BECHTEL ASSOCIATES PROFESSIONAL CORPORATION

MIDLAND PLANT UNITS 1 & 2

JOB 7220

ADMINISTRATION BUILDING FOUNDATION SETTLEMENTS ALONG COLUMN LINE 0.4

Prepared by:

GEOTECHNICAL SERVICES
December, 1977.

INTRODUCTION

Early in September, 1977, we were requested by project engineering to assist in reviewing conditions surrounding footing settlements during construction of the Midland Project Administration Building. The foundation location plan for this building is shown in Figure 1. The affected foundations are those along Column Line 0.4.

The following data are presented to enable construction and engineering in evaluating the settlement of these footings.

BACKGROUND

The original ground at the Midland site was at approximately Elevation 603 in the vicinity of the administration building. After ground surface preparation, plant area fill was placed to approximately Elevation 634. An excavation was later made to about Elevation 610 to accommodate construction of the steam tunnel. Figure 2 shows a cross-section of the tunnel and the approximate excavation scheme. After construction of the tunnel, the west side of the tunnel excavation was backfilled to approximate Elevation 620 to construct the foundations along Column Line 0.4 of the administration building. After foundation construction, the remainder of the excavation was backfilled with sand to grade as shown in Figure 2.

During the early part of September, Geotech was made aware of settlements along the Column Line 0.4. The settlement data are given in Table 1.

FIELD OBSERVATIONS

During the week of September 19-23, 1977, several site reviews were made by engineering, construction, and Geotech personnel. These took place before and after the removal of the subject footings.

Upon removal of Column PA 0.4, it was noted that the soil under and adjacent to it was soft. This was confirmed by pushing a 3/4"ϕ steel bar with little effort approximately two feet into the ground, by walking on the soil and noting its spongy characteristics, and by pushing of a shovel with little effort.

Tests taken at that time in and adjacent to PA 0.4 included moisture content, density, and unconfined compression. These tests also were taken at Column LN 0.4.

After these field observations, it was decided that two borings should be taken to further evaluate the conditions along Column Line 0.4.

ONLY!

At that time, Bechtel Construction's decision was that all affected footings be removed.

BORINGS

On September 27 and 28, 1977, two test borings were completed at footings LN 0.4 and HT 0.4. At footing LN 0.4, standard penetration tests (SPT) and shelby tubes (ST) were taken. At footing HT 0.4, standard penetration tests were taken.

Borings included visual inspection and description of soils, Qp tests (compressive strength of soil by the pocket penetrometer method) and any visual observations of water conditions (loss or gain).

Samples for proctor testing were also taken as shown in log of holes, LNA, LNB, and NTA.

The boring logs are shown on Figures 3 through 7.

TESTING PROGRAM

Shelby tubes taken from Boring LN were submitted to U. S. Testing Laboratory for unconfined compressive tests.

Samples taken at foundations PA 0.4 and LN 0.4 were also taken by U. S. Testing personnel and unconfined compression tests were made. Results of testing are giv[illegible] in Table 2.

It was also decided to run Proctor tests on the samples taken directly under and adjacent to footings in order to determine the standard to be used in calculating the in situ percent compaction. These results are found in Figures 8, 9, and 10.

The Proctor curve in Figure 8 was used to calculate the in situ percent compaction using the in situ dry density data reported by the Field. This information is compared in Figure 8 with the percent compaction previously reported. This comparison shows that the percent compaction was in all cases lower than that previously determined.

In order to illustrate the effect of a reduced percent compaction on the strength of soil, th[illegible] of California Bearing Ratio (CBR) tests previously made on three identical samples of the Midland soils are presented in Figure 11. The samples were compacted at three levels of compaction effort, which resulted in compactive energies of 56,000 ft-lb/ft^3, 20,000 ft-lb/ft^3, and 12,400 ft-lb/ft^3, respectively. It is seen that the pressure values for a penetration of 0.1" at the maximum dry density reduced from 94.5 psi to 5 psi by reducing the compactive energy from 56,000 ft-lb/ft^3 to 12,400 ft-lb/ft^3.

CONCLUSION

Based on available data the material under and adjacent to the subject footings, (Elevation 618-622) had insufficient bearing capacity to support the foundations.

The backfilled other than the soil in question (below 618) appears adequate and this conclusion is supported by SPT borings and compression tests.

Administration Building
Anchor Bolts for Col. Line 0.4
Top Bolt Elev. 634' - 2-1/2"
Per Dwg. 981, Rev. 1, Sec. D

The Columns and Grade Beam
For Column Line 0.4 Shows
Settlement Per As Built
Elevations Taken 8-23-77

Column	Elevation	Δ Settlement (ft)
Pa	634.10	0.11
N_k	634.03	0.17
M_P	634.01	0.20
L_N	634.05	0.16
K_P	634.02	0.19
K_B	633.93	0.28
J_F	633.93	0.28
H_T	633.92	0.29

Table 2

MIDLAND UNITS 1 & 2

ADMINISTRATION BUILDING EXCAVATION

UNCONFINED COMPRESSION TESTS

Sample No.	Sample Location	Sample Elevation	*Unconfined Compression Strength Lbs Per Sq Ft	**Allowable Bearing Value Lbs Per Sq Ft	Percent Strain	Re
1	PA - .04	622.0	730	625	20.0	
2	PA - .04	621.0	487	420	20.0	
A	PA - .04	612.0	1984	1709	6.7	
B	PA - .04	611.0	633	546	20.0	
3	LN - .04	622.0	9.4	788	12.0	
4	LN - .04	621.0	2081	1792	5.0	
ST-1	Boring LN	617.5	4241	3653	10.3	
ST-2	Boring LN	615.5	2145	1849	20.0	
ST-3	Boring LN	603.0	5945	5123	9.1	
ST-4	Boring LN	597.5	3137	2704	20.0	
ST-5	Boring LN	588.0	2837	2423	20.0	

... D 2166-66(72) **1/3 x 5.14 x 1/2 x Unconfined

Figure 1

FOUNDATION LOCATION PLAN

ADMINISTRATION BUILDING

MIDLAND NUCLEAR UNITS 1 & 2

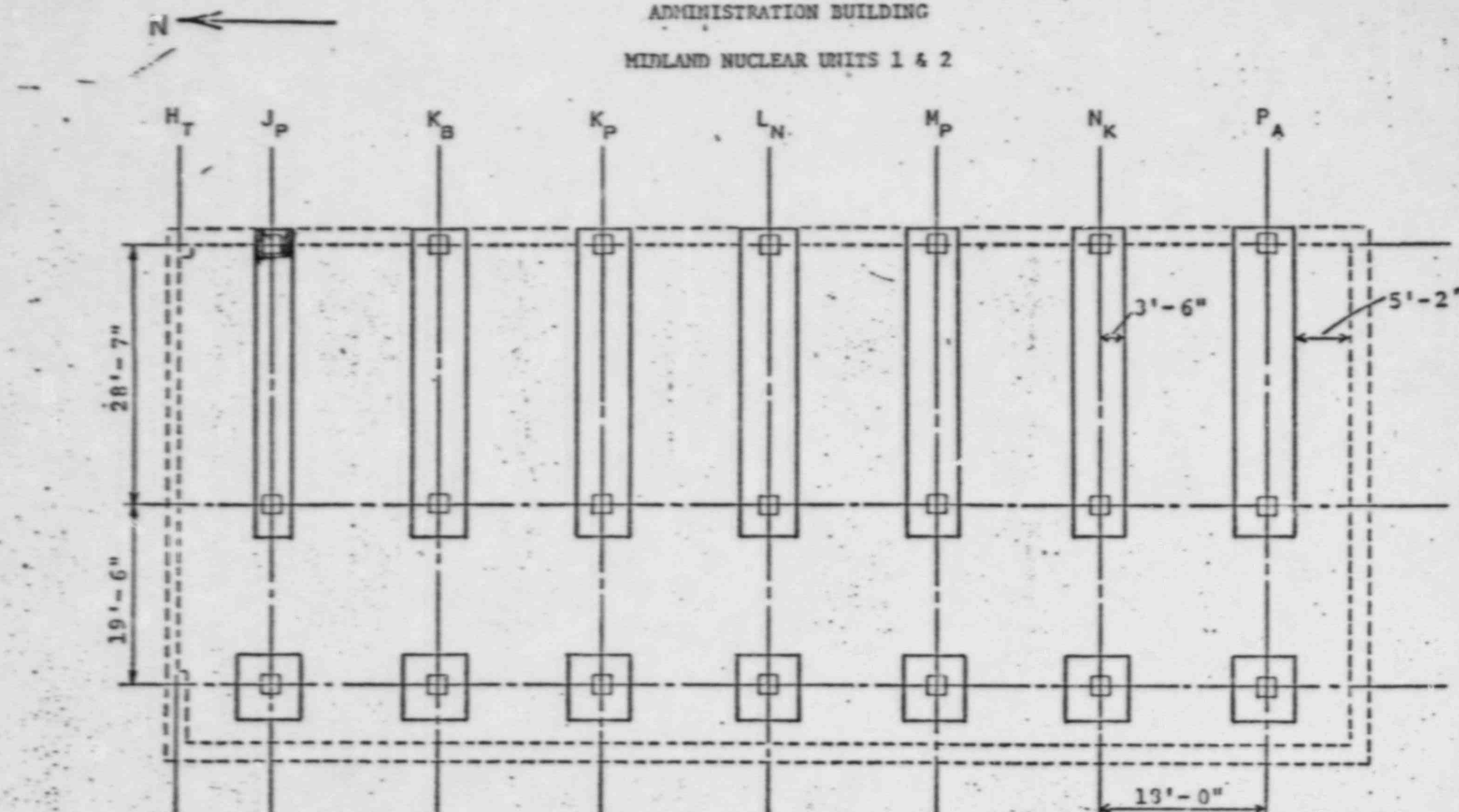
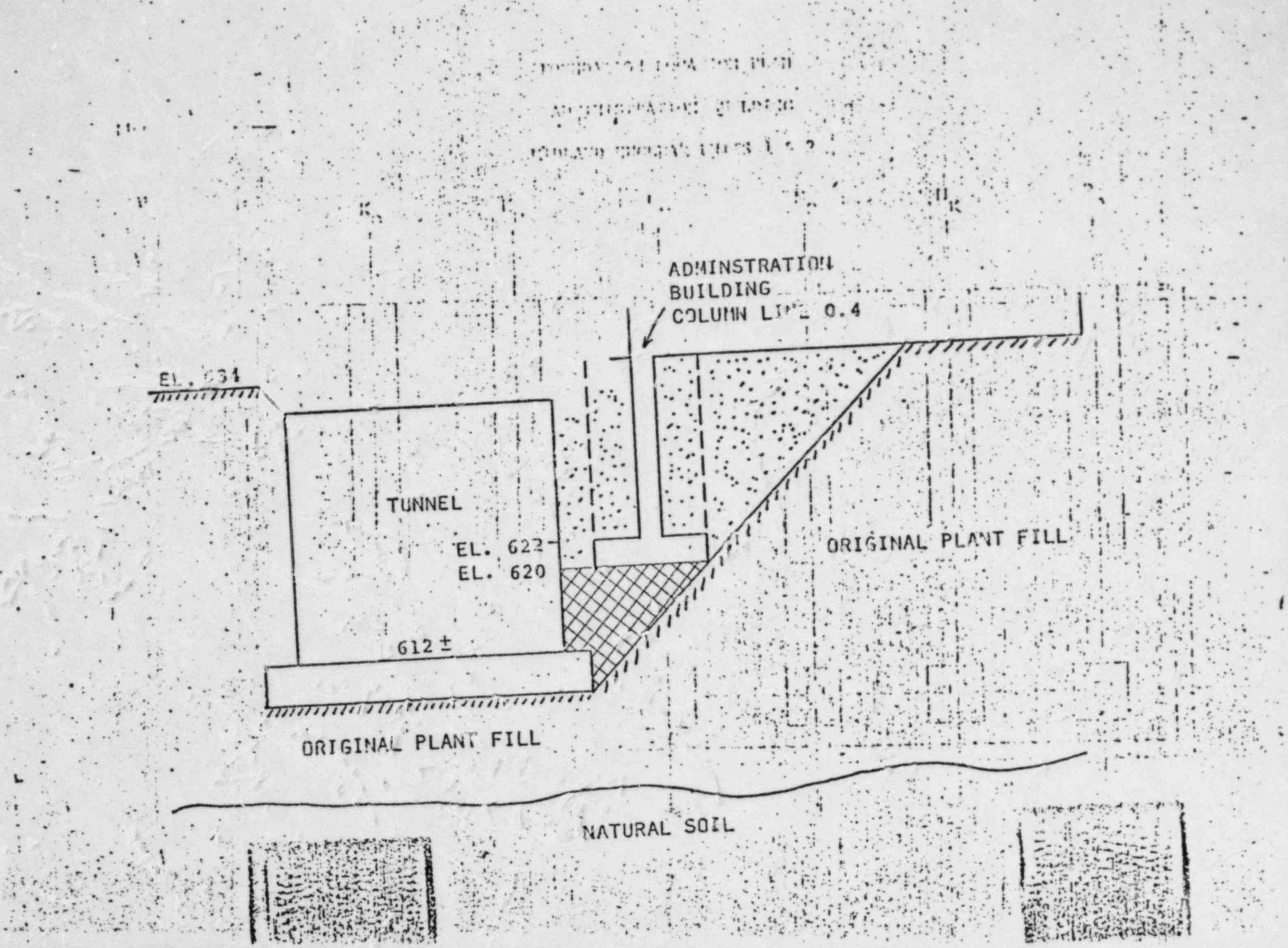


Figure 2


ADMINSTRATION
BUILDING
COLUMN LINE 0.4
EL. 634
TUNNEL
EL. 622
EL. 620
612 ±
ORIGINAL PLANT FILL
ORIGINAL PLANT FILL
NATURAL SOIL

BORING LOG

Project	Job No.	Sheet	Hole No.
MIDLAND NUCLEAR PLANT	7220	1 of 1	L_N

Site	Coordinates	Angle from horiz.	Bearing
ADMINISTRATION BLDG.	APPROX. 2' E OF FOOTING ℄ 0.4-L_N	90°	—

Begun	Completed	Driller	Drill make and model	Hole size	Overburden (ft.)	Rock (ft.)	Total depth
9/27/77	9/28/77	SINGLETON (ABEL DRIL.)	CME-550	5"	—	—	43.5

Core recovery (ft/%)	Core boxes	Samples	El. top of casing	Ground el.	Depth/el. ground water	Depth/el. top of rock
—	—	18	—	622.0	(SEE NOTES COL.)	—

Sample hammer weight/fall	Casing left in hole: dia./length	Logged by
140#/18"	NONE	JERRY B. GIVENS

Date	Sampler type and diameter	Sampler advance / length core run	Sample recovery / core recovery	Sample blows "N" / percent core recovery	Penetration blows 1st 6"	2nd 6"	3rd 6"	Elevation (622')	Depth	Sample
9/27/77								620		
9/27/77	2"ST	2'	1.5'	—	—	—	—	619.5	2.5–4.5	1
9/27/77	2"ST	2'	0.9'	—	—	—	—		4.5–6.5	2
9/27/77	2"SS	1.5'	1.0'	35	11	13	22		7–8.5	3
9/27/77	2"SS	1.5'	1.2'	37	13	17	20		9.5–11	4
9/27/77	2"ST	2'	0'	—	—	—	—		12–14	5
9/27/77	2"SS	1.5'	0.8'	28	10	14	14		14.5–16	6
9/27/77	2"ST	2'	1.0'	—	—	—	—		17–19	7
9/27/77	2"SS	1.5'	0.9'	31	17	16	15		20–21.5	8
9/27/77	2"ST	2'	1.7'	—	—	—	—		22.5–24.5	9
9/28/77	2"SS	1.5'	0.5'	19	6	9	10		25.5–27	10
9/28/77								594.5		
9/28/77	2"ST	2'	0'	—	—	—	—		28–30	11
9/28/77	2"SS	1.5'	0.2'	10	4	5	5	591.0	30–31.5	12
9/28/77	2"ST	2'	1.3'	—	—	—	—	589.0	32–34	13
9/28/77	2"SS	1.5'	0.2'	20	8	9	11		34.5–36	14
9/28/77	2"SS	0.9'	0.9'	100+	84	100/.4' (?)	—	585.0	37–37.9 (?)	15
9/28/77	2"SS	0.8'	0.8'	100+	71	100/.3'	—		39.5 (?)	16
9/28/77	[illegible]	0.9' (?)	0.8'	100+	8[illegible]	100/72.5 (?)	—		40.5–41.5 (?)	17
9/28/77	2"SS	0.5'	0.2'	100+	103	—	—	578.5	43–43.5	18

Graphic log: FILL

DESCRIPTION AND CLASSIFICATION

0'-2' SILTY SAND, TAN, LOOSE (BACKFILL) (SP/SM)

2'-2.5' GREY GRAVELLY CLAY (CL)
2.5'-27.5' SANDY CLAY, GREY W. TRACE TO LITTLE GRAVEL, LOW TO MEDIUM PLASTICITY, HARD (CL)
7'-25.5' BROWNISH GREY (FILL)

12' LARGE COBBLE (? BENT TUBE)
14.5' INCREASE IN SAND CONTENT
15.5' 1" STONE

22' STONE
22'-27.5' STIFF TO MEDIUM STIFF
22.5' DECREASE IN SAND CONTENT
25.5'-27.5' MEDIUM PLASTICITY

27.5'-31' SAND SEAM? LOOSE? (POOR RECOVERY AREA - TUBE PUSHED EASILY) (FILL)

31'-33' SANDY CLAY, GREY, STIFF TO MEDIUM STIFF (CL) (FILL)

33'-37' SILTY SAND, TAN W LITTLE RUSTY BROWN COLOR, FINE TO MEDIUM GRAINED, MEDIUM DENSE (SP/SM) (FILL)
3[illegible]-37' TAN

37'-43.5' SILTY SAND, GREY, FINE TO MEDIUM GRAINED, VERY DENSE, MOIST (SP/SM)
38.5'-43.5' FINE GRAINED

TOTAL DEPTH = 43.5'
EL. BOTTOM = 578.5

NOTES ON WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.

5" AUGER TO 8.5'; SET 5" CASING; DRILL W. 4" TRI-CONE ROLLER BIT AND RE-CIRCULATING WATER BELOW 8.5'

SLIGHT WATER SEEPAGE AT 2.5'

USED DEWITT GLAZING COMPOUND AND MASKING TAPE TO SEAL TUBES

SAVED SS SAMPLES IN JARS

#1 Qp = 4.5+ TSF
#2 Qp = 4.5+ TSF
#3 Qp = 4.5+ TSF
#4 Qp = 4.5+ TSF
#5 NO Qp - TUBE BENT BADLY
#6 Qp = 2.25 TSF
#7 NO Qp - TIP OF TUBE BENT
#8 Qp = 4.5 TSF
#9 Qp = 3.75, 4.[illegible] TSF
#10 Qp = 1.1 TSF
#11 NO Q - TUBE PUSHED EASILY
#12 NO Qp = NOT ENOUGH RECOVERY (ABOUT 2 TSF)
#13-#18 NO Qp (SAND)

WATER LEVEL 5.9' AFTER CASING PULLED

HOLE BACKFILLED WITH SOIL AFTER COMPLETION

SS = SPLIT SPOON; ST = SHELBY TUBE; D = DENNISON; P = PITCHER; O = OTHER

Site	Hole No.
ADMINISTRATION BLDG.	L_N

10070-1

BORING LOG

PROJECT			
MIDLAND NUCLEAR PLANT	7220	1 of 1	LNA

SITE	COORDINATES	ANGLE FROM HORIZ.	BEARING
ADMINISTRATION BLDG.	2' NORTH OF LN	90°	—

BEGUN	COMPLETED	DRILLER	DRILL MAKE AND MODEL	HOLE SIZE	OVERBURDEN (FT.)	ROCK (FT.)	TOTAL DEPTH
9/28/77	9/28/77	SINGLETON (ABELDRIL.)	CME-550	5"	—	—	5'

CORE RECOVERY (FT./%)	CORE BOXES	SAMPLES	EL. TOP OF CASING	GROUND EL.	DEPTH/EL. GROUND WATER	DEPTH/EL. TOP OF ROCK
—	—	1	—	622	(SEE HOLE "LN")	—

SAMPLE HAMMER WEIGHT/FALL	CASING LEFT IN HOLE: DIA./LENGTH	LOGGED BY:
N/A	NONE	JERRY B. GIVENS

SAMPLER TYPE AND DIAMETER	SAMPLER ADVANCE LENGTH CORE RUN	SAMPLE RECOVERY CORE RECOVERY	SAMPLE BLOWS "N"	PERCENT CORE RECOVERY	PENETRATION BLOWS 1ST 6"	2ND 6"	3RD 6"	ELEVATION	DEPTH	GRAPHIC LOG	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
								622				0'-2.5' SAND BACKFILL	5" AUGER TO 5'; TOOK BULK SAMPLE FOR COMPACTIC TEST FROM 2.5'-5' AND COMBINED IT WITH BULK SAMPLE FRO HOLE LNB
								619.5	2.5			2.5'-5' COMPACTED CLAY	HOLE BACKFILL WITH SOIL AFTER COMPLE.
BULK	2.5'	2.5'	—	—	—	—	—	617	5		1	TOTAL DEPTH = 5' EL. BOTTOM = 617	REFER TO BORING LOG "LN" FOR MOR INFO. CONCERN. SOIL PROFILE

SS = SPLIT SPOON; ST = SHELBY TUBE; D = DENNISON; P = PITCHER; O = OTHER

SITE: ADMINISTRATION BLDG.

HOLE NO.: LNA

BORING LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
MIDLAND NUCLEAR PLANT	7220	1 of 1	LNB

SITE	COORDINATES	ANGLE FROM HORIZ.	BEARING
ADMINISTRATION BLDG.	2' WEST OF LNA	90°	—

BEGUN	COMPLETED	DRILLER	DRILL MAKE AND MODEL	HOLE SIZE	OVERBURDEN (FT.)	ROCK (FT.)	TOTAL DEPTH
9/28/77	9/29/77	SINGLETON (ABELDRIL)	CME-550	5"	—	—	5'

CORE RECOVERY (FT./%)	CORE BOXES	SAMPLES	EL. TOP OF CASING	GROUND EL.	DEPTH/EL. GROUND WATER	DEPTH/EL. TOP OF ROCK
—	—	1	—	622	(SEE HOLE "LN")	—

SAMPLE HAMMER WEIGHT/FALL	CASING LEFT IN HOLE: DIA./LENGTH	LOGGED BY:
N/A	NONE	JERRY B. GIVENS

SAMPLER TYPE AND DIAMETER	SAMPLER ADVANCE LENGTH CORE RUN	SAMPLE RECOVERY CORE RECOVERY	SAMPLE BLOWS "N" / PERCENT CORE RECOVERY	PENETRATION BLOWS 1ST 6"	2ND 6"	3RD 6"	ELEVATION	DEPTH	GRAPHIC LOG	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
							622					
											0'-2.5' SAND BACKFILL	5" AUGER TO 5'; TOOK BULK SAMPLE FOR COMPACTION TEST FROM 2.5'-5' AND COMBINED IT WITH BULK SAMPLE FROM HOLE LNA
BULK	2.5'	2.5'	—	—	—	—	619.5	2.5		1	2.5'-5' COMPACTED CLAY	HOLE BACKFILL WITH SOIL AFTER COMPLET.
							617	5			TOTAL DEPTH = 5' EL. BOTTOM = 617	REFER TO BORING LOG "LN" FOR MORE INFO. CONCERNING SOIL PROFILE

SS = SPLIT SPOON; ST = SHELBY TUBE; D = DENNISON; P = PITCHER; O = OTHER

SITE	HOLE NO.
ADMINISTRATION BLDG.	LNB

BORING LOG

MIDLAND NUCLEAR PLANT | 7220 | 1 of 1 | H_T

SITE	COORDINATES	ANGLE FROM HORIZ.	BEARING
ADMINISTRATION BLDG.	AT ℄ OF FOOTING 0.4-H_T	90°	—

BEGUN	COMPLETED	DRILLER	DRILL MAKE AND MODEL	HOLE SIZE	OVERBURDEN (FT.)	ROCK (FT.)	TOTAL DEPTH
9/28	9/28	SINGLETON (ABEL DRILL)	CME 550	5"	—	—	50'

CORE RECOVERY (FT./%)	CORE BOXES	SAMPLES	EL. TOP OF CASING	GROUND EL.	DEPTH/EL. GROUND WATER	DEPTH/EL. TOP OF ROCK
—	—	10	—	631	(SEE NOTES COL.)	—

SAMPLE HAMMER WEIGHT/FALL	CASING LEFT IN HOLE: DIA./LENGTH	LOGGED BY:
140#/18"	NONE	JERRY B. GIVENS

SAMPLER TYPE AND DIAMETER	SAMPLER ADVANCE LENGTH CORE RUN	SAMPLE RECOVERY CORE RECOVERY	SAMPLE BLOWS "N" PERCENT CORE RECOVERY	PENETRATION BLOWS 1ST 6"	2ND 6"	3RD 6"	ELEVATION	DEPTH	GRAPHIC LOG	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
							631				0'-11.5' SILTY SAND, TAN (BACKFILL) (SP/SM)	5" AUGER TO 8.5' SET CASING DRILLED W/ 4" TRI-CONE ROLLER BIT USING RE-CIRCULATING H_2O
2"SS	1.5'	0.7'	8	2	3	5	619.5	11.5/13	FILL	1	11.5'-16' SANDY CLAY, GREYISH BROWN, GRAVEL TO 1/2", SOFT TO MEDIUM STIFF, MEDIUM PLASTICITY, MOIST (CL)	#1 Qp = 1.5 TSF
2"SS	1.5'	0.9'	5	1	2	3		13.5/15		2		#2 Qp = 0.8 TSF
2"SS	1.5'	0.9'	25	7	12	13	615	16/17.5		3	16'-28.5' SILTY CLAY, BROWNISH GREY, LITTLE GRAVEL, VERY STIFF TO HARD, MEDIUM PLASTICITY, MOIST (CL)	#3 Qp = 4.5+ TSF
2"SS	1.5'	1.0'	20	8	9	11		[illegible]/20		4		#4 Qp = 4.5+ TSF
2"SS	1.5'	0.5'	18	16	12	6		[illegible]		5	23.2 INCREASE IN SAND CONTENT	#5 Qp = 3 TSF
2"SS	1.5'	0.9'	22	8	10	12	602.5	28.5/30		6	28.5'-47' SANDY CLAY, TANNISH BROWN, VERY STIFF, MEDIUM PLASTICITY, MOIST (CL) PIECES OF COAL STREAKING THROUGH SAMPLE 6; 29.9'-33.5 SEAM OF GREY SILTY FINE TO MEDIUM SAND	#6 Qp = 3.25 TSF (CLAY)
2"SS	1.5'	1.0'	30	10	15	15		33.5/35		7	33.5-38.5 GREYISH BROWN, SEAMS OF SAND	#7 Qp (NONE, TOO SANDY)
2"SS	1.5'	1.0'	10	2	5	5		38.5/40		8	38.5-47 STIFF	#8 Qp = 1.75 TSF (BREAKING UP, SANDY)
2"SS	1.5'	0.2'	15	5	6	9		43.5/45		9		#9 NO Qp (TOO LITTLE REC.)
2"SS	1.5'	1.5	111	18	40	71	584 / 581	48.5/50		10	47-50' FINE SILTY SAND, GREY, VERY DENSE, TRACE ORGANICS, CLAYEY SILT LENSES, SLIGHT MOISTURE (SM)	#10 NO Qp (SAND)
											TOTAL DEPTH = 50' EL. BOTTOM = 581'	WATER LEVEL AT 8' WHILE DRILLING, WENT TO 7.1' AFTER DRILLING COMPLETED AND CASING REMOVED. HOLE BACKFILLED W/ SOIL AFTER COMPLETION

SS = SPLIT SPOON; ST = SHELBY TUBE; D = DENNISON; P = PITCHER; O = OTHER	SITE	HOLE NO.
	ADMINISTRATION BLDG.	H_T

10078-1

BORING LOG

PROJECT	MIDLAND NUCLEAR PLANT
JOB NO.	7220
SHEET	1 of 1
HOLE NO.	H_{TA}
SITE	ADMINISTRATION BLDG.
COORDINATES	1.0' NORTH OF HOLE "H_T"
ANGLE FROM HORIZ.	90°
BEARING	—
BEGUN	9/28/77
COMPLETED	9/28/77
DRILLER	SINGLETON/ABEL DRIL.
DRILL MAKE AND MODEL	CME-550
HOLE SIZE	5"
OVERBURDEN (FT.)	—
ROCK (FT.)	—
TOTAL DEPTH	14.5'
CORE RECOVERY (FT./%)	—
CORE BOXES	—
SAMPLES	1
EL. TOP OF CASING	—
GROUND EL.	631
DEPTH/EL. GROUND WATER	(SEE HOLE "H_T")
DEPTH/EL. TOP OF ROCK	—
SAMPLE HAMMER WEIGHT/FALL	N/A
CASING LEFT IN HOLE: DIA./LENGTH	NONE
LOGGED BY:	JERRY B. GIVENS

SAMPLER TYPE AND DIAMETER	SAMPLER ADVANCE / LENGTH CORE RUN	SAMPLE RECOVERY / CORE RECOVERY	SAMPLE BLOWS "N"	PERCENT CORE RECOVERY	PENETRATION BLOWS 1ST 6"	2ND 6"	3RD 6"	ELEVATION	DEPTH	GRAPHIC LOG	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
								631					
										FILL		0'-11.5' SAND BACKFILL	5" AUGER TO 14.5'; TOOK BULK SAMPLE FOR COMPACTI. TEST FROM 11.5'-14.5'
BULK	3'	3'	—	—	—	—	—	619.5	11.5		1	11.5'-14.5' COMPACTED CLAY	HOLE BACKFILL WITH SOIL AFTER COMPL
								616.5	14.5			TOTAL DEPTH = 14.5' EL. BOTTOM = 616.5	REFER TO BORING LOG "H_T" FOR MORE INFO. CONCERNING SOIL PROFILE

SS = SPLIT SPOON; ST = SHELBY TUBE; D = DENNISON; P = PITCHER; O = OTHER

SITE: ADMINISTRATION BLDG.

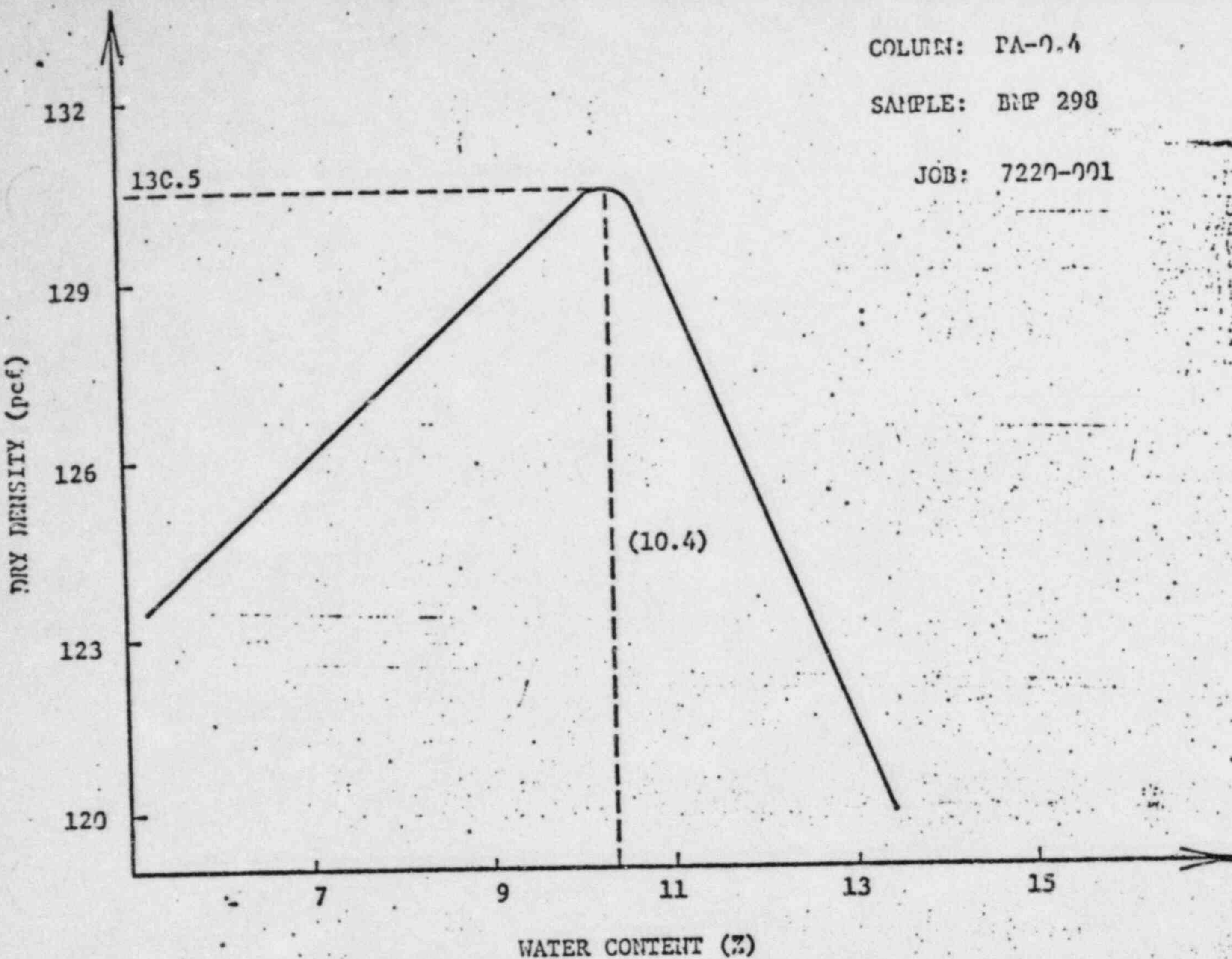
HOLE NO. H_{TA}

1002/01

COLUMN: PA-0.4

SAMPLE: BMP 298

JOB: 7220-001



Std. Compaction Data Used			Field Data		Original Calculated % Compaction	From Above Data % Compaction
Name	$\gamma_{d(max)}$	Wo	$\gamma_{d(f)}$	Wof		
BMP 262	123.9	11.8	117.5	17.5	94.0	90.0
			120.5	18.8	97.0	92.3
BMP 269	127.3	10.0	127.5	13.3	101.6	97.7
BMP 270	124.6	11.1	118.7	16.7	95.7	91.0
BMP 273	117.0	15.2	108.5	19.5	92.7	83.1

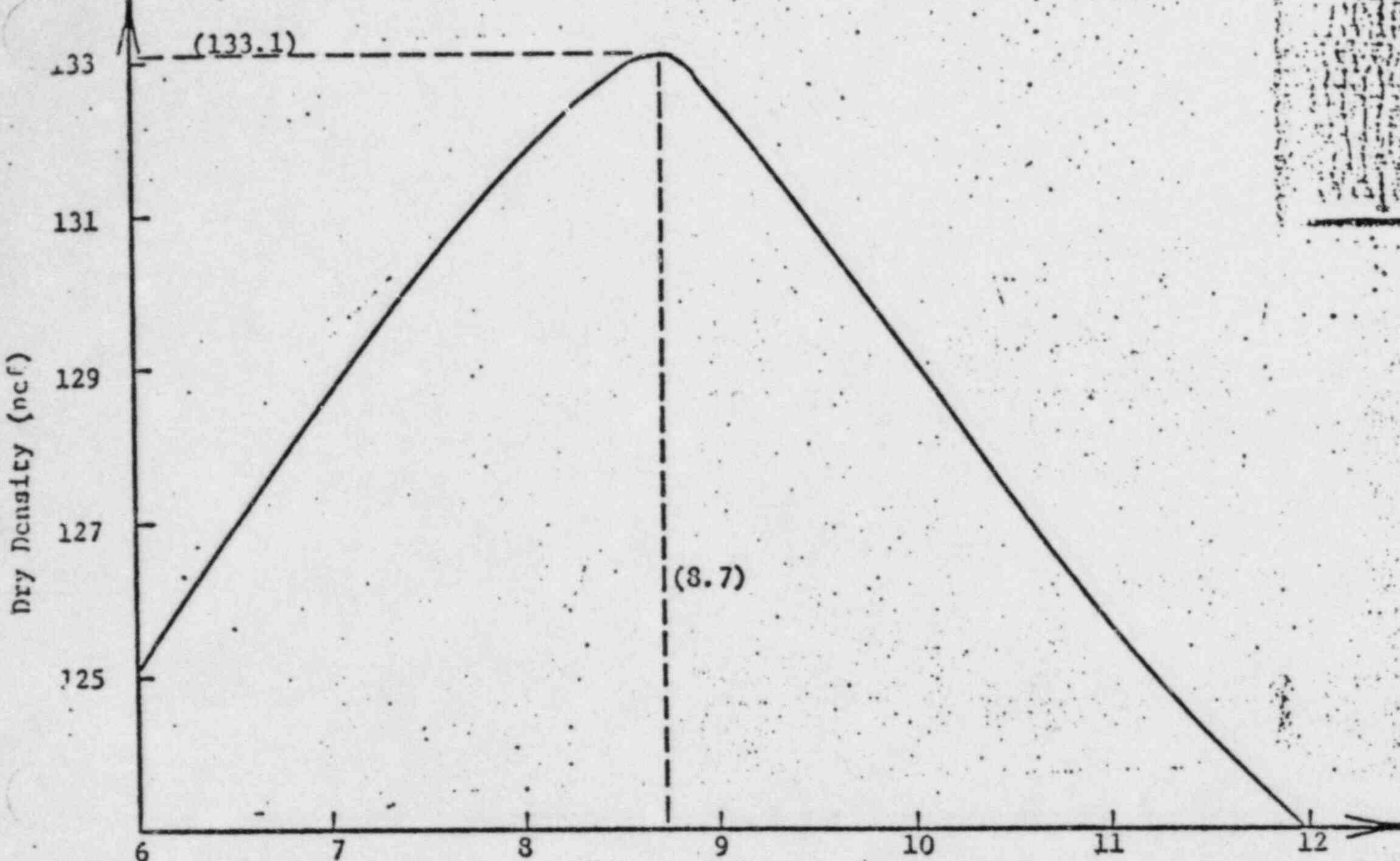
$\gamma_{d(max)}$ = Maximum dry density as determined for a particular compaction test

Wo = Corresponding optimum water content

$\gamma_{d(f)}$ = Field dry density

Wof = Corresponding field moisture content

Fig 8



MOISTURE CONTENT %

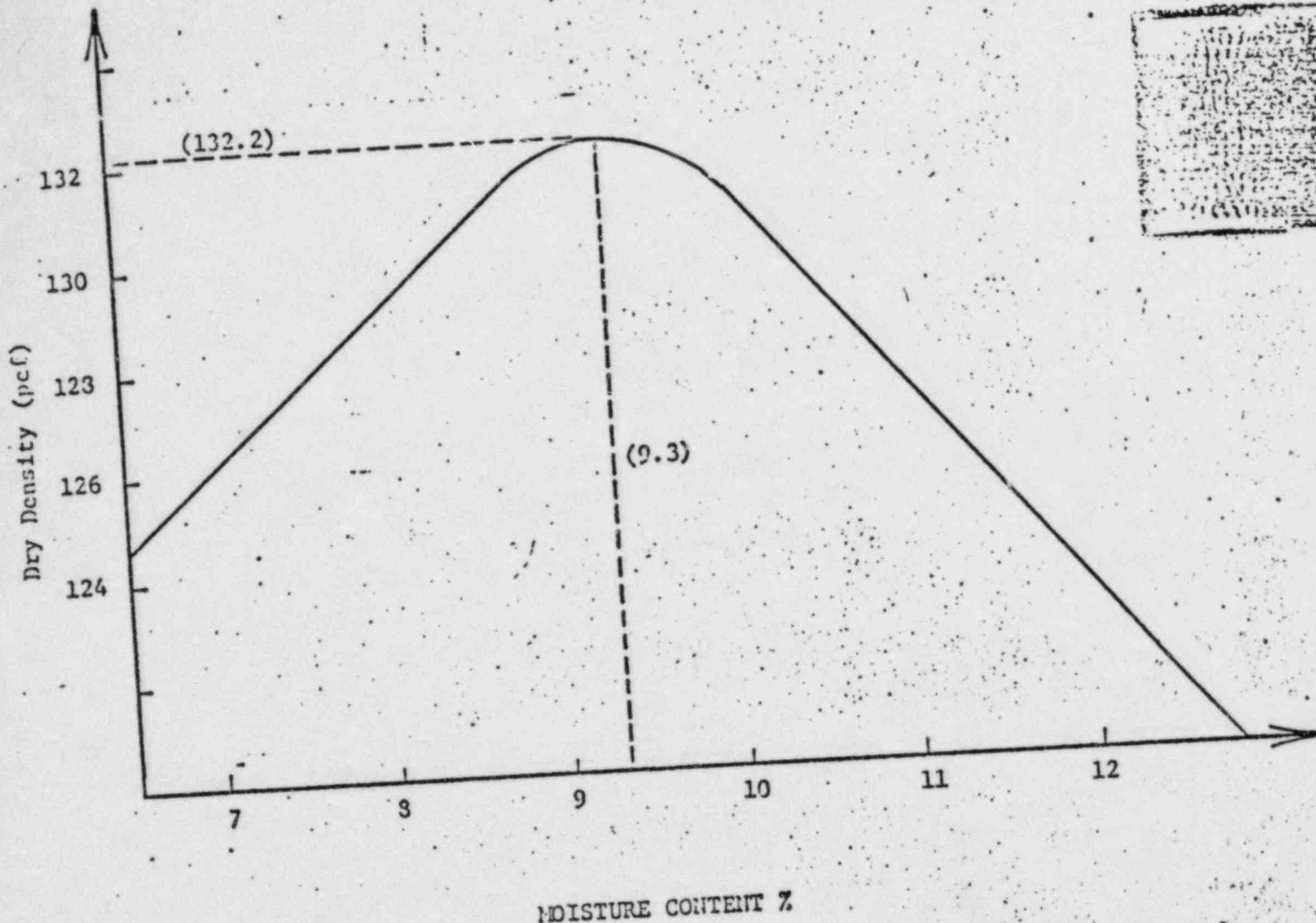
LOCATION: Administration Building

COLUMN: LN-0.4

SAMPLE: BMP-299

JOB: 7220-001

Fig 9



LOCATION: ADMINISTRATION BUILDING

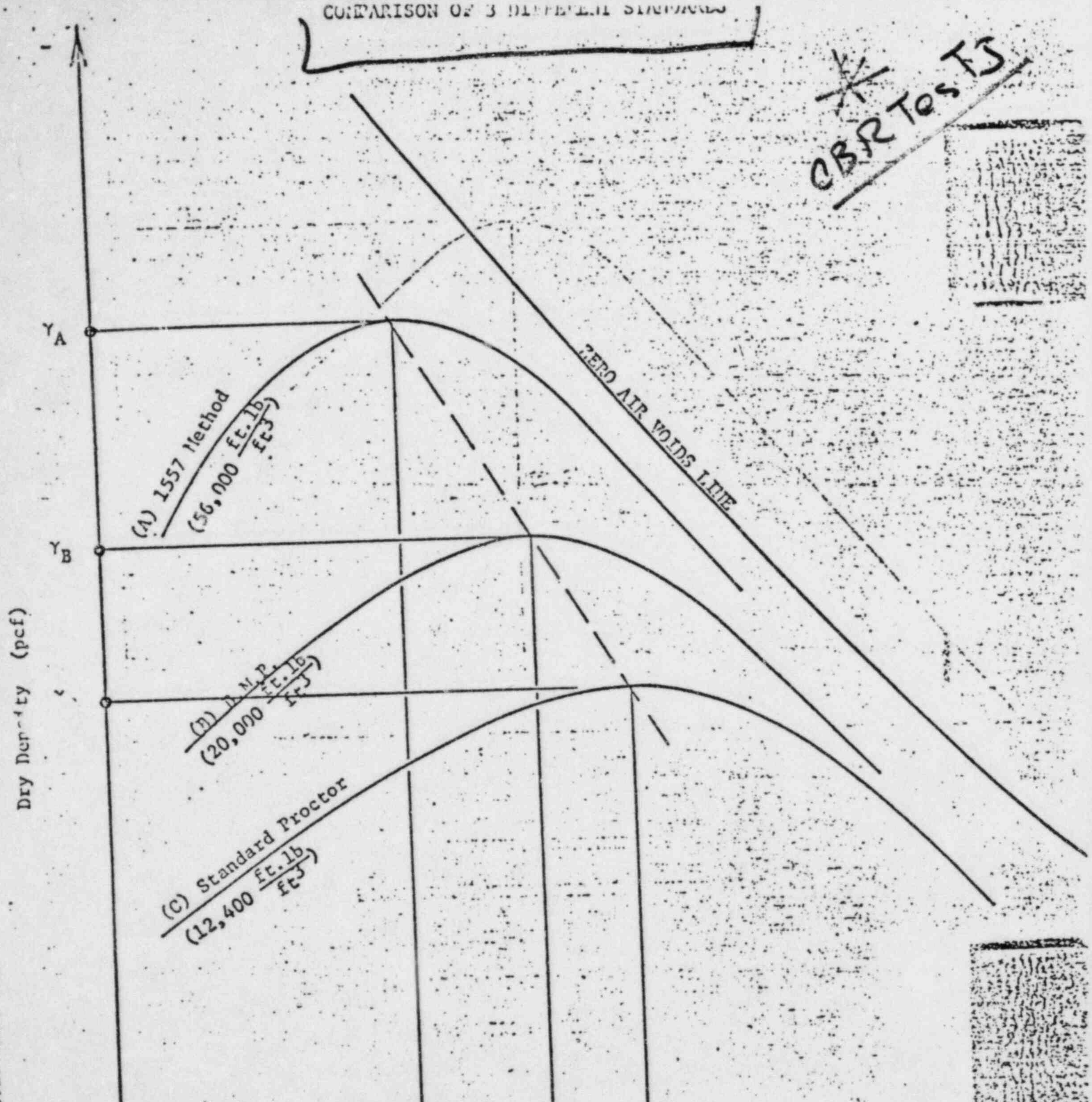
COLUMN: HT-0.4

SAMPLE: BMP-300

JOB: 7220-001

Fig 10

COMPARISON OF 3 DIFFERENT STANDARDS



	Optimum Water Content	Maximum Dry Density	Load at 0.1" Penetration
A	12.7(%)	124.5(pcf)	94.5 (psi)
B	14.0(%)	117.0(pcf)	57.2 (psi)
C	15.0(%)	112.8(pcf)	5 (psi)

Fig. 11

BECHTEL

Jim BETTS — Preliminary given by DeHorn 1 Pg on 1/25/79

BORING LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
MIDLAND NUCLEAR PLANT	7220	1 of 1	E

LOCATION	COORDINATES	ANGLE FROM HORIZ.	BEARING
EVAPORATOR AND AUX. BOILER	AT FOOTING 8-CA	90°	—

BEGUN / COMPLETED	DRILLER	DRILL MAKE AND MODEL	HOLE SIZE	OVERBURDEN (FT.)	ROCK (FT.)	TOTAL DEPTH
5/23/77 5/23/77	SINGLETON (ASEL DRL.)	CME-550	5"	—	—	36.5'

CORE RECOVERY (FT./%)	CORE BOXES	SAMPLES	EL. TOP OF CASING	GROUND EL.	DEPTH/EL. GROUND WATER	DEPTH/EL. TOP OF ROCK
—	—	14	—	633	(SEE NOTES COL.)	—

SAMPLE HAMMER WEIGHT/FALL	CASING LEFT IN HOLE: DIA./LENGTH	LOGGED BY
140#/18"	NONE	JERRY B. GIVENS

Sampler type and diameter	Sampler advance	Sample recovery	Sample blows	Penetration blows 1st 6"	2nd 6"	3rd 6"	Elevation	Sample
							633	
							629.5	
SS	1.5'	1.7	30	15	9	11	628.5	1
SS	1.5'	1.1	23	12	11	12		2
SS	1.5'	1.5	33	10	15	15	623.5	3
SS	1.5'	1.5	30	15	15	15	621	4
SS	1.5'	1.5'	58	16	21	37	617.5	5
SS	1.5'	1.5'	56	13	24	32	615	6
							614	
SS	1.5'	1.0'	32	16	15	17	612.5	7
	[illegible]	1.?'	[illegible]	10	[illegible]	[illegible]		8
	1.5'	1.5'	29	11	14	15	608.5	9
SS	1.5'	[illegible]	43	12	21	22	607	10
SS	1.5'	[illegible]	59	15	24	35	605	11
SS	1.5'	1.5'	58	12	13	45	601.5	12
SS	[illegible]	[illegible]	55+	22	55	—	600	13
SS	[illegible]	[illegible]	51+	22	5?	—	596.5	14

DESCRIPTION AND CLASSIFICATION

0'-3.5' SILTY SAND, TAN (BACKFILL) (SP/SM)

3.5'-4.5' CONCRETE MUDMAT

4.5'-9.5' CLAYEY SAND TO SANDY CLAY, GREY, [illegible] STIFF, SLIGHT TO LOW PLASTICITY, SLIGHT MOISTURE (SC/CL)

9.5'-12' CLAYEY SILT, BROWN, PEBBLES TO 1/2", [illegible] (ML)

12'-15.5' SILTY CLAY, BROWN W/ [illegible] GREY, [illegible], PEBBLES TO 1/2", HARD (CL)

15.5'-18' SAND, GREY, MEDIUM [illegible], MOIST TO [illegible] (SP)

18'-19' [illegible]

19'-20.5' GREY SAND, DENSE (SP)

20.5'-24.5' SILTY CLAY, BROWN W/ [illegible], [illegible] STIFF (CL) [illegible] (A [illegible] GONE)

24.5'-26' SAND [illegible] TO [illegible] STREAKS OF [illegible]

26'-28' SILTY SAND, [illegible], GREY, DENSE, TR. TO LITTLE GRAVEL (SM)

28'-31.5' SILTY CLAY, BROWN, HARD (CL)

29.5' SAND SEAM

31.5'-33' SANDY CLAY, BROWN, [illegible]

33'-36.5' FINE TO MED. SAND, [illegible], VERY DENSE, TRACE CLAY, LOW MOIST. (SP)

TOTAL DEPTH = 36.5'

EL. BOTTOM = 596.5

NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.

5" AUGER TO 3.5', DRILLING W/ 4" TRICONE AND [illegible] CIRCULATION WATER

#1 Qp = 4.5+ TSF

#2 Qp = 4.5+ TSF

#3 Qp = 4.5+ TSF

#4 Qp = 4.5+ TSF

#5 Qp = (NONE-SAND)

#6 Qp = 4.5+ TSF

#7 Qp = 4.5+ TSF

#8 Qp = 4.5 TSF

#9 Qp = 4.5+ TSF

[illegible] WITH "DAMBIT" [illegible] HOLE [illegible] DRILLED TO [illegible] AFTER #8-PE [illegible] CASING TO 21' BECAUSE WATER [illegible] AND [illegible] HOLE

#10 Qp = (SAND)

#11 Qp = 4.5+ TSF

#12 Qp = (SAND)

#13 Qp = (SAND)

#14 Qp = (SAND)

WATER AT 5.4' WHILE DRILLING

WATER LEVEL AT 5.1' AFTER DRILLING

SS = SPLIT SPOON; ST = SHELBY TUBE; D = DENISON; P = PITCHER; O = OTHER

SITE	HOLE NO.
EVAPORATOR AND AUX. BOILER BLDG.	E

170-1

Jim Betts 2 pgs

BORING LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
MIDLAND UNITS 1 AND 2	7220	1 of 1	DG-25

SITE	COORDINATES	ANGLE FROM HORIZ.	BEARING
Diesel Generator Building	S5176, E305	90°	—

BEGUN	COMPLETED	DRILLER	DRILL MAKE AND MODEL	HOLE SIZE	OVERBURDEN (FT.)	ROCK (FT.)	TOTAL DEPTH
10/6/78	10/7/78	Raymond Intn'l	CME-55	4"	—	—	34.5'

CORE RECOVERY (FT./%)	CORE BOXES	SAMPLES	EL. TOP OF CASING	GROUND EL.	DEPTH/EL. GROUND WATER	DEPTH/EL. TOP OF ROCK
—	—	17	—	634.5	NOT RECORDED	—

SAMPLE HAMMER WEIGHT/FALL	CASING LEFT IN HOLE: DIA./LENGTH	LOGGED BY:
140#/30"	—	MARSHALL

SAMPLE TYPE AND DIAMETER	SAMPLER ADVANCE / LENGTH CORE RUN	SAMPLE RECOVERY / CORE RECOVERY	SAMPLE BLOWS	PERCENT CORE RECOVERY	PENETRATION BLOWS 1ST 6"	2ND 6"	3RD 6"	ELEVATION	DEPTH	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
								634.5	0		0-29.5 FEET: MAN-MADE FILL GRAVEL FILL TO 2 FEET	1. DRILLED WITH 4-INCH TRICONE BIT AND REVERT. 2. WATER LOSS AT 18 FEET.
									5			
SS 2"	18"	16"	31		14	14	17		10	1	sandy CLAY, gray, very stiff, low plasticity, moist (CL)(FILL)	
SS 2"	18"	18"	49		16	21	28			2	"	
SS 2"	18"	14"	22		11	13	9			3	"	
									15			
SS 2"	18"	14"	12		8	6	6			4	" STIFF	
SS 2"	18"	8"	3		1	1	2			5	" SOFT	
									20			
SS 2"	18"	16"	36		11	13	23			6	" HARD	
SS 2"	18"	10"	48		11	18	30			7	very silty CLAY, gray, hard, low plasticity, moist, trace sand (CL)(FILL)	
									25			
SS 2"	18"	8"	48		6	18	30			8	sandy CLAY, gray, hard, low plasticity, moist, some gravel (CL)(FILL)	
SS 2"	18"	16"	49		14	20	29			9	" trace organics	
								605.0	29.5			
									30			
SS 2"	18"	18"	76		16	36	40			10	29.5 - 34.5 FEET: clean SAND, brown, dense, nonplastic, wet (SP)	

BECHTEL

Jim Betts:

BORING LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
MIDLAND NUCLEAR PLANT	7220	1 - 1	D

SITE	COORDINATES	ANGLE FROM HORIZ.	BEARING
DIESEL GENERATOR BLDG.	S. 5186 E. 305	90°	—

BEGUN	COMPLETED	DRILLER	DRILL MAKE AND MODEL	HOLE SIZE	OVERBURDEN (FT.)	ROCK (FT.)	TOTAL DEPTH
9/29/77	9/30/77	SINGLETON (ABEL DRIL.)	CHE-550	5"	—	—	31.5'

CORE RECOVERY (FT./%)	CORE BOXES	SAMPLES	EL. TOP OF CASING	GROUND EL.	DEPTH/EL. GROUND WATER	DEPTH/EL. TOP OF ROCK
—	—	12	—	629.4	(SEE NOTES COL.)	—

SAMPLE HAMMER WEIGHT/FALL	CASING LEFT IN HOLE: DIA./LENGTH	LOGGED BY:
140#/18"	NONE	JERRY B. GIVENS

Elevation (top): 629.4

Sampler type and diameter	Sampler advance / length core run	Sample recovery / core recovery	Sample blows per ft.	1st 6"	2nd 6"	3rd 6"	Elevation	Sample
2SS	1.5'	0.9'	21	17	10	11	624.9	1
2SS	1.4'	1.2'	34+	10	10	24/2"	622	2
2SS	1.5'	[illegible]	16	5	5	11	621.4	3
2SS	1.5'	0.5'	31	16	17	14		4
2SS	1.5'	[illegible]	26	10	10	16		5
2SS	1.5'	[illegible]	47	10	22	25		6
2SS	1.5'	1.2	65	15	23	36		7
2SS	1.5'	[illegible]	57	15	25	32		8
2SS	1.5'	[illegible]	58	20	33	25		9
2SS	1.5'	[illegible]	107	30	44	63	603.9	10
2SS	1.5'	[illegible]	113	35	49	64		11
2SS	1.0"	[illegible]	102+	44	102	—	597.9	12

Graphic log: FILL

DESCRIPTION AND CLASSIFICATION

0'-4.5' SILTY TO SANDY CLAY, GREY, SLIGHT TO LOW PLASTICITY (CL)

4.5'-7.4' SAND, TAN, MEDIUM DENSE, SLIGHTLY MOIST (BACKFILL) (SP)

7.4'-8' CONCRETE MUDMAT

8'-25.5' SILTY TO SANDY CLAY, GREY, LITTLE GRAVEL, LOW MOIST., LOW PLASTICITY, VERY STIFF TO HARD (CL)

23'-24.2' SEAM OF CLAYEY SAND W/ TRACE ORGANICS, GREYISH BRN.
24.2' TAN MEDIUM SAND SEAM [illegible]

25.5'-31.5' SILTY SAND, BROWN, MEDIUM GRAINED, WET, VERY DENSE (SM)

TOTAL DEPTH = 31.5'
EL. BOTTOM = 597.9

NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.

5" AUGER TO 20.5', SET CASING, BEGAN DRILLING WITH 4" TRI-CONE ROLLER BIT AND RECIRCULAT WATER

Qp #1 = 4 TSF
Qp #2 = (SAND)
Qp #3 = SAMPLE BREAKS UP AT 3.5 TSF
Qp #4 = 4.5+ TS[F]
Qp #5 = SAMPLE CRUMBLES, LO MOISTURE
Qp #6 = 4.5 TSF
Qp #7 = 4.5 TSF
Qp #8 = 4.5+ TSF
Qp #9 (TIP) = 4.5
Qp #10 (SAND)
Qp #11 (SAND)

HOLE CAVING [illegible] @ 23' SO USE 3/4 BAG QUIC GEL

WATER LEVEL AT 10.4 AFTER DRILLING

HOLE BACKFILL WITH SOIL AFTER COMPLETION

Left margin: 9/29/77 — 9/30/77

Admin Bldg

Bechtel Power Corporation

Post Office Box 2167
Midland, Michigan 48640

February 1, 1978

U. S. Testing Company, Inc.
1415 Park Avenue
Hoboken, New Jersey 07030

Attention: Mr. D. Edley

Job 7220 Midland Project
Subcontract 7220-C-208
Failure of Fill Supporting the Administration Building Grade Beam at Column Line 0.4
C-208-B-286

Reference: Telex Number C-208-B-283 Dated December 30, 1977 From J. F. Newgen

Dear Mr. Edley:

Pursuant to the referenced Telex, we have conducted an evaluation of the subject failure condition. Our engineering analysis has determined that the failure was caused by insufficient compaction of the fill which was placed in May and June of 1977. A careful review of the test data provided by U. S. Testing Company indicates that this fill was erroneously reported to be in conformance with Bechtel specification requirements by U. S. Testing Company. This conclusion is supported by the following facts.

1. A summary of fifteen (15) compacted fill density tests taken by U. S. Testing to evaluate the subject fill as it was compacted is provided in Table 1. The location of each test is plotted in Figure #1. Although several initial tests indicate test failure due to insufficient compaction, each failure is properly cleared by a passing test at or near the location of the failure.

2. Maximum laboratory dry density values (from Bechtel Modified Proctor Tests) used as the standards for evaluating acceptability of fill compaction were selected by U. S. Testing Lab Technicians. In a Jobsite meeting with T[illegible] and B. Cheek of Bechtel, J. Speltz of U. S. Testing stated that the testing technician uses a visual comparison between soil characteristics (primarily color) of the in-place sample and bottled samples of material with known maximum laboratory dry density, to select the appropriate standard. Visual examination by Bechtel soils engineers of the subject fill during the subsequent grade beam removal indicated the material was uniform in appearance with minimal variation in soil characteristics (color and plasticity) over the full extent of the fill placement.

Bechtel Power Corporation

3. The value of maximum laboratory dry density selected for comparison of the in-place dry densities in the subject fill varies between 132.9 lb./ft.3 and 116.0 lb./ft.3. This variation includes most of the full range of maximum laboratory density standards which represent significantly differing soil characteristics of the clay soils in use on this project. A graph of the maximum laboratory dry density plotted with the corresponding in-place dry density for each test is given in Figure #2. Note that for three compacted fill density tests (1469, 1494 and 1498) taken within a few feet of each other and at the same elevation, two significantly different maximum laboratory densities were used as the compaction standard by the same U. S. Testing technician.

4. Testing during removal of the subject fill was conducted by U. S. Testing in accordance with Bechtel direction and Specification 7220-C-208 requirements. A summary of test data and results is given in Table #2. The results of compacted fill density tests taken during subject fill removal confirm dry density values taken during initial fill. Bechtel modified proctor tests taken during fill removal in three locations (one at the north and south edges of the fill and one approximately in the center) confirm that the maximum laboratory dry density was uniform as the appearance of the material indicated. In addition, the subsequent testing indicates the value of maximum laboratory dry density was between 130.5 lb./ft.3 and 133.1 lb./ft.3. From these test results it is apparent that the lower maximum laboratory dry density standards selected during the original fill testing were not appropriate. As shown in Table #2, this error resulted in actual compaction in the range of [illegible] to [illegible] of optimum for three areas of the subject fill, a substantial deviation from the 95% of optimum compaction required by Specification 7220-C-208.

In conclusion, the U. S. Testing Company failure to report deviations from specified compaction requirements which was the result of repeated erroneous selection of compaction standards by U. S. Testing Company employees represents a violation of the Specification 7220-C-208, Section II, requirements, and U. S. Testing Company is therefore liable for costs associated with the subsequent failure of the fill. Such costs include but are not limited to the cost of removal and investigation of the original [illegible] and its supporting fill in addition to all replacement costs which amounts to a total of $134,6[illegible].00. An outline itemizing these costs is provided as Attachment #2 of this letter.

We trust U. S. Testing Company, Inc. will fulfill its contractual obligations with respect to this matter in a timely manner.

Very truly yours,

J. F. Neygen

JFN/CMC/JB/dj
Attachments
cc: P. A. Bechtel
T. C. Cooke
R. [illegible]
P. A. [illegible]nez
J. Speltz

... MIDLAND POWER PLANT 7220 DATE: 9/22/77 ... [illegible] investigations.

STA. CO.	DENSITY			MOISTURE	
	COUNT ONE			COUNT ONE	
	COUNT TWO			COUNT TWO	
	COUNT THREE			COUNT THREE	
	COUNT FOUR			COUNT FOUR	
	TOTAL			TOTAL	
	AVERAGE COUNT	426		AVERAGE COUNT	403

AREA: ℄ ADMIN. BLDG.

IDENTIFICATION	TEST NUMBER					
	DATE OF TEST	9/22/77	9/22/77			
	STATION OR LOCATION	0.4 P_A	0.4 P_A			
	OFFSET FROM CENTERLINE	E. EDGE OF FOOTING	W. EDGE OF FOOTING			
	ELEVATION	613	613.0			
	DEPTH OF TEST	6"	6"	6"	6"	6"
	ZONE NUMBER	1	1			
DENSITY	DENSITY COUNT	460	433			
	COUNT RATIO (DENSITY)	1.080	1.993			
	WET DENSITY #/Ft³	138.5	144.5			
	TOTAL DENSITY DRY #/Ft³	118.7	127.5			
MOIST.	MOISTURE COUNT	336	290			
	COUNT RATIO (MOISTURE)	.819	.720			
	MOISTURE FROM MANUAL CHART #/Ft³	19.8	17.0			
	MOISTURE %	16.7	13.3			
	PROCTOR CURVE NUMBER	BMP-270	BMP-219			
	MAXIMUM DENSITY #/Ft³	124.6	127.3			
	OPTIMUM MOISTURE %	11.1	10.0			
	% DENSITY REQUIRED	95%	95%	95%	95%	95%
	MOISTURE TOLERANCE REQUIRED					
	% FIELD DENSITY	95%	101.6			
	P-PASS F-FAILURE	F-M	F-M			
	[illegible]	NO	NO			
	AREA OF TEST	PLANT	PLANT			

REMARKS: INFO ONLY GAUGE NO. 2932

JERRY MORRIS NOTIFIED OF RESULTS 9/22/77 @ 10:00 By R.S.

CHECKED BY: [signature]

[signature]

TESTED BY

APPROVED BY

FORM MET-203 4/18/77

PROJECT: MIDLAND POWER PLANT 7220 DATE: 9/19/77

Quality Control Construction Support

STANDARD COUNT	DENSITY		MOISTURE
COUNT ONE	432	COUNT ONE	430
COUNT TWO	431	COUNT TWO	428
COUNT THREE	434	COUNT THREE	442
COUNT FOUR	429	COUNT FOUR	431
TOTAL	1726	TOTAL	1731
AVERAGE COUNT	432	AVERAGE COUNT	433

AREA:

IDENTIFICATION					
TEST NUMBER					
DATE OF TEST	9/19/77				
STATION OR LOCATION	2' E. of E. SIDE of FILTER E/S, RM, SIDE	N_K 0.4	M_P 0.4	P_A 0.4	
OFFSET FROM CENTERLINE	S. END OF ADMIN BULD, BEAM	ADMIN. BULD.			
ELEVATION	622	622	622	622	
DEPTH OF TEST	6"	6"	6"	6"	6"
ZONE NUMBER	1	1	1	1	
DENSITY					
DENSITY COUNT	529	464	478	447	
COUNT RATIO (DENSITY)	1.225	1.074	1.106	1.035	
WET DENSITY #/Ft³	130.0	139.0	137.0	141.5	
TOTAL DENSITY DRY #/Ft³	108.5	119.2	117.5	121.7	
MOISTURE					
MOISTURE COUNT	381	338	350	353	
COUNT RATIO (MOISTURE)	.880	.781	.808	.815	
MOISTURE FROM MANUAL CHART #/Ft³	21.5	18.8	19.5	19.8	
MOISTURE %	19.5	15.7	16.6	16.2	
DATA					
PROCTOR TEST NUMBER	BMP 218	BMP 276	BMP-[illegible]	BMP-[illegible]	
MAXIMUM DENSITY #/Ft³	117.0	124.6	123.9	123.9	
OPTIMUM MOISTURE %	15.2	11.1	11.8	11.8	
% DENSITY REQUIRED	95%	95%	95%	95%	95%
MOISTURE TOLERANCE REQUIRED	± 2%	± 2%	± 2%	± 2%	
% FIELD DENSITY	92.7	95.7	94.8	98.2	
P-PASS F-FAILURE	F-MD	F-M	F-MD	F-M	
RETEST	NO	NO	NO	NO	
AREA OF TEST	PLANT	PLANT	PLANT	PLANT	

REMARKS: GAUGE NO. 2932

INFO ONLY

SOIL REMOVED

R. Smith

TESTED BY

APPROVED BY

CHECKED BY: [signature]

FORM MCI-204 [illegible]

7-24

(TO [illegible] TO [illegible] %
[illegible] CHARGE.)

