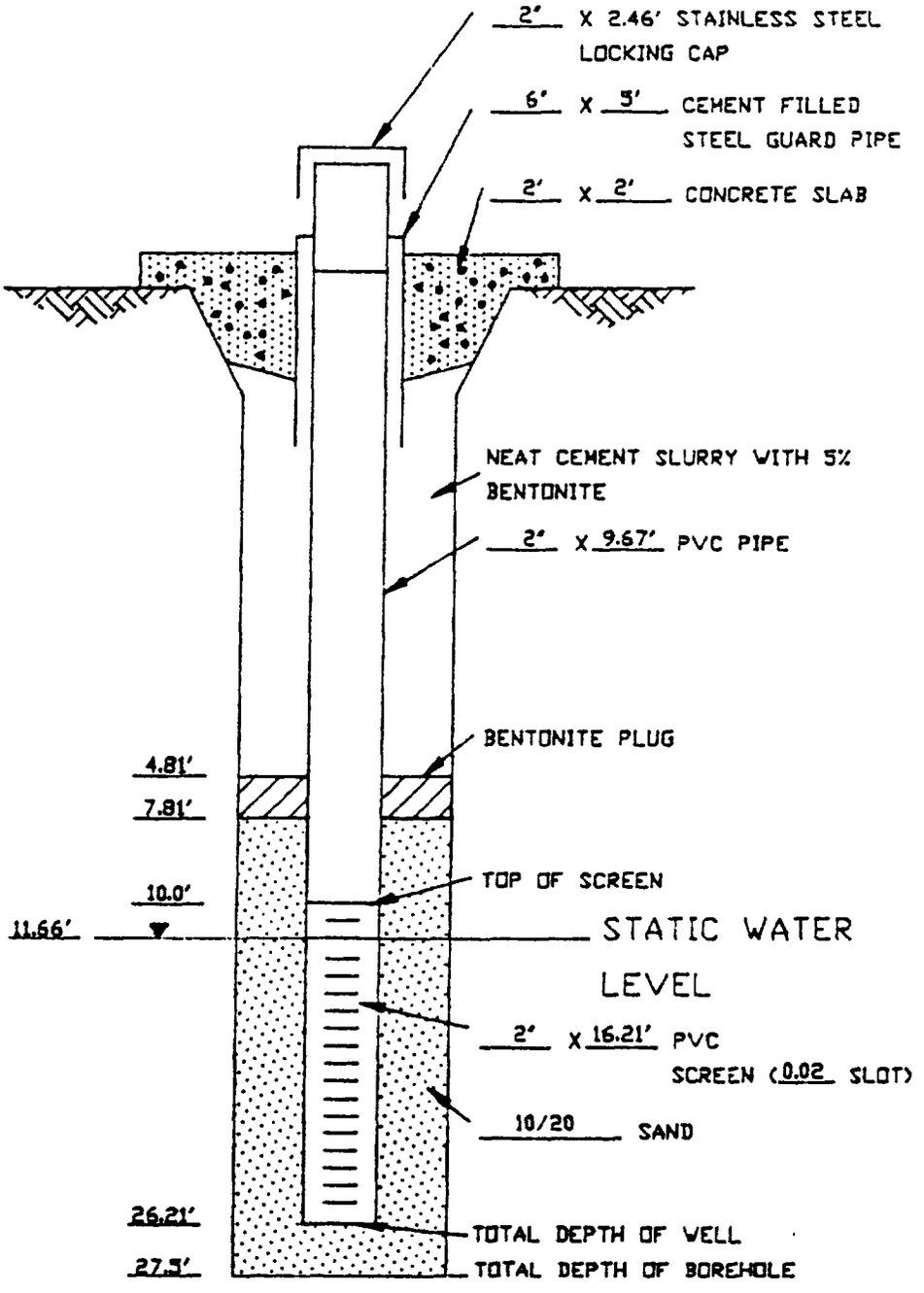
SITE ID: Riddle LOCATION ID: R-4
SITE COORDINATES (ft.): 1825 FNL, 1625 FWL
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
STATE: New Mexico COUNTY: San Juan
DRILLING METHOD: HSA
DRILLING CONTR.: Western Technologies
DATE STARTED: 6/29/88 DATE COMPLETED: 6/29/88
FIELD REP.: W.S. Dubyk
COMMENTS: Cored w/continuous sampler.

LOCATION DESCRIPTION: _____

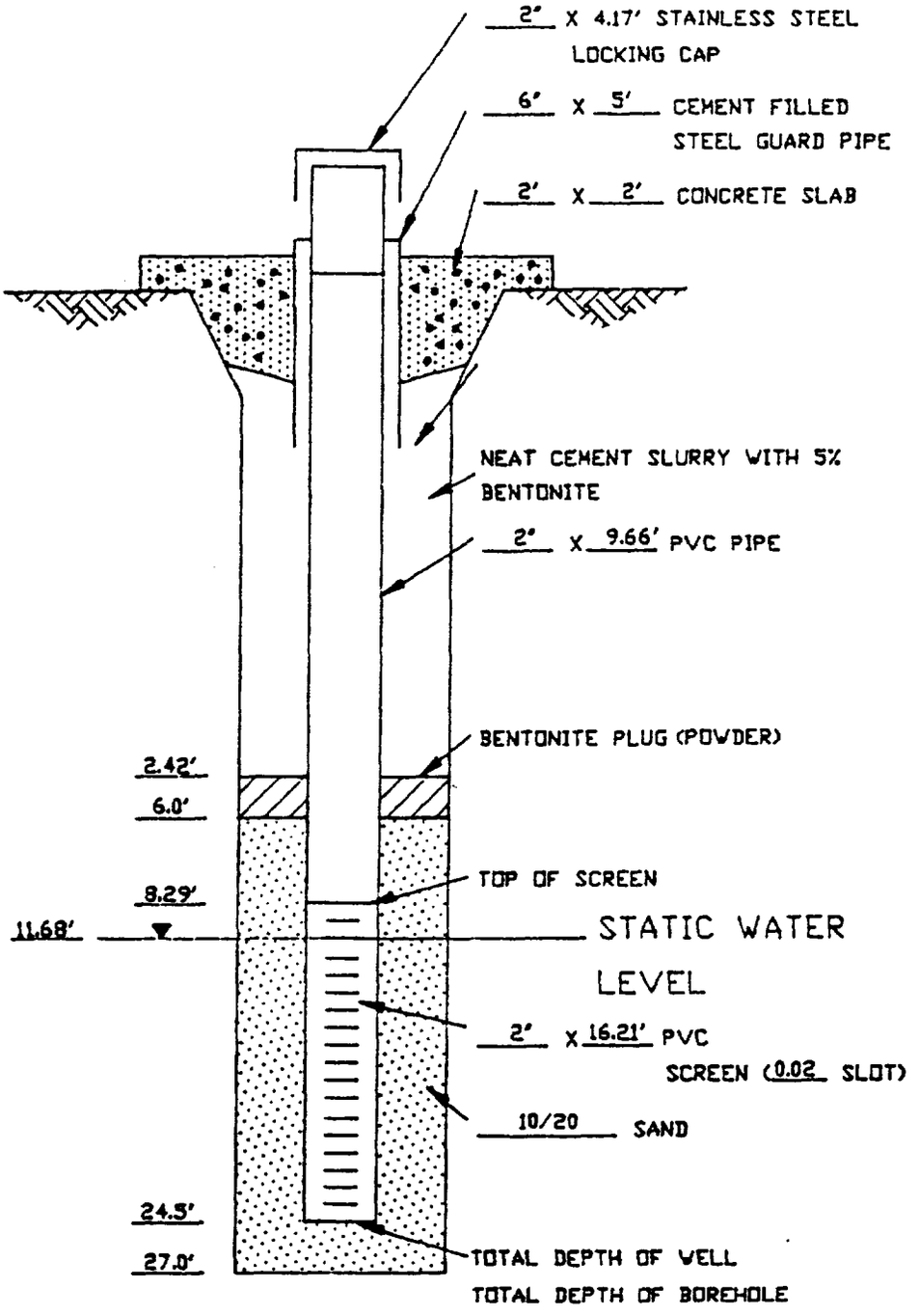
DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE REC.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
0				1	0'	2.5'	90%		SW	0'-2.5' Sand - light brown 5 YR 6/4 fine to medium grained, well sorted, quartz rich, moderate to well rounded, concentrated, damp.
5				2	2.5'	7.5'	50%		SW	2.5'-7.5' Sand - light brown 5 YR 6/4 to dark yellowish orange 10 YR 6/6; fine-medium grained quartz rich, some organic material, 1 piece of gravel, damp.
10				3			90%		SW	7.5'-12.5' Sand - as above, some layers of coarse, angular sand. Predominantly quartz, some organic material. Damp.
15				4	7.5'	12.5'	35%		SC	12.5'-17.5' Sand and Silt - very fine to medium grained, well sorted light brown gray 5 YR 6/1 to light brown 5 YR 6/2. Some admixed clay. Wet.
20				5	12.5'	17.5'	50%		SC	17.5'-22.5' Sand and Silt - clayey, very fine to coarse grained, light brown gray 5 YR 6/1, very wet, probably flowed into barrel.
25				6	17.5'	22.5'	0%		SC	22.5'-27.5' - as above, flowing sand.
	T.D. 27.5									
30				7	22.5'	27.5'	50%			

