Department of Energy
Albuquerque Operations Office
P.O. Box 5400
Albuquerque New Mexico 87115

APR 16 1997

Mr. Joseph J. Holonich, Chief
Uranium Recovery Branch
Office of Nuclear Material Safety and Safeguards
Mail Stop T7J9
U. S. Nuclear Regulatory Commission
11545 Rockville Pike
Washington, DC 20555

Dear Mr. Holonich:

Enclosed is our "Response to NRC Comment on Settlement" at the Ambrosia Lake, New Mexico, Uranium Mill Tailings Remedial Action disposal site. Also enclosed is the survey data for the settlement monuments.

With respect to your letter dated March 26, 1997, we believe our response provides assurance that future settlement behavior will not adversely affect the radon barrier and preferential erosion channels will not occur. Should there be any questions, please have your staff contact me at (505) 845-5758.

Sincerely,

Michael F. Abrams

Michael F. Abrams
Site Manager
Environmental Restoration Division

NLOH
WM-67

Enclosures (2)

cc w/enclosures:
S. Cox, TAC
R. Waddington, RAC

cc w/out enclosures:
D. Gillen, NRC-HQ
S. Hamp, ERD
E. Artiglia, TAC

Response to NRC Comment on Settlement

Settlement at the Ambrosia Lake disposal cell has been analyzed using all the data that has been gathered to date. The most recent survey, performed in December 1996 and January 1997, was used to verify that primary consolidation is complete and that secondary compression will be within the range of that predicted in design. Design calculations were based on the results of settlement measurements obtained during large-scale test embankment construction.

The settlement data presented in Figures 1 through 9 show that settlement due to primary consolidation was essentially complete at the end of construction. In Figure 9, where the data is plotted on semi-log paper, it is particularly evident that the rate of settlement changes dramatically at the end of construction. The last two settlement readings have been used to extrapolate the rate of secondary compression and to predict the long-term (1000 yr.) settlement of the disposal cell. This information has been used to develop confidence that the cell is performing as expected with respect to settlement and that routine settlement monitoring is not necessary as part of the long-term surveillance.

When the field data are used in extrapolation, the estimated post-construction settlement average (for 1000 yr.) is 6.2 inches for the in-situ tailings and 6.5 inches for relocated, compacted tailings over in-situ tailings (Table 1). These values compare closely to the design values of 2.2-4.5 inches for the in-situ tailings and 3.4 to 7.5 inches for the compacted tailings over in-situ tailings. The key comparison is for the settlement of the relocated, compacted tailings over in-situ tailings because the combined settlement was used in design to show that horizontal strains in the radon barrier would not result in cracking.

Settlement data were also used to evaluate the secondary compression rate. The rates obtained from the extrapolation are presented in Table 1. The ratios of the coefficient of secondary compression (C_α) to the consolidation index (C_c)were compared with published values to judge the reasonableness of the secondary compression rates. Ratios from both the laboratory test results and the actual settlement measurements were evaluated and are given in Table 3. The values have an average of 0.039 for in-situ tailings and 0.037 for relocated, compacted tailings over in-situ tailings. Values of C_α/C_c from the literature (Refs. 1,2, and 3) are listed below for comparison:

- Granular soils 0.015 to 0.03
- Inorganic soft clays 0.04 ± 0.01
- Highly organic plastic clays 0.05 ± 0.01
- Inorganic silts 0.03 to 0.06

Analysis of the undrained shear strength (primarily from piezocone soundings) for the in-situ tailings indicates that the sand-slimes are classified as "very stiff" and the slimes are classified as "medium" consistency. Therefore, the ratios of C_α/C_c are expected to be somewhat less than values for inorganic soft clays but not as

small as values for granular soils. The values for inorganic silts most closely approximate the tailings.

The most recent survey, performed on January 3, 1997, was affected by windy site conditions that may have introduced error in readings taken for DM-1, DM-2, DM-4, DM-5, and DM-6. Survey readings for DM-3, DM-7, and DM-8 were taken prior the rising of the wind. The windy conditions made it difficult to read the rod. The survey required that the surveying rod be read twice at each location; once on the metal rod extension of the settlement plate and one on the concrete base surrounding the settlement plate rod casing. The difference in these two readings was used to relate the concrete base elevations (obtained in a December 16, 1996 survey) to the settlement plate readings. No difficulties were reported for the December survey. The potential error in the survey measurements has been conservatively estimated to be a maximum of 0.1 feet for a single reading. The entire survey loop closed to 0.1 feet.

Rates of secondary compression from these field measurements show some scatter, which may be due in part to normal survey error. The attempt to measure very small elevation differences and to use those in extrapolation causes any survey error to be magnified. If an assumed potential error of 0.1 feet is added to the most recent measurements, the extrapolation to obtain estimated post-construction settlement results in much higher values (Table 2). Typical methods for calculating settlement will not yield results of that magnitude. Furthermore, when the potential error is used in determining C_α, the resulting C_α/C_c values are unreasonably high and do not match published data.

In summary:

- Long-term post-construction settlement predicted from measured settlement correlates well with long-term design values.

- C_α/C_c values from extrapolation of measured settlement correlate well with published values

- Measured settlements show early completion of primary consolidation as predicted from load testing

It is therefore concluded that the current data is sufficient to allow settlement monitoring to be discontinued. Furthermore, it is concluded that actual settlements should continue to closely correlate with the design values.

Because the overall settlements at the various locations are close to those predicted in design, differential settlement will be within the design limits. This means that cover cracking will not be an issue. Concerns that differential settlement could result in an increase in erosion potential can also be allayed. Differential settlement for this type of facility is a result of the variable thickness of more compressible layers, in this case, the in-situ tailings. Because the variation in thickness is gradual, the differential settlement typically occurs over a relatively large area and results in a vast, shallow, bowl-shaped depression. At Ambrosia Lake, the greatest thickness of in-situ tailings in near the center of the cell, thus the center of the

"bowl" would not be close to edges of the cell. for this reason it is not anticipated that differential settlement will steepen slopes or cause concentration of flows during storm events.

References:

1. Mesri, G. and Castro, A., March 1987, "C_α/C_c Concept and K During Secondary Compression", ASCE JGE, v. 113, n. 3.
2. Mesri G., Stark, T.D., and Chen, C.S., "Discussion of C_α/C_c Concept Applied to Compression of Peat", ASCE JGE, v. 120, n. 4.
3. Holtz, Robert D. and Kovacs, William D., 1981, "An Introduction to Geotechnical Engineering", Prentice-Hall.