TITLE 7220 MIDLAND 1&2

CPCo

ESTIM. BR/DH — APPROVED

PRICED BR/DH — DATE 1-6-78

CHECKED — SHEET 1 OF 1

DESCRIPTION	QUANTITY	UNIT	UNIT COST MAT'L	UNIT COST S/C	MH UNIT	MH TOTAL	$/MH	TOTAL COST MATERIAL	TOTAL COST LABOR	TOTAL COST SUB-CONT.	TOTAL
ADMIN BLDG FOOTING & GRADE BEAM REPAIR											
FORMWORK	3,100	SF	1.93			1,250	12.65	5980	15810		
REBAR - FABRICATION						190	18.50		3520		
INSTALLATION	14	T	340			600	17.60	4760	10560		
EMBED METAL - FABRICATION						10	19.70		200		
- INSTALLATION	380	LB	0.80			30	13.30	300	410		
STRUCTURAL CONCRETE	165	CY	36.00			450	11.55	5940	5200		
BACKFILL CONCRETE	585	CY	33.00			210	12.30	19310	2580		
BACKFILL SAND	610	CY	2.10			510	11.30	1280	5760		
S/T DIRECT						3,250		37570	44040		81610
[illegible]											
DISTRIBUTABLES [illegible]											
MANUAL LABOR @ 30% DIRECT LABOR						980	14.50		4210		
NON MANUAL " @ 35% " [illegible]						1,140	11.50		13110		
MATERIAL @ 20% DIR. LABOR & [illegible]								8810			
S/TOTAL DISTR.								8810	27320		36130
S/T 1											130770
S/C SOIL TEST BORINGS											
[illegible]ICE DATED 30 SEP 77 RAYMOND INTL										2460	
[illegible]STS ON FILL CONC	1	LOT				8	20.00			160	
[illegible]MPACTION TESTS ON ABOVE SAND FILL	25			50.00						1250	
TOTAL										3870	3870
ROUND OFF											<10>
TOTAL											134,600

Sun ry of Compacted Fill Density Te.c Data

for

Administration Building Original Fill

(Tests Grouped by General Area and Date of Test)

TEST NO.	DATE TAKEN	TESTED BY	LOCATION	ELEV.	IN-PLACE DRY DENS.	MAX. LAB. DRY DENS.	% COMP.	REMARKS
911	5-23-77	SM	2' N. of N. Steam Tunnel Wall - 25' W. of Turb. #1	614.5	133.1	132.9	100.2	Pass
914	5-24-77	SM	2' N. of Steam Tunnel Wall - 50' W. of Turb. #1	614.6	125.7	123.9	101.5	Fail - Moisture (Too Dry - 9%)
1403	6- 3-77	RS	4' N. of N. Wall Steam Tunnel - 15' W. of 1.0	621.5	111.0	116.0	95.7	Pass
1404	6- 3-77	RS	5' N. of N. Wall Steam Tunnel - 24' W. of 1.0	623.0	115.7	121.0	95.6	Fail - Moisture (Too Dry - 10.2%)
1362	5-27-77	SM	10' N. of Steam Tunnel - 4' E. of E. Side	615.5	114.2	117.0	97.6	Pass
1422	6- 8-77	BS BT	8' E. of E. Steam Tunnel - 24' N. of N. Steam Tunnel	622.0	117.7	123.9	95.0	Pass
[illegible]	6-13-77	BG	3' S. Hg line - 4' E. of E. Steam Tunnel Wall	617.0	115.2	127.3	90.5	Fail - Comp.
[illegible]	6-15-77	RS	3' S. of Hg line 4' E. of E. Steam Tunnel Wall	617.0	118.2	117.0	101.0	Pass - [illegible] Clears 146[illegible], [illegible]
495	6-13-77	RS	3' S. of Hg line 3' E. of E. Steam Wall	617.0	112.2	127.3	88.2	Fail - Comp.
91	6-15-77	BT	8' E. of E. Steam Tunnel Wall - 46' N. of N. Steam Tunnel Wall	616.0	113.0	127.3	88.3	Fail - Comp.
517	6-16-77	BT	5' E. of E. Steam Tunnel Wall - 60' N. of N. Wall	620.0	119.7	123.9	96.6	Pass
519	6-16-77	BT	8' E. of E. Steam Tunnel Wall - 48' N. of N. Wall	618.0	124.0	127.3	97.4	Pass - Retest Clears 1491
492	6-15-77	BT	38' W. of 1.0 - 5' N. of N. Steam Tunnel Wall	626.0	116.2	127.3	91.3	Fail - Comp.
518	6-15-77	BT	38' W. of 1.0 - 5' N. of N. Wall	626.0	122.7	127.3	96.4	Fail - Moisture
	6-16-77	BT	33' W. of 1.0 - 5' N. of N. Wall	626.0	122.7	127.3	96.4	Pass - Retest Clears 1492, 1518

[illegible] 2

Summary of Test Data and Results

for

Fill Below Original Beam at 0.4 Line

Administration Building (All Tests by U. S. Testing)

DESCRIPTION OF TEST	ELEVATION OF TEST	TEST RESULTS AT COLUMN H_T	TEST RESULTS AT COLUMN L_N	TEST RESULTS AT COLUMN P_A	NOTE CODE
1. Initial Compacted Fill Density Test	617' ±	In-Place Dry Density = 118 lb./ft.^{3} Test No. .494	In-Place Dry Density = 119.7 lb./ft.^{3} Test No. 1517	In-Place Dry Density = 114.2 lb./ft.^{3} Test No. 1362	A
2. Proctor Selected by U.S.T. Technician for Item No. 1 Tests	617' ±	BMP - 278 Max. Lab. Dry Density = 117 lb./ft.^{3}	BMP - 262 Max. Lab. Dry Density = 123.9 lb./ft.3	BMP - 278 Max. Lab. Dry Density = 117 lb./ft.^{3}	
3. In-Place Proctor After Beam Removal	617' ±	BMP - 300 Max. Lab. Dry Density = 132.2 lb./ft.^{3}	BMP - 299 Max. Lab. Dry Density = 133.1 lb./ft.^{3}	BMP - 298 Max. Lab. Dry Density = 130.5 lb./ft.^{3}	
Reported % Compaction	617' ±	101%	96%	97.6%	B
5. % Compaction Using In-Place Proctor	617' ±	89.3%	89.9%	87.5%	C
6. Compacted Fill Density Tested After Beam Removal	617' ±	*Dry Density = 119.7 lb./ft.^{3}	Mp & 0.4 Dry Density = 117.5 lb./ft.^{3}	Dry Density = 108.5 lb./ft.^{3}	D
7. % Compaction Using In-Place Proctor & Dry Density Taken After Beam Removal	617' ±	90.5%	88.3%	83.1%	

*Average of three Tests at This Location

Note Code:

A. Test Results do not include failing tests which were cleared by retest

B. Reported % Compaction during initial fill compaction

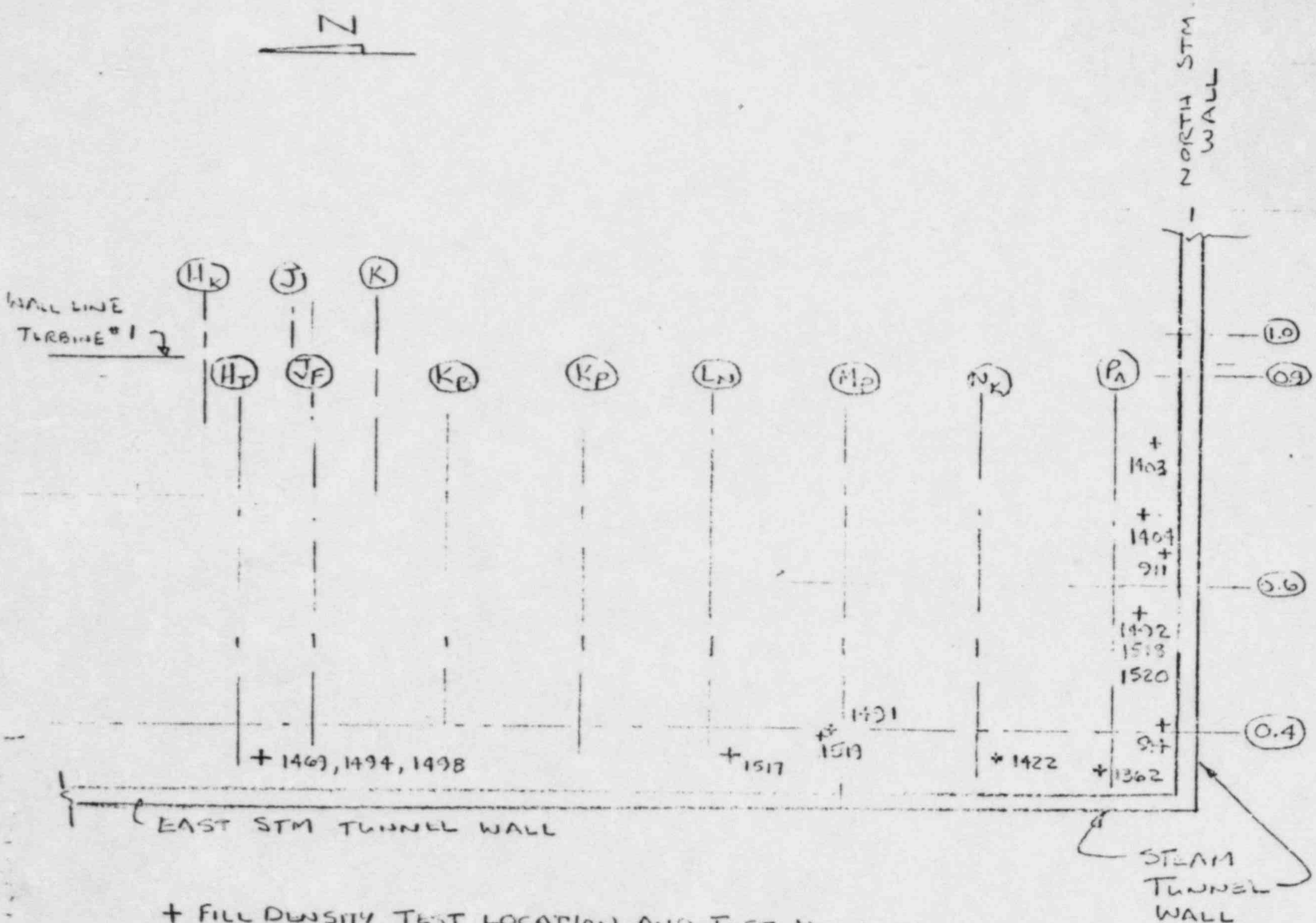
C. Actual % Compaction calculated using Item No. 1 tests divided by Item No. 3 proctor information

D. Tests taken after footing removal were not numbered by U.S.T., and were submitted for information only to Bechtel. Copies of reports are included as Attachment No. 1

DESIGN BY [illegible] DATE [illegible] CHECKED BY ____ DATE ____ SHEET NO. ____

PROJECT MIDLAND · 7220 JOB NO. 7220

SUBJECT [illegible] BLDG CALCULATION NO. ____ FILE NO. ____



+ FILL DENSITY TEST LOCATION AND TEST NUMBER

PLAN
1" = 20'

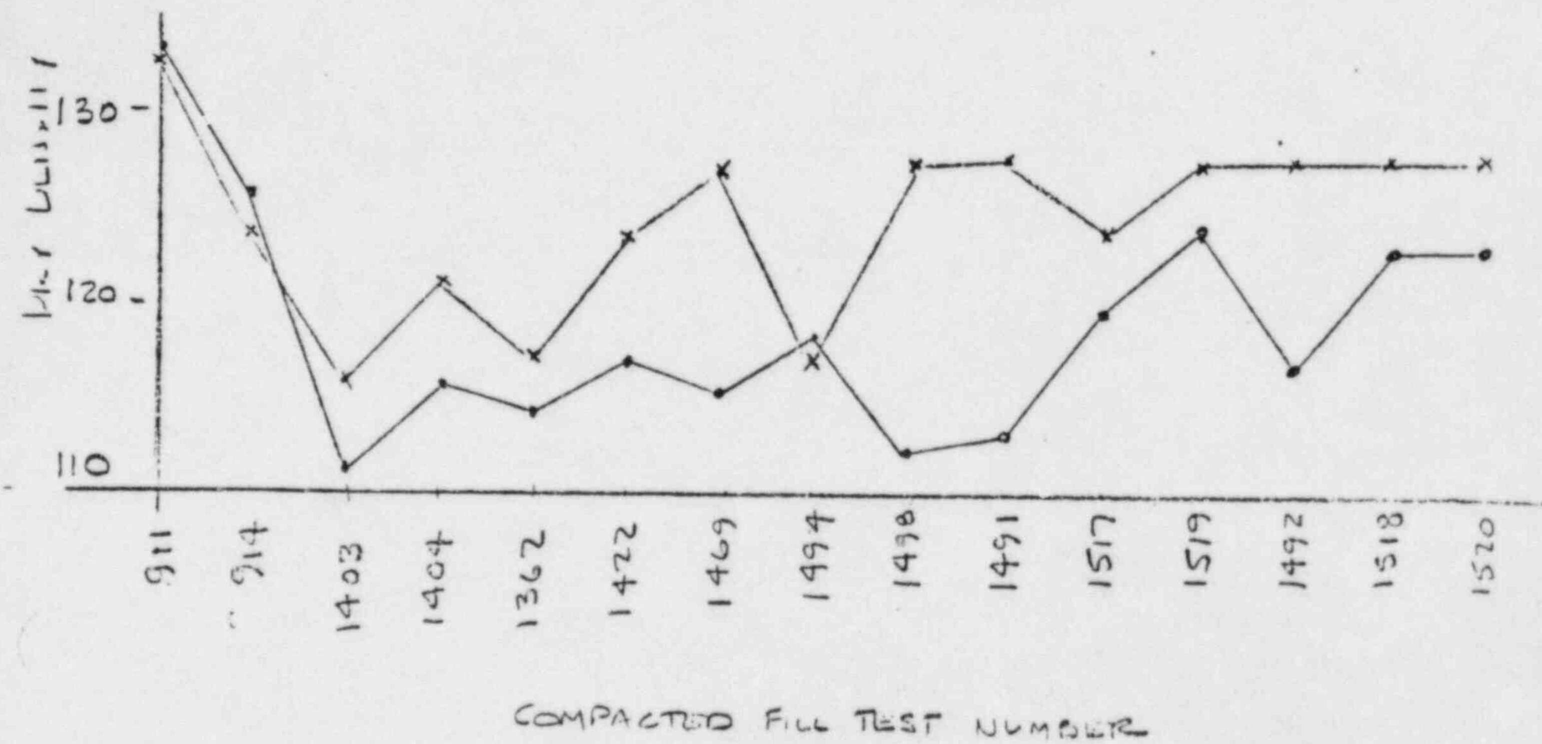
FILL TEST LOCATIONS @ ADMIN BLDG. FOR TESTS DURING ORIGINAL FILL.

DATE ______

DESIGN BY E.C. [illegible] DATE 1/13/72 CHECKED BY ______ SHEET NO. ______

PROJECT ______ JOB NO. ______

SUBJECT ADMINISTRATION BLDG CALCULATION NO. ______ FILE NO. ______



x———x MAX. LAB. (PROCTOR) DRY DENSITY SELECTED BY THE UC TESTING TECHNICIAN DURING ORIGINAL TESTING OF COMPACTED FILL

o———o IN PLACE DRY DENSITY TAKEN DURING COMPACTION OF ORIGINAL FILL

United States Testing Company, Inc.

Power Generation Services Division
1415 PARK AVENUE
HOBOKEN, NEW JERSEY 07030 (201) 792-2400 (212) 943-0498

C-2.8

March 13, 1978

BECHTEL POWER CORPORATION
Post Office Box 2167
Midland, Michigan 48640

ATTN: Mr. J. F. Newgen

4549 C...

Job 7220 Midland Project
Subcontract 7220-C-208
C-208-B-256
USTCO C-208-141

Gentlemen:

File covering the captioned Project, including your letter of February 1, 1978 addressed to Mr. David Edley of this Company and your telex dated December 30, 1977, have been referred to this office. From our extensive review of the files and investigation it is clear that the work in question was under the direction and control of Bechtel Power Corporation (Bechtel) rather than United States Testing Company, Inc. It is also clear that the identification of test locations, selection of sites, and elevations for the work in question were made by Bechtel and not by the United States Testing Company.

It is also apparent from the contractual documents that acceptance or rejection of the tasks performed thereunder was neither to be made by the United States Testing Company nor was it the responsibility of this Company to do so.

Based on the facts disclosed in our review and investigation we must deny that United States Testing Company is liable for the costs of $134,600 referred to in your letter of February 1, 1978.

Very truly yours,

UNITED STATES TESTING COMPANY, INC.

BY: [signature]
Jack E. Joel
Counsel

JBJ/ran

cc: D. Edley

PAGE 2

46 0363

6" SPACING

6"	6"	6"	6"		6"	6"	6"	6"	6"	6"			6"
		1.5	0.5	0.5	2.5	1.0	2.0	0.5	1.0	2.5	1.0	1.0	2.0
				1.0	2.0	0.5	1.0	1.0	0.5	1.0	0.5	4.5	0.5 -20
		0.5	1.0	1.5	1.5	1.0	1.5	1.5	4.5	4.5	0.5	1.5	1.0 -2?
		1.5	1.0	1.5	1.0	0.5	1.5	0.5	0.5	0.5	1.0	1.0	0 -3?
			SIDES FALLING IN			1.0	3.0	1.5	0.5	2.5	2.5	1.5	0.5 -32"
1.5	1.0	1.0	1.5	4.0	4.5	3.5	4.0	4.5	4.5	4.5	4.5	4.5	4.5 -34"
	4.5	1.0	2.5	1.0	2.5	1.0	1.0	1.0	2.0	1.0	4.5	1.5	3.0 -36"
	1.0	1.5	2.5	2.0	1.5	2.0	3.0	0.5	4.5	0.5	0.5	0.75	1.5 -43"
1.0	0.5	3.75	1.0	1.5	1.5	1.0	4.5	0.5	0.5	1.0	1.0	1.0	4.0 -44"
		1.0	1.0	0.5	1.5	1.0	4.5	0.5	0.5	1.0	1.0	1.5	1.5 -48"
	1.0	1.0	4.5	2.5	0.75	1.0	0.5	2.5	2.5	1.0	1.0	0.5	0.5 -52"
								0.5	2.0	0.5	1.5		-60"
								1.0	0.75	1.0	1.0		-64"
								0.5	0.5	0.5	0.5		-68"
								3.5	4.5	4.0	4.0		-72"
								1.5	1.0	0.5	0.5		-76"
								2.5	3.0	0.5	0.5		-80"
								1.5	1.0	1.0	1.0		-84"

TEST PIT # 1 SOUTH WALL

PAGE 1

1" SPACING

DISTANCE DOWN FROM CONCRETE

35 2.0 2.5 1.0 0.5 1.0 4.0 4.0 2.5 3.5 [illegible] 4.5 4.5 4.5 4.5 3.5 4.5 4.5 4.5 4.5 3.0 4.5 2.5 2.5 3.0 4.5 4.0 4.5 0.3 0 1.5 2.0 1.0 0.5 1.0 1.5 0 1.5 0.5 0.5 0.6 0.5 [illegible] -1"

4.5 4.5 4.5 3.0 4.5 4.5 4.5 4.0 4.5 2.5 0.7 2.0 2.6 3.2 2.5 3.0 3.0 0.5 0 4.5 1.8 1.0 0.3 1.0 0.6 0 1.0 1.5 0.5 1.0 [illegible] 0 -2"

4.5 1.5 0 1.5 1.5 1.0 2.5 2.7 2.7 1.0 1.5 1.5 1.5 1.5 1.0 6" COBBLE 1.5 1.5 1.0 1.5 1.7 2.5 1.5 2.0 1.5 1.5 1.5 1.2 3.0 1.5 2.5 2.5 2.0 [illegible] 1.4 1.5 [illegible] 4.5 -3"

4.5 1.5 0 1.5 1.5 1.0 0.5 2.7 2.7 1.0 1.5 1.5 1.5 1.5 1.0 6" COBBLE 0.5 1.2 1.5 2.5 1.0 0.5 0 1.0 0.6 0 1.0 1.5 0 1.2 1.5 0.5 0 1.5 2.5 [illegible] 1.0 4"

4.5 2.0 2.5 4.5 4.0 3.0 1.5 2.5 3.0 2.5 2.6 [illegible] 3.0 2.5 1.75 3.5 1.5 1.5 6" COBBLE 1.5 1.5 1.5 2.0 1.2 1.5 2.0 1.5 1.0 2.5 2.5 2.5 4.5 2.5 2.0 4.5 1.5 1.0 4.0 3.5 [illegible] 1.0 1.0 -5"

3.5 4.5 4.5 3.5 4.5 4.0 2.5 3.5 3.0 3.5 4.5 3.0 4.5 [illegible] 3.0 4.5 2.5 6" COBBLE 0 3.0 3.5 4.0 4.5 3.0 1.5 4.5 4.5 4.0 4.5 4.5 4.5 3.5 4.5 3.5 1.0 3.5 4.5 4.5 2.0 2.0 6"

3.0 4.0 4.0 4.0 4.5 3.5 3.0 2.0 1.5 1.5 3.0 2.5 2.0 2.5 3.5 4.5 4.5 4.5 4.5 4.5 3.0 2.5 1.5 4.5 [illegible] 4.0 3.0 4.5 3.0 2.5 1.0 4.0 [illegible] 3.0 2.0 1.5 1.5 [illegible] 0.5 1.0 0 [illegible] [illegible] 0.5 0.5 1.5 -7"

2.5 4.5 2.5 2.5 2.5 2.5 1.75 3.0 3.0 2.0 3.0 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.0 3.5 4.5 3.0 4.5 2.0 2.5 1.25 1.75 2.0 3.5 2.0 [illegible] 2.0 4.5 4.0 1.5 0.5 0 0.5 0.75 0.6 -8"

4.5 4.5 1.5 2.0 3.0 2.0 2.0 1.5 2.0 1.0 1.0 2.0 2.5 1.5 1.5 1.5 3.5 2.0 4.5 3.0 4.5 0.5 3.5 0.5 0.5 0.5 1.0 0.5 1.5 1.0 0.5 1.5 1.75 1.5 3.5 4.5 4.5 2.5 1.5 1.5 4.5 [illegible] 0 1.5 1.0 -14"

4.0 2.5 3.6 1.5 2.0 1.5 2.5 4.5 1.5 4.5 4.5 2.0 3.5 3.0 3.0 3.5 2.5 1.5 1.0 1.5 1.0 1.5 1.0 2.5 1.5 1.0 1.5 2.0 1.5 1.5 2.5 [illegible] 1.0 [illegible] 1.5 -15"

2.5 1.0 1.5 1.5 2.5 2.0 3.0 4.0 1.0 1.0 4.5 4.5 4.5 4.5 2.5 2.5 4.0 3.0 2.0 1.5 2.5 3.5 4.5 1.5 2.0 3.5 1.5 2.0 1.5 1.5 1.0 0.5 -20

2.0 1.5 0.5 0.5 1.5 2.0 1.0 3.0 2.5 2.0 1.0 0.5 2.0 2.5 2.0 1.75 4.5 4.5 3.5 2.0 3.0 1.0 1.0 0.5 1.0 1.0 1.75 1.5 0.5 -22"

2.5 0.5 1.0 1.0 1.5 1.0 1.5 1.0 1.0 1.0 1.5 1.5 1.0 1.5 1.0 1.5 1.5 1.0 4.5 4.5 2.5 2.5 2.0 1.0 0.5 1.5 2.0 1.5 1.5 0.5 0.5 0.5 0 0.5 1.0 4.5 -24"

Page 2 is continuation of page 1

Tons/Sq. Ft.

Info received from CPCo about the diesel bldg. settlement.

NOV 20 1978

TABLE OF CONTENTS

1. PLANT AREA BORING PLAN
   a. PLANT AREA BLOWCOUNT VS. ELEVATION GRAPH
2. DIESEL GENERATOR BUILDING
   a. BORING PLAN
   b. CROSS-SECTIONS
   c. BLOWCOUNT VS. ELEVATION GRAPHS
   d. LAB DATA
   e. SETTLEMENT DATA

3. TANK FARM
   a. BORING PLAN
   b. CROSS-SECTIONS
   c. BLOWCOUNT VS. ELEVATION GRAPHS

4. CONDENSATE STORAGE TANKS
   a. BORING PLAN
   b. CROSS-SECTIONS
   c. BLOWCOUNT VS. ELEVATION GRAPHS

5. GUARD HOUSE
   a. CROSS-SECTION
   b. BLOWCOUNT VS. ELEVATION GRAPH

6. TRANSFORMERS
   a. CROSS-SECTION

TABLE OF CONTENTS (CONT.)

7. BORING LOGS

8. DUTCH CONE LOGS

9. OTHER INFORMATION

a. WEATHER DATA

b. PENETROMETER READINGS

LEGEND

FILL (CLAY)

FILL (SAND)

SANDS (SP)

SILTY SANDS (SM)

CLAYS (CL)

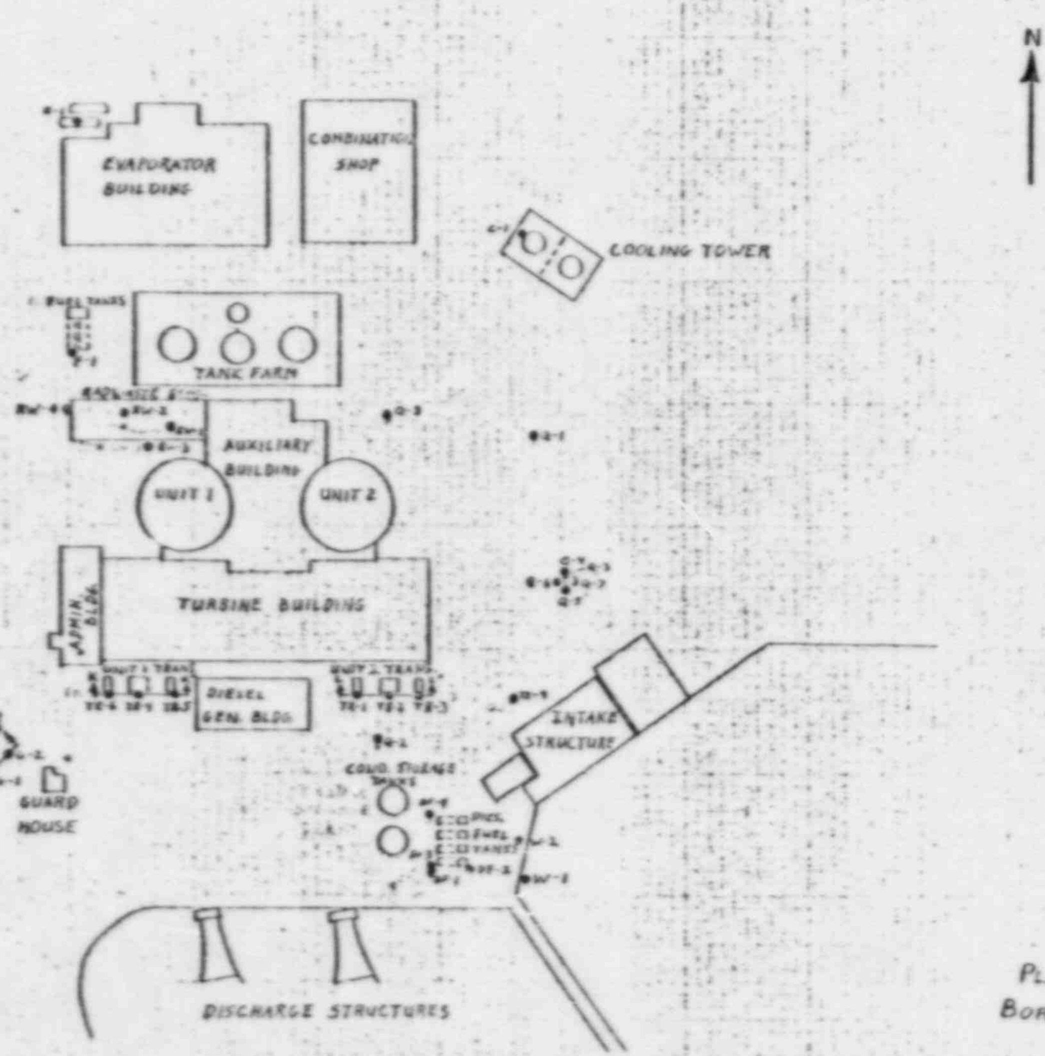
12 INDICATES STANDARD PENETRATION BLOWCOUNT

ST INDICATES SHELBY TUBE TAKEN

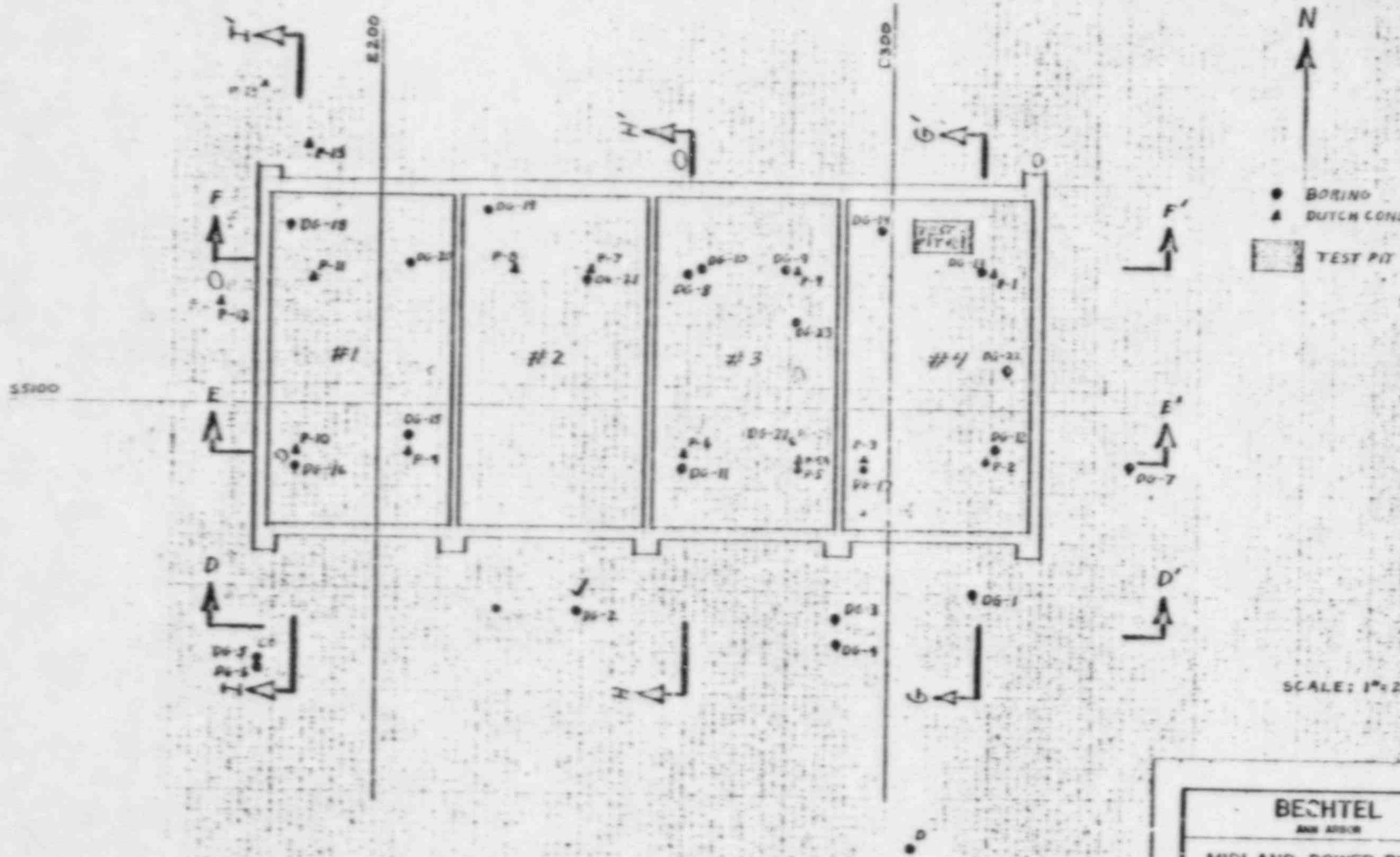
OS INDICATES OSTERBERG TUBE TAKEN

INDICATES DUTCH CONE PROBE WITH SHADED AREA SHOWING MATERIALS WITH LESS THAN 5KSF CONE BEARING.

INDICATES WATER LEVEL ON 9/25/78



PLANT AREA
BORING PLAN



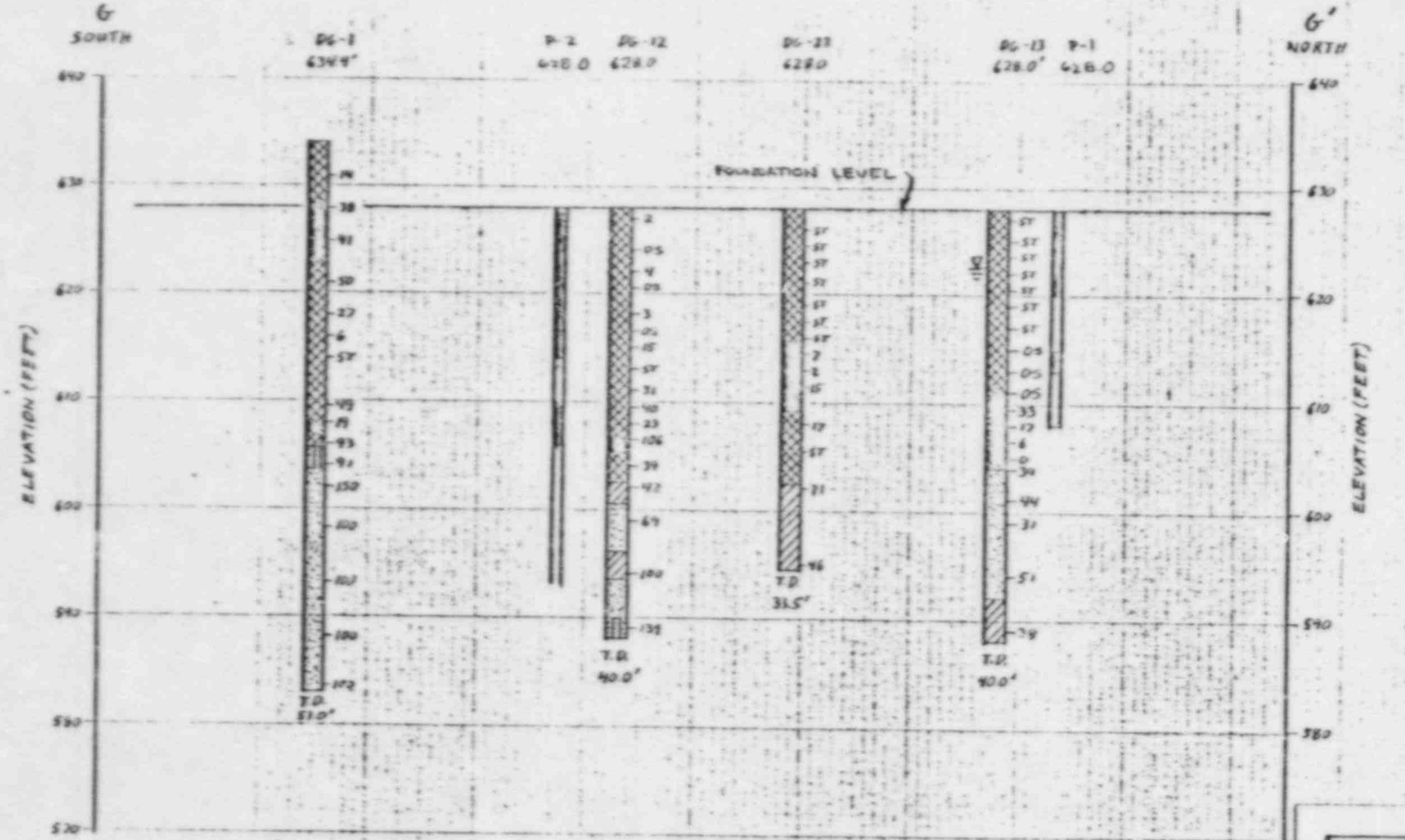
BECHTEL
ANN ARBOR

MIDLAND POWER PLANT

DIESEL GENERATOR BUILDING
BORING PLAN

JOB NO. 7220

FIGURE



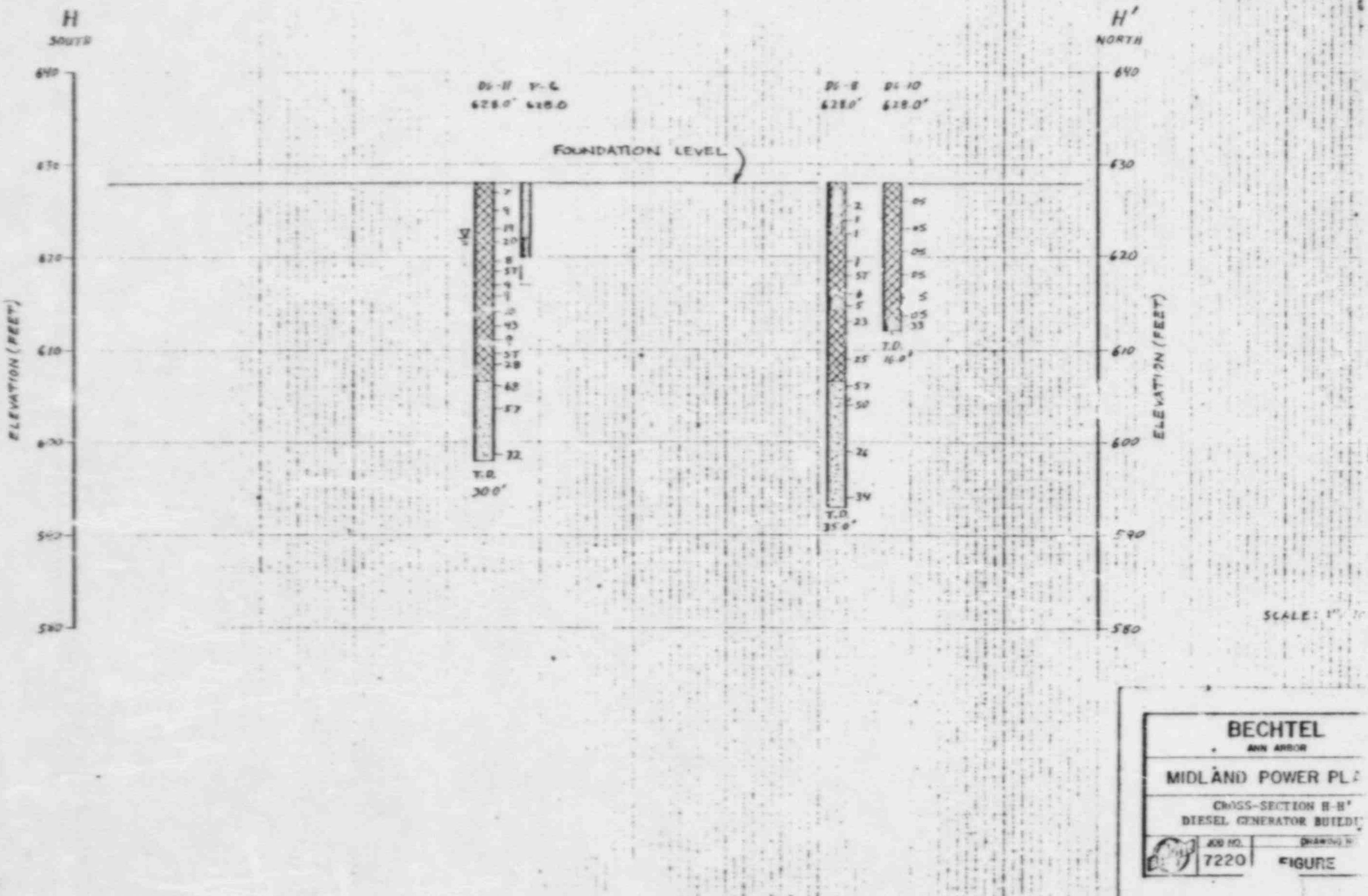
BECHTEL
ANN ARBOR

MIDLAND POWER PLANT

CROSS-SECTION G-G'
DIESEL GENERATOR BUILDING

JOB NO.	DRAWING NO.
7220	FIGURE

(FROM PRELIMINARY REPORT)


H
SOUTH
H'
NORTH
ELEVATION (FEET)
640
630
620
610
600
590
580
DG-11 V-6
628.0' 628.0
DG-8 DG-10
628.0' 628.0'
FOUNDATION LEVEL
T.D. 30.0'
T.D. 35.0'
T.D. 16.0'
SCALE: 1"
BECHTEL
ANN ARBOR
MIDLAND POWER PLA
CROSS-SECTION H-H'
DIESEL GENERATOR BUILDI
JOB NO.
7220
FIGURE

M. nd Nuke

BAG Samples

LABORATORY TESTING DATA SUMMARY

Reviewed by ____
Date ____

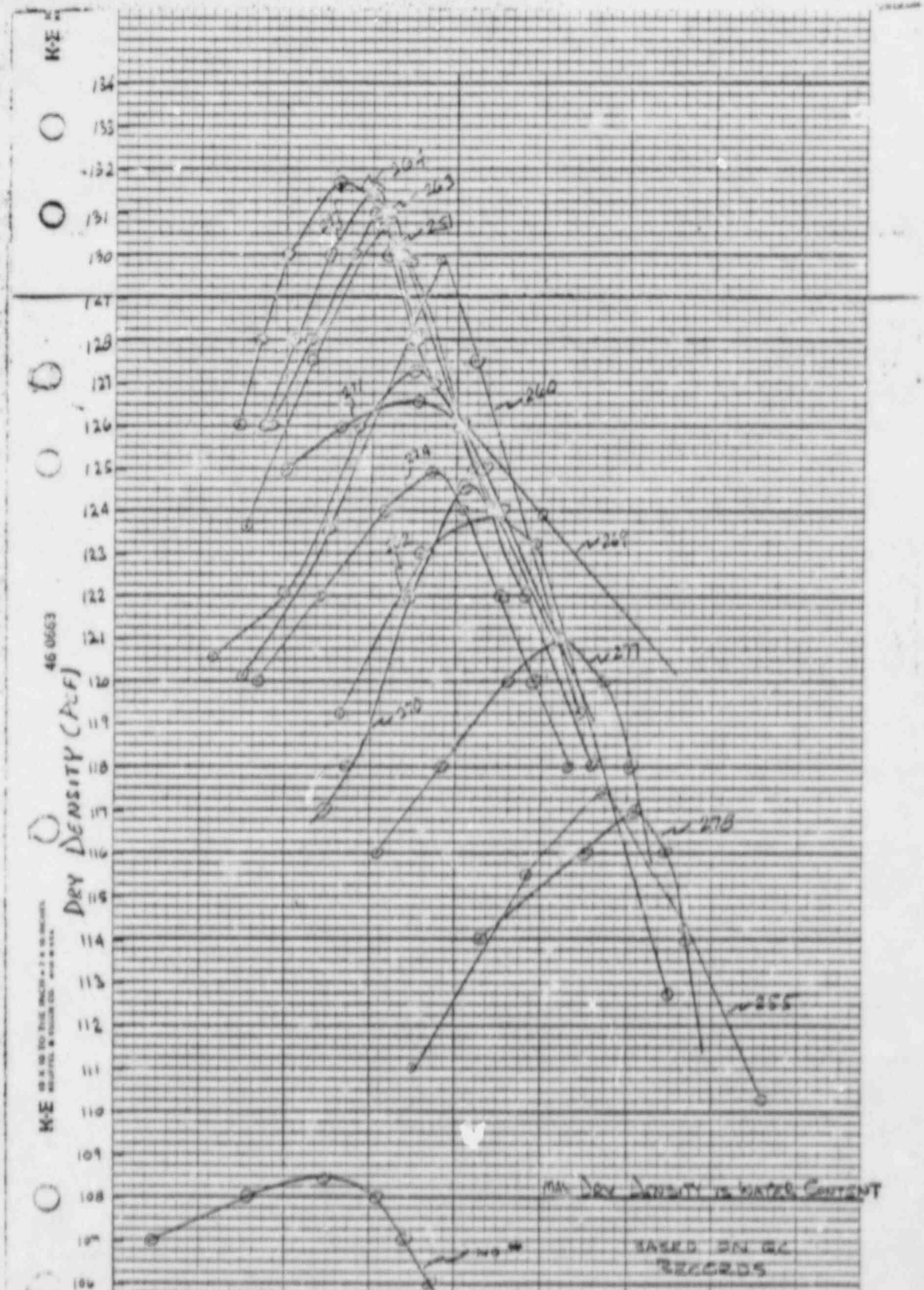
Project No. 2190 Project Engr. ____ Assigned By ____ Date: Assigned 12 Sept 78 Required ____

Boring No.	Sample No.	Depth ft.	Laboratory or Test No.	Identification Tests: Water Content %	LL %	PL %	Sieve -200 %	Hyd -2μ %	G_s	γ_d pcf	Permeability	Strength Tests: Torvane or Type Test	σ_c or $\bar{\sigma}_c$ psi	Failure Criteria	$\sigma_1 - \sigma_3$ psi	Strain %	Compaction γ_d max / W opt	Laboratory Log and Soil Description
Random Fill	Zone 2		120				55											brown sandy clay, fine grained soil of low plasticity with 45% fine to coarse SAND and fine gravel sizes (CL)
Random Fill	Zone 2		121				52					ASTM D1557-70 Method D Bechtel Modified Proctor					137.6 / 7.0 131.4 / 9.2	brown sandy clay, fine grained soil of low plasticity with 45-50% fine to coarse SAND and fine gravel sizes (CL)
Random Fill	Zone 2		122				54											brown sandy clay, fine grained soil of low plasticity with 40-45% fine to coarse SAND and fine gravel sizes (CL)
Random Fill	Zone 2		123				47											Brown clayey SAND, fine to coarse SAND grains with 45-50% fines of low plasticity (SC)
Random Fill	Zone 2		124				38											Brown clayey SAND, fine to coarse SAND grains with 35-40% fines of low plasticity (SC)
Random Fill	Zone 2		125				38					ASTM D1557-70 Method D Bechtel Modified Proctor					135.6 / 6.9 131.6 / 8.8	Brown clayey SAND, fine to coarse SAND grains with 35-40% fines of low plasticity (SC)

PRELIMINARY

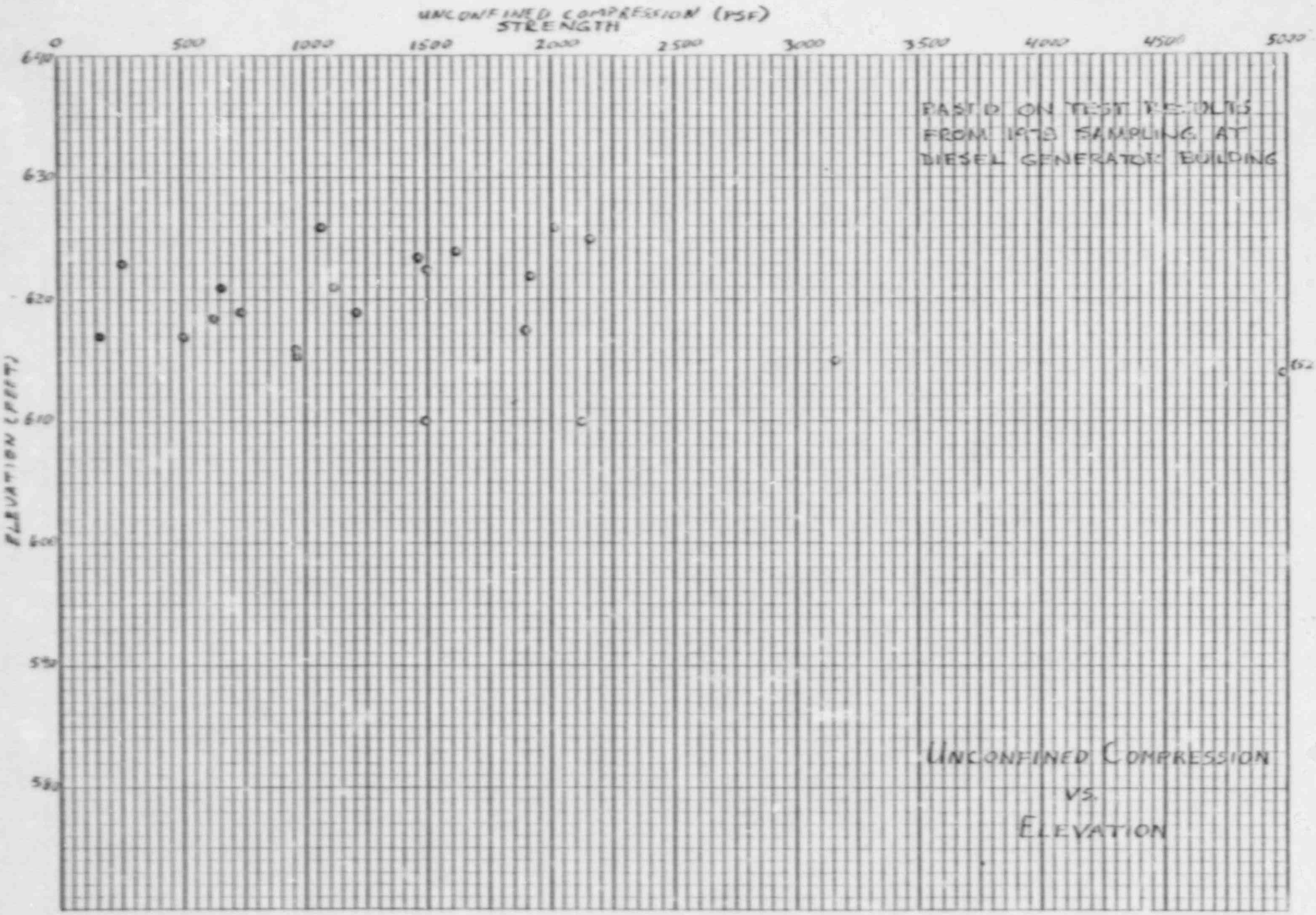
GOLDBERG, ZOINO, DUNNICLIFF & ASSOCIATES, INC.

SUMMARY OF LAB TESTS

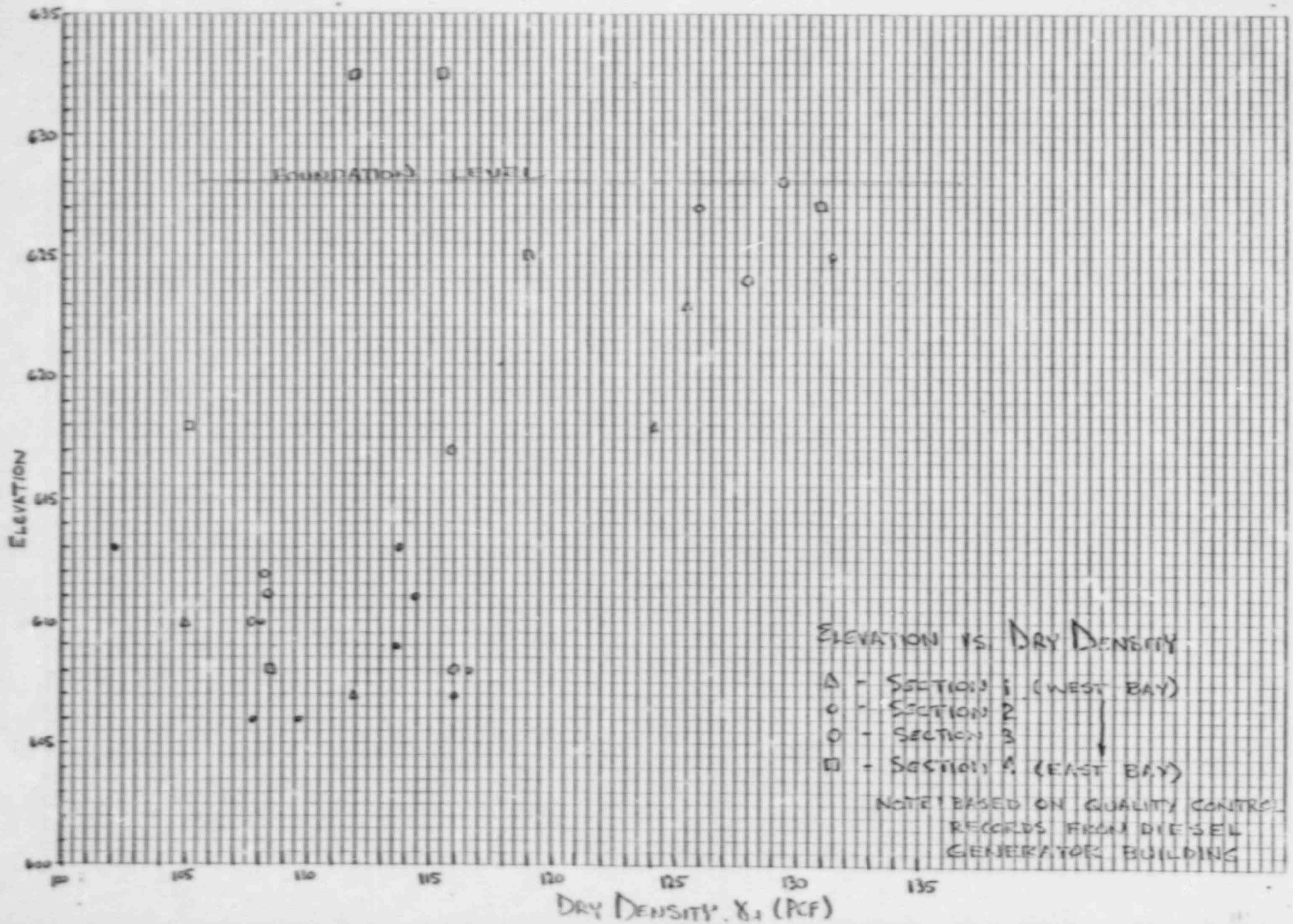


DRY DENSITY (PCF)
MOISTURE CONTENT (%)
MAX DRY DENSITY VS WATER CONTENT
BASED ON QC RECORDS

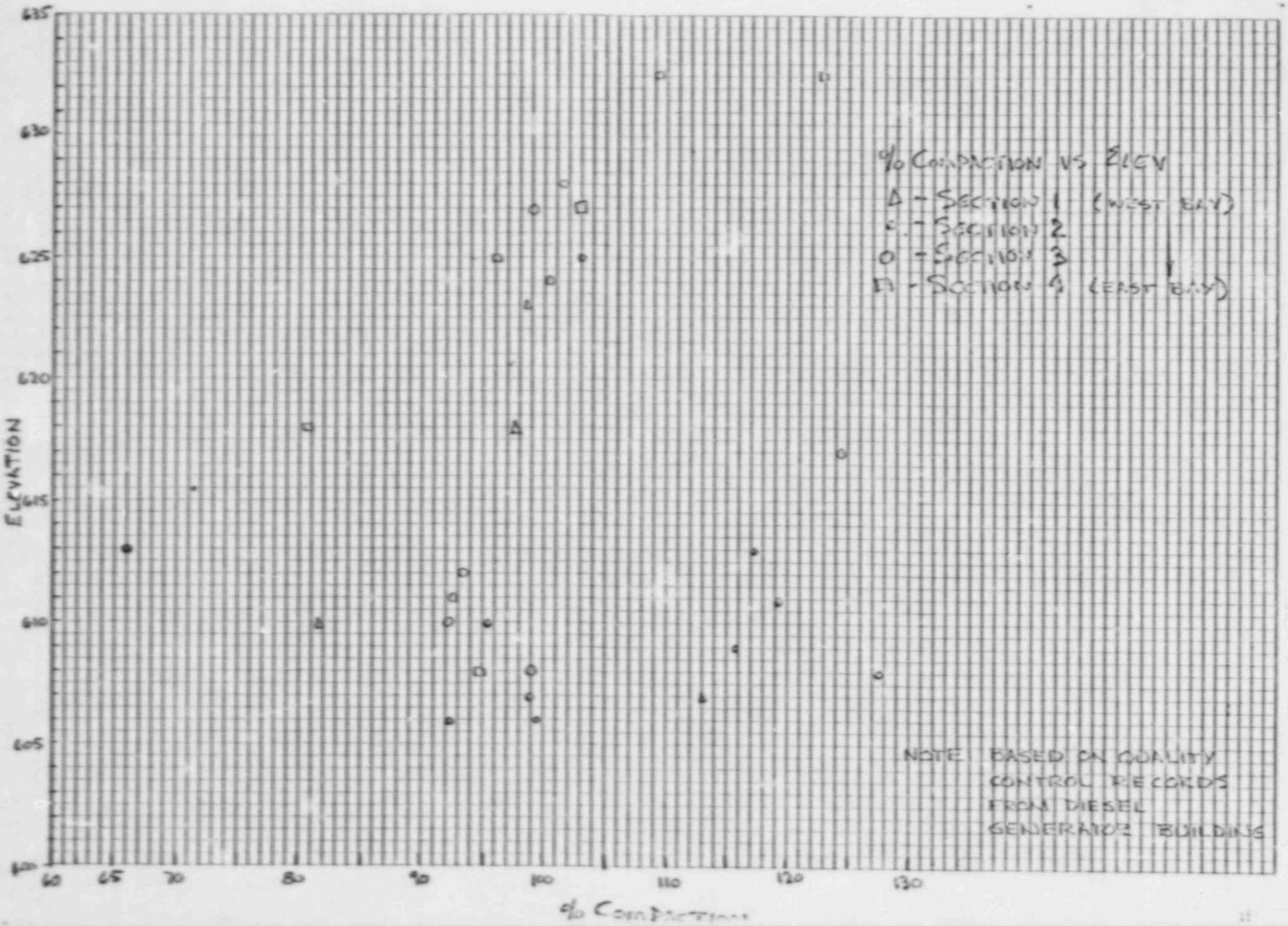
K+E 10 X 10 TO THE INCH 46 0782

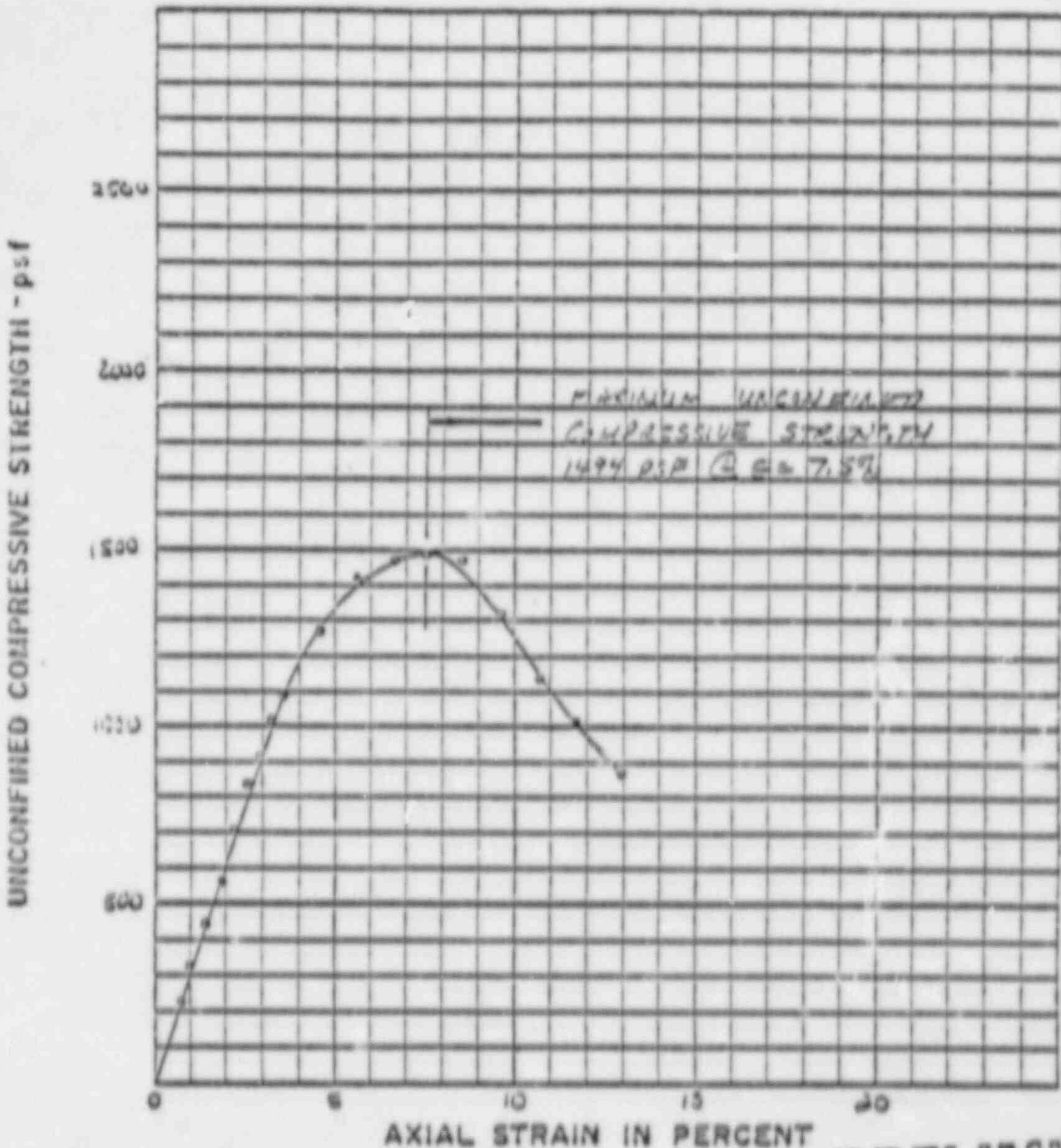


K-E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A. 46 0663

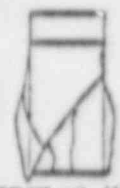


K+E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. 46 0663





SKETCHES AT FAILURE



TEST NO. U28.1

TEST NO. ____

TEST NO. ____

PRELIMINARY

TEST NO. / SYMBOL		U28.1		
INITIAL CONDITIONS: INITIAL WATER CONTENT, %	w_o	13.3		
INITIAL CONDITIONS: INITIAL DRY UNIT WEIGHT, pcf	γ_d	119.4		
INITIAL CONDITIONS: SAMPLE HEIGHT & DIAMETER, in.	H_o / D_o	5.85 / 2.84		
RATE OF STRAIN PERCENT PER MINUTE		0.5		

SOIL DESCRIPTION: ____

LIQUID LIMIT ____ % PLASTIC LIMIT ____ % SPECIFIC GRAVITY ____

SAMPLE PREPARATION UNDISTURBED

MIDLAND NUCLEAR POWER PLANT
MIDLAND, MI

UNCONFINED COMPRESSION TESTS

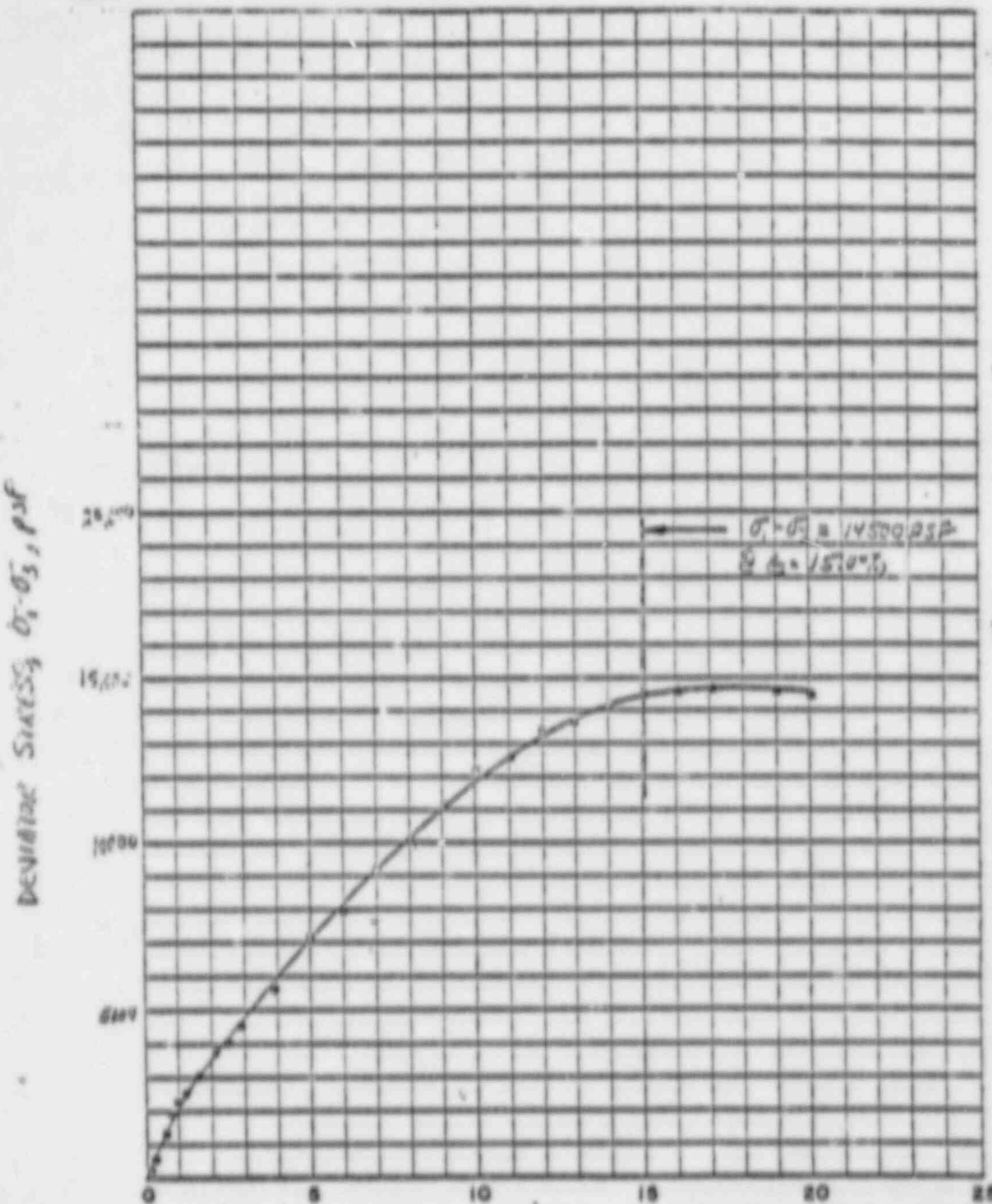
BORING NO. 0411
SAMPLE 12
DEPTH 19.8-19.3
TECH. ____
REVIEWER ____

TEST SERIES NO. 29
DATE Sept 1978

FILE 2193

FIGURE

GOLDBERG, ZOINO, DUNNICLIFF AND ASSOC., INC.
CONSULTANTS IN GEOTECHNICAL ENGINEERING



SKETCHES AT FAILURE

TEST NO. T32-1

TEST NO. ____

TEST NO. ____

TEST NO. ____

PRELIMINARY

TEST NO./SYMBOL	INITIAL CONDITIONS: INITIAL WATER CONTENT, %	INITIAL DRY UNIT WEIGHT, PCF	SAMPLE HEIGHT & DIAMETER, IN	CONDITIONS BEFORE SHEAR: INITIAL STRESSES σ_3, PSF	FINAL BACK PRESSURE,	VOLUMETRIC STRAIN, %	PORE PRESSURE RESPONSE, %	FINAL CONDITIONS: FINAL WATER CONTENT, %	FINAL DRY UNIT WEIGHT,	RATE OF STRAIN, PERCENT PER MINUTE
T32-1	9.3	130.5	[illegible]	2592	—	—	—	—	—	0.5

SOIL DESCRIPTION: ____

LIQUID LIMIT ____ % PLASTIC LIMIT ____ % SPECIFIC GRAVITY ____

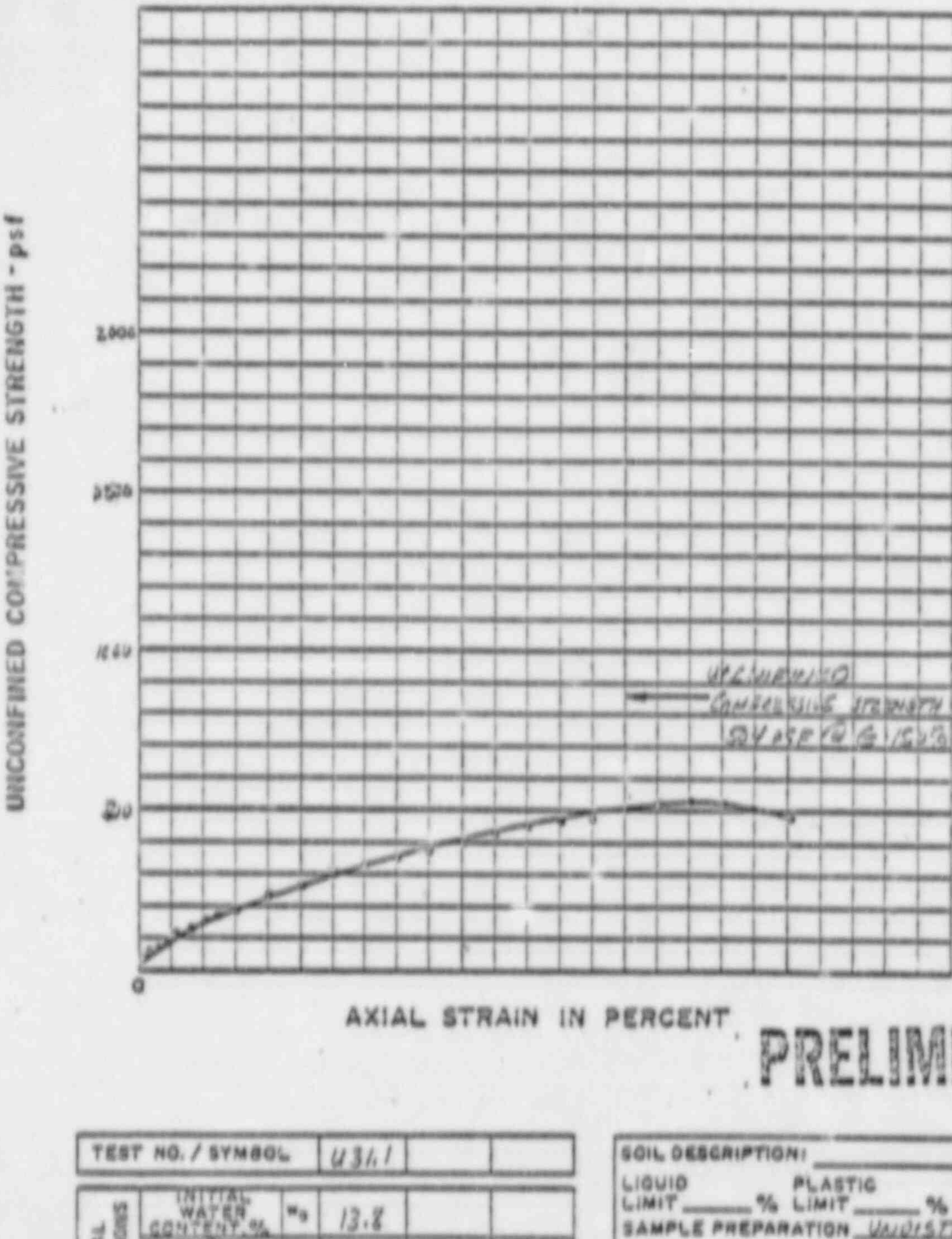
MIDLAND NUCLEAR POWER PLANT
MIDLAND, MI.

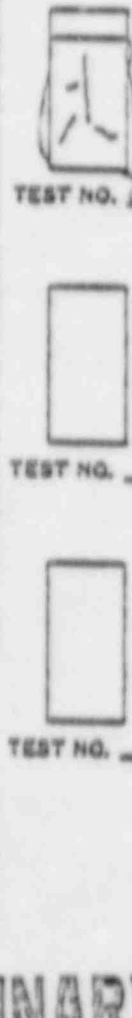
TRIAXIAL COMPRESSION TESTS (UU)

BORING NO. GT1
SAMPLE 4
DEPTH 17.3-18.0
TECH. ____
REVIEWER ____

TEST SERIES NO. T2
DATE SEPT 1977
FILE 6190

GOLDBERG, ZOINO, DUNNICLIFF & ASSOCIATES, INC.
CONSULTANTS IN GEOTECHNICAL ENGINEERING





PRELIMINARY

TEST NO. / SYMBOL		U3l.l		
INITIAL CONDITIONS: INITIAL WATER CONTENT, %	w_o	13.8		
INITIAL CONDITIONS: INITIAL DRY UNIT WEIGHT, pcf	γ_d	110.7		
INITIAL CONDITIONS: SAMPLE HEIGHT & DIAMETER, in.	H_o / D_o	6.00 / 2.38		
RATE OF STRAIN PERCENT PER MINUTE		0.5		

SOIL DESCRIPTION: ____

LIQUID LIMIT ____ % PLASTIC LIMIT ____ % SPECIFIC GRAVITY ____

SAMPLE PREPARATION UNDISTURBED

Midland Nuclear Power Plant
Midland, MI

UNCONFINED COMPRESSION TESTS

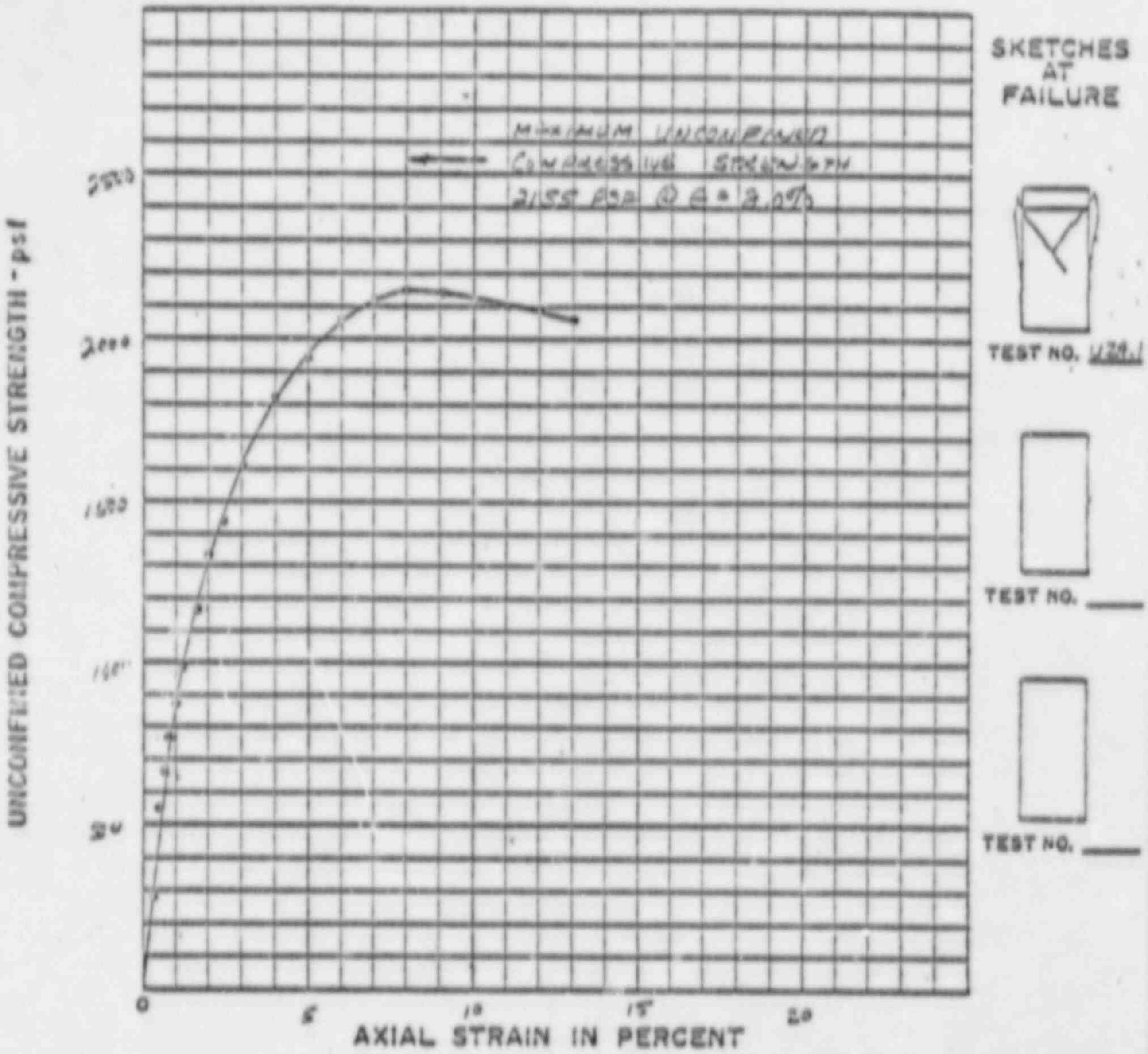
BORING NO. OG12
SAMPLE 6
DEPTH 10.7-11.2
TECH. ____
REVIEWER ____

TEST SERIES NO. 31
DATE Sept 1978

FILE 3190

GOLDBERG, ZOINO, DUNNICLIFF AND ASSOC., INC.
CONSULTANTS IN GEOTECHNICAL ENGINEERING

FIGURE



PRELIMINARY

TEST NO. / SYMBOL		U29.1		
INITIAL CONDITIONS: INITIAL WATER CONTENT, %	w_0	11.5		
INITIAL DRY UNIT WEIGHT, pcf	γ_d	122.2		
SAMPLE HEIGHT & DIAMETER, in.	H_0 / D_0	3.30 / 1.40		
RATE OF STRAIN PERCENT PER MINUTE		0.5		

SOIL DESCRIPTION:
LIQUID LIMIT ____ % PLASTIC LIMIT ____ % SPECIFIC GRAVITY ____
SAMPLE PREPARATION UNDISTURBED

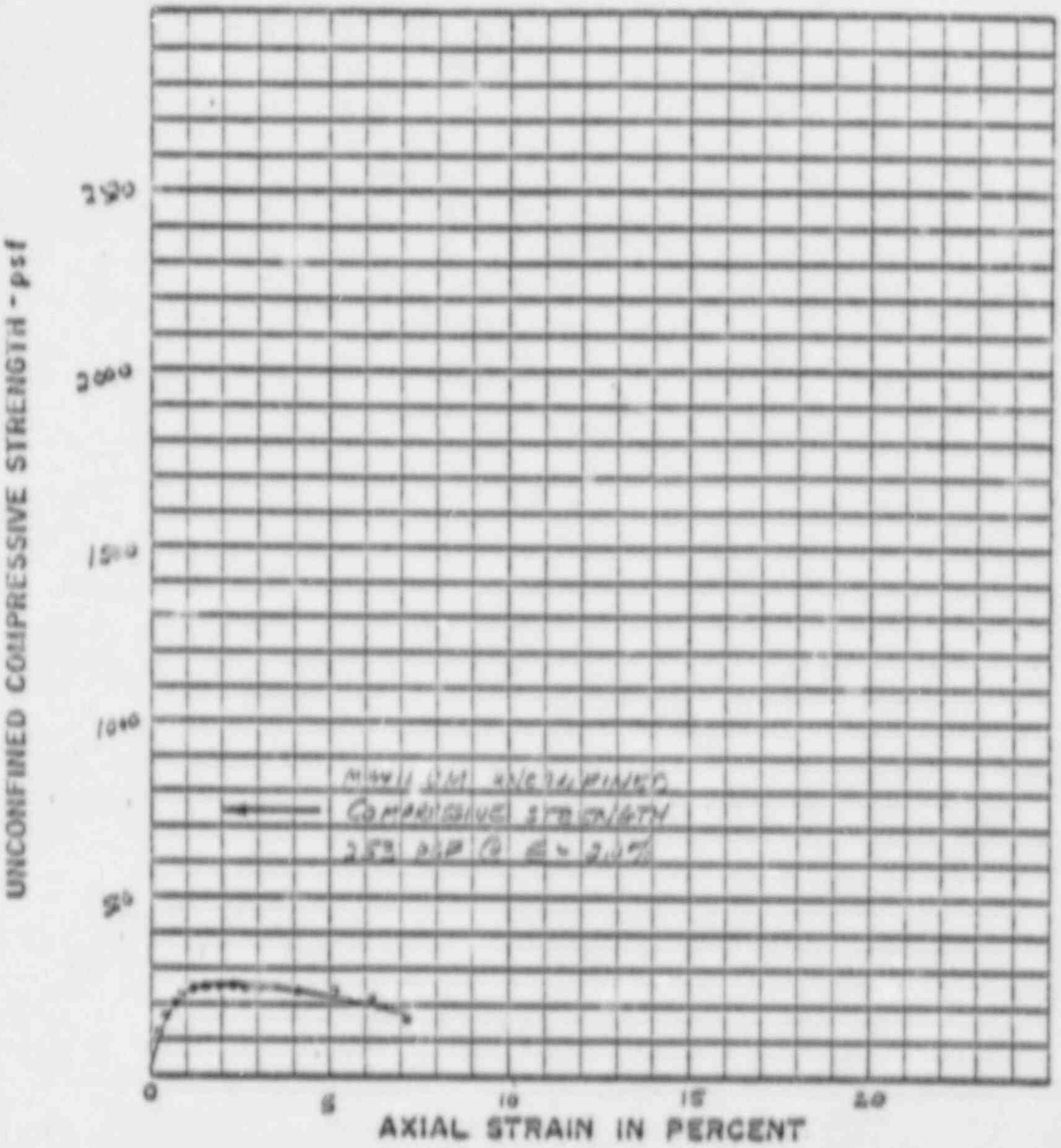
Midland Nuclear Power Plant
Midland, MI.