APPENDIX B

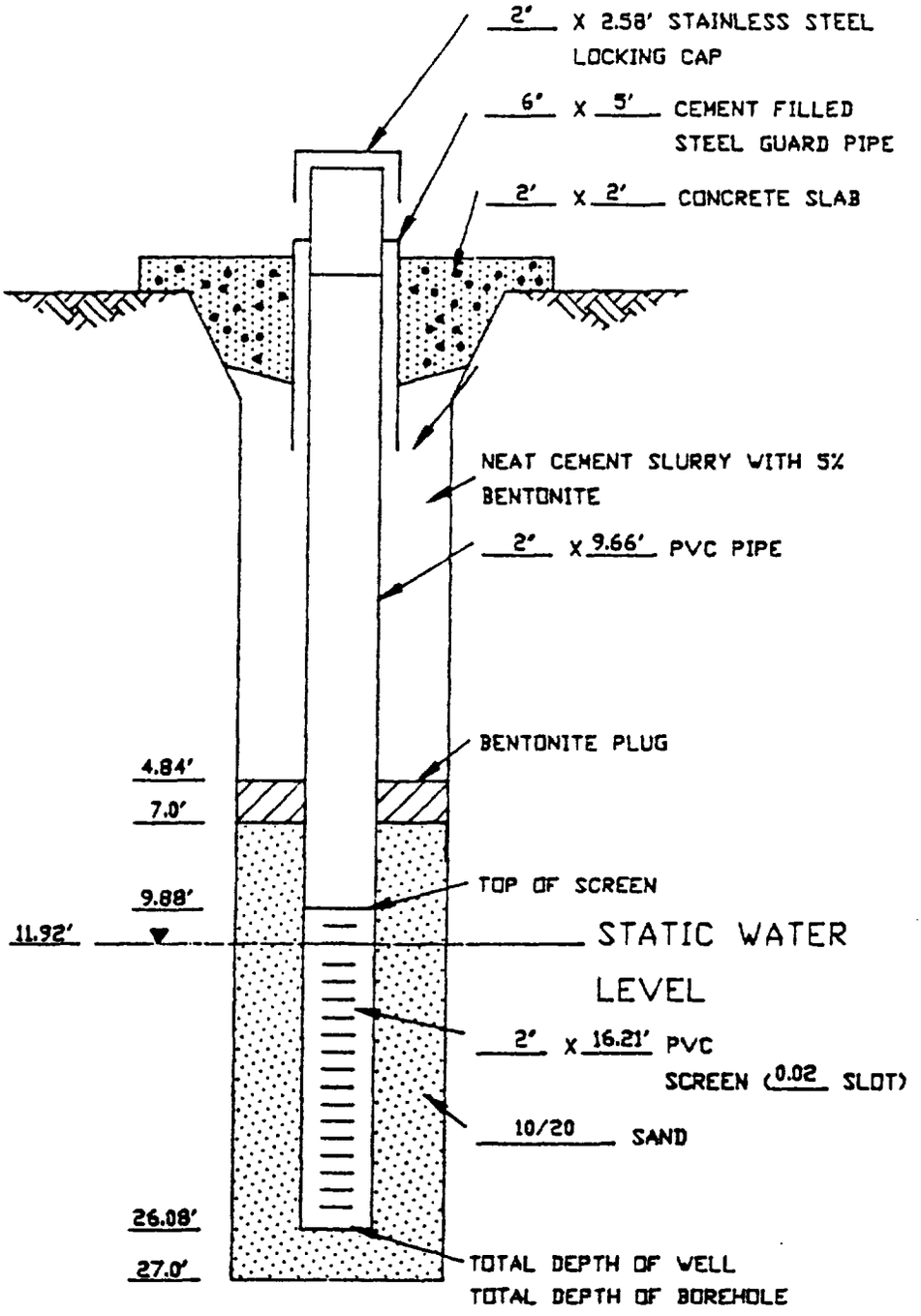
WELL COMPLETION DIAGRAMS



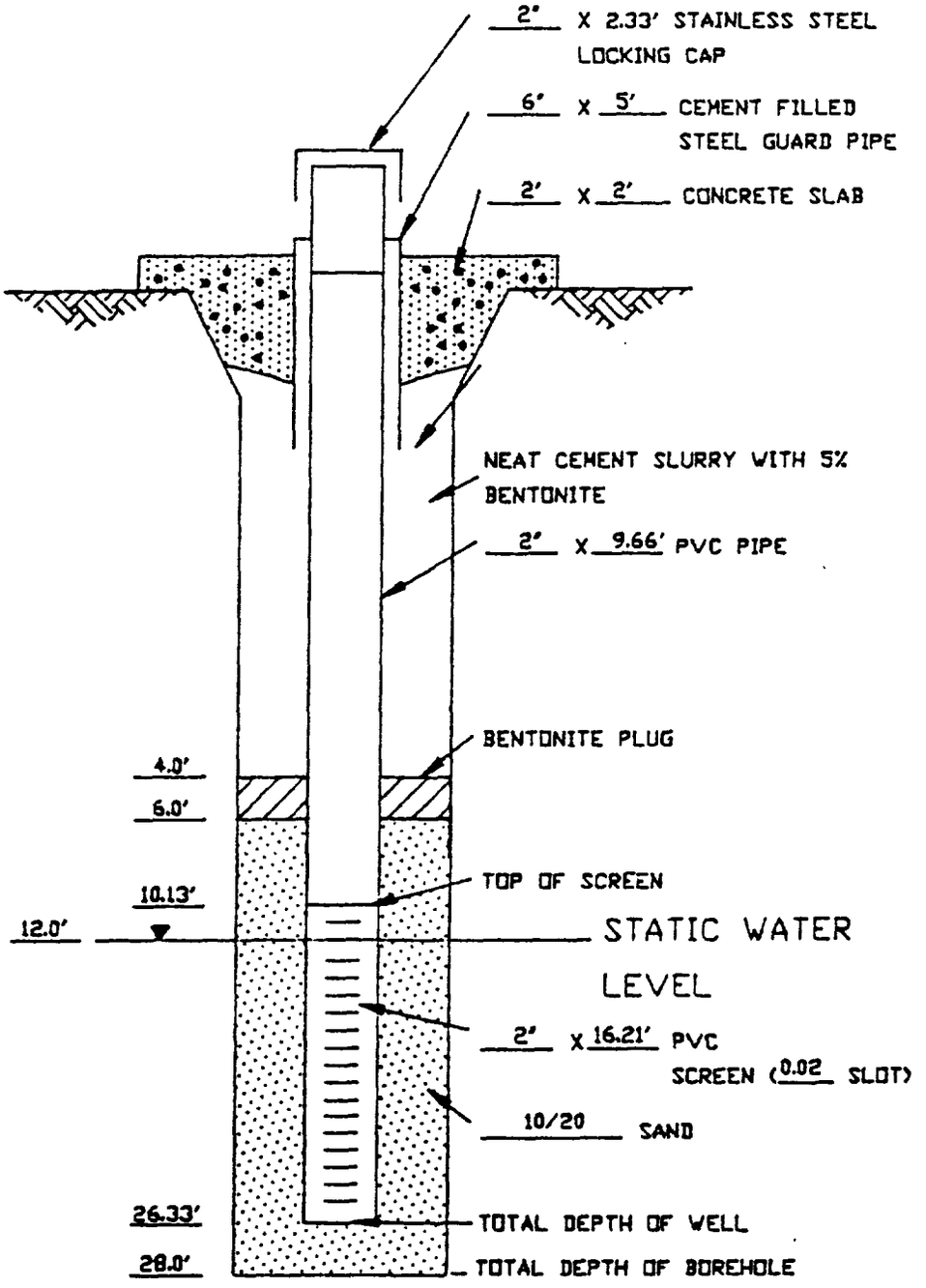
TENNECO WELL COMPLETION DIAGRAM
RIDDLE SITE: WELL R-1



TENNECO WELL COMPLETION DIAGRAM
RIDDLE SITE, WELL R-2

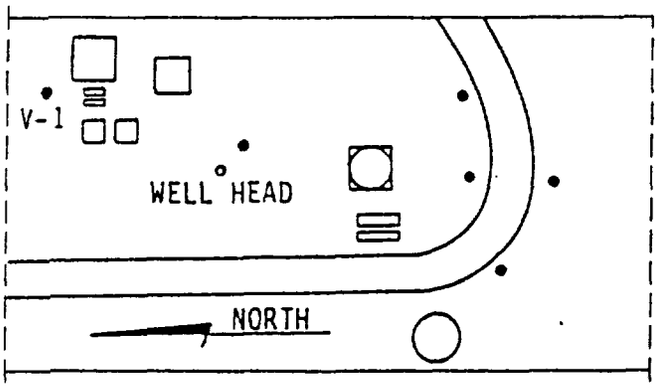


TENNECO WELL COMPLETION DIAGRAM
RIDDLE SITE: WELL R-3



TENNECO WELL COMPLETION DIAGRAM
RIDDLE SITE: WELL R-4

BOREHOLE LOG (SOIL)



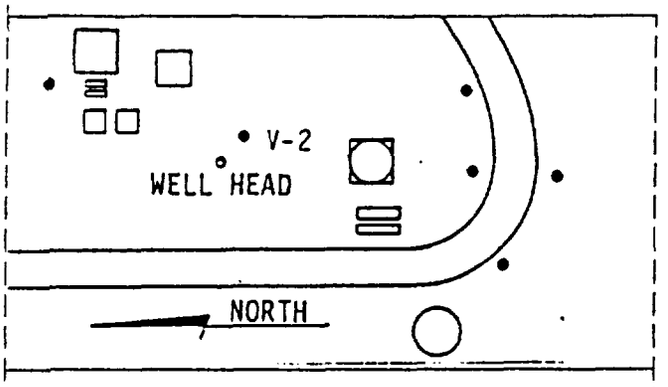
___1/4 ___1/4 ___1/4 ___1/4 S 24 T 29N R 11W

SITE ID: Valdez LOCATION ID: V-1
SITE COORDINATES (ft.): 2390 FWL, 2500 FEL
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
STATE: New Mexico COUNTY: San Juan
DRILLING METHOD: HSA
DRILLING CONTR.: Western Technologies
DATE STARTED: 7/01/88 DATE COMPLETED: 7/01/88
FIELD REP.: W.S. Dubyk, P. Linley
COMMENTS: _____

LOCATION DESCRIPTION: _____

DEPTH	LITH.	REC	SAH	RUN #	RUN FROM	RUN TO	SAMPLE REC.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
0									CH	0'-13' Clay - moderate brown 5 YR 3/4, plastic, damp, no odor.
5									MH	13'-17' Silt - dark yellowish brown, 10 YR 4/2, with clay and minor sand grains.
									GC	17'-20.5' Gravel - with clay and sand, poor cutting return. Water noted at 17'.
10										
15										
20	T.D. 20.17'									
25										
30										

BOREHOLE LOG (SOIL)



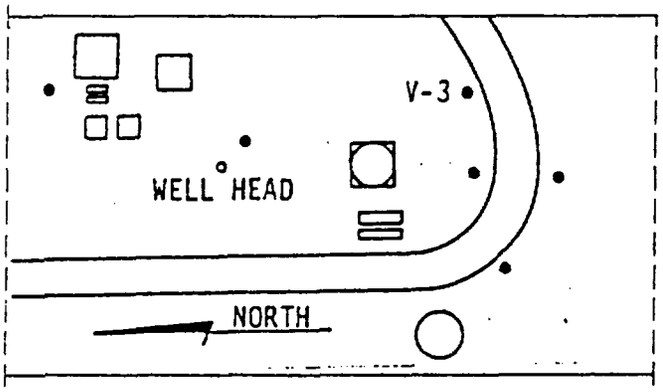
___1/4 ___1/4 ___1/4 ___1/4 S 24 T 29N R 11W

SITE ID: Valdez LOCATION ID: V-2
SITE COORDINATES (ft.): 2390 FNL, 2500 FEL
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
STATE: New Mexico COUNTY: San Juan
DRILLING METHOD: HSA
DRILLING CONTR.: Western Technologies
DATE STARTED: 7/01/88 DATE COMPLETED: 7/01/88
FIELD REP.: W.S. Dubyk, P. Linley
COMMENTS: Cored.

