WPO # 40831
417279

Records Package for Screening Effort NS5A:
Pumping from the Culebra Outside of the Controlled Area

Michael G. Wallace

Lead Staff Member: Michael Wallace, Dept. 6849 (contractor) (MS 1328)

Table of Contents:

Summary Memo of Record for NS5a;
Pumping from the Culebra Outside of the Controlled Area.
Michael Wallace

Recommended Screening Decision:

NS5a is recommended to be screened out on the basis of low consequence.

Statement of Screening Issues:

Concerns have been raised that a well pumping from outside the Controlled Area (CA) in the Culebra could increase hydraulic gradients to the south, thereby speeding up groundwater flow velocities in that direction, thereby increasing releases to the accessible environment (AE).

Approach, Discussion, and Results:

From a regulatory standpoint, we are to consider the possible impacts on performance from any existing pumping activities as well as any planned (near future) activities, propagated out to their expected lifetimes. Although there are some wells that tap into the Culebra to the west-southwest, they are a significant distance away, and they will have no observable effect on performance, due not only to their distance and low pumping rates, but also to the low permeability zones that lie between the waste panel area and the LWB in that direction. The nearest Culebra well to the south of the LWB is the Engle Trap Well (also known as the Ingle Well), approximately ten kilometers away (see Figure 1, also Cooper and Glanzman, 1971).

There are no plans for additional water wells in the area of concern south of the LWB for any unit, including the Culebra (Daley, 96). Numerous other sources of fresher water are more readily available, lending assurance to this projection (Daley, 96). For example, there are freshwater pipelines nearby, which are used to supply water to the potash-mining operations and to WIPP (see attachment #1, BLM map). These pipelines are used by ranchers in the area as well. Also there are shallower sources of fresher groundwater, relative to the Culebra, such as the Dockum and the Dewey Lake.

The Engle Trap Well is windmill driven and is operated only intermittently. The estimated pumping rate averaged out over a year is 0.5 gallons per minute (gpm) (Beauheim, 96). This well has been in operation since 1931. As this well is near the lower corner of the PA SECOFL Culebra regional groundwater model, its effects on performance, if any, are already implicitly accounted for in the analyses. That is because the regional model uses external constant head boundary conditions, in conjunction with transmissivity distributions to calibrate to hydraulic head histories throughout the enclosed region. Through this calibration, the bottom boundary conditions act as a surrogate, in part, for the well pumping that goes on in that area.

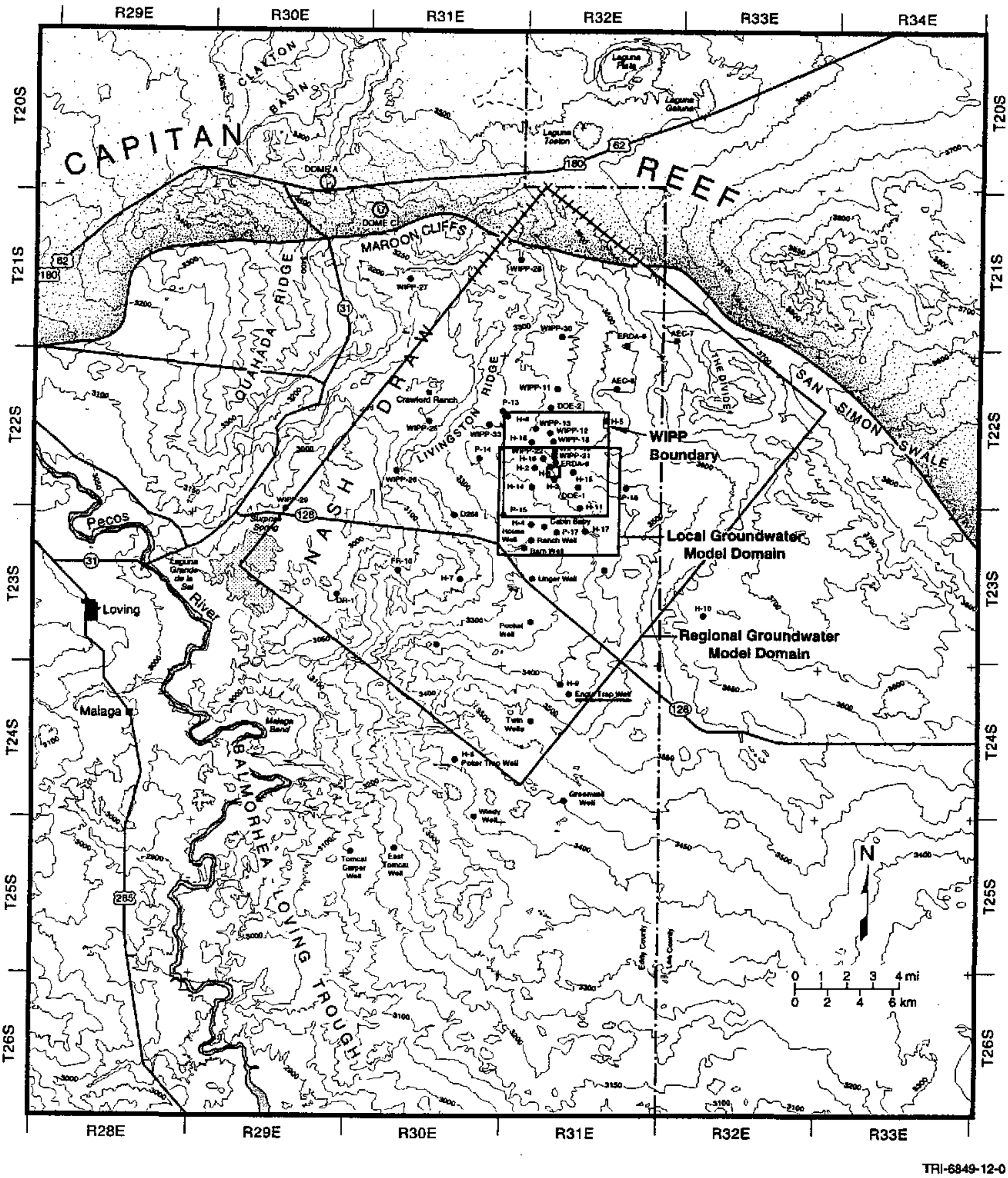

Figure 1. Well locations Near the WIPP Site

SWCF-A: 1.2.07.3: PA:QA:TSK:NSS

In any event, the impact of this well on flow velocities in the WIPP region is nominal. A simple approximation of the impact was conducted using the Theis equation. The equation predicts head changes over time within an infinite homogenous isotropic confined aquifer of constant thickness at any radius from a well pumping at a constant rate. It has the following form:

$$s = \frac{Q}{4\pi T}\left(-0.577216 - \ln u + u - \frac{u^2}{2\cdot 2!} + \frac{u^3}{3\cdot 3!} - \cdots\right)$$

where:

$$u = \frac{r^2 S}{4Tt}$$

and

s = change in head, h_0 - h_t at a radius r [L]. s is also termed 'drawdown'
h = hydraulic head [L]
Q = pumping rate [L^3/T]
T = transmissivity [L^2/T]
r = radius [L]
S = Storativity []
t = time [T]

The equation was used to predict/estimate drawdown due to pumping from the Engle Trap well at a rate of 0.5gpm for various periods of time, from 50 years to 10,000 years. A value of 10^{-4} m^2/s was selected as the most representative transmissivity value from the suite of transmissivity fields developed for the PA, in that area (Lavenue, 96). The drawdowns were calculated for two positions. The first position, r_1, represents the distance from the point on the southern LWB that lies on a straight line connecting the center of the waste panel area to the Engle Trap well. That distance is approximately 11,265m. The second position, r_2, represents the distance between the center of the waste panel area and the Engle Trap well. That distance is approximately 14,162m.

The difference between the two drawdowns, divided by the distance between them, (s_1-s_2)/2897m (at any particular time), can be intrepreted as the contribution of the Engle Trap well pumping to the overall hydraulic gradient driving flow from north to south between those points. Table NS5a.1 summarizes this information.

Figure 2 shows a sample head contour map from the PA realizations. In the vast majority (if not all) of the realizations, heads in the panel area stay in a narrow range between 915 m and 925m, while heads near the Engle Trap Well are almost always 905m. The total hydraulic gradient across this region can therefore be generally approximated to range from 0.001 to 0.0007 (m/m), depending on the particular T-field realization used in the PA.

SWCF-A:1.2.07.3:PA:QA:TSK:NS5a

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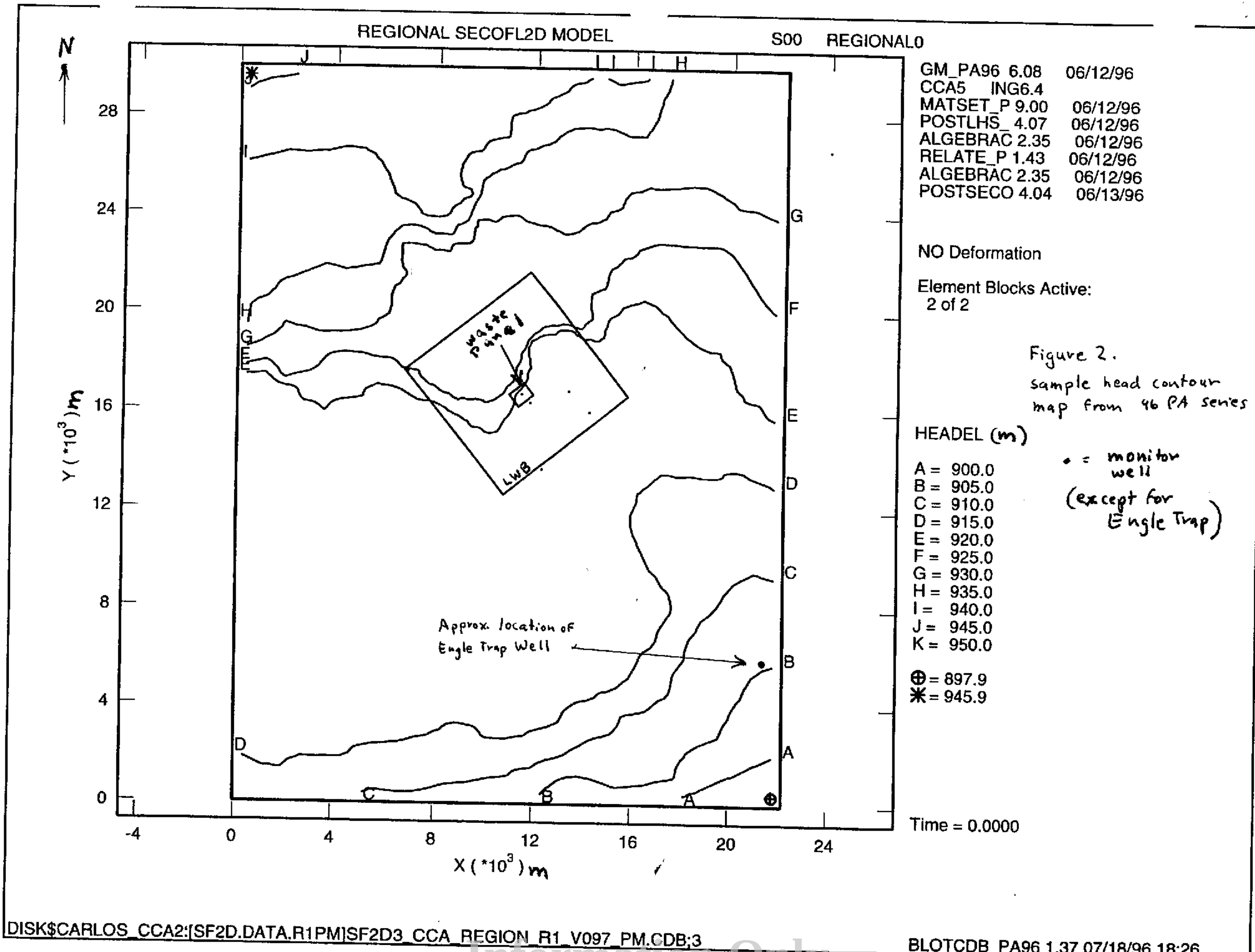