UNCONFINED COMPRESSION TESTS

BORING NO. DG12 TEST SERIES NO. 127
SAMPLE 2
DEPTH 3.0-3.4 DATE Sept 1978
TECH.
REVIEWER

GOLDBERG, ZOINO, DUNNICLIFF AND ASSOC., INC.
CONSULTANTS IN GEOTECHNICAL ENGINEERING

FILE 2190



SKETCHES AT FAILURE

TEST NO. 1173.2

TEST NO. ____

TEST NO. ____

PRELIMINARY

TEST NO. / SYMBOL		1173.2		
INITIAL CONDITIONS — INITIAL WATER CONTENT, %	w_o	16.4		
INITIAL CONDITIONS — INITIAL DRY UNIT WEIGHT, pcf	γ_d	98.5		
INITIAL CONDITIONS — SAMPLE HEIGHT & DIAMETER, in.	H_o / D_o	5.83 / 2.83		
RATE OF STRAIN PERCENT PER MINUTE		0.5		

Note: SAMPLE HAD VOID AT MID-HEIGHT

SOIL DESCRIPTION: ____

LIQUID LIMIT 72 % PLASTIC LIMIT 12 % SPECIFIC GRAVITY ____

SAMPLE PREPARATION UNDISTURBED

MIDLAND NUCLEAR POWER PLANT
MIDLAND, MI.

UNCONFINED COMPRESSION TESTS

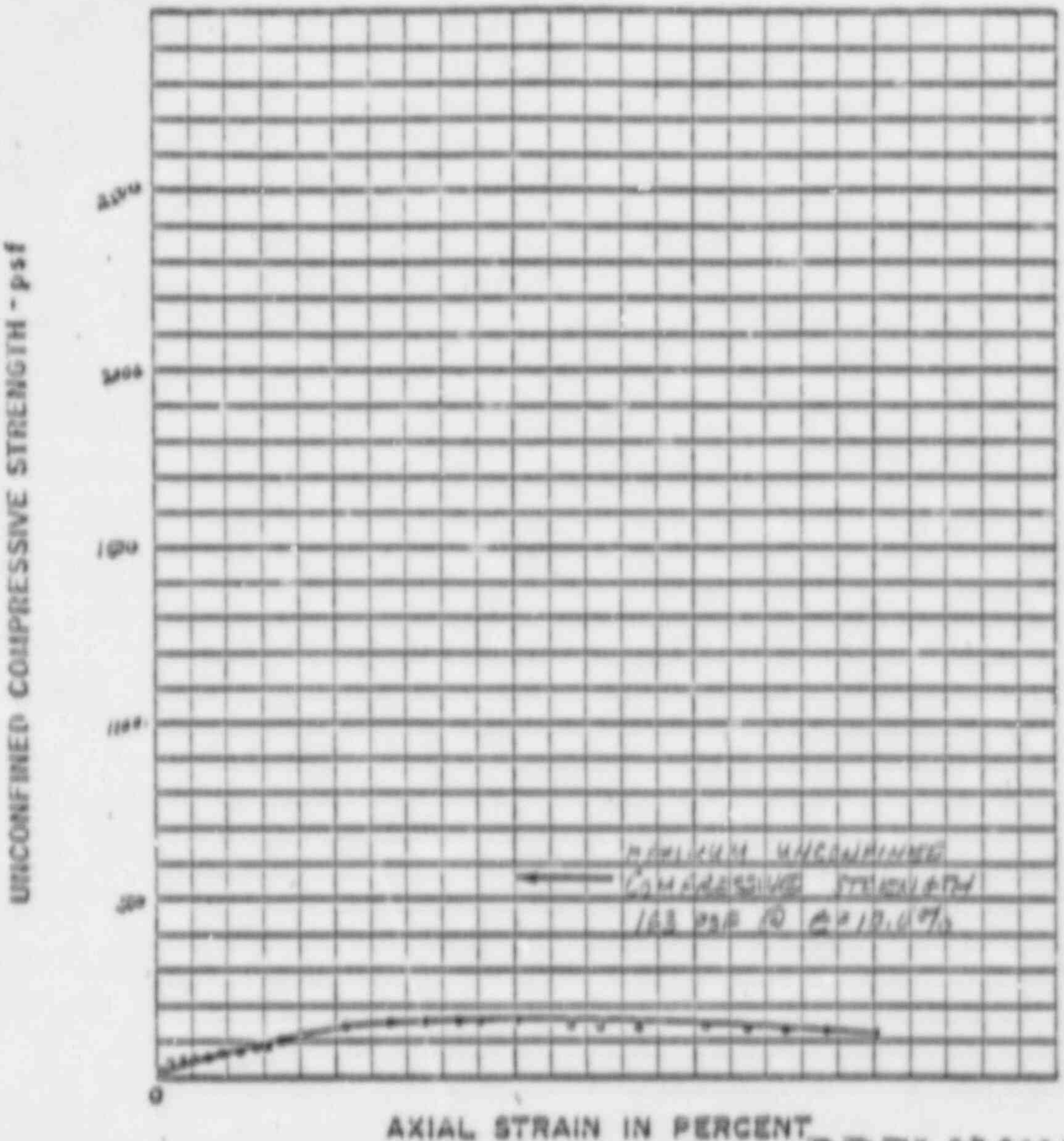
BORING NO. DG10
SAMPLE 1
DEPTH 20.5 ft
TECH. ____
REVIEWER ____

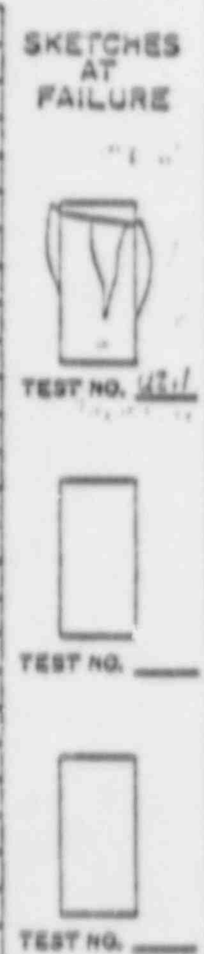
TEST SERIES NO. 23
DATE Sept 1977

FILE 2170

FIGURE ____

GOLDBERG, ZOINO, DUNNICLIFF AND ASSOC., INC.
CONSULTANTS IN GEOTECHNICAL ENGINEERING





PRELIMINARY

TEST NO. / SYMBOL		UE.1		
INITIAL CONDITIONS: INITIAL WATER CONTENT, %	w_o	13.7		
INITIAL CONDITIONS: INITIAL DRY UNIT WEIGHT, pcf	γ_d	117.4		
INITIAL CONDITIONS: SAMPLE HEIGHT & DIAMETER, in.	H_o / D_o	6.00 / 2.88		
RATE OF STRAIN PERCENT PER MINUTE		0.5		

Note: Sample slumped under its own weight.

SOIL DESCRIPTION: Brown clayey sand (SC)
LIQUID LIMIT 21 % PLASTIC LIMIT 12 % SPECIFIC GRAVITY ____
SAMPLE PREPARATION UNDISTURBED

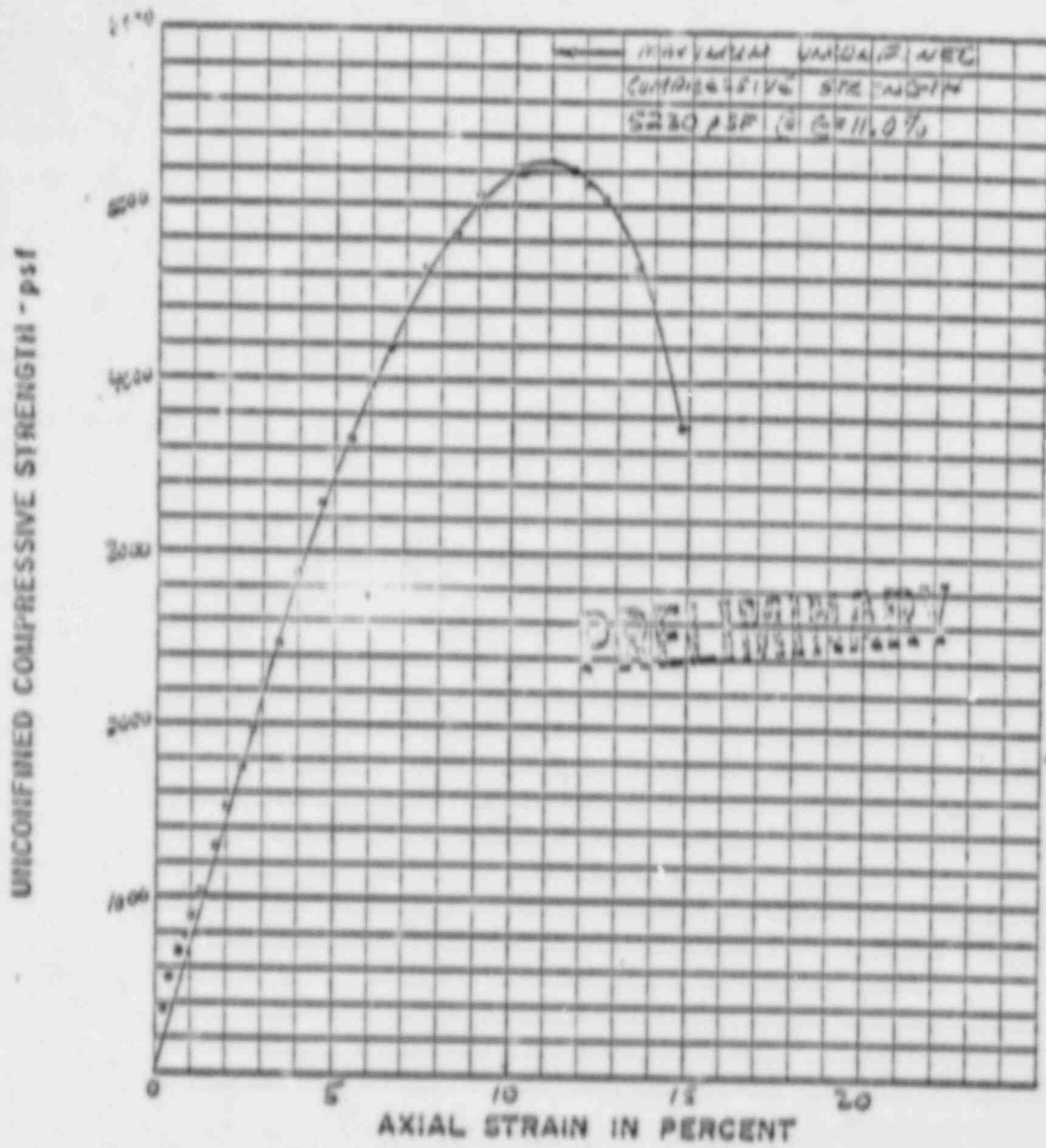
Midland Nuclear Power Plant

UNCONFINED COMPRESSION TESTS

BORING NO. OG 2 TEST SERIES
SAMPLE 5 NO. 21
DEPTH 16.5-17.5 DATE Sept 1978
TECH. ____
REVIEWER ____ FILE 2190

GOLDBERG, ZOINO, DUNNICLIFF AND ASSOC., INC.
CONSULTANTS IN GEOTECHNICAL ENGINEERING

FIGURE



SKETCHES AT FAILURE

TEST NO. U1.1

TEST NO. ____

TEST NO. ____

TEST NO. / SYMBOL		U1.1		
INITIAL CONDITIONS: INITIAL WATER CONTENT, %	w_o	10.5		
INITIAL CONDITIONS: INITIAL DRY UNIT WEIGHT, pcf	γ_d	127.7		
INITIAL CONDITIONS: SAMPLE HEIGHT & DIAMETER, in.	H/D	6.00 / 2.83		
RATE OF STRAIN PERCENT PER MINUTE		0.5		

SOIL DESCRIPTION: Brown Sandy Clay (CL)

LIQUID LIMIT 20 % PLASTIC LIMIT 12 % SPECIFIC GRAVITY ____

SAMPLE PREPARATION UNDISTURBED

MIDLAND NUCLEAR POWER PLANT
MIDLAND, MI

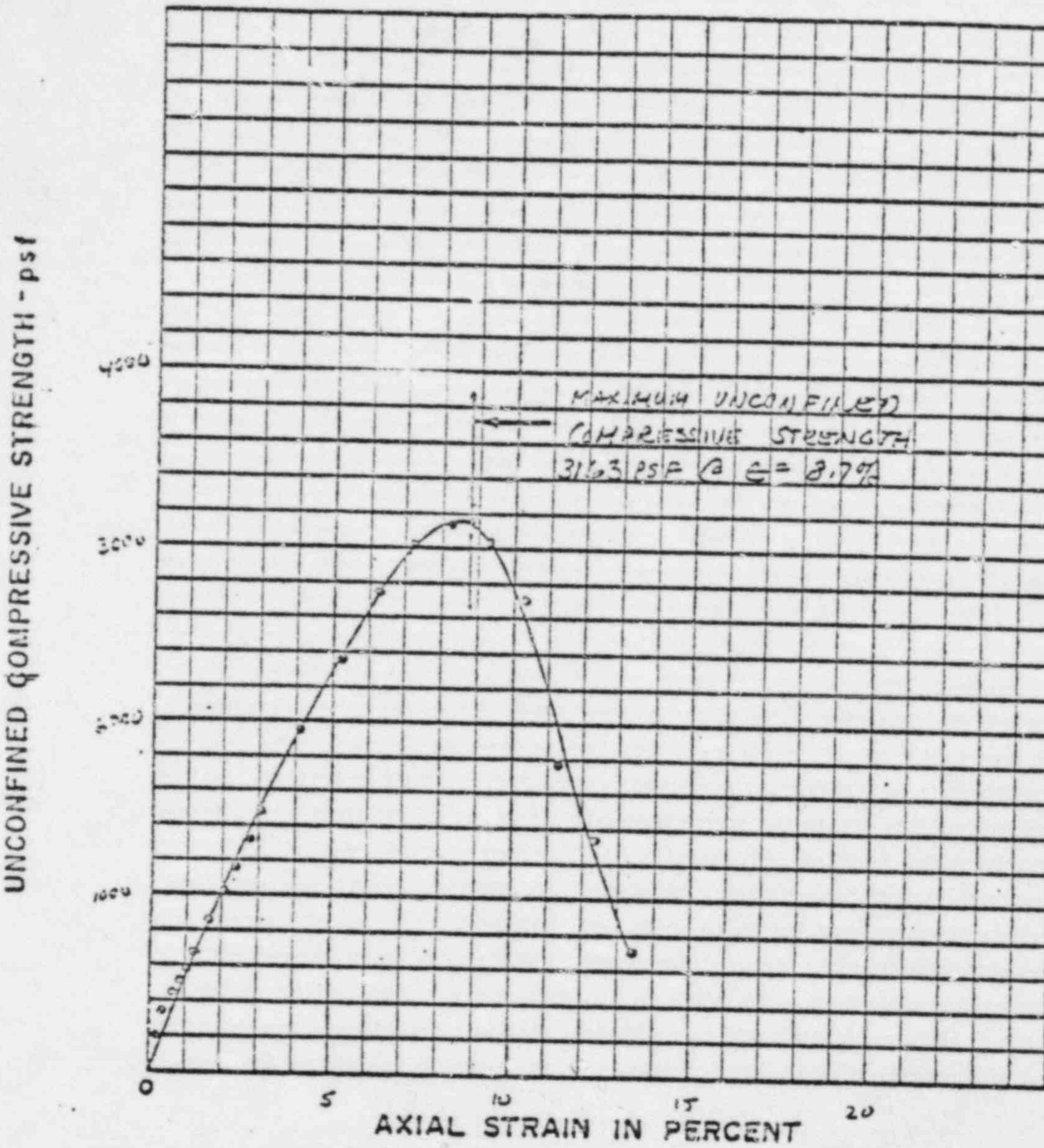
UNCONFINED COMPRESSION TESTS

BORING NO. DG1
SAMPLE ____
DEPTH 19.7-20.2
TECH. ____
REVIEWER ____

TEST SERIES NO. 1
DATE Sept 1978
FILE 2190

GOLDBERG, ZOINO, DUNNICLIFF AND ASSOC., INC.
CONSULTANTS IN GEOTECHNICAL ENGINEERING

FIGURE



SKETCHES AT FAILURE

TEST NO. U3.1

TEST NO. ____

TEST NO. ____

PRELIMINARY

TEST NO. / SYMBOL		U3.1		
INITIAL CONDITIONS — INITIAL WATER CONTENT, %	w_o	15.8		
INITIAL CONDITIONS — INITIAL DRY UNIT WEIGHT, pcf	γ_d	115.1		
INITIAL CONDITIONS — SAMPLE HEIGHT & DIAMETER, in.	H_o/D_o	5.85 / 2.88		
RATE OF STRAIN PERCENT PER MINUTE		0.5		

SOIL DESCRIPTION: Brown Silty clay, Sandy (CL)

LIQUID LIMIT 25 % PLASTIC LIMIT 14 % SPECIFIC GRAVITY ____

SAMPLE PREPARATION UNDISTURBED

MIDLAND NUCLEAR POWER PLANT
MIDLAND, MI

UNCONFINED COMPRESSION TESTS

BORING NO. DG5
SAMPLE 6
DEPTH 19.1-19.6
TECH. ____
REVIEWER ____

TEST SERIES NO. 3
DATE Sept 1978
FILE 2190

FIGURE

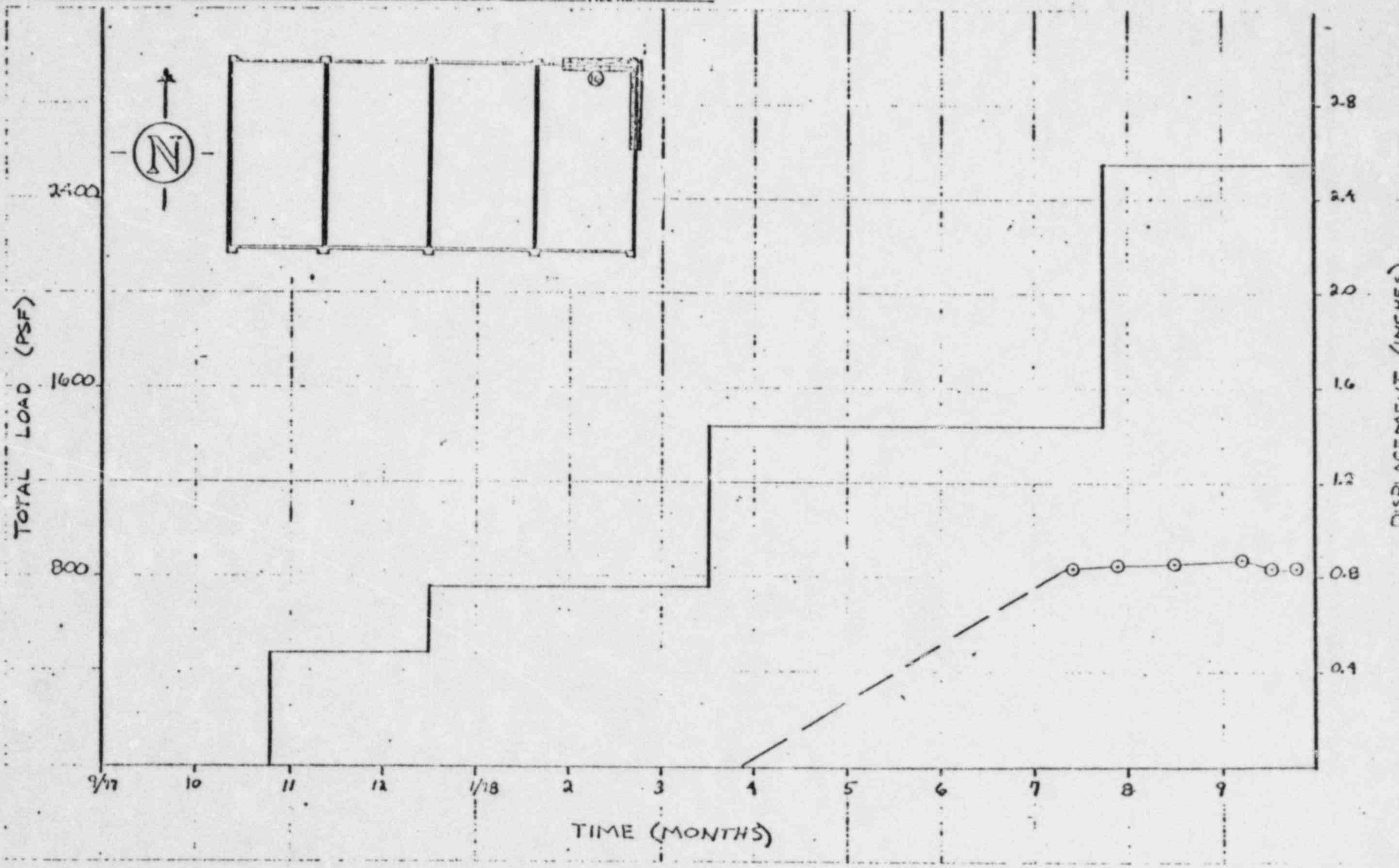
GOLDBERG, ZOINO, DUNNICLIFF AND ASSOC., INC.
CONSULTANTS IN GEOTECHNICAL ENGINEERING

BY Carl Dirnbauer DATE 9/13 CHECKED BY ______ DATE ______ SHEET ______

CT. Midland Plant Units 1+2 JOB # 20

SUBJECT ______ FILE NO. ______

FOOTING SECTION (2) AND SCRIBE Nº (16)



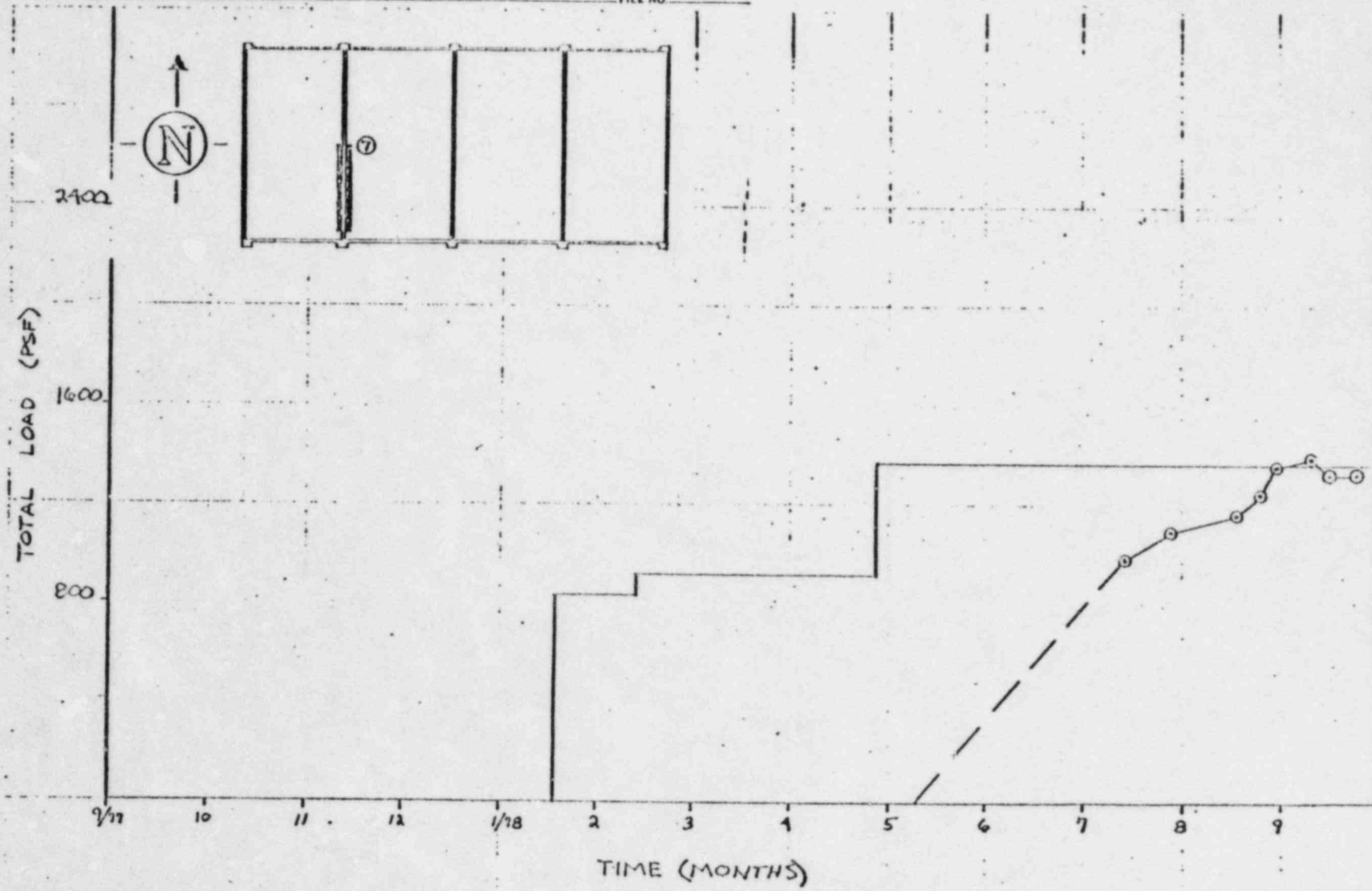
CALCULATION SHEET

BY: CARL DIRNBAUER DATE: 9/13 CHECKED BY: ______ DATE: ______ SHEET: ______

PROJECT: MIDLAND PLANT UNITS 1+2 JOB NO.: 20 FILE NO.: ______

SUBJECT: ______

FOOTING SECTION (10) AND SCRIBE Nº 7.



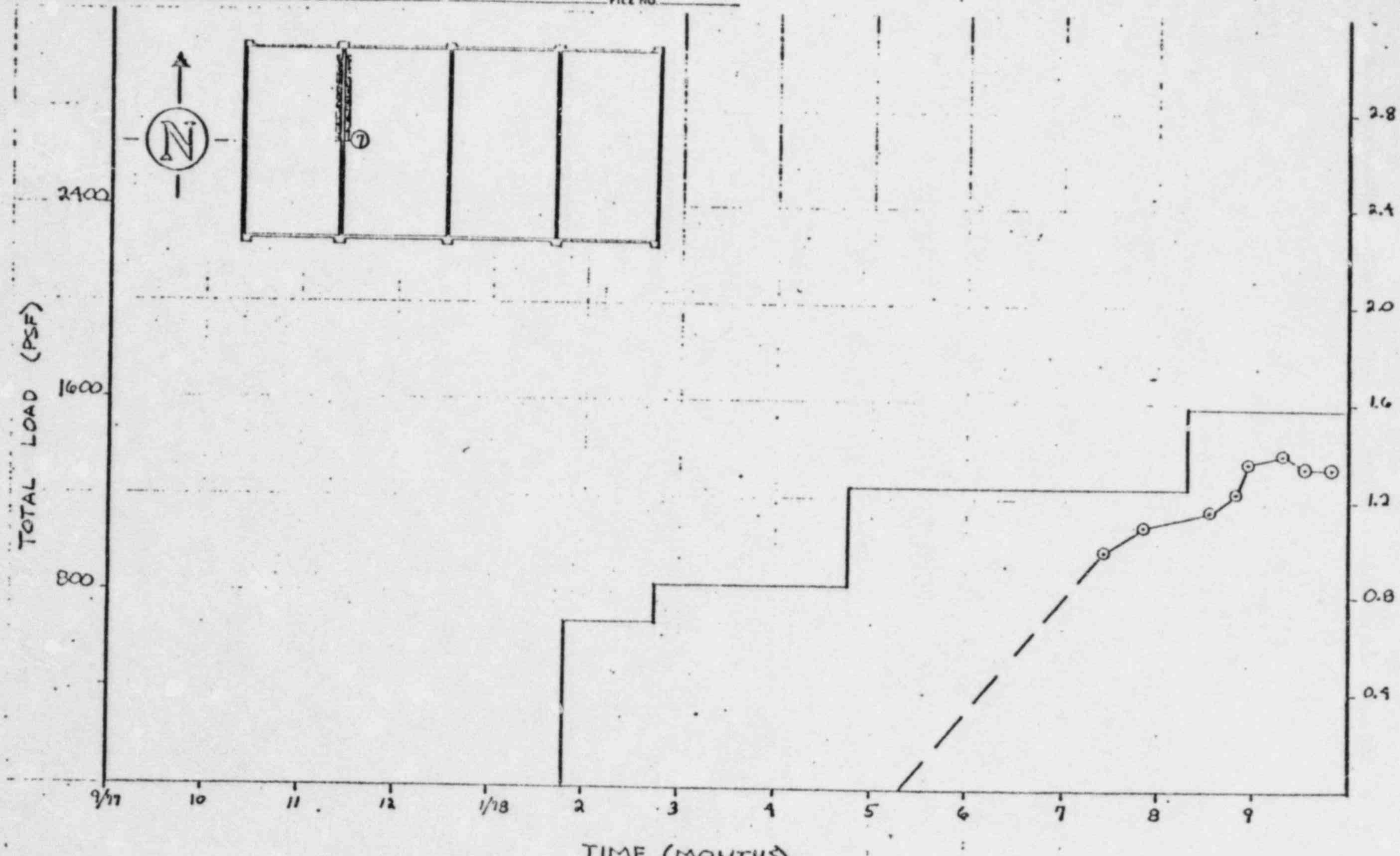
BY CARL DIRNBAUER DATE 9/13 CHECKED BY ______ DATE ______

SHEET ______

PROJECT MIDLAND PLANT UNITS 1+2 JOB NO 20

SUBJECT ______ FILE NO ______

FOOTING SECTION (9) AND SCRIBE Nº (7)



CALCULATION SHEET

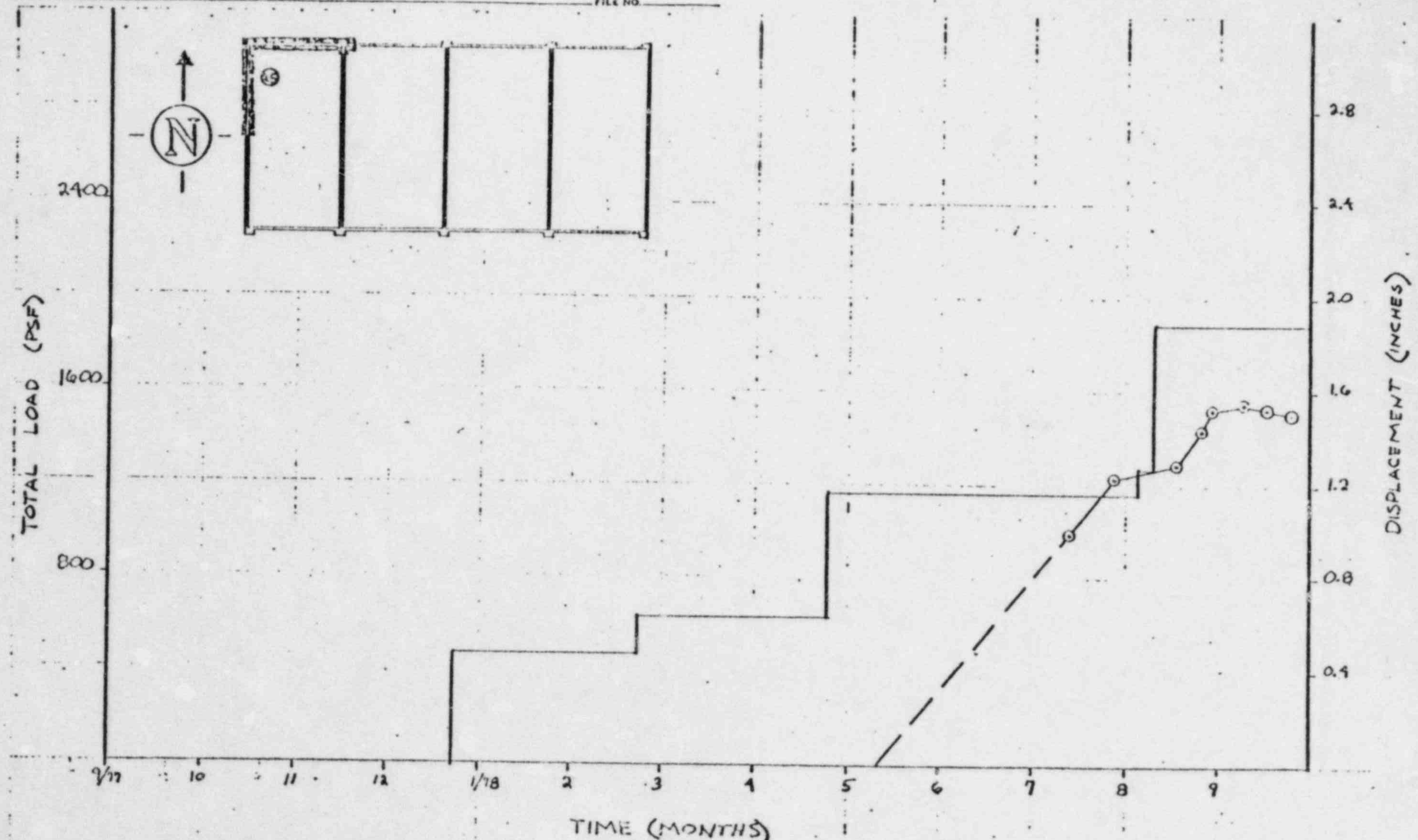
BY CARL DIRNBAUER DATE 9/13 CHECKED BY ____ DATE ____

SHEET —

PROJECT MIDLAND PLANT UNITS 1+2 JOB NO. 2G

SUBJECT ____ FILE NO. ____

FOOTING SECTION (8) AND
SCRIBE Nº (25)



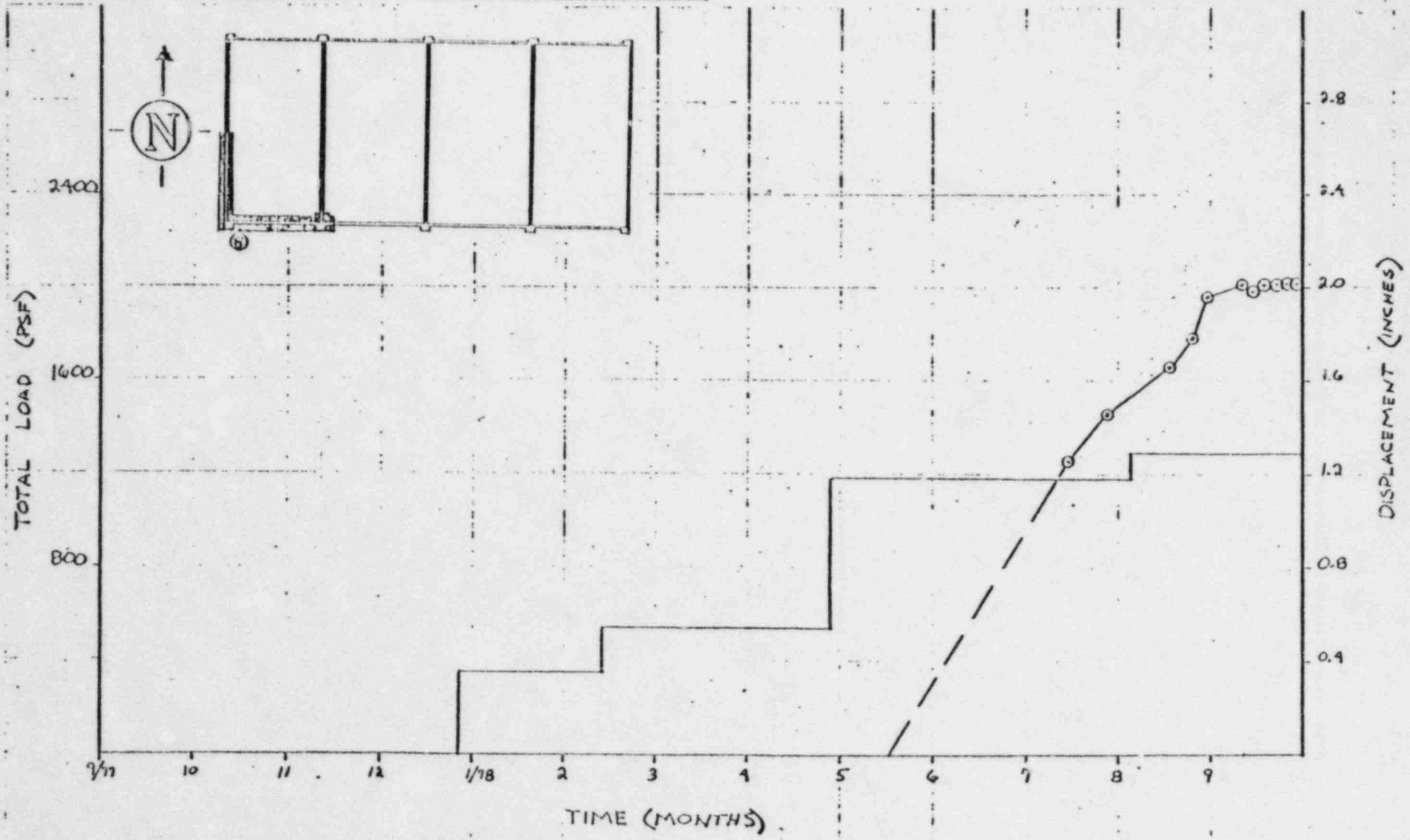
CALCULATION SHEET

DESIC CARL DIRNBAUER DATE 9/13 CHECKED BY ______ SHEET NO. ______ DATE ______

PROJECT MIDLAND PLANT UNITS 1+2 JOB NO. 72__ FILE NO. ______

SUBJECT ______

FOOTING SECTION (7) AND SCRIBE Nº (8)

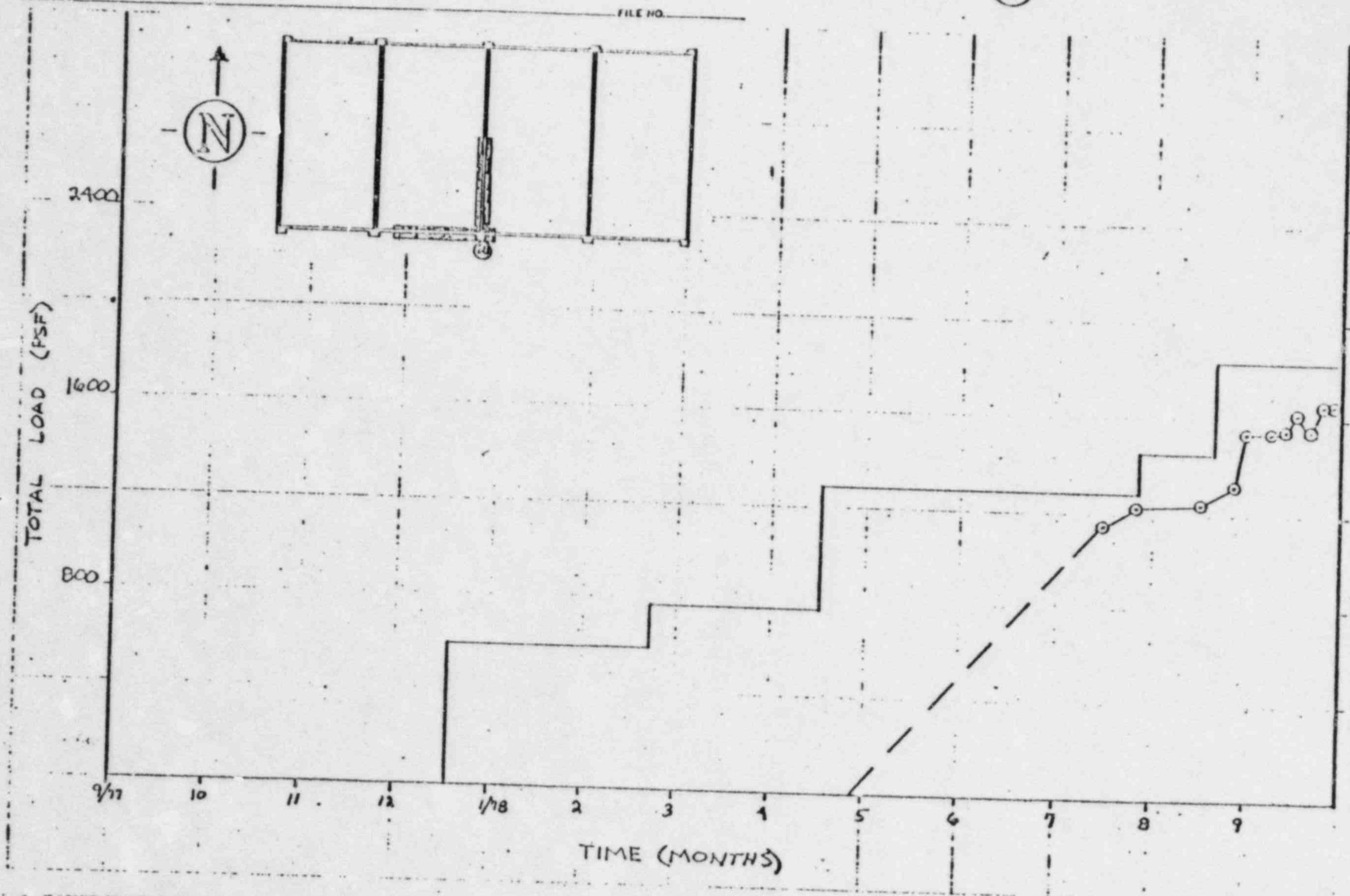


BY CARL DIRNBAUER DATE 9/13 CHECKED BY ______ DATE ______

MIDLAND PLANT UNITS 1+2 SHEET ______ JOB NO. 10

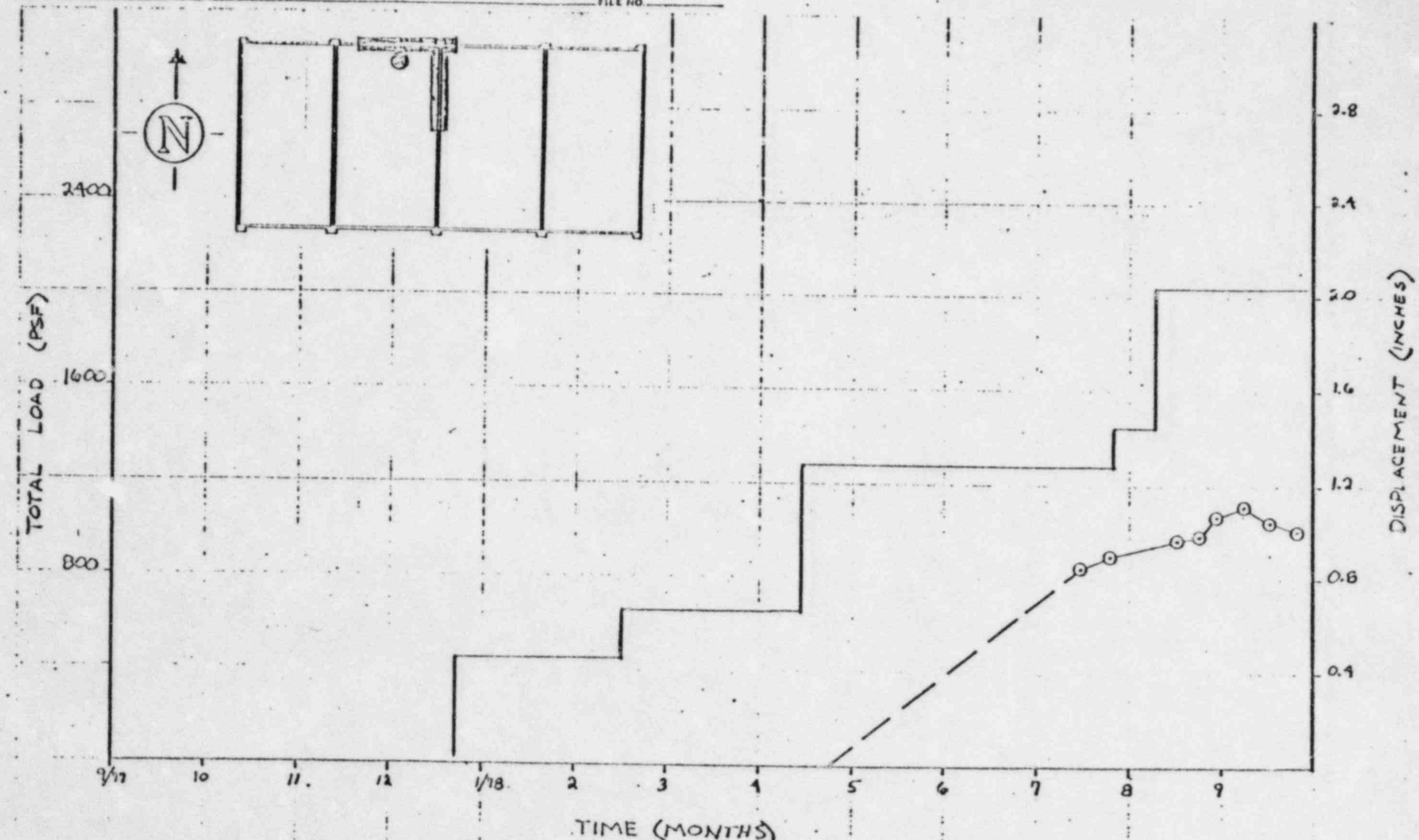
SUBJECT ______ FILE NO. ______

FOOTING SECTION (6) AND
SCRIBE No (21)



BY CARL DIRNBAUER DATE 9/13 CHECKED BY ______ DATE ______
SHEET ______
SUBJECT MIDLAND PLANT UNITS 1+2 JOB NO. 220
FILE NO. ______

FOOTING SECTION (5) AND SCRIBE № (22)



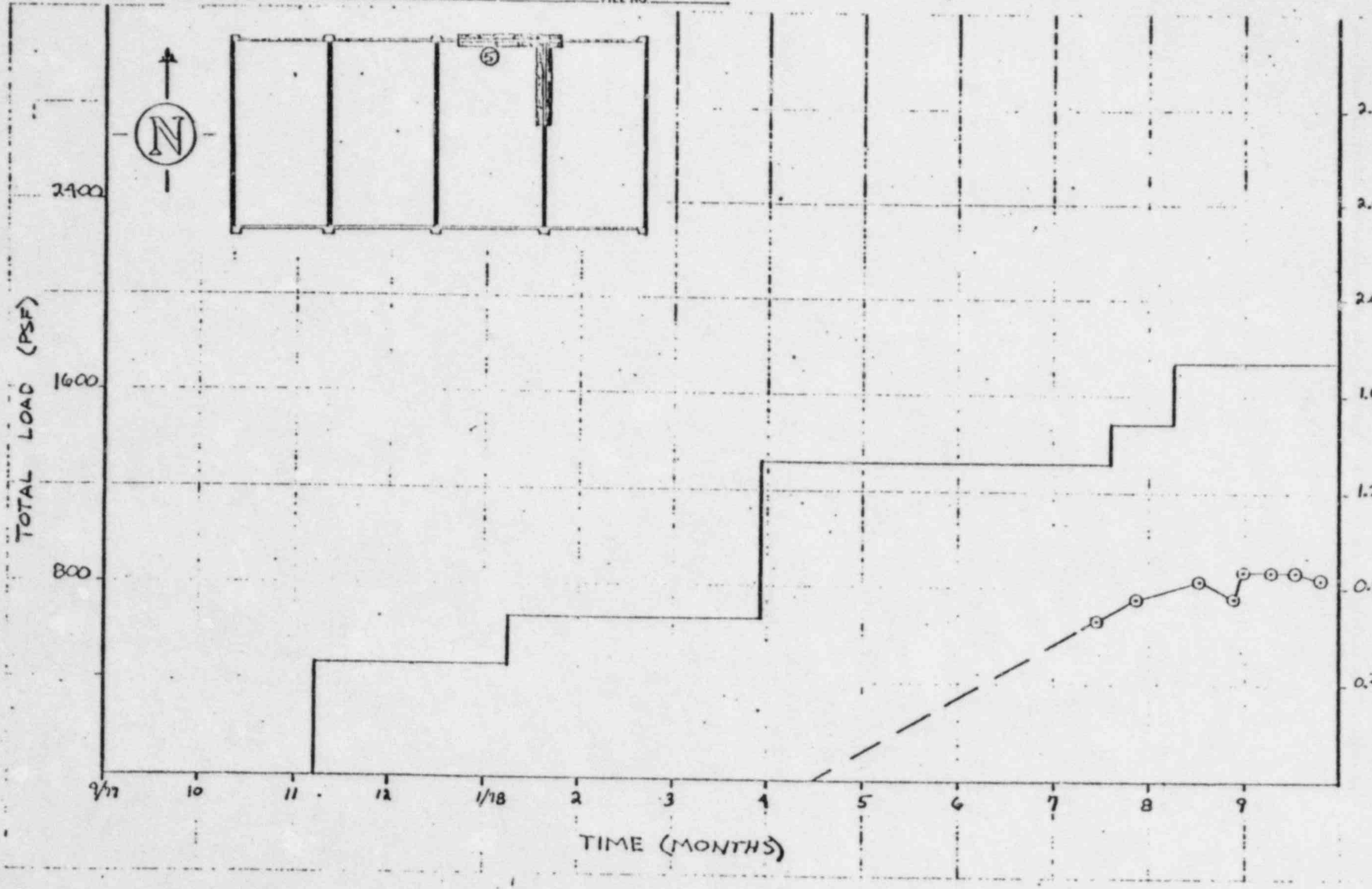
CALCULATION SHEET

BY CARL DIRNBAUER DATE 9/13 CHECKED BY ______ DATE ______

PROJECT MIDLAND PLANT UNITS 1+2 SHEET NO. ______ JOB NO. 1220

SUBJECT ______ FILE NO. ______

FOOTING SECTION (4) AND SCRIBE Nº (5)

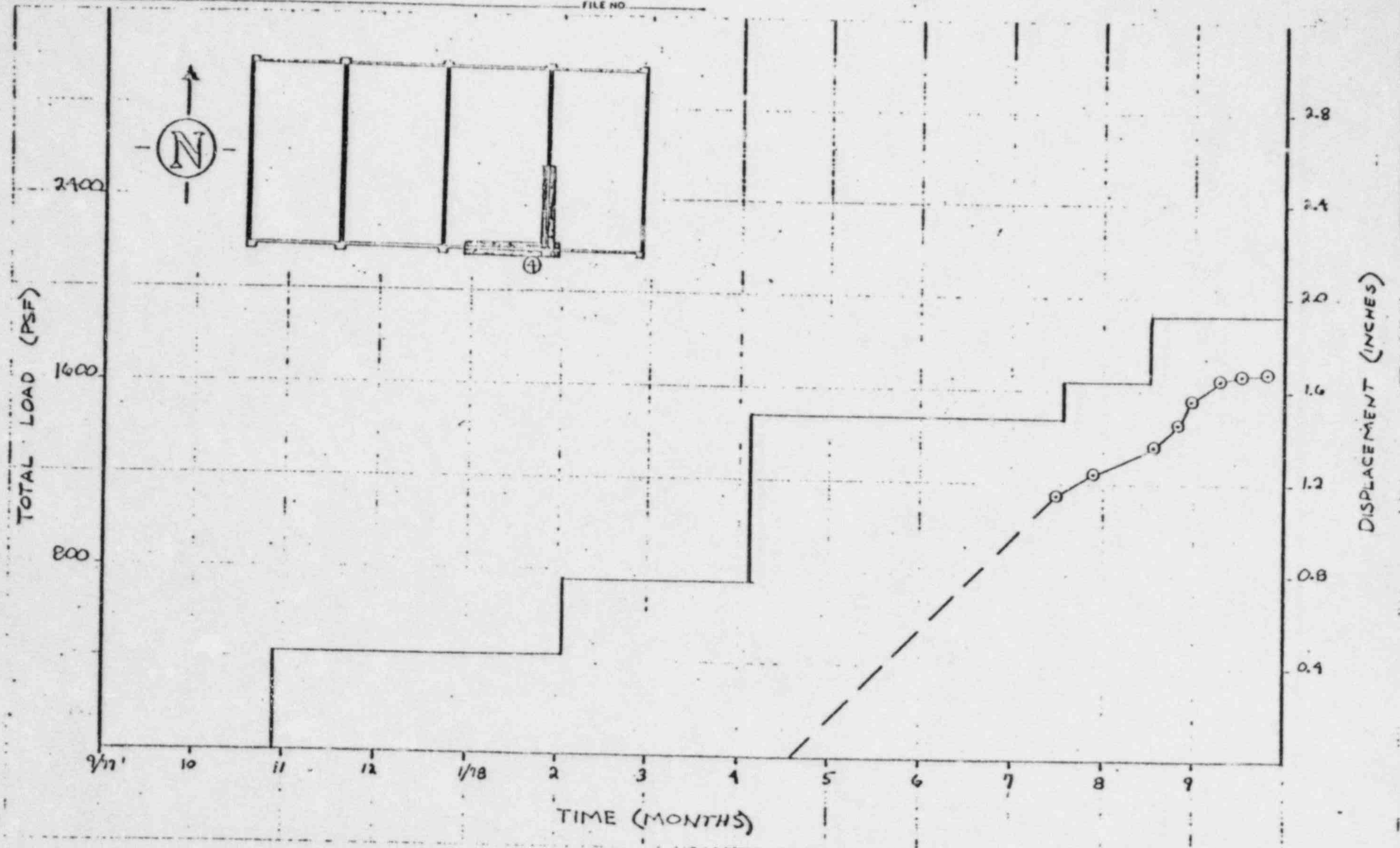


CALCULATION SHEET

BY CARL DIRNBAUER DATE 9/13 CHECKED BY ______ DATE ______ SHEET NO. ______

SUBJECT MIDLAND PLANT UNITS 1+2 JOB NO. ______ FILE NO. ______

FOOTING SECTION (3) AND SCRIBE Nº (4)



CALCULATION SHEET

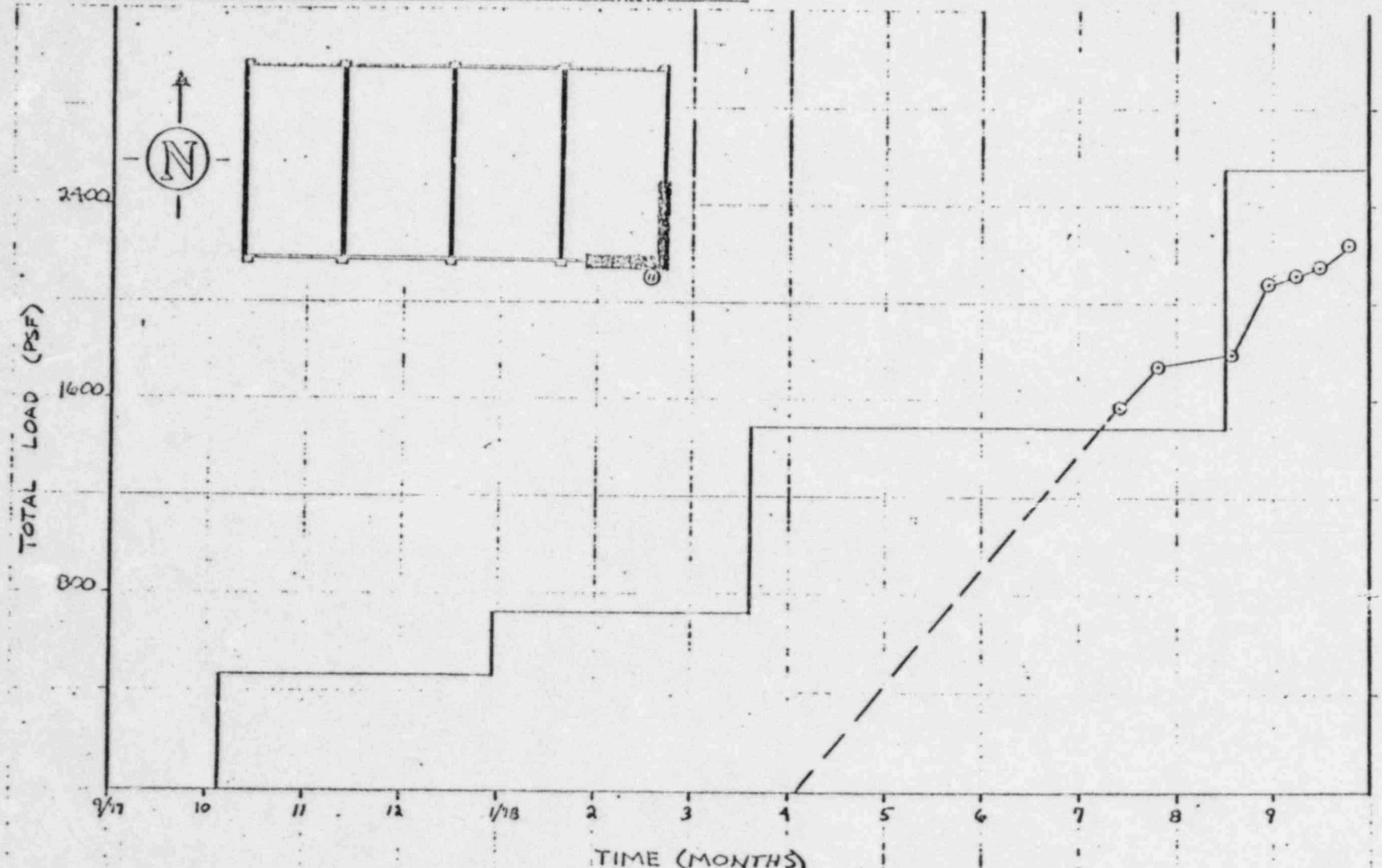
DATE 9/13/78

CARL DIRNBAUER DATE 9/13 CHECKED BY RAO SHEET NO —

MIDLAND PLANT UNITS 1+2 JOB NO. 10

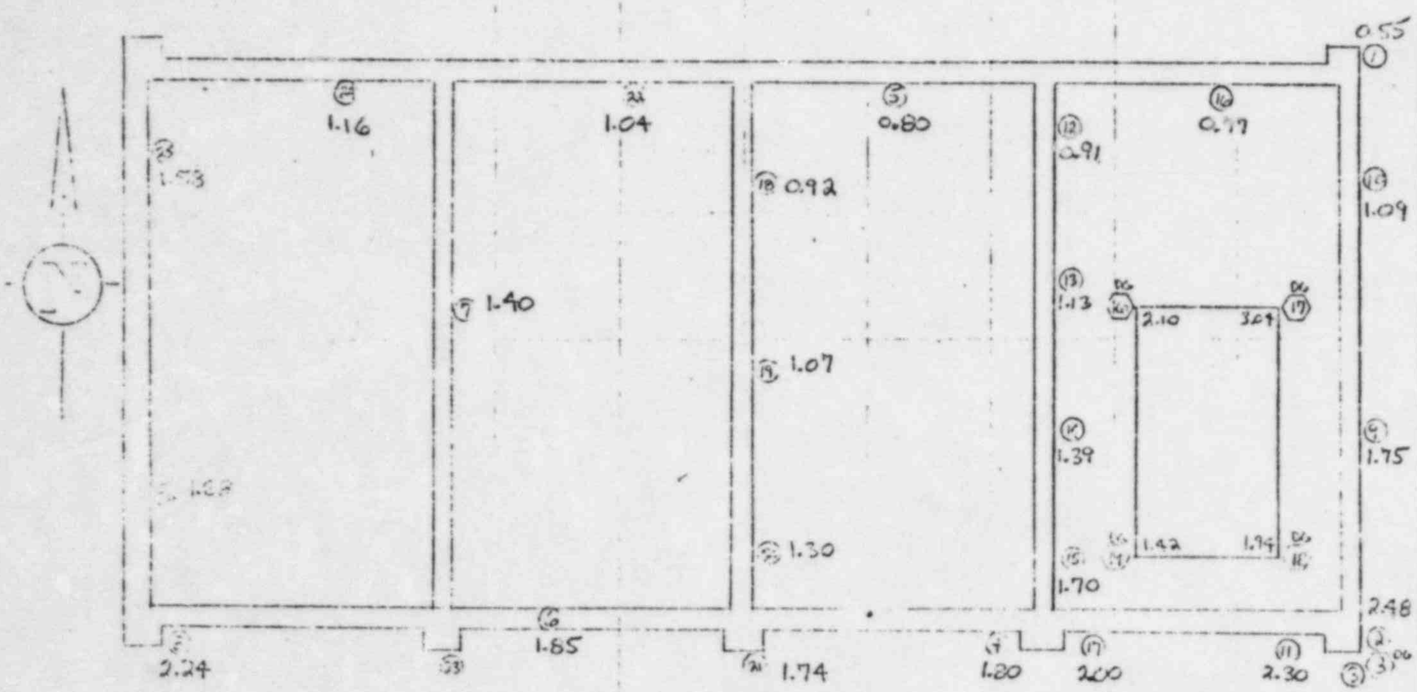
SUBJECT ________ FILE NO ________

FOOTING SECTION (1) AND SCRIBE Nº (11)



CALCULATION SHEET

DESIGN BY [illegible] LAKE/LAMBE	DATE 9/11/
CHECKED BY	DATE
PROJECT MIDLAND PLANT UNITS 1+2	SHEET NO.
SUBJECT	JOB NO.
	FILE NO.



SCRIBE #	TOTAL SETTLEMENT (INCHES)
1	0.55
2	2.48
3	DISCONTINUED
4	1.80
5	0.80
6	1.85
7	1.40
8	[illegible]
9	1.75
10	1.09
11	2.30
12	0.97
13	[illegible]
14	[illegible]
15	[illegible]
16	[illegible]
17	[illegible]
18	0.92
19	1.07
20	1.30
21	1.74
22	1.04
23	[illegible]
24	1.16
25	1.59
26	1.88

DIESEL GENERATOR BLDG.

SETTLEMENT DATA:
AS OF 10/6/78

○ – SCRIBE MARKS

DG ○ – SETTLEMENT MARKERS

DG MARKER #	TOTAL SETTLEMENT (IN)
3	0.74
16	2.10
17	3.04
18	1.94
19	1.42

} AS OF 9/22/78.