LOCATION DESCRIPTION: _____

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE REC.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
0				1	0'	3'	100%		CH	0'-3' Clay - silty, damp, pale brown 5 YR 5/2 plastic, no odor, fill material.
5				2	3'	8'	60%		SC	3'-8' Sand and Silt - clayey, poorly sorted, moderately rounded, very fine to coarse, yellowish gray damp, probably fill. Grayish Orange Pink 5 Y 7/2.
10				3	8'	13.5'	100%		CH	8'-13.5' Clay - slightly silty, plastic damp, no odor, caliche streaks in fracs. Dark yellowish brown 10 YR 4/2.
15				4	13.5'	18.5'	75%		CH	13.5'-18.5' Clay - as above. Gravel at 18.4', to 2" diameter, slightly rounded, in clay and sand matrix. No coring after 18.5'.
20	T.D. 21.5'			5	18.5'	21.5'	0%		GC	18.5'-21.5' Gravel - no recovery, very slow drilling.
25										
30										

BOREHOLE LOG (SOIL)



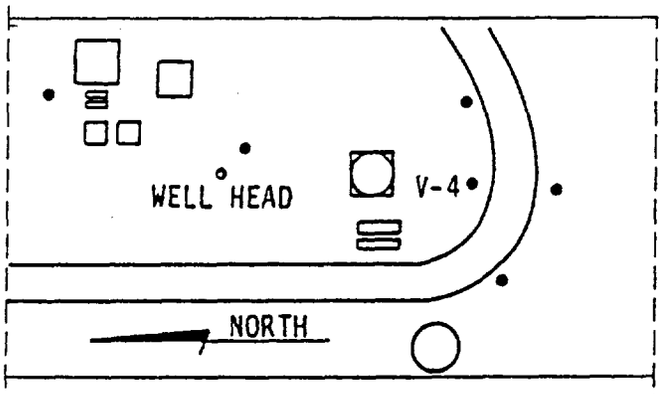
___1/4 ___1/4 ___1/4 ___1/4 S 24 T 29N R 11W

SITE ID: Valdez LOCATION ID: V-3
SITE COORDINATES (ft.): 2390 FNL, 2500 FEL
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
STATE: New Mexico COUNTY: San Juan
DRILLING METHOD: HSA
DRILLING CONTR.: Western Technologies
DATE STARTED: 6/30/88 DATE COMPLETED: 6/30/88
FIELD REP.: W.S. Dubyk, P. Linley
COMMENTS: _____

LOCATION DESCRIPTION: _____

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE REC.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
0									ML	0'-8' Fill - very fine grained silty clay, no odor, light brown 5 YR 6/4.
5									CH	8'-18' Clay - silty, minor rounded quartz grains; plastic, cohesive, carbonate, damp, no odor caliche in fracs. Water at 18' medium brown, 5 YR 4/4.
10										
15									GC	18'-23' Gravel - no sample return difficult drilling.
20										
25	TD 22.94'									
30										

BOREHOLE LOG (SOIL)



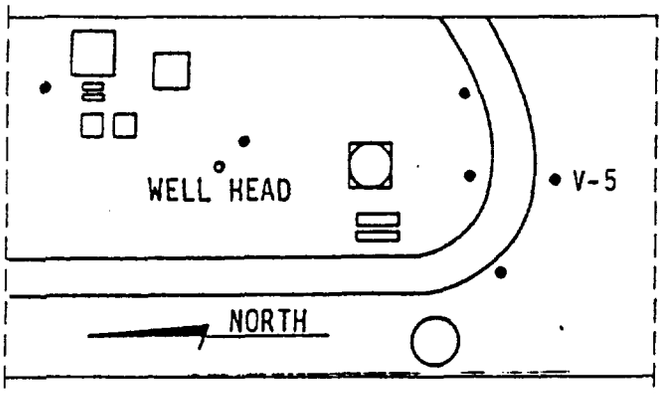
___1/4 ___1/4 ___1/4 ___1/4 S 24 T 29N R 11W

SITE ID: Valdez LOCATION ID: V-4
SITE COORDINATES (ft.): 2390 FNL, 2500 FEL
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
STATE: New Mexico COUNTY: San Juan
DRILLING METHOD: HSA
DRILLING CONTR.: Western Technologies
DATE STARTED: 7/1/88 DATE COMPLETED: 7/1/88
FIELD REP.: W.S. Dubyk, P. Linley
COMMENTS: Cored with continuous sampler

LOCATION DESCRIPTION: _____

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE REC.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
0				1	2'	7'	100%			0'-7' Fill - Clayey sand, no odor.
									CH	7'-13' Clay - Dusky, yellowish brown 10 YR 2/2, laminated, damp, plastic. Hydrocarbon string at 11', odor noted.
5				2	7'	12'	100%			
									CH	13'-17.5' Clay - as above, grades downward into sandy clay, medium yellowish brown, 10 YR 5/4.
10				3	12'	14'	50%			17.5'-18' Sand - with minor gravel moderately yellowish
									GC	brown 10 YR 5/4 moderately sorted, fine to coarse grained. Core to 18'.
15				4	14'	18'	100%		GC	18' Gravel - no sample, difficult drilling.
20										
	T.D. 23'									
25										
30										

BOREHOLE LOG (SOIL)



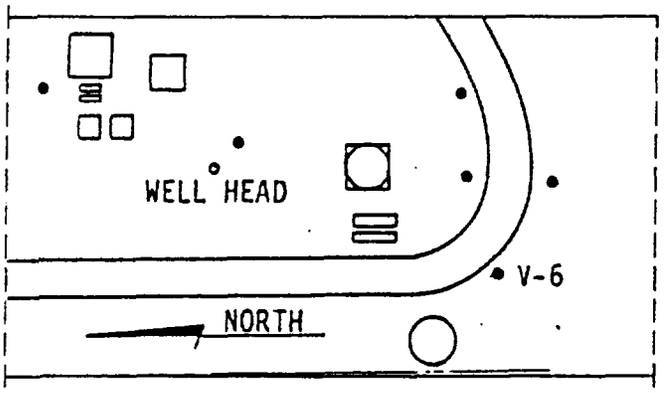
___1/4 ___1/4 ___1/4 ___1/4 S 24 T 29N R 11W

SITE ID: Valdez LOCATION ID: V-5
SITE COORDINATES (ft.): 2390 FNL, 2500 FEL
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
STATE: New Mexico COUNTY: San Juan
DRILLING METHOD: HSA
DRILLING CONTR.: Western Technologies
DATE STARTED: 6/30/88 DATE COMPLETED: 6/30/88
FIELD REP.: W.S. Dubyk, P. Linley
COMMENTS: _____

LOCATION DESCRIPTION: _____

DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE REC.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
0										0'-8' Fill - Silty clay, light brown 5 YR 5/6, no odor.
									CH	9'-13' Clay - Silty, laminated, dusky brown 5 YR 2/2 plastic, damp, no odor.
5										
									MH	13'-17.5' Silt - with clay and ~20% medium to coarse sand grains. Laminated, dusky brown 5 YR 2/2 damp, no odor, plastic.
10										
									GC	17'-23' Gravel - no sample return. H_2O at 17' noted at top of hole. Difficult drilling at 18'.
15										
20										
	T.D. 23'									
25										
30										

BOREHOLE LOG (SOIL)