Table NS5a.1 Estimation of Drawdown-Induced Gradients (due to pumping from Engle Trap well) Across a Portion of the WIPP Site.

		t (years)			
		50	100	1000	10000
	u_1=	0.004021	0.002011	0.000201	2.01E-05
	u_2=	0.006355	0.003178	0.000318	3.18E-05
drawdown at LWB (m)	s_1=	0.124062	0.141409	0.199156	0.256943
drawdown at center of Waste Panel Area (m)	s_2=	0.112632	0.12995	0.18767	0.245455
(s_1-s_2)/2400m =		3.95E-06	3.96E-06	3.96E-06	3.97E-06

This calculation indicates that the contribution to the southerly velocities made by this well pumping for 100 years would be no greater than 0.6%. In other words, for cases of the PA in which flow is to the south in the Culebra, less than 6 thousandths of the magnitude of the average velocity can be attributed to the pumping by the Engle Trap well.

A similar percentage would be obtained if only 60 years of pumping (the current history) were considered.

Summary, Conclusions, and Basis for Screening Decision:

Concerns have been raised that a well pumping from outside the Controlled Area (CA) in the Culebra could increase hydraulic gradients to the south, thereby speeding up groundwater flow velocities in that direction, thereby increasing releases to the AE.

The nearest down-gradient well from the LWB was identified. That well was in close proximity to the 2-D Culebra regional groundwater flow model southern boundary, which was a constant-head type. That well also has been in operation for approximately 60 years. Considering the low pumping rate (a windmill well), and its proximity to the constant-head boundary, it was concluded that the current model already implicitly accounts for the effects of this well.

An additional analysis was performed to estimate what the relative effect of the pumping-induced gradient is compared to the gradient resulting from the imposed boundary conditions. As stated, all other things being equal, this gradient comparison is essentially the same as a velocity comparison. It was found that less than 6 thousandths of the magnitude of the average velocity can be attributed to the pumping by the Engle Trap well.

As this pumping is already implicitly accounted for in the current PA, and as it has an insignificant impact on velocities in the WIPP area, this issue is recommended to be screened out on the basis of low consequence.

References and Supporting Correspondance:

Cooper, J.B., and Glanzman, V.M., 1971, *Geohydrology of Project Gnome site, Eddy County, New Mexico*: U.S. Geological Survey Professional Paper 712-A, 24p. Table 2, first entry. *Relevant section is included in this FEP as Attachment #2*

Conversation with Rich Beauheim, Dept. 6115, SNL, Albuquerque, NM. 7-8-96. *log follows on a subsequent page of this FEP package*

Lavenue, A. M., 1996, *Analysis Package for Groundwater Modeling Analysis for the Generation of Transmissivity Fields for the Culebra Flow and Transport Calculations.* SWCF-A:1.2.07.4.1:PA:QA:Analyses:AP018

Phone conversation with Steve Daley, Bureau of Land Management (BLM), Carlsbad, NM. 7-8-96. *log follows on a subsequent page of this FEP package*

Phone conversation with Susan Brett, Bureau of Land Management (BLM), Carlsbad, NM. 7-8-96. *log follows on a subsequent page of this FEP package*

U.S. BLM, 1978, Surface-Minerals Management Status map, Jal Quadrangle, New Mexico, Texas

WIPP PA (Performance Assessment) Department. 1992-1993. *Preliminary Performance Assessment for the Waste Isolation Pilot Plant, December 1992.* SAND92-0700, Volume 3: Model Parameters. Table 2.6-1, p.2-76, Albuquerque, NM: Sandia National Laboratories

7-8-96

Michael Wallace, Dept. 6849 (RE/SPEC Inc.), MS 1328

Log of phone conversation with Steve Daley, U. S. Bureau of Land Management (BLM), Carlsbad, NM

phone:505-887-6544

I inquired about stock wells in the WIPP vicinity that pump water from the Culebra. I was specifically interested in such wells that lay to the south of the LWB. I also asked if there were any plans submitted by anyone to the BLM to develop new wells that meet this criteria.

Steve responded that there are no plans for additional wells in that locale. He stated that there are not likely to be any plans in the future either. He attributed this to such factors as 1: ample supplies of fresh water (for stock watering purposes) are readily available from pipelines that criss-cross the area which currently serve ranchers, potash mine companies, and WIPP. This water is piped in from the Lovington cap rock, part of the Ogallala aquifer to the east. Also 2: The salinity of the Culebra in that area is such that it is only marginally suited, if at all, for stock watering. Shallower aquifers, such as the Dockum, or Dewey Lake have water of better quality.

Steve referred me to a USGS report by Cooper and Glanzman, 1971, which had data on stock wells in that general area.

7-8-96

Michael Wallace, Dept. 6849 (RE/SPEC Inc.), MS 1328

Log of conversation with Richard Beauheim, Dept. 6115, MS 1324

Rick told me that there are no stock wells within 2 miles to the south of the southern LWB that pump from the Culebra. The few stock wells within that limit pump from the Dockum or Dewey Lake aquifer.

There was an old windmill-driven well within that proximity (near T23S, R30E, sec.7), that pumped from the Culebra, but it has not been in operation for several decades. Apparently it was abandoned because the pumping rate was too low to support stock watering.

The nearest well to the south of the southern LWB that pumps from the Culebra is the Engle Trap Well, also known as the Ingle well. It is windmill driven*, used for stock watering, and probably pumps at an annual average of 0.5 gpm.

* this is confirmed by Cooper and Glanzman, 1971, table 2

10-25-96

Log of phone conversations with Susan Brett, U. S. Bureau of Land Management (BLM), Carlsbad, NM

phone:505-887-6544

I inquired as to the status and ownership or leaseholdership of the Engle Trap Well. Susan told me that the well is on State land, but the well is in their records. The BLM has an activity there in which they are attempting to compile information on stock wells in the general area, but it is a low priority activity, and results are not currently available.