TABLE 1 SECONDARY SETTLEMENT EVALUATION

Location	Tailings Thickness Ho ft	Settlement Summary: Assumed end of primary day = 750		At 12/16/1998 day = 1329		in 1000 years from 750 to 365,000 days		Secondary Compression Rate	Average $C_{\alpha\varepsilon}$
		tp days	sp ft	t' days	s' ft	t1000 days	s1000 ft	$C_{\alpha\varepsilon}$	
(1)	(2)	(3)	(3)	(3)	(3)		(4)	(5)	
DM-1	22.20	750	1.49	1329	1.54	365000	0.54	0.009065	0.009231
DM-2	20.40	750	2.72	1329	2.82	365000	1.08	0.019729	
DM-3	21.00	750	1.98	1329	1.97	365000	0.00	0.0	
DM-4	19.80	750	0.81	1329	0.85	365000	0.43	0.008131	
DM-5	50.00	750	0.27	1329	0.35	365000	0.87	0.006440	0.004094
DM-6	48.60	750	0.25	1329	0.37	365000	1.30	0.009938	
DM-7	56.00	750	0.53	1329	0.53	365000	0.00	0.0	
DM-8	53.00	750	0.44	1329	0.43	365000	0.00	0.0	
									0.006663

Notes:

(1) DM-1 thru DM-4 were placed on compacted tailings subgrade (i.e. on top of in-situ tailings)
DM-5 thru DM-8 were placed on top of compacted tailings

(2) Thickness of in-situ tailings only for DM-1 thru DM-4; Combined thickness of compacted tailings and in-situ tailings for DM-5 thru DM-8

(3) See plotted data. Assume primary consolidation was complete at end of construction (prior to or at day No. 750)

(4) $s1000 = C_{\alpha\varepsilon}\ Ho\ \log(t1000 / tp)$

(5) $C_{\alpha\varepsilon} = (s' - sp) / Ho / (\log t'/tp)$

TABLE 2 SECONDARY SETTLEMENT: EVALUATION WITH ADDITION OF ASSUMED SURVEY ERROR TO SETTLEMENT

Location	Tailings Thickness Ho	Settlement Summary: Assumed end of primary day = 750		Settlement Summary: At 12/18/1998 day = 1329*		Settlement Summary: in 1000 years from 750 to 365,000 days		Secondary Compression Rate	Average
		tp	sp	t'	s'	t1000	s1000		
	ft	days	ft	days	ft	days	ft	$C_{\alpha\varepsilon}$	$C_{\alpha\varepsilon}$
(1)	(2)	(3)	(3)	(3)	(3)		(4)	(5)	
DM-1	22.20	750	1.49	1329	1.64	365000	1.62	0.027194	0.028090
DM-2	20.40	750	2.72	1329	2.92	365000	2.16	0.039458	
DM-3	21.00	750	1.98	1329	2.07	365000	0.97	0.01725	
DM-4	19.80	750	0.81	1329	0.95	365000	1.51	0.028458	
DM-5	50.00	750	0.27	1329	0.45	365000	1.95	0.014489	0.011682
DM-6	48.80	750	0.25	1329	0.47	365000	2.38	0.018219	
DM-7	56.00	750	0.53	1329	0.63	365000	1.08	0.007187	
DM-8	53.00	750	0.44	1329	0.53	365000	0.97	0.008834	
									0.019886

Notes:

(1) DM-1 thru DM-4 were placed on compacted tailings subgrade (i.e. on top of in-situ tailings)
DM-5 thru DM-8 were placed on top of compacted tailings

(2) Thickness of in-situ tailings only for DM-1 thru DM-4; Combined thickness of compacted tailings and in-situ tailings for DM-5 thru DM-8

(3) See plotted data. Assume primary consolidation was complete at end of construction (prior to or at day No. 750)

(4) $s1000 = C_{\alpha\varepsilon}\, Ho \log (t1000 / tp)$

(5) $C_{\alpha\varepsilon} = (s' - sp) / Ho / (\log t'/tp)$

* = Values in Table 1 increased by 0.1 ft.

Table 3: Ratio of Secondary Compression Rate to Compression Index

Material	C_c	C_α	e	C_α / C_c (3)
Slimes (1)	0.535	3.1×10^{-3}	1.43	0.014
Sand-slimes (1)	0.120	1.6×10^{-3}	0.71	0.023
Remolded (2)	0.092	1.4×10^{-3}	0.67	0.025
Settlement measurements of in-situ tailings (4):				
DM-1	0.43	9.06×10^{-3}	0.81	0.038
DM-2	0.43	19.7×10^{-4}	0.81	0.083
DM-3	0.43	0	0.81	0
DM-4	0.43	8.13×10^{-3}	0.81	0.034
Average (6):	-	-	-	**0.039**
Settlement measurements of compacted tailings overlying in-situ tailings (5):				
DM-5	0.18	6.44×10^{-3}	0.64	0.059
DM-6	0.18	9.94×10^{-3}	0.64	0.090
DM-7	0.22	0	0.66	0
DM-8	0.20	0	0.64	0
Average (6):	-	-	-	**0.037**

Notes:

1. Laboratory tests on undisturbed samples.
2. Laboratory tests on remolded samples.
3. $C_\alpha = C_{\alpha_e} (1+e)$
4. Average e for in-situ tailings estimated as 0.81. Average $C_c = 0.43$ from analysis of two test embankments.
5. Average e and C_c for compacted tailings overlying in-situ tailings estimated as a depth-weighted average. Average e = 0.57 for compacted tailings from field density measurements. Use $C_c = 0.092$ for compacted tailings.
6. Average of all results, i.e., effects of survey error on C_α are distributed over all 4 locations.