CALCULATION SHEET

DATE ______

DESIGN BY Dirnbauer DATE 9/11/78 CHECKED BY ______ SHEET NO. ______

PROJECT MIDLAND PLANT UNITS 1+2 JOB NO. ______

SUBJECT SETTLEMENT DATA FILE NO. ______

SCREED NUMBER	INITIAL DATE	INITIAL ELEV	TOTAL SETTLEMENT (FT) + OBSERVATION DATE: 7/10	7/27	8/5?	8/25	8/31	9/8?	9/11?	9/15/78	9/19/78	9/22/78	9/25/78	9/29/78	10/3	10/6
1	3/28/78	639.50'	0.063	0.071	0.063	0.061	0.061	0.056	0.051	0.051	0.047	0.050	0.047	0.048	0.048	0.046
2	4/1/78		0.142	0.159	0.166	0.185	0.192	0.195	0.194	0.197	0.197	0.200	0.202	0.207	0.207	0.207
3	4/1/78		0.141	0.162	0.166	0.185	0.195	0.195	—	—	—	—	—	—	—	—
4	4/18/78		0.096	0.103	0.115	0.122	0.131	0.136	—	0.139	—	0.140		0.148		0.150
5	4/15/78		0.056	0.064	0.069	0.063	0.075	0.074	—	0.074	—	0.070		0.078		0.067
6	4/22/78		0.096	0.104	0.112	0.122	0.133	0.137	—	0.139	—	0.139		0.148		0.154
7	5/8/78		0.086	0.093	0.097	0.103	0.113	0.117	—	0.110	—	0.112		0.116		0.117
8	5/10/78		0.106	0.121	0.139	0.152	0.164	0.169	0.164	0.168	0.168	0.171	0.174	0.188	0.188	0.187
9	4/1/78		0.111	0.121	0.124	0.137	0.140	0.142	0.140	0.142	0.142	0.145	0.146	0.147	0.148	0.146
10	3/28/78		0.083	0.091	0.087	0.092	0.081	0.091	—	0.090	—	0.090		0.090		0.091
11	4/1/78		0.130	0.147	0.150	—	0.176	0.179	—	0.182	—	0.186		0.190		0.192
12	4/16/78		0.070	0.071	0.080	—	0.080	0.082	—	0.079	—	0.079		—		0.076
13	4/12/78		0.080	0.080	0.089	—	0.091	0.093	—	0.091	—	0.091		—		0.094
14	4/18/78		0.090	0.090	0.093	0.106	0.110	0.112	—	0.116	—	0.114		—		0.116
15	4/18/78		0.099	0.102	0.109	0.121	0.130	0.132	—	0.134	—	0.134		—		0.142
16	3/28/78		0.070	0.071	0.072	—	—	0.074	—	0.069	—	0.069		—		0.064
17	4/13/78		0.110	0.112	0.125	0.141	0.151	0.155	0.151	0.158	0.157	0.161	0.164	0.166	0.163	0.167
18	4/25/78		0.063	0.063	0.069	—	0.073	0.074	—	0.074	—	0.075		0.083		0.077
19	4/28/78		0.073	0.073	0.080	—	0.086	0.086	—	0.089	—	0.089		0.092		0.089
20	4/28/78		0.078	0.083	0.086	0.096	0.104	0.101	—	0.104	—	0.105		0.108		0.108
21	4/28/78		0.096	0.103	0.107	0.112	0.128	0.127	0.128	0.134	0.131	0.137	0.137	0.142	0.140	0.145
22	4/25/78		0.071	0.076	0.081	0.084	0.092	0.094	—	0.089	—	0.091		0.091		0.087
23	5/12/78		0.100	0.112	0.118	0.130	0.142	0.145	—	0.142	—	0.146		0.152		0.158
24	5/8/78		0.080	0.081	0.088	0.100	0.099	0.102	—	0.097	—	0.091		0.098		0.097
25	5/8/78		0.090	0.103	0.109	0.120	0.127	0.130	—	0.127	—	0.124		0.132		0.132
26	5/12/78		0.100	0.112	0.122	0.131	0.144	0.144	—	0.144	—	0.142		0.149		0.157

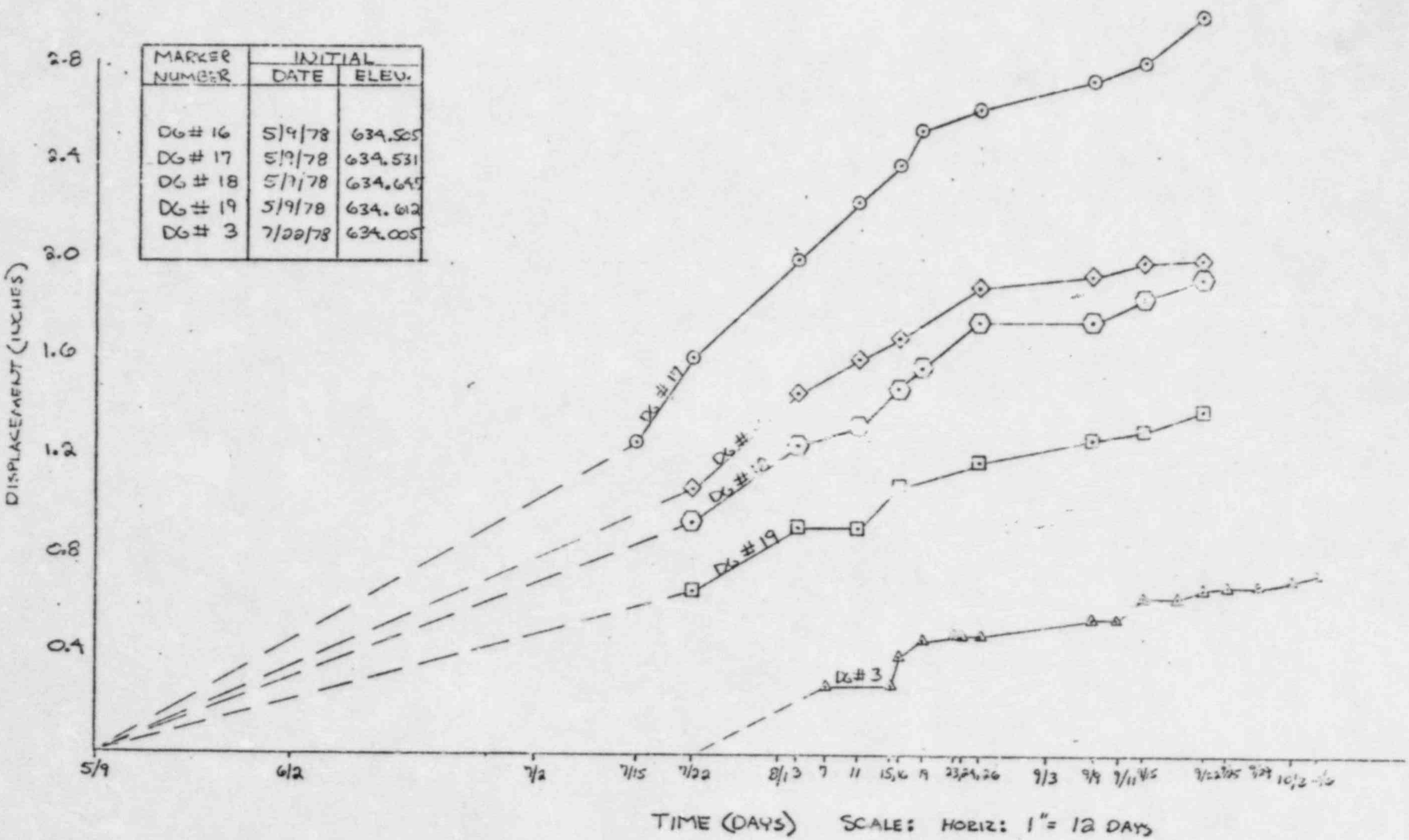
MARKER NUMBER	INITIAL DATE	INITIAL ELEV	TOTAL SETTLEMENT (FT) + OBSERVATION DATE: 7/15/78	7/22	8/3	8/7	8/11	8/15	8/16	8/19	8/23	8/24	8/26	9/9	9/11	9/15	9/19	9/22
DG-16	5/19/78	634.505		0.089	0.123		0.134		0.143				0.159	0.163		0.168		0.175
DG-17	5/19/78	634.531	0.167	0.135	0.175		0.181		0.201	0.213			0.220	0.229		0.235		0.253
DG-18	5/19/78	634.645		0.081	0.107		0.111		0.134	0.131			0.139	0.148		0.156		.16[illegible]
DG-19	5/19/78	634.612		0.056	0.079		0.079		0.098				0.100	0.109		0.114		.118
DG-3	7/22/78	634.055				0.083		0.033	0.094	0.090	0.093	0.093	0.043	0.044	0.048	0.054	.054	.057

CARL DIRNBAUER DATE 9/11/78 CHECKED BY ______ SHEET N ___ DATE ___

PROJECT MIDLAND PLANT UNITS 1-2 JOB NO. ______

SUBJECT DIESEL GEN. BLDG [illegible] SETTLEMENT MARKERS FILE NO. ______

MARKER NUMBER	INITIAL DATE	INITIAL ELEV.
DG # 16	5/9/78	634.505
DG # 17	5/9/78	634.531
DG # 18	5/9/78	634.645
DG # 19	5/9/78	634.612
DG # 3	7/22/78	634.005



CALCULATION SHEET

DESIGN ARL DIRNBAUER DATE 9/11/78 CHECKED BY ______ DATE ______ SHEET NO. ______

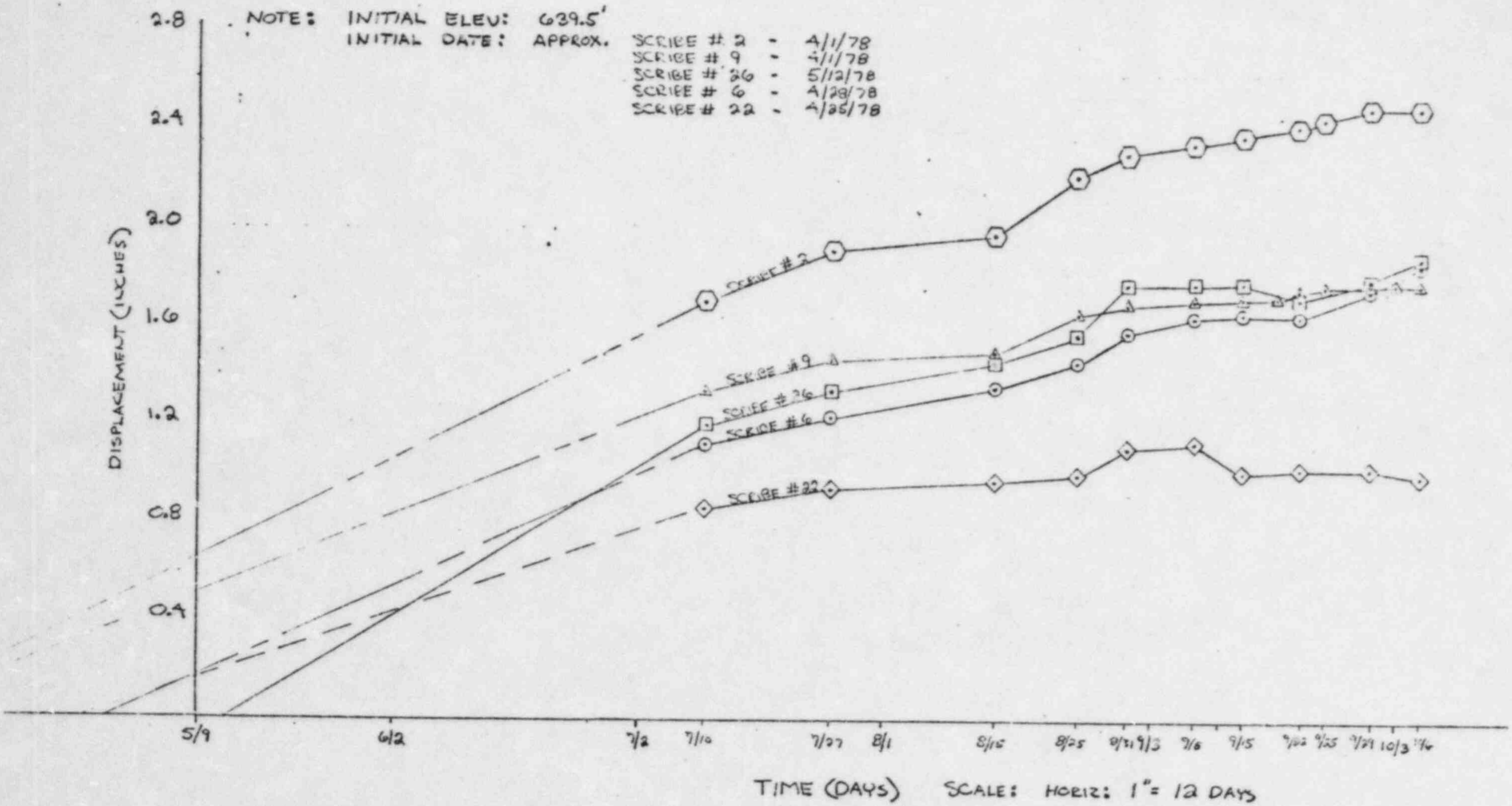
PROJECT MIDLAND PLANT UNITS 1-2 JOB NO. ______

SUBJECT DIESEL GEN. BLDG SCRIBES FILE NO. ______

GENERAL NOTES

1] ALL SCRIBE MARKS WERE INSTALLED AT EL. 639.5'

2] NO DATE WERE RECORDED WHEN INSTALLING SCRIBES. DATES ARE ESTIMATED FROM THE CONCRETE POUR DATES. [TWO WKS. AFTER POUR (TYP)]

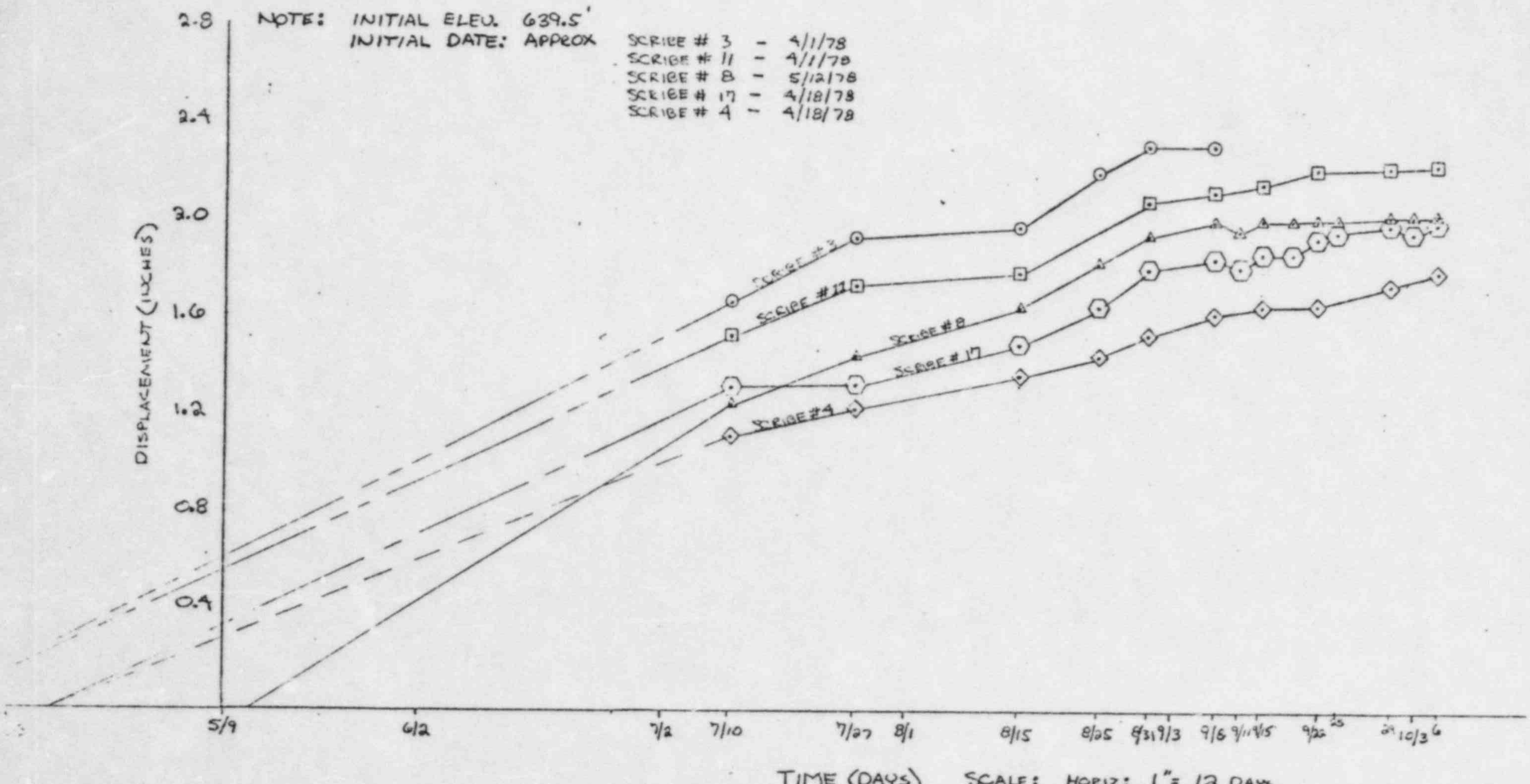


CALCULATION SHEET

BY: CARL DIRNBAUER DATE: 9/11/78 CHECKED BY: ________ DATE: ________ SHEET NO. ________

PROJECT: MIDLAND PLANT UNITS 1-2 JOB NO. ________

SUBJECT: DIESEL GEN. BLDG SCRIBES FILE NO. ________



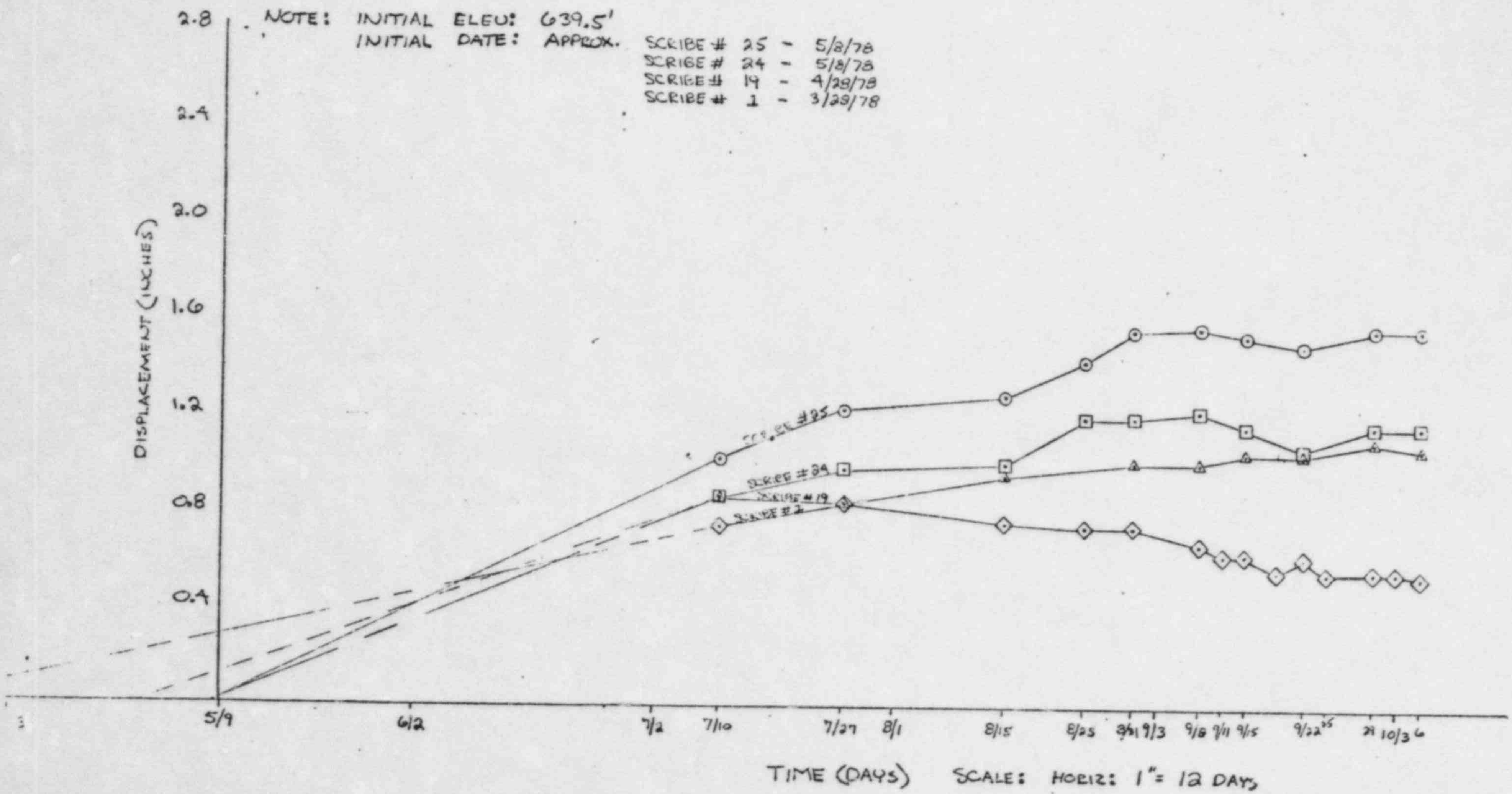
CALCULATION SHEET

BY CARL DIRNBAUER DATE 9/11/78 CHECKED BY ______ DATE ______

SHEET NO. ______

PROJECT MIDLAND PLANT UNITS 1-2 JOB NO. ______

SUBJECT DIESEL GEN. BLDG SCRIBES FILE NO. ______



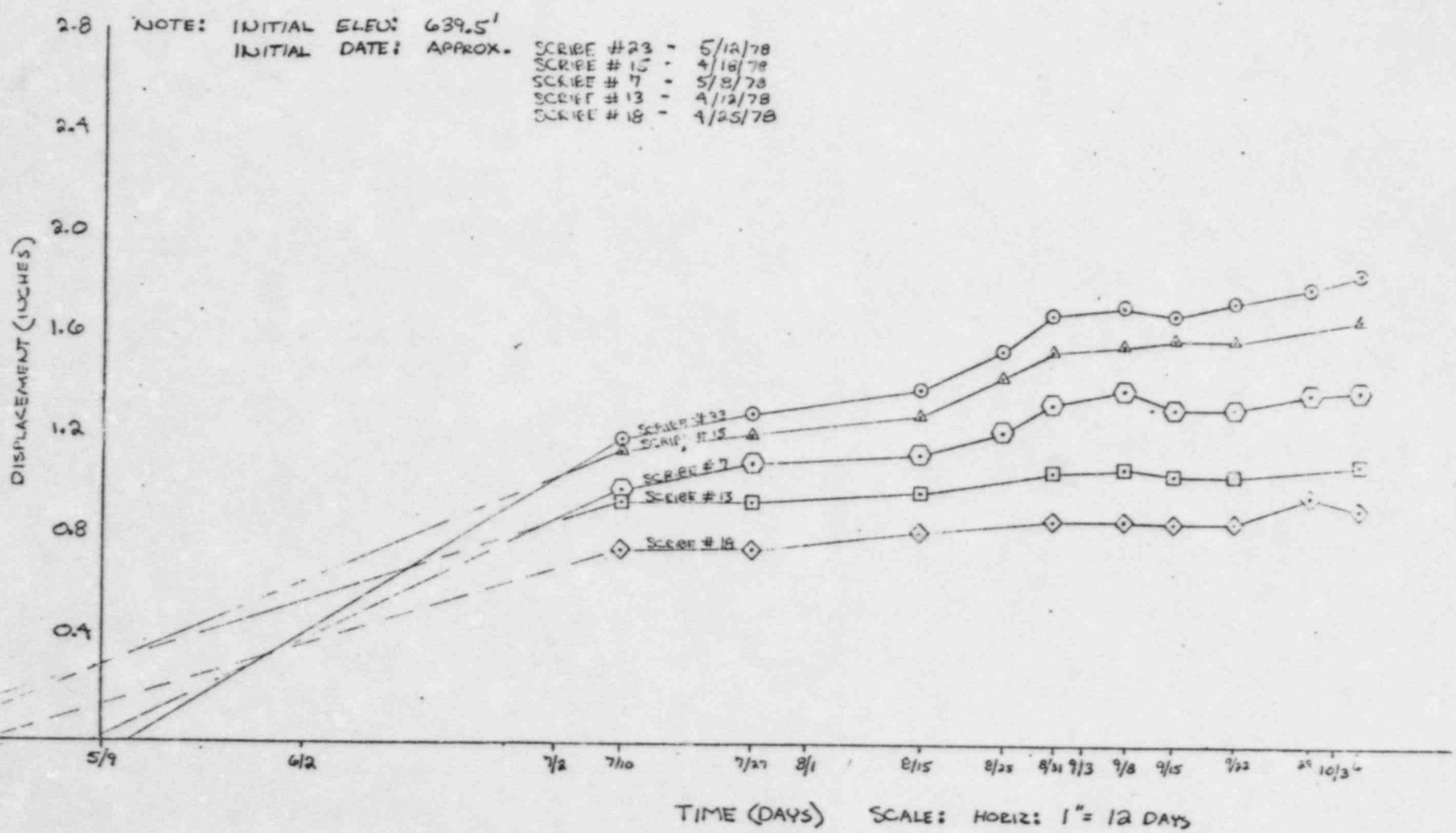
CALCULATION SHEET

DATE ____

DESIGN ARL DIRNBAUER DATE 9/11/78 CHECKED BY ____ SHEET NO. ____

PROJECT MIDLAND PLANT UNITS 1-2 JOB NO. ____

SUBJECT DIESEL GEN. BLDG SCRIBES FILE NO. ____



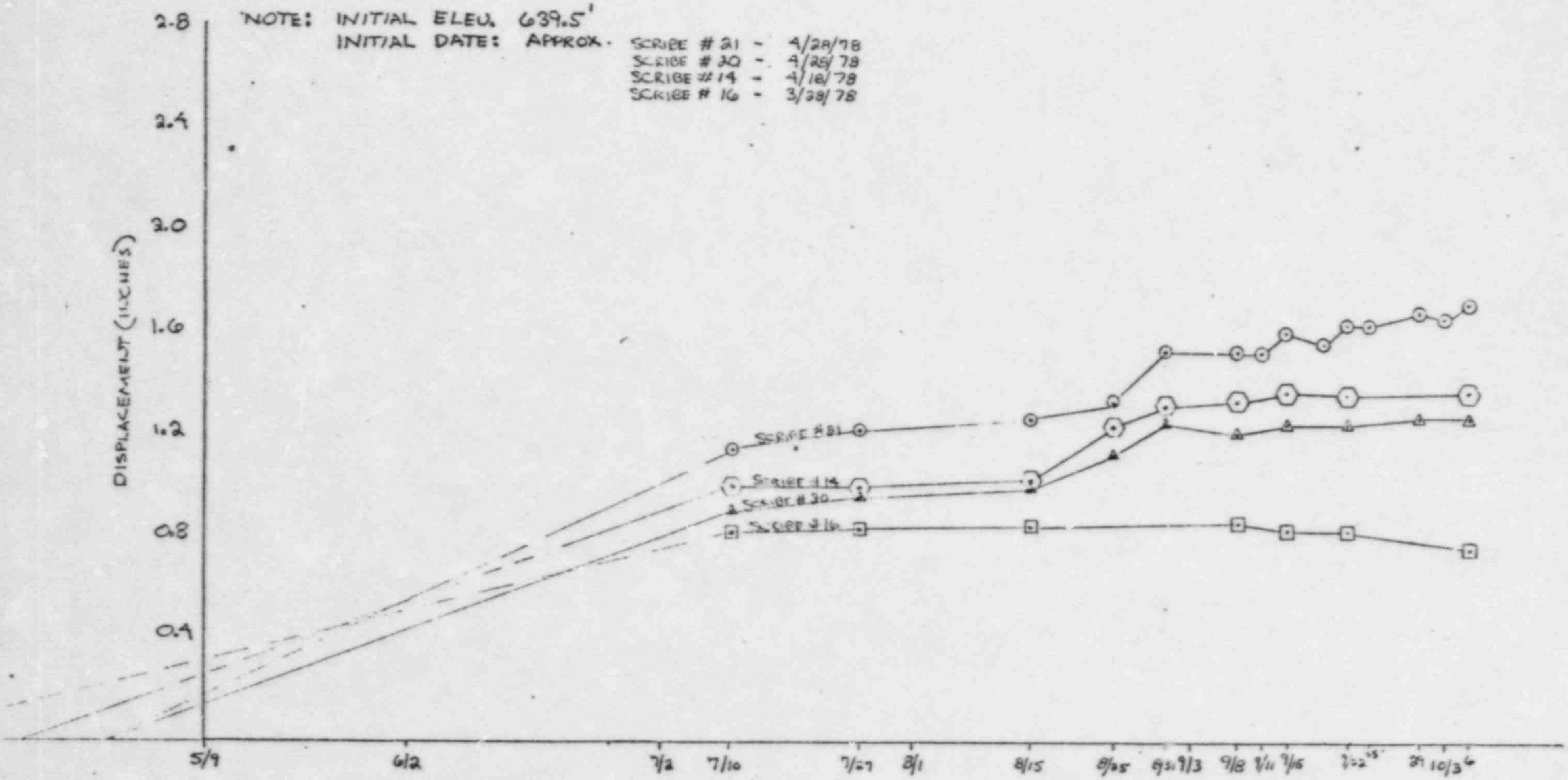
CALCULATION SHEET

DESIGN IRL DIRNBAUER DATE 9/11/78 CHECKED BY ______ DATE ______ SHEET NO. ______

PROJECT MIDLAND PLANT UNITS 1-2 JOB NO. ______

SUBJECT DIESEL GEN. BLDG SCRIBES FILE NO. ______

NOTE: INITIAL ELEV. 639.5'
INITIAL DATE: APPROX. SCRIBE #21 - 4/28/78
SCRIBE #20 - 4/28/78
SCRIBE #14 - 4/18/78
SCRIBE #16 - 3/28/78



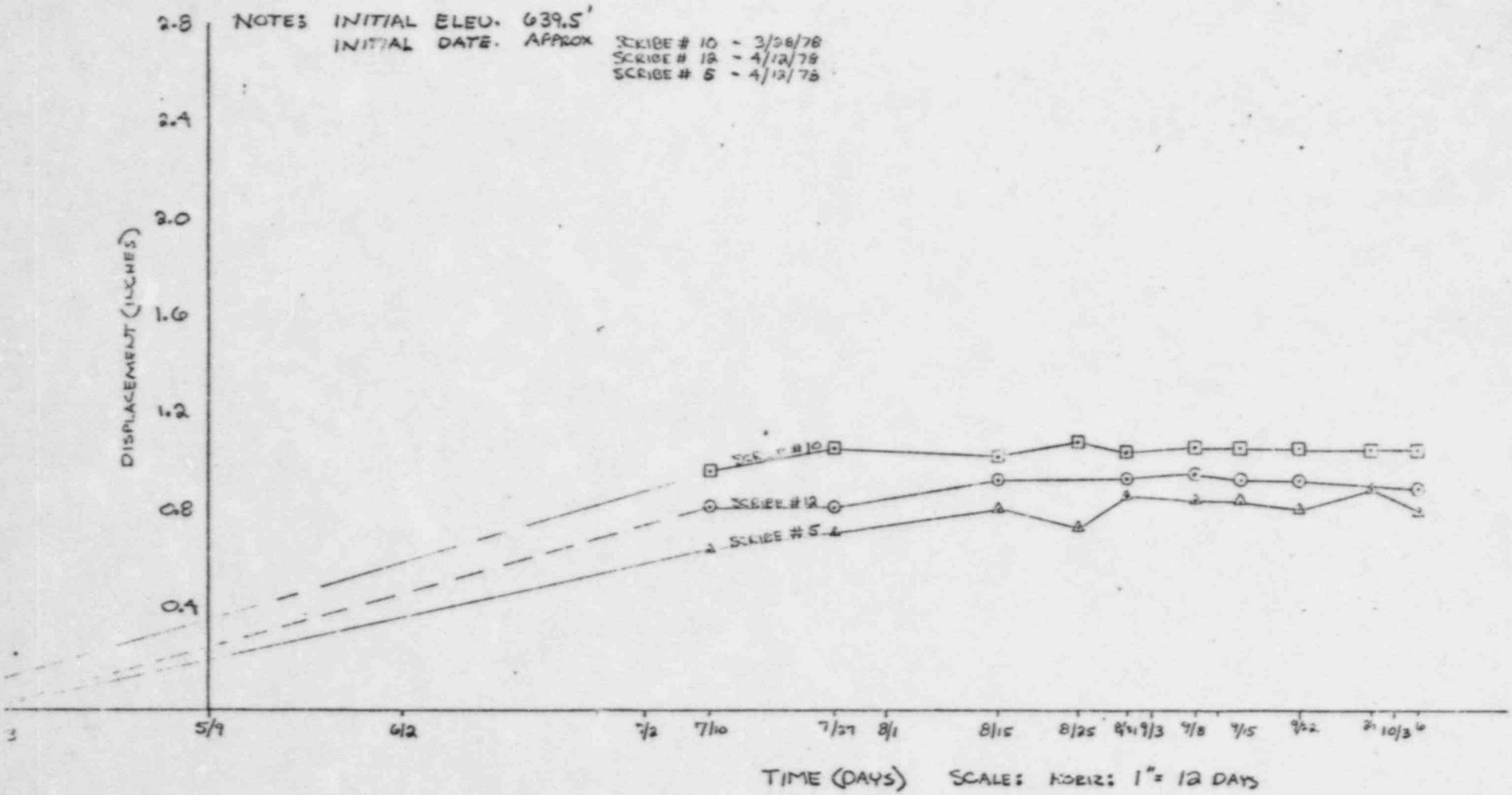
TIME (DAYS) SCALE: HORIZ: 1" = 12 DAYS

CALCULATION SHEET

DESIGN ARL DIRNBAUER DATE 9/11/78 CHECKED BY ______ DATE ______ SHEET NO. ______

PROJECT MIDLAND PLANT UNITS 1-2 JOB NO. ______

SUBJECT DIESEL GEN. BLDG SCRIBES FILE NO. ______



H

Project No. 7220
Boring No. ---
Source N. Miller Dike
[Ha]mmer weight 10 lbs
[Drop] distance 18 ins
Layers 4
[N]o. Blows 25

-200
-74
...ith
...proctor

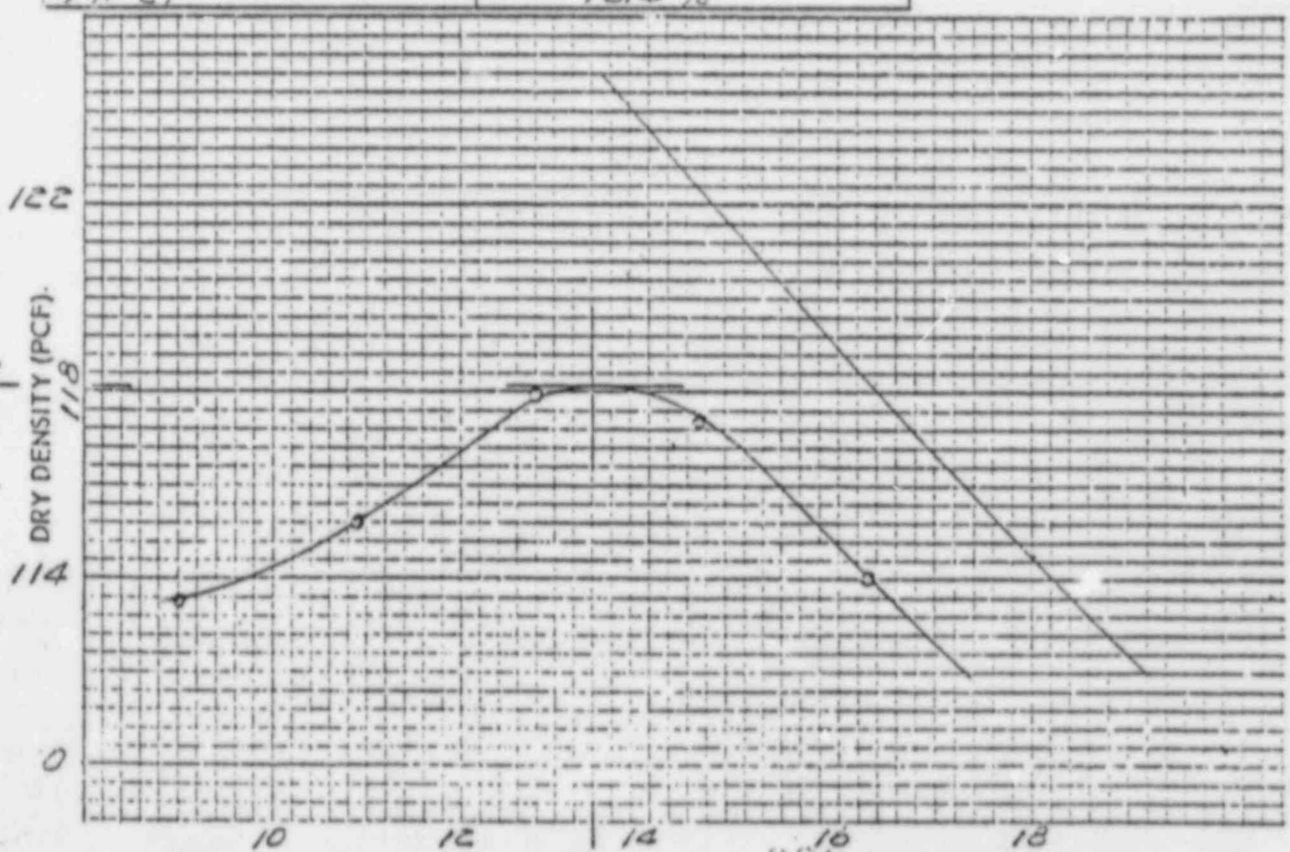
...3

Attached are all the BMP
Proctors performed in D G Area

BMP #s [illegible] 264
252 251
254 269
255 270
256 271
257 274
260 278
261 257
262 277
263

Brown silty cla[y]

Mold No.					
Wt. wet sample + Mold (gm)					
Wt. of Mold (gm)	[illegible]	[illegible]	[illegible]	[illegible]	6648.0
Wt. of wet sample (gm)	4511.0	4350.0	4526.0	4570.0	4512.0
Vol. of sample (CC)	2124.0	2124.0	2124.0	2124.0	2124.0
Wet Unit Weight (lb. /cu.ft.)	129.7	127.8	133.0	134.3	132.6
Can No.	57	77	56	76	74
Wt. wet sample + Can (gm.)	773.4	680.7	791.7	770.4	780.9
Wt. Dry sample + Can (gm.)	716.1	621.6	710.8	683.0	683.0
Wt. water (gm.)	57.3	59.1	80.9	87.4	97.9
Wt. can (gm.)	76.1	78.9	76.5	79.0	80.6
Wt. dry sample (gm.)	640.0	542.7	634.3	604.0	602.4
Moisture Content %	9.0	10.9	12.8	14.5	16.3
Average Moisture Content %	—	—	—	—	—
Dry Unit Weight (lb. /cu.ft.)	113.5	115.2	117.9	117.3	114.0
Max. Dry Density	118.1 lbs/cu. ft.				
M. C.	13.4 %				



0203

SP. G. = 2.74
UST O-303

[signature] Lead Engineer 12-23

COMPACTION TEST

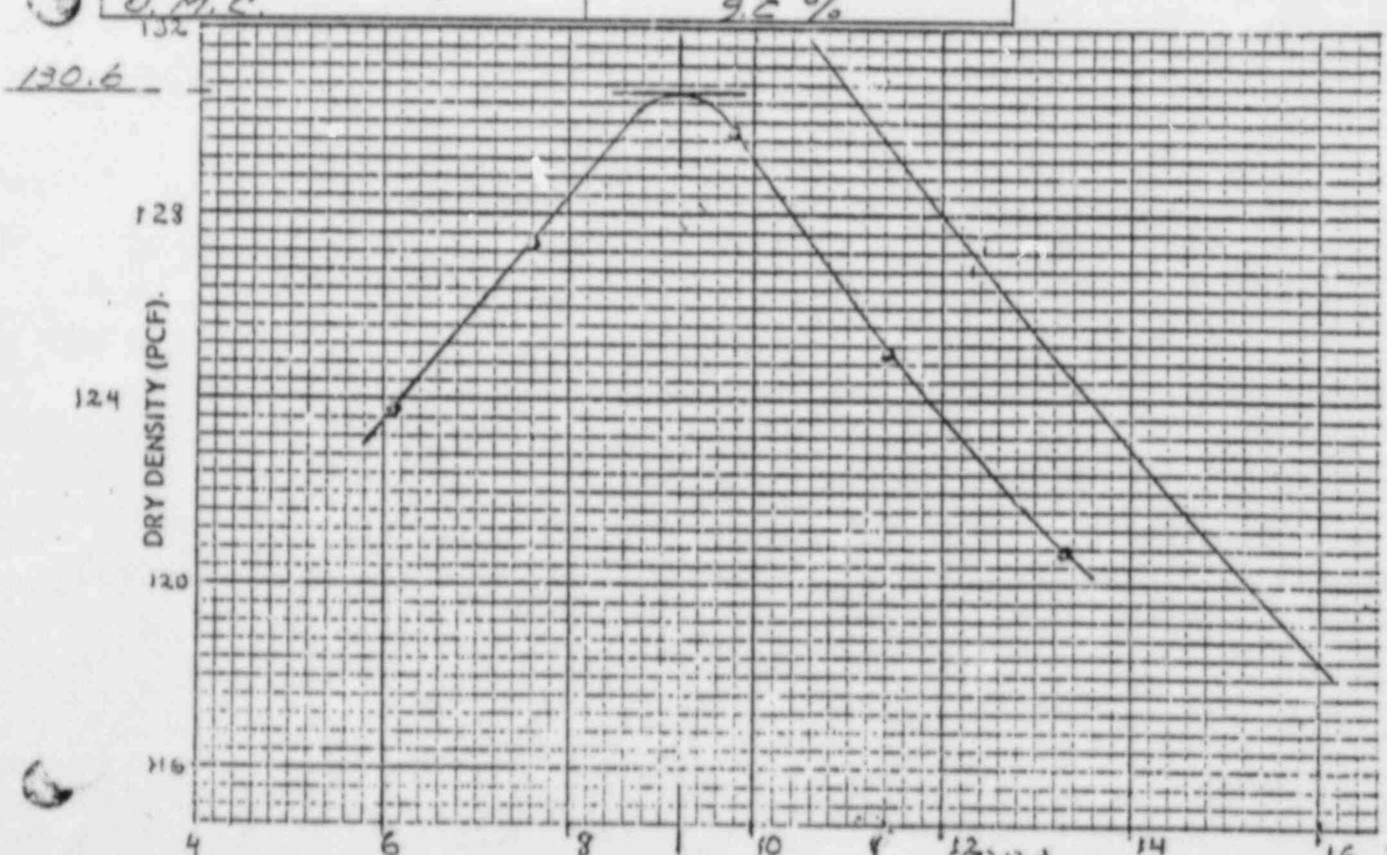
Project No. 7220
Boring No. NONE
Source South Dike 51+00
Hammer weight 10 LB.
Drop distance 18 INCHES
No. Layers 4
No. Blows 25

Lab. No. 251
Date 1-7-75
Initials JB
Type of test SMP
Mold size 6 INCHES

Grayish Br. Sandy silty Clay, W/Tr. Gravel.

TEST DATA						
Mold No.	PM-1	PM-1	PM-1	PM-1	PM-1	
Wt. wet sample + Mold (gm)	11106	11306	11490	11382	11292	
Wt. of Mold (gm)	6640	6640	6640	6640	6640	
Wt. of wet sample (gm)	4466	4666	4850	4742	4652	
Vol. of sample (CC)	2124	2124	2124	2124	2124	
Wet Unit Weight (lb. /cu.ft.)	131.2	137.1	142.5	139.3	136.7	
Can No.	57	71	56	58	74	
Wt. wet sample + Can (gm.)	651.3	652.8	653.0	652.8	651.5	
Wt. Dry sample + Can (gm.)	618.3	612.3	601.5	594.0	584.6	
Wt. water (gm.)	33.0	40.5	51.5	58.8	66.9	
Wt. can (gm.)	76.1	79.0	76.5	79.1	80.6	
Wt. dry sample (gm.)	542.2	533.3	525.0	514.9	504.0	
Moisture Content %	6.1	7.6	9.8	11.4	13.3	
Average Moisture Content %	6.1	7.6	9.8	11.4	13.3	
Dry Unit Weight (lb. /cu.ft.)	123.7	127.4	129.8	125.0	120.7	

Max Dry Density	130.6 lbs/cu. ft.
O.M.C.	9.2 %



SP.G. = 2.72

C304

Kurt Nidermeyer [illegible]

COMPACTION TEST

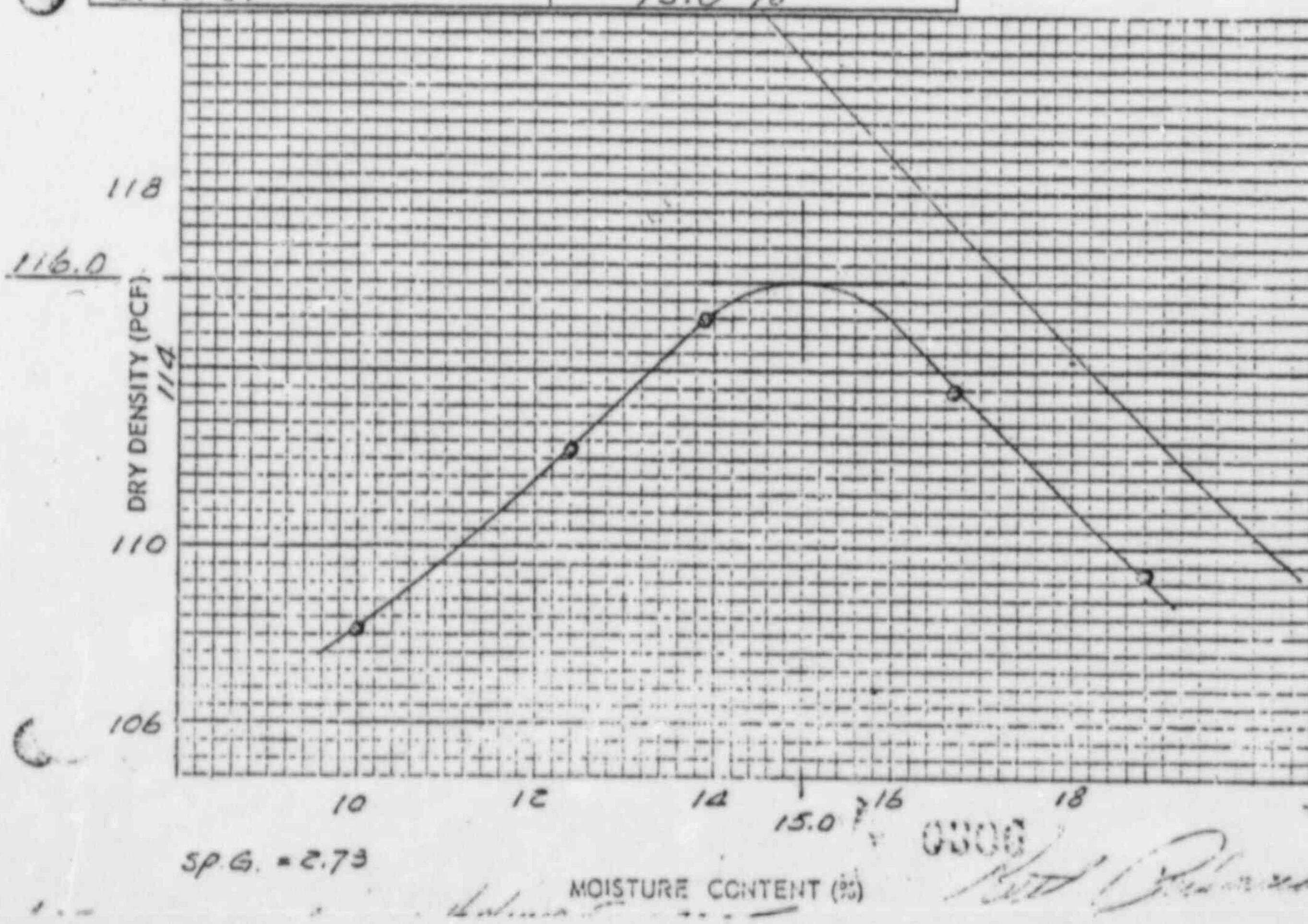
Project No. TCCO
Boring No. —
Source E Dike 0+00
Hammer weight 10 lbs
Drop distance 18 ins
No. Layers 4
No. Blows 25

Lab. No. BMP-252
Date 1-13-75
Initials T.M.
Type of test S.M. proctor
Mold size 6"

Brown, silty clay w/so. sand & tr. Gravel.

TEST DATA						
Mold No.	PM-1	PM-1	PM-1	PM-1	PM-1	
Wt. wet sample + Mold (gm)	10686	10932	11106	11152	11064	
Wt. of Mold (gm)	6640	6640	6640	6640	6640	
Wt. of wet sample (gm)	4046	4292	4466	4512	4424	
Vol. of sample (CC)	2124	2124	2124	2124	2124	
Wet Unit Weight (lb. /cu.ft.)	118.9	126.1	131.2	132.6	130.0	
Can No.	18	14	16	15	16	
Wt. wet sample + Can (gm.)	669.8	692.5	684.5	691.0	693.0	
Wt. Dry sample + Can (gm.)	615.9	625.8	611.7	605.0	597.3	
Wt. water (gm.)	53.9	66.7	72.8	86.0	95.7	
Wt. can (gm.)	76.8	90.0	86.9	89.5	86.9	
Wt. dry sample (gm.)	539.1	535.8	524.8	515.5	510.4	
Moisture Content %	10.0	12.4	13.9	16.7	18.8	
Average Moisture Content %	10.0	12.4	13.9	16.7	18.8	
Dry Unit Weight (lb. /cu.ft.)	108.1	112.2	115.2	113.6	109.4	

Max. Dry Density	116.0 lbs/cu.ft.
O. M. C.	15.0 %



SP.G. = 2.73

0306

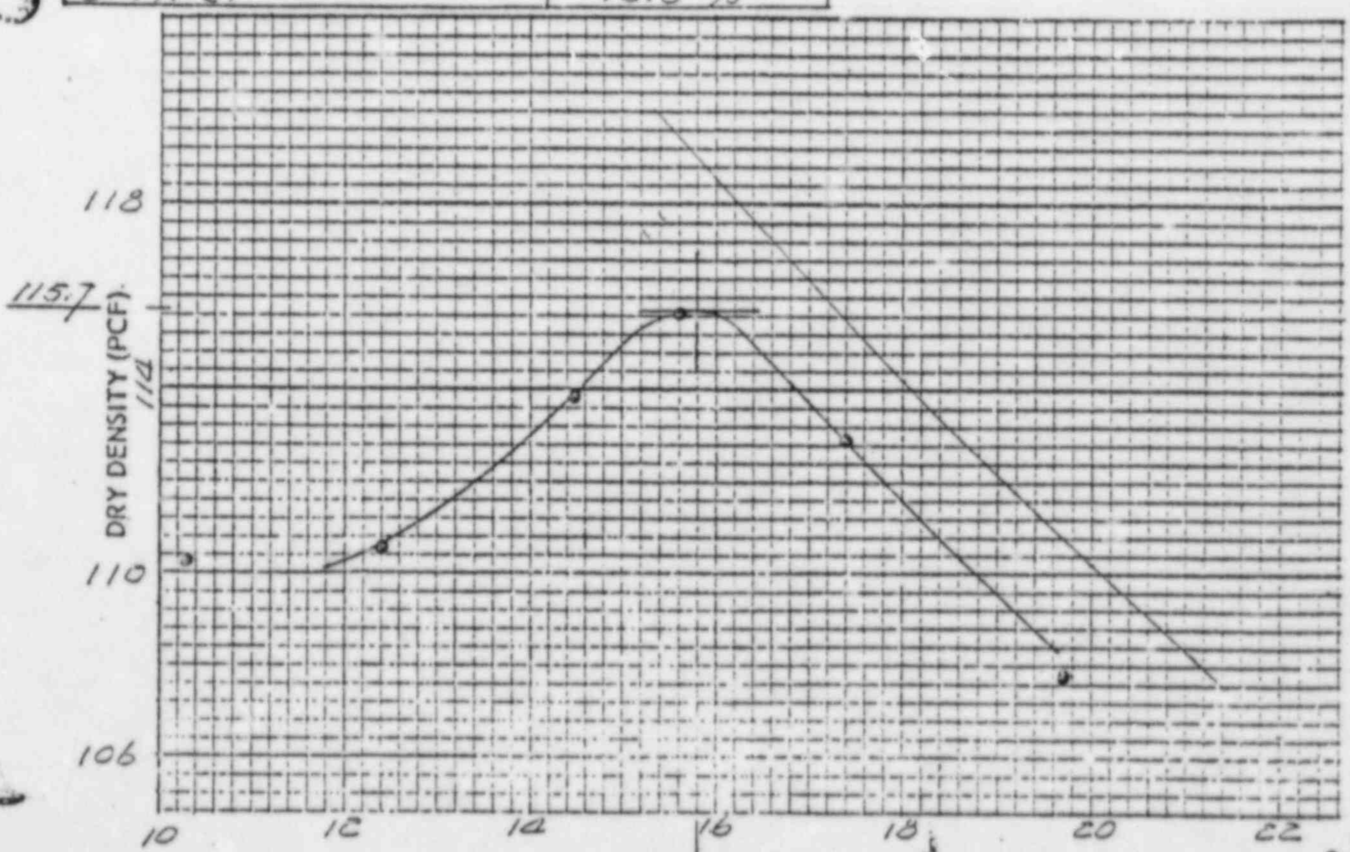
COMPACTION TEST

Project No. 7220
Boring No. —
Source N. Miller Dike 1+00
Hammer weight 10 lbs
Drop distance 18 ins
No. Layers 4
No. Blows 25

Lab. No. BMP-254
Date 8-8-75
Initials P.W.
Type of test A.M. proctor
Mold size 6"

Brown silty Clay. w/little Sand & Tr. Gravel.

TEST DATA						
Mold No.	PM-2	PM-2	PM-2	PM-2	PM-2	PM-2
Wt. wet sample + Mold (gm)	9960	10048	10254	10376	10332	10207
Wt. of Mold (gm)	5820	5820	5820	5820	5820	5820
Wt. of wet sample (gm)	4140	4228	4434	4556	4512	4387
Vol. of sample (c.c)	2124	2124	2124	2124	2124	2124
Wet Unit Weight (lb. /cu.ft.)	121.6	124.2	130.3	133.8	132.6	128.9
Can No.	58	56	74	71	70	72
Wt. wet sample + Can (gm.)	584.6	583.1	592.0	596.5	593.9	592.6
Wt. Dry sample + Can (gm.)	536.7	527.3	527.2	526.7	517.8	508.1
Wt. water (gm.)	47.3	55.8	64.8	69.8	76.1	84.5
Wt. can (gm.)	79.1	76.5	80.6	80.5	80.0	79.2
Wt. dry sample (gm.)	457.6	450.8	446.6	446.2	437.8	428.9
Moisture Content %	10.3	12.4	14.5	15.6	17.4	19.7
Average Moisture Content %						
Dry Unit Weight (lb. /cu.ft.)	110.2	110.5	113.8	115.7	112.9	107.7
Max. Dry Density	115.7 lb/cf					
O. M. C.	15.8 %					



Sp. G. = 2.73

MOISTURE CONTENT (%)

0300

[signature] 8-15-75

COMPACTION TEST

Project No. 7220
Boring No. —
Source N. Miller Dike 16+00
Hammer weight 10 lbs
Drop distance 18 ins
No. Layers 4
No. Blows 25

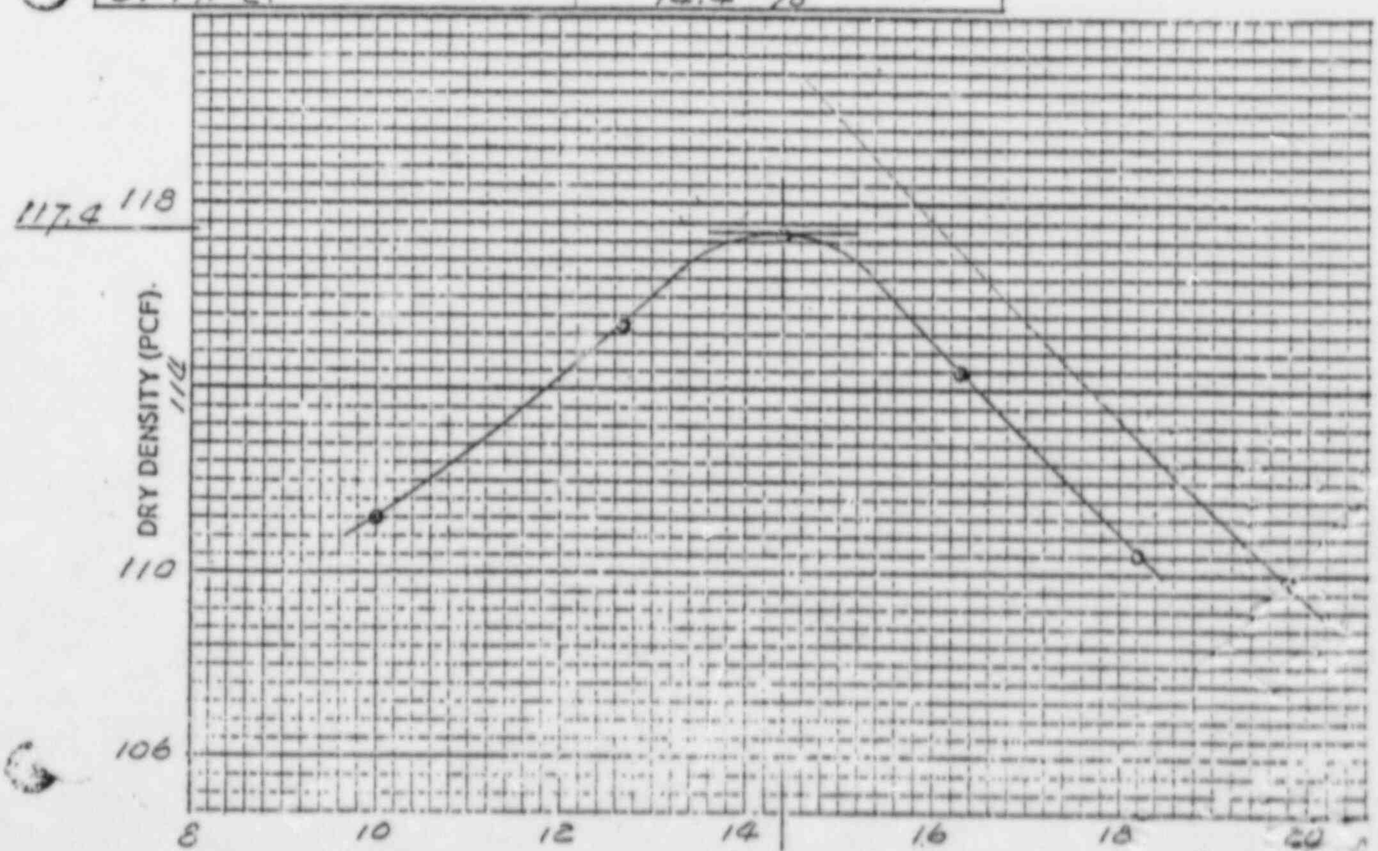
Lab. No. BMP-255
Date 9-18-75
Initials P.W.
Type of test B.M. Proctr
Mold size 6"

Brown Sandy silty Clay, w/tr. coarse sand.

TEST DATA

Mold No.	PM-2	PM-2	PM-2	PM-2	PM-2	
Wt. wet sample + Mold (gm)	9984	10245	10392	10352	10267	
Wt. of Mold (gm)	5820	5820	5820	5820	5820	
Wt. of wet sample (gm)	4164	4425	4572	4532	4447	
Vol. of sample (C.C.)	2124	2124	2124	2124	2124	
Wet Unit Weight (lb. /cu.ft.)	122.3	130.0	134.3	133.1	130.6	
Can No.	71	74	70	56	58	
Wt. wet sample + Can (gm.)	592.5	595.3	595.6	591.6	594.4	
Wt. Dry sample + Can (gm.)	546.1	537.4	530.6	519.5	515.2	
Wt. water (gm.)	46.4	57.9	65.0	72.1	79.2	
Wt. can (gm.)	80.5	80.6	80.0	76.5	79.1	
Wt. dry sample (gm.)	465.6	456.8	450.6	443.0	436.1	
Moisture Content %	10.0	12.7	14.4	16.3	18.2	
Average Moisture Content %	—	—	—	—	—	
Dry Unit Weight (lb. /cu.ft.)	111.2	115.4	117.4	114.4	110.5	

Max. Dry Density	117.4 lbs/cu. ft.
O. M. C.	14.4 %



Sp.G. = 2.70

U311 [signature] 8-28-75

COMPACTION TEST

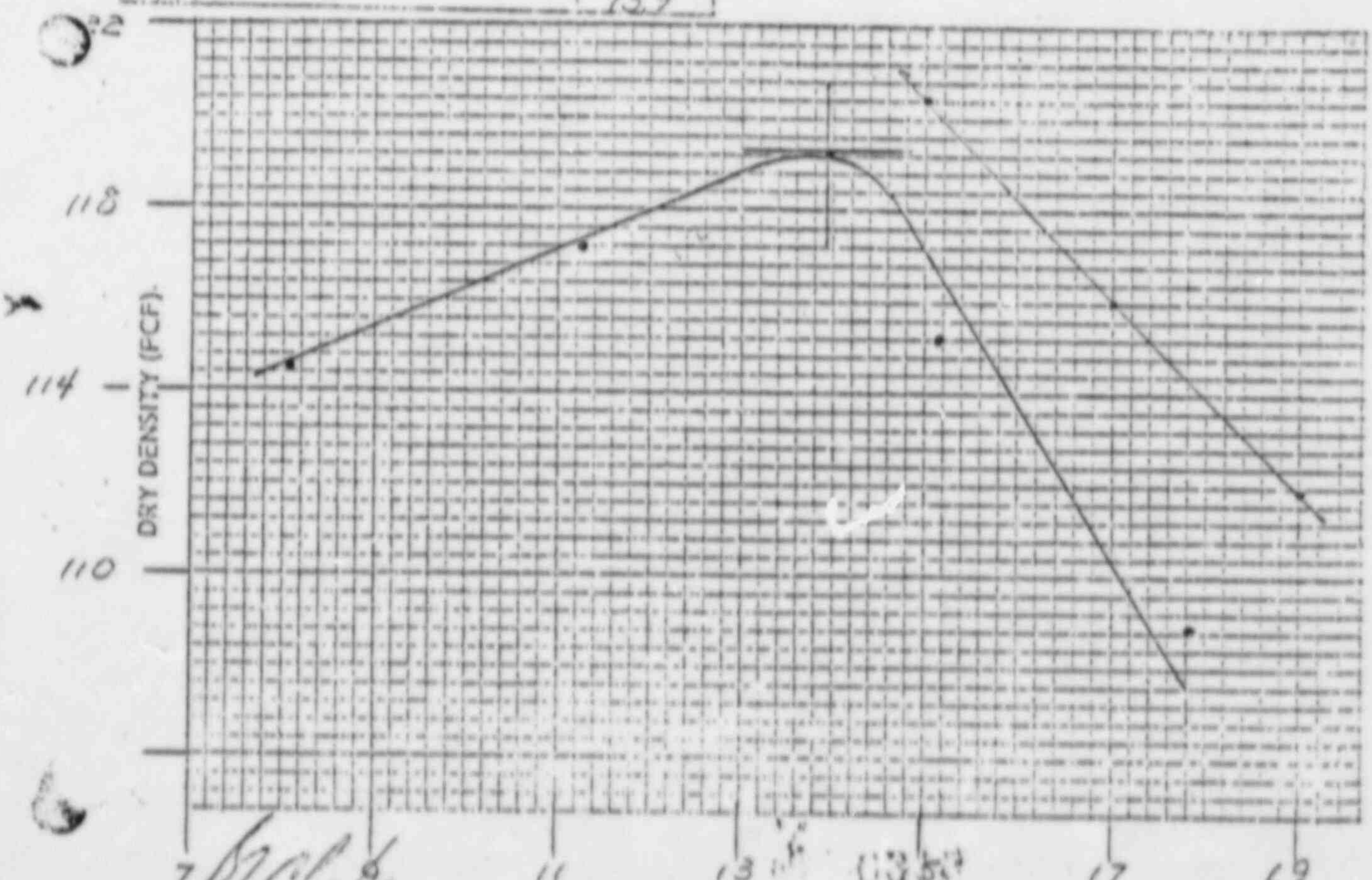
Project No. 7220
Boring No. NONE
Source MURGARD BORROW PIT
Hammer weight 10 LBS.
Drop distance 18"
No. Layers 4
No. Blows 25

Lab. No. 256
Date 8/21/75
Initials GL
Type of test BMP
Mold size 6"

* CORRECTED COPY

TEST DATA

Mold No.	PM-1		PM-1		PM-1		PM-1		PM-1		
Wt. wet sample + Mold ( )	10855		11090		11276		11164		11015		
Wt. of Mold ( )	6648		6648		6648		6648		6648		
Wt. of wet sample ( )	4207		4442		4628		4516		4367		
Vol. of sample ( )	2124		2124		2124		2124		2124		
Wet Unit Weight (lb. /cu.ft.)	123.6		130.5		136.0		132.7		128.3		
Can No.	54	30	36	28	74		39	49	37	4	
Wt. wet sample + Can (gm.)	283.0	269.0	266.4	287.5	570.2		253.4	266.5	302.1	310.3	
Wt. Dry sample + Can (gm.)	266.7	250.5	243.8	261.8	510.4		224.3	237.2	262.6	269.2	
Wt. water (gm.)	16.3	18.5	22.6	25.7	59.8		29.1	29.3	39.5	41.1	
Wt. can (gm.)	39.4	36.7	36.9	36.9	80.6		33.7	38.0	35.4	43.3	
Wt. dry sample (gm.)	227.3	213.8	206.9	224.9	429.8		190.6	199.2	227.2	225.9	
Moisture Content %	7.2	8.7	10.9	11.4	13.9		15.3	14.9	17.4	18.2	
Average Moisture Content %	8.0		11.2		13.9		15.1		17.8		
Dry Unit Weight (lb. /cu.ft.)	114.4		117.4		119.4		115.3		108.9		
Max Dry Density	119.4										
OMC	13.9										



* CORRECTED MOISTURE LINE ON GRAPH. VALUE REMAINS THE

B. C. [illegible]
12/17/75

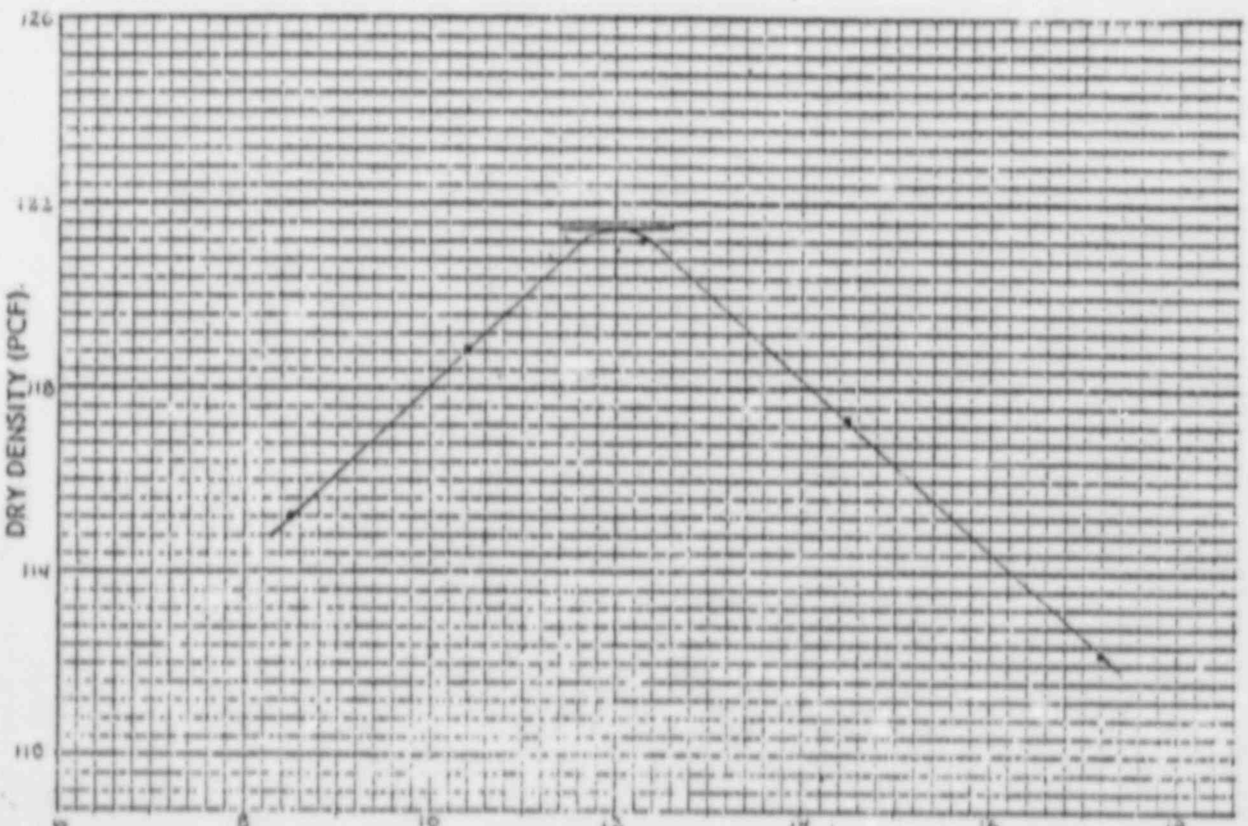
COMPACTION TEST

Project No. 7220
Boring No. Mone
Source —
Hammer weight 10 LB.
Drop distance 18"
No. Layers 4
No. Blows 25

Lab. No. 257
Date 8/27/75
Initials Dr.
Type of test BMP
Mold size 6"

TEST DATA						
Mold No.	PM-1	PM-1	PM-1	PM-1	PM-1	
Wt. wet sample + Mold ( )	10903	11110	11277	11227	11139	
Wt. of Mold ( )	6648	6648	6648	6648	6648	
Wt. of wet sample ( )	4255	4462	4629	4579	4285 4490	
Vol. of sample ( )	2124	2124	2124	2124	2124	
Wet Unit Weight (lb. /cu.ft.)	125.0	131.1	136.0	134.5	131.9	
Can No.	76	74	72	57	77	
Wt. wet sample + Can (gm.)	758.2	611.5	621.9	611.7	719.4	
Wt. Dry sample + Can (gm.)	705.2	561.5	562.3	544.0	625.3	
Wt. water (gm.)	53.0	50.0	59.6	67.7	94.1	
Wt. can (gm.)	79.0	80.6	79.2	76.1	78.9	
Wt. dry sample (gm.)	626.2	480.9	483.1	467.9	546.4	
Moisture Content %	8.5	10.4	12.3	14.5	17.2	
Average Moisture Content %	8.5	10.4	12.3	14.5	17.2	
Dry Unit Weight (lb. /cu.ft.)	115.2	118.8	121.1	117.5	112.5	

121.7



12.0
MOISTURE CONTENT (%)

0315

EPA 9/5/75

d ST Au. 73

COMPACTION TEST

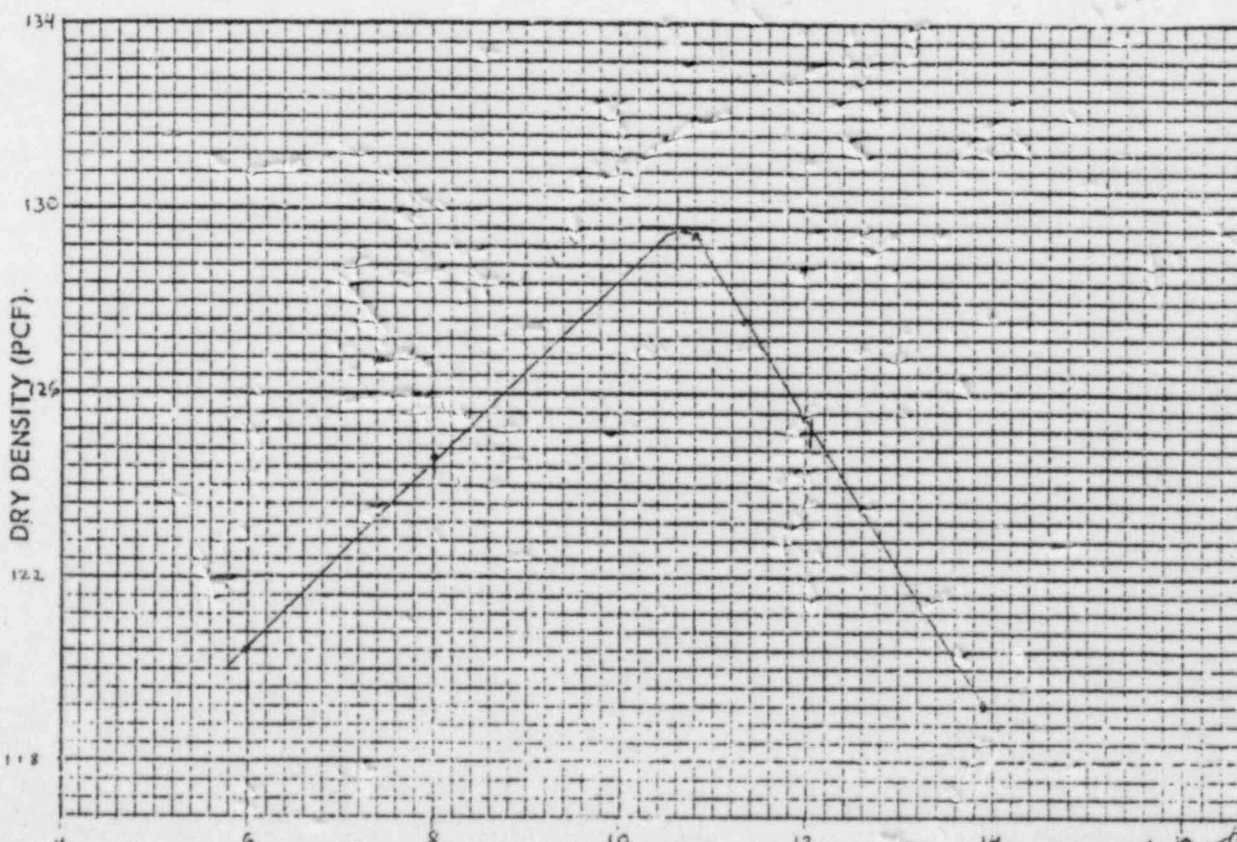
Project No. 1220
Boring No. NONE
Source ~
Hammer weight 10 lb.
Drop distance 18"
No. Layers 4
No. Blows 25

Lab. No. 760
Date 9/23/75
Initials JK
Type of test BMP
Mold size 6"

TEST DATA

Mold No.	PM-2	PM-2	PM-2	PM-2	PM-2	
Wt. wet sample + Mold ( )	10171	10432	10695	10653	10438	
Wt. of Mold ( )	5815	5815	5815	5815	5815	
Wt. of wet sample ( )	4356	4617	4880	4838	4623	
Vol. of sample ( )	2124	2124	2124	2124	2124	
Wet Unit Weight (lb. /cu.ft.)	128.0	135.6	143.4	142.1	135.8	
Can No.	70	58	57	78	74	
Wt. wet sample + Can (gm.)	661.9	672.4	617.8	676.9	766.2	
Wt. Dry sample + Can (gm.)	629.0	628.6	565.0	616.4	682.4	
Wt. water (gm.)	32.9	43.8	52.8	60.5	83.8	
Wt. can (gm.)	80.0	79.1	76.1	80.2	80.6	
Wt. dry sample (gm.)	549.0	549.5	488.9	536.2	601.8	
Moisture Content %	6.0	8.0	10.8	11.3	13.9	
Average Moisture Content %	6.0	8.0	10.8	11.3	13.9	
Dry Unit Weight (lb. /cu.ft.)	120.8	125.6	129.4	127.7	119.2	