She provided me the name of the owner and his phone number:

Jimmy Richardson, 505-885-6175

I later tried to call Mr. Richardson. I left a message on his answering machine, but he did not return the call.

mgw, 7-10-96, NS5a: Pumping from the Culebra Outside the CA
companion worksheet to the SMOR
calculation of NS hydraulic gradients
due to drawdowns caused by pumping constantly at the
Engle Well, several miles south of the CA boundary.
governing equations (see SMOR for details)

$$s = \frac{Q}{4\pi T}\left(-0.577216 - \ln u + u - \frac{u^2}{2\cdot 2!} + \frac{u^3}{3\cdot 3!} - \cdots\right)$$

$$u = \frac{r^2 S}{4Tt}$$

r1=(m) 11265 S= 2.00E-05 *T=(m²/s) 1.00E-04* *Q=(m³/s) 3.15E-05*
r2=(m) 14162 (approx. 0.5gpm)

	t (years)			
	50	100	1000	10000
u_1=	0.004021	0.002011	0.000201	2.01E-05
u_2=	0.006355	0.003178	0.000318	3.18E-05
s_1=	0.124062	0.141409	0.199156	0.256943
s_2=	0.112632	0.12995	0.18767	0.245455
(s_1-s_2)/2897m =	3.95E-06	3.96E-06	3.96E-06	3.97E-06

notes: Theis equation used. Well function truncated after 5th element of series.
r1 is the distance from the southern LWB to the Engles well.
r2 is the distance from the waste panel area to the Engles well.
The distance between the waste panel area and the southern LWB is approx. 2897 m.
The term: (s_1-s_2)/2897m is the hydraulic gradient from the waste panel area to the LWB induced by the pumping at Engles well assuming the particular pumping rates at the particular times.
The 'undisturbed' base gradients across that area range from .007 to .001 m/m.
The expected pumping rate; Q=0.5gpm, source R. Beauheim, 96
T, transmissivity, selected as representative from latest suite of Transmissivity Fields generated by M. Lavenue for 96 PA (Lavenue, 96)
S, storage coeffient from 92 PA (WIPP PA, 1992, 93)

Glossary

existing states, or *present states*; Physical conditions about the WIPP site, including the subsurface, as they currently exist. This includes conditions (such as hydraulic heads in the saturated zone) that may be currently influenced by human activities in the area, such as petroleum or potash resource development.

near future states; Physical conditions about the WIPP site, including the subsurface, as they are expected to evolve up to the completion of any resource-development activity iniated (i.e., for which a potash or petroleum lease exists and an application for a resource-development permit has been filed with the State and/or the BLM) as of the date of sealing of the WIPP shafts, if the activity could affect physical conditions important to performance of the WIPP. This definition does not include conditions resulting from any leases (and resulting development activities) that may be granted in the future.

future states: Physical conditions about the WIPP site, including the subsurface, as they are expected to evolve in the absence of resource extraction activities initiated subsequent to the date of sealing of the WIPP shafts, except potash mining

Names of Participants:

Michael Wallace Dept. 6849 (RE/SPEC, Inc.) MS 1328

Dates Analysis Conducted:

Summer, Fall, 1996

Plan of Work:

A set of screening analyses have been performed to evaluate the sensitivity of the WIPP repository performance to the following FEP:

FEP Screening Issue NS5a: Pumping From the Culebra Outside of the Controlled Area

This records package provides background information on the process used for conducting the screening analyses and summarizes the scenarios considered, identifies the computer codes and input and output files used in the calculations, and describes the performance measures that are used to help establish FEPs screening decisions. The statement of recommended screening decision for the FEP is provided in the attached Summary Memo of Record.

Planning Memos of Record:

The Approved Planning Memo of Record is provided on the following two pages.

NS-5a: PUMPING FROM THE CULEBRA OUTSIDE OF THE CONTROLLED AREA
Planning Memo of Record

TO: D. R. Anderson

FROM: M. Wallace

SUBJECT: FEP Screening Issue NS-5a

STATEMENT OF SCREENING ISSUE

Concerns have been raised that a well or cluster of wells pumping from the Culebra outside the controlled area could increase the north-to-south hydraulic gradients, thereby speeding up groundwater flow velocities in that direction, and increasing releases to the accessible environment.

Oil and gas operations in the area might lead to the Culebra being exploited as a source of fluid for water flooding operations. It may be possible to argue that the Culebra is not a desirable candidate source for such water and currently it seems likely that it could be entirely ruled out. This is being addressed in a separate SNL/DOE effort. The results of that effort will dictate whether it is necessary to give this screening issue further consideration.

Other pumping, such as pumping for municipal or stock watering purposes cannot be entirely ruled out. Yet their impacts are expected to be far less than the potential impact of pumping for oil and gas production would be.

APPROACH
Calculation Design

The location of pumping that could lead to the fastest travel times to the accessible environment would be just outside of the southern boundary of the controlled area, in the middle of the high-transmissivity (T) zone that extends into the controlled area close to the proposed radionuclide release point. Placing the pumping within or 'behind' any lower-T zone would obviously not increase velocities to the accessible environment.

Currently, the likely maximum sustainable pumping rate in that high-T zone, for any particular well would be on the order of only 20 gpm (Beauheim __). The limiting case would then be drawdowns severe enough to dewater the Culebra. Therefore it makes the most sense to approximate the effects of pumping through a constant-head term in the pumping location. The value of head assigned there would be bound by being set equal to the elevation of the bottom of the Culebra at that position. Alternatively, a sink term equivalent to 20 gpm could be applied at that location.

The basic model setup and grid would be identical to the setup defined for the areal 2-D model part of screening issue NS-8. The boundary conditions, however would be implemented in the same manner as was done for the series of calculations in the 1992 performance assessment. In other words, the heads along the model boundary would be representative of current head levels, not of the land surface elevations.

This setup would be used for the suite of 70 T-field realizations.

Resource estimate for NS-5a: PUMPING FROM THE CULEBRA OUTSIDE OF THE CONTROLLED AREA

Michael Wallace: 80 hrs. Rebecca Blaine: 40 hrs. Tech Reps 20 hrs.

Documentation of Changes from Work Analysis Plan:

In the work analysis plan (Planning Memo of Record) calculations using SECOFL2d were planned, in which hypothetical wells were to be considered, placed at worst-case locations and withdrawing water from the Culebra at worst-case rates.