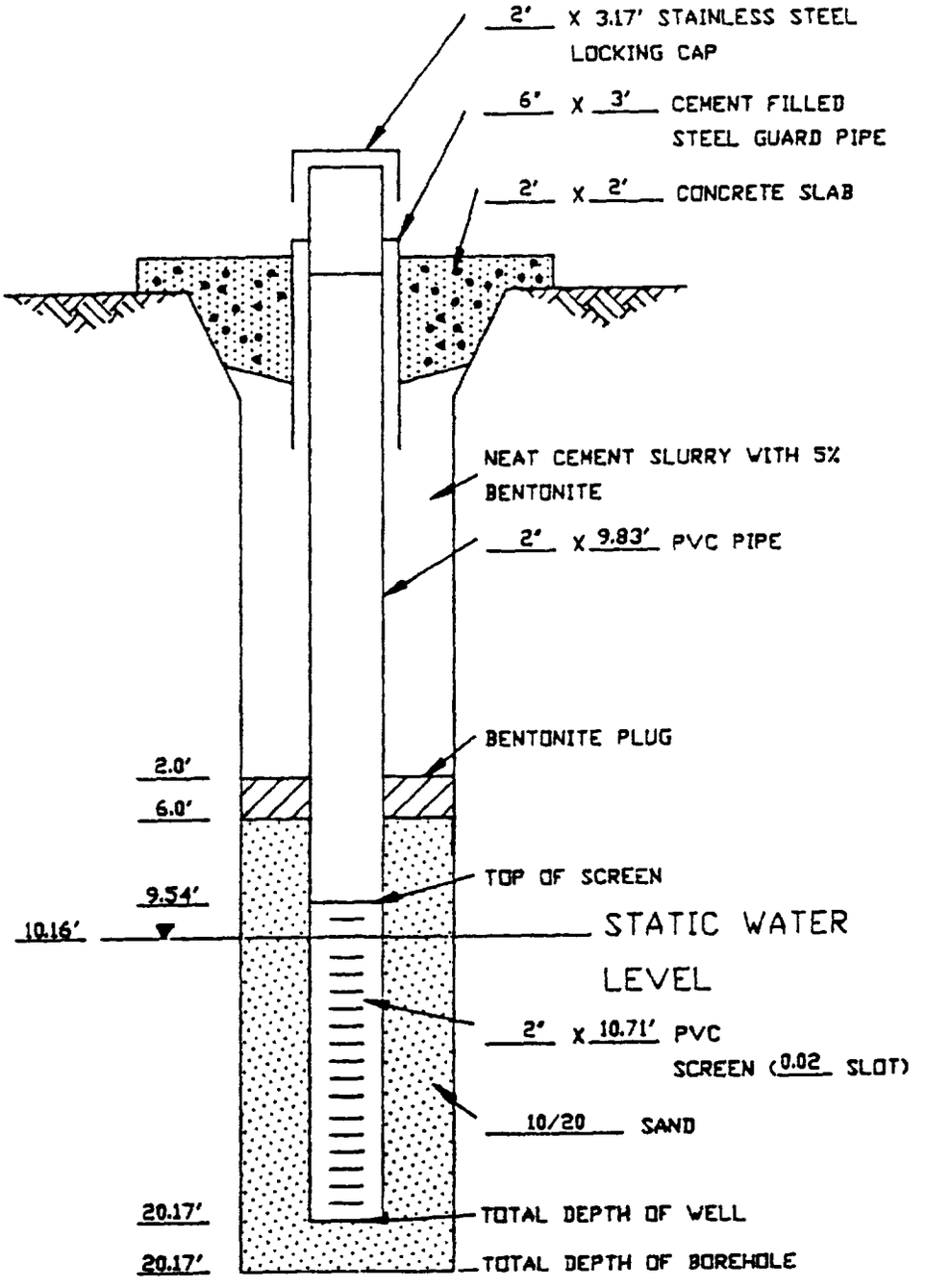


___1/4 ___1/4 ___1/4 ___1/4 S 24 T 29N R 11W

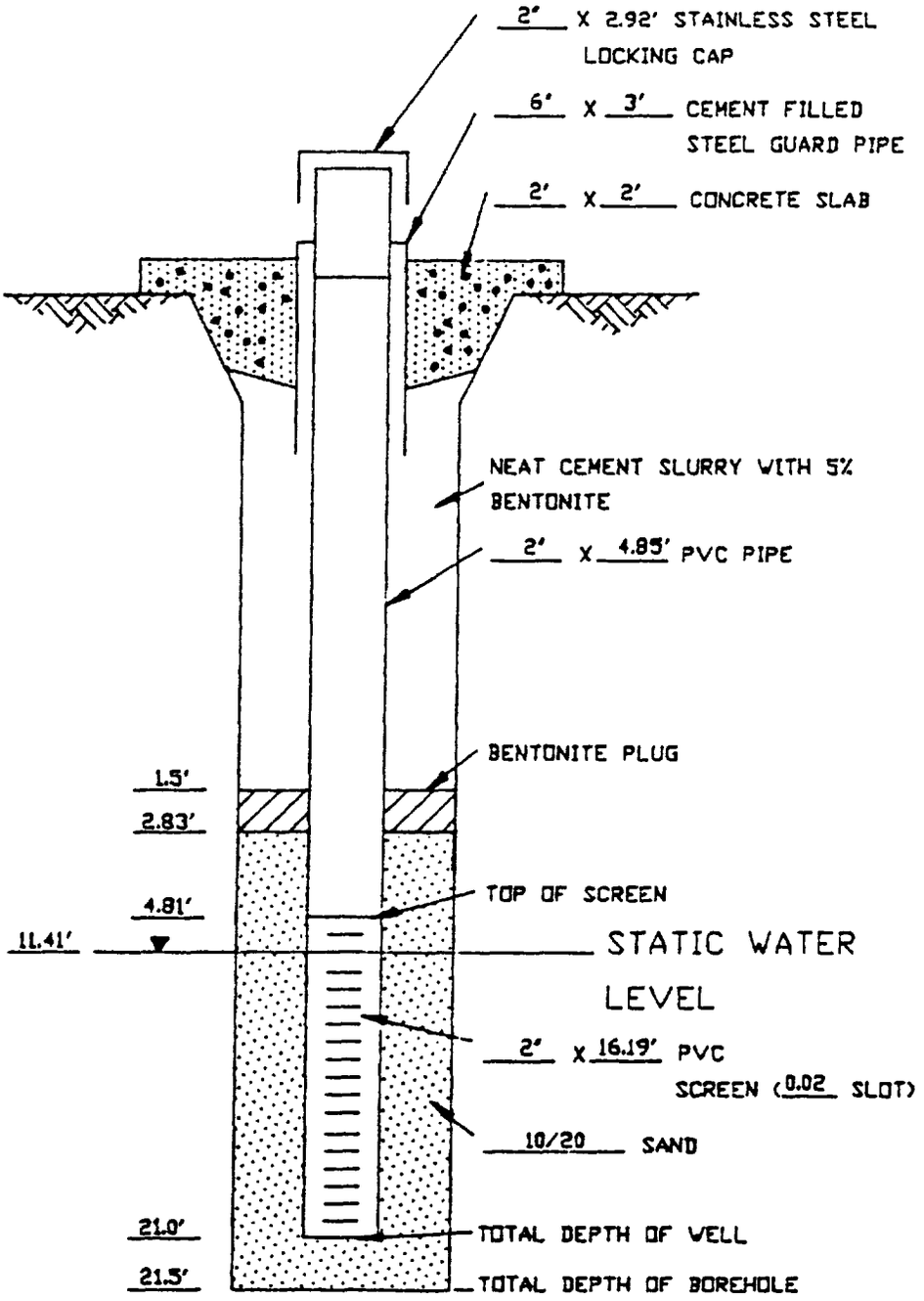
SITE ID: Valdez LOCATION ID: V-6
SITE COORDINATES (ft.): 2390 FNL, 2500 FEL
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
STATE: New Mexico COUNTY: San Juan
DRILLING METHOD: HSA
DRILLING CONTR.: Western Technologies
DATE STARTED: 6/29/88 DATE COMPLETED: 6/30/88
FIELD REP.: W.S. Dubyk, P. Linley
COMMENTS: _____

LOCATION DESCRIPTION: _____

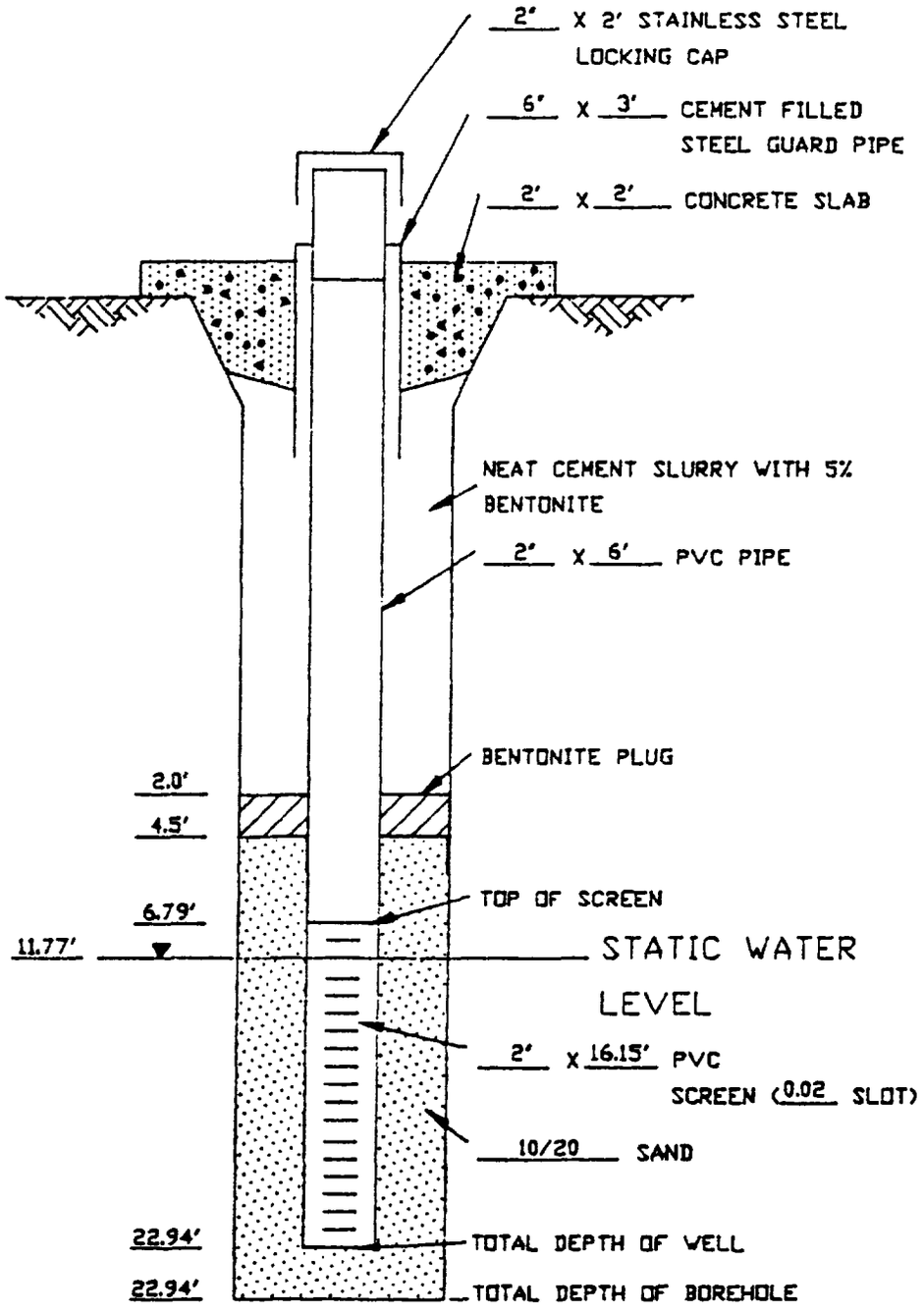
DEPTH	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE REC.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
0										0'-9' Fill - Silty clay, pale brown 5 YR 5/2, very fine grained.
									CH	9'-17' Clay - Silty, carbonate, lined fracs. medium brown 5 YR 4/4, odor at 12'.
5										
									GC	17'-18' Gravel - cobbles, difficult drilling.
10										
									CH	18'-20' Clay - grayish brown 5 YR 3/2; odor noted; plastic, wet.
15										
									GC	20'-20.5' Cobbles - gravel, no sample return. Very difficult drilling (refusal).
20										
	TD 20.81'									
25										
30										