129.8



0322

MOISTURE CONTENT (%) 10.6

UST 8-154

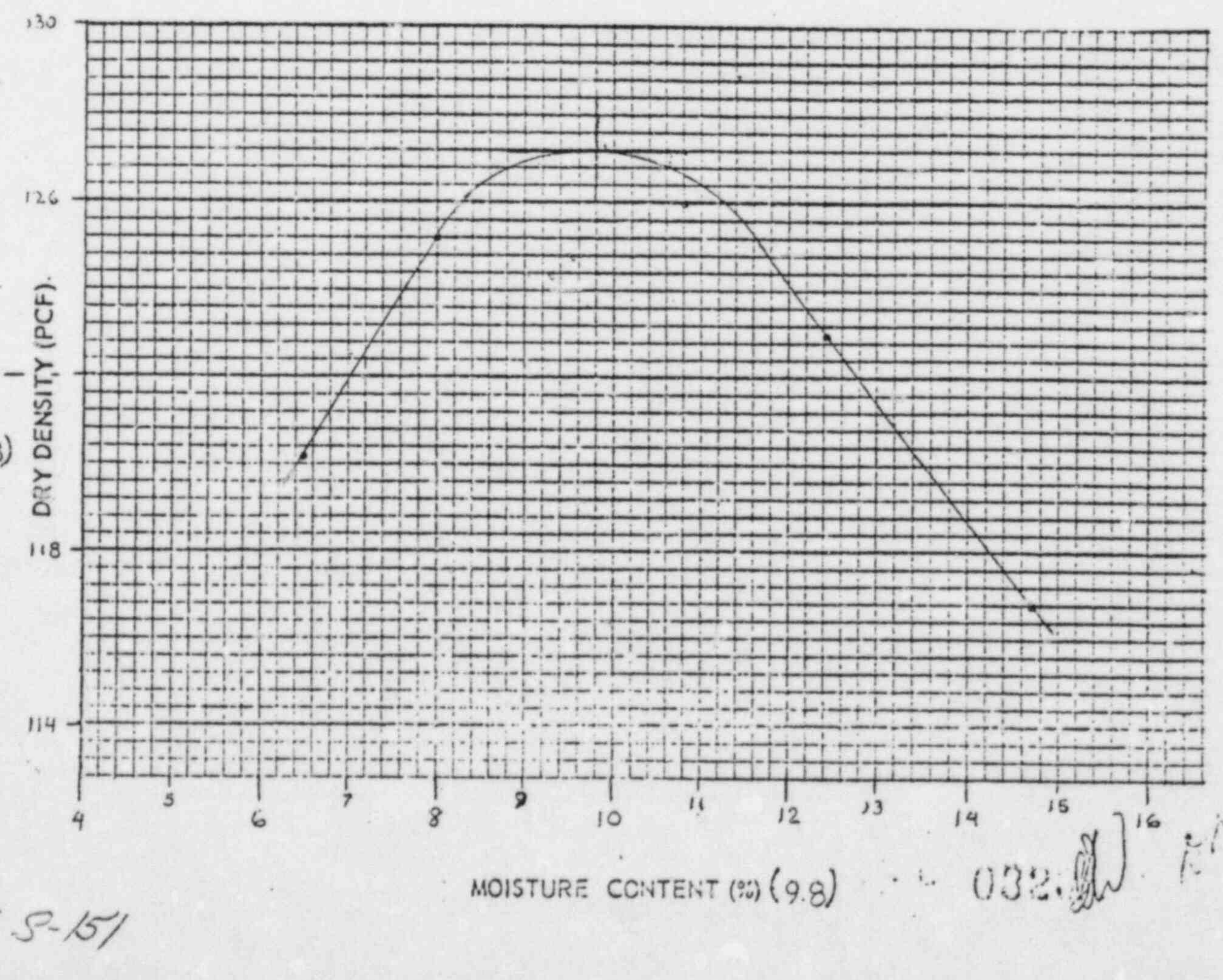
QPA 9/25/75

COMPACTION TEST

Project No. 7220
Boring No. NONE
Source -
Hammer weight 10 LB.
Drop distance 18"
No. Layers 4
No. Blows 25

Lab. No. 761
Date 9/23/75
Initials [illegible]
Type of test BMP
Mold size 6"

TEST DATA						
Mold No.	PM-1	PM-1	PM-1	PM-1	PM-1	
Wt. wet sample + Mold ( )	11015	11256	11400	11345	11208	
Wt. of Mold ( )	6648	6648	6648	6648	6648	
Wt. of wet sample ( )	4367	4608	4752	4697	4560	
Vol. of sample ( )	2124	2124	2124	2124	2124	
Wet Unit Weight (lb. /cu.ft.)	128.3	135.4	139.6	138.0	134.0	
Can No.	71	56	79	73	11	
Wt. wet sample + Can (gm.)	700.5	709.8	701.6	706.6	705.0	
Wt. Dry sample + Can (gm.)	662.5	663.0	641.2	637.2	624.8	
Wt. water (gm.)	38.0	46.8	60.4	69.4	80.2	
Wt. can (gm.)	80.5	76.5	80.3	79.5	78.2	
Wt. dry sample (gm.)	582.0	586.5	560.9	557.7	546.6	
Moisture Content %	6.5	8.0	10.8	12.4	14.7	
Average Moisture Content %	6.5	8.0	10.8	12.4	14.7	
Dry Unit Weight (lb. /cu.ft.)	120.5	125.4	126.0	122.8	116.8	



032

UST S-151

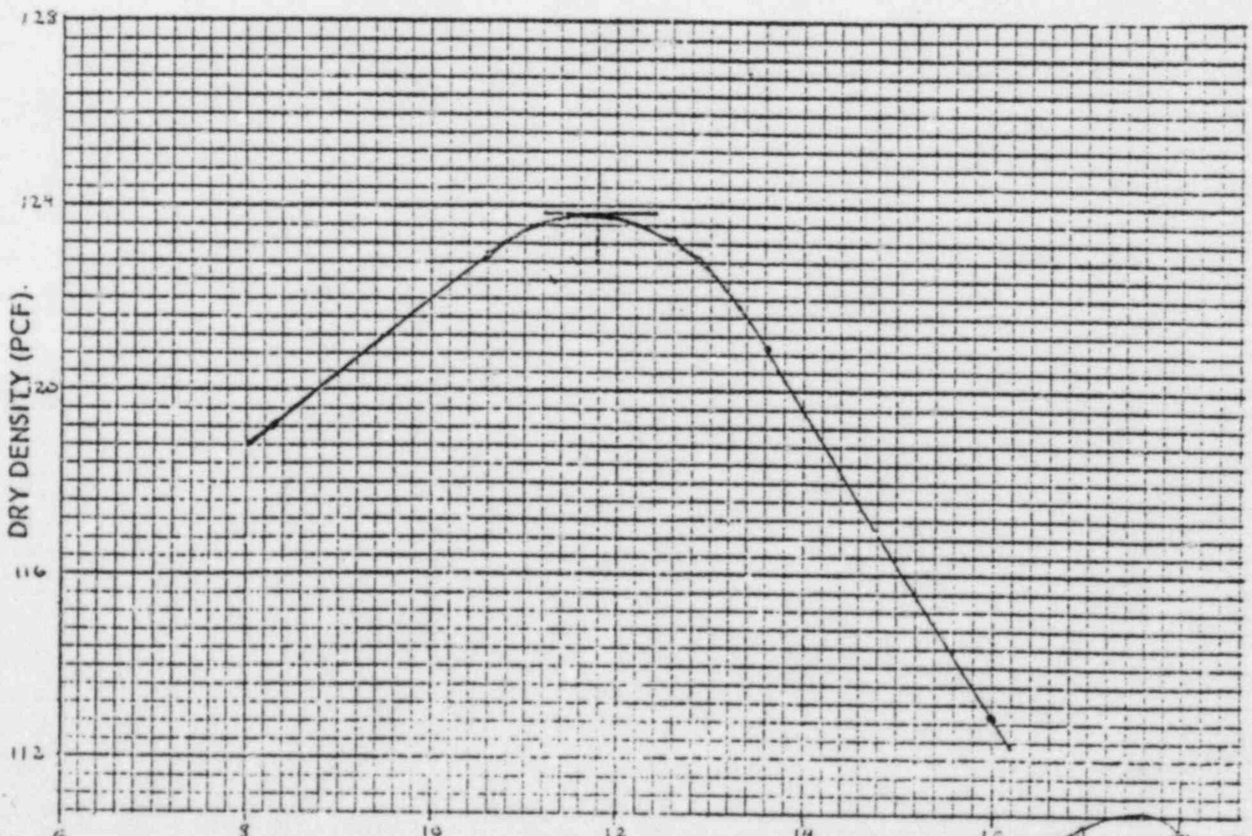
COMPACTION TEST

Project No. 7220
Boring No. NONE
Source –
Hammer weight 10 LB.
Drop distance 18"
No. Layers 4
No. Blows 25

Lab. No. 262
Date 9/24/75
Initials J.F. & J.K.
Type of test BMD
Mold size 6"

TEST DATA						
Mold No.	PM-2	PM-2	PM-2	PM-2	PM-2	
Wt. wet sample + Mold ( )	10210	10440	10533	10468	10275	
Wt. of Mold ( )	5815	5815	5815	5815	5815	
Wt. of wet sample ( )	4395	4625	4718	4653	4460	
Vol. of sample ( )	2124	2124	2124	2124	2124	
Wet Unit Weight (lb. /cu.ft.)	129.1	135.9	138.6	136.7	131.0	
Can No.	78	58	70	57	57	
Wt. wet sample + Can (gm.)	603.3	624.0	601.5	602.9	596.4	
Wt. Dry sample + Can (gm.)	563.4	571.8	543.3	539.7	524.3	
Wt. water (gm.)	39.9	52.2	58.2	63.2	72.1	
Wt. can (gm.)	80.2	79.1	80.0	76.1	76.1	
Wt. dry sample (gm.)	483.2	492.7	463.3	463.6	448.2	
Moisture Content %	8.3	10.6	12.6	13.6	16.0	
Average Moisture Content %	8.3	10.6	12.6	13.6	16.0	
Dry Unit Weight (lb. /cu.ft.)	110.2	122.9	123.1	120.9	112.9	

123.9



A 0325

MOISTURE CONTENT (%) 11.8

M.D. 9/26/75

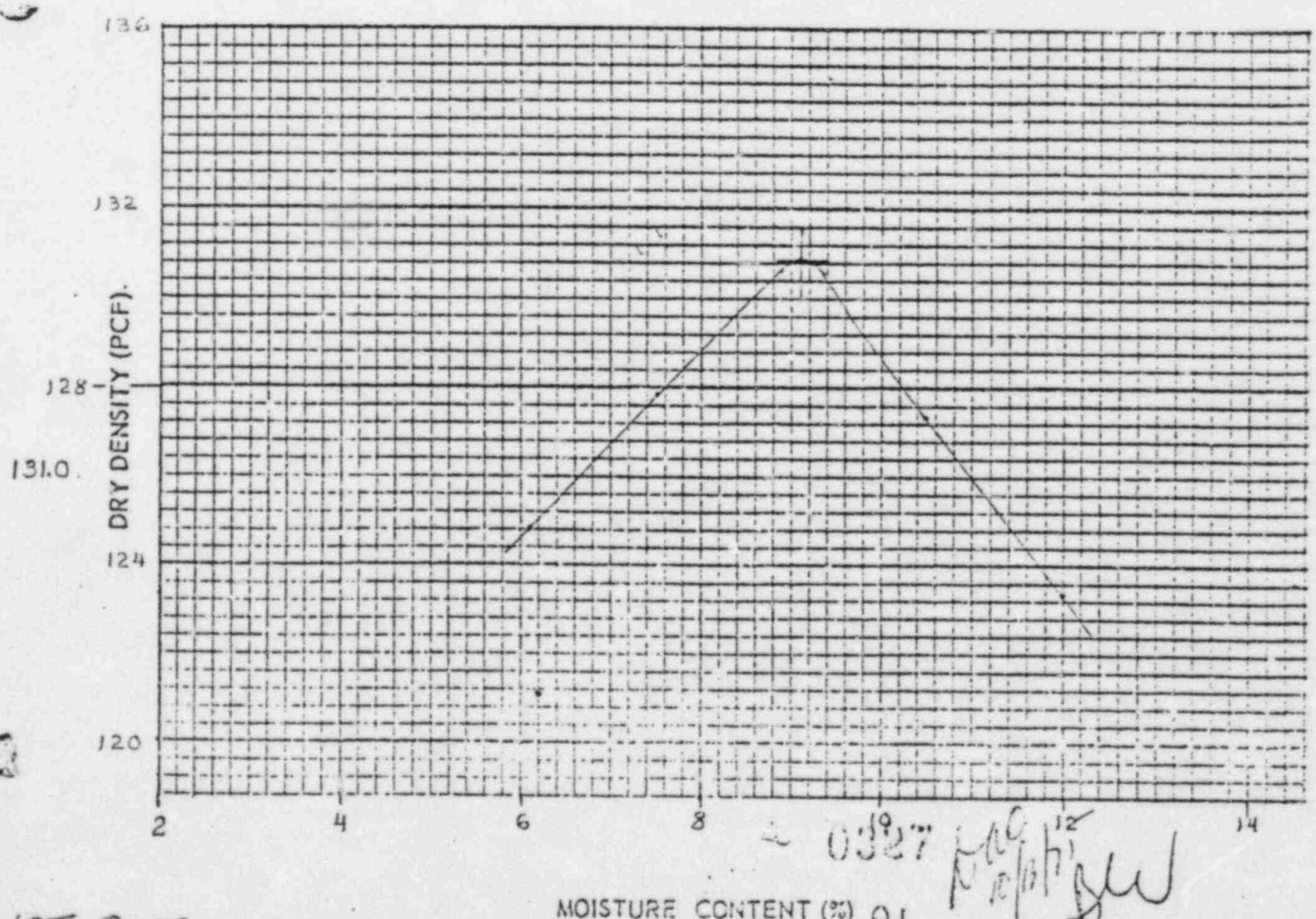
UST S-191

COMPACTION TEST

Project No. 7220
Boring No. NONE
Source —
Hammer weight 10 LB.
Drop distance 18"
No. Layers 4
No. Blows 25

Lab. No. 263
Date 10-6-75
Initials J.F.
Type of test BMP
Mold size 6"

TEST DATA						
Mold No.	PM-1	PM-1	PM-1	PM-1	PM-1	
Wt. wet sample + Mold ( )	11155	11325	11510	11440	11332	
Wt. of Mold ( )	6648	6648	6648	6648	6648	
Wt. of wet sample ( )	4507	4677	4862	4792	4684	
Vol. of sample ( )	2124	2124	2124	2124	2124	
Wet Unit Weight (lb. /cu.ft.)	132.4	137.4	142.8	140.8	137.6	
Can No.	56	70	58	72	74	
Wt. wet sample + Can (gm.)	634.3	608.4	604.5	602.0	601.7	
Wt. Dry sample + Can (gm.)	602.2	571.7	560.7	552.3	545.9	
Wt. water (gm.)	32.1	36.7	43.8	49.7	55.8	
Wt. can (gm.)	76.5	80.0	79.1	79.2	80.6	
Wt. dry sample (gm.)	525.7	491.7	481.6	473.1	465.3	
Moisture Content %	6.1	7.5	9.1	10.5	12.0	
Average Moisture Content %	6.1	7.5	9.1	10.5	12.0	
Dry Unit Weight (lb. /cu.ft.)	124.8	127.8	130.9	127.4	123.7	



0327

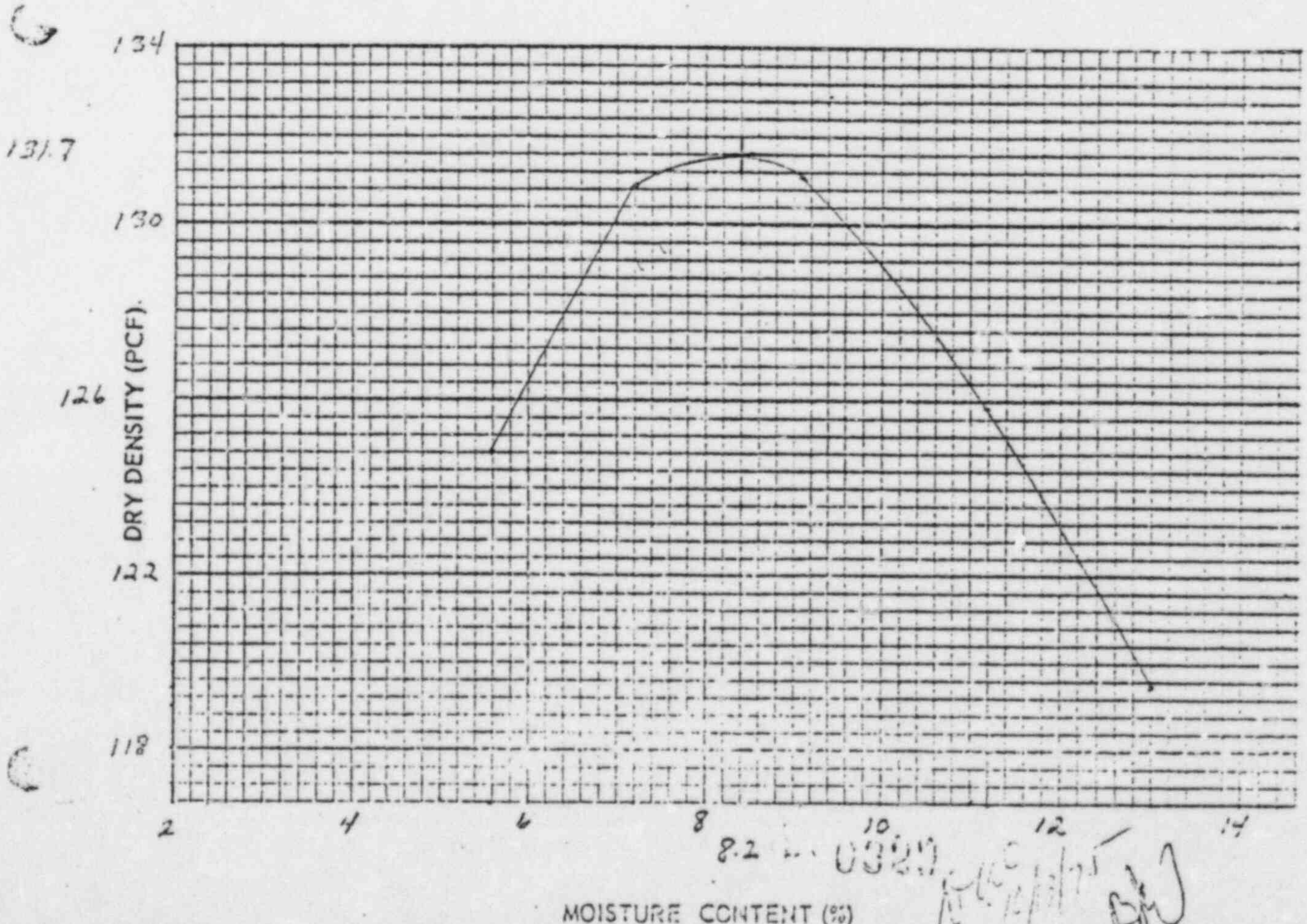
USI O-78

COMPACTION TEST

Project No. 7220	Lab. No. BMP 264
Boring No. None	Date 10-6-75
Source —	Initials GF
Hammer weight 10	Type of test BMP
Drop distance 18"	Mold size 6"
No. Layers 4	
No. Blows 25	

TEST DATA

Mold No.	PMI	PMI	PMI	PMI	PMI	
Wt. wet sample + Mold ( )	11133	11422	11515	11406	11241	
Wt. of Mold ( )	6648	6648	6648	6648	6648	
Wt. of wet sample ( )	4485	4774	4867	4758	4593	
Vol. of sample ( )	2124	2124	2124	2124	2124	
Wet Unit Weight (lb. /cu.ft.)	131.8	140.3	143.0	139.8	134.9	
Can No.	11	71	78	51	79	
Wt. wet sample + Can (gm.)	602.1	600.0	624.0	602.1	603.7	
Wt. Dry sample + Can (gm.)	574.2	565.3	578.2	548.7	543.6	
Wt. water (gm.)	27.9	34.7	45.8	53.4	60.1	
Wt. can (gm.)	78.2	80.5	80.2	76.1	80.3	
Wt. dry sample (gm.)	496	484.8	477.0	472.6	463.3	
Moisture Content %	5.6	7.2	9.1	11.2	13.0	
Average Moisture Content %	5.6	7.2	9.1	11.2	13.0	
Dry Unit Weight (lb. /cu.ft.)	124.8	130.9	131.1	125.7	119.4	



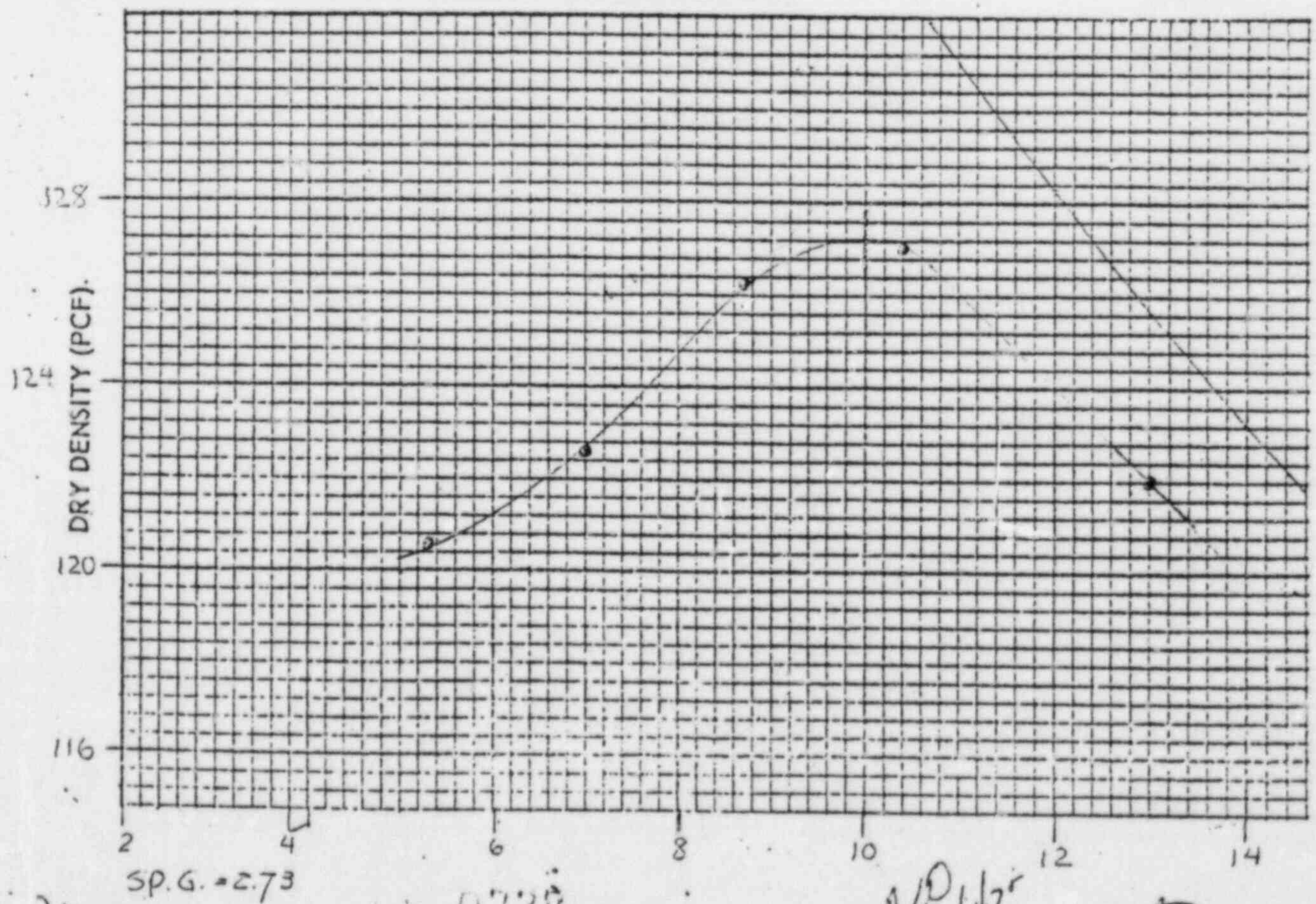
0323

Project No. 7220
Boring No. NONE
Source PLANT AREA
Hammer weight 10 LB.
Drop distance 18"
No. Layers 4
No. Blows 25

Lab. No. [illegible]
Date 11-24-75
Initials [illegible]
Type of test [illegible]
Mold size 6"

TEST DATA

Mold No.	PM-2	PM-2	PM-2	PM-2	PM-2	
Wt. wet sample + Mold (gm)	10138	10277	10440	10590	10508	
Wt. of Mold (gm)	5815	5815	5815	5815	5815	
Wt. of wet sample (gm)	4323	4462	4625	4775	4693	
Vol. of sample (c.c.)	2124	2124	2124	2124	2124	
Wet Unit Weight (lb. /cu.ft.)	127.0	131.1	137.3	140.3	137.9	
Can No.	57	70	71	79	78	
Wt. wet sample + Can (gm.)	601.1	617.0	604.0	605.3	608.0	
Wt. Dry sample + Can (gm.)	574.6	582.0	562.3	556.0	547.3	
Wt. water (gm.)	26.5	35.0	41.7	49.3	60.7	
Wt. can (gm.)	76.1	80.0	80.5	80.3	80.2	
Wt. dry sample (gm.)	498.5	502.0	481.8	475.7	467.1	
Moisture Content %	5.3	7.0	8.7	10.4	13.0	
Average Moisture Content %	5.3	7.0	8.7	10.4	13.0	
Dry Unit Weight (lb. /cu.ft.)	120.6	122.5	126.3	127.1	122.0	
MAX DRY DENSITY	127.3					
O. M. C.	10.0					



SP.G. = 2.73

12/4/75

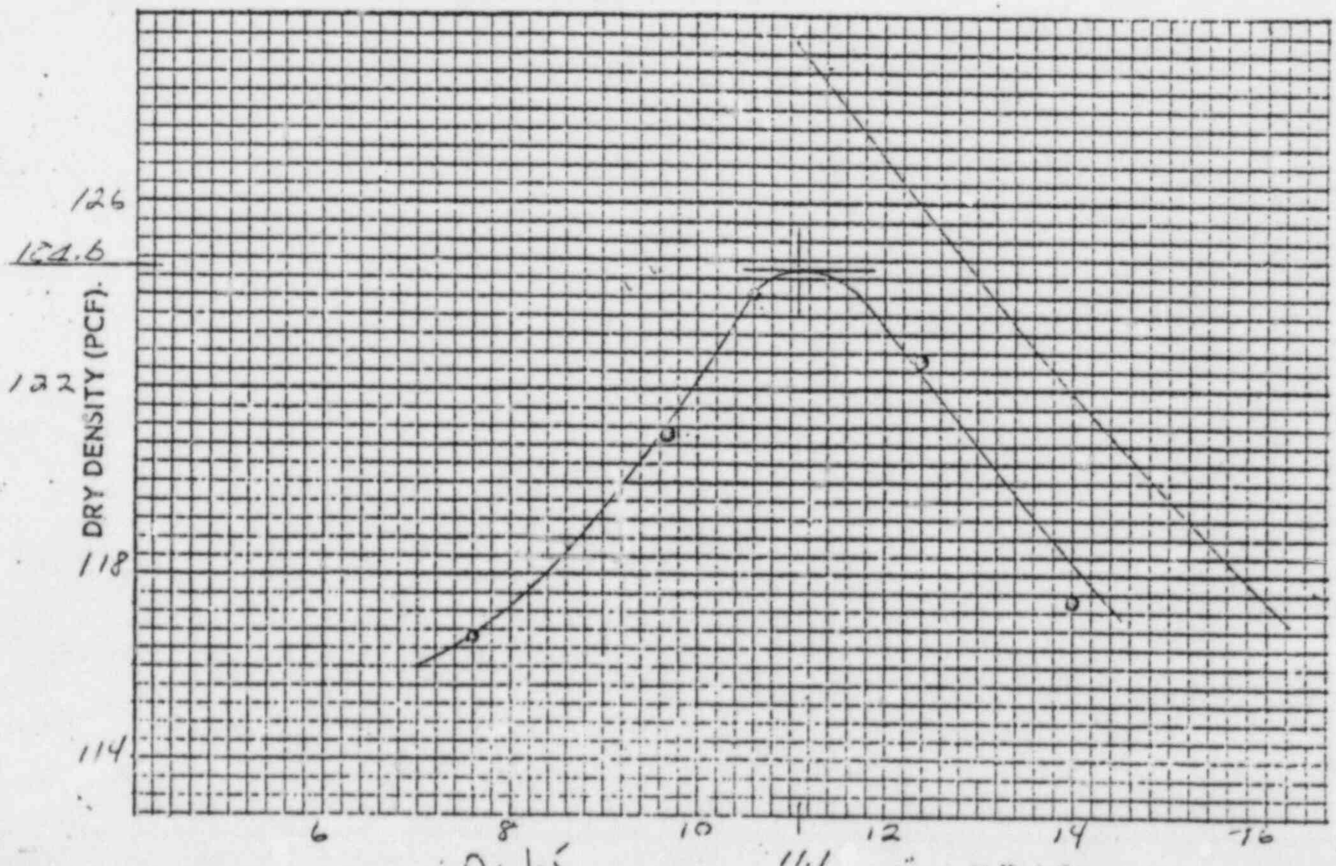
12.1.75

COMPACTION TEST

Project No. 7220
Boring No. —
Source Plant Area
Hammer weight 10 lb
Drop distance 18"
No. Layers 4
No. Blows 25

Lab. No. BMP-270
Date 12-1-75
Initials J.K.
Type of test Proctor
Mold size 6"

TEST DATA						
Mold No.	PM-2	PM-2	PM-2	PM-2	PM-2	
Wt. wet sample + Mold (gm)	10087	10328	10488	10510	10370	
Wt. of Mold (gm)	5815	5815	5815	5815	5815	
Wt. of wet sample (gm)	4272	4513	4673	4695	4555	
Vol. of sample (C.C.)	2124	2124	2124	2124	2124	
Wet Unit Weight (lb. /cu.ft.)	125.5	132.6	137.3	137.9	133.8	
Can No.	56	57	70	79	71	
Wt. wet sample + Can (gm.)	611.0	613.5	613.2	601.5	602.8	
Wt. Dry sample + Can (gm.)	573.3	566.1	562.2	543.8	538.8	
Wt. water (gm.)	37.7	47.4	51.0	57.7	64.0	
Wt. can (gm.)	76.5	76.1	80.0	80.3	80.5	
Wt. dry sample (gm.)	496.8	490.0	482.2	463.5	458.3	
Moisture Content %	7.6	9.7	10.6	12.4	14.0	
Average Moisture Content %	—	—	—	—	—	
Dry Unit Weight (lb. /cu.ft.)	116.6	120.9	124.1	122.7	117.4	
Max Dry Density	124.6					
O. M. C.	11.1					



SP.G. = 2.69

ACO 12/4/75

0340

MOISTURE CONTENT (%)

P.W.

11.1 [illegible]

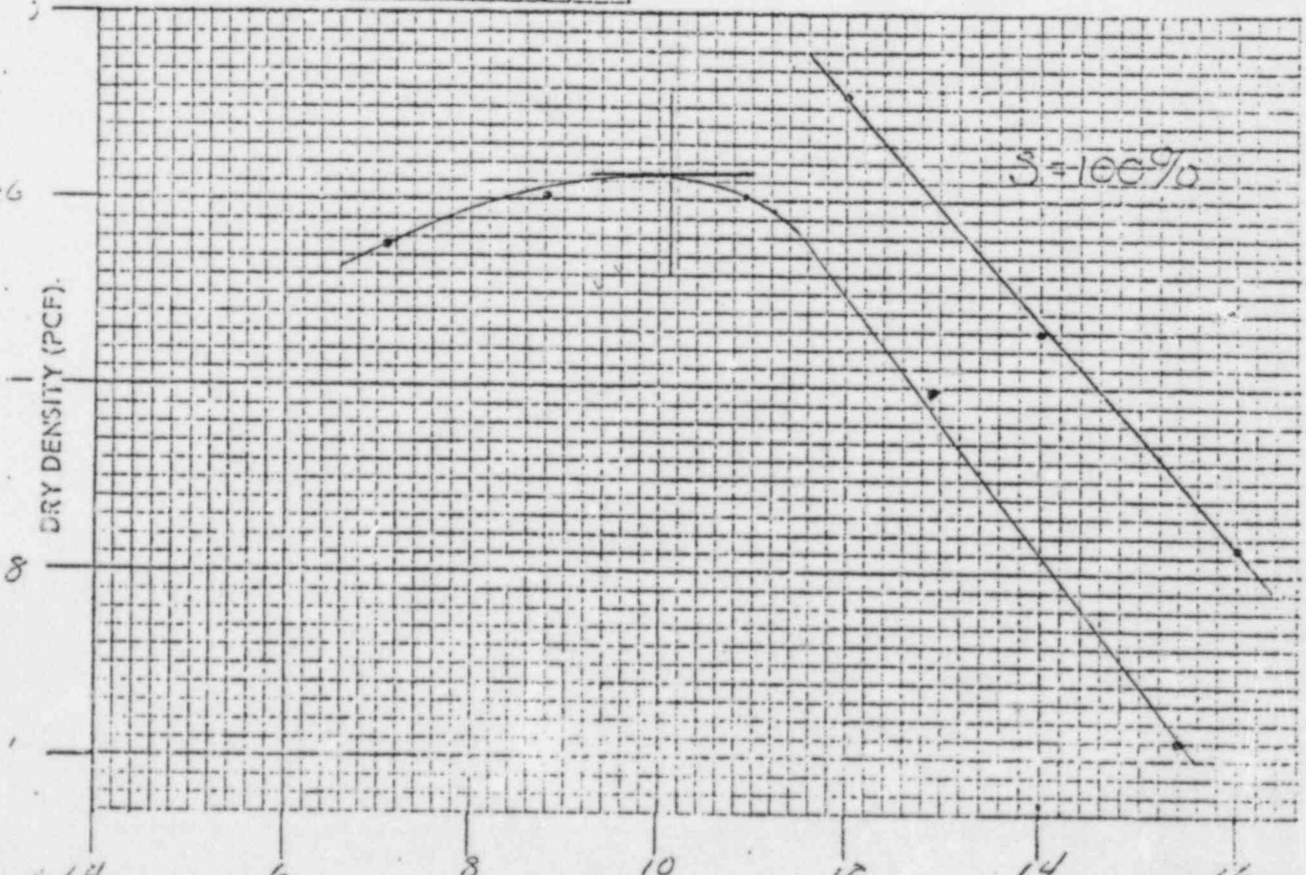
12.1-75

COMPACTION TEST

Project No. 7220
Boring No. NONE
Source S.DIKE 38+00
Hammer weight 10LB.
Drop distance 18"
No. Layers 4
No. Blows 25

Lab. No. 271
Date 6-25-76
Initials D.P. & J.K.
Type of test BMP
Mold size 6"

TEST DATA						
Mold No.	PM-1	PM-1	PM-1	PM-1	PM-1	
Wt. wet sample + Mold ( )	11196	11305	11395	11315	11128	
Wt. of Mold ( )	6635	6635	6635	6635	6635	
Wt. of wet sample ( )	4561	4670	4760	4683	4493	
Vol. of sample ( )	2124	2124	2124	2124	2124	
Wet Unit Weight (lb. /cu.ft.)	134.0	137.2	139.8	137.6	132.0	
Can No.	77	70	11	73	79	
Wt. wet sample + Can (gm.)	600.0	600.0	600.0	600.0	600.0	
Wt. Dry sample + Can (gm.)	565.3	558.0	548.8	540.5	530.8	
Wt. water (gm.)	34.7	42.0	51.2	59.5	69.2	
Wt. can (gm.)	78.4	80.5	78.2	79.5	80.3	
Wt. dry sample (gm.)	486.9	477.5	470.6	461.0	450.5	
Moisture Content %	7.1	8.8	10.9	12.9	15.4	
Average Moisture Content %	7.1	8.8	10.9	12.9	15.4	
Dry Unit Weight (lb. /cu.ft.)	125.1	126.1	126.1	121.9	114.4	
Max. Dry Density	126.6					
O.M.C.	10.1					



0342

QA/QC REVIEW
Glenn J. Yearley 12/15/76

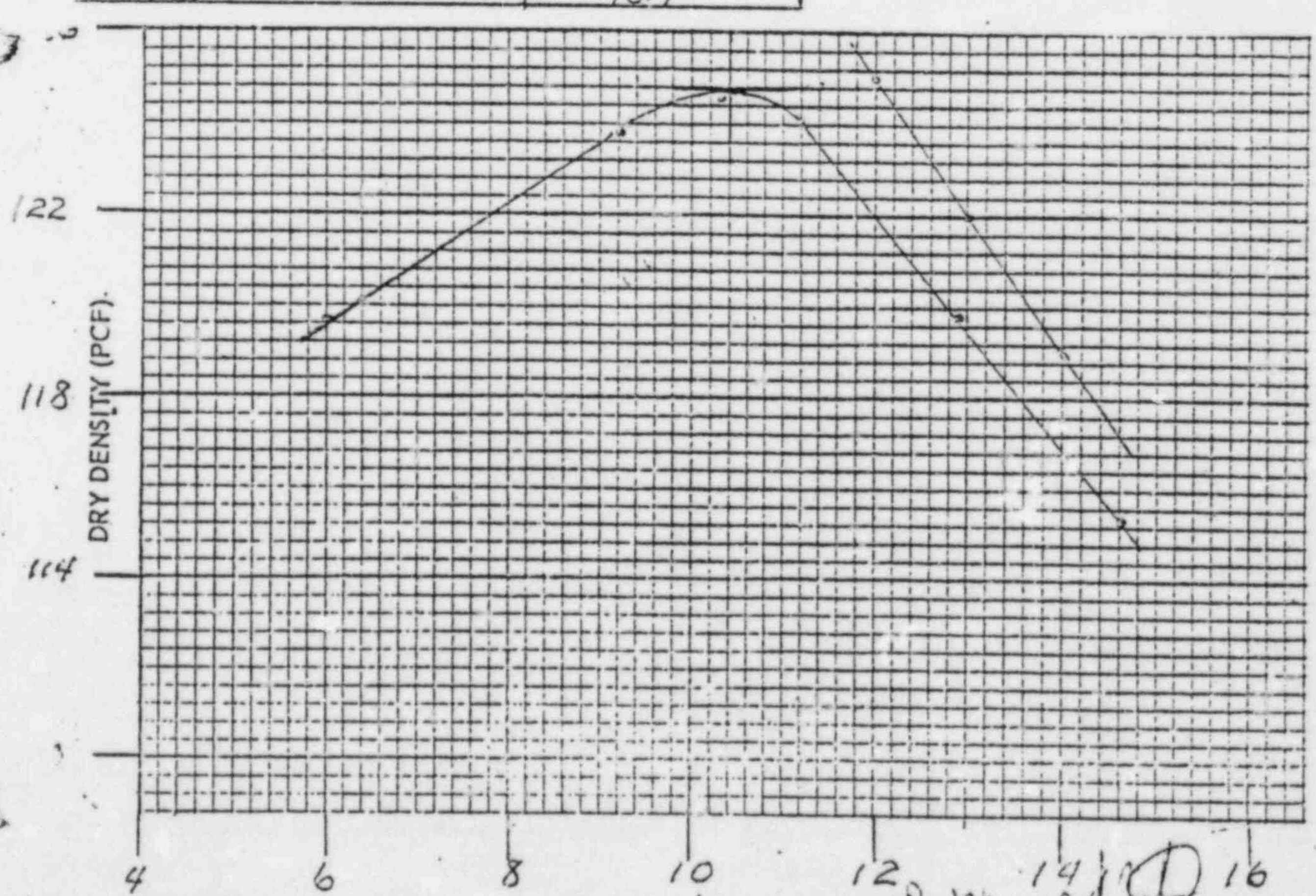
12/15/76

COMPACTION TEST

Project No. 7220
Boring No. NONE
Source W. RA. RAMP
Hammer weight 10 LB.
Drop distance 18"
No. Layers 4
No. Blows 25

Lab. No. 274
Date 7-8-76
Initials J.
Type of test BIMP
Mold size 6"

TEST DATA						
Mold No.	PM-2	PM-2	PM-2	PM-2	PM-2	
Wt. wet sample + Mold ( )	10124	10369	10483	10410	10306	
Wt. of Mold ( )	5809	5809	5809	5809	5809	
Wt. of wet sample ( )	4315	4560	4674	4601	4497	
Vol. of sample ( )	2124	2124	2124.	2124	2124	
Wet Unit Weight (lb. /cu.ft.)	126.8	134.0	137.3	135.2	132.1	
Can No.	71	73	79	77	70	
Wt. wet sample + Can (gm.)	600.0	600.0	600.0	600.0	600.0	
Wt. Dry sample + Can (gm.)	570.6	556.2	551.5	540.3	533.6	
Wt. water (gm.)	29.4	43.8	48.5	59.7	66.4	
Wt. can (gm.)	80.5	79.5	80.3	78.9	80.0	
Wt. dry sample (gm.)	490.1	476.7	471.2	461.4	453.6	
Moisture Content %	6.0	9.2	10.3	12.9	14.6	
Average Moisture Content %	6.0	9.2	10.3	12.9	14.6	
Dry Unit Weight (lb. /cu.ft.)	119.6	122.7	124.5	119.8	115.3	
Max Dry Density	124.8					
O. M. C.	10.4					



UST Ol-274 a

7/28/76

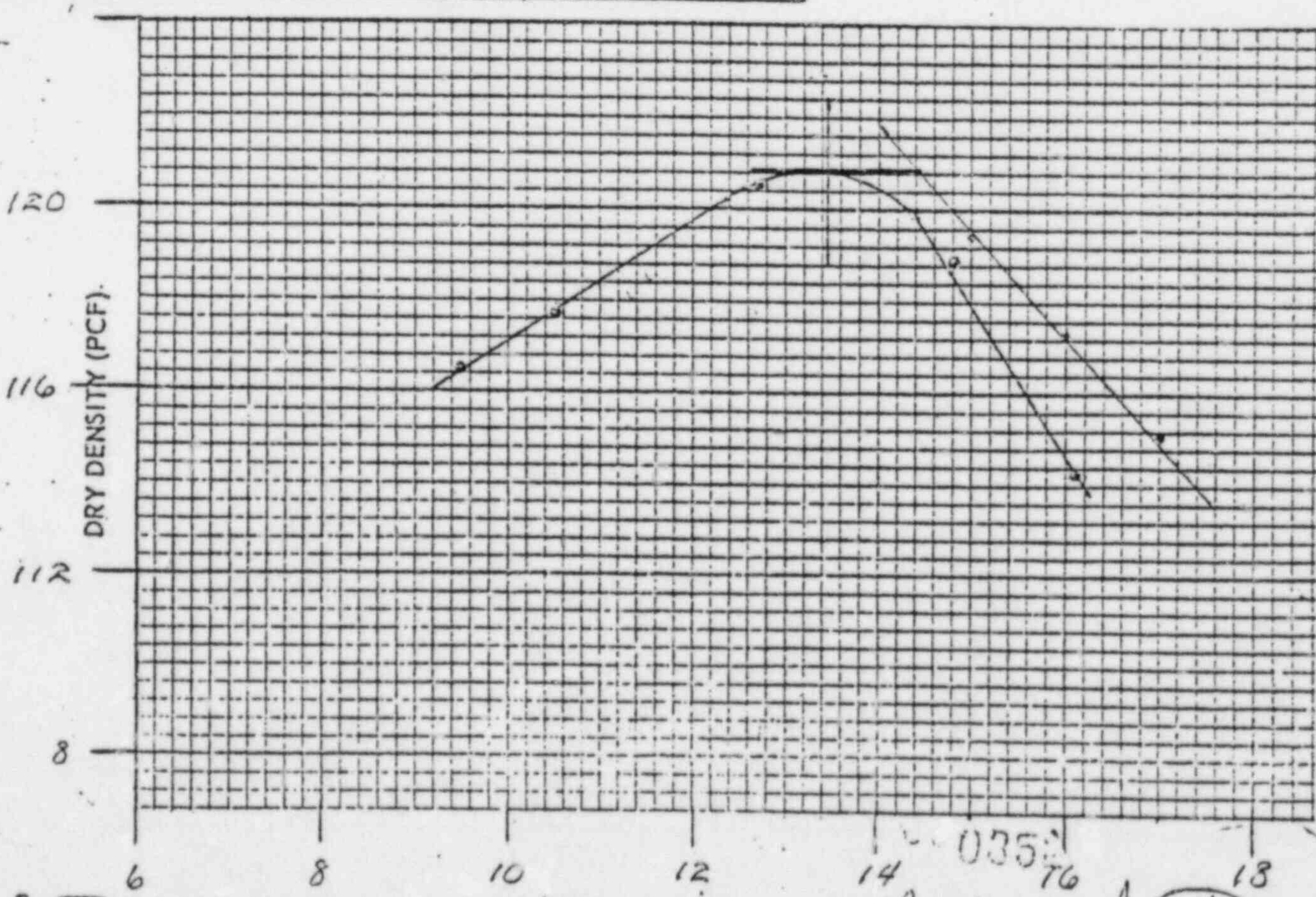
7-28-76

COMPACTION TEST

Project No. 7220
Boring No. NONE
Source E.DIKE (10650)
Hammer weight 10 LB.
Drop distance 18"
No. Layers 4
No. Blows 25

Lab. No. BMP-277
Date 7-29-76
Initials D.P.E.
Type of test BMP
Mold size 6"

TEST DATA						
Mold No.	PM-1	PM-1	PM-1	PM-1	PM-1	
Wt. wet sample + Mold ( )	10978	11055	11259	11286	11151	
Wt. of Mold ( )	6635	6635	6635	6635	6635	
Wt. of wet sample ( )	4343	4420	4624	4651	4516	
Vol. of sample ( )	2124	2124	2124	2124	2124	
Wet Unit Weight (lb. /cu.ft.)	127.6	129.9	135.8	136.6	132.7	
Can No.	72	73	79	70	77	
Wt. wet sample + Can (gm.)	600.0	600.0	600.0	600.0	600.0	
Wt. Dry sample + Can (gm.)	555.0	550.7	541.4	533.0	527.8	
Wt. water (gm.)	45.0	49.3	58.6	67.0	72.2	
Wt. can (gm.)	79.2	79.5	80.3	80.0	78.9	
Wt. dry sample (gm.)	475.8	471.2	461.1	453.0	448.9	
Moisture Content %	9.5	10.5	12.7	14.8	16.1	
Average Moisture Content %	9.5	10.5	12.7	14.8	16.1	
Dry Unit Weight (lb. /cu.ft.)	116.5	117.6	120.5	119.0	114.3	
Max Dry Density	121.0					
O. M. C.	13.4					



1st Am -17a

0352

8/6/76

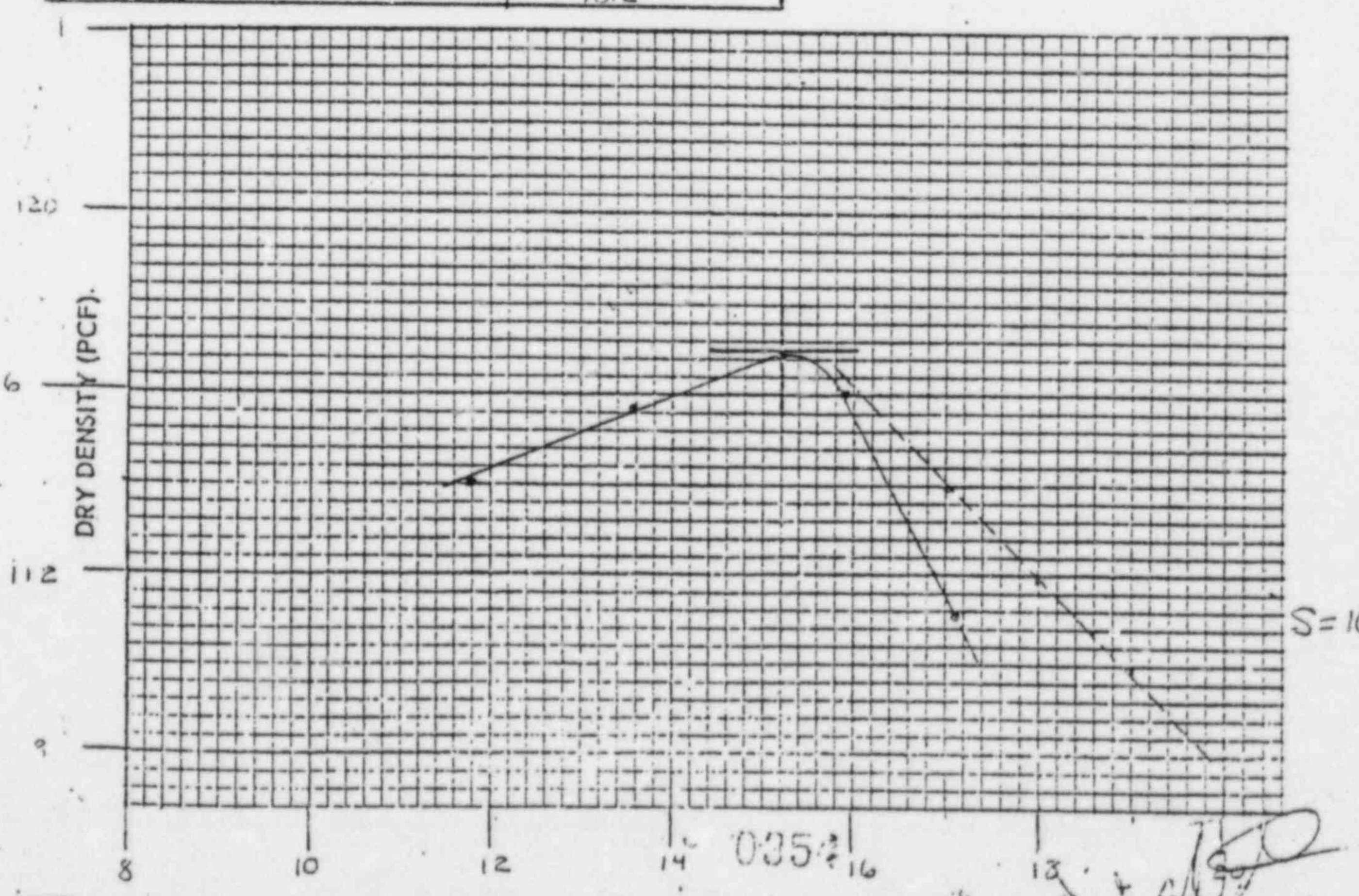
8-5-76

8-25-76

Project No. 7220
Boring No. NONE
Source BAFFLE DIKE @ 6400
Hammer weight 10LB.
Drop distance 18"
No. Layers 4
No. Blows 25

Lab. No. 273
Date 8-18-76
Initials R.M. & T.K.
Type of test BMP
Mold size 6"

TEST DATA						
Mold No.	PM-1	PM-1	PM-1	PM-1	PM-1	
Wt. wet sample + Mold ( )	10945	11090	11196	11187	11041	
Wt. of Mold ( )	6610	6610	6610	6610	6610	
Wt. of wet sample ( )	4335	4463	4585	4577	4431	
Vol. of sample ( )	2124	2124	2124	2124	2124	
Wet Unit Weight (lb. /cu.ft.)	127.4	131.6	134.7	134.5	130.2	
Can No.	58	57	56	57	71	
Wt. wet sample + Can (gm.)	228.2	210.9	361.8	600.0	600.0	
Wt. Dry sample + Can (gm.)	212.5	194.8	324.1	528.6	524.1	
Wt. water (gm.)	15.7	16.1	37.7	71.4	75.9	
Wt. can (gm.)	79.1	76.1	76.5	76.1	80.5	
Wt. dry sample (gm.)	133.4	118.7	247.6	452.5	443.6	
Moisture Content %	11.8	13.6	15.2	15.9	17.1	
Average Moisture Content %	11.8	13.6	15.2	15.9	17.1	
Dry Unit Weight (lb. /cu.ft.)	114.0	115.8	116.9	116.0	111.2	
MAX DRY DENSITY	117.0					
O. M. C.	15.2					



0354

8-25-76

8/27/76

UST
Am-184

COMPACTION TEST

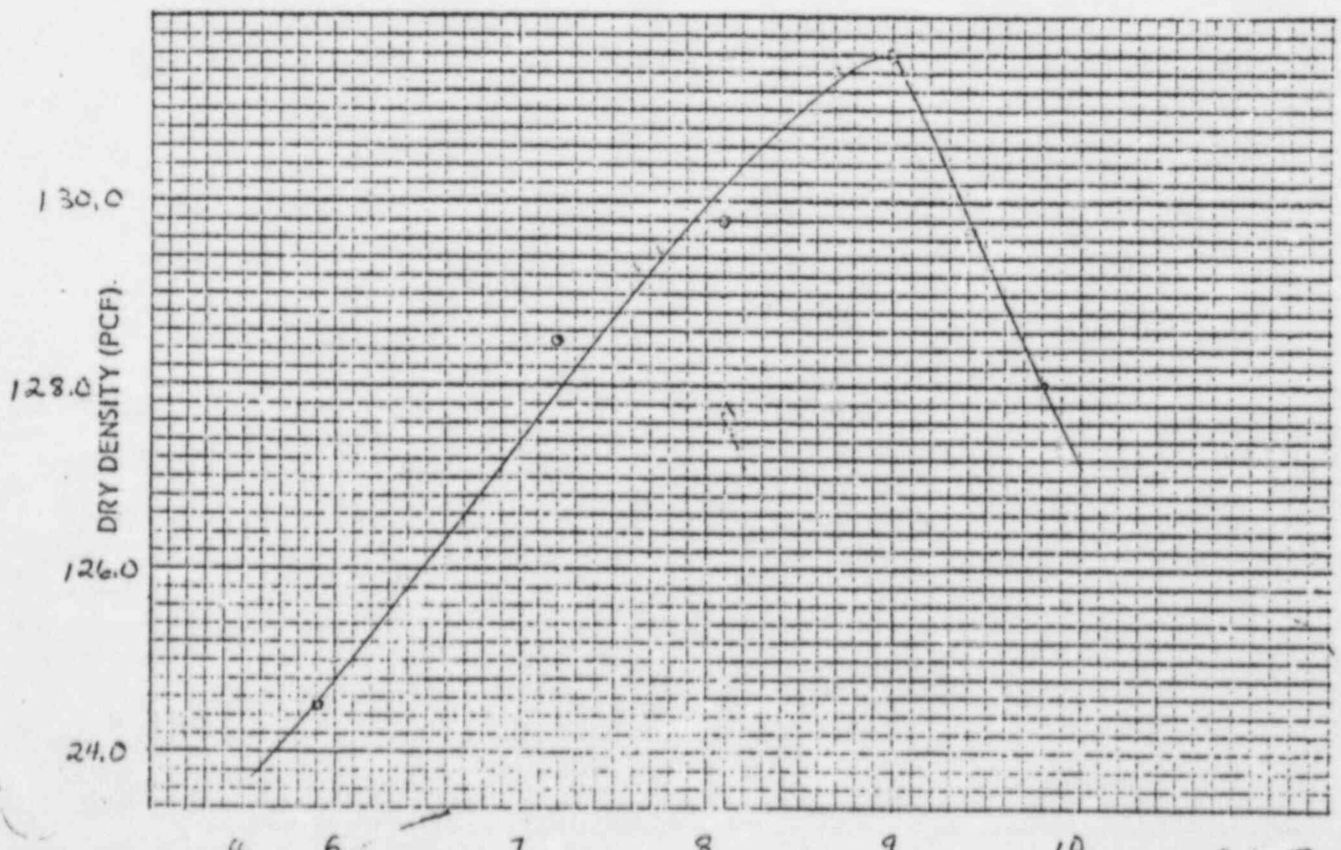
Project No. 7220
Boring No. — —
Source Stockpile
Hammer weight 10 lbs
Drop distance 18"
No. Layers 4
No. Blows 25

Lab. No. C636
Date 8-1-77
Initials JR - DW
Type of test BMP-
Mold size 6"

297

TEST DATA						
ASTM 1557-D- BMP C-210						
Mold No.	167	167	167	167	167	167
Wt. wet sample + Mold (g)	11121	11322	11464	11416	11411	11516
Wt. of Mold (g)	6632	6632	6632	6632	6632	6632
Wt. of wet sample (g)	4489	4690	4832	4784	4779	4884
Vol. of sample (CF)	0.075	0.075	0.075	0.075	0.075	0.075
Wet Unit Weight (lb. /cu.ft.)	131.8	137.7	141.9	140.5	140.3	143.4
Can No.	79	57	56	78	77	65
Wt. wet sample + Can (gm.)	737.5	647.1	697.0	758.0	600.0	600.0
Wt. Dry sample + Can (gm.)	696.5	603.4	637.4	699.2	554.8	550.4
Wt. water (gm.)	41.0	43.7	59.6	68.8	45.2	49.6
Wt. can (gm.)	80.3	76.4	76.9	80.4	90.0	76.4
Wt. dry sample (gm.)	696.5	603.4	637.4	699.2	554.8	550.4
Moisture Content %	5.9	7.2	9.4	9.8	8.1	9.0
Average Moisture Content %	—	—	—	—	—	—
Dry Unit Weight (lb. /cu.ft.)	124.5	128.5	129.7	128.0	129.8	131.6

Max dry density 131.6
OMC 9.0



TL 3-22-78

8-2-77

MOISTURE CONTENT (%)

CHECKED BY:

0377

Project ________

Date ________

BECHTEL CO RPORATION

WEEKLY COMPACTED FILL DENSITY TEST REPORT QC-6C

Spec. No. ________

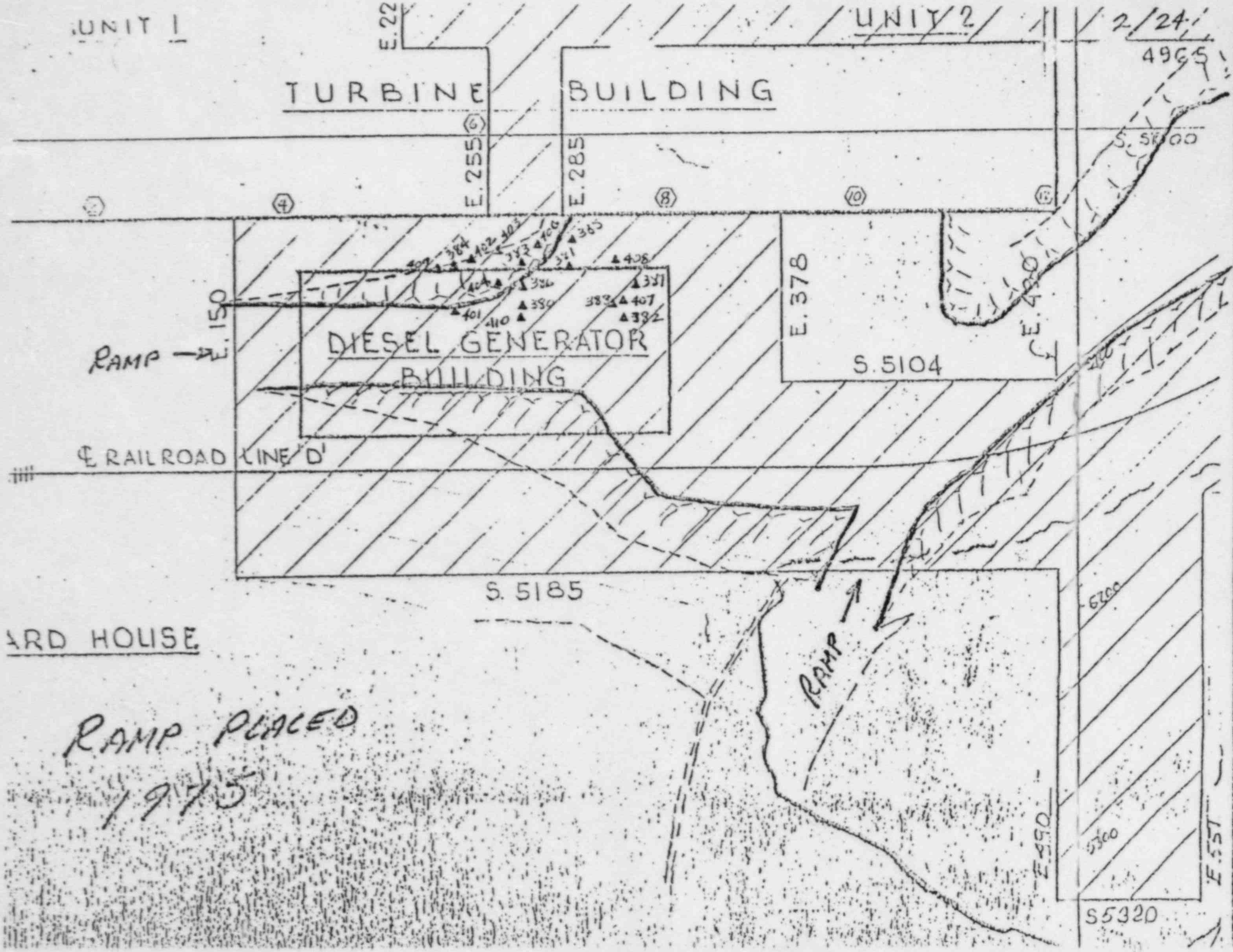
Lab. Insp. ________

Tested Week of ________

South RAMP PLACED 1975

Sheet 1 of 24

Date Taken	Test No.	Unified No. Classification RD	Zone	Location	Elev. of Test	Depth Below Final Grade (ft.)	In Place Wet Density (lb/c.f.)	Water Content (%)	In Place Dry Density (lb/c.f.)	Max. Lab. Dry Density (lb/c.f.)	Percent compaction % of RD	Remarks
10/20/75	380	38	2	36' S of ℄ Line @ 6.6	594	-	118.6	6.4	111.5	113.3 / 91.6	93	P
10/20/75	381	"	"	20' S of ℄ Line 20' E of 6.6	594	-	119.6	7.3	111.5	" "	93	P
10/20/75	382	"	"	39' S of ℄ Line 44' E of 6.6	594	-	118.1	7.9	109.5	" "	85	P
10/20/75	383	"	"	20' S of ℄ Line @ 6.6	594	-	120.6	8.7	110.9	" "	91	P
10/20/75	384	"	"	20' S of ℄ Line 30' W of 6.6	594		119.4	9.6	108.9	" "	83	P
10/20/75	385	"	"	10' S of ℄ Line 22' E of 6.6	595		119.3	8.4	110.1	" "	88	P
10/20/75	386	"	"	40' S of ℄ Line @ 6.6	595		120.5	8.2	111.4	" "	93	P
10/20/75	387	"	"	40' S of ℄ Line 45' W of 6.6	595		123.9	10.4	112.2	" "	96	P
10/20/75	388	"	"	43' S of ℄ Line 40' E of 6.6	596		122.9	9.0	112.8	" "	98	P
10/21/75	401	"	"	40' S of ℄ Line 32' W of 6.6	597		121.6	8.0	112.6	" "	97	P
10/21/75	402	"	"	15' S of ℄ Line 26' W of 6.6	597		117.9	8.5	108.7	" "	82	P
10/21/75	403	"	"	10' S of ℄ Line 10' W of 6.6	597		121.4	8.3	112.1	" "	96	P
10/21/75	404	"	"	30' S of ℄ Line 10' W of 6.6	597		121.3	8.3	112.0	" "	95	P
10/21/75	406	"	"	10' S of ℄ Line 6' E of 6.6	598		119.8	8.4	110.5	" "	89	P
10/21/75	407	"	"	40' S of ℄ Line 34' E of 6.6	598		121.0	6.5	113.6	" "	101	P
10/21/75	408	"	"	20' S of ℄ Line 34' E of 6.6	598		120.8	7.3	112.6	" "	97	P
10/21/75	409	"	"	20' S of ℄ Line 40' W of 6.6	598.5		123.1	8.7	113.2	" "	100	P
10/21/75	410	"	"	45' S of ℄ Line 6' E of 6.6	598		120.2	9.8	109.5	" "	85	P



UNIT 1
UNIT 2
2/24
4965
TURBINE BUILDING
E.22
E.255
E.285
E.378
E.490
E.551
S.5100
S.5104
S.5185
S5320
DIESEL GENERATOR BUILDING
RAMP
℄ RAILROAD LINE 'D'
150
6200
6300
ARD HOUSE
RAMP PLACED 1975

BECHTEL C(⁀ORATION

WEEKLY COMPACTED FILL DE' TY TEST REPORT QC-6C

Spec. No. ________

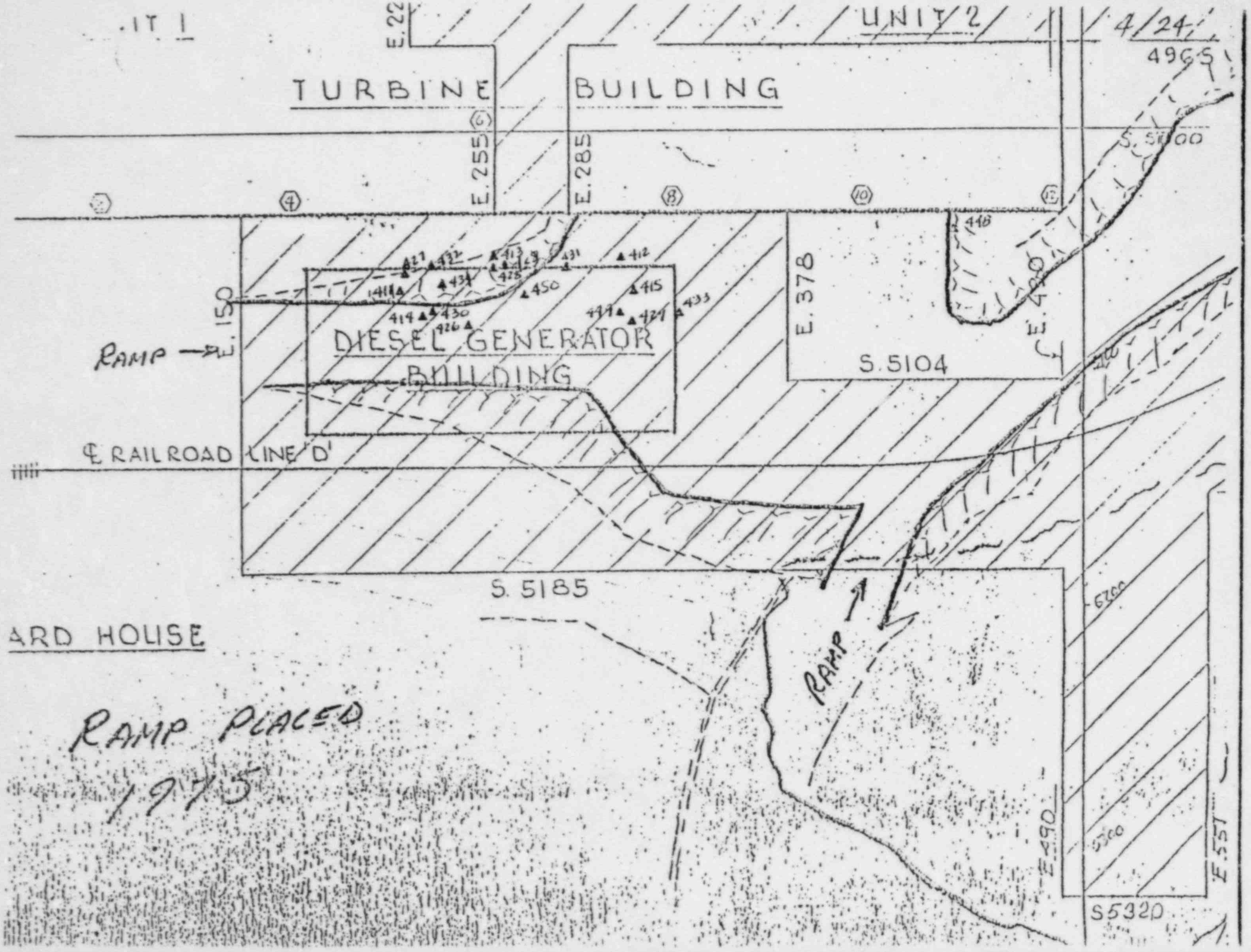
Lab. Insp. ________

Tested Week of ________

Sheet 3 of 24

South Ramp Placed 1975

Date Taken	Test No.	Unified No. Classification RD	ZONE	Location	Elev. of Test	Depth Below Final Grade (ft.)	In Place Wet Density (lb/c.f.)	Water Content (%)	In Place Dry Density (lb/c.f.)	Max. Lab. Dry Density (lb/c.f.)	Percent compaction % of RD	Remarks
10/21/75	411	38	2	40'S of Q Line 60'W of 6.6	599		121.3	11.3	109.0	113.3 / 91.6	83	P
10/21/75	412	"	"	17'S of Q Line 45'E of 6.6	600		122.9	5.1	116.9	" "	86	P
10/21/75	413	"	"	18'S of Q Line 12'W of 6.6	600		123.4	9.0	113.2	" "	100	P
10/21/75	414	"	"	45'S of Q Line 50'W of 6.6	600		118.2	9.1	108.3	" "	81	P
10/21/75	415	"	"	32'S of Q Line 45'E of 6.6	601		120.6	8.6	111.0	" "	91	P
10/22/75	425	30	2	20'S of Q Line 18'W of 6.6	601		115.9	7.6	107.7	113.3 / 91.6	96	P
10/22/75	426	"	"	50'S of Q Line 28'W of 6.6	601		118.0	7.5	109.8	" "	106	P
10/22/75	427	36	2	20'S of Q Line 60'W of 6.6	601		128.5	9.0	117.9	120.9 / 103.1	85	P
10/22/75	428	"	"	20'S of Q Line 15'W of 6.6	604		130.2	8.4	120.1	" "	96	P
10/22/75	429	38	2	45'S of Q Line 40'E of 6.6	603		121.2	10.2	110.0	113.3 / 91.6	87	P
10/22/75	430	39	2	40'S of Q Line 45'W of 6.6	603		117.4	11.3	105.5	109.1 / 92.0	82	P
10/22/75	431	"	"	25'S of Q Line 20'E of 6.6	604		121.1	11.3	108.8	" "	99	P
10/22/75	432	38	2	15'S of Q Line 50'W of 6.6	604		122.8	10.4	111.2	113.3 / 91.6	92	P
10/22/75	433	"	"	45'S of Q Line 65'E of 6.6	605		121.3	10.7	109.6	" "	86	P
10/22/75	434	"	"	35'S of Q Line 45'W of 6.6	605		123.3	11.2	110.9	" "	91	P
10/23/75	448	37	2	6'S of Q Line 14'W of 11.0	605		116.4	10.2	105.6	108.2 / 89.1	89	P
10/23/75	449	"	"	46'S of Q Line 36'E of 6.6	606		119.3	10.1	108.4	" "	101	P
10/23/75	450	36	"	36'S of Q Line 2'W of 6.6	606		116.2	7.7	107.9	120.9 / 103.1	99	P



IT 1
UNIT 2
4/24
4965
TURBINE BUILDING
E.22
E.255
E.285
E.378
E.490
E.551
E.150
S.5000
S.5104
S.5185
S5320
DIESEL GENERATOR BUILDING
℄ RAILROAD LINE 'D'
RAMP
RAMP
ARD HOUSE
RAMP PLACED 1975