Figure 1: Fill Height & Total Settlement @ DM-1

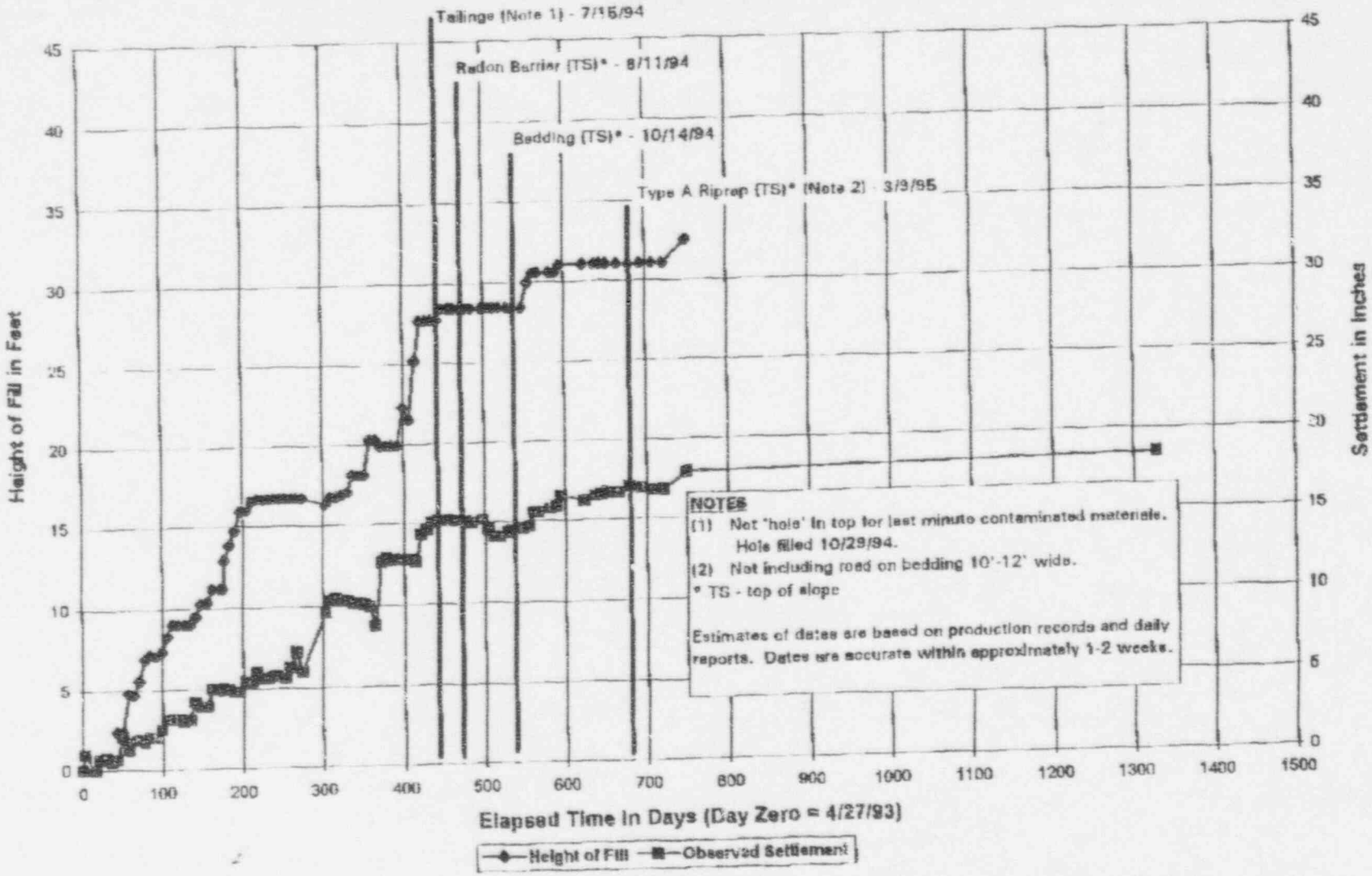

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Figure 2: Fill Height & Total Settlement @ DM-2

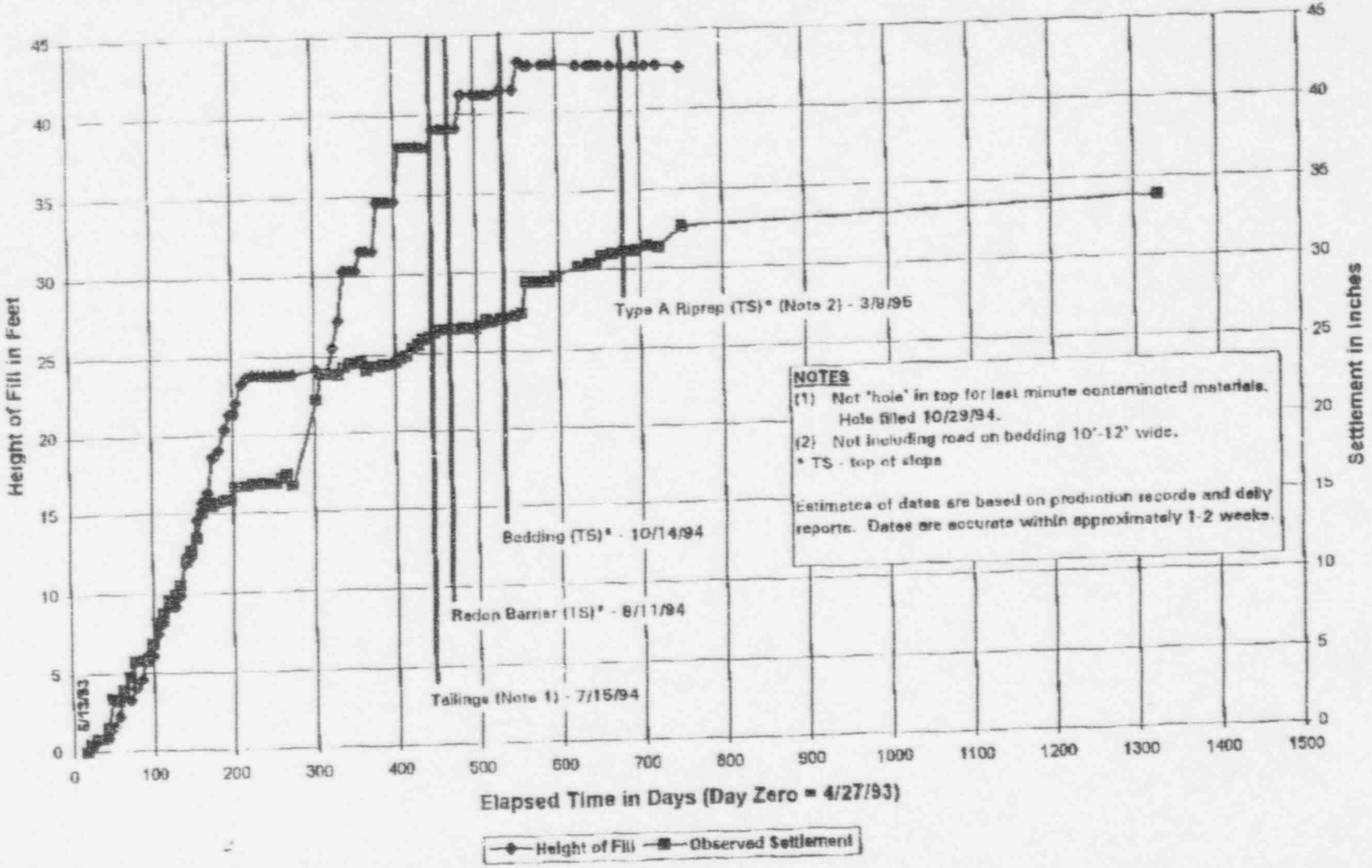

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Figure 3: Fill Height & Total Settlement @ DM-3