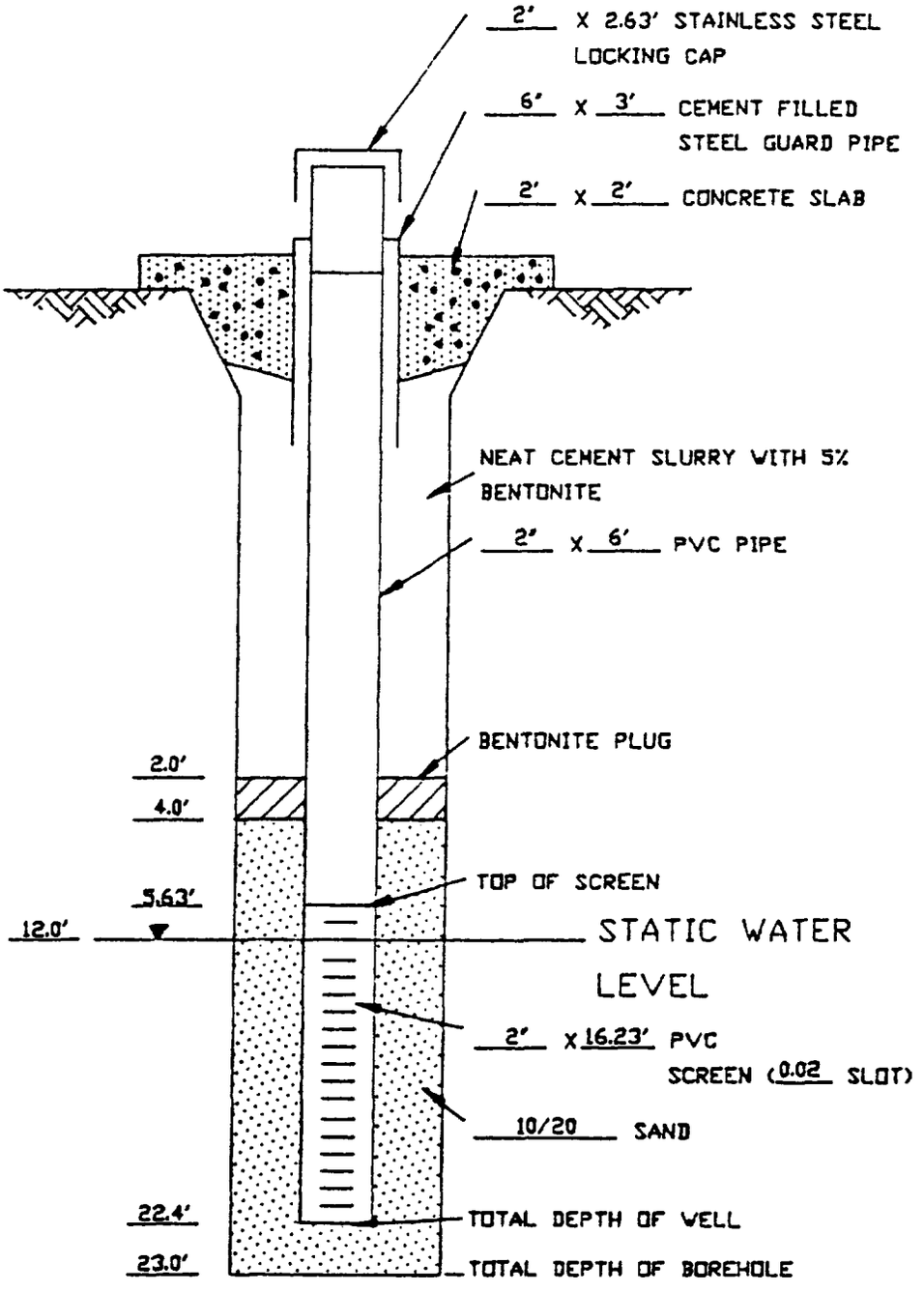
TENNECO WELL COMPLETION DIAGRAM
VALDEZ SITE: WELL V-1



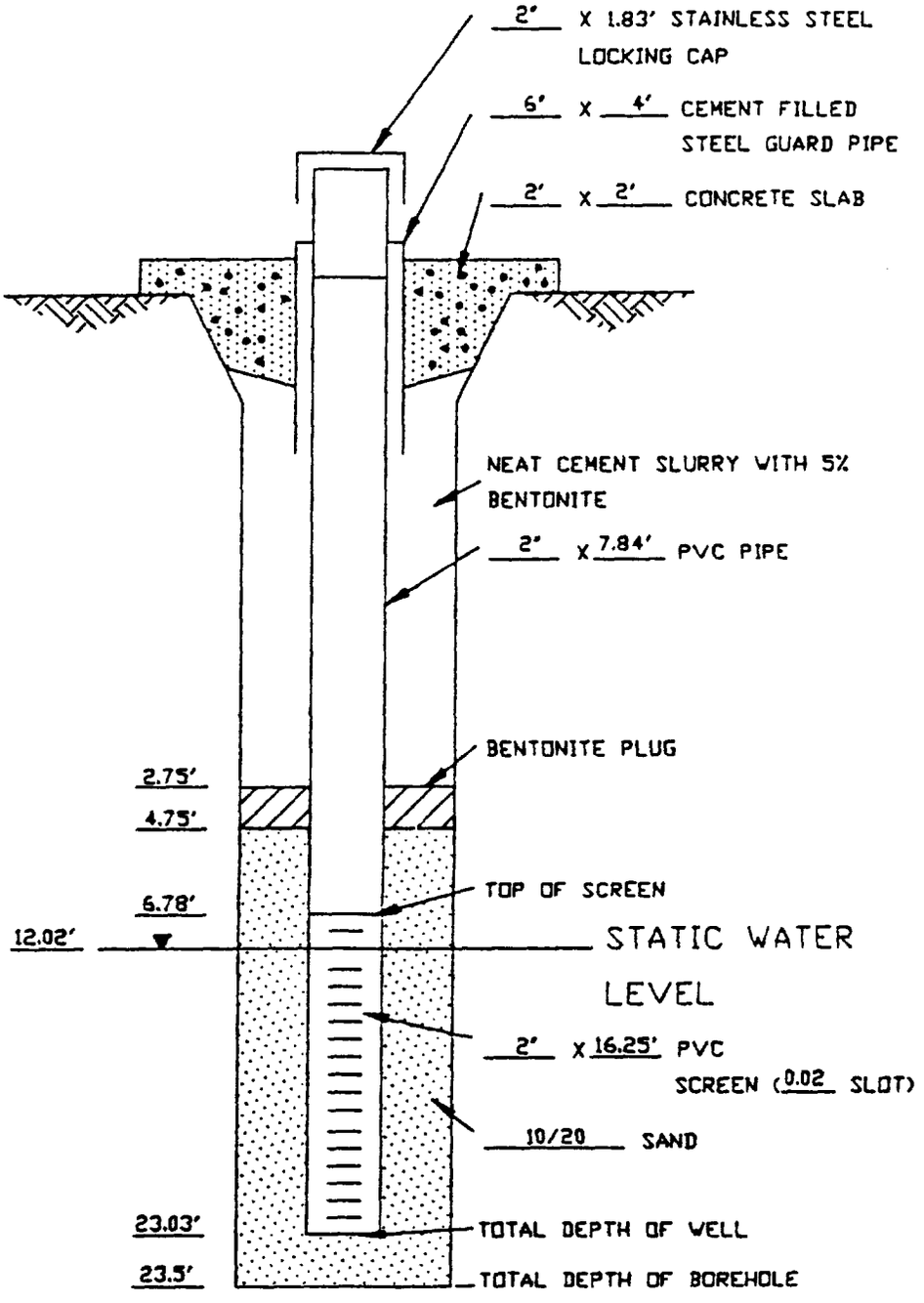
TENNECO WELL COMPLETION DIAGRAM
VALDEZ SITE: WELL V-2



TENNECO WELL COMPLETION DIAGRAM
VALDEZ SITE: WELL V-3

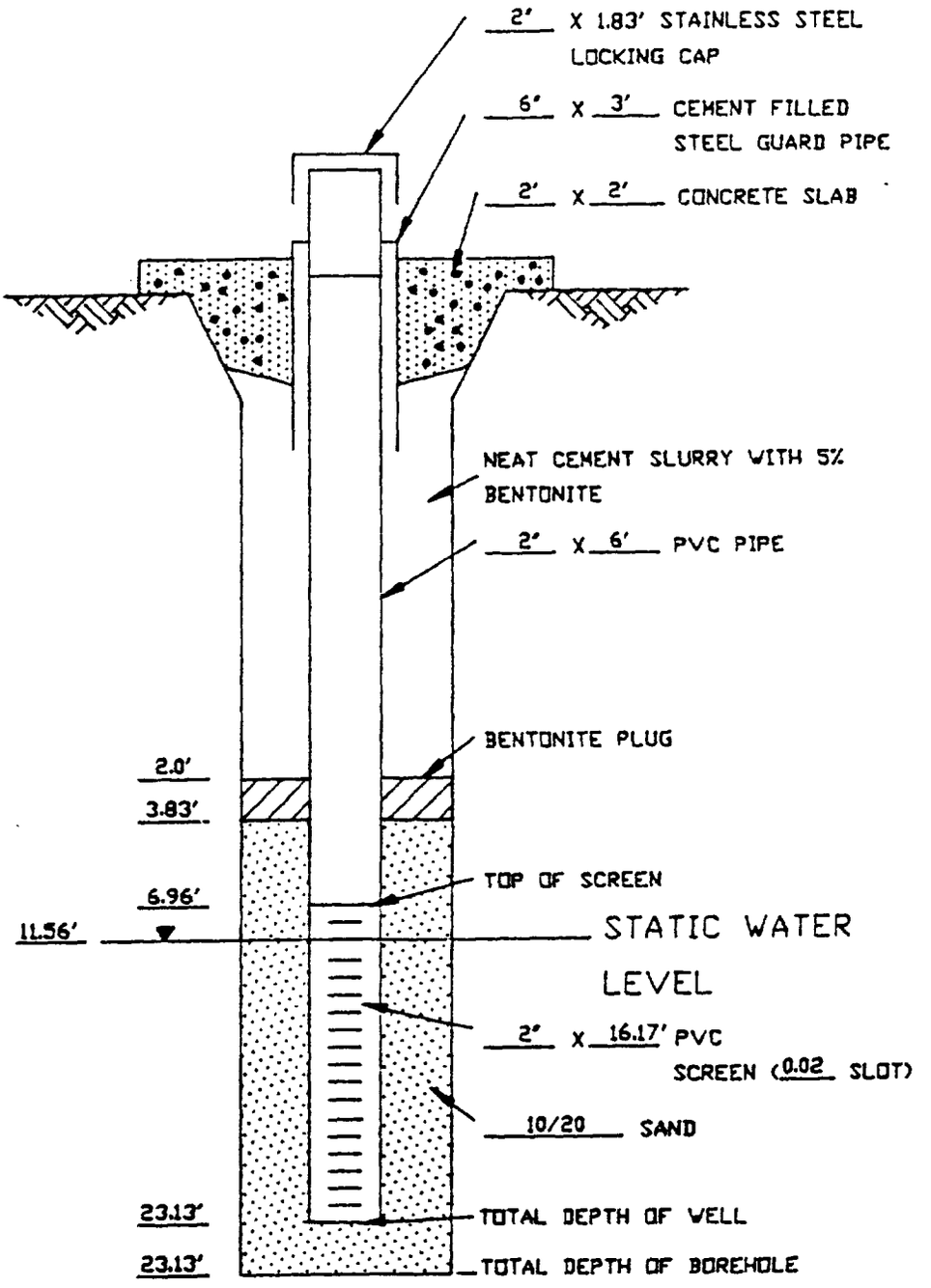


TENNECO WELL COMPLETION DIAGRAM
VALDEZ SITE: WELL V-4

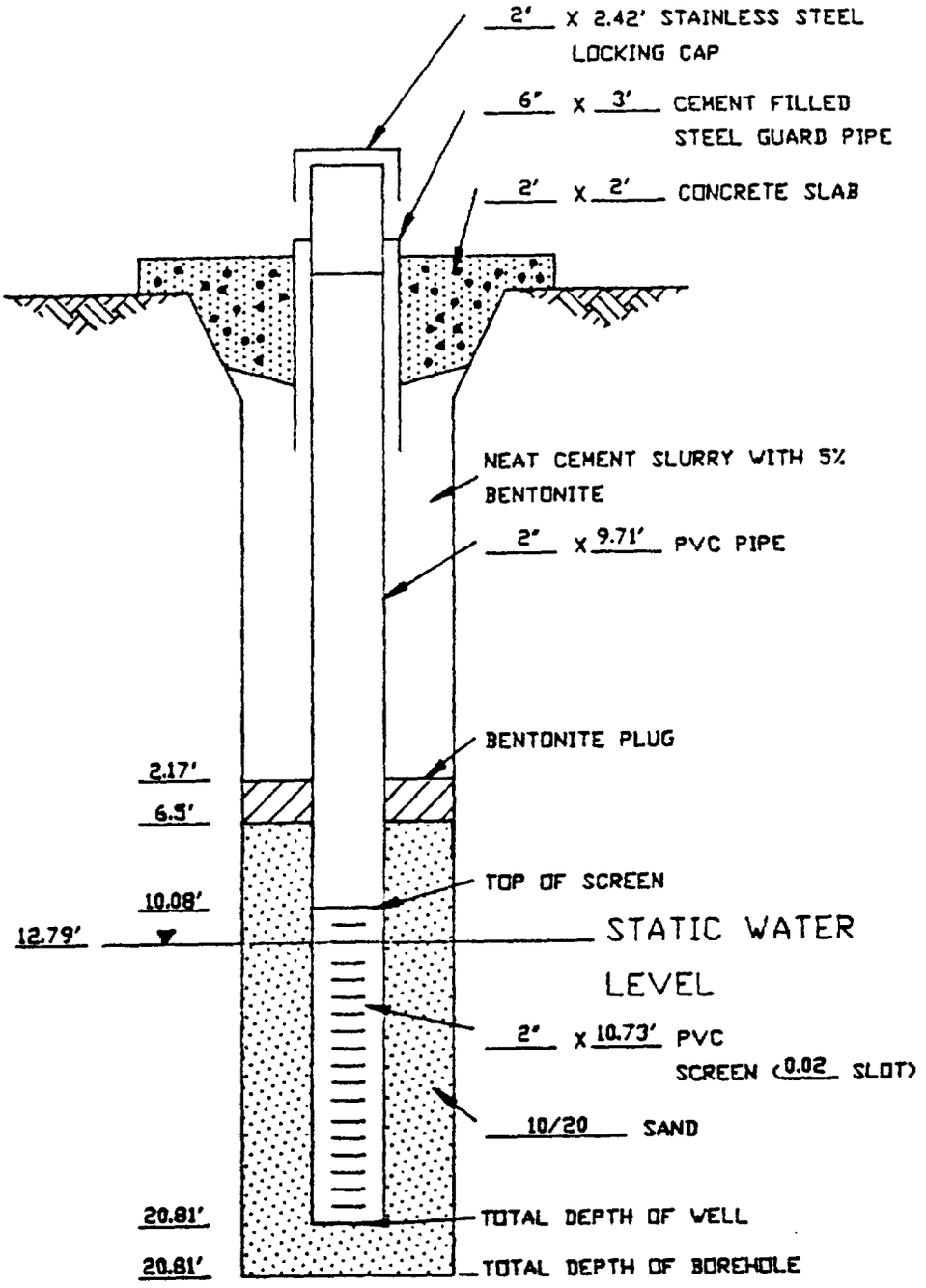


TENNECO WELL COMPLETION DIAGRAM

VALDEZ SITE: WELL V-4A



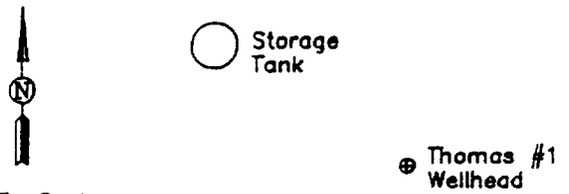
TENNECO WELL COMPLETION DIAGRAM
VALDEZ SITE WELL V-5



TENNECO WELL COMPLETION DIAGRAM
VALDEZ SITE: WELL V-6

MW-1 Lithlog

LOCATION MAP:



NW 1/4 SE 1/4 NW 1/4 SW 1/4 S 30 T 29N R 11W

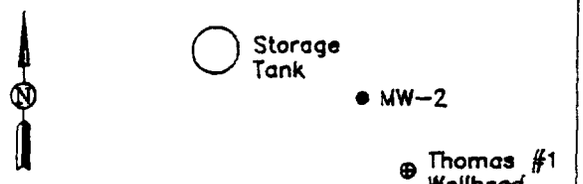
SITE ID: Thomas #1 LOCATION ID: MW-1
SITE COORDINATES (ft.):
N 1215.49 E 1069.32
GROUND ELEVATION (ft. MSL): 5375.66
STATE: N.M. COUNTY: San Juan
DRILLING METHOD: Drive Point
DRILLING CONTR.: H+GCL
DATE STARTED: 8-29-91 DATE COMPLETED: 8-30-91
FIELD REP.: M. Mohorcich, P. Eberly
COMMENTS:

LOCATION DESCRIPTION: 6' East And 215' North Of Thomas #1 Wellhead

DEPTH (ft.)	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
										0–1.5' Sandy Silt: With Roots And Some Caliche, Moderatly Consolidated.
										1.5–2.5' Silty Sand: Fine To Medium Sand.
										2.5–4' Silty Clay: Moderatly Consolidated.
										4–6' Clayey Sand: Water Detected At 4'.
5										
										Note: Drove In Well From 6'
10										10.66' T.D. Well = 10.66'
15										

MW-2 Lithlog

LOCATION MAP:



Not To Scale

NW 1/4 SE 1/4 NW 1/4 SW 1/4 S 30 T 29N R 11W

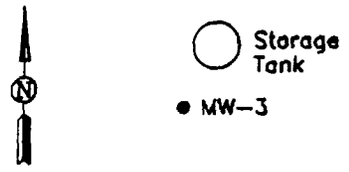
SITE ID: Thomas #1 LOCATION ID: MW-2
SITE COORDINATES (ft.):
N 1057.96 E 1027.11
GROUND ELEVATION (ft. MSL): 5375.71
STATE: N.M. COUNTY: San Juan
DRILLING METHOD: Drive Point
DRILLING CONTR.: H+GCL
DATE STARTED: 8-29-91 DATE COMPLETED: 8-30-91
FIELD REP.: M. Mohorcich, P. Eberly
COMMENTS:

LOCATION DESCRIPTION: 36' West And 58' North Of Thomas #1 Wellhead.

DEPTH (ft.)	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
										0–2.5' Sand: 10YR 5/4, Fine To Medium Grained, Unconsolidated.
										2.5–3.0' Clayey Sand: 10YR 4/2, Moderately Consolidated.
										3.0–3.5' Sand Loss In Clay With Black Stain And Hydrocarbon (HC) Odor At 3.3'.
										3.5–4.0' Clayey Sand: Black, Fine Grained Sand, HC Odor And Stained.
										4.0–5.5' Sand: Black, Fine Grained From 4.0'–5.0', H2O At 4.5', Medium To Coarse Grained From 5.0'–5.5'
5										
										Note: Drove In Well From 5.5'.
10										10.79' T.D. Well = 10.79'
15										

MW-3 Lithlog

LOCATION MAP:



Not To Scale

NW 1/4 SE 1/4 NW 1/4 SW 1/4 S 30 T 29N R 11W

SITE ID: Thomas #1 LOCATION ID: MW-3
SITE COORDINATES (ft.):
N 1063.88 E 896.19
GROUND ELEVATION (ft. MSL): 5374.28
STATE: N.M. COUNTY: San Juan
DRILLING METHOD: Drive Point
DRILLING CONTR.: H+GCL
DATE STARTED: 8-29-91 DATE COMPLETED: 8-30-91
FIELD REP.: M. Mohorcich, P. Eberly
COMMENTS:

LOCATION DESCRIPTION: 167' West And 64' North Of Thomas #1 Wellhead.

DEPTH (ft.)	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
										0–1.5' Silty Sand: 10YR, Roots, Moderately Consolidated.
										1.5–2.0' Clayey Sand 10YR, Well Sorted, Unconsolidated.
										2.0–4.0' Sand: 5Y 6/4, Medium To Coarse Grained, Clay Poor, Unconsolidated Grades To Black Highly Organic, Staining And Odor At 2.5–4.0'. H2O At 4'.
5										
										Note: Drove In Well From 4'.
10										10.80' T.D. Well = 10.80'
15										

MW-4 Lithlog

LOCATION MAP:

Storage Tank

Thomas #1 Wellhead

Not To Scale

MW-4

NW1/4 SE1/4 NW1/4 SW1/4 S 30 T 29N R 11W

SITE ID: Thomas #1 LOCATION ID: MW-4
SITE COORDINATES (ft.):
N 972.75 E 946.58
GROUND ELEVATION (ft. MSL): 5374.31
STATE: N.M. COUNTY: San Juan
DRILLING METHOD: Drive Point
DRILLING CONTR.: H+GCL
DATE STARTED: 8-29-91 DATE COMPLETED: 8-30-91
FIELD REP.: M. Mohorcich, P. Eberly
COMMENTS:

LOCATION DESCRIPTION: 116' West And 27' South Of Thomas #1 Wellhead.

DEPTH (ft.)	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
										0-1.5' Sandy Silt: Very Fine Grained Sand in Silt.
										1.5-2.3' Cobbles & Gravel: Up To 5" In Diameter, Unconsolidated.
5										Note: Unable To Auger Past 2.3' Due To Cobbles. Drove Well From 2.3'.
10										10.82' T.D. Well = 10.82'
15										

MW-6 Lithlog

LOCATION MAP:

⊕ Thomas #1 Wellhead

Not To Scale

Trailer

● MW-5

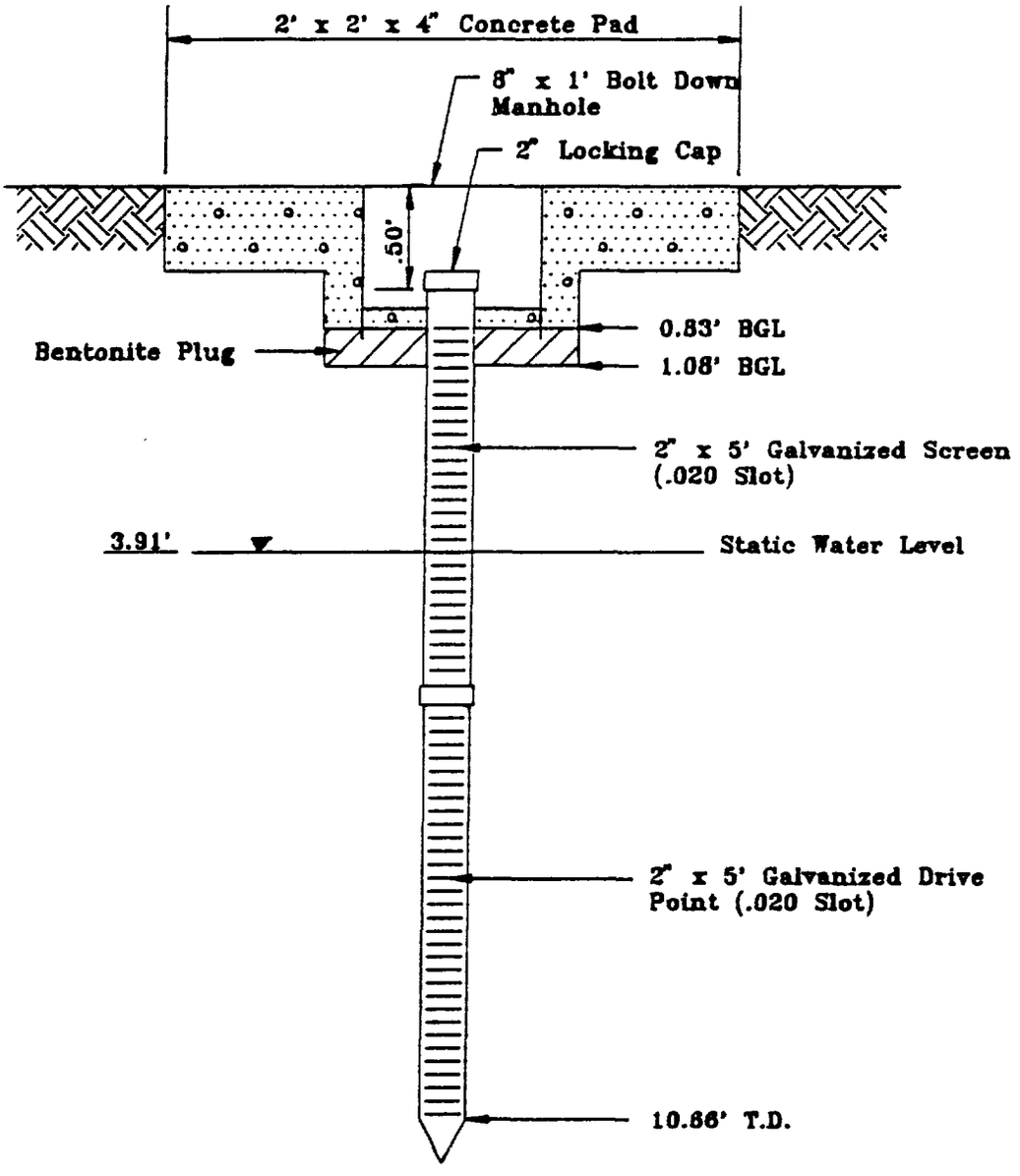
NW 1/4 SE 1/4 NW 1/4 SW 1/4 S 30 T 29N R 11W

SITE ID: Thomas #1 LOCATION ID: MW-5
SITE COORDINATES (ft.):
N 851.28 E 728.94
GROUND ELEVATION (ft. MSL): 5375.07
STATE: N.M. COUNTY: San Juan
DRILLING METHOD: Drive Point
DRILLING CONTR.: H+GCL
DATE STARTED: 8-29-91 DATE COMPLETED: 8-30-91
FIELD REP.: M. Mohorcich, P. Eberly
COMMENTS:

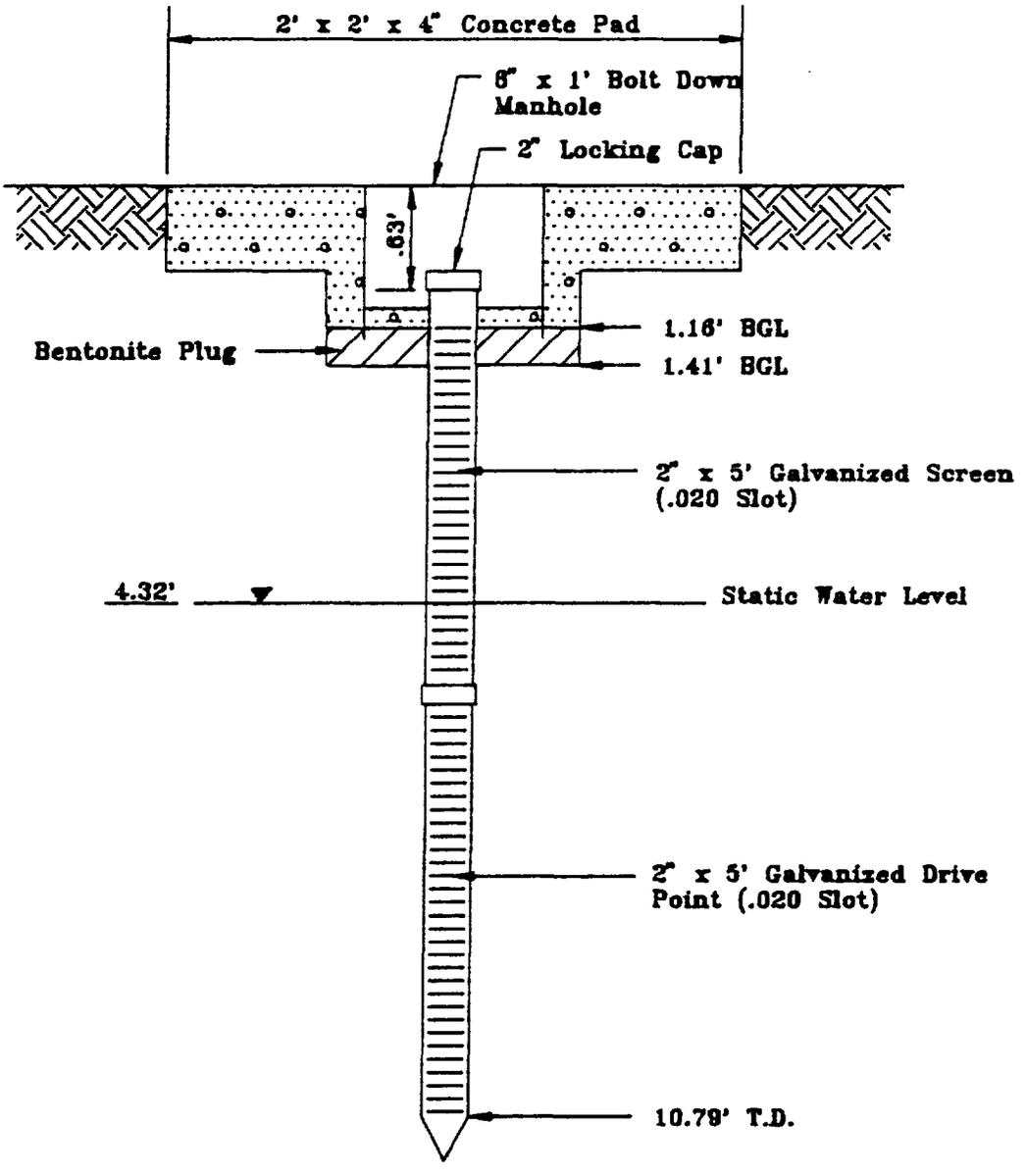
LOCATION DESCRIPTION: 334' West And 149' South Of Thomas #1 Wellhead.

DEPTH (ft.)	LITH.	REC	SAM	RUN #	RUN FROM	RUN TO	SAMPLE I.D.	SAMPLE TYPE	USCS	VISUAL CLASSIFICATION
										0–2.0' Sandy Silt: Organic, Very Moist From Irrigating.
5										Note: Drove In Well From 2'.
10										10.79' T.D. Well = 10.79'
15										