Project ______

Date ______

BECHTEL CORPORATION

WEEKLY COMPACTED FILL DENSITY TEST REPORT QC-6C

Spec. No. ______

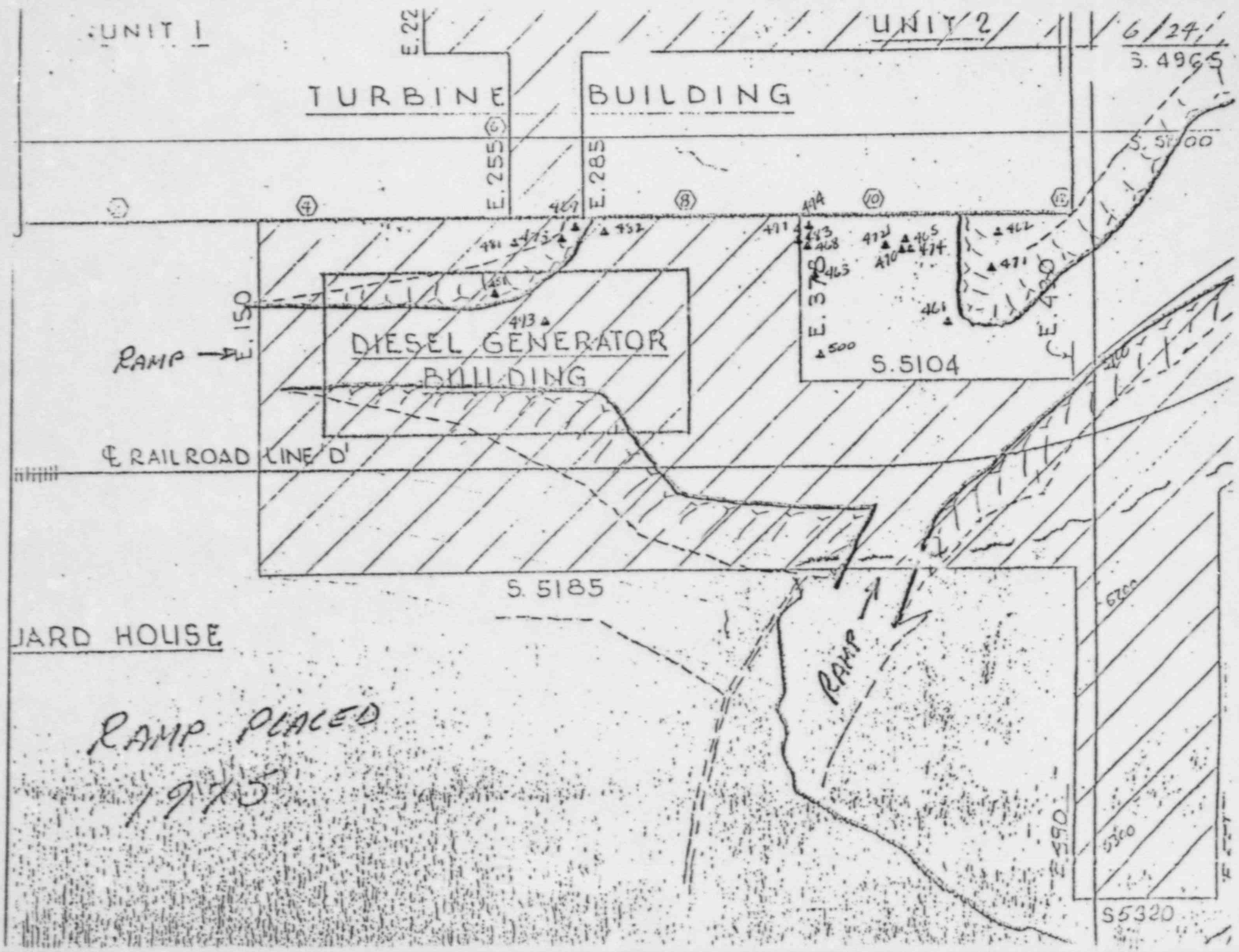
Lab. Insp. ______

Tested Week of ______

Sheet 5 of 24

South Ramp Placed 1975

Date Taken	Test No.	Unified No. Classification RD	Zone	Location	Elev. of Test	Depth Below Final Grade (ft.)	In Place Wet Density (lb/c.f.)	Water Content (%)	In Place Dry Density (lb/c.f.)	Max. Lab. Dry Density (lb/c.f.)	Percent compaction % of RD	Remarks
10/23/75	451	36	2	36' S of Q Line 24' W of G.G.	606	–	121.6	10.2	110.3	120.9 / 103.1	110	P
10/24/75	461	39	2	50' S of Q Line 11' W of 11.0	607		121.3	12.2	108.1	109.1 / 92.0	95	P Non-Q Area
10/24/75	462	"	"	8' S of Q Line 12' E of 11.0	607		118.0	7.7	109.6	" "	103	P "
10/24/75	463	"	"	10' S. of Q Line 28' W of 10.0	608		116.3	9.6	106.1	" "	85	P "
10/24/75	465	"	"	9' S of Q Line 30' W of 11.0	608		118.2	10.0	107.4	" "	92	P "
10/27/75	468	"	"	12' S of Q Line 83' W of 11.0	611		120.0	11.2	107.9	" "	94	P "
10/27/75	469	38	2	3' S of Q Line 14' E of G.G.	601		124.2	13.4	109.5	113.3 / 91.6	85	P – Q
10/27/75	470	"	"	10' S of Q Line 27' W of 11.0	609		123.5	11.6	110.5	" "	90	P Non-Q Area
10/27/75	471	"	"	27' S of Q Line 8' E of 11.0	608		119.7	9.6	109.2	" "	84	P "
10/28/75	472	39	2	10' S. of Q Line 40' W of 11.0	614		120.8	11.2	108.6	109.1 / 92.0	98	P "
10/28/75	473	"	"	4' S of Q Line 8' E of G.G.	603		119.2	10.9	107.5	" "	92	P Q
10/28/75	474	"	"	10' S of Q Line 25' W of 11.0	612		121.4	11.8	108.6	" "	98	P Non-Q Area
10/29/75	481	"	"	5' S of Q Line 18' W of G.G.	603		117.4	8.3	108.4	" "	97	P Q
10/29/75	482	"	"	5' S of Q Line 30' E of G.G.	603		122.1	9.1	111.9	" "	119	P Q
10/29/75	483	"	"	10' S of Q Line 83' W of 11.0	608		122.6	12.0	109.5	" "	102	P Non Q
10/31/75	493	BMP 262 OMC 11.8	Zone 2	48' S of Q Line ℄ of G.G.	607		134.6	12.3	119.9	123.9	97	P Q
10/31/75	494	RD 40	Zone 2	2' S of Q Line 25' W of 10.0	608		134.2	7.5	124.8	126.7 / 112.2	% of RD 88	P Area Non Q
10/31/75	497	"	"	2' S of Q Line 83' W of 11.0	608		131.8	5.5	124.9	" "	89	P Area Non Q


UNIT 1
UNIT 2
6/24
S. 4965
TURBINE BUILDING
E. 22
E. 255
E. 285
S. 5100
E. 150
E. 375
E. 430
E. 590
DIESEL GENERATOR BUILDING
RAMP
S. 5104
℄ RAILROAD LINE 'D'
S. 5185
JARD HOUSE
RAMP
RAMP PLACED 1975
S5320

Project ____

Date ____

BECHTEL CO[illegible]ORATION

WEEKLY COMPACTED FILL DE[illegible]TY TEST REPORT QC-6C

Spec. No. ____

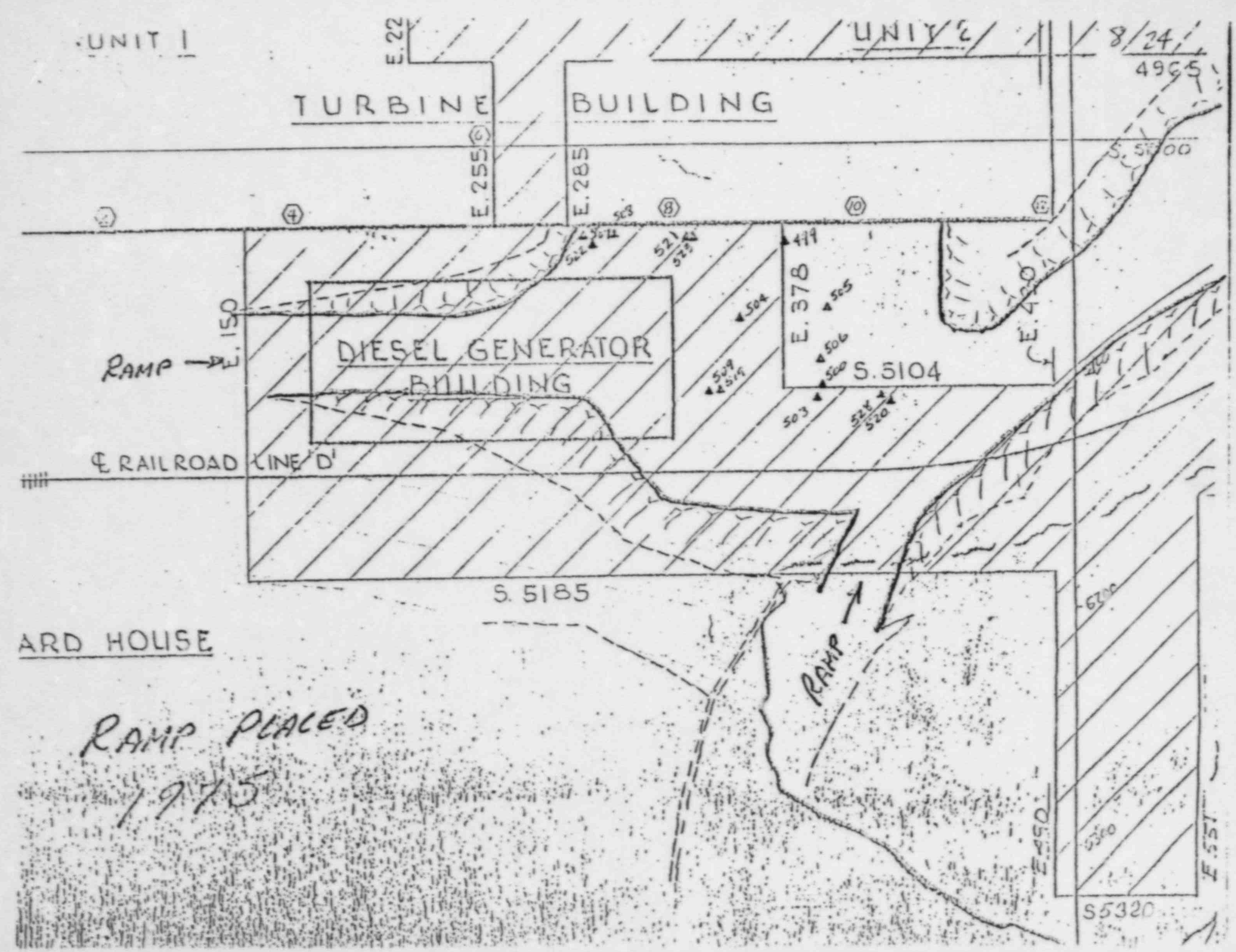
Lab. Insp. ____

Tested Week of ____

South Ramp Placed 1975

Sheet 7 of 24

Date Taken	Test No.	Unified No. Classification (RD / ZONE)	Location	Elev. of Test	Depth Below Final Grade (ft.)	In Place Wet Density (lb/c.f.)	Water Content (%)	In Place Dry Density (lb/c.f.)	Max. Lab. Dry Density (lb/c.f.)	Percent compaction	Remarks
10/30/75	499	40 2	3' S of Q Line 80' W of 11.0	614		136.1	7.1	127.1	126.7/112.2	102	P
11/5/75	500	BMP 260 OMC 10.6 Zone 2	73' S of Q Line 60' W of 11.0	609		139.0	12.6	123.5	129.8	95	P
11/6/75	503	" " "	75' S of Q Line 20' E of 9.0	611		142.0	11.2	127.8	129.8	99	P
11/6/75	504	" " "	42' S of Q Line 12' W of 9.0	612		143.5	12.4	127.7	129.8	98	P
11/11/75	505	252 15.0 2	36' S of Q Line 28' E of 9.0'	612		124.9	13.0	110.5	116.0	95	P
11/11/75	506	260 10.6 2	62' S of Q Line 34' E of 9.0	613		144.3	11.7	129.2	129.8	100	P
11/12/75	507	261 9.8 2	4' S of Q Line 25' E of 6.6	610		142.0	9.3	129.9	127.3	102	P
11/12/75	508	262 11.8 2	2' S of Q Line 37' E of 6.6	607		135.3	10.7	122.2	123.9	99	P
11/12/75	509	" " "	77' S of Q Line 25' W of 9.0	614		139.0	12.3	123.8	123.9	100	P
11/14/75	519	" " "	75' S of Q Line 22' W of 9.0	614		141.3	13.7	124.3	123.9	100	P
11/14/75	520	" " "	83' S of Q Line 53' E of 9.0	614		141.5	14.9	123.2	123.9	99	F (Moisture) Cleared by 528
11/14/75	521	RD 40 Zone 2	3' S of Q Line 70' E of 6.6	613		137.2	8.5	126.5	126.7/112.1	99	P
11/14/75	522	" "	3' S of Q Line 30' E of 6.6	611		135.4	7.8	125.6	" "	93	P
11/14/75	523	" "	3' S of Q Line 70' E of 6.6	614		127.7	7.3	119.0	" "	50	F
11/17/75	528	BMP 262 OMC 11.8 ZONE 2	85' S of Q Line 53' E of 9.0	614		140.2	13.6	123.4	123.9	100	P Clears 520



UNIT 1
UNIT 2
8/24
4965
TURBINE BUILDING
E. 22
E. 255
E. 285
E. 150
E. 378
E. 450
E. 551
S. 5000
S. 5104
S. 5185
S5320
DIESEL GENERATOR BUILDING
RAMP
℄ RAILROAD LINE 'D'
ARD HOUSE
RAMP
RAMP PLACED 1975

Project ____ ____________

Date ____ ____________

BECHTEL CORPORATION

WEEKLY COMPACTED FILL DENSITY TEST REPORT QC-6C

Spec. No. ________

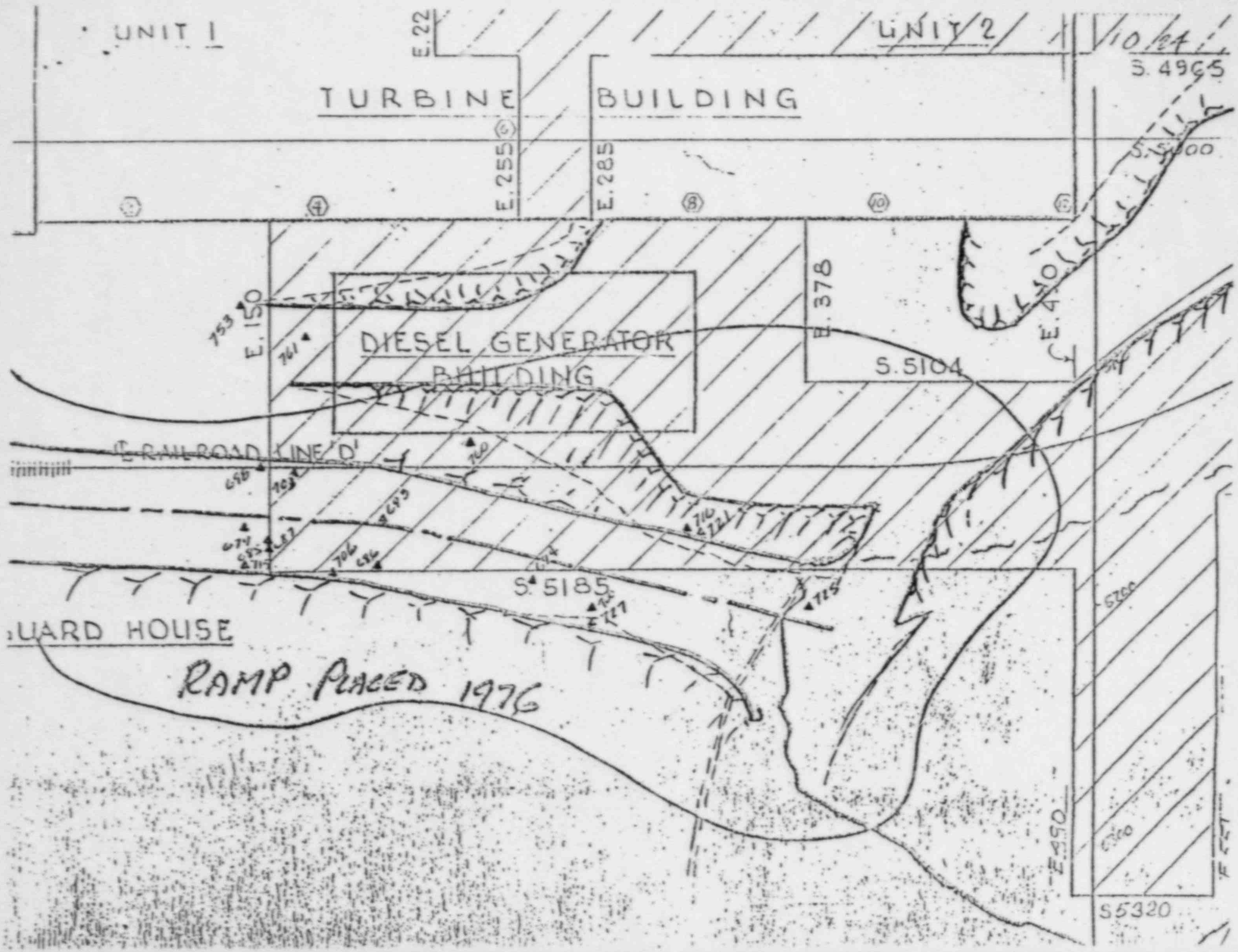
Lab. Insp. ________

Tested Week of ________

Sheet 9 of 24

South Access Ramp 1976

Date Taken	Test No.	Unified No. Classification (BMP OMC ZONE)	Location (So. Access Ramp)	Elev. of Test	Depth Below Final Grade (ft.)	In Place Wet Density (lb/c.f.)	Water Content (%)	In Place Dry Density (lb/c.f.)	Max. Lab. Dry Density (lb/c.f.)	Percent compaction	Remarks
7/12/76	679	255 14.4 1	1+40 5'R ℄	608	-	131.0	13.2	115.8	117.4	99.0	P
7/13/76	685	" " "	1+50 10'L ℄	607	-	131.5	18.7	110.8	117.4	94.0	F (Cleared by 687)
7/13/76	686	" " "	2+00 18'L ℄	607		134.5	16.2	115.8	117.4	99.0	P
7/13/76	687	" " "	1+50 10'L ℄	601		129.0	13.4	113.8	117.4	97.0	P (Clears 685)
7/14/76	693	256 13.6 1	2+00 ℄	608.5		140.5	15.2	122.0	119.4	102.0	P
7/14/76	694	" " "	2+70 12'R ℄	608		137.0	13.0	121.3	119.4	102.0	P
7/14/76	698	254 15.8 1	1+45 25'L ℄	609.5		134.5	16.5	115.5	115.7	99.9	P
7/15/76	700	255 - 14.4 1	2+00 10'R ℄	610.5		138.0	15.0	120.0	117.4	102.0	P
7/15/76	703	254 - 15.8 1	1+60 25'L ℄	611.0		132.5	14.7	115.5	115.7	99.9	P
7/15/76	706	257 12.0 2	1+80 10'R ℄	612.0		138.6	13.9	121.6	121.7	100	P
7/19/76	715	254 15.8 1	1+40 20'R ℄	613.0		139.5	15.9	116.0	115.7	100	P
7/19/76	716	" " "	2+30 30'L ℄	612.0		130.5	13.7	114.7	115.7	99	F (Moisture)
7/[illegible]/76	721	" " "	2+30 30'L ℄	612		130.5	15.7	112.7	115.7	97	P Clears 716
7/20/76	725	RD 50 Zone 1	195'S of Q - 60'E 80	604		124.5	8.6	114.6	115.9/96.8	94	RD.
7/21/76	727	252 - 15.0 2	2+00 25'L ℄	612		138.5	14.9	120.5	116.0	104	P
7/23/76	753	255 14.4 2	57'S of Q Line 55'E of 2.0	607		135.0	16.4	116.0	117.4	99	P
7/24/76	760	" " "	2+30 45'L ℄	613		138.5	13.5	122.0	117.4	104	P
7/27/76	761	" " "	55'S of Q Line 77'E of 2.0	608		135.5	16.3	116.5	117.4	99	P



UNIT 1
UNIT 2
TURBINE BUILDING
E. 22
E. 255
E. 285
S. 4965
S. 5000
E. 150
E. 378
E. 410
S. 5104
DIESEL GENERATOR BUILDING
℄ RAILROAD LINE 'D'
S. 5185
E. 490
S5320
UARD HOUSE
RAMP PLACED 1976

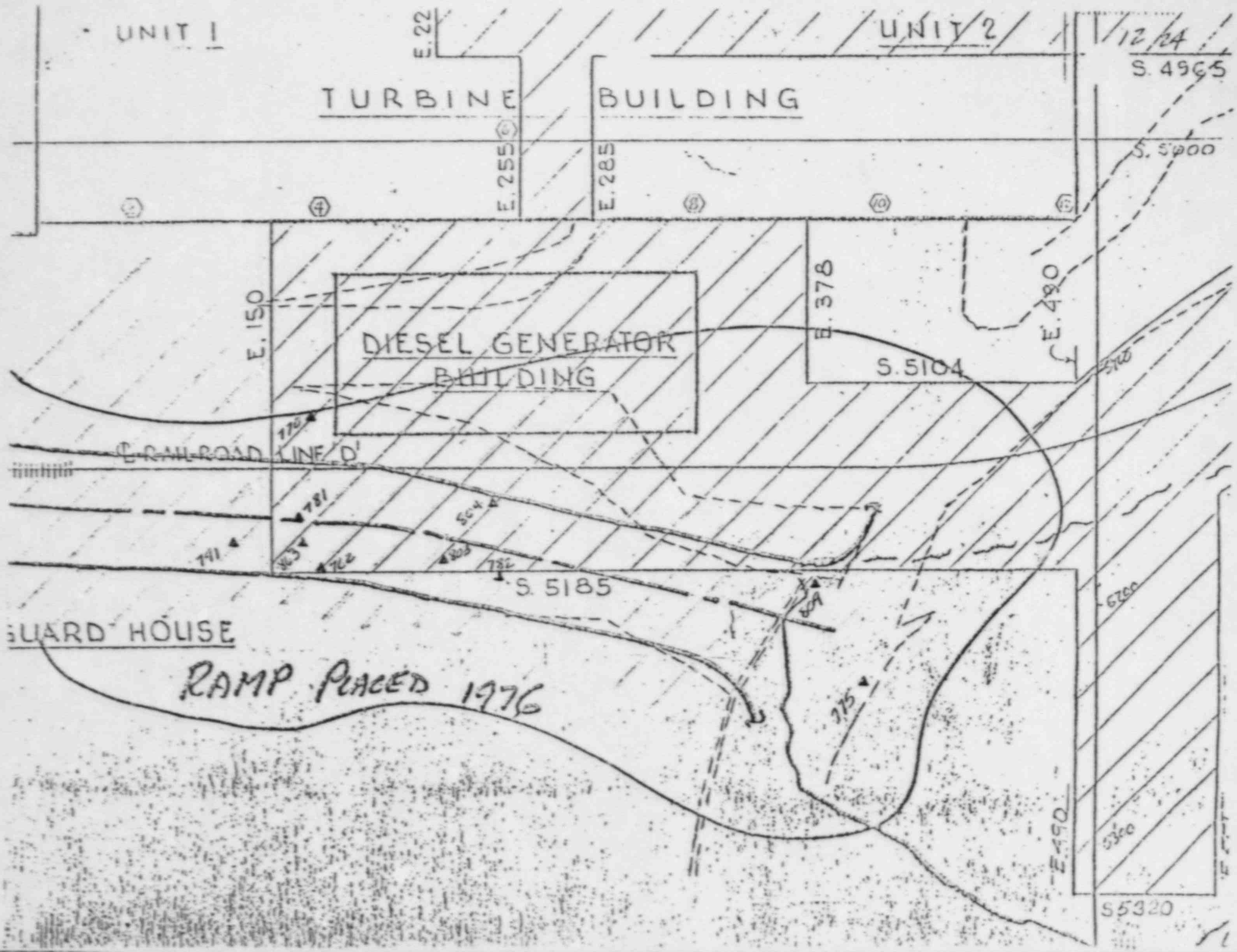
roject ___ Date ___

BECHTEL CC ORATION
WEEKLY COMPACTED FILL DE TY TEST REPORT QC-6C

Spec. No. ___
Lab. Insp. ___
Tested Week of ___
Sheet 11 of 24

South Access Ramp 1976

Date Taken	Test No.	Unified No. Classification (Cmp OMC Zone)	Location	Elev. of Test	Depth Below Final Grade (ft.)	In Place Wet Density (lb/c.f.)	Water Content (%)	In Place Dry Density (lb/c.f.)	Max. Lab. Dry Density (lb/c.f.)	Percent compaction	Remarks
7/24/76	762	255 14.4 2	1+75 12'L ℄	615.5	–	138.0	14.0	121.0	117.4	103	P
7/26/76	770	254 15.8 2	1+60 50'L ℄	612.5	–	136.5	14.2	119.5	115.7	103	P
7/26/76	775	255 14.4 2	4+00 20'R ℄	609		139.7	15.3	121.2	117.4	103	P
7/26/76	781	262 11.8 2	1+60 ℄	616		137.5	12.2	122.5	123.9	99	P
7/26/76	782	" " "	2+55 15'R ℄	613.5		137.5	12.0	122.7	123.9	99	P
7/27/76	791	" " "	1+35 10'R ℄	617		139.0	11.2	125.0	123.9	101	P
7/28/76	803	" " "	2+30 10'R ℄	616.5		143.5	12.5	127.5	123.9	103	P
7/28/76	804	254 15.8 2	2+50 30'L ℄	609.0		140.5	15.1	122.0	115.7	105	P
7/28/76	809	RD 41 Zone 2	3+90 25'L ℄	606		124.6	14.6	108.7	108.7 / 89.6	100%	RD
8/10/76	863	200 13.4 2	1+75 10'R ℄	616.5		137.0	14.4	119.75	118.1	101.4	P


UNIT 1
UNIT 2
12/24
S. 4965
E. 22
TURBINE BUILDING
E. 255
E. 285
S. 5000
E. 150
DIESEL GENERATOR BUILDING
E. 378
E. 490
S. 5104
RAILROAD LINE 'D'
S. 5185
GUARD HOUSE
RAMP PLACED 1976
E. 490
S5320

Project ____ ____

Date ____ ____

BECHTEL CORPORATION

WEEKLY COMPACTED FILL DENSITY TEST REPORT QC-6C

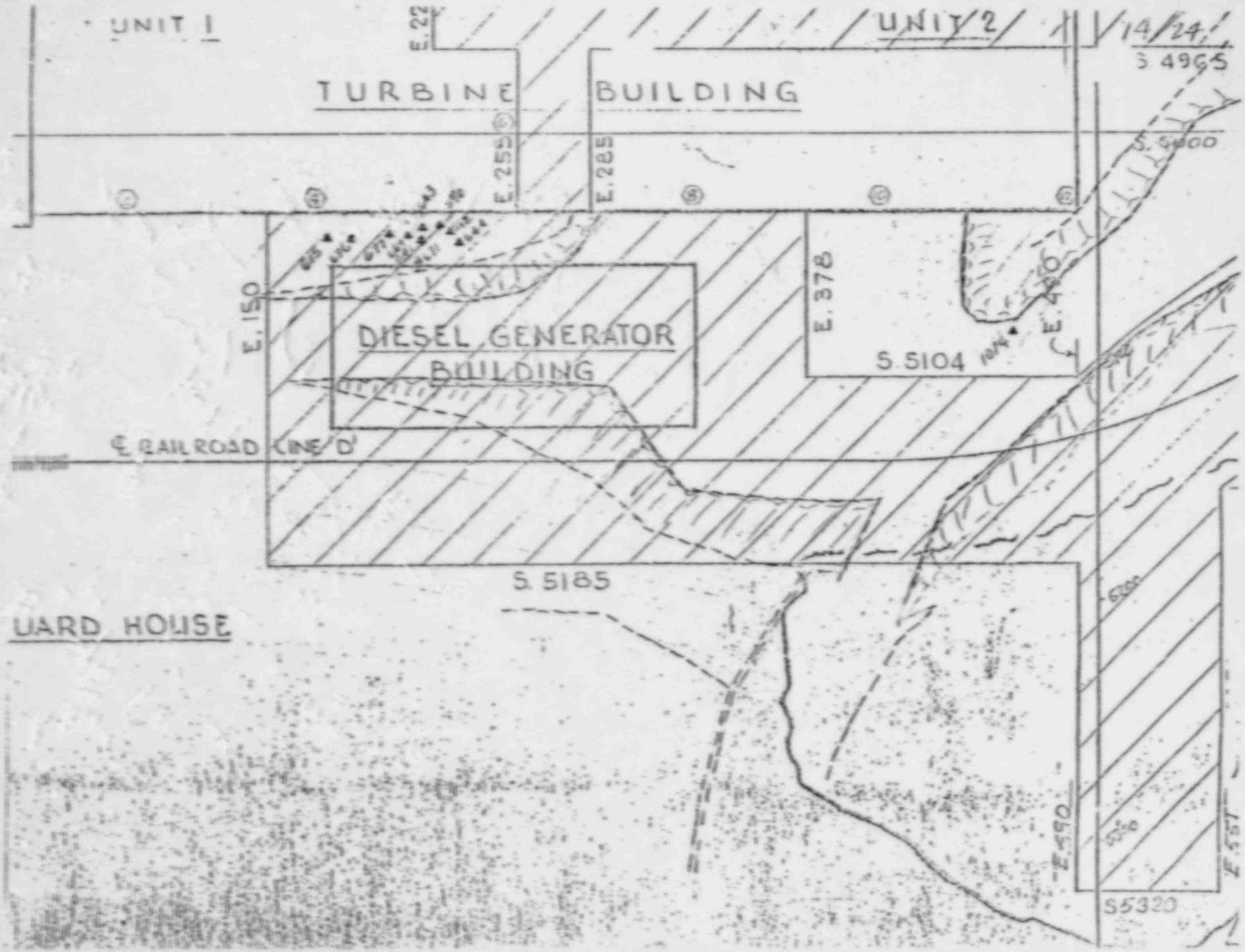
Spec. No. ____ ____

Lab. Insp. ____ ____

Tested Week of ____

Sheet 13 of 24

Date Taken	Test No.	Unified No. Classification RD	Unified No. Classification ZONE	Location	Elev. of Test	Depth Below Final Grade (ft.)	In Place Wet Density (lb/c.f.)	Water Content (%)	In Place Dry Density (lb/c.f.)	Max. Lab. Dry Density (lb/c.f.)	Percent compaction	Remarks
6/9/76	590	30	2	2' S of Q Line 15' W of 5.3 Line	597*		128.7	20.8	106.5	108.5 / 91.5	90.0	* Original Ground per
6/9/76	592	43	2	2' S of Q Line 15' W of 5.3 Line	597		115.4	7.3	107.5	110.5 / 90.8	87.0	Dwg C-41 P Rev 4 Note 1
6/30/76	641	"	"	5' S of Q Line 39' W of 6.0	600		114.9	7.5	106.9	" "	85.0	P
7/1/76	643	"	"	3' S of Q Line 39' W of 6.0	602		119.4	9.4	109.1	" "	94.0	P
7/1/76	644	"	"	8' S of Q Line 18' W of 6.0 Line	604		122.8	10.2	111.4	" "	104.0	P
7/7/76	667	41	1	4' S of Q Line 18' W of 5.0	606		118.7	8.0	109.9	108.7 / 89.6	105.0	P
7/8/76	671	"	"	18' S of Q Line 36' W of 6.0	607		121.6	8.8	111.8	" "	113.0	P
7/9/76	675	"	"	12' S of Q Line 75' W of 6.0	602		119.5	8.0	110.6	" "	108.0	P
7/9/76	676	"	"	15' S of Q Line 61' W of 6.0	605		123.7	7.8	114.7	" "	125.0	P
7/12/76	677	"	"	10' S of Q Line 45' W of 6.0	607		113.6	6.6	106.6	" "	91.0	P
9/1/76	1014	BMP 251 OMC 9.2	ZONE 2	52' S of Q Line 22' W of 12.0	608	·	145.0	10.1	131.8	130.6	101.0	P


UNIT 1
UNIT 2
14/24
S. 4965
E. 22
TURBINE BUILDING
S. 5000
E. 255
E. 285
DIESEL GENERATOR BUILDING
E. 150
E. 378
E. 490
S. 5104
€ RAILROAD LINE 'D'
S. 5185
UARD HOUSE
E. 490
E. 551
S5320

Project ______ ______________

Date ______ ______________

BECHTEL CORPORATION

WEEKLY COMPACTED FILL DENSITY TEST REPORT QC-6C

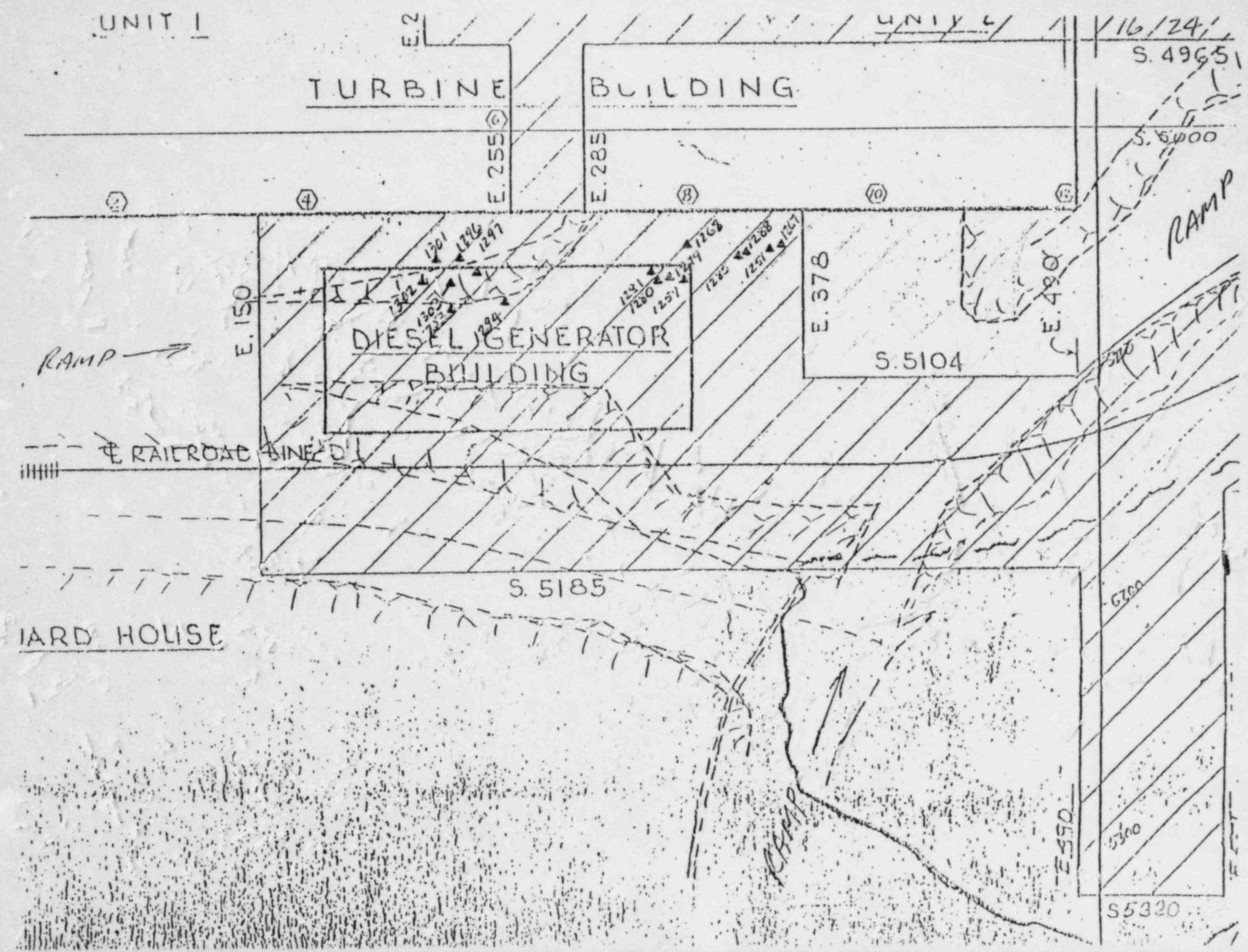
Spec. No. ________ ________

Lab. Insp. ______ ________

Tested Week of ________________

Sheet 15 of 24

Date Taken	Test No.	Unified No. Classification RD	Zone	Location	Elev. of Test	Depth Below Final Grade (ft.)	In Place Wet Density (lb/c.f.)	Water Content (%)	In Place Dry Density (lb/c.f.)	Max. Lab. Dry Density (lb/c.f.)	Percent compaction	Remarks
4/[illegible]/77	1251	55	2	14' S of Q Line on 9.0 Line	609		115.4	5.1	109.8	109.7/90.2	100.4	P % of RD
4/[illegible]/77	1259	"	"	30' S of Q Line ℄ of 8.0	608		115.1	6.1	108.5	" "	98.9	P
4/[illegible]/77	1267	"	"	15' S of Q Line ℄ of 9.0	611		118.0	6.9	110.4	" "	102.9	P
4/[illegible]/77	1268	"	"	15' S of Q Line ℄ of 9.0	611		120.1	6.8	112.5	" "	111.5	P
4/[illegible]/77	1279	"	"	30' S of Q Line 5' W of 8.0	609		115.2	6.0	108.7	" "	95.7	P
4/[illegible]/77	1280	"	"	30' S of Q Line 5' W of 8.0	613		117.8	5.9	111.2	" "	106.2	P
4/[illegible]/77	1281	"	"	30' S of Q Line 5' W of	611		117.5	5.9	111.0	" "	105.4	P
4/[illegible]/77	1285	Bwp Curve 274 10-4	Zone 1	14' S of Q Line 148' W of 12.0	616		142.25	13.2	125.7	124.8	100.	F (Moisture)
4/[illegible]/77	1288	" "	"	14' S of Q Line 148' W of 12.0	616		142.5	9.9	129.7	124.8	103.9	P Clears 1285
4/[illegible]/77	1294	RD 55	Zone 2	40' S of Q Line 2' of 6.0	608		122.2	4.7	116.7	109.7/90.2	127.7	P % of RD
4/[illegible]/77	1290	"	"	25' S of Q Line 35' E of 6.0	610		114.8	6.4	107.9	" "	92.3	P
4/[illegible]/77	1297	"	"	27' S of Q Line 57' E of 6.0	612		114.8	6.1	108.2	" "	93.6	P
[illegible]/77	1301	"	"	30' S of Q Line 4' W of 6.0	606		122.4	11.7	109.6	" "	99.6	P
5/[illegible]/77	1302	"	"	32' S of Q Line 28' W of 6.0	606		118.2	9.5	107.9	" "	92.3	P
5/[illegible]/77	1303	"	"	32' S of Q Line 20' W of 6.0	610		118.0	8.7	108.6	" "	95.3	P


UNIT 1
UNIT 2
TURBINE BUILDING
DIESEL GENERATOR BUILDING
IARD HOUSE
RAMP
RAMP
RAMP
℄ RAILROAD LINE
E. 150
E. 255
E. 285
E. 378
E. 490
E. 550
S. 4965
S. 5000
S. 5104
S. 5185
S 5320
1301
1296
1297
1302
1303
1294
1231
1280
1251
1274
1268
1285
1288
1251
1267

Project ________ ________

Date ________ ________

BECHTEL CORPORATION

WEEKLY COMPACTED FILL DENSITY TEST REPORT QC-6C

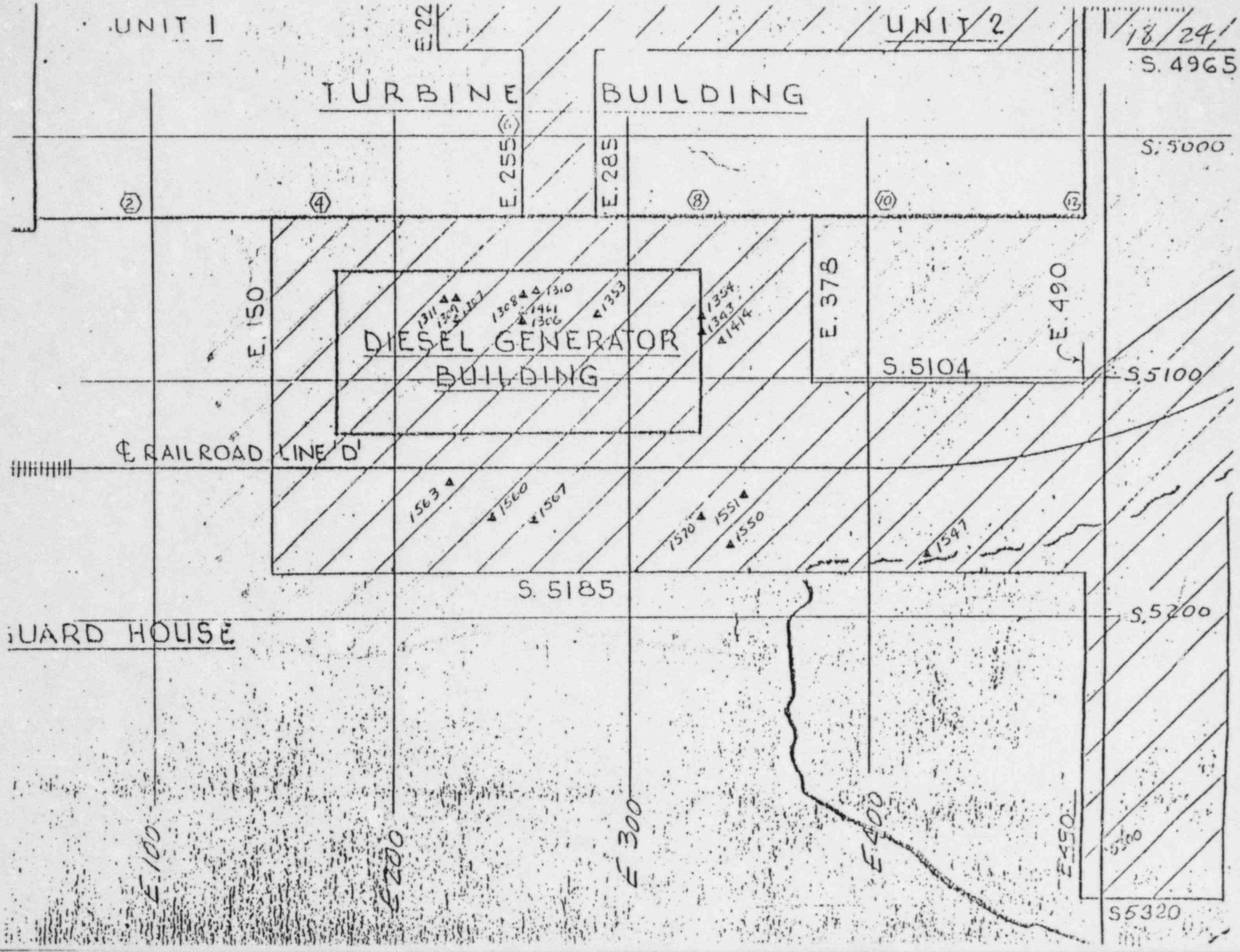
Spec. No. ________ ________

Lab. Insp. ________ ________

Tested Week of ________

Sheet 17 of 24

Date Taken	Test No.	Unified No. Classification	Location	Elev. of Test	Depth Below Final Grade (ft.)	In Place Wet Density (lb/c.f.)	Water Content (%)	In Place Dry Density (lb/c.f.)	Max. Lab. Dry Density (lb/c.f.)	Percent compaction	Remarks
5/3/77	1306	RD Zone 55 2	45'S of Q Line 6'E of 6.0	609		122.5	7.8	113.6	109.7 / 90.2	115.9	P % of RD
5/3/77	1307	" "	34'S of Q Line 24'W of 6.0	611		122.3	6.8	114.5	" "	119.4	P
5/3/77	1308	" "	35'S of Q Line 10'E of 6.0	611		115.8	6.9	108.3	" "	92.8	P
5/3/77	1309	" "	35'S of Q Line 25'W of 6.0	610		113.0	7.1	105.5	" "	81.6	P
5/3/77	1310	" "	32'S of Q Line, 14'E of 6.0	613		120.5	5.8	113.9	" "	117.1	P
5/3/77	1311	" "	35'S of Q Line 28'W of 6.0	613		109.8	7.4	102.2	" "	66.1	F NCR1004
5/11/77	1343	" "	50'S of Q Line on 8.0 Line	612		111.0	5.6	105.1	" "	79.8-	P - 80% of RD
5/25/77	1353	" "	40'S of Q Line 3'W of 7.0	618		110.3	4.8	105.2	" "	80.5	P
5/25/77	1354	" "	40'S of Q Line ℄ of 8.0	620		118.5	9.1	108.6	" "	95.3	P
6/7/77	1414	BMP OMC Zone 278 15.2 1	57'S of Q Line 30'W of 9.0	622		141.5	13.2	125.0	117.0	106.8	P
6/10/77	1461	RD Zone 55 2	39'S of Q Line 6'E of 6.0	617		122.6	5.5	115.9	109.7 / 90.2	124.7	P % of RD
6/22/77	1547	BMP OMC Zone 277 13.4 2	S 5175 - E 430	625.5		137.0	13.0	121.2	121.0	100.2	P
6/22/77	1550	269 10.0 1	S 5170 - E 345	617		138.5	9.7	126.2	127.3	99.1	P
6/22/77	1551	" " "	S 5155 - E 350	613.5		133.0	9.7	121.2	127.3	95.1	P
6/23/77	1560	262 11.8 1	S 5165 - E 245	621		131.5	10.0	119.5	123.9	96.4	P
6/23/77	1563	271 10.1 1	S 5142 - E 223	620		131.5	8.9	120.7	126.6	95.3	P
6/24/77	1567	269 10.0 1	S 5162 - E 265	622		135.5	9.1	124.2	127.3	97.6	P
6/24/77	1570	" " "	S 5165 - E 334	622		140.5	9.8	128.0	127.3	100.5	P



UNIT 1
UNIT 2
18/24
S. 4965
TURBINE BUILDING
E. 22
E. 255
E. 285
S. 5000
2
4
6
8
10
12
E. 150
DIESEL GENERATOR BUILDING
E. 378
E. 490
S. 5104
S. 5100
℄ RAILROAD LINE 'D'
1311
1309
1308
1310
1441
1306
1353
1354
1343
1414
1563
1560
1567
1570
1551
1550
1547
S. 5185
S. 5200
GUARD HOUSE
E 100
E 200
E 300
E 400
E 450
S5320

reject ______ ______________

ate ________ ______________

BECHTEL CORPORATION

WEEKLY COMPACTED FILL DENSITY TEST REPORT QC-6C

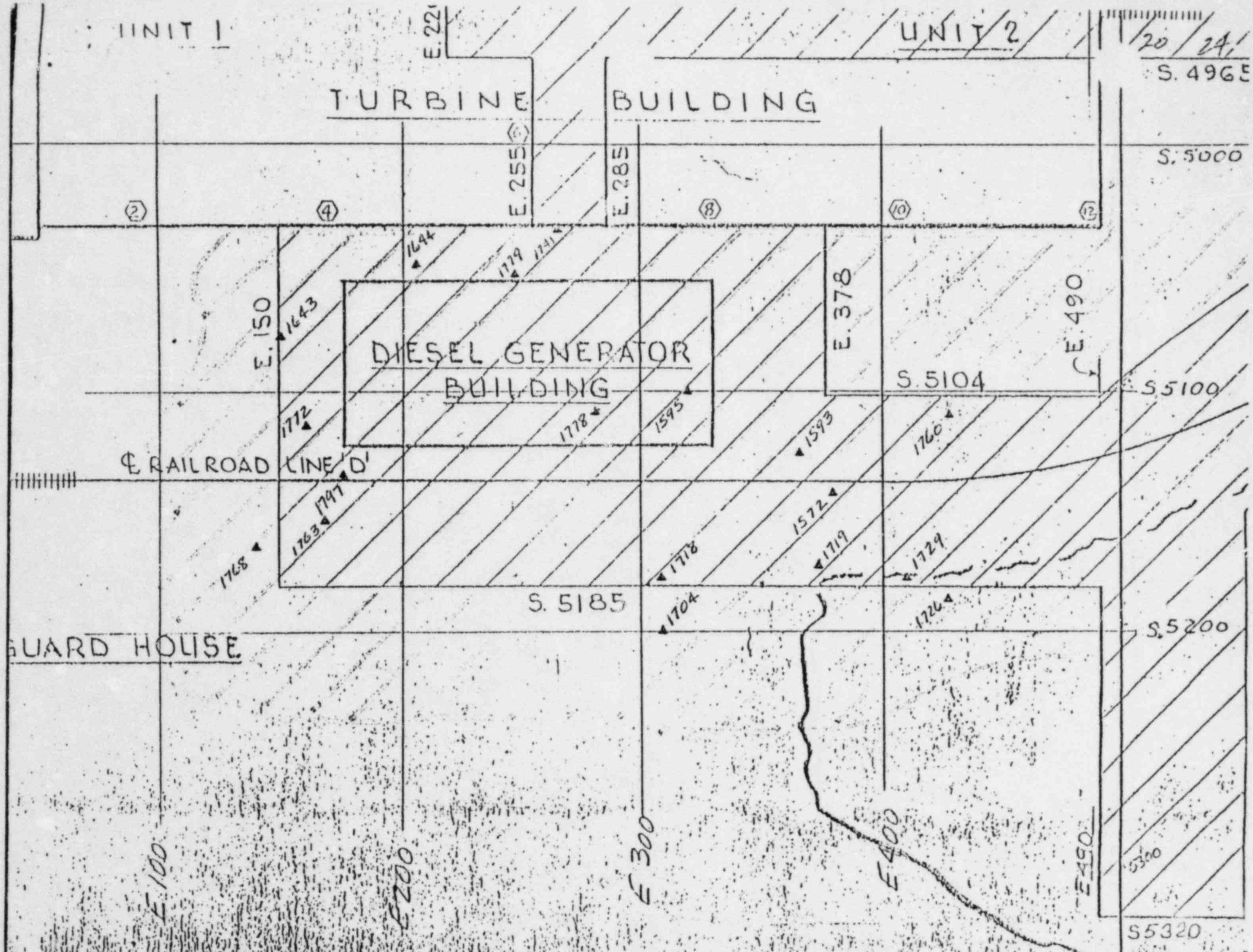
Spec. No. ________ ________

Lab. Insp. ________ ________

Tested Week of ____________________

Sheet 19 of 24

Date Taken	Test No.	Unified No. Classification BMP OMC ZONE	Location	Elev. of Test	Depth Below Final Grade (ft.)	In Place Wet Density (lb/c.f.)	Water Content (%)	In Place Dry Density (lb/c.f.)	Max. Lab. Dry Density (lb/c.f.)	Percent compaction	Remarks
6/24/77	1572	269 10.0 1	S 5140-E 380	623.5		140.0	10.2	127.0	127.3	99.8	P
7/1/77	1593	" " "	S 5125-E 370	626		135.5	11.5	121.5	127.3	95.4	P
7/1/77	1595	262 11.8 1	S 5100-E 320	625		131.0	10.1	119.0	123.9	96.0	P
7/11/77	1643	269 10.0 1	S. 5087-E 150	615		141.5	10.5	128.0	127.3	100.5	P
7/11/77	1644	" " "	S 5050-E 207	618		138.5	11.5	124.2	127.3	97.6	P
7/21/77	1704	270 11.1 1	S 5200-E 308	623		135.0	12.3	120.2	124.6	96.5	P
7/22/77	1718	278 15.2 1	S 5182-E 308	624		146.0	14.5	127.5	117.0	109.0	P
7/22/77	1719	270 11.1 1	S 5175-E 375	626.5		142.0	11.4	127.5	124.6	102.3	P
7/23/77	1726	274 10.4 1	S 5188-E 432	628.5		136.5	11.0	123.0	124.8	98.6	P
7/23/77	1729	270 11.1 1	S 5180-E 410	629		140.5	12.0	125.5	124.6	100.7	P
7/2[illegible]/77	1741	" " "	S. 5034-E 270	627		141.6	12.2	125.7	124.6	100.9	P
7/27/77	1760	260 10.6 1	S 5112-E 437	629.5		148.5	9.2	136.0	129.8	104.8	P
7/2[illegible]/77	1763	" " "	S. 5145-E 170	616		136.5	8.8	125.5	129.8	96.7	P
7/28/77	1768	269 10.0 1	S. 5162-E 145	619		143.0	10.9	129.0	127.3	101.3	P
7/28/77	1772	262 11.8 1	S. 5128-E 160	620.5		139.5	12.0	124.5	123.9	100.1	P
7/28/77	1778	269 10.0 1	S 5105-E 280	624		141.5	10.5	128.0	127.3	100.5	P
7/29/77	1779	" " "	S 5060-E 245	625		147.0	11.8	131.5	127.3	103.3	P
7/30/77	1797	" " "	S 5135-E 175	623		139.0	10.8	125.5	127.3	98.6	P



UNIT 1
UNIT 2
TURBINE BUILDING
DIESEL GENERATOR BUILDING
GUARD HOUSE
℄ RAILROAD LINE 'D'
S. 4965
S. 5000
S. 5100
S. 5104
S. 5185
S. 5200
S5320
E. 22
E. 150
E. 255
E. 285
E. 378
E. 490
E 100
E 200
E 300
E 400
2
4
6
8
10
12
1643
1644
1779
1741
1772
1778
1595
1593
1760
1797
1763
1768
1572
1718
1719
1729
1704
1726

Project ______ ______

Date ______ ______

BECHTEL C(~)ORATION

WEEKLY COMPACTED FILL D( )TY TEST REPORT QC-6C

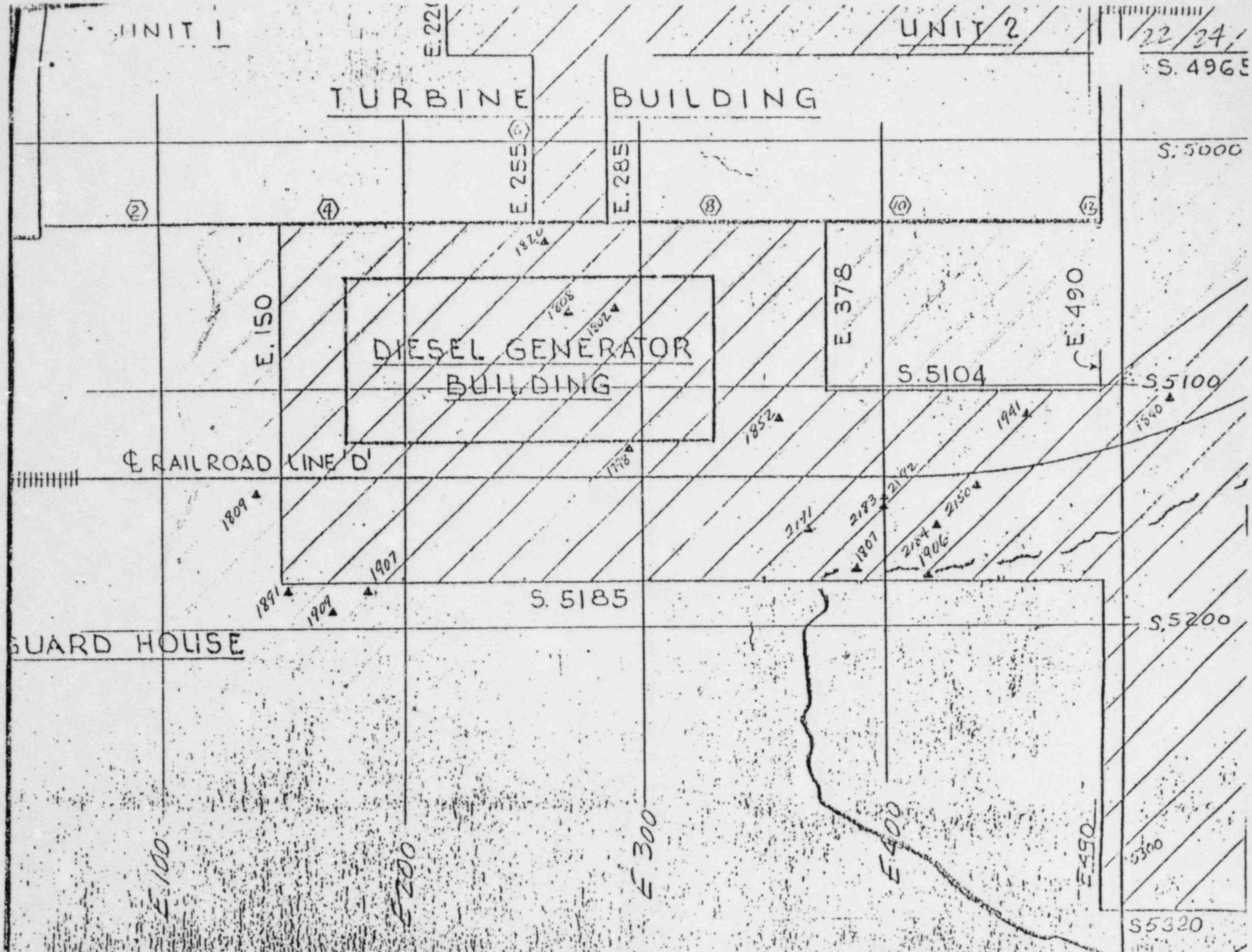
Spec. No. ______ ______

Lab. Insp. ______ ______

Tested Week of ______

Sheet 21 of 24

Date Taken	Test No.	Unified No. Classification (BMP OMC ZONE)	Location	Elev. of Test	Depth Below Final Grade (ft.)	In Place Wet Density (lb/c.f.)	Water Content (%)	In Place Dry Density (lb/c.f.)	Max. Lab. Dry Density (lb/c.f.)	Percent compaction	Remarks
7/30/77	1798	269 10.0 1	S 5122 - E 298	627		144.0	9.9	131.0	127.3	102.9	P
8/1/77	1802	" " "	S 5070 - E 290	627		140.5	11.5	126.0	127.3	99.0	P
8/2/77	1807	271 10.1 1	S 5182 - E 390	631		140.0	10.5	126.7	126.6	100.1	P
8/2/77	1808	269 10.0 1	S 5074 - E 270	628		143.0	10.4	129.5	127.3	101.7	P
8/2/77	1809	" " "	S 5140 - E 140	627		142.5	10.5	129.0	127.3	101.3	P
8/3/77	1820	270 11.1 1	S 5042 - E 265	626.5		134.5	11.2	121.0	124.6	97.1	P
8/9/77	1840	269 10.0 1	S 5107 - E 520	632		143.0	11.5	128.2	127.3	100.7	P
8/12/77	1852	" " "	S 5112 - E 359	629		139.5	11.8	125.0	127.3	98.0	P
8/17/77	1891	263 9.1 1	S 5187 - E 155	621		144.0	9.3	131.7	131.0	100.5	P
8/19/77	1906	RD 55 Zone 2	150' S of Q Line 80' W of 12.0	620		115.2	7.2	107.5	109.7 / 90.2	90.5	P % of RD
8/19/77	1907	BMP OMC Zone 297 9.0 1	S 5187 - E 185	628		147.0	10.9	132.5	131.6	100.7	P
8/20/77	1909	269 10.0 1	S 5190 - E 169	630		141.5	11.4	127.0	127.3	99.8	P
8/26/77	1941	RD 55 Zone 2	S 5110 - E 465	628		116.4	5.7	110.1	109.7 / 90.2	101.7	P % of RD
9/30/77	2150	55 2	115' S of Q Line 5' W of 11.0	625		124.6	9.1	114.2	109.7 / 90.2	118.2	P % of RD
10/5/77	2183	BMP OMC ZONE 277 13.4 1	S-5150 - E 400	629		143.0	12.9	126.7	121.0	105.0	P
10/5/77	2184	" " "	S 5165 - E 420	630.5		145.0	13.1	128.2	121.0	106.0	P
10/6/77	2191	270 11.1 1	S 5163 - E 372	631		146.0	12.6	129.7	124.6	104.1	P
10/6/77	2192	" " "	S 5148 - E 400	633		144.0	12.9	127.5	124.6	102.3	P


UNIT 1
UNIT 2
22/24
S. 4965
TURBINE BUILDING
E. 220
S. 5000
E. 255
E. 285
E. 150
E. 378
E. 490
DIESEL GENERATOR BUILDING
S. 5104
S. 5100
℄ RAILROAD LINE 'D'
S. 5185
S. 5200
GUARD HOUSE
E 100
E 200
E 300
E 400
E 490
S 5320
1820
1808
1802
1778
1852
1941
1840
1809
1891
1909
1907
2171
2183
2172
2184
2150
1807
1906
5300

Project ______

Date ______

BECHTEL C(ORATION

WEEKLY COMPACTED FILL DE   TY TEST REPORT   QC-6C

Spec. No. ______

Lab. Insp. ______

Tested Week of ______

Sheet 23 of 24

Date Taken	Test No.	Unified No. Classification (BMP OMC ZONE)	Location	Elev. of Test	Depth Below Final Grade (ft.)	In Place Wet Density (lb/c.f.)	Water Content (%)	In Place Dry Density (lb/c.f.)	Max. Lab. Dry Density (lb/c.f.)	Percent compaction	Remarks
10/6/77	2193	277 13.4 1	S5166-E427	633		144.0	13.7	126.7	121.0	104.7	P
10/6/77	2195	270 11.1 1	S5130-E442	631		145.5	12.4	129.5	124.6	103.9	P
10/7/77	2202	" " "	S5151-E407	633		140.5	12.2	125.2	124.6	100.5	P
10/10/77	2211	277 13.4 1	S5175-E129	631		139.5	12.3	124.2	121.0	102.6	P
10/26/77	2342	255 14.4 1	S5155-E324	630		138.0	12.2	123.0	117.4	104.8	P
10/26/77	2343	271 10.1 1	S5163-E280	632		136.0	10.8	122.7	126.6	96.9	P
10/27/77	2355	RD 55 Zone 2	19' W of E/wall 2' N of N/wall	632.5		123.3	6.8	115.4	109.7 / 94.2	122.8	P % of RD
10/27/77	2356	" "	22' S of N/wall 2' E of E/wall	632.5		120.0	7.2	111.9	" "	109.1	P
11/12/77	2428	" "	50' E of E/wall 20' S of Q Line	624		117.9	7.2	110.0	" "	101.3	P
11/16/77	2435	" "	40' S of Q Line @ 12.0 Line	627		118.8	5.8	112.3	" "	110.7	P
12/23/77	2457	" "	145' S of Q Line 3' E of 10.0	629		117.6	7.9	109.0	" "	97.0	P
12/23/77	2458	" "	150' S of Q Line 12' W of 11.0	626		115.5	5.3	109.7	" "	100 -	P
12/29/77	2459	" "	170' S of Q Line 33' W of 11.0	631		120.4	6.4	113.2	" "	114.3	P
12/29/77	2460	" "	200' S of Q Line 20' W of 11.0	630		124.7	8.9	114.5	" "	119.4	P
3/30/78	2475	" "	180' S of Q Line 12' E of 3.0	630		119.5	7.6	111.1	" "	105.8	P
3/31/78	2477	" "	175' S of Q Line 10' E of 3.0	632		116.4	3.0	113.0	" "	113.5	P
4/12/78	2497	BMP OMC ZONE 269 8.2 1	175' S of Q Line 40' E of 8.0	632		146.0	12.7	129.5	131.7	98.3	P
4/12/78	2501	" " "	100' S of Q Line 40' E of 8.0	633		144.0	13.2	127.2	131.7	96.6	P

Project ______________

Date ______________

BECHTEL CORPORATION

WEEKLY COMPACTED FILL DENSITY TEST REPORT QC-6C

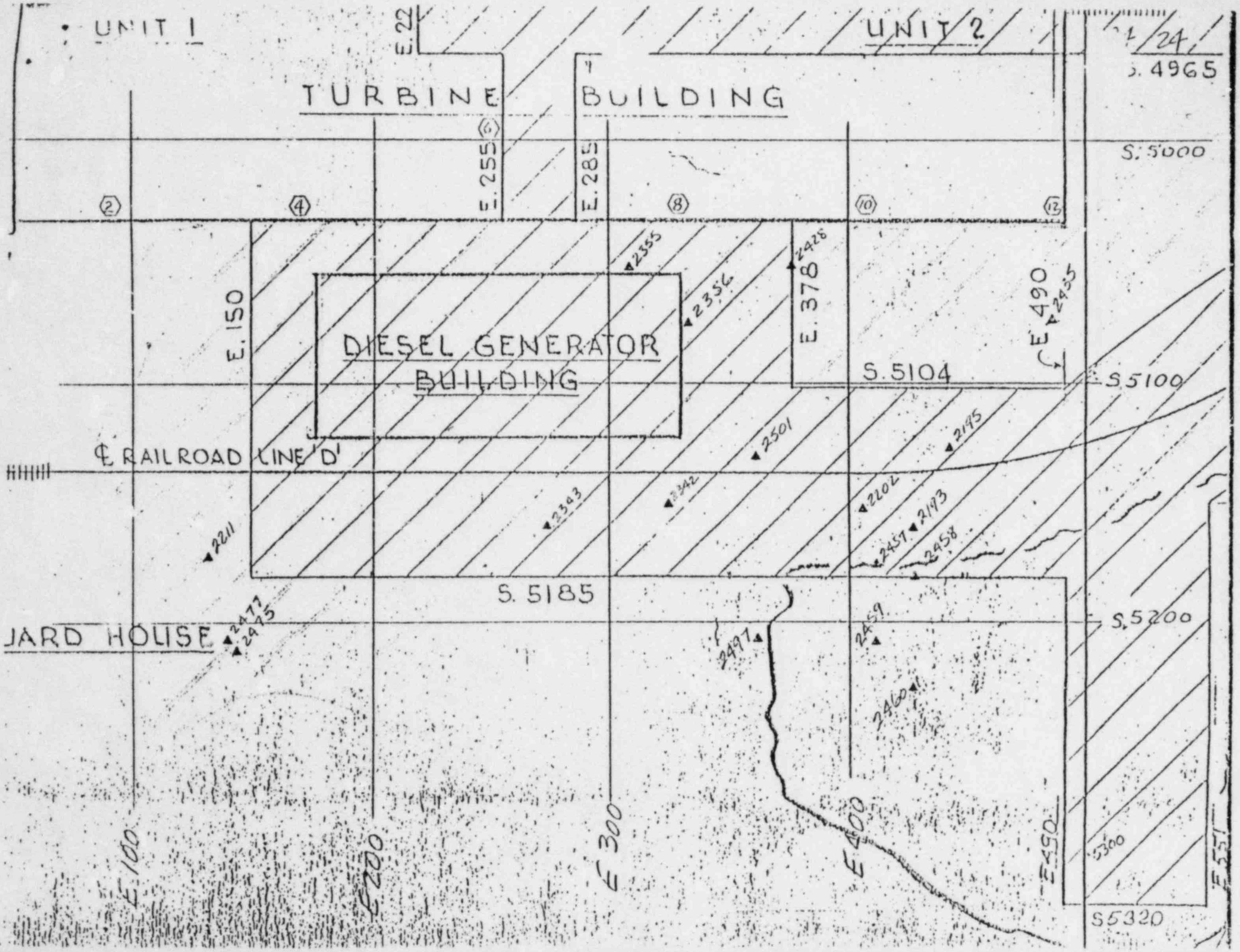
Spec. No. ________

Lab. Insp. ________

Tested Week of ________

Sheet 23 of 24

Date Taken	Test No.	Unified No. Classification (BMP OMC Zone)	Location	Elev. of Test	Depth Below Final Grade (ft.)	In Place Wet Density (lb/c.f.)	Water Content (%)	In Place Dry Density (lb/c.f.)	Max. Lab. Dry Density (lb/c.f.)	Percent compaction	Remarks
10/5/77	2193	277 13.4 1	S5166-E427	633		144.0	13.7	126.7	121.0	104.7	P
10/6/77	2195	270 11.1 1	S5130-E442	631		145.5	12.4	129.5	124.6	103.9	P
10/7/77	2202	" " "	S5151-E407	633		140.5	12.2	125.2	124.6	100.5	P
10/10/77	2211	277 13.4 1	S5175-E127	631		139.5	12.3	124.2	121.0	102.6	P
10/26/77	2342	255 14.4 1	S5155-E324	630		138.0	12.2	123.0	117.4	104.8	P
10/26/77	2343	271 10.1 1	S5163-E280	632		136.0	10.8	122.7	126.6	96.9	P
10/27/77	2355	RD 55 Zone 2	19' W of E/wall 2' N of N/wall	632.5		123.3	6.8	115.4	109.7 / 93.2	122.8	P % of RD
10/27/77	2356	" "	22' S of N/wall 2' E of E/wall	632.5		120.0	7.2	111.9	" "	109.1	P
11/12/77	2428	" "	50' E of E/wall 20' S of Q Line	624		117.9	7.2	110.0	" "	101.3	P
11/12/77	2435	" "	40' S of Q Line @ 12.0 Line	627		118.8	5.8	112.3	" "	110.7	P
12/23/77	2457	" "	145' S of Q Line 3' E of 10.0	629		117.6	7.9	109.0	" "	97.0	P
12/23/77	2458	" "	150' S of Q Line 12' W of 11.0	626		115.5	5.3	109.7	" "	100 -	P
12/29/77	2459	" "	170' S of Q Line 33' W of 11.0	631		120.4	6.4	113.2	" "	114.3	P
12/29/77	2460	" "	200' S of Q Line 20' W of 11.0	630		124.7	8.9	114.5	" "	119.4	P
3/30/78	2475	" "	180' S of Q Line 12' E of 3.0	630		119.5	7.6	111.1	" "	105.8	P
3/31/78	2477	" "	175' S of Q Line 10' E of 3.0	632		116.4	3.0	113.0	" "	113.5	P
4/12/78	2497	BMP OMC Zone 269 8.2 1	175' S of Q Line 40' E of 8.0	632		146.0	12.7	129.5	131.7	98.3	P
4/12/78	2501	" " "	100' S of Q Line 40' E of 8.0	633		144.0	13.2	127.2	131.7	96.6	P


UNIT 1
UNIT 2
TURBINE BUILDING
E.22
S.4965
S.5000
E.255
E.285
E.150
E.378
E.490
DIESEL GENERATOR BUILDING
S.5104
S.5100
℄ RAILROAD LINE 'D'
S.5185
S.5200
JARD HOUSE
S5320
E.100
E.200
E.300
E.400
E.450
E.551
2355
2356
2428
2435
2501
2195
2342
2343
2202
2193
2457
2458
2211
2477
2475
2491
2459
2460
5300

J

GJMaynard, P-14-434

RCBauman, P-14-A12

40051517

GSK
KRK
RLT
JAP

July 28, 1978

MIDLAND PROJECT
MIDLAND FSAR REVIEW
FILE: 0505.8 SERIAL: 2624

0505.8

JJSullivan, P-14-432
AJBirkle, P-14-435
TJMcElroy, P-14-430
GAHunt, P-14-420
PAHaupila, P-14-426
RMVanSoof, P-24-410
TCCooke, Midland

The CP Co review of FSAR material will be performed on a "prime reviewer" basis similar to the existing procedure for reviewing Bechtel design documents. The attached table shows our first cut at developing a division of responsibility for the prime review.

Each prime reviewer will have the following basic review responsibilities:

1. Perform a technical review

2. Resolve comments made by other reviewers

3. Perform the CP Co licensing review to assure compliance with Reg Guide 1.70, FSAR Format and Content, and the Standard Review Plan requirements as applicable to the Midland FSAR.

Item 3, above, is extremely important to the success of our Operating License effort and should receive a high priority. It will entail a detailed review of text against the requirements of Reg Guide 1.70 and the Standard Review Plans. Sections which do not contain sufficient content will be returned to the author for additional work.