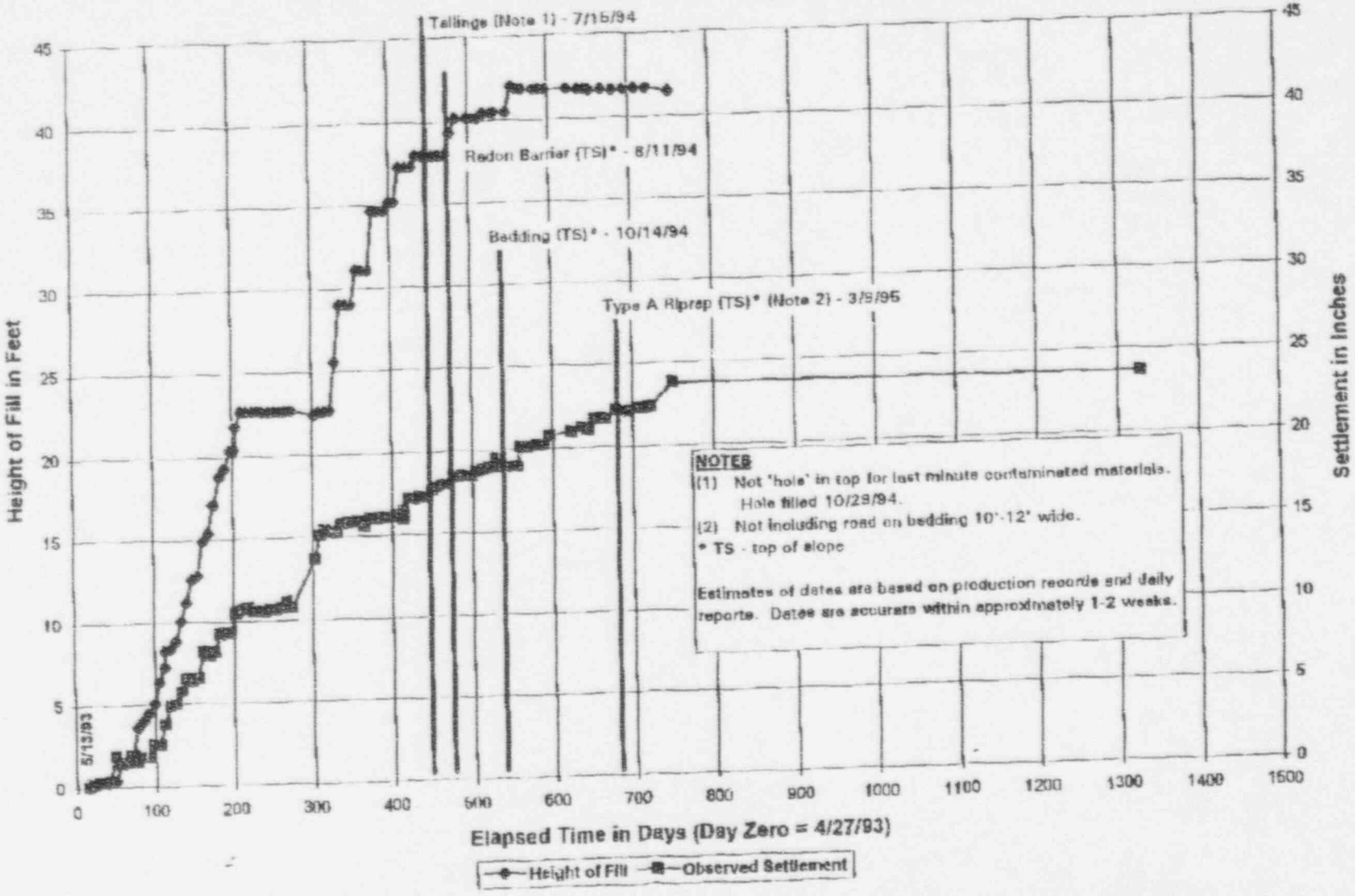

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Figure 4: Fill Height & Total Settlement @ DM-4

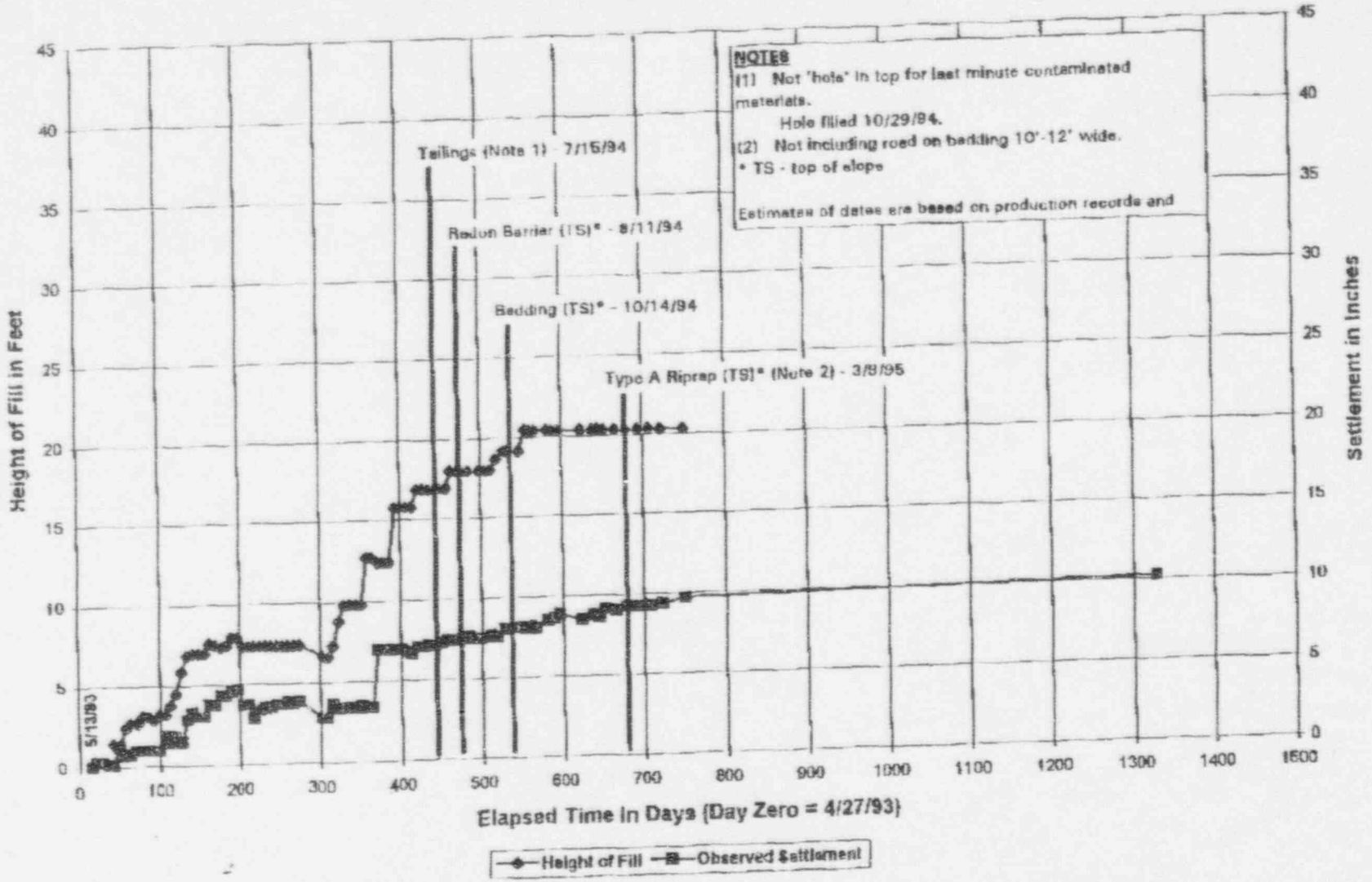

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Figure 5: Total Settlement @ DM-5