Since that memo was written, 40CFR was released by the EPA, in which the guidelines stress how the PA would address future states (see glossary section). Under those guidelines, relevant to this issue, PA is to consider only existing activities propogated out to so-called near-future conditions. And, PA is to consider only existing and currently planned activities propagated out into the so-called future-states time period.

Therefore, hypothetical wells, pump rates, and positions are not considered. Instead, the SMOR describes how existing activities were identified and that there were no planned additional pumping activities. Then reasoned arguments, supplemented by a simple non-model calculation were presented to screen this issue.

Software:
Title and version of software used:

	date	wpo#
Spreadsheets		
Microsoft Excel Ver. 5.0c	fall, 96	na
Plotting and Data Presentation Packages		
BLOTCDB Ver. 1.37 6-4-96	summer, 96	WPO21260

Pointer to SWCF Records:

A copy of the Grade X code is available in the Records Center. Other codes have been archived by Department 6351, Computational Support, on the following tapes: F95074, F95080, F95654, F95714, F95738, and F95081.

Computer platform:

All codes other than the *Spreadsheets* and *Plotting and Data Presentation Packages* were run on the WIPP Alpha Cluster, open VMS Ver. 1.5.

Spreadsheets and *Plotting and Data Presentation Packages* (other than BLOTCDB)were run on a Gateway 2000
Operating System, Windows 95

Documentation of deviations from baseline data set, including rationale:

A primary purpose of this fep was to explore the need for incorporating new data and/or concepts into the next round of PA calculations. Therefore, there are deviations from the baseline data set, by necessity. See Summary Memo of Record (in this Records Package) for the related documentation and rationale.

Attachment #1, USBLM Surface-Minerals Management Status Map Jal Quadrangle, New Mexico – Texas is an oversized map and cannot be scanned.

Geohydrology of Project Gnome Site, Eddy County, New Mexico

GEOLOGICAL SURVEY PROFESSIONAL PAPER 712-A

Prepared in cooperation with the U.S. Atomic Energy Commission

[redacted]

Cooper, J.B., and
Glanzman, V.M.
1971

[redacted]

Attachment #2 (sheet 1 of 5)

SWCF-A:1.2.07: PA: QA: TSK: NS5q page 17 homes, and a group of houses at the Pecos turbine station of the El Paso Natural Gas Co.

To accurately determine the water level, well depth, capacity and condition of the pump, casing size, and other aspects of some wells in the proximity of the project site, pumping equipment was removed from the wells for insertion of measuring devices and for inspection of the pumps. Fifteen wells, including nine within a 5-mile radius of the test site, were investigated in this manner during March and April 1959. Specific data on the 67 wells investigated are given in table 2.

Water samples were collected to determine the chemi-

TABLE 2.—*Records of wells in the Project Gnome area*

Owner or name: The owner of, or name used for, well at time of visit.
Altitude: From topographic maps.
Depths: Reported depths are given to the nearest foot; measured depths are given to the nearest 0.1 foot. P, pumping level.
Diameter: The diameter of the casing, or the mean diameter of the hole, if uncased.
Measuring point: Epb, edge of pump base; Ls, land surface; Tal, top of air-line flange; Tap, top of access pipe; Tc, top of casing; Tcb, top of concrete block; Tcm, top of metal cover; Tpc, top of pipe clamp; Tpp, top of pump pipe; Twc, top of wood cover.

Geologic source: Prl, lower member of the Rustler; Prc, Culebra Dolomite Member of the Rustler; Prm, Magenta Dolomite Member of the Rustler; Tr, rocks of Triassic age; QTu, undifferentiated rocks of probable Quaternary and Tertiary age; Qg, Gatuna Formation; Qal, Quaternary alluvium.
Type of pump, power, and use: Pump designations: T, turbine; L, cylinder; N, none. Power designations: W, windmills; Ic, internal combustion; N, none; Use: S, stock; D, domestic; I, irrigation; In, industrial; N, none.
Remarks: Name enclosed in quotation marks is local name of well. CA, chemical analysis available; L, electric logs available; R, reported information.