Please review the attached draft division of responsibility and offer comments relative to the assigned responsibilities. Also, please return a marked copy of the table showing Consumers Power persons whom the prime reviewer feels should receive draft FSAR sections for review. The Project will handle the administrative task of distributing material to all reviewers and collecting initial comments in a manner similar to the prime review of engineering documents.

A schedule showing all key FSAR preparation dates is attached for your use. It is estimated that the FSAR will consist of approximately 12 volumes of single spaced text printed on both sides of the page.

Since the Midland FSAR will be one of the first to be filed under the new NRC Format and Content requirements, and can make little use of existing PSAR material, a major CP Co effort will be required to perform the three basic review functions listed above. For this reason we request that you include a firm commitment for adequate Engineering Services Department support in your response to this memo.

Your reply by August 11, [illegible] will be appreciated.

C-2.1V

Bechtel Associates Professional Corporation

Inter-office Memorandum

BEBC - 831

To J. F. Newgen

Date August 7, 1975

Subject Midland Plant Units 1 & 2
Job No. 7220
Earthwork Compaction Requirements
File: C-210, 0274, C-1140

From R. L. Castleberry

Of Engineering

Copies to

At Ann Arbor

Reference: Telecon, C. A. Hunt of CPCo to R. L. Rixford dated 9-19-74

This letter satisfies a commitment made to Mr. C. A. Hunt of CPCo on 9-19-74 shortly before earthwork operations ceased for the season. On that date Mr. Hunt called to express concern about control of compaction in the plant area fill. This concern was brought about by the fact that Canonie was not using a roller in the plant area.

Mr. Hunt was told that contrary to the specifications for the dike, which include a procedure specifying equipment, number of passes, etc., the specification for the plant area only requires that the end result be a certain degree of compaction with no restriction on the equipment used to attain it.

CPCo's concern centered about the ability of the inspector to assure adequate compaction in the absence of a formal compaction procedure. This concern was discussed with Mr. Hunt and the roles of the Subcontractor, Field Engineer, Inspector and Testing Laboratory personnel were emphasized.

It was finally agreed that a phone call to the Field (followed up by an ICM), stressing that vigilance on the part of the inspectors would be required in areas where compaction methods are not specified, would satisfy CPCo's concern about control of compaction in the plant area.

Hence, a telecon to R. A. Grote on 9-18-74, about this subject, was repeated on 9-19-74, after talking to Mr. Hunt, to transmit this concern to the Field; and now that earthwork operations are resuming this memo completes the commitment.

R. L. Castleberry

RLR/jeh

Attachment A

Route To	This Copy For	Consumers Power	
FMSouthworth	SHHowell		File 16.3.1
HWSlager	GSKeeley		Issue Date October 10, 1975
CGFilla	TCCooke		Project Midland 1 & 2
	DMLaeding		File Title NCR's on Bechtel Project Engineering
	WFKelub	Nonconformance	
	TLRichardson	Report No QF-66	
	Subject File		

This Nonconformance Report is Issued To:
Mr. R. L. Castleberry
Midland Project Engineer
Bechtel Power Corporation
Ann Arbor, MI 48106

who is responsible for corrective action.

Prepared By [illegible] Date [illegible]
Approved By [illegible] Date [illegible]
Written Reply Requested By Date [illegible]
Corrective Action Requested By Date [illegible]

Nonconformance Description and Supporting Details: In the response to [illegible] Question [illegible] in the PSAR, it states in part that "Soils above elevation 603 will be cohesive soils as engineered backfill". Contrary to this statement, [illegible] Rev. [illegible] Section 3.[illegible] states in part that "The materials used for structural backfill within three feet of the exterior wall of any plant area structure, shall be cohesionless and free-draining".

AEC Reportable Yes [ ] No [X] See Procedure 9 (For Nuclear Projects Only)

Stop Work Necessary Yes [ ] No [X] See Procedure 11 - Stop Work No. ____

Recommended Corrective Action: (1) For the Bechtel's Engineering Department Procedure Instruction 4.1.1 Section 3.[illegible], an SAR change notice would be applicable [illegible] BEPI 4.1.1 Section 3.[illegible], "Fabrication or construction of items differing in design or quality from the SAR shall not [illegible] change is approved by Consumers Power Company". This statement should be evaluated to determine whether work should be stopped in the field until the SAR change is approved by Consumers Power Company.

Corrective Action Taken:

(1) SAR Change Notice No. 0097 was written and approved to clarify the use of cohesive and cohesiveless soils for support of Class I structures.
(2) Bechtel Engineering determined that work could be continued in the field because the cohesionless material is actually better than cohesive material.

Verification of Corrective Action Required[1] Yes [X] No [ ]

Method of Verification[1]:
Reviewed a copy of SAR Change Notice No. 0097.

Nonconformance Closure Confirmed By[1] Donald E. Horn
Date 12-12-75

[1] To be completed at time of closure by Consumers Power QA Services.

5.1.11 State whether the upper natural undisturbed sands are to be used for support of any Class 1 components or critical appurtenances such as Class 1 piping.

Answer:

The locations of the major structures were specifically selected so that these would be founded on the stiff-to-hard cohesive soils which underlie the site and not on the upper sands. However, certain Class 1 components and piping will be founded on the upper natural undisturbed sands or on controlled compacted fill on these upper natural undisturbed sands. These Class 1 components will include the emergency diesel generators, condensate and borated water storage tanks and associated piping, the service water piping and electrical conduit and portions of the station fire protection system.

The potential for liquefaction of the natural undisturbed sands at the site has been examined based on standard penetration test data assuming post-construction conditions. The final ground surface will be at Elevation 634 with the maximum groundwater at Elevation 627. "Soils above Elevation 605 will be cohesive soils in an engineered backfill." Some natural sandy soils will remain in place in varying thicknesses over the site between Elevation 605 and Elevation 575. Standard penetration tests and/or in-place density tests will be performed to determine what sand should be removed in the field. Sands with a relative density of 50 percent or less will be removed.

Standard penetration data were obtained from several test borings drilled at the site in 1969. These data have been converted to relative density (dr) using a relationship developed by A.R.S.S. Bazaraa in a dissertation presented to the graduate college of the University of Illinois, Urbana, Illinois. This dissertation entitled "Use of Standard Penetration Test for Estimating Settlements of Shallow Foundations in Sand" presents the most thorough study existing on the relationship between standard penetration (n) values and relative density. The values of relative density for on-site soils obtained in this manner are shown plotted against elevation on Figure 5.1.11-1. Bazaraa's method of evaluating the relative density of sands from standard penetration test data is an extension of Gibbs and Holtz's method. A comparison of the two methods is presented on Figure 5.1.11-2. As shown on the figure, Bazaraa's method is more conservative than the Gibbs and Holtz method.

The maximum earthquake (DBE) has a maximum site surface acceleration of 0.12 g and the fundamental period of ground motion has been assumed to be about 0.75 second with an anticipated total duration of about 30 seconds for the earthquake; this would result in 40 cycles of shaking. Of the 40 cycles, 20 might be considered to be of sufficient magnitude to induce shear stresses that would produce a tendency toward liquefaction of the sands. It is necessary to estimate what the average magnitude of these shear stresses might be. An upper bound of these shear stresses at any depth can be obtained by assuming the soil to be a rigid body and multiplying the total weight of the column of soil above the depths in question by the maximum acceleration coefficient. This upper bound value can only be reached once during the earthquake. In actual conditions, the soil flexibility and the variation of magnitude of shearing stress from cycle to cycle have shown that a reasonable but still conservative estimate of the equivalent cyclic shearing stress is to take 80 percent of the upper bound shearing stress as the value of the uniform cyclic shear stress. On this basis, the computed values of this shearing stress at various elevations within the sand layer are shown in the following table:

Elevation (Feet)	Total Vertical Pressure σ_t	Eff Vertical Pressure σ'_v	Equivalent Uniform Shear Stress τ	$\frac{\tau}{\sigma'_v}$	Relative Density Required To Prevent Liquefaction
605	3625	2260	348	.154	36
600	4270	2595	410	.158	37
595	4915	2930	472	.161	38
590	5560	3265	534	.164	39
585	6205	3600	596	.165	39
580	6850	3935	658	.167	39

A relationship which has been used to estimate the relative density at or below which fine to medium sands could be susceptible to liquefaction in 10 cycles is as follows.[1]

$$\frac{\tau}{\sigma'_v} = \frac{\text{Relative Density}}{200} \qquad (1)$$

[1] Seed, H. Bolton and Idriss, I. M., "Analyses of Soil Liquefaction Niigata Earthquake," Journal of the Soil Mechanics and Foundation Division, ASCE Vol 93 SM3, May 1967.

This equation was developed on the basis of cyclic triaxial compression test data. In their closure to Reference 1, Seed and Idriss indicated that under cyclic simple shear conditions, such as those developed in the field, it has been found[2] that the cyclic shear stress causing liquefaction is likely to be about 50 percent of the cyclic shear stress causing liquefaction in a triaxial compression test; consequently, the modified equation (1) to the following:

$$\frac{\tau}{\sigma'_v} = \frac{\text{Relative Density}}{400} \qquad (2)$$

The results of recent studies by W. D. Finn, which were presented in a paper at the Seventh International Soil Mechanics and Foundation Engineering Conference in Mexico City in September 1969, indicated that tests conducted with a ribbed simple shear machine produced the same results as those obtained with triaxial testing equipment. Also, Casagrande, in a paper on liquefaction presented at the ASCE Environmental Engineering Conference in Chicago in October 1969, stated that triaxial shear testing was superior to simple shear testing in obtaining meaningful results for liquefaction analyses. On this basis, we have concluded that equation (1) is the more appropriate relationship for evaluating liquefaction potential from relative density data and have therefore utilized it in our analyses.

Extending equation (1) for the case of 20 cycles, the following equation is obtained:

$$\frac{\tau}{\sigma'_v} = \frac{\text{Relative Density}}{235} \qquad (3)$$

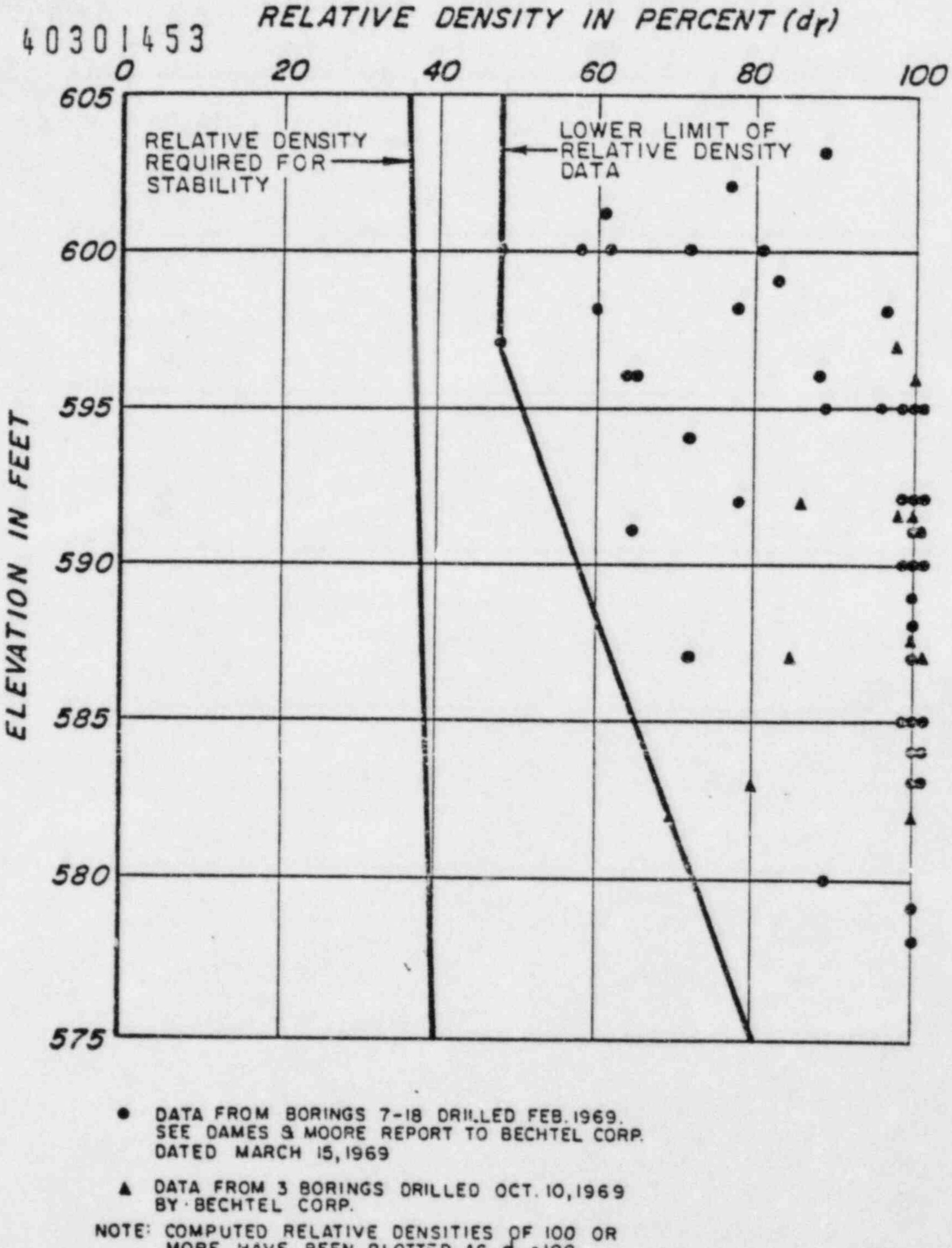
The minimum relative densities required for stability as calculated from equation (3) are tabulated in the above table and are plotted on Figure 5.1.11-1.

Based on a comparison shown on Figure 5.1.11-1 of in-place soil relative densities measured at the site to estimated relative densities above which liquefaction will not occur, it is concluded that the natural sands at the site are not susceptible to liquefaction during the postulated maximum earthquake.

---

[2] Peacock, Wm. H. and Seed, H. Bolton, "Sand Liquefaction Under Cyclic Loading Simple Shear Conditions," ASCE SM Journal, Vol 94, May 1968.

40301453

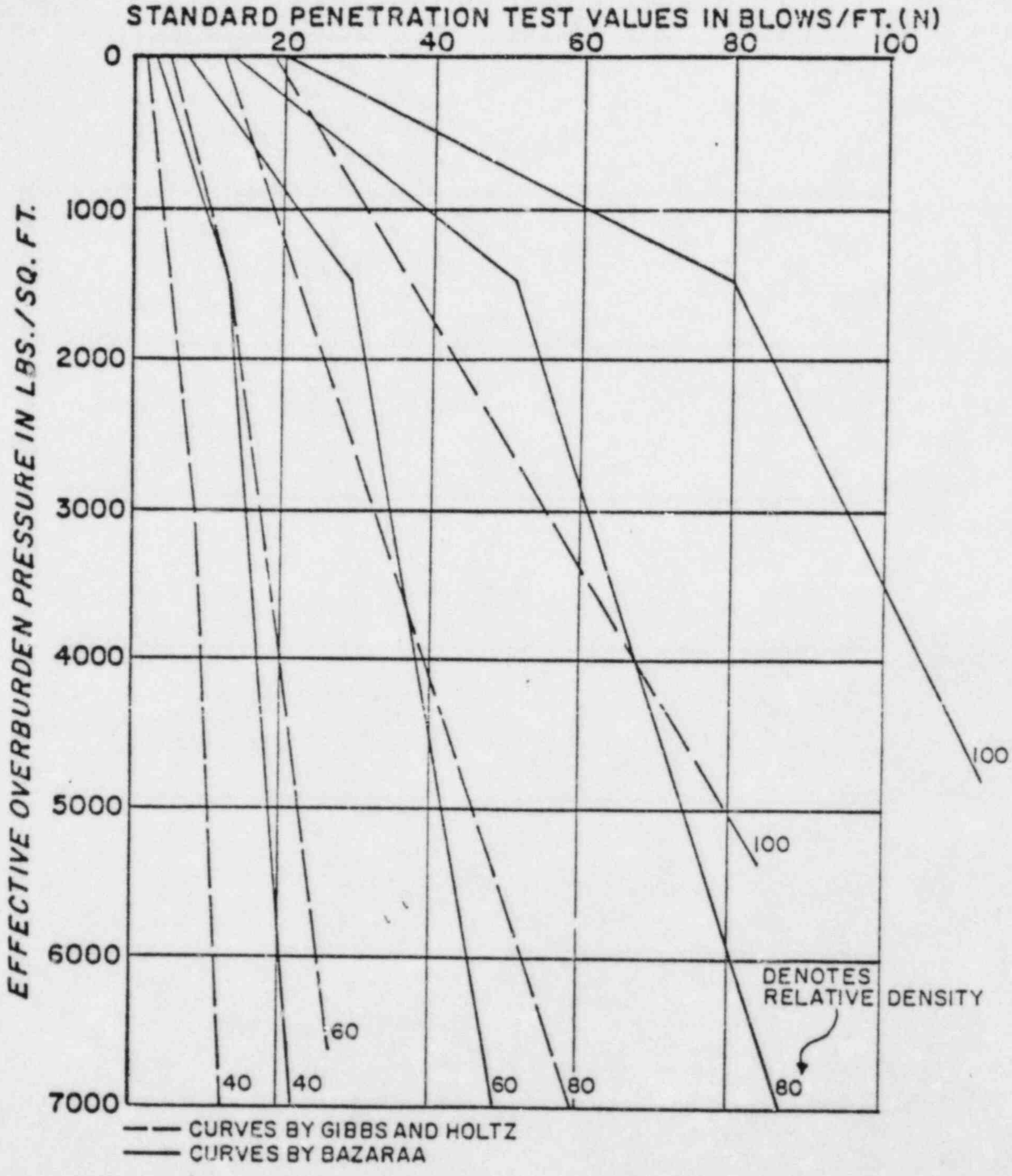


RELATIVE DENSITY DATA

DAMES & MOORE

FIGURE 5.1.11-1

40301454



COMPARISON OF GIBBS AND HOLTZ METHOD TO BAZARAA METHOD

DAMES & MOORE

FIGURE 5.1-11-2

QUALITY ASSURANCE PROGRAM
SAR CHANGE NOTICE

PSAR
FSAR

JOB NO. 7220 DISCIPLINE Civil No. 0097

ORIGINATOR R. L. Ryden DATE 12/1/75

REFERENCED SECTIONS OF SAR

DRL Questions 5.1.11 & 2.14

PSAR Section 2.8.4

DESCRIPTION OF CHANGE

→ The FSAR will clarify the use of cohesive and cohesiveless soils for support of Class I structures.

REFERENCED SPECIFICATIONS, DRAWINGS OR DESIGN CONCEPTS

BLC-2054, 10/30/75

Technical Specification 7220-C-211

JUSTIFICATION ATTACHED

CPCo letter Serial 86FQA75 to R. L. Castleberry dated 11/6/75.

Recommend incorporation in the FSAR

[signature]	12/1/75	R. L. Baker	12/1/75	[signature]	12/1/75
SUBMITTED BY (GROUP SUPERV.)	DATE	REVIEWED BY (SAR COORDINATOR)	DATE	REVIEWED BY (NUCLEAR ENGINEER)	DATE
[signature]	12/1/75	[signature]	12/4/75		
APPROVED BY (PROJECT ENG.)	DATE	APPROVED BY (CPCo)	DATE	INCORPORATED IN SAR (SAR COORDINATOR)	DATE

MIDLAND

AA-C-110473

Consumers Power Company

Midland Project: P.O. Box 1963, Midland, Michigan 48640 • Area Code 517 631-0951

November 6, 1975

Mr. R. L. Castleberry
Midland Project Engineer
Bechtel Power Corporation
P.O. Box 1000
Ann Arbor, MI 48106

MIDLAND PROJECT - RESPONSE TO NCR QF-66
File: 16.3.1 Serial: 86FQA75

Confirming my telecon with you November 3, 1975 and DEHorn's telecon with JLHurley this date, Section 5.1.11 of the PSAR and Section 5.1.1 of Specification C-211, Rev. 2 will be brought into agreement by issuance of an SAR Change Notice by December 1, 1975. We understand that work is already underway on this and that the delay is due to people being off in your Ann Arbor office.

The approval of the SAR Change Notice will allow closure of NCR QF-66.

would like to suggest on future NCR's in which the initial response disagrees ..th the agreed upon corrective action, that the reply be discussed with us before it is sent to avoid additional work and delay to get the NCR closed.

J. L. Corley
Midland Quality Assurance Superintendent

CC: HWSlager
GSKeeley
TCCooke
GLRichardson
WFHolub

NOV 10 1975
DEC
A.A. 7

No later than 12/1

0211,0535.2

R. C.

CHRON. FILE

Bechtel Associates Professional Corporation

Post Office Box 1000
3621 South State Road
Ann Arbor, Michigan 48106

40082286

NOV 3 1975

October 30, 1975

BLC-2054

cc:

Consumers Power Company
P. O. Box 1963
Midland, Michigan 48640

Attention: Mr. J. Corley

Subject: Consumers Power Company
Midland Plant - Job 7220
CPCo Nonconformance Report
No. QF-66
File: 0462, 0270, 0535.2

Gentlemen:

It appears that the originators of NCR QF-66 may have misinterpreted those sections of the PSAR which deal with the type soils used as support for Class I structures. The questions raised in the NCR have been derived from one PSAR sentence, rather than by consideration of the totality of PSAR material on the subject. The PSAR does not state that all the backfill material above 605 will be cohesive, as implied by the NCR. However, it is true that over 85% of the backfill material used is cohesive.

The DRL question 5.1.11 in the PSAR addressed the method of support for Class I components or critical appurtenances, such as Class I piping. Basically, the DRL requested the PSAR to address a solution to the potential for liquefaction of any in situ sandy soils that may be supporting Class I structures.

Fine sands and silty sands with a low relative density (loosely deposited or compacted) are susceptible to liquefaction; but, sand or cohesionless soils with a properly selected grain size distribution deposited or compacted to a sufficient relative density are not sensitive to liquefaction. Also, most cohesive (clay type) soils are not normally susceptible to liquefaction because of their inner molecular structure. The cohesive and cohesionless soils listed in Specification C-211 as structural backfill have been selected and the compaction specified so that proper support will be provided for all structures and the potential for liquefaction is eliminated.

Many areas of the PSAR, such as DRL questions 2.14 and 5.1.11 and PSAR sections 2.8.4.3 and 2.8.4.6, indicate that controlled compacted fill which by definition is either cohesive or cohesionless (granular) will be used to support Class I structures. However, due to economics more than 85% of the controlled compacted backfill on the project is cohesive material and only where it is considered an engineering requirement is granular material used.

OCT 31 1975
MIDLAND PROJECT

Bechtel Associates Professional Corporation

Consumers Power Company
BLC-2054
Page 2

40082287

The PSAR gives explicit criteria on how the plant fill will be designed and placed, both in the text and subsequent answers to DRL questions. Specification C-211 Rev. 2 was developed in accordance with the requirements of the PSAR and the structural backfill is being installed in accordance with this specification. Based on the foregoing, we hold that the PSAR and Specification C-211, Rev. 2, properly state Project license commitments; hence no revision of either document is appropriate, nor is any work stoppage necessary.

Very truly yours,

R. L. Castleberry
Project Engineer

RR:gt

cc: R. C. Bauman

the horizontal components of adjacent foundation loads. Excluding the horizontal components of adjacent foundation loads, the long-term lateral pressures against rigid and nonrigid walls are computed using the following equivalent fluid unit weights:

	Backfill Material Adjacent to Structure	Equivalent Fluid Unit Weight (Lb/Ft^3)	
		Above Water Level	Below Water Level
Nonrigid Walls	Sand Soils	40	80
	Clay Soils	50	90
Rigid Walls	Sand Soils	60	100
	Clay Soils	80	110

Lateral pressures developed adjacent to rigid walls immediately following placement and compaction of backfill materials may exceed the long-term pressures in the portion of the wall near the ground surface. Consequently, rigid walls are designed for the equivalent fluid unit weights presented above or a uniformly distributed pressure of 600 pounds per square foot, whichever is greater at any particular depth.

2.8.4.6 Fill Material

Fills up to approximately 35 feet in thickness are used in the attainment of the proposed final plant grade of 634 feet. Sources of possible fill material are available from the plant excavation consisting of sandy soils and clay soils; from borrow sources within the proposed reservoir area consisting of dune sand deposits, sandy surface soils, and clay and silt soils; and from off-site sources. All of these materials are suitable for use in construction of the plant fills.

2.8.4.7 Dewatering

Plant excavations will extend through sandy soils below the groundwater level and into relatively impervious clay soils.

While only minor water seepage is anticipated in the lower clay soils, dewatering operations will be required in connection with excavations in the sandy soils.

PSAR

frequency of the plant buildings would exist, the amplification ratio on an assumed free surface of blue-grey clay would be less than 2.0. However, the intensities recorded in the Midland area from historic earthquakes already reflect the amplification ratio and these intensities are relatively low.

2.7.4 SUMMARY

The Midland nuclear site is located in a region of slight seismic activity for which there is no known geologic control of earthquake distribution or occurrence. Earthquake history for this region begins in 1610. Table 2-7 shows that, although earthquakes have been felt in this region of the United States, Midland experienced all with low intensity. An intensity of V (MM) is assumed to have been experienced at the site as a result of the February 6, 1872 earthquake. Intensities at the site from all other earthquakes were less than V.

2.7.5 DESIGN CRITERIA

The maximum intensity experienced at the proposed Midland nuclear site as a result of any historic earthquake is V. Intensity V corresponds to a surface acceleration of 0.03 g on Hershberger's (1956) curve. A conservative value of 0.06 g should be adequate for design of the plant (design earthquake) and a 0.12 g surface acceleration (maximum earthquake) is recommended for safe shutdown. Although not used in this report, other common terminology for these earthquakes is "Operating Basis Earthquake" and "Design Basis Earthquake," respectively.

2.8 SOILS

2.8.1 INTRODUCTION

This section presents the summarized results of studies of the foundation investigation phase of the environmental study at the proposed Midland Nuclear Power Plant, including the Dames & Moore reports entitled "Report, Foundation Investigation and Preliminary Exploration for Borrow Materials, Proposed Nuclear Power Plant, Midland, Michigan, for Consumers Power Company" filed with the AEC by Amendment No. 1 (dated February 3, 1969) to the Application, and "Supplement to Report - Foundation Investigation and Preliminary Explorations for Borrow Materials, Proposed Nuclear Power Plant, Midland, Michigan," dated March 15, 1969.

The proposed location is adjacent to plant facilities of Dow on the western shore of the Tittabawassee River in Midland, Michigan. The soils overlying bedrock are of glacial origin and consist of glacial tills, glacial outwash, and glacial lake deposits.

Several programs of investigative borings have been made in the project area to determine the subsurface soil profile, to evaluate the foundation soil bearing capacity and settlement characteristics, and to substantiate that suitable fill materials are available within the proposed cooling water reservoir area.

PSAR

The results of these investigations indicate that the foundation soils are satisfactory to support the plant loads and that suitable fill materials are available within the proposed reservoir area.

2.8.2 SUBSURFACE EXPLORATION

The program indicated that in the plant area the site is blanketed by a layer of topsoil containing roots and other organic material which range in thickness from about 4 to 12 inches, except in marshy areas where 2 to 3 feet of organic silty soils are present.

Underlying the surface in some areas are sands which are loose near ground surface but become very dense with depth and were found to range from 0 to 60 feet. These sandy soils are underlain by very stiff to hard cohesive soils, predominantly gray silty clay, which extend to depths of 30 to 60 feet. These cohesive soils contain numerous silt lenses.

The deeper soils consist of uniformly hard cohesive soils, predominantly brownish-gray silty clay, containing some sand and gravel to a depth of about 140 to 200 feet. Below these deep cohesive soils is very dense and clayey, sandy gravel down to bedrock. A portion of this layer consists of very dense poorly graded sand at depths extending from 240 to 360 feet below ground surface.

In the cooling pond, part of the area is blanketed by sandy and silty soils varying widely in density and composition and ranging in depth from 2 to 22 feet below ground surface. These sandy and silty soils are underlain by firm to very hard cohesive soils. All of these materials should be considered suitable for incorporation in the plant and dike fills.

2.8.3 LABORATORY TESTS

The laboratory test program for determination of design criteria consisted of direct shear, unconfined compression, triaxial compression, dynamic triaxial compression, and consolidation tests on selected undisturbed soil samples from the plant area; plus moisture-density tests in conjunction with each strength and consolidation test and on other undisturbed samples; compaction, relative density, and permeability tests on remolded soil samples from the proposed cooling pond area, particle size distribution of selected soils in the plant and reservoir areas; rock compression tests on the deep shale bedrock; and Atterberg limits on selected samples from both areas.

2.8.4 DESIGN CRITERIA

2.8.4.1 Fill and Backfill

All fill and backfill materials are adequately compacted to insure stability of the fill and to provide adequate support for structures founded on this fill without excessive settlements. *

2.8.4.2 Excavation Slopes

Excavations through the dewatered sandy soil are cut on a slope of one vertical to one and one-half horizontal or flatter. Excavations through clay soils are cut on a slope of two vertical to one horizontal or flatter. Temporary excavations within clay soils and which are not subject to surcharge loading are cut vertically with an unsupported height of up to 15 feet.

Temporary excavations through dewatered sand fill soils are cut on a slope of one vertical to one and one-half horizontal or flatter. Temporary excavations through compacted clay fill soils which are not subjected to surcharge loading are cut vertically with an unsupported height of up to 10 feet.

Permanent slopes through compacted granular fill soils are constructed on slopes of one vertical to four horizontal or flatter. Permanent slopes through compacted cohesive fill soils are constructed on slopes of one vertical to two horizontal.

2.8.4.3 Foundation Design

The reactor buildings and the lower portion of the auxiliary buildings are at elevations such that foundations are established on the stiff to hard cohesive soils which underlie the site.

Within this material and extending from a depth of 240 to 360 feet below ground surface is a layer of very dense granular material with Standard Penetration Test blow counts on the order of 200 blows or greater per 6-inch penetration. These soils are considered to provide excellent foundation support without excessive settlement under both static and dynamic conditions of loading. These structures are founded on earth-supported mat foundations.

The south portion of the auxiliary building has its base at elevation 610 while the existing ground surface soils in this area vary between elevation 605 and elevation 612. The surface soils in this area are loose sands of variable thickness which do not provide suitable foundation support. Consequently, these soils are to be removed down to the underlying very stiff to hard cohesive soils and foundation grade then attained by the placement of controlled compacted granular or cohesive fill.

All loose in-site sands, soft or compressible clay soils, and organic soils will be excavated in the turbine building area. The turbine building and turbine generators are supported on mat foundations on controlled compacted fill.

The ultimate bearing capacities for the mat foundations are summarized below:

Unit	Supporting Soils	Foundation Elevation (Feet)	Gross Ultimate Bearing Capacity Lb/Ft^2
Reactor Building	Very Still to Hard Natural Clay Soils	582.5	45,000
Auxiliary Building	Very Stiff to Hard Natural Clay Soils	562.0 580.0	50,000 45,000
	Controlled Compacted Fill	610.0	30,000
Turbine Building	Controlled Compacted Fill	610.0	30,000
Turbine Generators	Controlled Compacted Fill	602.0	30,000

The preceding tabulation assumes that the fill is composed of compacted clay soils; if compacted sand fill is used, the ultimate aforementioned bearing capacities will be greater than the tabulated values.

Shallow spread foundations established in the controlled compacted fill for the support of appurtenant structures are at a minimum depth of 4-1/2 feet below the adjacent plant grade to prevent the effects of frost action. The allowable bearing pressures for spread foundations on controlled compacted fill are tabulated below:

Supporting Soils	Minimum Foundation Depth (Feet)	Allowable Net Bearing Pressure (psf) Dead + Live Load (FS = 3.0)	Allowable Net Bearing Pressure (psf) Dead, Live & Seismic Loads (FS = 2.0)
Controlled Compacted Clay Fill	4.5	5,000	7,500
Controlled Compacted Granular Fill:			
Foundation Width = 2 Ft	4.5	2,800	4,200
Foundation Width = 4 Ft	4.5	3,100	4,650
Foundation Width = 8 Ft	4.5	3,700	5,550
Foundation Width = 12 Ft	4.5	4,300	6,450

2.8.4.4 Settlement

The maximum total and differential settlements are estimated based on consolidation tests. The estimated settlements include the effects of lowering the groundwater level, excavating, placement of plant fill to elevation 634, the imposed structural loads and subsequent raising of groundwater level to normal cooling pond surface elevation 627.

The results of settlement analyses for structures supported on mat foundations are tabulated below:

Unit	Estimated Maximum Settlement Inches	Estimated Maximum Differential Settlement Inches
Reactor Buildings	1 - 1-1/2	1/4 - 1/2
Auxiliary Building		
At Elevation 562	1/2 - 1	1/4 - 1/2
At Elevation 580	1/2 - 1	1/4 - 1/2
At Elevation 610	1-1/2 - 2	1/4 - 1/2
Turbine Building	1-1/2 - 2	1/4 - 1/2
Turbine Generator Mats	1-1/2 - 2	1/4 - 1/2

It has been further estimated that the maximum differential settlements which could occur between adjacent structures are as follows:

Adjacent Units	Estimated Maximum Differential Settlements Between Structures Inches
Auxiliary at Elevation 562 and at Elevation 580	1/2
Auxiliary at Elevation 562 and at Elevation 610	1
Auxiliary at Elevation 580 and Reactor	1/2
Auxiliary at Elevation 610 and Reactor	3/4
Auxiliary at Elevation 610 and Turbine Building	1/2
Turbine Building and Turbine Mat	1/2

Earthquake loading of short duration should not cause additional settlement of appreciable magnitude. The estimated additional settlements under earthquake loading are less than 1/4 inch.

Although detailed settlement analyses are not performed to evaluate settlements of shallow spread footings established in the compacted plant fill, it is estimated that settlements will be on the order of 1/2 inch or less provided that the allowable bearing pressures are not exceeded and the fill is adequately compacted.

Time Rate of Settlement - It is estimated that one-tenth to one-half of the maximum settlements tabulated previously occur, as elastic recompression, essentially simultaneously with the load application. The remaining one-half to nine-tenths of the maximum settlements occur in accordance with the time rates estimated from consolidation test data and presented below:

Approximate Percent of Total Settlement	Time Years
20	2
50	10
90	50

Settlement of conventional spread foundations, established on an appreciable thickness of controlled compacted granular fill, occurs essentially as the load is applied to the foundation.

2.8.4.5 Lateral Pressures

The walls of structures below final plant grade, elevation 634, are subjected to horizontal loads imposed by backfill materials, hydrostatic pressures, and

K

CALCULATION SHEET

when were Dwg's issued for C. Ferrell
Cor 3/16/77 dwg 1001 Rev 0

ORIGINATOR PKC DATE 10/17/76 CALC. NO. 5-71 REV. NO. 0
PROJECT Midland Unit 1 & 2 CHECKED [illegible] DATE 3/[illegible]/77
SUBJECT Settlement analysis JOB NO. 7220-001
SHEET NO. 15/49 File 5233

the coefficient of [illegible] (C/1+e)

Therefore, based on the weighted average values used in the settlement analysis are as follows:

Elev.		D & M	compressibility	weighted average
634				
	compacted fill	—	0.001 *	0.001
609				
	compacted fill	—	0.001 *	0.001
603				
		0.009 (clay) / 0.01 (sand)	0.0019	0.002
581.5				
		0.005	0.0027	0.003
506				
		0.003	0.0023	0.002
543				
		0.003	0.0028	0.003
403				
		0.005	0.0057	0.006
363				
	incompressible			

* estimated values based on experience. Fill was compacted to 95% Bechtel [illegible] method. Majority of the [illegible] test data is on 100% compaction.

AAO-520 6/76

BECHTEL

CALCULATION SHEET

ORIGINATOR DKC DATE 8/4/[illegible] CALC. NO. S-71 REV. NO. 0
PROJECT Midland [illegible] FSAR CHECKED [illegible] DATE [illegible]
SUBJECT Settlement Evaluation JOB NO. 7220-[illegible]
SHEET NO [illegible] 8530 21/49

Load Configuration TABLE A

Load Type	DIMENSION (FT. x FT.)	FOUNDATION ELEV. (FT)	LOAD Intensity; L. (PSF) (K)
AREA FILL	400'x 500'	603	4090 ; 2,944
REACTOR BUILDING	DIAMETER = 124.4	585.5	8,000 ; 9710
Auxiliary Building (part A)	77' x 138'	562	7,000 ; 8731
Auxiliary Building (part B+C)	42' x 70'	579	8,000 ; 2,620
Auxiliary Building (part D)	43' x 100'	609	6,000 ; 2,580
Auxiliary Building (part E+F)	90' x 28'	609	6,000 ; 427
Auxiliary Building (part G)	75' x 25'	630	4,000 ; 840
Auxiliary Building (part H)	42' x 28'	609	6,000 ; 705
Turbine Building	140' x 440'	609	3000 ; 10,800
Turbine MAT (A)	145' x [illegible]	602	5000 ; 290[illegible]
Turbine Building MAT (B)	185' x 4[illegible]	[illegible]2	5000 ; 37[illegible]

CALCULATION SHEET

ORIGINATOR ______ DATE ______ CALC. NO. 5-71 REV. NO. ______

PROJECT Millstone Unit No. 2, FSAR CHECKED ______ DATE ______

SUBJECT Settlement ______ JOB NO. ______

SHEET NO. 22/49 File ______

Table A

Load Type	DIMENSION (FT. x FT.)	FOUNDATION ELEV. (FT.)	LOAD INTENSITY (psf)	TOTAL LOAD (K)
RADWASTE Building	56' x 75'	6.54 -	4000	16,500
DIESEL GENERATOR Building	70' x 135'	6.54 -	3000	32550
primary makeup water storage	41' Diameter	6.34 -	2500	3300
Borated water storage Tank	54' Diameter	6.34	2500	5725.6
Condensate storage Tank	41' Diameter	6.34 -	2500	3300
Auxiliary Building (I & J)	7' x 13' (Equivalent base)	5.07	6500	7605

Notes

1) the total load was calculated by
$140 \times 440 \times 3 - 24000 - 37000 - 100 \times 15 \times 6$
$= 184800 - 24000 - 37000 - 9000 = 104800$

2) the total load was calculated by
$72 \times ? \times 8 - \frac{1}{2} \times 10 \times 15 \times 8$
$= 23520 - 900 = 22620$

3) the total load was calculated by
$90 \times 28 \times 6 - 15 \times 65 \times 6 = 15120 - 5850 = 9270$

TO EJGallagher, NRC

FROM JLCorley, Midland

DATE December 7, 1978

SUBJECT FCR C-302 DATED 10/31/75
One (1) page following.

12/7/78
recd 12/12
dc

FIELD CHANGE REQUEST

PROJECT NO. 7220

1. PAGE 1 OF 1

Q No. 1.002

2. No. C-302

3. DATE MO 10 DAY 31 YR 75

SPEC. 7220-C-211 REV. 2

5. TITLE Compaction of Cohesive Soils

6. DESIGN ORIGIN: ENGRG ☒ VENDOR ☐ (IDENTIFY) NAME

7. EXISTING CONDITION: Paragraph 5.5.2 of Specification 7220-C-211, Rev. 2 states that cohesive material shall be compacted to not less than 95% maximum density as determined by Modified Proctor method (ASTM D1557, Method D) but does not list the Bechtel Modified parameters.

8. CHANGE REQUEST / SKETCH

Field requests that paragraph 5.5.2 of specification 7220-C-211, Rev. 2 be revised to read:

> Cohesive material shall be compacted to not less than 95 percent maximum density. Maximum dry density will be determined in accordance with ASTM D1557, Method D provided that the sample is prepared in 4 layers, each compacted with 25 blows with a 10 pound hammer dropping 18 inches giving a compactive energy equal to 20,000 foot-pounds per cubic foot. (Bechtel Modified Proctor Density Test).

The added clarification requested above is required to prevent Specification 7220-C-211 from being interpreted as requiring more compactive effort than necessary. What is necessary is to place the same compactive requirements on cohesive material in areas inaccessible to motorized rollers as are placed on cohesive material in areas accessible to motorized rollers. Cohesive materials within the plant area that are accessible to motorized rollers are compacted to the requirements of Section 13.0 of Specification 7220-C-210, Rev. 4 which references the Bechtel Modified Proctor (Paragraph 12.4.5.1) as the method of determining maximum dry density.

RECEIVED
AUG 1976
BECHTEL POWER CORP.
JOB 7220
HR [signature]

UNCONTROLLED
NOT TO BE USED
FOR CONSTRUCTION

10. REVIEWED BY: | Date
CIVIL [signature] 10/31/75
ELECT. [signature] 10/31/75
MECH. [signature] 10-31-75
WELDING [signature] 10-31-75

9. PREPARED BY: [signature]

11. APPROVAL OF FIELD DISPOSITION: [signature] 10-31-75
Project Field Engineer Date

12. PROJECT ENG'R'G APPROVAL: YES ☒ NO ☐ PROJ. ENGR.: [signature] for RLC Date: 8-4-76

REMARKS: Issued SCN C-211-6001 to incorporate this change. [signature] 8-4-76

QC – 2 FCR
REV. 2-1-72

Bechtel Associates Professional Corporation
Ann Arbor, Michigan

CONTROLLED C-210

CONSUMERS POWER COMPANY
RECEIVED
AUG 1 1977
MIDLAND PLANT PROJECT
MIDLAND, MICHIGAN

Port Copy

TECHNICAL SPECIFICATION
FOR
PLANT FOUNDATION EXCAVATION AND COOLING POND DIKES
FOR THE
CONSUMERS POWER COMPANY
MIDLAND PLANT, UNITS 1 AND 2
MIDLAND, MICHIGAN

RECEIVED
JUL 22 1977
BECHTEL POWER CORP.
JOB 7220

TCC
BHP
JSS
TC
CMD
CLERICAL
GWS
WCB
EME
RMW
DES
WFS
MFD
DJV
RLB
DAK
PKW
ZAJ
JJD
DDJ
FILE

Consisting of:

1. Specific Conditions
2. G 321C

No.	DATE	REVISIONS	BY	CH'K	AP
5	7-8-77	Revised as noted on facing sht. Inc. SCN 7001	[illegible]	[illegible]	[illegible]
4	6/4/75	Revised as noted on facing sht. Inc. SCN 4005 & FCR C-20	AD	[illegible]	[illegible]
3	7/10/74	Revised as noted on facing sht. Inc. SCNs 4001, 4002, 4003, 4004	ALD	[illegible]	[illegible]
2	7/27/73	Issued for Subcontract	[illegible]	[illegible]	[illegible]
1	[illegible] 73	~~Added Rev. 1 and Revised (See Facing Sheet)~~		[illegible]	[illegible]
0	[illegible] 73	~~Issued for Bids~~	G.L.	[illegible]	[illegible]
A	[illegible]	[illegible]			

ORIGIN		JOB No. 7220-006
BECHTEL		SPEC/DES GUIDE No. 7220-C-210 (Q)

SHEET 1 OF

See Rev. 4

1) For soils with little or no gravel: 6 inch diameter, 9 inch depth, cylindrical hole. (Volume of hole determined by 6 inch minimum size sand cone.) 6-19-75

2) For soils containing appreciable gravel: 10 to 12 inch diameter, 12 to 14 inch depth, conical hole. (Volume of hole determined by 12 inch maximum size sand cone.

A nuclear density device may be used provided that the results are compatible with those obtained by the specified procedure. 2

The density of material is defined as the weight of the material per unit of volume of the material in place.

12.4.5 Laboratory Maximum Density and Optimum Moisture Content

12.4.5.1 Cohesive Soils

The maximum dry density and optimum moisture content of cohesive material will be determined in the laboratory in accordance with ASTM Designation D 1557 Method D, provided that the sample is prepared in 4 layers, each compacted with 25 blows with a 10 pound hammer dropping 18 inches giving a compactive energy equal to 20,000 foot-pounds per cubic foot. (Bechtel modified Proctor Density test)

12.4.5.2 Cohesionless Soils

The maximum density of cohesionless soils will be determined in accordance with the applicable requirements of ASTM Designation D 2049.

12.4.6 Specific Gravity

ASTM Designation D 854.

12.5.2 Zone 1 and Zone 1A

Zone 1 and Zone 1A material shall be placed in the embankment fill as shown on the Drawings or as required and compacted as specified. The uncompacted lift thickness shall be determined by field personnel after evaluation of the proposed compaction equipment. However, in no case shall the uncompacted lift thickness exceed 12 inches.

12.5.3 Zone 2

Zone 2 material shall be placed in the embankment fill as shown on the Drawings or as required and compacted as specified. The uncompacted lift thickness of Zone 2 material shall be determined by field personnel after evaluation of the proposed compaction equipment. However, in no case shall the uncompacted lift thickness exceed 12 inches.

12.5.4 Zone 3

Zone 3 material shall be placed in the embankment as shown on the Drawings or as required. The uncompacted lift thicknesses shall be determined by field personnel after evaluation of the proposed compaction equipment. However, in no case shall the uncompacted lift thickness exceed 12 inches. Approved placement methods shall be used which will prevent segregation of the materials and prevent mixing with other materials. Approval of the placing method will be on the basis of demonstrated ability to place Zone 3 materials without segregation. The surface of the adjacent fill shall be sloped throughout the construction operations so that water will readily drain away from Zone 3 toward the outer slopes of the embankment. The Subcontractor shall take particular care to prevent water from draining into Zone 3. Construction equipment shall cross Zone 3 only at specifically approved locations and elevations and the number of crossings shall be periodically changed as required. Provision shall be made to protect Zone 3 material from contamination at each crossing, and any contaminated Zone 3 material shall be removed and replaced with satisfactory material all be and at the expense of the Subcontractor. A vibratory roller or other suitable equipment may be substituted for the rubber tired roller to achieve the required compaction of Zone 3 material only.

13.6 Moisture Control

Moisture control of the plant area and berm material shall conform to Section 12.6.

13.7 Compaction Requirements

13.7.1 Cohesive Soils

All cohesive backfill in the plant area and the berm shall be compacted to not less then 95 percent of maximum density as determined by ASTM D 1557, Method D.

13.7.2 Cohesionless Soils

All cohesionless backfill in the plant area and the berm shall be compacted to not less than 80 percent of relative density as determined by ASTM D 2049, with the exception that Zone 4, 4A, 4Z, 5, 5A and 6 materials need no special compactive effort other than as described in section 12.8.1.

5

13.8 Slides and Winter Protection

All provisions for slides and winter protection shall be similar to requirements in Sections 12.9 and 12.10

13.9 Measurement & Payment

13.9.1 Measurement

Embankment will be measured in place to the nearest cubic yard of embankment material of the various zones, satisfactorily placed and compacted in the plant area and the berm. Such measurement will be made between the foundation lines as determined by survey in the field and the neat fill lines, grades and slopes shown. No allowance will be made for settlement of the foundation or of the embankment during construction.

13.9.2 Payment

Embankment will be paid for at the applicable contract price stated in the Price Schedule for the items listed below.

Bechtel Associates Professional Corporation
Ann Arbor, Michigan

PART COPY
UNCONTROLLED

RECEIVED
JUN - 2 1978
BECHTEL POWER CORP.
JOB 7220
PER:

TECHNICAL SPECIFICATION
FOR
PLANT FOUNDATION EXCAVATION AND COOLING POND DIKES
FOR THE
CONSUMERS POWER COMPANY
MIDLAND PLANT, UNITS 1 AND 2
MIDLAND, MICHIGAN

SECT 12 & 13

S.C.N. No.'s	FCR No.'s	PCN No.'s
None		

ARE OUTSTANDING AGAINST THIS SPECIFICATION
SEE BEHIND COVER SHEET

Consisting of:

1. Specific Conditions
2. G 321C

No.	DATE	REVISIONS	BY	CH'K	APPR
6	4-25-78	Revised as noted on facing sheet INC SCN 8001	DAZ		RLC
5	7-8-77	Revised as noted on facing sht. Inc. SCN 7001			RLC
4	6/4/75	Revised as noted on facing sht. Inc. SCN 4005 & FCR C-20	AD		
3	7/10/74	Revised as noted on facing sht. Inc. SCNs 4001, 4002, 4003, 4004	ALD		
2	7/27/73	Issued for Subcontract			
1	4/25/73	~~Added Rev. 1 and Revised (See Facing Sheet)~~	RLR		
0	3/29/73	~~Issued for Bids~~			
A	1/12/73	Issued for Client [illegible]	G.L.		

ORIGIN: BECHTEL

JOB No. 7220-006

SPEC/DES GUIDE No.	REV.
7220-C-210 (Q)	6

SHEET	LATEST REV.	SHEET	LATEST REV.	SHEET	LATEST REV.	SHEET	LATEST REV.	SHEET	LATEST REV.	SHEET	LATEST REV.	SHEET	LATEST REV.
i	6	23	0	48	0	72	0						
ii	6	24	0	49	0	73	0						
iii	1	25	0	50 50A	5 5	74	0						
1	[illegible]	26	0	51	0	75	1						
2	2	27	0	52	0	76	0						
3	0	28	0	53	0	Table 12-1							
4	0	29	0	54	0	1	3						
5	0	30	0	55	0	2	3						
6	0	31	1	56	0								
7	0	32	0	56A	5	Table 7-1							
8	0	33	0	57	5	1	1						
9	2	34	0	58	0	2	1						
10	0	35	0	59	1	3	1						
11	0	36	1	60	0	4	1						
12	0	37	0	61	0	5	1						
13	0	38	0	62	4	Table 7-2							
14	0	39	0	63	5	1	1						
15	1	40	0	64	5	2	1						
16	0	41	0	65	5	Table 7-3							
17	0	42	6	66	0	1	1						
18	0	43	6	67	1	63A	5						
19	3	44	0	68	1								
20	2	45	0	69	0								
21	0	46	5	70	0								
22	0	47	5	71	0								

NO.	DATE	REVISIONS	BY	CHK'D	APP'D	NO.	DATE	REVISIONS	BY	CHK'D	APP'D
6	4/25/78	Rev Shs i,ii,42,43	DAZ	[illegible]	RLC						
5	7/8/75	Revised Shts. i,ii,42, 46, 47, 50, 56A, 57, 63, 64, an 65 added 50A, 63A	[illegible]	[illegible]	RLC						
4	[illegible]/75	Revised Shts. i,ii, 43 and 62	[illegible]	[illegible]	[illegible]						
3	7/10/[illegible]	Revised Shts. i, ii, 19, 47, table 1201, (1,2	[illegible]	[illegible]	[illegible]						
2	2/27/73	Rev. pgs. 2,9,19, 20,43,56A	[illegible]	[illegible]	[illegible]						
1	4/[illegible]	Rev. pgs. i,ii,iii,15, 33,39,63,64,67,68,73	[illegible]	[illegible]	[illegible]						

FACING SHEET

PLANT FOUNDATION EXCAVATION AND
COOLING POND DIKES
CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 AND 2
[illegible]

BECHTEL

JOB No 7220

Specification 7220-C-210

Sheet ii

REV. 6

TABLE OF CONTENTS

FOR

PLANT FOUNDATION EXCAVATION AND

COOLING POND DIKES

FOR THE

CONSUMERS POWER COMPANY

MIDLAND PLANT, UNITS 1 AND 2

MIDLAND, MICHIGAN

	TITLE	PAGE
1.0	INTRODUCTION	1
2.0	CODES AND STANDARDS	4
3.0	MOBILIZATION	4
4.0	RIVER POLLUTION	5
5.0	CARE OF WATER	5
6.0	CLEARING GRUBBING AND REMOVAL OF STRUCTURES	7
7.0	SEALING WELLS AND EXPLORATORY HOLES	12
8.0	EXCAVATION	18
9.0	SLURRY TRENCH	26
10.0	FOUNDATION PREPARATION	34
11.0	EXISTING EARTHWORK - RECONDITION	36
12.0	DIKE AND RAILROAD EMBANKMENT CONSTRUCTION	39
13.0	PLANT AREA BACKFILL AND BERM BACKFILL	56A
14.0	GROUT	59
15.0	SEEDING	60
16.0	QUALITY ASSURANCE PROGRAM REQUIREMENTS	63
17.0	MISCELLANEOUS STRUCTURAL WORK AND OTHER DRAINAGE ITEMS	64
18.0	TEMPORARY CONSTRUCTION LAYDOWN AREA	74

12.0 DIKE AND RAILROAD EMBANKMENT CONSTRUCTION

12.1 Definitions

12.1.1 Embankment

Embankment is all required earth placed and, unless otherwise specified, compacted within the limits of the Cooling Pond Dike, Baffle Dike, and Railroad Embankment or as shown on the Drawings. Embankment shall also include those materials which are placed in diversion channels and drainage ditches as shown on the Drawings to act as protection against erosion.

12.1.2 Suitability of Material

The Contractor will determine the suitability of all materials.

12.2 Lines and Grades

The embankments shall be constructed to the lines, grades and cross sections shown on the Drawings. The Subcontractor shall furnish and supply all equipment, materials and labor required to set out the work. Survey markers and grade stakes shall be set out in accordance with the lines and grades shown on the Drawings. The Subcontractor may be required by the Contractor to remove and dispose of any embankment fill placed outside the prescribed slope lines. Such removal and disposal shall be by and at the expense of the Subcontractor.

12.3 Materials

12.3.1 General

The Subcontractor's attention is invited to Table 12-1 for a listing of the various zones of the embankment, their description, and the source of materials for the various zones. Table 12-1 is included at the end of this Section, 12. Unless otherwise approved in writing, materials for the various zones of embankment shall be obtained from the borrow areas and sources shown on the Drawings. Approval of a borrow area or other source does not mean that all material within that area is suitable for embankment construction. If, for any reason, the Subcontractor places unsuitable material, or material not previously approved by the Contractor, in the embankment or within any zone of the embankment, all such unsuitable material shall be removed and disposed of and replaced with suitable material, all by and at the expense of the Subcontractor. The criteria by which the Contractor will be guided in his determination of the suitability of materials in final position or condition in the embankment are set forth in Paragraph 12.6 and on Table 12-1 included at the end of this Section 12. These criteria apply to material characteristics as placed in complete portions of the embankment. Any or all of the tests specified which are applicable to materials in the borrow areas or other sources, or in the embankment, may be used by the Contractor in determining the suitability of materials.

12.3.2 Riprap - Zone 5

There is currently stockpiled at the jobsite an unknown quantity of Zone 5 material, the location of which is shown on the drawings.

The Subcontractor shall use the existing Zone 5 material in areas specified on the drawings until the supply is exhausted. No new Zone 5 material shall be purchased, and Zone 5A material will then be substituted for Zone 5 areas.

Existing Zone 5 material will be made available in an "as - is" condition at no cost to the Subcontractor.

12.3.2.1 Riprap- Zone 5A

The riprap shall be obtained from a source approved by the Contractor. The rock shall be sound and free of cracks or seams. Neither the breadth nor the width of any piece of riprap shall be less than one third of its length.

Loading, hauling and placing of riprap shall be conducted in a manner which will minimize breakage. The sands and fines content of the riprap shall be limited to those resulting from handling during hauling and placing of material.

12.3.3 Organic and Deleterious Materials

Materials containing brush, roots, peat, sod or other organic, perishable or deleterious materials shall not be placed in the embankment Zones 1 through 5.

12.3.4 Gravel-Zones 4 and 4A

Gravel shall be located and placed as shown on the drawings. Zone 4A material shall identify gravel surface course material placed on the dike crests; all areas other than the dike crest requiring gravel materials, shall be designated Zone 4. Zone 4 and 4A materials shall conform to gradation requirements given in Table 12-1.

12.4 Testing of Embankment Materials

12.4.1 General

The Contractor will take all samples and perform all tests of the embankment materials for control of the placement operations. The Contractor will conduct density and other tests on the compacted embankment and the related laboratory testing to determine the relative degree of compaction and other properties. In addition, concurrent with construction, the Contractor will take samples of the materials from the borrow areas and the embankment and test these samples for moisture content and gradation. Testing by the Contractor will be done as frequently as the Contractor deems necessary, without cost to the Subcontractor, provided that the Subcontractor shall, at its expense, furnish labor and materials to assist in obtaining the samples for testing. Tests performed by the Contractor will be in accordance with the following procedures.

12.4.2 Moisture Content

ASTM Designation D 2216. Other methods such as a nuclear density device in accordance with ASTM D 3017 and using manufacturer's instructions, for rapid moisture determination may be used, provided that the results are compatible with those obtained by the specified procedure. Compatibility of the methods will be determined by the Contractor. 6

12.4.3 Gradation

ASTM Designation D 422 or C136, whichever is applicable for the soil being tested. 5

12.4.4 Density of Soil in Place

ASTM Designation D 1556. The size of the density hole or pit shall be selected in accordance with the following criteria.

1) For soils with little or no gravel: hole size shall be in accordance with ASTM D 1556. (Volume of hole determined by 6 inch minimum size sand cone.) 4

2) For soils containing appreciable gravel: 10 to 12 inch diameter, 12 to 14 inch depth, conical hole. (Volume of hole determined by 12 inch maximum size sand cone.

A nuclear density device may be used in accordance with ASTM D 2922 and manufacturer's instructions, provided that the results are compatible with those obtained by the specified procedure. 6

The density of material is defined as the weight of the material per unit of volume of the material in place.

12.4.5 Laboratory Maximum Density and Optimum Moisture Content

12.4.5.1 Cohesive Soils

The maximum dry density and optimum moisture content of cohesive material will be determined in the laboratory in accordance with ASTM Designation D 1557 Method D, provided that the sample is prepared in 4 layers, each compacted with 25 blows with a 10 pound hammer dropping 18 inches giving a compactive energy equal to 20,000 foot-pounds per cubic foot. (Bechtel modified Proctor Density test)

12.4.5.2 Cohesionless Soils

The maximum density of cohesionless soils will be determined in accordance with the applicable requirements of ASTM Designation D 2049.

12.4.6 Specific Gravity

ASTM Designation D 854.

12.4.7 Atterberg Limits

ASTM Designation D 423 and Designation D-424.

12.4.8 Strength

12.4.8.1 Shear Strength

Strength tests for cohesionless soils will be performed generally in accordance with Chapter XI, "Triaxial Compression Tests on Cohesionless Soil," of "Soil Testing for Engineers" by T. William Lambe. Tests will be made on soil samples taken from the placed embankment soil.

12.4.9 Permeability

ASTM Designation D 2434.

12.5 Placement

12.5.1 General

No embankment materials shall be placed on any foundation until the foundation has been approved by the Contractor. The ultimate location of such material shall be subject to approval. The gradation and distribution of materials throughout each zone of the compacted embankments shall be such that the embankments will be free from lenses, pockets, streaks, and layers of material differing substantially in texture or gradation from surrounding material of the same zone.

Excavation in the borrow area shall be carried out in such a manner that the material placed in the embankment for compaction shall not contain large solid lumps or clods of material which will not break down and compact satisfactorily when rolled as specified. Material shall be placed so that when compacted it forms a homogeneous mass and any voids between stones or large soil lumps are completely filled with compacted material.

No embankment shall be placed upon a frozen surface nor shall any ice or frozen earth be incorporated in the embankment. Embankment construction for which moisture conditioning is required shall be suspended when the ambient temperature is 32°F and falling, unless otherwise approved by the Contractor.

Unless otherwise specified, all embankment zones being placed shall be raised simultaneously with the top surface of the embankment to form an approximately horizontal plane extending transversely to the final slopes and longitudinally to the abutments.

At any particular section along the axis of the dike, during construction, a temporary differential elevation of 20 feet will be permitted within the embankment provided the bonding surface has a slope not exceeding 3 horizontal to 1 vertical. Such bonding surface shall extend across the various zones of the embankment to form a plane.

At any particular section perpendicular to the axis of the dike the temporary differential elevation between any two adjoining zones due to construction operations shall not exceed 12 inches.

The embankments shall be maintained at all times in such condition that the surfaces will readily drain. In any areas where materials become soft or yielding due to becoming wet or saturated such materials shall be removed, disposed of, and replaced with suitable material all by and at the expense of the Subcontractor. The entire surface of any section of the dike embankment shall be maintained in such condition, as determined by the Contractor, that construction equipment can travel on any part of all sections. Ruts in the surface of any layer shall be filled and leveled satisfactorily before compacting.

The Subcontractor shall exercise extreme care in placing and compacting embankment fill in the proximity of all structures. The Subcontractor shall also carefully place all Zone 1 and Zone 2 material to preclude any contamination of the sand drain.

12.5.2 Zone 1 and Zone 1A

Zone 1 and Zone 1A material shall be placed in the embankment fill as shown on the Drawings or as required and compacted as specified. The uncompacted lift thickness shall be determined by field personnel after evaluation of the proposed compaction equipment. However, in no case shall the uncompacted lift thickness exceed 12 inches. 5

12.5.3 Zone 2

Zone 2 material shall be placed in the embankment fill as shown on the Drawings or as required and compacted as specified. The uncompacted lift thickness of Zone 2 material shall be determined by field personnel after evaluation of the proposed compaction equipment. However, in no case shall the uncompacted lift thickness exceed 12 inches. 5

12.5.4 Zone 3

Zone 3 material shall be placed in the embankment as shown on the Drawings or as required. The uncompacted lift thicknesses shall be determined by field personnel after evaluation of the proposed compaction equipment. However, in no case shall the uncompacted lift thickness exceed 12 inches. 5 Approved placement methods shall be used which will prevent segregation of the materials and prevent mixing with other materials. Approval of the placing method will be on the basis of demonstrated ability to place Zone 3 materials without segregation. The surface of the adjacent fill shall be sloped throughout the construction operations so that water will readily drain away from Zone 3 toward the outer slopes of the embankment. The Subcontractor shall take particular care to prevent water from draining into Zone 3. Construction equipment shall cross Zone 3 only at specifically approved locations and elevations and the number of crossings shall be periodically changed as required. Provision shall be made to protect Zone 3 material from contamination at each crossing, and any contaminated Zone 3 material shall be removed and replaced with satisfactory material all be and at the expense of the Subcontractor. A vibratory roller or other suitable equipment may be substituted for the rubber tired roller to achieve the required compaction of Zone 3 material only.

12.5.5 Zone 4, Zone 4A, Zone 4A

Zone 4 and 4A material shall be placed as embankment fill and ripgap bedding in the embankment as shown on the Drawings or as required. In areas of Zone 4, no special compaction is required; however, construction equipment shall be routed in such a manner that some compaction is achieved. In areas of Zone 4A, material shall be placed in layers not more than seven inches in uncompacted thickness, and shall be rolled as directed by the Contractor.

In areas of Zone 4A not accessible to roller equipment operation, the material shall be compacted in accordance with Paragraph 12.8.3.1 of these specifications with the lift thickness determined by field personnel after evaluation of the proposed compaction equipment. However, in no case shall the uncompacted lift thickness exceed 7 inches. 5

Placing shall be carried out so that the material does not segregate. If segregation does occur, the material shall be removed and replaced with suitable material all by and at the expense of the Subcontractor.

Zone 4 material shall be placed only on the outside of the pond dikes (over the sand drain). Zone 4Z shall be used only on the baffle dike, on the inside of the pond dikes, and on those outside areas of the dike where it will not contaminate the discharge face of the Zone 3 sand drain material.

12.5.6 Zone 5 and Zone 5A

Zone 5 and 5A material shall be placed in the embankment fill as shown on the drawings or as required. Zone 5 material shall identify riprap protection material generally placed along selected portions of the ourside slope of the cooling pond (the east and northeast sides) and along selected portions of the inside slope of the cooling pond in areas of a short fetch. All other areas requiring riprap protection shall be designated Zone 5A.

Zone 5 and 5A material shall be placed in such a manner as to produce a reasonably well graded mass of rock with the minimum practical percentage of voids. The larger pieces shall be uniformly distributed throughout the rock mass and the smaller pieces shall fill the voids between the larger pieces. Hand placing may be required to a limited extent, but only as necessary to obtain the results specified

A tolerance of plus 6 inches or minus 3 inches from the slope lines, elevations and grades shown, will be allowed in the finished surfaces of the Zone 5 and Zone 5A materials. Zone 5 and 5A materials shall conform to gradation requirements given in Table 12-1.

Where Zone 5 or 5A material is placed as slope protection at drops in the drainage ditches, as shown on the drawings, it shall be grouted after it has been placed in its final position. The zone shall be grouted over its entire thickness. Prior to grouting, the rock particles shall be flushed with water and the material shall be thoroughly wetted. Care shall be exercised to ensure that all voids are satisfactorily filled with grout.

12.5.7 Zone 6

Zone 6 materials shall be placed as downstream slope protection for the embankment fill as shown on the Drawings or as required. The method of placement will be at the Subcontractors option and subject to approval by the Contractor. Approval will be based on demonstrated ability to place Zone 6 material satisfactorily.

12.5.8 Spreading

Immediately after dumping embankment material on any zone having a specified maximum uncompacted lift thickness, that material shall be spread by bulldozer, grader, or other approved means in approximately horizontal layers over the previously compacted fill. Unless otherwise required, the uncompacted thickness of the layers prior to compaction shall not exceed those specified.

12.5.9 Loosening Surface of Materials

If the compacted surface of any layer of material is determined by the Contractor to be too smooth to bond properly with the succeeding layer, it shall be loosened by harrowing or by other approved methods, and, if required by the Contractor, it shall be sprinkled or otherwise moisture conditioned before the succeeding lift is placed thereon. In addition, any surface crust formed on a layer of fill material that has been dumped and spread shall be broken up by harrowing and, if required by the Contractor, moisture conditioned to the full depth of the layer prior to rolling. Harrowing shall be done with a disc or a spring-toothed harrow or other approved equipment. If one pass of the equipment does not accomplish the breaking up and blending of the material, additional passes of the equipment may be required.

12.5.10 Removal of Stones, Roots and Debris

Any oversize material transported to the embankment for use in Zones 1 through 4 shall be removed to Zone 5 or 5A provided that it falls within the specified requirements for Zone 5 or 5A. Roots and other debris shall be removed from the embankment and disposed of in the disposal areas as specified.

12.6 Moisture Control

12.6.1 Zone 1, Zone 1A, and Zone 2

Insofar as practicable, Zone 1, Zone 1A and Zone 2 material which require moisture control, shall be moisture-conditioned in the borrow areas. Moisture conditioning is the operations required to decrease the moisture content of material, which as required by the specification is too wet or to increase the moisture content of materials, which, as required by the specification is too dry. The water content during compaction shall not be more than 2 percentage points below optimum moisture content and shall not be more than 2 percentage points above optimum moisture content provided that in Zone 2 the wet limit for compaction of the material shall be that moisutre content at which the rubber tires of the specified rubber tired rollers rut the surface of the fill by more than 6 inches.

For Zone 2 material placed in the Bullock Creek area and other areas as specified by the Bechtel representative, the water content during compaction shall be not more than 2 percentage points below optimum moisture content and not more than 5 percentage points above optimum moisture content. If the moisture content exceeds 2 percent above optimum the fill shall be placed with a compactive effort equal to at least 95 percent of the Bechtel Modified Proctor (as described in Section 12.4.5.1), or 80 percent relative density as determined by ASTM A-2049, whichever is applicable. If the material in the borrow area does not contain the required moisture content, it shall be moistened by sprinkling from a truck equipped with a sprinkler. The sprinkler truck shall be capable of uniformly distributing the water over the entire area to be used. When required by the Contractor, material in the borrow area shall be processed with plows, discs, dozers, motor graders or other approved equipment to distribute the moisture uniformly throughout the material to be used, or for the purpose of aerating material containing excessive moisture. If moisture conditioning is done in the borrow area, care shall be exercised to moisten the material uniformly and excessive runoff or accumulation of water shall be avoided in depressions.

Tests done in accordance with Paragraph 12.4.2 will indicate the degree of moistening or aerating necessary to comply with Paragraph 12.6.1. After placement of loose material on the embankment fill, the moisture content shall be further adjusted as necessary to bring such material within the moisture content limits required for compaction. If the material placed is too wet for compaction, it shall be aerated as specified and dried until the moisture content of the entire layer is uniform and reduced to within the required

If the material placed is too dry for suitable compaction, it shall be sprinkled and disked, harrowed or otherwise mixed until the moisture content of the entire layer is uniform and within the specified limits. Such sprinkling shall be by sprinkler turck which shall be equipped with pressure spray bars and valves to give a uniform and even application of water to the areas being covered and a positive control of the rate of application at all times. Rolling of any section of embankment containing material too wet or too dry

1.5A

to obtain the required compaction shall be delayed until the moisture content of the material is brought to within the required limits or the material shall be removed and replaced with suitable material by and at the expense of the Subcontractor.

12.6.2 Zone 3, Zone 4, Zone 4A, Zone 5, Zone 5A and Zone 6

Moisture conditioning of material for Zones 3, 4, 4A, 5, 5A and 6 is not required.

12.7 Compaction Equipment

12.7.1 General

All compaction equipment shall conform to the following specifications. The Subcontractor shall maintain such equipment in first class operating condition at all times and, where required by the Contractor, shall immediately make any adjustment necessary to obtain the required compaction. When rollers are operated one behind the other in the same track, all rollers operated in this manner shall have the same general dimensions, weights, and operating characteristics. Equipment used to pull rollers shall have sufficient power to satisfactorily pull the rollers when they are ballasted to the specified weights. The Subcontractor may use compaction equipment other than that specified, provided that the Subcontractor shall, at its expense, demonstrate that such substituted equipment will achieve equal or better degrees of compaction and other characteristics than those achieved by the equipment specified, all as determined by the Contractor.

12.7.2 Rubber-Tired Rollers

Rubber-tired rollers shall have a minimum of 4 wheels equipped with pneumatic tires which shall be of such size and ply that tire pressures can be maintained between 80 and 100 pounds per square inch for a 25,000 pound wheel load during rolling operations. Unless otherwise required, rolling shall be done with tires inflated to 100 psi. The roller wheels shall be located abreast in a rigid steel frame, each wheel loaded by an individual weight box so that each will carry an equal load when traversing uneven ground. The spacing of the wheels shall be such that the distance between the nearest edges of adjacent tires shall be not greater than one-half of the tire width of a single tire at the operating pressure for a 25,000 pound wheel load. The weight boxes shall be suitable for ballast loading such that the load per wheel may be varied as required from 18,000 to 25,000 pounds. The roller shall be towed at speeds not to exceed 10 miles per hour.

An alternate roller approved by the Contractor may be used in which case additional passes may be required.

12.7.3 Power Tampers

Power tampers shall be operator-held type of a size capable of performing the required compaction and shall be subject to approval. Approval will be on the basis of demonstrated ability of the tampers to accomplish adequate compaction as determined by the Contractor.

12.8 Compaction Requirements

12.8.1 Rolling

After material has been placed and spread on the fill and the moisture content and condition of the fill is satisfactory, the material shall immediately be compacted. All roller passes shall be made parallel to the axes of the dikes or embankment unless otherwise approved by the Contractor. The rolling requirements for each zone of the dikes and embankment are as follows:

Zone	Type of Compaction Equipment	Minimum Number of Passes per Lift
1	50-ton Rubber Tired Roller	4
1A	50-ton Rubber Tired Roller	4
2	50-ton Rubber Tired Roller	4
3	50-ton Rubber Tired Roller or Vibr. Roller	4
4	Construction Equipment routed over the zone or additional rolling as directed by Contractor	-
4A	50-ton Rubber Tired Roller as directed by Contractor.	-
5	Not Required	-
5A	Not Required	-
6	Not Required	-

A pass shall consist of the entire coverage of the area with at least one trip of the equipment specified. In order to effect complete coverage of the area being rolled, each trip of the roller shall overlap the adjacent trip by not less than 2 feet. Dumping, spreading, sprinkling, disking, or harrowing, and compacting may be performed at the same time at different points along the section where there is sufficient area to permit these operations to proceed simultaneously.