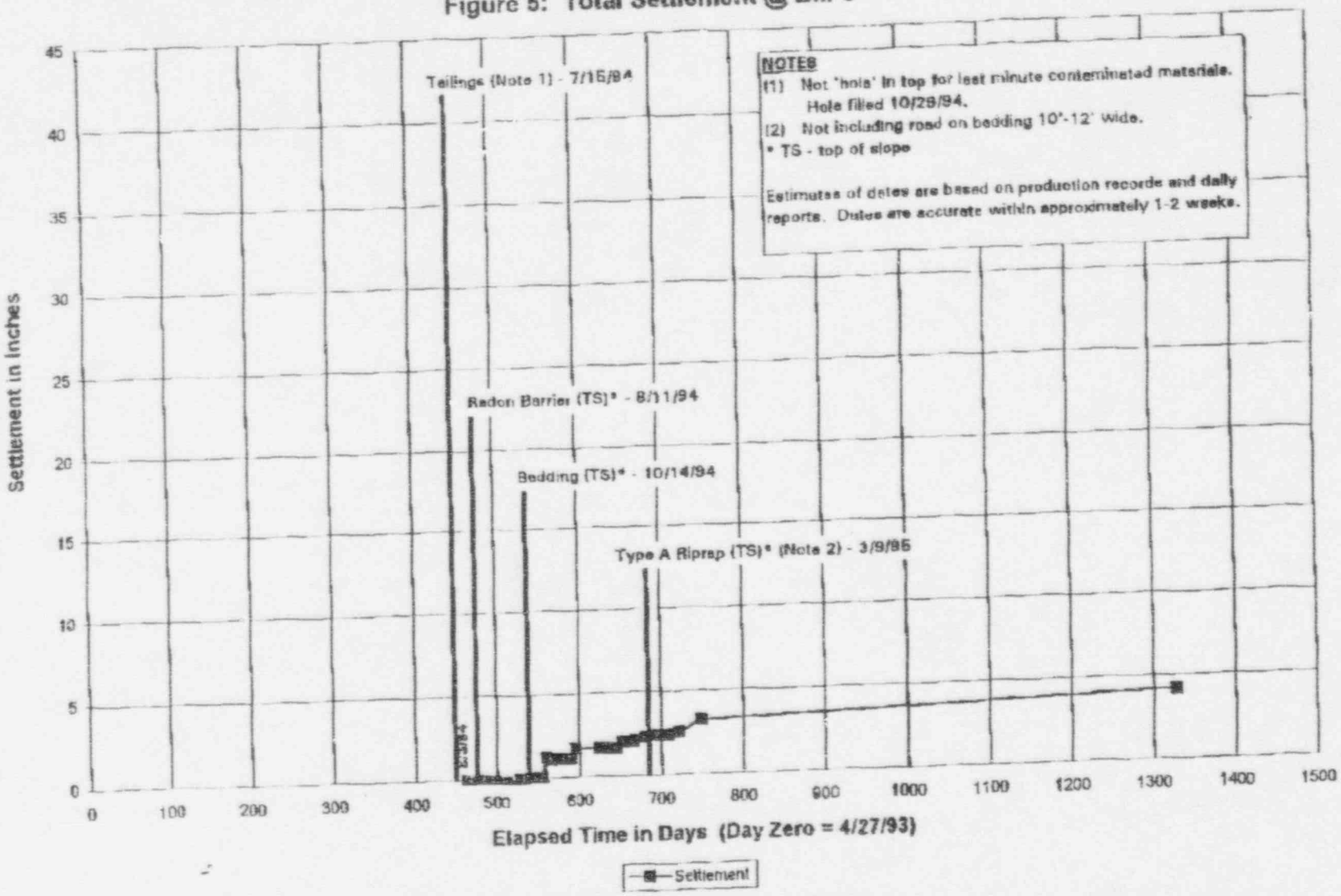

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Figure 6: Total Settlement @ DM-6

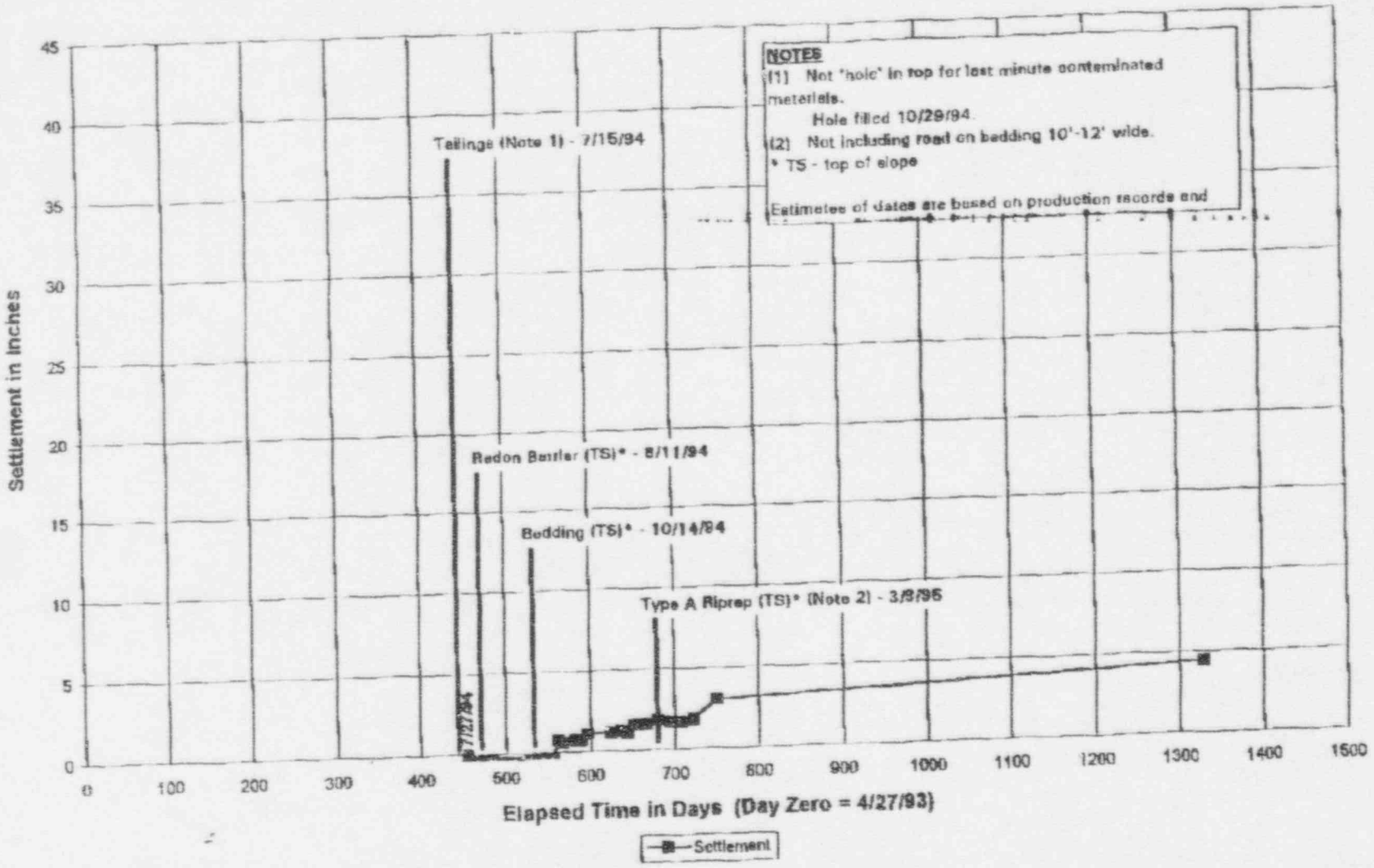

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Figure 7: Total Settlement @ DM-7