Location No.	Owner or name	Altitude above sea level (feet)	Depth (feet)	Diameter (inches)	Water level: Depth below land-surface datum (feet)	Water level: Date of measurement	Measuring point: Description	Measuring point: Distance above land-surface datum (feet)	Geologic source	Type of pump, power, and use	Remarks
1.29.25.441	A. V. Pugh	3,320	210	10	180	4-15-59			Prc or Prm	L, W, D, S	Two wells at this location. Surface casing only, R.
25.441a	do	3,320	210	10	175	4-15-59			Prc or Prm	L, Ic, D, S	Well cased to total depth, R.
21.30.15.333	Wayne Cowden	3,220	175.3	6	124.3	4-15-59	Tc	0.5	Prc or Prm	L, W, S	Well not used recently.
22.423	do	3,180	219.4	6	104.6	4-15-59	Tc	.6	Prc	L, W, S	Well not used recently. Water salty, R.
21.31.18.322	Cowden and Smith	3,310		6	P155.8	4-15-59	Tc	1.0	Tr	L, W, S	
22.28.15.334a	L. J. Culley	3,095	55.6	6	75.4	4-17-59	Tc	.9	Qal	L, W, D, S	Five wells at this location, two dry, three used. Water contains gypsum. R.
15.334b	do	3,095	86.2	6	76.0	4-17-59	Tc	1.0	Qal	L, Ic, D, S	Surface casing only, R. Water contains gypsum, R.
15.334c	do	3,095	88.1	6	86.5	4-17-59	Tc	.6	Qal	L, W, S	Well not in use.
22.29.11.144	Mark Smith and Sons	3,090	170.0	10	149.2	4-14-59	Tc	.1	Prc	L, W, S	Do.
33.241	Mrs. Dublin	3,020	69.9	6	55.0	4-14-59	Tpc	.6	Prm(?)	L, W, S	Two wells at this location.
22.29.33.241a	do	3,020	56.5	6	53.0	4-14-59	Tc	.1	Prm(?)	L,W,S	Well not in use.
22.30. 5.431	International Minerals and Chemical Corp.	3,120		14	66.4	4-14-59	Tc	2.3	Prc	N,N,N	Unused supply well for potash refinery.
5.443	do	3,100		14	57.1	4-14-59	Tc	1.0	Prc	N,N,N	Do.
8.241	do	3,155	180.3	24	104.8	4-14-59	Twc	.2	Prc	N,N,N	Do.
10.311	Mark Smith and Sons.	3,135	66.7	6	60.7	2-19-59	Tc	1.3	Qg(?)	L,W,D,S	"Ranch Headquarters well."
20.120	do	3,070	128.7	5	73.0	2-19-59	Tc	3.3	Prc	N,N,N	Salty water, R.
32.111	do	3,010	107.0	6	45.2	2-19-59	Tc	1.0	Prc	L,W,S	CA.
22.31. 15.130	do	3,460		6	P158.2	2-19-59	Tpc	2.8	Tr	L,W,S	Two wells at this location.
15.130a	do	3,460	167.3	12	150.9	2-19-59	Tc	2.7	Tr	N,N,N	
14.241	D. C. Harroun	2,980	124.3	16	16.2	2- 6-59	Tc	.2	Qal	T,Ic,I	Well cased to total depth, R.
14.241a	do	2,980	114.4	16	14.8	2- 6-59	Tal	1.1	Qal	T,Ic,I	Do.
14.243	do	2,980	145.7	16	14.7	2- 6-59	Epb	1.8	Qal	T,Ic,I	Do.
23.30. 2.444	C. H. and W. O. James.	3,250	317.6	6	260.8	4- 3-59	Tc	1.0	Prc	N,N,N	Well filled. Replace by well 444a at same location. L, CA.
2.444a	do	3,250	318.4	7	260.5	4-20-59	Tc	1.0	Prc	L,W,S	"Little Windmill well." Well cased to 314 feet. Drilled in 1959.
6.424	James and Briones	2,980	30.0	6	6.5	8-19-58	Tc	.0	Qal	L,W,S	"Nash Well."
19.123	do	3,045	89.0	7	70.4	4- 7-59	Tc	1.3	Prc	L,W,S	"South Well." Surface casing only. L, CA.
21.122	C. H. and W. O. James.	3,165	203.6	5	179.2	4- 6-59	Tc	1.3	Prc	L,W,S	"Indian Well." Cased to 160 feet. L, CA.
23.31. 6.320	do	3,300	212.9	12	144.7	2- 4-59	Tc	1.0	Tr	L,W,S,D	Surface casing only, R. Poor quality. water, R.
6.444	do	3,310	166.4	6	105.6	2- 4-59	Tc	1.8	Tr	L,W,S,D	"Ranch Headquarters well." Poor quality water, R.
7.222	do	3,300	122.4	10	94.4	2- 4-59	Tc	1.1	Tr	L,Ic,S	Well not used recently.
7.222a	do	3,300	94.5	5		2- 4-59	Tc	.2	Tr	N,N,N	Well dry.
7.240	do	3,315	138.2	4	94.7	4- 2-59	Tpp	2.8	Tr	L,W,S	"Conoco well." L, CA.
17.310	do	3,305	354.0	10	109.4	3-27-59	Tcb	.9	Tr	L,W,S	"Unger well." Well uncased. L, CA.
23.31. 26.340	C. H., W. O., and F. James.	3,480	361.3	6	P256.9	2-4-59	Tpc	1.2	Tr	L, W, S	"Fairview well." Well uncased, R CA.
29.113	C. H. and W. O. James.	3,335	223.9	4	138.4	3-26-59	Tc	.7	Tr	L, W, S	"Walker well." Surface casing only. L, CA.
23.32. 4.222	do	3,630	550	8					Tr	L, W, S	"Clifton well." Surface casing only, R.
21.222	C. H., W. O., and F. James.	3,700	550	8	500				Tr	L., Ic, S	"Swag well." Two wells at this location. Surface casing only, R.
21.222a	do	3,700	550	6	510				Tr	L, W, S	Well cased to total depth, R.
24.30. 8.113	Bill Eaton	3,280	191.9	6	176.0	3-23-59	Tc	.0	Qg	L, W, S, D	"Ranch Headquarters well." Well cased to 190 feet. L, CA.
12.430	W. M. Snyder	3,510	500	6	367.1	6-14-61	Tc	.6	Tr	L, Ic, S	"Poker well."
18.231	Bill Eaton	3,200	451.6	6	227.8	3-19-59	Tc	.4	Prc or Prl	L, W, S	"Two mile mill." Well cased to 220 feet. L, CA.
23.312	W. M. Snyder	3,425	428.1	6	423.1	3-26-59	Tc	.7	Tr	L, W, S	"New well." Well cased to total depth, R. Well reported to be 474. feet deep. L.
36.333	do	3,450	476.8	6	445.3	3-19-59	Tc	1.2	QTu	L, W, S	"Windy well." Well cased to 412 feet L, CA.

Attachment #2 (sheet 2 of 5)

SWCFA: 1.2.07.3: PA: QA: TSK: NS5a
Attachment #2 (sheet 3 of 5)