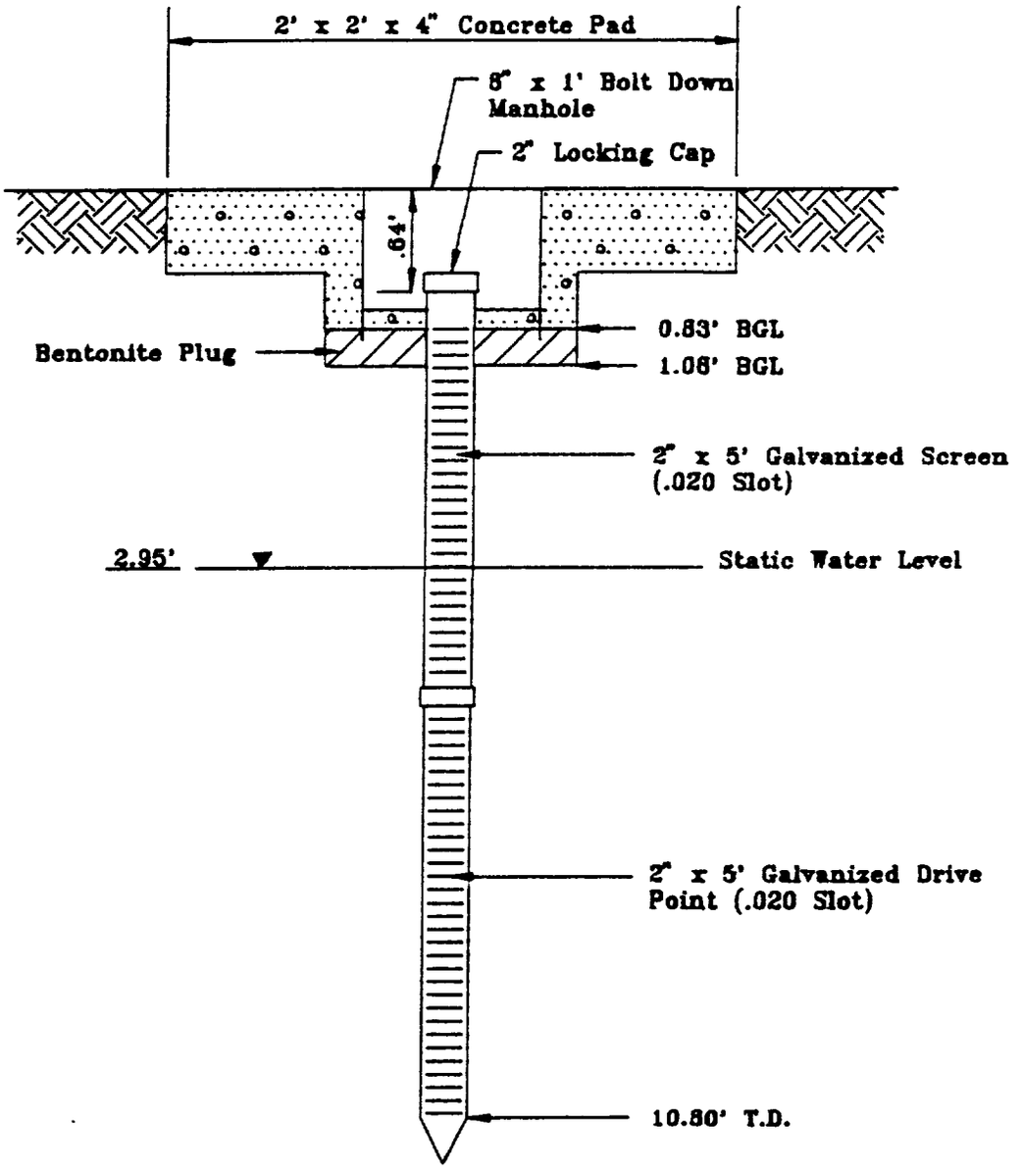
Monitor Well MW-1 Completion Diagram



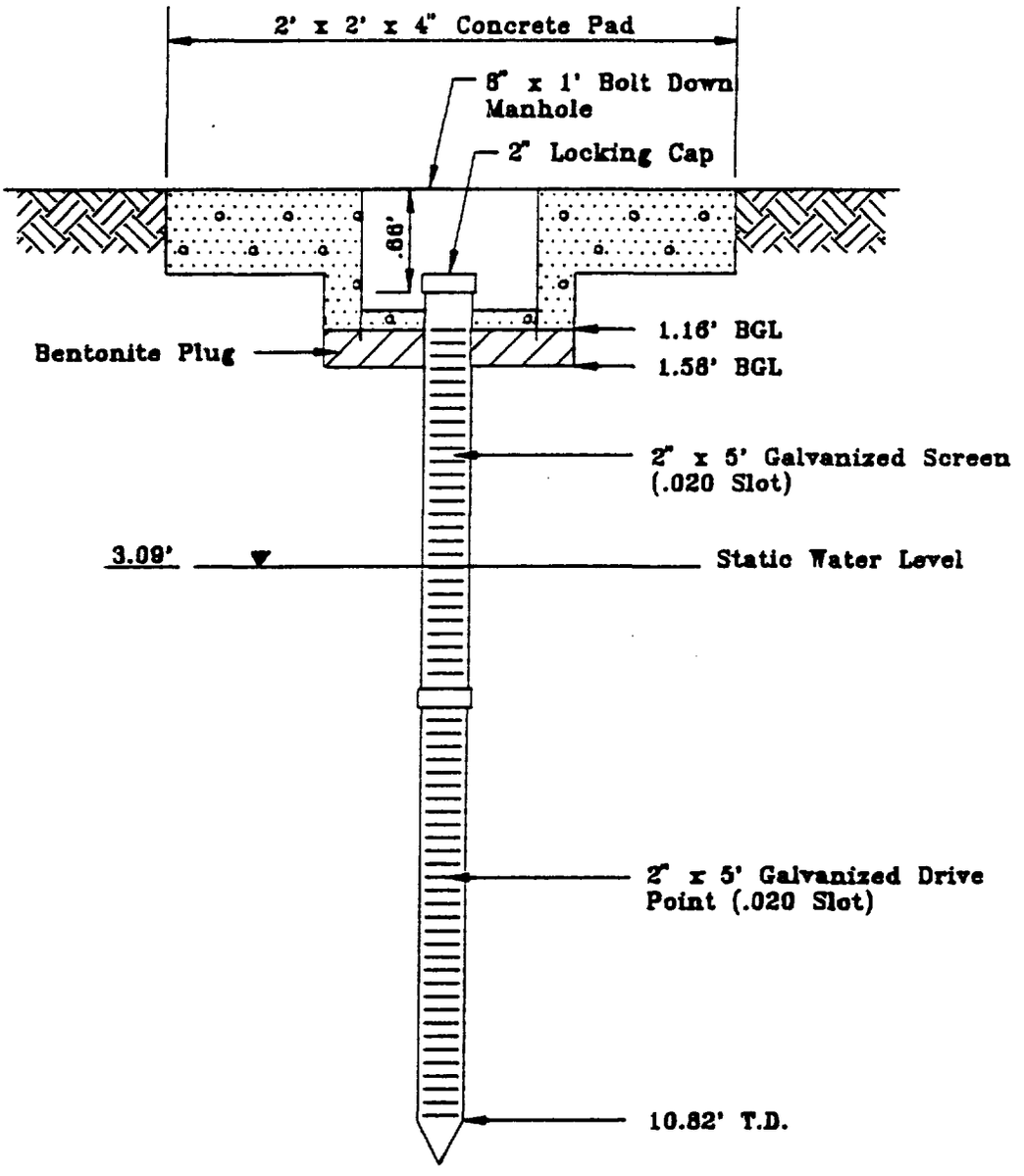
Monitor Well MW-2 Completion Diagram



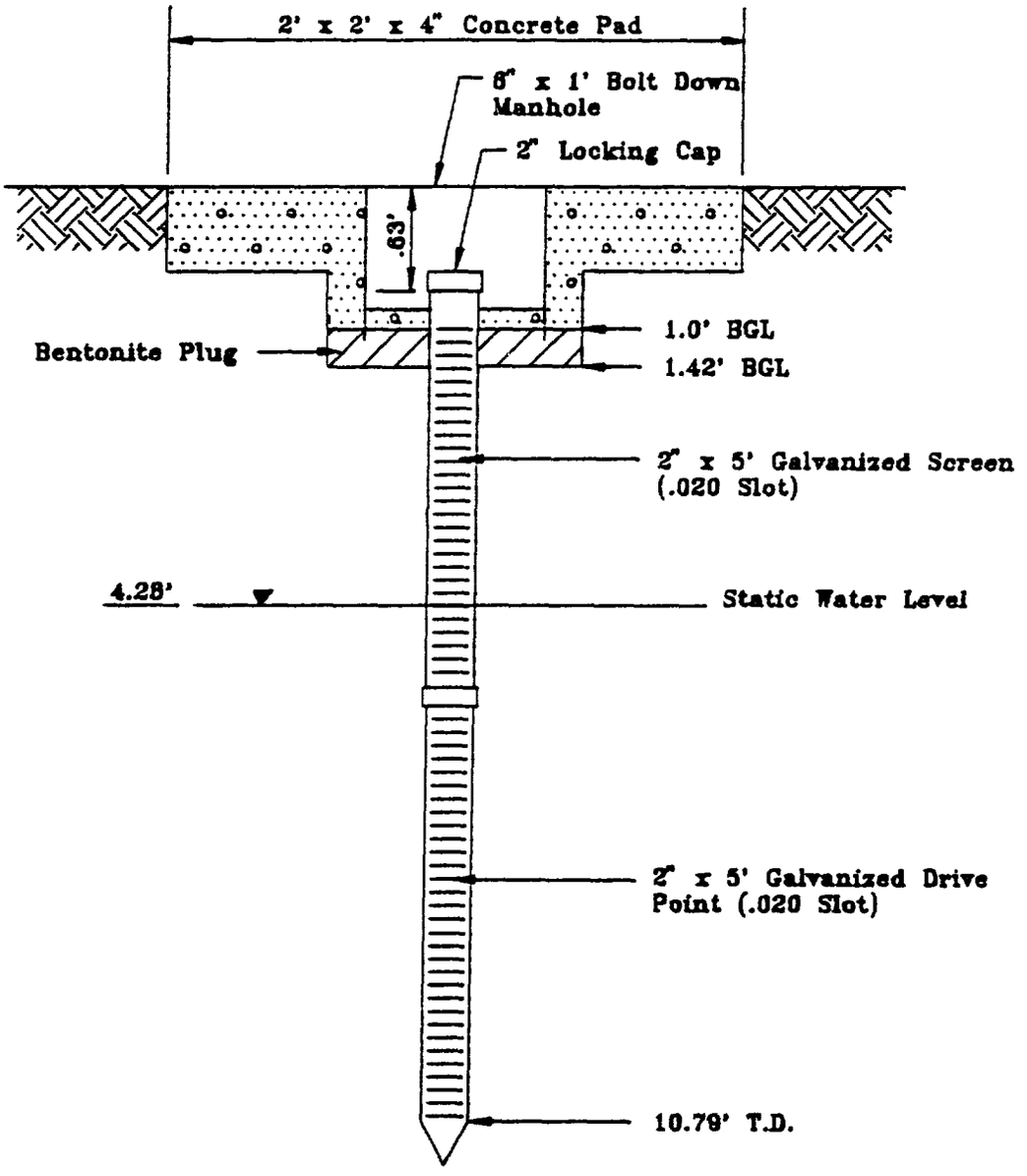
Monitor Well MW-3 Completion Diagram



Monitor Well MW-4 Completion Diagram



Monitor Well MW-5 Completion Diagram



Section 5.5.2 of the API Environmental Guidance Document, 1989

FCGPA Exhibit 13 for the May 21, 1992 Continuation of the April 9, 1992, New Mexico Oil Conservation Commission Hearing on Case Number 10436

May 18, 1992

Prepared for:

The Four Corners Gas Producers Association

Prepared by:

H⁺GCL

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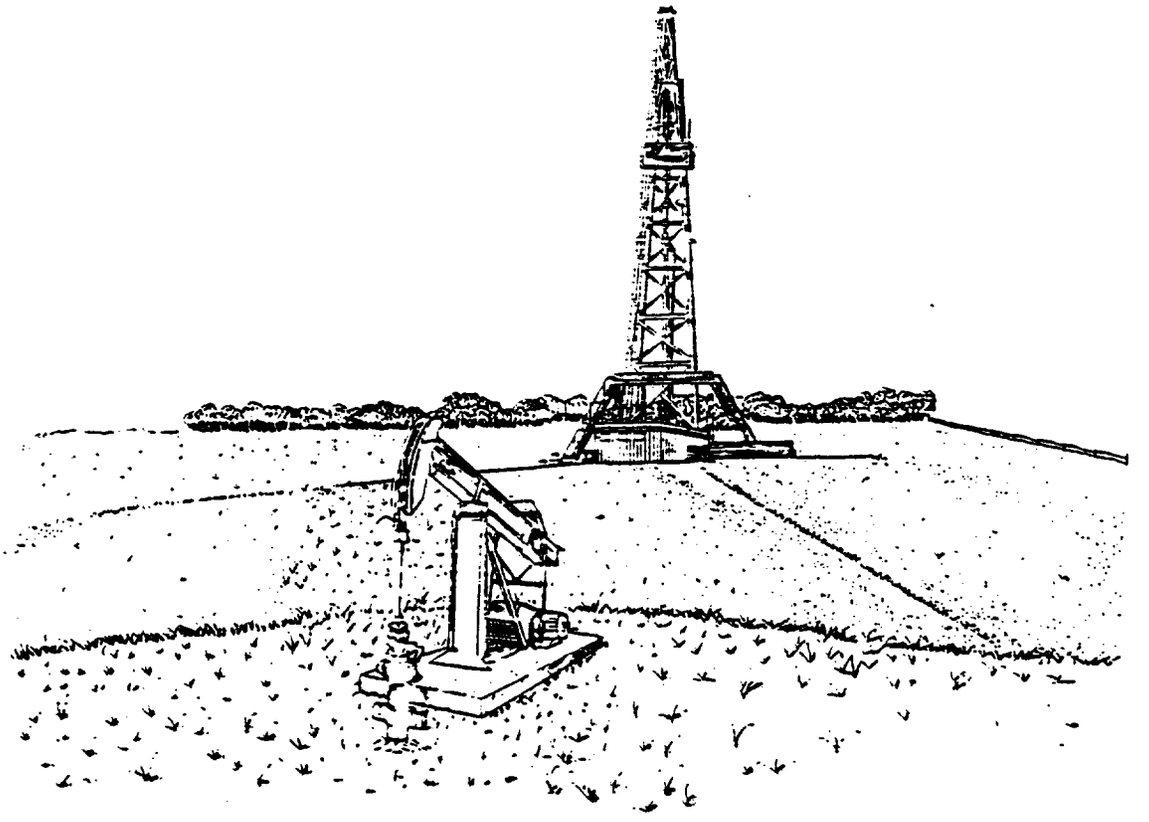
API ENVIRONMENTAL GUIDANCE DOCUMENT

ONSHORE SOLID WASTE MANAGEMENT IN EXPLORATION AND PRODUCTION OPERATIONS



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APPENDIXES

7) Oil-based mud liquids should generally be returned to vendors or reclaimed at permitted facilities.

8) Oil-based mud solids should be taken to offsite disposal facilities capable of handling oily wastes or mixed with soil to less than one percent oil and grease content by weight during burial or landspreading onsite. It may be possible to reduce the oil content of some muds by washing mud solids to reach this criteria. Burial of solids with oil and grease content in excess of one percent may be feasible when approved solidification techniques are used. When drilling wells where both freshwater and oil-based muds are used, consideration should be given to segregating the oil-based system to minimize total volume of oily waste.

9) Pit sites should be compacted, contoured, and vegetated where necessary to provide ground support stability and prevent erosion of the well location. Records should be kept of pit locations.

10) Operators should keep records of type, volume, analytical data, destination, and hauler used for waste fluids and solids transported to offsite facilities.

5.5.2 Production Pits

Construction, operation, and closure of onsite pits should generally follow the same guidelines as those for reserve pits described in Sections 5.5.1.1, 5.5.1.2, and 5.5.1.3. Unlined onsite pits used for disposal of waste should be restricted to areas where soil conditions, hydrological factors and rainfall prevent significant soil or groundwater contamination. The following guidelines should be used for various onsite production pits.

5.5.2.1 Blowdown and Emergency Pits

Blowdown and emergency pits (flare pits, pressure vessel relief pits, and fluid overflow pits) should not be used for storage or disposal. Fluids diverted to emergency pits should be removed as quickly as practical and in accordance with local, state, and federal land regulations. Siting and construction should minimize surface or groundwater contamination.

5.5.2.2 Workover Pits

Workover pits used to contain workover fluids should be open only for the duration of the workover. Siting of these pits should consider the presence of usable groundwater and surface waters. If site-specific considerations indicate that these waters could be endangered, pits should be lined or tanks used if workover or drilling fluids will contain TDS in excess of 3000 ppm (approximately 4 mmhos/cm conductivity), or hydrocarbons or potentially toxic additives or compounds.

5.5.2.3 Basic Sediment Pits

Basic sediment pits have been used for temporary storage of oily wastes such as paraffin and vessel bottoms. Their contents are periodically cleaned out or burned. Basic sediment pits should be lined or replaced with tankage.

5.5.2.4 Percolation Pits

Percolation pits allow liquid contents to drain or seep through the bottom and sides of the pit into surrounding soils. Percolation pits should be used only for disposal of produced waters where permitted by regulatory agencies and USDWs are not present or endangered.

5.5.2.5 Unlined Skimming/Settling Pits

Unlined skimming/settling pits are used in association with discharges to provide additional retention time for the settling of solids allowing more complete residual oil separation. Unlined skimming/settling pits should be used only in conjunction with permitted state/NPDES discharges. Pit walls should be constructed to prevent seepage and should provide two feet of free board above normal operating levels.

5.5.2.6 Produced Water Pits

Produced water pits have been used in lieu of tankage. Produced water pits should be lined and only be operated as a substitute for process vessels with NPDES or injection well regulated disposal of the produced water.

5.5.2.7 Evaporation Pits

In areas where small volumes of waste waters are generated, evaporation pits have been used. Disposal of waste water by evaporation results in the concentration of salts and residual hydrocarbons. Surface evaporation pits should be lined where ground-water or usable soils may be endangered.

5.6 Annular Injection of Reserve Pit Fluids

Annular injection is a disposal method where pumpable reserve pit fluids are injected down the surface casing/protective casing annulus (or other casing/casing annulus) of a drilling well into formations not containing usable sources of drinking water. As a general rule, the maximum surface injection pressure should be limited to 0.5 psi per foot of protective casing annulus depth or one-half the burst strength of the protective casing annulus, whichever is less. In addition, underground sources of drinking water must be protected by sufficient casing and cement to prevent contamination due to injected drilling fluids.

5.7 Underground Injection Wells

The production process produces fluids from and injects fluids into underground reservoirs, an activity which is permitted by state and federal agencies. The injection of fluids brought to the surface during oil and gas production, for disposal or enhanced oil recovery are subject to state and federal underground injection control regulations. Underground injection wells associated with exploration and production activities are classified by EPA as Class II wells. However, a few states have required that some gas plant wastes be disposed in EPA classified Class I industrial disposal wells. EPA classified Class V wells should not be used for disposal of E&P wastes without specific regulatory agency approval.

Injection wells must be designed to prevent endangerment of usable sources of drinking water. Operators must demonstrate mechanical integrity by ensuring that there is no leak in the tubing, casing, or packer, and that an injected fluid is confined within the injection zone through proper cementing. Underground injection wells represent a safe environmental practice for disposal of produced water, facility waste fluids and hydrocarbon containing wastes. Class II wells should be used whenever practical to dispose of nonhazardous and exempt exploration and production waste fluids.