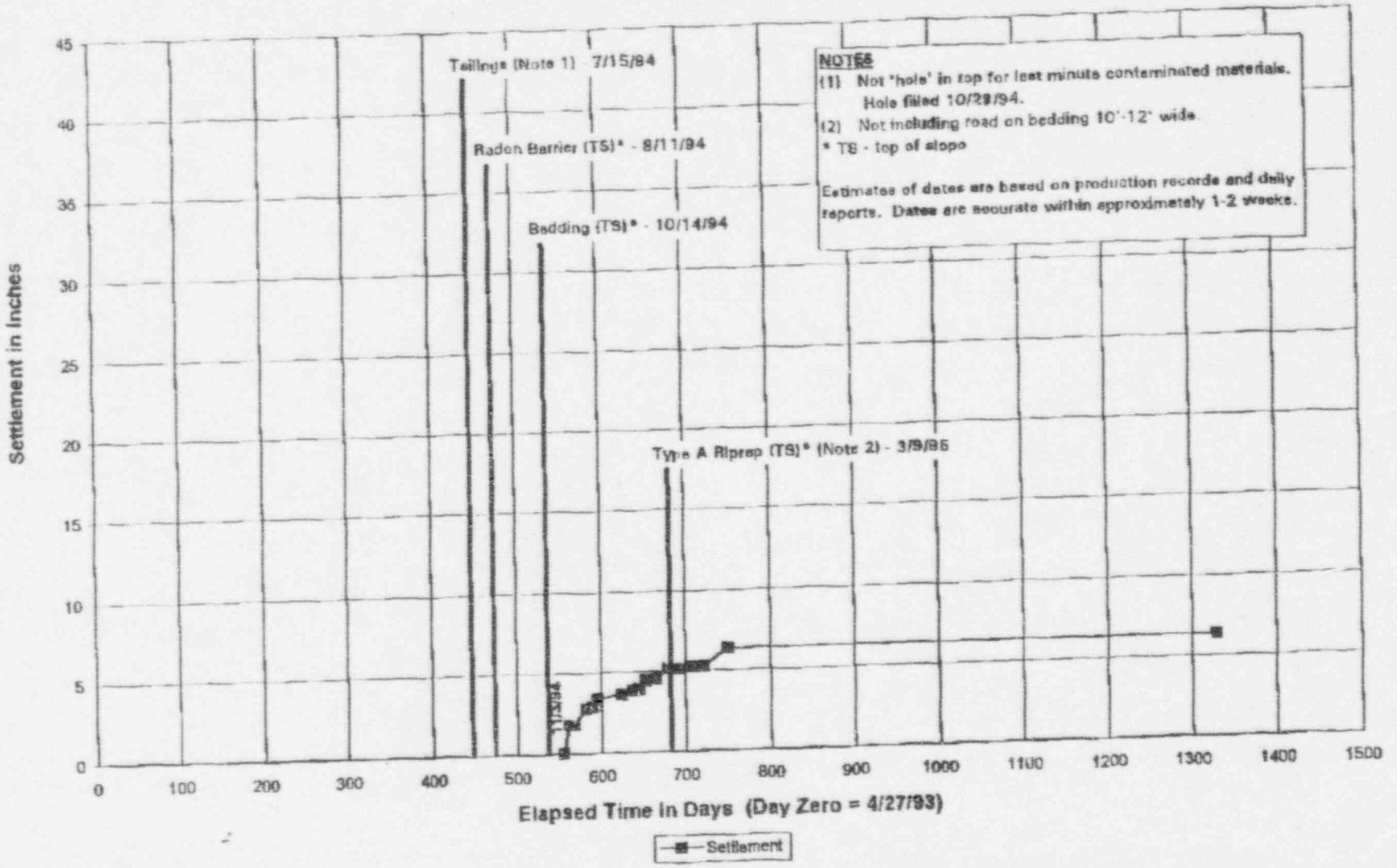

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Figure 8: Total Settlement @ DM-8