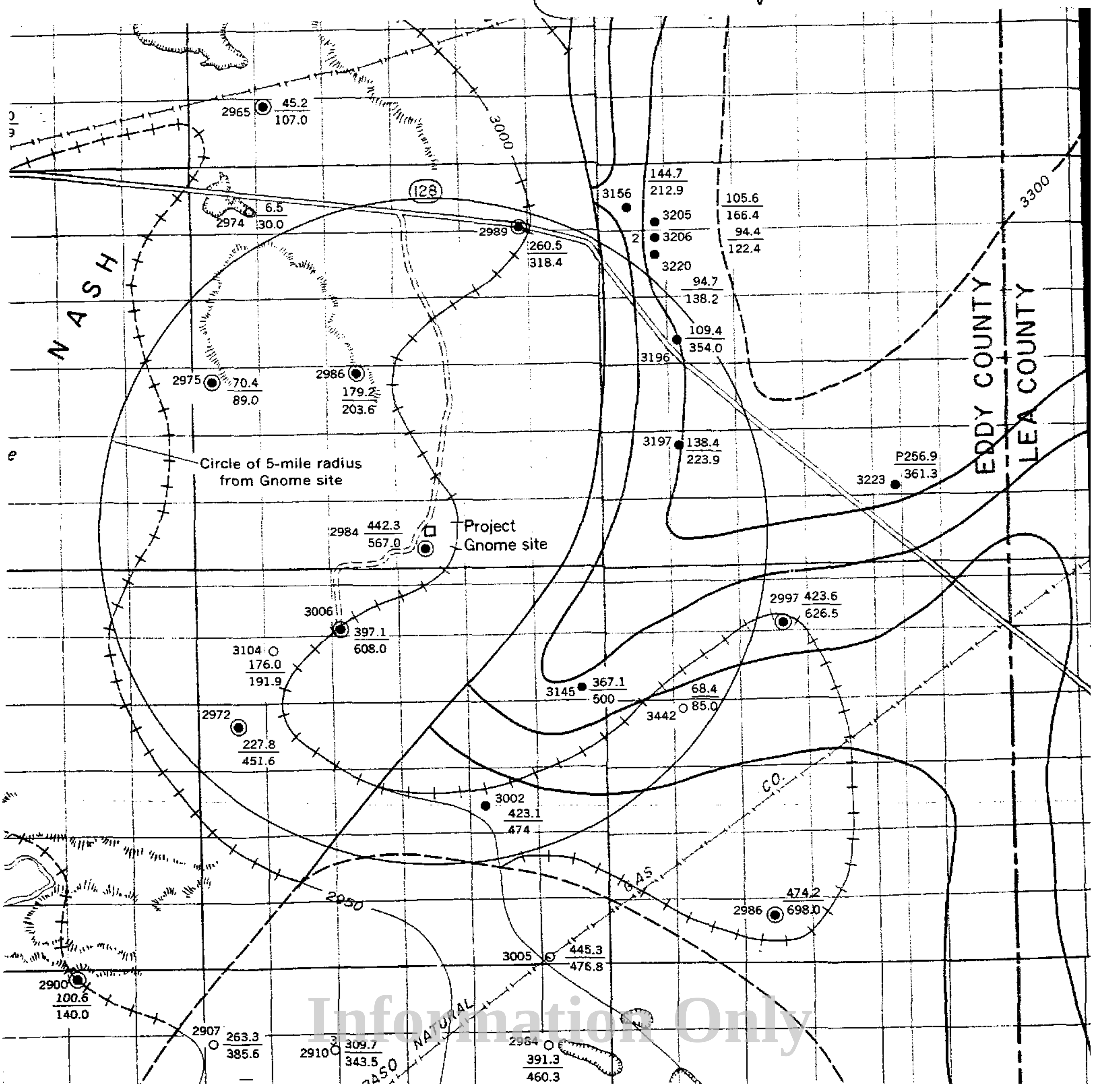


TABLE 2.—*Records of wells in the Project Gnome area*—Continued

Location No.	Owner or name	Altitude above sea level (feet)	Depth (feet)	Diameter (inches)	Water level: Depth below land-surface datum (feet)	Water level: Date of measurement	Measuring point: Description	Measuring point: Distance above land-surface datum (feet)	Geologic source	Type of pump, power, and use	Remarks
24.31.4.430	W. M. Snyder	3,420	626.5	5	423.6	3-13-59	Tcb	0.9	Prc	L, W, S	"Ingle well." Well not cased. L, CAl
17.111	do	3,510	85.0	7	68.4	3-25-59	Tc	1.2	Qg	L, W, S, D	"Ranch Headquarters well." Well cased to total depth, R. L, CA.
33.124	do	3,460	698.0	5	474.2	3-12-59	Tc	1.0	Prc	L, W, S	"Keyhole well." Well cased to total depth, R. L, CA.
24.32.3.322	Frank James	3,650	550	10					T̄R	L, W, S	"New well." Two wells at this location. Surface casing only, R.
3.322a	do	3,650	500	8		4-13-59			T̄R	N, N, N	Well dry and caved in. Surface casing only, R.
10.344	do	3,588	60	6	33.6	4-13-59	Tc	1.0	Qal	L, W, S, D	"Ranch Headquarters well." Surface casing only, R.
24.32.33.422	Richard Ritz	3,510	366.4	12	313.4	2-18-59	Tc	.6	T̄R	L, W, S	"Burro well."
25.29. 2.111		3,000	140.0	8	100.6	10-23-58	Ls	.0	Prc(?)	N, N, N	Potash test hole. Drilled to 857 feet.
16.444	J. G. Ross	3,025	200(?)	6	170.1	8-19-58	Tc	1.2	Prc	L, W, S	"Pickett well." Well cased to total depth, R. CA.
32.211	do	2,985	110.6	8	98.7	3-24-59	Tc	.9	Prc	N, N, N	Surface casing only. Potash test hole. L, CA.
25.30. 7.111	W. M. Snyder	3,170	385.6	7	263.3	3- 7-59	Tc	.0	QTu	L, W, S	"Carper well." Well cased to 250 feet. Oil test hole converted to water well. L, CA.
7.330	Ralph Lowe	3,180	295.0	7		6-14-51			QTu	N, N, N	Drilled to supply water for oil tests.
8.224	W. M. Snyder	3,220	343.5	7	309.7	8-19-58	Tc	.0	QTu	N, N, N	Three wells at this location.
8.224a	do	3,220							QTu	N, N, N	Hole crooked, R.
8.224b	do	3,220		7	P332.55	6-14-61	Tc	1.0	QTu	L, W, S	"Tomcat well."
12.113		3,375	460.3	5	391.3	3-25-59	Tc	.7	QTu	N, N, N	Drilled to supply water for oil test. L.
21.333	J. G. Ross	3,200	298.1	6	P266.1	2- 5-59	Tc	1.0	QTu	L, W, S, D	Well cased to total depth, R. CA.
25.31.21.400	Mrs. E. R. Johnson and others.	3,340	400	7	P318.0	2-17-59	Tc	.4	QTu	L, W, S, D	Do.
25.33.20.443		3,395	200–250	6					T̄R	L, W, S	
26.29.22.340	J. G. Ross	2,875	200(?)	6	68.7	8-19-58	Tc	2.0	Prc	L, W, S	Well not used recently.
26.30. 5.334	El Paso Natural Gas Co.	3,090	770	11	169.9	2-18-59	Epb	1.9	QTu	T, Ic, In, D	Water well No. 1 Pecos Turbine station. Cased to total depth.
5.343	do	3,100	775	11, 9	182.6	8-18-58	Tap	3.3	QTu	T, Ic, In, D	Water well No. 2 Pecos Turbine station. Cased to total depth. CA.
8.111	Mrs. E. R. Johnson and others.	3,085	400	7	163.8	2-18-59	Tcm	.3	QTu	L, W, S	"West well."
26.31. 8.310	Ross Estate	3,230	309.6	6	P287.1	2-18-59	Tc	1.4	QTu	L, W, S, D	"Ranch Headquarters well." Two wells at this location.
8.310a	do	3,230	324.5	6	275.8	8-18-58	Tc	1.5	QTu	N, N, N	Well has never been placed in service