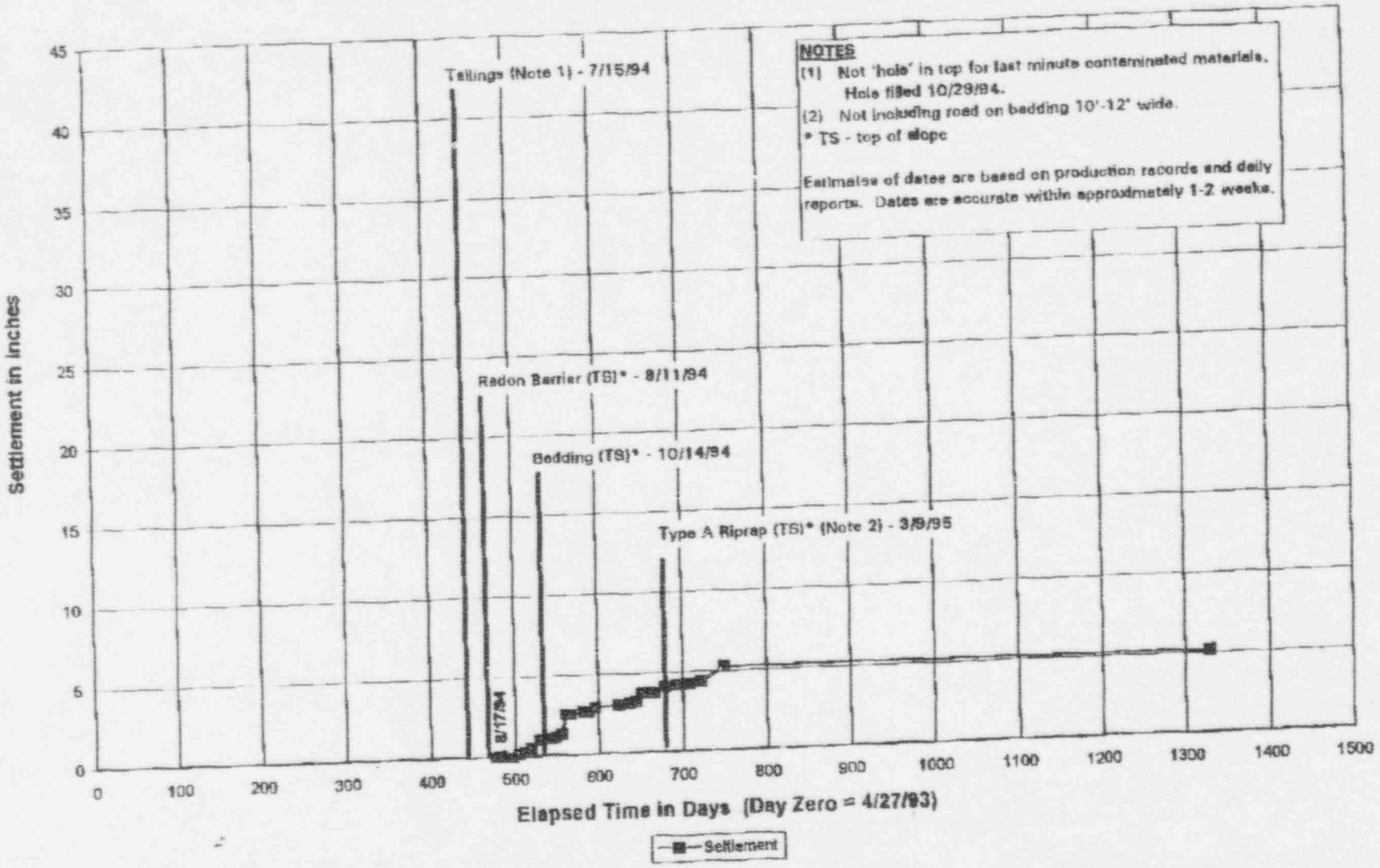

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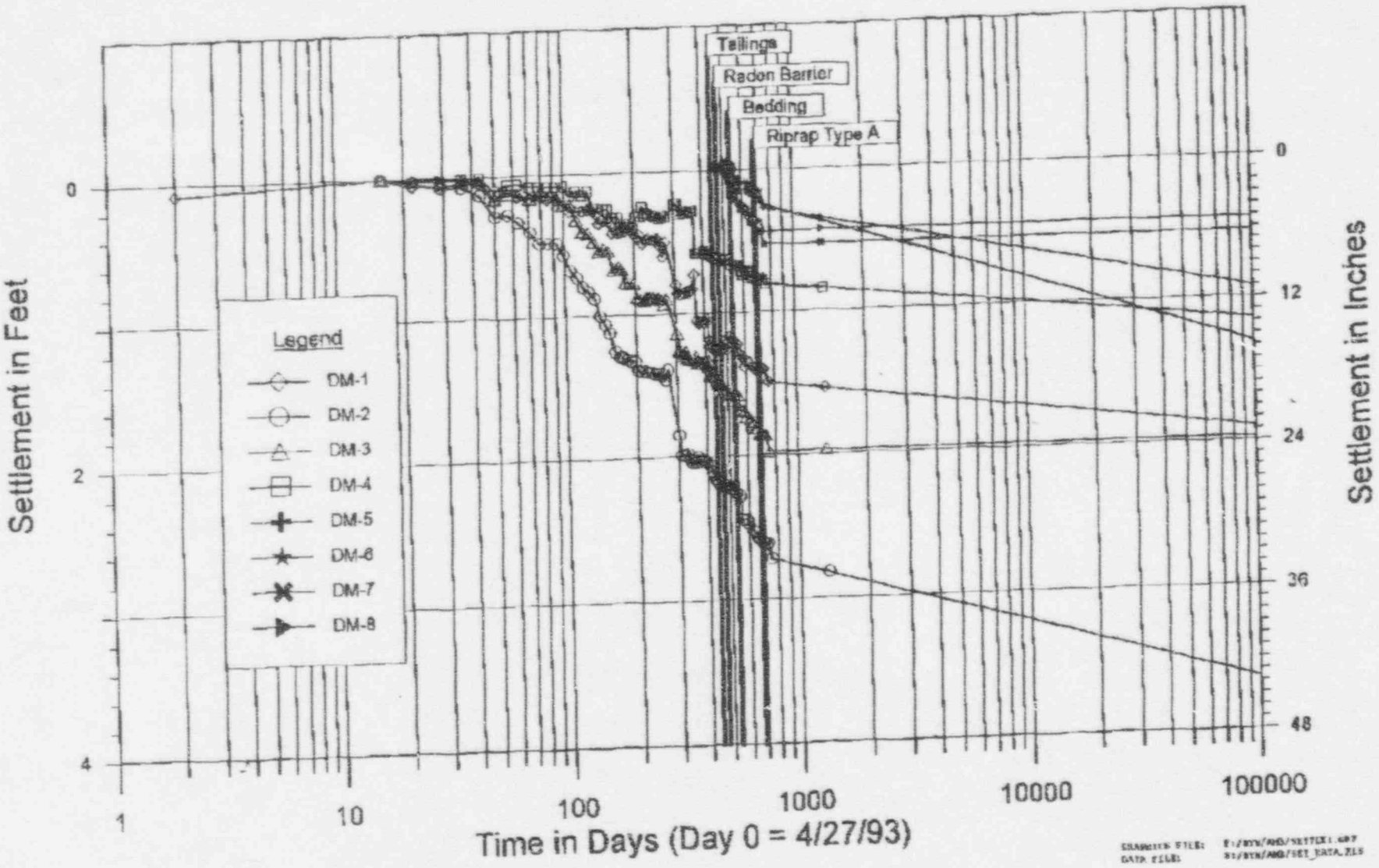
Figure 9: Settlement Curves



SURVEY OF SETTLEMENT MONUMENTS - AMBROSIA

On December 16, 1996, Albuquerque Surveying went to the Ambrosia disposal cell to survey the eight settlement monuments following a request by M. Abrams of DOE. Abq. Survey was unable to remove the caps over the monuments so surveyed and marked a location on top of the concrete base enclosing the monuments. The results of the survey were delivered to MK-Ferguson by fax on December 17, 1996. A copy of the results is attached.

On January 3, 1997, MK Ferguson went to the Ambrosia cell to tie the Abq. Survey results into the monument check points (rod, pipe). The greatest deviation found between the last survey on file (May 1995) and now was 0.15 ft. This may be due to settlement but is likely partly the result of survey error. The high wind velocity at the time of the survey made readings difficult. However, the closure on the survey was within 0.10 ft. The following table shows the delta for the eight monuments between May 17, 1995 and the December/January readings recently completed:

DM - 1		DM - 2		DM - 3		DM - 4	
Rod	Pipe	Rod	Pipe	Rod	Pipe	Rod	Pipe
22.78	22.28	33.29	32.71	33.35	32.79	14.07	13.57
22.73	22.19	33.19	32.56	33.36	32.68	14.03	13.45
(0.05)	(0.09)	(0.10)	(0.15)	0.01	(0.11)	(0.04)	(0.12)

DM - 5		DM - 6		DM - 7		DM - 8	
Rod	Pipe	Rod	Pipe	Rod	Pipe	Rod	Pipe
26.32	25.82	26.28	25.78	26.34	25.84	26.23	25.73
26.24	25.74	26.16	25.85	26.34	25.84	26.24	25.69
(0.08)	(0.08)	(0.12)	0.07	0.00	0.00	0.01	(0.04)

Note: The first line shows readings from 5/17/95; the second line shows readings obtained from the 12/16/96 and 1/03/97 surveys.

ALBUQUERQUE SURVEYING COMPANY INC.
2119 MENAUL BOULEVARD, N.E. • ALBUQUERQUE, N.M. 87107
PHONE 884-2036
FAX 884-3796

December 17, 1996

Mr. R.E. Waddington
MK-Ferguson Company
PO Box 9136
Albuquerque, NM 87119

Re: Ambrosia Lake UMTRA Site
Elevations of 8 Displacement Monuments

Dear Mr. Waddington,

Attached to this letter please find the following:

1) Printout of coordinates and elevations of 8 displacement monuments.
2) Sketch showing location of displacement monuments.
3) Copies of field notes.

Bench mark used was Pt.# 201, 2.5" iron pipe with brass cap, elev. = 6,963.58. This bench mark was used during the entire project. Second bench mark used, Pt.# 103, Brass cap set in concrete located southeast of the site, was also recovered at this time, and elevation verified. Both benchmarks are located away from the pile.

Elevations shown are located on top of concrete pad on the north side of each monument pipe. All displacement monuments have caps and locks and we were unable to determine elevations of tops of pipes or tops of rods inside pipes.

If you have any questions please feel free to call me.

Sincerely,

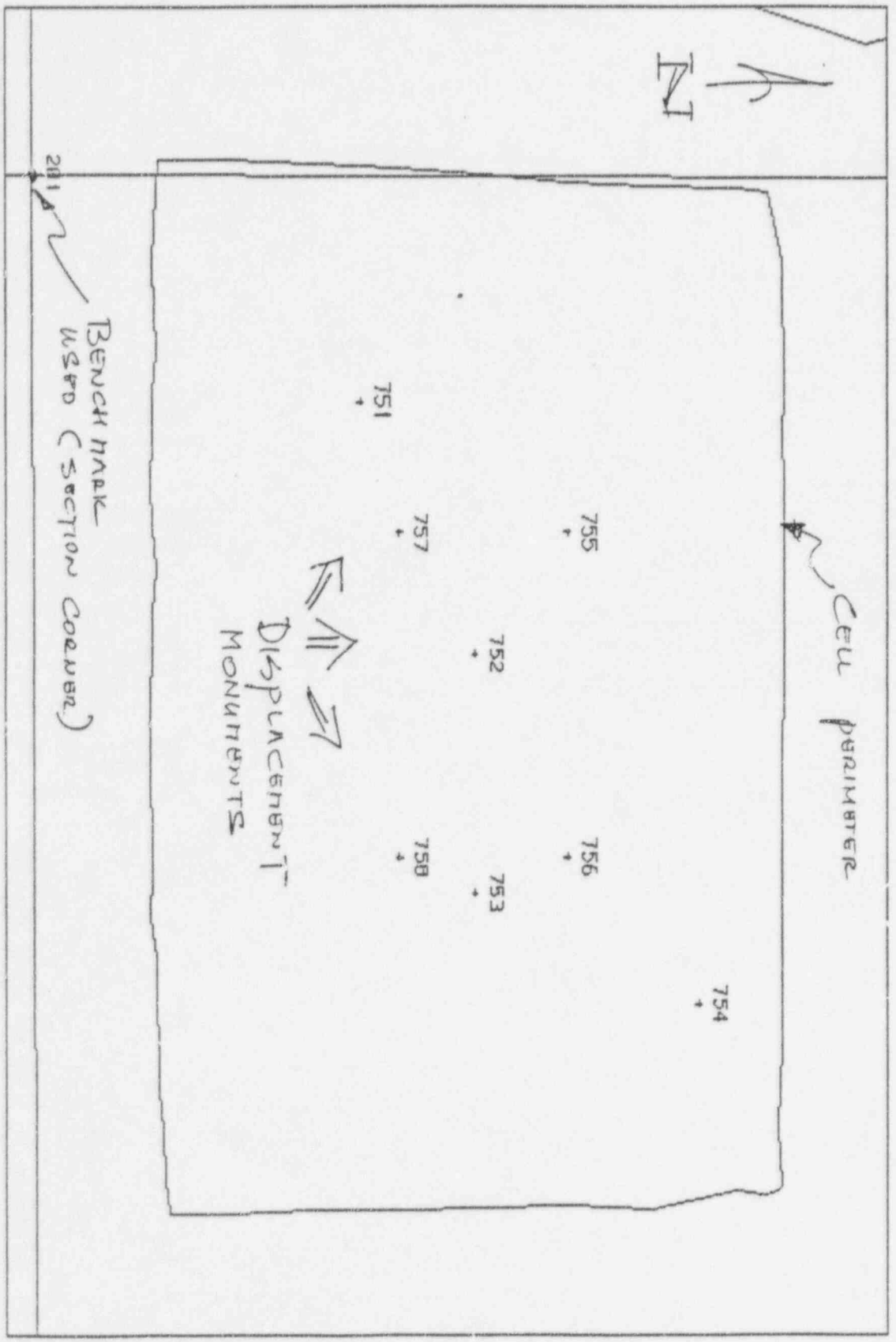
ALBUQUERQUE SURVEYING COMPANY, INC.

Vladimir Jirik
Project Coordinator

VJ/lj

LIST COORDINATES

	PT#	NORTH	EAST	ELE
BRASS CAP	103	603058.7747	513057.2449	6989.8
SC 28,29,32,33	201	603044.6600	508896.4600	6963.5
DM-1	751	603810.0000	509420.0000	7022.8
DM-2	752	604080.0000	510000.0000	7033.0
DM-3	753	604080.0000	510550.0000	7033.2
DM-4	754	604610.0000	510810.0000	7013.4
DM-5	755	604300.0000	509720.0000	7026.1
DM-6	756	604300.0000	510470.0000	7026.3
DM-7	757	603900.0000	509720.0000	7026.4
DM-8	758	603900.0000	510470.0000	7026.2


N
CELL PERIMETER
754
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751
DISPLACEMENT MONUMENTS
281
BENCH MARK USED (SECTION CORNER)

11/3/97	BS	HI		ELEV.		Survey of Displacement Monuments - Ambrosia Lake
#7 conc	+8 43	34.88		26.45	From Alb. Survey data	Windy, cold ▲ R Washington
Rod #7	+8 54			26.34		Prtly Cdy ▢ - B. Pettibon
Pipe #7	+9 04			25.84		Rod - J. Robertson
#2 Conc.	+1 82			33.06		
Rod	+1 69			33.19		
Pipe	+2 32			32.56		
#8 conc	+8 62			26.26		
Rod	+8 64			26.24		
Pipe	+9 19			25.69		
#3 conc	+2 41			33.27		
Rod	+1 52			33.36		
Pipe	+2 20			32.68		

STA	FS	HI	BS	ELEV
	0.42			
TP1	-9.35			26.46
		32.60	+6.14	
#6 CONC		+8.54	+6.14	26.46
ROD		+8.55	+6.44	26.16
PIPE			+6.75	25.85
#5 CONC			6.53	26.07
ROD			6.36	26.24
PIPE			6.86	25.74
	+10.51			
TP#2	-9.76			22.09
		22.71	+0.62	
#4 CONC		+9.40		13.31
ROD		+8.68		14.03
PIPE		+9.26		13.45

Sta.	FS	HI	BS	Elev.
TP1 TP#3	-0.23			22.48
		30.92	+8.44	
#6. #6 conc	+ 4.66			26.26
TP#4	-0.94			29.98
		34.53	+4.55	
#5 BM Monument	-0.22			34.75
TP #7 conc	+8.14			26.37
#1 TP#5	-9.84			
		27.54	+2.85	
#1 conc.	-4.80			22.74
Rod	-4.81			22.73
Pipe	-5.35			22.19

		FS	HI	Elev
#7 Conc.		+ 1.19		26.35
Orig.	B.S.	Elev	from	Alb Survey =
				26.45
				- 26.35
			Δ =	.10 closure
Total	BS(+)	= 31.03		
Total	FS(-)	= 31.13		
	Δ =	-.10		

11/21/97	BS	HI		ELEV.	
#7 cone	+8 43	34.88		26.45 —	From Alb. Survey data
Rod #7	+8 54			26.37	
Pipe #7	+7 04			25.81	
#2 Cone.	+1 87			33.06	
Rod	+1 69			33.19	
Pipe	+2 32			32.56	
#8 cone	+8 62			26.26	
Rod	+8 64			26.24	
Pipe	+9 19			25.69	
#3 cone	+1 61 +2 41			33.27	
Rod	+1 52			33.36	
Pipe	+2 20			32.68	

Survey of Displacement Monuments - Ambrosia Lake

Windy, cold ⊼ - R Waddington

Prtly Cdy ⊡ - B. Pettibon

Rod - J. Robertson

STA	FS	HI	BS	ELEV
	0 42			
TP1	-9 35			26.46
		32.60	+6 14	
#6 CONC		+8 44	+6 14	26.46
ROD		+8 45	+6 44	26.16
PIPE			+6 75	25.85
#5 CONC			6 53	26.07
ROD			6 86	26.24
PIPE			6 86	25.74
	+10 51			
TP#2	-9 76			22.09
		22.71	+0 62	
#4 CONC		+9 40		13.31
ROD		+8 68		14.03
PIPE		+9 26		13.45

Sta.	FS	HI	BS	Elev.
TP; TP#3	-0.23			22.48
		30.92	+8.44	
#6. #6 conc	+4.66			26.26
i TP#4	-0.94			29.98
		34.53	+4.55	
~~#3~~ BM Monument	-0.22			34.75
TP #7 conc.	+8.16			26.37
~~#7~~				
#i TP#5	-9.84			
		27.54	+2.85	
#1 conc.	-4.80			22.74
Rod	-4.81			22.73
Pipe	-5.35			22.19

		FS	HI	Elev
#7 Cone.		+1.19		26.35
Orig.	B.S.	Elev	Ryan	Alb. Survey =
				26.45
				-26.35
				Δ = .10 closure
Total	BS(+)	= 31.03		
Total	FS(-)	= 31.13		
	Δ	= -.10		