cal characteristics and radioactivity background level of the water in the study area before the nuclear explosion. Results of chemical and radiochemical analyses are given in tables 3 and 4.

Because of the lapse of time between the nuclear event and the original investigation of the nine privately owned wells within a 5-mile radius of the test site, a second investigation of the wells (and of an additional well drilled in May 1961) to establish their depth and water level and to determine the condition of pumps was made November 23 to December 9, 1961. For both investigations the pumps were removed by a contractor of the U.S. Atomic Energy Commission, and measurements were made by personnel of the U.S. Geological Survey.

The owner, depth of well, depth to water, and condition of the pump for each well within the 5-mile radius are listed in table 5. Depth and water-level data obtained from both investigations are included.

OBSERVATIONS AT TIME OF NUCLEAR EXPLOSION

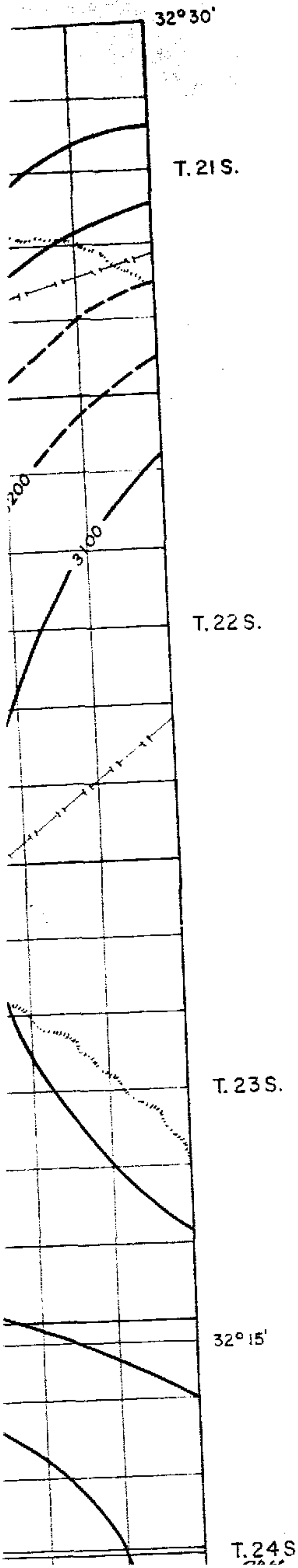
At the time of the nuclear explosion, ground-water levels close to the site were under observation at U.S. Geological Survey test holes 1, 2, 4, and 5. Observations were also made in two wells near the Malaga Bend of the Pecos River south of Carlsbad, N. Mex., 9 miles west of the project site, and in others wells to the north in the Roswell artesian basin.

The four observation wells at and near the project site had float-type continuous recording gages. The recording gages consist essentially of a height-element mechanism to register the level of the water surface and a clock movement which feeds a chart at a constant rate while a marking stylus moves laterally across the chart and produces a graphic record of water level against time. Water-level changes are transmitted to the height-element mechanism and stylus by a wire line attached to a counterweighted float which rests on the water surface. The gages were equipped with a time-element mechanism which moved the chart at a rate of 0.1 inch per hour. The height element registered a graph change of 2 inches for each foot of water-level change in holes 1 and 4, and 10 inches for each foot of water-level change in holes 2 and 5.

The recording gages were housed in metal shelters over the well casing. The shelters were securely bolted to a concrete platform, and the gages were fastened to the shelters. For several days before the explosion, the

Attachment # 2 (Sheet 4 of 5)

SWCF-A: 1.2.07.3: PA: QA: TSK: NS5q



EXPLANATION

WATER WELLS

○
Well finished in rocks of Quaternary or Tertiary age

●
Well finished in rocks of Triassic age

◉
Well finished in rocks of Permian age

3220 ○ 2 P266.1/298.1

Well data

Number at left is altitude of potentiometric surface, in feet above mean sea level. Upper right number is depth to water, in feet below land surface. Lower right number is depth of well, in feet below land surface. Blue number indicates number of wells at location. Measured depths are in feet and tenths; reported depths are in feet. P, *indicates well being pumped at time of measurement*

——— *3400* – – – –

Water table or potentiometric contour for formations of Quaternary or Tertiary age

Dashed where inferred or uncertain. Contour interval 50 feet. Datum is mean sea level

——— *3500* — — —

Potentiometric contour for formations of Triassic age

Dashed where inferred or uncertain. Contour interval 50 feet except where data are meager. Datum is mean sea level

—+—+— *3050* +—+—+

Water table or potentiometric contour for formations of Permian age

Dashed where inferred or uncertain. Contour interval 50 feet. Datum is mean sea level

– – – – – – – –

Approximate position of boundary between rocks of Quaternary and Tertiary ages, and older rocks

————————

Approximate position of boundary between rocks of Triassic age and rocks of Permian age

Majority of water-level measurements made August 1958 to April 1959

Attachment #2 (Sheet 5 of 5)
SWCF-A:1.2.07.3:PA:QA:TSK:NS9