12.8.2 Additional Rolling

If, as determined by the Contractor, the desired compaction of any portion of embankment is not obtained by the minimum passes specified, additional passes shall be made over the surface area of such designated portions of the embankment until the desired degree of compaction has been attained. However, where lift thickness is greater than specified, or moisture content at time of rolling is improper or specified rolling has not been performed, such rolling shall be by and at the expense of the Subcontractor.

12.8.3 Fill Not Accessible to Specified Rollers

12.8.3.1 General

Unless otherwise specified, all embankment fill not accessible to roller compaction shall be compacted by power or hand tampers, or by rolling, or other approved means to the same degree required for like materials compacted by roller. Fill containing both sides of a wall, pipe or structure shall be kept at approximately the same elevation and compacted equally on the sides until placement has reached the required elevation.

12.9 Slides

In the event of slides in any part of any of the embankment prior to final acceptance, the Subcontractor shall remove material from the slide area as required, and shall rebuild that portion of the embankment. In case it is determined by the Contractor that the slide was caused through the fault or negligence of the Subcontractor, the removal and disposal of the material and the rebuilding of the embankment shall be performed by and at the expense of the Subcontractor. Otherwise, such work will be paid for under the applicable items of excavation and embankment.

12.10 Winter Protection of the Embankment

The Subcontractor shall take whatever precautions are necessary to protect the partially completed embankments for the winter period. Subcontractor will also perform any necessary reconditioning resulting from lack of winter protection.

12.11 Measurement and Payment

12.11.1 Embankment

12.11.1.1 Measurement

Embankment will be measured in place to the nearest cubic yard of embankment material of the various zones, satisfactorily placed and compacted in the dikes and the railroad embankment. Such measurement will be made between the foundation lines as determined by survey in the field and the neat fill lines, grades and slopes shown. No allowance will be made for settlement of the foundation or of the embankment during construction.

12.11.1.2 Payment

Embankment will be paid for at the applicable contract price stated in the Price Schedule for the items listed below; provided that embankment placed around walls, pipes, structures and elsewhere requiring the use of special compactors for compaction will not be paid for separately.

Item 15A	Embankment, Zone 1
Item 16	Embankment, Zone 1A
Item 17A	Embankment, Zone 2
Item 18A	Embankment, Zone 3
Item 19	Embankment, Zone 4
Item 20	Embankment, Zone 4A
Item 21	Embankment, Zone 5
Item 22	Embankment, Zone 5A
Item 23	Embankment, Zone 6

Payment for Item 21 shall reflect savings for use of Contractor-furnished materials located on-site; such materials are available to the Subcontractor in an "as-is" condition.

12.11.2 Additional Rolling for Compaction

12.11.2.1 Measurement

Additional rolling for compaction will be measured to the nearest 1/4 hour as the number of hours such additional rolling is satisfactorily performed.

12.11.2.2 Payment

Additional rolling for compaction will be paid for at the contract price stated in the Price Schedule for the item listed below.

Item 24 Additional Rolling

Rolling for compaction of Zone 4A material, if required by Contractor, will be paid for at the contract price stated in the Price Schedule for Item 24. No payment will be made for additional rolling required of alternate rollers to meet the same compactive effort of the 50-ton roller.

12.11.3 Winter Protection

Winter protection will not be paid for separately, nor will any payment be made for costs to recondition the materials as a result of the Subcontractor's failure to provide adequate winter protection.

13.0 PLANT AREA BACKFILL AND BERM BACKFILL

13.1 General

This section covers only embankment materials placed in the plant area, (as defined on the contract drawings) and also backfill material required to provide a minimum 100 foot wide berm adjacent to the emergency cooling pond area. All work under this section shall be subject to the Quality Assurance provisions as required by Section 16.0 "Quality Assurance Program Requirements".

13.2 Definition

The term backfill as used in this section shall include all types of embankment zone materials required in the plant area and the berm, except that the following materials shall be considered structural backfill: 1) backfill materials to be placed within three feet of any plant area structure, or 2) backfill areas inaccessible to motorized rollers. Structural backfill will not be placed by the Subcontractor. 5

13.3 Materials

Materials shall conform to the applicable paragraphs of Section 12.3. 2

13.4 Testing

Testing of all materials placed in the plant area and the berm will be performed in accordance with the tests listed in Section 12.4.

13.5 Placement

Material placement procedures shall conform to Section 12.5. Attention shall be given to not exceed the lift thickness specified for the various zones of materials.

13.6 Moisture Control

Moisture control of the plant area and berm material shall conform to Section 12.6.

13.7 Compaction Requirements

13.7.1 Cohesive Soils

All cohesive backfill in the plant area and the berm shall be compacted to not less then 95 percent of maximum density as determined by ASTM D 1557, Method D.

13.7.2 Cohesionless Soils

All cohesionless backfill in the plant area and the berm shall be compacted to not less than 80 percent of relative density as determined by ASTM D 2049, with the exception that Zone 4, 4A, 4Z, 5, 5A and 6 materials need no special compactive effort other than as described in section 12.8.1.

5

13.8 Slides and Winter Protection

All provisions for slides and winter protection shall be similar to requirements in Sections 12.9 and 12.10

13.9 Measurement & Payment

13.9.1 Measurement

Embankment will be measured in place to the nearest cubic yard of embankment material of the various zones, satisfactorily placed and compacted in the plant area and the berm. Such measurement will be made between the foundation lines as determined by survey in the field and the neat fill lines, grades and slopes shown. No allowance will be made for settlement of the foundation or of the embankment during construction.

13.9.2 Payment

Embankment will be paid for at the applicable contract price stated in the Price Schedule for the items listed below.

Item 15B - Embankment, Zone 1

Item 17B - Embankment, Zone 2

Item 18B - Embankment, Zone 3

13.9.3 Zones 4, 4A, 5, 5A, and 6 placed in the plant area will be paid for under the appropriate item as listed in 12.11.1.2. No other payment will be made.

13.9.4 Pay items 15B, 17B, and 18B will be full payment for placing and compacting the material. No payment for additional compactive work to meet unanticipated problems for slides and winter protection will be made.

BECHTEL

QUALITY CONTROL INSTRUCTION

JOB NO. 7220

MASTER QC INSTRUCTION TITLE: COMPACTED BACKFILL

2. MASTER QC INSTRUCTION NO.	REV.	3. PROJECT QC INSTRUCTION NO.	4. LOG NO.
C-1.02	I	7220/C-1.02	

INSPECTION CRITERIA

5. TYPE	6. IDENTIFICATION NO.	7. REV.	8. TITLE
Spec.	C-210	*4	Plant Foundation Excavation and Cooling Pond
Spec.	C-211	*2	Structural Backfill
Spec.	C-208	*7	Materials Testing Service

*Note: Rev. No.'s shown in Block 7 only identify the applicable revisions of inspection criteria documents used to prepare Rev. 0 of this QCI. Subsequent revisions to the inspection criteria documents that require revision to this QCI shall be noted appropriately in Block 11, i.e., "PQCI revised to incorporate changes as required by Rev. ________." In addition current revisions of specific engineering and vendor drawings, sketches, specification, procedures and instructions shall be entered on the applicable Inspection Record.

REVISION

9. REV.	10. DATE	11. DESCRIPTION	12. BY	13. CHK'D	14. APP'D
3	2-13-78	Added "Moisture Content Content Control Log" to Block 7, Act/Tasks 2.2.3.2. & 2.3.3.2	DKO	GJC	[illegible]
2	8/2/77	Incorporated CPco Comments and C-208, Rev. 10, C-210, Rev. 4 and C-211, Rev. 3	GJC	JRC	JER

BECHTEL

QUALITY CONTROL INSTRUCTION

JOB NO. 7220

1. MASTER QC INSTRUCTION NO.	REV
C-1.02	I
2. PROJECT QC INSTRUCTION NO.	REV
7220/C-1.02	3

3. ACT NO.	4. ACTIVITY DESCRIPTION	5. INSPECTION CRITERIA	6. INSP ACT CODE	7. SUPPLEMENTARY RECORD

GENERAL INSTRUCTIONS

Purpose

The purpose of this QCI is to provide sufficient inspection activities to assure that the required quality for safety related activities for compacted backfill have been achieved.

Scope

This QCI covers the installation of compacted backfill by hand-held equipment and motorized roller equipment. The scoping of the inspection Records for this PQCI are not to exceed a time period of one week.

Special Instructions

1. Backfilling operations will be separated into two sections (1) work done by hand-held equipment and (2) motorized roller equipment. The following specifications will be used in the following cases:
   a) Spec. C-211 -- Within 3' of a structure.
   b) Spec. C-211 -- Hand work in the plant area done by Bechtel.
   c) Spec. C-210 -- Work performed in the plant area with roller equipment.

2. When preparing Block Number 7 "Reference Criteria" on the IR the QCE shall enter the documents necessary to perform the designated inspections. These documents shall include; (1) the primary specification(s) revision number(s) with all specification change notices and applicable FCR's, (2) Project Engineering approved drawings with all DCN's and applicable field change requests. The primary specifications are those identified in Block Number 6 of this QCI cover sheet.

3. All documents used as inspection criteria for quality verification shall be "controlled" documents.

NOTE: Reference criteria shall be reviewed daily and changes in revision recorded on the IR. Evidence of this review shall be documented on the inspection assignment record.

FP 21073

QUALITY CONTROL INSTRUCTION JOB NO. 7220	1. MASTER QC INSTRUCTION NO. C-1.02	REV I		
	2. PROJECT QC INSTRUCTION NO. 7220/C-1.02	REV 3		

3. ACT NO.	4. ACTIVITY DESCRIPTION	5. INSPECTION CRITERIA	6. INSP ACT CODE	7. SUPPLEMENTARY RECORD

GENERAL INSTRUCTIONS

Special Instructions (Cont'd)

4. Where Project Engineering approved documents exist within the scope of work to be performed, the Project Engineering approved document shall be used.

5. If during the review of the reference criteria documents or at any time later during the performance of these inspections, the QCE determines the reference criteria documents are not adequate to perform the required inspections (i.e., incomplete or omitted details, lack of cross-referencing between drawings, documents require clarity) he shall notify the Lead Discipline QCE. The Lead Discipline QCE shall discuss the problem with the PFQCE who will take the necessary action for resolution. The inspection and sign off shall not be completed until the QCE is satisfied that the document problem, if any, has been satisfactorily resolved.

6. The inspection codes in Column 6 of the QCI for in-process and final inspection activities are supplemented by one of three different symbols to further define the type of inspection required: 1. (V) visual inspection, 2. (M) measurements, and 3. (V&M) visual inspection and measurement. (V) is to inspect by visual examination, (M) is to inspect by physical measurement of dimensions or count of required quantity. (V&M) is to visually examine to detect the apparent worst condition, take a measurement to verify acceptance and visually compare the other items based on this measurement.

7. Section 2.0, In-Process Inspection Activities, provides instructions for the activities that require in-process inspection. The in-process inspection is performed progressively as the work proceeds to assure the materials and items are being installed or placed in accordance with the project design requirements, and before the item becomes inaccessible to inspection.

QUALITY CONTROL INSTRUCTION

JOB NO. 7220

1. MASTER QC INSTRUCTION NO.	REV
C-1.02	I
2. PROJECT QC INSTRUCTION NO.	REV
7220/C-1.02	3

3. ACT NO.	4. ACTIVITY DESCRIPTION	5. INSPECTION CRITERIA	6. INSP ACT CODE	7. SUPPLEMENTARY RECORD
	GENERAL INSTRUCTIONS			
	8. Section 3.0, Final Inspection Activities, provides instructions for inspection of the items inspected under Activity 2.0 to assure all items are correctly completed.			
	9. Incomplete items and nonconforming items noted during these inspection activities shall be controlled to prevent inadvertent use or installation in accordance with SF/PSP G-3.2. The type of documentation generated shall depend on the nature of the item as described in SF/PSP G-3.2. Incomplete items which require documentation shall be recorded on Form QC DR-1. All discrepancies recorded on Form QC DR-1 must be closed out prior to final sign-off of the relevant activities under 3.0, Final Inspection Activities.			
	10. The total number of pages to the Discrepancy Report, QC DR-1, shall be progressively recorded on the IR as each new page of Discrepancies is added in accordance with SF/PSP G-6.1.			
	11. The laboratory test reports listed in Block No. 7 in this QCI shall be filed separately from the Inspection Records in the QC Vault under Specification Sections C-211.3 and C-210.3.			

FP-21073

Designation: D 1557 – 70

American Association State Highway Officials Standard
AASHO No. T180

Standard Methods of Test for

MOISTURE-DENSITY RELATIONS OF SOILS USING 10-lb (4.5-kg) RAMMER AND 18-in. (457-mm) DROP[1]

This Standard is issued under the fixed designation D 1557; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 These methods cover the determination of the relationship between the moisture content and density of soils when compacted in a mold of a given size with a 10-lb (4.5-kg) rammer dropped from a height of 18 in. (457 mm). Four alternative procedures are provided as follows:

	Sections
Method A—A 4-in. (102-mm) mold: soil material passing a No. 4 (4.75-mm)	3 and 4
Method B—A 6-in. (152-mm) mold: soil material passing a No. 4 (4.75-mm) sieve	5 and 6
Method C—A 4-in. mold: soil material passing a ¾-in. (19-mm) sieve	7 and 8
Method D—A 6-in. mold: soil material passing a ¾-in. sieve	9 and 10

1.2 The method to be used should be indicated in the specification for the material being tested. If no method is specified, the provisions of Method A shall govern.

2. Apparatus

2.1 *Molds*—The molds shall be cylindrical in shape, made of metal, and shall have the capacity and dimensions indicated in 2.1.1 and 2.1.2. They shall have a detachable collar assembly approximately 2½ in. (63.5 mm) in height, to permit preparation of compacted specimens of soil - water mixtures of the desired height and volume. The molds may be of the "split" type, consisting of two half-round sections or a section of pipe split along one element, which can be securely locked in place to form a cylinder as described above. The molds may also be the "taper" type, provided the tapering of the internal diameter is uniform and not more than 0.200 in./linear ft (16.6 mm/m) of mold height. The mold and collar assembly shall be so constructed that it can be fastened firmly to a detachable base plate. Capacity and dimensions of the molds shall be as follows:

2.1.1 *Mold*, 4.0-in. (102-mm) having a capacity of 1/30 (0.0333) ± 0.0003 ft^3 (0.93 ± 0.008 cm^3), with an internal diameter of 4.0 ± 0.016 in. (102 ± 0.41 mm) and a height of 4.584 ± 0.005 in. ((116.33 ± 0.13 mm) (see Fig. 1).

2.1.2 *Mold*, 6.0-in. (152.4-mm), having a capacity of 1/13.333 (0.075) ± 0.00075 ft^3 (2.12 ± .02 cm^3), with an internal diameter of 6.0 ± 0.026 in. (152 ± 0.66 mm) and a height of 4.584 ± 0.005 in. (116.33 ± 0.13 mm) (see Fig. 2).

2.2 *Rammer:*

2.2.1 A manually operated metal rammer having a 2.0 ± 0.005 in. (50.8 ± 0.13 mm) diameter circular face and weighing 10 ± 0.02 lb (4536 ± 9 g). The rammer shall be equipped with a suitable guidesleeve to control the height of drop to a free fall of 18.0 ± 1/16 in. (457.2 ± 1.6 mm) above the elevation of the soil. The guidesleeve shall have at least 4 vent holes not smaller than ⅜ in. (9.5 mm) spaced 90 deg apart and ¾ in. (19.1 mm) from each end and shall provide sufficient clearances that free falls of the rammer shaft and head will not be

[1] These methods are under the jurisdiction of ASTM Committee D-18 on Soil and Rock for Engineering Purposes.

Current edition approved Jan. 22, 1970. Originally issued 1958. Replaces D 1557 – 66 T.

.tricted.

2.2.2 *Mechanical Rammer*—A metal rammer that is mechanically operated by a device equipped to control the height of drop to a free fall of 18.0 ± 1/16 in. (457.2 ± 1.6 mm) above the soil surface elevation and to uniformly distribute such drops on the soil surface. The manufactured weight of the rammer shall be 10.0 ± 0.02 lb (4536 ± 9 g) and the operating weight shall be determined from a calibration in accordance with ASTM Method D 2168, for Calibration of Mechanical Laboratory Soil Compactors.[2] There shall be 0.1 ± 0.03-in. (2.54 ± 0.76-mm) clearance between the rammer and the smallest internal diameter of the mold.

2.2.3 *Rammer Face*—The circular face rammer shall be used but a sector face rammer may be used as an alternative, provided the report shall indicate the type of face used other than the 2-in. (50.8-mm) circular face.

2.2.4 *Circular-Face Rammer* shall have a flat face, 2.0 ± 0.005-in. (50.8 ± 0.13-mm) diameter with a soil contacting face of 3.142 ± 0.031 in.^{2} (20 ± 0.2 cm^2).

2.2.5 *Sector-Face Rammer* for use with 4.0-in. (101.6-mm) diameter molds shall have a flat face, 1.9 ± 0.02-in. (48.3 ± 0.5-mm) radius with a soil contacting face of 3.14 ± 0.03 in.^{2} (20 ± 0.2 cm^2) which is a sector of a circle.

2.2.6 *Sector-Face Rammer* for use with 6.0-in. (152.4-mm) diameter molds shall have a flat face, 2.9 ± 0.02-in. (50.8 ± 0.51-mm) radius with a soil contacting face of 3.14 ± 0.03 in.^{2} (20 ± 0.2 cm^2) which is a sector of a circle.

2.3 *Sample Extruder (optional)*—A jack, frame, or other device adapted for the purpose of extruding compacted specimens from the mold.

2.4 *Balances*—A balance or scale of at least 25-lb (11.34-kg) capacity sensitive to 0.01 lb (4.54 g) and a balance of at least 1000-g capacity sensitive to 0.1 g.

2.5 *Drying Oven*—A thermostatically controlled drying oven capable of maintaining a temperature of 230 ± 9 F (110 ± 5 C) for drying moisture samples.

2.6 *Straightedge*—A steel straightedge about 12 in. (305 mm) in length and having one beveled edge.

2.7 *Sieves*—2-in. (50-mm), ¾-in. (19-mm) and No. 4 (4.75-mm) sieves conforming to the requirements of ASTM Specification E 11, for Wire-Cloth Sieves for Testing Purposes.[3]

2.8 *Mixing Tools*—Miscellaneous tools such as mixing pan, spoon, trowel, spatula, etc., or a suitable mechanical device for thoroughly mixing the sample of soil with increments of water.

METHOD A

3. Sample

3.1 If the soil sample is damp when received from the field, dry it until it becomes friable under a trowel. Drying may be in air or by use of drying apparatus such that the temperature of the sample does not exceed 140 F (60 C). Then thoroughly break up the aggregations in such a manner as to avoid reducing the natural size of individual particles.

3.2 Pass an adequate quantity of the representative pulverized soil through the No. 4 (4.75-mm) sieve. Discard the coarse material, if any, retained on the No. 4 sieve.

3.3 Select a representative sample, weighing approximately 7 lb (3.18 kg) or more, of the soil prepared as described in 3.1 and 3.2.

4. Procedure

4.1 Thoroughly mix the selected representative sample with sufficient water to dampen it to approximately four percentage points below optimum moisture content.

4.2 Form a specimen by compacting the prepared soil in the 4-in. (102-mm) mold (with collar attached) in five equal layers to give a total compacted depth not to exceed 5 in. (127 mm). Compact each layer by 25 uniformly distributed blows from the rammer. During compaction, the mold shall rest on a uniform, rigid foundation, such as provided by a cylinder or cube of concrete weighing not less than 200 lb (90.72 kg). Following compaction, remove the extension collar, carefully trim the compacted soil even with the top of the mold by means of the straightedge, and weigh. Multiply the weight of the compacted specimen and mold, minus the weight of the mold, by 30 (or divide by 942.95), and record the result as the wet unit weight, γ_m, in pounds per cubic foot of the compacted soil.

4.3 Remove the material from t[he mold and] slice vertically through the cen[ter. Take a] representative sample of the mater[ial from one] of the cut faces and determine m[oisture con]tent in accordance with ASTM [Method D] 2216, for Laboratory Determinati[on of Mois]ture Content of Soil.[2]

4.4 Thoroughly break up the r[emainder of] the material until it will pass a N[o. 4 (4.75-]mm) sieve as judged by eye. A[dd water in] sufficient amounts to increase t[he moisture] content of the soil sample by [one or two] percentage points, and repeat the a[bove proce]dure for each increment of water[. Con]tinue this series of determinations [until there is] either a decrease or no change in t[he wet unit] weight, γ_m, in pounds per cubic [foot of the] compacted soil.

NOTE 1—This procedure has been fo[und satisfac]tory in most cases. However, in instanc[es where the] soil material is fragile in character an[d will reduce] significantly in grain size due to repea[ted compac]tion, and in cases where the soil is a he[avy-textured] clayey material into which it is difficult [to incorpor]ate water, a separate and new sample sh[all be used in] each compaction test. In these cases, [separate] samples shall be thoroughly mixed with [amounts of] water sufficient to cause the moisture co[ntents of the] samples to vary by approximately tw[o percentage] points. The moisture contents selected [shall bracket] the optimum moisture content, thus pr[oviding sam]ples which, when compacted, will increa[se in weight] to the maximum density and then decrea[se in weight.] The samples of soil-water mixtures shall [be placed in] covered containers and allowed to stand [for not less] than 12 h before making the moisture-d[ensity test.]

METHOD B

5. Sample

5.1 Select the representative sam[ple in ac]cordance with 3.3, except that it s[hall weigh] approximately 16 lb (7.26 kg).

6. Procedure

6.1 Follow the same procedure as [described] for Method A in Section 4, excep[t for the] following: Form a specimen by com[pacting the] prepared soil in the 6-in. (152.4-m[m) mold] (with collar attached) in five equal [layers to] give a total compacted depth not to [exceed 5] in. (127 mm), each layer being com[pacted by] 56 uniformly distributed blows from [the ram]mer. Multiply the weight of the c[ompacted] specimen and mold, minus the wei[ght of the] mold, by 13.33 (or divide by 2123.7[...]

[2] *Annual Book of ASTM Standards*, Part 19.
[3] *Annual Book of ASTM Standards*, Part 41.

cubic foot of the compacted soil.

4.3 Remove the material from the mold and slice vertically through the center. Take a representative sample of the material from one of the cut faces and determine moisture content in accordance with ASTM Method D 2216, for Laboratory Determination of Moisture Content of Soil.[2]

4.4 Thoroughly break up the remainder of the material until it will pass a No. 4 (4.75-mm) sieve as judged by eye. Add water in sufficient amounts to increase the moisture content of the soil sample by one or two percentage points, and repeat the above procedure for each increment of water added. Continue this series of determinations until there is either a decrease or no change in the wet unit weight, γ_m, in pounds per cubic foot of the compacted soil.

NOTE 1—This procedure has been found satisfactory in most cases. However, in instances where the soil material is fragile in character and will reduce significantly in grain size due to repeated compaction, and in cases where the soil is a heavy-textured clayey material into which it is difficult to incorporate water, a separate and new sample shall be used in each compaction test. In these cases, the separate samples shall be thoroughly mixed with amounts of water sufficient to cause the moisture contents of the samples to vary by approximately two percentage points. The moisture contents selected shall bracket the optimum moisture content, thus providing samples which, when compacted, will increase in weight to the maximum density and then decrease in weight. The samples of soil-water mixtures shall be placed in covered containers and allowed to stand for not less than 12 h before making the moisture-density test.

METHOD B

5. Sample

5.1 Select the representative sample in accordance with 3.3, except that it shall weigh approximately 16 lb (7.26 kg).

6. Procedure

6.1 Follow the same procedure as described for Method A in Section 4, except for the following: Form a specimen by compacting the prepared soil in the 6-in. (152.4-mm) mold (with collar attached) in five equal layers to give a total compacted depth not to exceed 5 in. (127 mm), each layer being compacted by 56 uniformly distributed blows from the rammer. Multiply the weight of the compacted specimen and mold, minus the weight of the mold, by 13.33 (or divide by 2123.76). Record the result as the wet unit weight, γ_m, in pounds per cubic foot of the compacted soil.

METHOD C

7. Sample

7.1 If the soil sample is damp when received from the field, dry it until it becomes friable under a trowel. Drying may be in air or by use of drying apparatus such that the temperature of the samples does not exceed 140 F (60 C). Then thoroughly break up the aggregations in such a manner as to avoid reducing the natural size of individual particles.

7.2 Pass an adequate quantity of the representative pulverized soil through the 3/4-in. (19-mm) sieve. Discard the coarse material, if any, retained on the 3/4-in. sieve.

NOTE 2—If it is advisable to maintain the same percentage of coarse material (passing a 2-in. (50.8-mm) sieve and retained on a No. 4 (4.75-mm) sieve) in the moisture-density sample as in the original field sample, the material retained on the 3/4-in. (19-mm) sieve shall be replaced as follows: Pass an adequate quantity of the representative pulverized soil through the 2-in. (50-mm) and 3/4-in. (19-mm) sieves. Discard the coarse material retained on the 2-in. sieve. Remove the material passing the 2-in. sieve and retained on the 3/4-in. sieve and replace it with an equal weight of material passing the 3/4-in. sieve and retained on the No. 4 sieve. Take the material for replacement from the unused portion of the sample.

7.3 Select a representative sample, weighing approximately 12 lb (5.4 kg) or more, of the soil prepared as described in 7.1 and 7.2.

8. Procedure

8.1 Thoroughly mix the selected representative sample with sufficient water to dampen it to approximately four percentage points below optimum moisture content.

8.2 Form a specimen by compacting the prepared soil in the 4-in. (101.6-mm) mold (with collar attached) in five equal layers to give a total compacted depth not to exceed 5 in. (127 mm). Compact each layer by 25 uniformly distributed blows from the rammer. During compaction, the mold shall rest on a uniform, rigid foundation, such as is provided by a cylinder or cube of concrete weighing not less than 200 lb (90.7 kg). Following compaction, remove the extension collar and carefully trim the compacted soil even with the top of the mold by means of the straightedge. Patch holes developed in the surface by removal of coarse material with smaller size material. Weigh the mold and moist soil. Multiply the weight of the compacted specimen and mold, minus the weight of the mold, by 30 (or divide by 942.95), and record the result as the wet unit weight, γ_m, in pounds per cubic foot of the compacted soil.

8.3 Remove the material from the mold and slice vertically through the center. Take a representative sample of the material from one of the cut faces, weigh immediately, and dry in an oven at 230 ± 9 F (110 ± 5 C) for at least 12 h, or to constant weight, to determine the moisture content. The moisture content sample shall weigh not less than 500 g.

8.4 Thoroughly break up the remainder of the material until it will pass a ¾-in. (19-mm) sieve and 90 percent of the soil aggregations will pass a No. 4 (4.75-mm) sieve as judged by eye. Add water in sufficient amounts to increase the moisture content of the soil sample by one or two percentage points, and repeat the above procedure for each increment of water added. Continue this series of determinations until there is either a decrease or no change in the wet unit weight, γ_m, in pounds per cubic foot of compacted soil (see Note 1).

METHOD D

9. Sample

9.1 Select the representative sample in accordance with 7.3, except that it shall weigh approximately 25 lb (11.3 kg).

10. Procedure

10.1 Follow the same procedure as described for Method C in Section 8, except for the following: Form a specimen by compacting the prepared soil in the 6-in. (152.4-mm) mold (with collar attached) in five equal layers to give a total compacted depth not to exceed 5 in. (127-mm) each layer being compacted by 56 uniformly distributed blows from the rammer. Multiply the weight of the compacted specimen and mold, minus the weight of the mold, by 13.33 (or divide by 2123.76). Record the result as the wet unit weight, γ_m, in pounds per cubic foot of the compacted soil.

CALCULATIONS AND REPORT

11. Calculations

11.1 Calculate the moisture content and the dry unit weight of the soil as compacted for each trial, as follows:

$$= [(A - B)/(B - C)] \times 100$$

and

$$\gamma_d = [\gamma_m/(w + 100)] \times 100$$

where:

w = percentage of moisture in the specimen,
A = weight of container and wet soil,
B = weight of container and dry soil,
C = weight of container,
γ_d = dry unit weight, in pounds per cubic foot of compacted soil, and
γ_m = wet unit weight, in pounds per cubic foot of compacted soil.

12. Moisture-Density Relationship

12.1 Plot the dry unit weights in pounds per cubic foot (densities) of the soil as ordinates and the corresponding moisture contents as abscissas. Draw a smooth curve connecting the plotted points.

12.2 *Optimum Moisture Content*, w_o—The moisture content corresponding to the peak of the curve drawn as directed in 12.1 shall be termed the "optimum moisture content" of the soil under the above compaction.

12.3 *Maximum Density*, γ_{max}—The dry unit weight in pounds per cubic foot of the soil at "optimum moisture content" shall be termed "maximum density" under the above compaction.

13. Report

13.1 The report shall include the following:

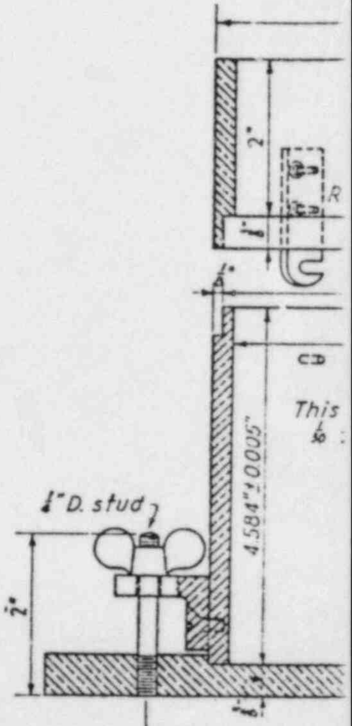
13.1.1 The method used (Method A, B, C, or D),

13.1.2 The optimum moisture content, and

13.1.3 The maximum density.

13.1.4 In Methods C and D, indication of removal or replacement of ¾-in. (19.1-mm) material.

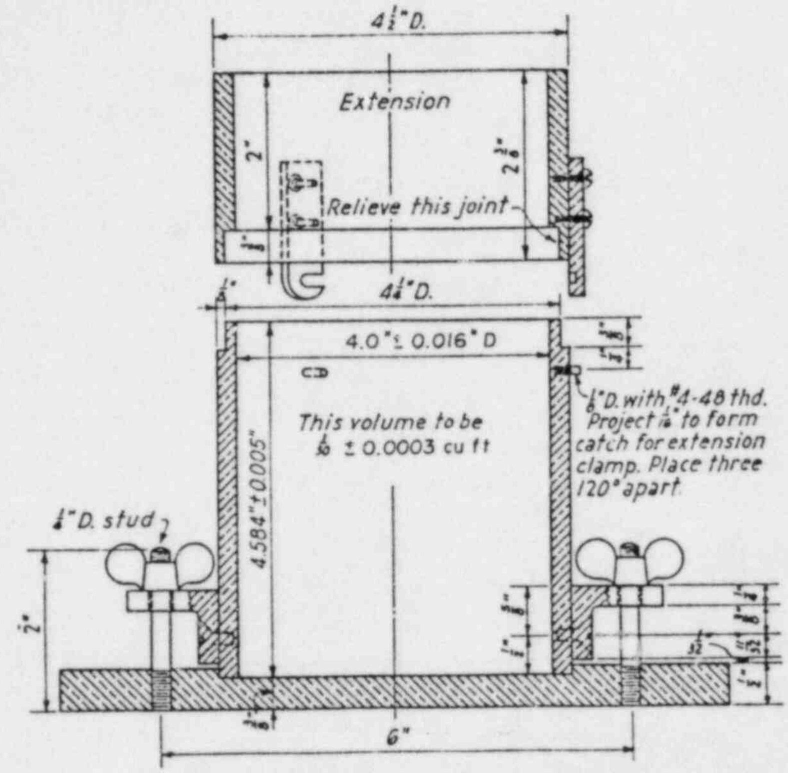
13.1.5 Type of face if other than 2-in. (50.8-mm) circular.



Met

in.	mm
1/32	0.8
1/8	3.2
1/4	6.4
11/32	8.7
3/8	9.5
1/2	12.7

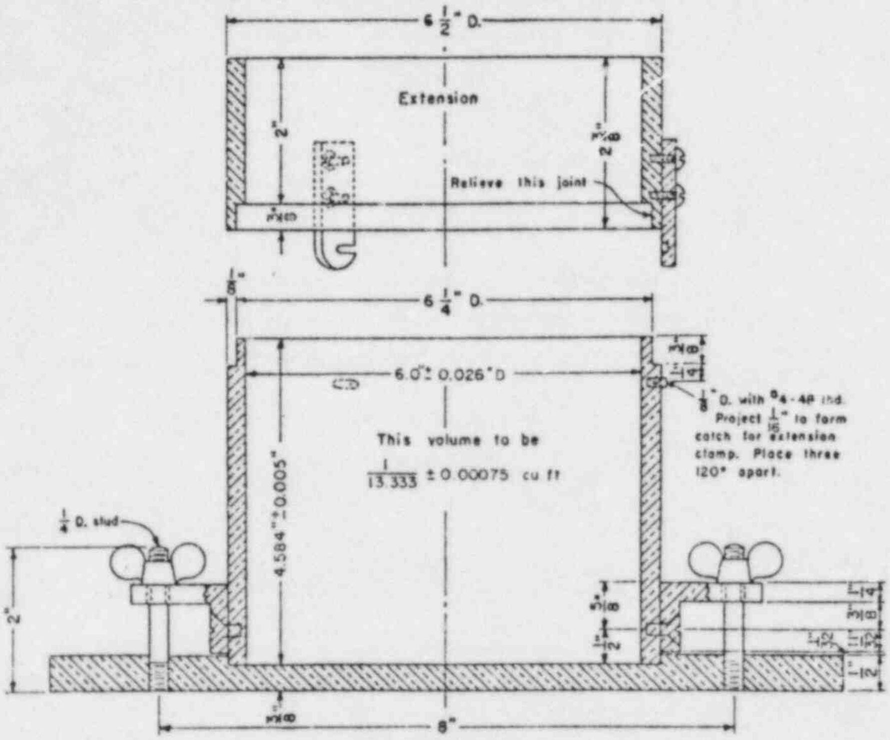
FIG. 1 Cylindrical M



Metric Equivalents

in.	mm	in.	mm
1/32	0.8	5/8	15.9
1/8	3.2	2	50.8
1/4	6.4	2 3/8	60.3
11/32	8.7	4 1/4	108.0
3/8	9.5	4 1/2	114.3
1/2	12.7		

FIG. 1 Cylindrical Mold, 4.0-in. (101.6-mm), for Soil Tests.



Metric Equivalents

in.	mm	in.	mm
1/32	0.8	5/8	15.9
1/8	3.2	2	50.8
1/4	6.4	2 3/8	60.3
11/32	8.7	4 1/4	108.0
3/8	9.5	4 1/2	114.3
1/2	12.7		

FIG. 2 Cylindrical Mold, 6.0-in. (152.4-mm) for Soil Tests.

Designation: D 1558 –

Standard Method o
MOISTURE-PE
RELATIONS OF

This Standard is issued under the fixed design
year of original adoption or, in the case of rev
last reapproval.

1. Scope

1.1 This method is for establishin
ture-penetration resistance relation
grained soils as determined by the
trometer.

2. Apparatus

2.1 *Moisture-Density Apparat*
forming to the requirements pre
ASTM Methods D 698, Test for
Density Relations of Soils, Using 5
kg) Rammer and 12-in. (304.8-mm) I

2.2 *Soil Penetrometer*—A soil p
ter (Fig. 1) consisting of a special sp
mometer with pressure-indicating sc
stem of the handle. The pressure sca
graduated to 90 lb in 2-lb divisions
encircling the stem at each 10-lb i
graduated to 40 kg in 1-kg divisions
encircling the stem at each 5-kg i
sliding ring on the stem shall in
maximum pressure obtained in the

2.3 *Set of Penetrometer Need*
penetrometer needle (Fig. 1) shall c
shank with a head of known end are
of interchangeable needles shall in
sizes given in Table 1. The needle sh
have graduations inscribed at interva
(or 10 mm) to indicate the depth of p
and shall have a length of not less tha
100 mm) excluding the threaded por

3. Sample

3.1 Prepare the sample in accord
either Method A or B of Methods D
preparation, the fraction passing t
(4.75-mm) sieve shall have at least 2
passing the No. 200 (75-μm) sieve.

Designation: D 1556 – 64 (Reapproved 1974)[ε]

American National Standard A37.161-1972
Approved June 30, 1972
By American National Standards Institute

Standard Method of Test for

DENSITY OF SOIL IN PLACE BY THE SAND-CONE METHOD[1]

This Standard is issued under the fixed designation D 1556; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

[ε] NOTE—The equation in 4.4 was editorially corrected in July 1974.

1. Scope

1.1 This method covers the determination of the in-place density of soils. The apparatus described herein is restricted to tests in soils containing particles not larger than 2 in. (50.8 mm) in diameter.

2. Apparatus

2.1 *Density Apparatus*—The density apparatus shall consist of a 1-gal (4-litre) jar and a detachable appliance consisting of a cylindrical valve with an orifice ½ in. (12.7 mm) in diameter and having a small funnel continuing to a standard *G* mason jar top on one end and a large funnel on the other end. The valve shall have stops to prevent rotating the valve past the completely open or completely closed positions. The apparatus shall conform to the requirements shown in Fig. 1.

NOTE 1—The apparatus described here represents a design that has proved satisfactory. Other apparatus of similar proportions will perform equally well so long as the basic principles of the sand-volume determination are observed. This apparatus, when full, can be used with test holes having a volume of approximately 0.1 ft³ (3 dm³). The base plate shown in the drawing is optional; its use may make leveling more difficult but permits test holes of larger diameter and may reduce loss in transferring soil from test-hole to container as well as afford a more constant base for tests in soft soils. When the base plate is used it shall be considered a part of the funnel in the procedures of this test method.

2.2 *Sand*—Any clean, dry, free-flowing, uncemented sand having few, if any, particles passing the No. 200 (75-μm) or retained on the No. 10 (2.00-mm) sieves. In selecting a sand for use several bulk density determinations should be made using the same representative sample for each determination. To be acceptable the sand shall not have a variation in bulk density greater than 1 percent.

2.3 *Balances*—A balance or scale of 10-kg capacity accurate to 1.0 g and a balance of 500-g capacity accurate to 0.1 g.

2.4 *Drying Equipment*—Stove or oven or other suitable equipment for drying moisture content samples.

2.5 *Miscellaneous Equipment*—Small pick, chisels, or spoons for digging test hole; 10-in. (254-mm) frying pan or any suitable container for drying moisture samples; buckets with lids, seamless tin cans with lids, canvas sacks or other suitable containers for retaining the density sample, moisture sample or density sand respectively; thermometer for determining the temperature of water, small paint-type brush, slide rule, note-book, etc.

3. Procedure

3.1 Determine the volume of the jar and attachment up to and including the volume of the valve orifice as follows (Note 2):

3.1.1 Weigh the assembled apparatus and record.

3.1.2 Place the apparatus upright and open the valve.

3.1.3 Fill the apparatus with water until it appears over the valve.

3.1.4 Close valve and remove excess water.

3.1.5 Weigh the apparatus and water and determine the temperature of the water.

3.1.6 Repeat the procedure described 3.1.1 to 3.1.5 at least twice. Convert the weight of water, in grams, to millilitres by correcting for the temperature as given in 4.1. The volume

[1] This method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock for Engineering Purposes.
Current edition approved Aug. 31, 1964. Originally issued 1958. Replaces D 1556 - 58 T.

used shall be the average of three determinations with a maximum variation of 3 ml.

NOTE 2—The volume determined in this procedure is constant as long as the jar and attachment are in the same relative position. If the two are to be separated match marks should be made to permit reassembly to this position.

3.2 Determine the bulk density of the sand to be used in the field test as follows (Notes 3 and 4):

3.2.1 Place the empty apparatus upright on a firm level surface, close the valve, and fill the funnel with sand.

3.2.2 Open the valve and, keeping the funnel at least half full of sand, fill the apparatus. Close the valve sharply and empty excess sand.

3.2.3 Weigh the apparatus with sand and determine the net weight of sand by subtracting the weight of the apparatus.

NOTE 3—Vibration of the sand during any sand weight-volume determination may increase the bulk density of the sand and decrease the accuracy of the determination. Appreciable time intervals between the bulk density determination of the sand and its use in the field may result in change in the bulk density caused by a change in the moisture content or effective gradation.

NOTE 4—It is possible to determine the bulk density of the sand in other containers of known volume that dimensionally approximate the largest test hole that will be dug. The general procedure used is that given in 3.4 for determining the volume of the test hole. If this procedure is to be followed it shall be determined that the resulting bulk density equals that given by the jar determination.

3.3 Determine the weight of sand required to fill the funnel as follows (Notes 5 and 6):

3.3.1 Put sand in the apparatus and secure the weight of apparatus and sand.

3.3.2 Seat the inverted apparatus on a clean, level, plane surface.

3.3.3 Open the valve and keep open until after the sand stops running.

3.3.4 Close the valve sharply, weigh the apparatus with remaining sand, and determine the loss of sand. This loss represents the weight of sand required to fill the funnel.

3.3.5 Replace the sand removed in the funnel determination and close the valve.

NOTE 5—This determination may be omitted if the procedure given in Note 7 is followed. When the base plate is used it shall be considered a part of the funnel.

NOTE 6—Where test holes of maximum volume are desired it is possible, after the bulk density determination, to settle the sand by vibration and increase the weight of sand in the apparatus. If this procedure is followed, the total weight of sand available shall be determined by reweighing.

3.4 Determine the density of the soil in place as follows:

3.4.1 Prepare the surface of the location to be tested so that it is a level plane.

3.4.2 Seat the inverted apparatus on the prepared plane surface and mark the outline of the funnel.

NOTE 7—In soils such that leveling is not successful a preliminary test shall be run at this point measuring the volume bounded by the funnel and ground surface. This step requires balances at the test site or emptying and refilling the apparatus. After this measurement is completed, carefully brush the sand from the prepared surface.

3.4.3 Dig the test hole inside the funnel mark, being very careful to avoid disturbing the soil that will bound the hole. Soils that are essentially granular require extreme care. Place all loosened soil in a container, being careful to avoid losing any material.

3.4.4 Seat the apparatus in the previously marked position, open the valve, and after the sand has stopped flowing, close the valve (Note 3).

3.4.5 Weigh the apparatus with remaining sand, and determine the weight of sand used in the test.

3.4.6 Weigh the material that was removed from the test hole.

3.4.7 Mix the material thoroughly and secure and weigh a representative sample for moisture determination.

3.4.8 Dry and weigh the moisture sample.

3.5 The minimum test hole volumes suggested in determining the in-place density of soil mixtures are given in Table 1. This table shows the suggested minimum weight of the moisture content sample in relation to the maximum particle size in soil mixtures.

4. Calculations

4.1 Calculate the volume of the density apparatus as follows:

$$V_1 = GT$$

where:

V_1 = volume of the density apparatus, ml,
G = water required to fill the apparatus, g,
T = water temperature-volume correction shown in column 3 of Table 2.

4.2 Calculate the bulk density of the sand as follows:

$$W_1 = 62.427\ W_2/V_1$$

where:

W_1 = bulk density of the sand,
W_2 = sand required to fill th
(3.2.3) g, and
V_1 = volume of apparatus, (4.1)

4.3 Calculate the moisture con dry weight of material removed f hole as follows:

$$w = [W_3 - W_4)/W_4] \times 1$$
$$W_6 = 0.2205\ W_5/(w + 10$$

where:

w = percentage of moisture, from test hole.
W_3 = moist weight of moisture s
W_4 = dry weight of moisture san
W_5 = moist weight of the mater test hole, g, and
W_6 = dry weight of material fro lb.

TABLE 1 Minimum Test Hole Volume Moisture Content Samples Based on Maxim ticle

Maximum Particle Size	Minimum Test Hole Volume, ft
No. 4 Sieve (4.75 mm)	0.025
½ in. (12.5 mm)	0.050
1 in. (25 mm)	0.075
2 in. (50 mm)	0.100

$$W_1 = 62.427\ W_2/V_1$$

where:

W_1 = bulk density of the sand, lb/ft³[3]

W_2 = sand required to fill the apparatus (3.2.3) g, and

V_1 = volume of apparatus, (4.1).

4.3 Calculate the moisture content and the dry weight of material removed from the test hole as follows:

$$w = [(W_3 - W_4)/W_4] \times 100$$

$$W_6 = 0.2205\ W_5/(w + 100)$$

where:

w = percentage of moisture, in material from test hole.

W_3 = moist weight of moisture sample, g,

W_4 = dry weight of moisture sample, g,

W_5 = moist weight of the material from the test hole, g, and

W_6 = dry weight of material from test hole, lb.

4.4 Calculate the in-place dry density of the material tested as follows:

$$V = (W_7 - W_8)/453.6\ W_1$$

$$W = W_6/V$$

where:

V = volume of test hole, ft,³

W_7 = sand used, g (3.4.5),

W_8 = sand in funnel (3.3.3) g, and

W = dry density of the tested material, lb/ft³

NOTE 8—It may be desired to express the in-place density as a percentage of some other density, for example, the laboratory maximum density determined in accordance with Method D 698, Test for Moisture-Density Relations of Soils, Using a 5.5-lb (2.5-kg) Rammer and a 12-in. (304.8-mm) Drop.[3] This relation can be determined by dividing the in-place density by the maximum density and multiplying by 100.

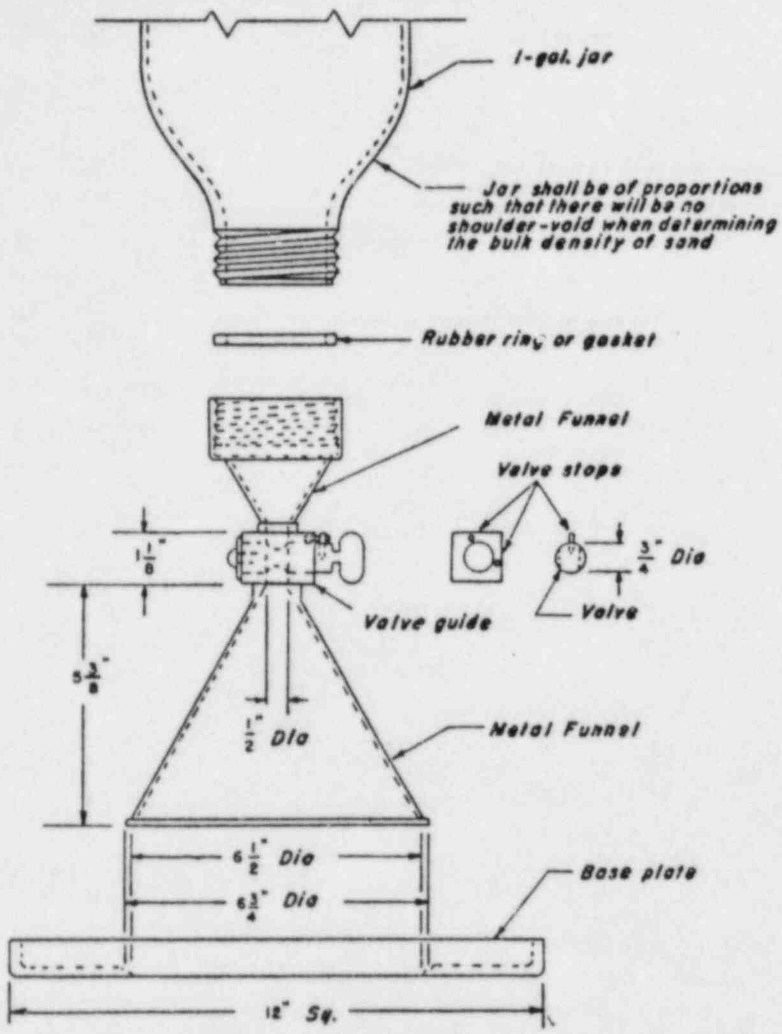
[3] *Annual Book of ASTM Standards*, Part 19.

TABLE 1 Minimum Test Hole Volumes and Minimum Moisture Content Samples Based on Maximum Size of Particle

Maximum Particle Size	Minimum Test Hole Volume, ft³	Minimum Moisture Content Sample, g
No. 4 Sieve (4.75 mm)	0.025	100
1/2 in. (12.5 mm)	0.050	250
1 in. (25 mm)	0.075	500
2 in. (50 mm)	0.100	1000

TABLE 2 Volume of Water per Gram Based on Temperature

Temperature		Volume of Water, ml/g
deg C	deg F	
12	53.6	1.00048
14	57.2	1.00073
16	60.8	1.00103
18	64.4	1.00138
20	68.0	1.00177
22	71.6	1.00221
24	75.2	1.00268
26	78.8	1.00320
28	82.4	1.00375
30	86.0	1.00435
32	89.6	1.00497



Metric Equivalents

in.	mm	in.	mm
½	12.7	6½	105.1
¾	19.1	6¾	171.5
1⅛	28.6	12	304.8
5⅜	136.5		

FIG. 1 Density Apparatus.

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, is entirely their own responsibility.

Designation: D 1557 – 7

Standard Methods o
MOISTURE-DEN
10-lb (4.5-kg) R
DROP[1]

This Standard is issued under the fixed designa year of original adoption or, in the case of revi last reapproval.

1. Scope

1.1 These methods cover the deter of the relationship between the mois tent and density of soils when comp mold of a given size with a 10-lb rammer dropped from a height of 1 mm). Four alternative procedures are as follows:

Method A—A 4-in. (102-mm) mold: soil material passing a No. 4 (4.75-mm) sieve
Method B—A 6-in. (152-mm) mold: soil material passing a No. 4 (4.75-mm) sieve
Method C—A 4-in. mold: soil material passing a ¾-in. (19-mm) sieve
Method D—A 6-in. mold: soil material passing a ¾-in. sieve

1.2 The method to be used shou dicated in the specification for the being tested. If no method is speci provisions of Method A shall govern

2. Apparatus

2.1 *Molds*—The molds shall be c in shape, made of metal, and shall capacity and dimensions indicated in 2.1.2. They shall have a detachab assembly approximately 2½ in. (63.5 height, to permit preparation of co specimens of soil - water mixture desired height and volume. The mold of the "split" type, consisting of t round sections or a section of pipe sp one element, which can be securely l place to form a cylinder as describe The molds may also be the "tape

:he average of th :rmina-
aximum variatio al.

: volume determined in this proce-
as long as the jar and attachment are
ative position. If the two are to be
1 marks should be made to permit
iis position.

ine the bulk density of the sand
he field test as follows (Notes 3

the empty apparatus upright on
rface, close the valve, and fill the
nd.

the valve and, keeping the funnel
full of sand, fill the apparatus.
: sharply and empty excess sand.
1 the apparatus with sand and
net weight of sand by subtract-
of the apparatus.

iration of the sand during any sand
determination may increase the bulk
and and decrease the accuracy of the
Appreciable time intervals between
determination of the sand and its use
result in change in the bulk density
hange in the moisture content or
ion.
is possible to determine the bulk
sand in other containers of known
nensionally approximate the largest
ll be dug. The general procedure used
3.4 for determining the volume of the
procedure is to be followed it shall be
t the resulting bulk density equals
ie jar determination.

iine the weight of sand required
nel as follows (Notes 5 and 6):
and in the apparatus and secure
apparatus and sand.
the inverted apparatus on a clean,
arface.
the valve and keep open until
l stops running.
: the valve sharply, weigh the
h remaining sand, and determine
id. This loss represents the weight
red to fill the funnel.
ace the sand removed in the fun-
tion and close the valve.

iis determination may be omitted if
given in Note 7 is followed. When the
ed it shall be considered a part of the

here test holes of maximum volume
is possible, after the bulk density
to settle the sand by vibration and
ight of sand in the apparatus. If this
followed, the total weight of sand
available shall be determined by reweighing.

3.4 Determine the density of the soil in place as follows:

3.4.1 Prepare the surface of the location to be tested so that it is a level plane.

3.4.2 Seat the inverted apparatus on the prepared plane surface and mark the outline of the funnel.

NOTE 7—In soils such that leveling is not successful a preliminary test shall be run at this point measuring the volume bounded by the funnel and ground surface. This step requires balances at the test site or emptying and refilling the apparatus. After this measurement is completed, carefully brush the sand from the prepared surface.

3.4.3 Dig the test hole inside the funnel mark, being very careful to avoid disturbing the soil that will bound the hole. Soils that are essentially granular require extreme care. Place all loosened soil in a container, being careful to avoid losing any material.

3.4.4 Seat the apparatus in the previously marked position, open the valve, and after the sand has stopped flowing, close the valve (Note 3).

3.4.5 Weigh the apparatus with remaining sand, and determine the weight of sand used in the test.

3.4.6 Weigh the material that was removed from the test hole.

3.4.7 Mix the material thoroughly and secure and weigh a representative sample for moisture determination.

3.4.8 Dry and weigh the moisture sample.

3.5 The minimum test hole volumes suggested in determining the in-place density of soil mixtures are given in Table 1. This table shows the suggested minimum weight of the moisture content sample in relation to the maximum particle size in soil mixtures.

4. Calculations

4.1 Calculate the volume of the density apparatus as follows:

$$V_1 = GT$$

where:

V_1 = volume of the density apparatus, ml,
G = water required to fill the apparatus, g,
T = water temperature-volume correction shown in column 3 of Table 2.

4.2 Calculate the bulk density of the sand as follows:

$$W_1 = 62.427\, W_2/V_1$$

wh.

W_1 = bulk density of the sand, lb/ft³
W_2 = sand required to fill the apparatus (3.2.3) g, and
V_1 = volume of apparatus, (4.1).

4.3 Calculate the moisture content and the dry weight of material removed from the test hole as follows:

$$w = [(W_3 - W_4)/W_4] \times 100$$

$$W_6 = 0.2205\, W_5/(w + 100)$$

where:

w = percentage of moisture, in material from test hole,
W_3 = moist weight of moisture sample, g,
W_4 = dry weight of moisture sample, g,
W_5 = moist weight of the material from the test hole, g, and
W_6 = dry weight of material from test hole, lb.

TABLE 1 Minimum Test Hole Volumes and Minimum Moisture Content Samples Based on Maximum Size of Particle

Maximum Particle Size	Minimum Test Hole Volume, ft³	Minimum Moisture Content Sample, g
No. 4 Sieve (4.75 mm)	0.025	100
½ in. (12.5 mm)	0.050	250
1 in. (25 mm)	0.075	500
2 in. (50 mm)	0.100	1000

4.4 Calculate the in-place dry of the material tested as follows:

$$V = (W_7 - W_8)/453.6\, W_1$$

$$W = W_6/V$$

where:

V = volume of test hole, ft,³
W_7 = sand used, g (3.4.5),
W_8 = sand in funnel (3.3.3) g, and
W = dry density of the tested material, lb/ft³

NOTE 8—It may be desired to express the in-place density as a percentage of some other density, for example, the laboratory maximum density determined in accordance with Method D 698, Test for Moisture-Density Relations of Soils, Using a 5.5-lb (2.5-kg) Rammer and a 12-in. (304.8-mm) Drop.[2] This relation can be determined by dividing the in-place density by the maximum density and multiplying by 100.

[2] *Annual Book of ASTM Standards*, Part 19.

TABLE 2 Volume of Water per Gram Based on Temperature

Temperature		Volume of Water, ml/g
deg C	deg F	
12	53.6	1.00048
14	57.2	1.00073
16	60.8	1.00103
18	64.4	1.00138
20	68.0	1.00177
22	71.6	1.00221
24	75.2	1.00268
26	78.8	1.00320
28	82.4	1.00375
30	86.0	1.00435
32	89.6	1.0045?

sed shall be the average of three determinations with a maximum variation of 3 ml.

NOTE 2—The vol[illegible]ermined in this procedure is constant as l[illegible] jar and attachment are the same relative [illegible]. If the two are to be separated match marks [illegible]uld be made to permit assembly to this position.

3.2 Determine the bulk density of the sand to be used in the field test as follows (Notes 3 and 4):

3.2.1 Place the empty apparatus upright on firm level surface, close the valve, and fill the funnel with sand.

3.2.2 Open the valve and, keeping the funnel at least half full of sand, fill the apparatus. Close the valve sharply and empty excess sand.

3.2.3 Weigh the apparatus with sand and determine the net weight of sand by subtracting the weight of the apparatus.

NOTE 3—Vibration of the sand during any sand weight-volume determination may increase the bulk density of the sand and decrease the accuracy of the determination. Appreciable time intervals between the bulk density determination of the sand and its use in the field may result in change in the bulk density caused by a change in the moisture content or effective gradation.

NOTE 4—It is possible to determine the bulk density of the sand in other containers of known volume that dimensionally approximate the largest test hole that will be dug. The general procedure used is that given in 3.4 for determining the volume of the test hole. If this procedure is to be followed it shall be determined that the resulting bulk density equals that given by the jar determination.

3.3 Determine the weight of sand required to fill the funnel as follows (Notes 5 and 6):

3.3.1 Put sand in the apparatus and secure the weight of apparatus and sand.

3.3.2 Seat the inverted apparatus on a clean, level, plane surface.

3.3.3 Open the valve and keep open until after the sand stops running.

3.3.4 Close the valve sharply, weigh the apparatus with remaining sand, and determine the loss of sand. This loss represents the weight of sand required to fill the funnel.

3.3.5 Replace the sand removed in the funnel determination and close the valve.

NOTE 5—This determination may be omitted if the procedure given in Note 7 is followed. When the base plate is used it shall be considered a part of the funnel.

NOTE 6—Where test holes of maximum volume are desired it is possible, after the bulk density determination, to settle the sand by vibration and increase the weight of sand in the apparatus. If this procedure is followed, the total weight of sand available shall be determined by reweighing.

3.4 Determine the density of the soil in place as follows:

3.4.1 Prepare the surface of the location to be tested so that it is a level plane.

3.4.2 Seat the inverted apparatus on the prepared plane surface and mark the outline of the funnel.

NOTE 7—In soils such that leveling is not successful a preliminary test shall be run at this point measuring the volume bounded by the funnel and ground surface. This step requires balances at the test site or emptying and refilling the apparatus. After this measurement is completed, carefully brush the sand from the prepared surface.

3.4.3 Dig the test hole inside the funnel mark, being very careful to avoid disturbing the soil that will bound the hole. Soils that are essentially granular require extreme care. Place all loosened soil in a container, being careful to avoid losing any material.

3.4.4 Seat the apparatus in the previously marked position, open the valve, and after the sand has stopped flowing, close the valve (Note 3).

3.4.5 Weigh the apparatus with remaining sand, and determine the weight of sand used in the test.

3.4.6 Weigh the material that was removed from the test hole.

3.4.7 Mix the material thoroughly and secure and weigh a representative sample for moisture determination.

3.4.8 Dry and weigh the moisture sample.

3.5 The minimum test hole volumes suggested in determining the in-place density of soil mixtures are given in Table 1. This table shows the suggested minimum weight of the moisture content sample in relation to the maximum particle size in soil mixtures.

4. Calculations

4.1 Calculate the volume of the density apparatus as follows:

$$V_1 = GT$$

where:

V_1 = volume of the density apparatus, ml,
G = water required to fill the apparatus, g,
T = water temperature-volume correction shown in column 3 of Table 2.

4.2 Calculate the bulk density of the sand as follows:

$$W_1 = 62.427\ W_2/V_1$$

where:

W_1 = bulk density of the sand, lb/ft³
W_2 = sand required to fill the apparatus (3.2.3) g, and
V_1 = volume of apparatus, (4.1).

4.3 Calculate the moisture content and the dry weight of material removed from the test hole as follows:

$$w = [(W_3 - W_4)/W_4] \times 100$$
$$W_6 = 0.2205\ W_5/(w + 100)$$

where:

w = percentage of moisture, in material from test hole.
W_3 = moist weight of moisture sample, g,
W_4 = dry weight of moisture sample, g,
W_5 = moist weight of the material from the test hole, g, and
W_6 = dry weight of material from test hole, lb.

TABLE 1 Minimum Test Hole Volumes and Minimum Moisture Content Samples Based on Maximum Size of Particle

Maximum Particle Size	Minimum Test Hole Volume, ft³	Minimum Moisture Content Sample, g
No. 4 Sieve (4.75 mm)	0.025	100
½ in. (12.5 mm)	0.050	250
1 in. (25 mm)	0.075	500
2 in. (50 mm)	0.100	1000

4.4 Calculate the in-place dry density of material tested as follows:

$$V = (W_7 \quad [illegible] \quad 453.6\ W_1$$
$$W \quad [illegible]$$

where:

V = volume of test hole, ft,³
W_7 = sand used, g (3.4.5),
W_8 = sand in funnel (3.3.3) g, and
W = dry density of the tested material, lb/f[illegible]

NOTE 8—It may be desired to express the in-place density as a percentage of some other density, for example, the laboratory maximum density determined in accordance with Method D 698, Te[illegible] for Moisture-Density Relations of Soils, Using a 5.[illegible] lb (2.5-kg) Rammer and a 12-in. (304.8-mm) Drop[illegible] This relation can be determined by dividing the in-place density by the maximum density and multiplying by 100.

---

[3] *Annual Book of ASTM Standards*, Part 19.

TABLE 2 Volume of Water per Gram Based on Temperature

Temperature		Volume of Water, ml/g
deg C	deg F	
12	53.6	1.00048
14	57.2	1.00073
16	60.8	1.00103
18	64.4	1.00138
20	68.0	1.00177
22	71.6	1.00221
24	75.2	1.00268
26	78.8	1.00320
28	82.4	1.00375
30	86.0	1.00435
32	89.6	1.00497

Mc

Atd 7eb 3-69
Cover letter filed in Gen. Information Binder

AMENDMENT 1

1 SOILS

1.1 INTRODUCTION

This Amendment presents the summarized results of studies of the foundation investigation phase of the environmental study at the proposed Midland nuclear power plant together with the report entitled "Foundation Investigation and Preliminary Exploration for Borrow Materials." The proposed location is adjacent to plant facilities of Dow on the western shore of the Tittabawassee River in Midland, Michigan. The soils overlying bedrock are of glacial origin and consist of glacial tills, glacial outwash, and glacial lake deposits.

A total of 55 borings have been made to determine the subsurface soil profile, to evaluate the foundation soil bearing capacity and settlement characteristics, and to substantiate that suitable fill materials are available within the proposed cooling water reservoir area.

The results of these investigations indicate that the foundation soils are satisfactory to support the plant loads.

1.2 SUBSURFACE EXPLORATION

The exploration program to date has consisted of 55 borings in the plant area and the cooling pond area, as shown in Section 2.6, on Figure 2-8, Location of Field Investigations.

The program indicated that in the plant area the site is blanketed by a layer of topsoil containing roots and other organic material which range in thickness from 4 to 8 inches, except in marshy areas where 2 to 3 feet of organic silty soils are present.

Underlying these soils are loose to dense sandy soils which range in depth from 0 to 40 feet. These sandy soils are underlain by very stiff to hard cohesive soils, predominantly gray silty clay, which extend to depths of 30 to 60 feet. These cohesive soils contain numerous silt lenses.

The deeper soils consist of uniformly hard cohesive soils, predominantly brownish-gray silty clay, containing some sand and gravel to a depth of about 140 to 200 feet. Below these deep cohesive soils is very dense and clayey, sandy gravel down to bedrock. A portion of this layer consists of very dense poorly graded sand at depths extending from 240 to 360 feet below ground surface.

In the cooling pond area, most of the area is blanketed by sandy soils which range in depth from 2 to 9 feet below ground surface. In two localized areas, 1 to 7 feet of silty surface soils were encountered. These sandy and silty soils are underlain by firm cohesive soils. All of these materials should be considered suitable for construction of the plant and dike fills.

1.3 LABORATORY TESTS

The laboratory test program consisted of direct shear, unconfined compression, triaxial compression, dynamic triaxial compression, and consolidation tests on selected undisturbed soil samples from the plant area; plus moisture-density tests in conjunction with each strength and consolidation test and on other undisturbed samples; compaction and permeability tests on remolded soil samples from the proposed cooling pond area, particle size distribution of selected granular soils in the reservoir area; rock compression tests on the shale bedrock; and Atterberg limits on selected samples from both areas.

From these tests, the allowable design values for bearing and settlement in the plant area, the sources of fill material, the estimated settlements in the hard cohesive soils in the plant area caused under maximum earthquake loading, and earthwork required in the plant area were determined.

1.4 DESIGN CRITERIA

1.4.1 FILL AND BACKFILL

All fill and backfill materials are adequately compacted to insure stability of the fill and to provide adequate support for structures founded on this fill without excessive settlements.

1.4.2 EXCAVATION SLOPES

Banks of deeper excavations cut through the dewatered sandy surface soils are cut on a slope of 1 vertical to 1-1/4 horizontal, and banks of deeper excavations cut through the cohesive soils are cut on a slope of 2 vertical to 1 horizontal. Temporary shallow excavations in cohesive soils are cut vertically. All of the above slopes apply to the controlled compacted fill as well as to the natural in-place soils.

1.4.3 FOUNDATION DESIGN

The reactor buildings and auxiliary building are at elevations such that foundations are established on the stiff to hard cohesive soils which underlie the site. Within this material and extending from a depth of 240 to 360 feet below ground surface is a layer of very dense granular material with Standard Penetration Test blow counts of the order of 200 blows or greater per 6-inch penetration. These soils are considered to provide excellent foundation support without excessive settlement under both static and dynamic conditions of loading. These structures are founded on earth-supported mat foundations.

The turbine building, which has its base at approximately elevation 604, does not encounter very stiff to hard cohesive soils at all locations due to the presence of sand-filled erosion channels in the surface of the clay layer. The natural soils at this elevation are beach sands of variable thickness which may not provide suitable foundation support. Consequently, these soils will be removed and foundation grade attained by the placement of controlled compacted fill. Foundation grade is attained using either granular or cohesive fill materials. The turbine building is supported on a mat foundation on the controlled compacted fill.

The allowable bearing pressures for the mat foundations are summarized below:

Structure	Supporting Soils	Foundation Elevation (Feet)	Allowable Bearing Pressure (psf): Dead + Live Load (FS = 3.0)	Allowable Bearing Pressure (psf): Dead, Live & Seismic Loads (FS = 2.0)
Reactor Building	Very Stiff to Hard Natural Cohesive Soils	576	16,500	25,000
Auxiliary Building	Very Stiff to Hard Natural Cohesive Soils	577	21,500	32,500
Turbine Building	Controlled Compacted Fill	604	10,000	15,000
Turbine Generator Pedestal	Controlled Compacted Fill	598	10,000	15,000

Shallow spread foundations established in the controlled compacted fill for the support of appurtenant structures are at a minimum depth of 4-1/2 feet below the adjacent plant grade to prevent the effects of frost action. The allowable bearing pressures for spread foundations founded on controlled compacted fill are tabulated below:

Supporting Soils	Minimum Foundation Depth (Feet)	Allowable Bearing Pressure (psf): Dead + Live Load (FS = 3.0)	Allowable Bearing Pressure (psf): Dead, Live & Seismic Loads (FS = 2.0)
Controlled Compacted Cohesive Fill	4.5	8,000	12,000
Controlled Compacted Granular Fill:			
Foundation Width = 2 Ft	4.5	3,000	4,500
Foundation Width = 4 Ft	4.5	[illegible],000	6,000
Foundation Width = 8 Ft	4.5	[illegible],000	7,500
Foundation Width = 12 Ft	4.5	[illegible],000	9,000

1.4.4 SETTLEMENT

The maximum total and differential settlements are estimated based on consolidation tests. The estimated settlements include the effects of lowering the groundwater level, excavating, placement of plant fill to elevation 628, and the imposed structural loads. The results of these analyses are tabulated below:

Unit	Estimated Maximum Settlement (Inches)	Estimated Maximum Differential Settlement (Inches)
Reactor Building	1 to 1-1/2	1/4 to 1/2
Turbine Building	1 to 1-1/2	1/4 to 1/2
Auxiliary Building	0 to 1/2	0 to 1/4

It has been further estimated that the maximum differential settlement which could occur between adjacent structures will be as follows:

Adjacent Units	Estimated Maximum Differential Settlement (Inches)
Auxiliary Building and Reactor Buildings	1
Auxiliary Building and Turbine Building	1
Reactor Buildings and Turbine Building	1/2

Earthquake loading of short duration should not cause additional settlement of appreciable magnitude. The estimated additional settlements under earthquake loading are less than 1/4 inch.

Although detailed settlement analyses are not performed to evaluate settlements of shallow spread footings established in the compacted plant fill, it is estimated that settlements will be on the order of 1/2 inch or less provided that the allowable bearing pressures are not exceeded and the fill is adequately compacted.

1.4.5 LATERAL PRESSURE

The walls of structures below final plant grade, elevation 628, are subjected to horizontal loads imposed by backfill materials, possible hydrostatic pressures during floods, and the horizontal components of adjacent foundation loads. In the design of rigid walls to resist the horizontal loads imposed by a granular backfill, submerged during flood periods, the submerged granular backfill is considered to act as an equivalent fluid with a density of 100 pounds per cubic foot. For continuously drained granular backfill, an equivalent fluid pressure of 64 pounds per cubic foot is used. Cohesive materials are not used as backfill against the walls of structures.

1.4.6 FILL MATERIAL

Fills up to approximately 25 feet in thickness are used in the attainment of the proposed final grade of 628 feet. Sources of possible fill material are available from the plant excavation consisting of sandy surface soils and underlying clay soils; from borrow sources within the proposed reservoir area consisting of dune sand deposits, sandy surface soils, and underlying clay and silt soils; and from off-site sources. All of these materials are suitable for use in construction of the plant fills.

EARTH SCIENCES

DAMES & MOORE

CONSULTING ENGINEERS IN THE APPLIED EARTH SCIENCES

ATLANTA NEW YORK
CHICAGO PORTLAND
HONOLULU SALT LAKE CITY
HOUSTON SAN FRANCISCO
LOS ANGELES SEATTLE
WASHINGTON D.C.
MADRID, SPAIN TEHRAN, IRAN
HALIFAX TORONTO
SAINT JOHN, NEW BRUNSWICK

309 WEST JACKSON BOULEVARD · CHICAGO, ILLINOIS 60606 · 312-922-1772

PARTNERS: JAMES B. THOMPSON · GEORGE D. LEAL

ASSOCIATE: WILLIAM G. PARATORE

June 28, 1968

Bechtel Corporation
220 Bush Street
San Francisco, California 94119

Attention: Mr. J. H. Blasingame,
Project Engineer

Gentlemen:

Twelve copies of our "Report, Foundation Investigation and Preliminary Explorations for Borrow Materials, Proposed Nuclear Power Plant, Midland, Michigan for Consumers Power Company" are herewith submitted.

The scope of our investigation was planned in collaboration with Messrs. Flach, Martinez, Currier and Ferris of the Bechtel Corporation. The requirements of our foundation investigation were outlined in Bechtel Corporation's "Specification Number 7220-C-1 Revision 0, Preliminary, dated 6-10-68, entitled Midland Plant Consumers Power Company, Job 7220, Soils Investigation and Testing Requirements, Technical Provisions". A layout of the proposed plant facilities and sections through the proposed power plant were provided to us on Bechtel Corporation Drawings Numbers SK-7220-C-1, Revision 2, SK-7220-C-2, Revision 2, and SK-7220-C-26, Revision 0 by Mr. Blasingame of the Bechtel Corporation.

It is our opinion that the site is suitable, from a foundation standpoint, for the support of the proposed structures, under both static and seismic loading. The subsurface conditions at the proposed locations of Units 1 and 2 are essentially the same and it is considered that both units may be supported on mat foundations. Detailed design data and recommendations pertaining to foundations for the proposed nuclear power plant and appurtenant facilities are presented in this report.

Based on a preliminary subsurface investigation of the Proposed Cooling Water Reservoir Areas, it is our opinion that there is an ample supply of cohesive soils which are suitable for use in the construction of fills. An estimate of the actual quantities of the various materials available are beyond the scope of our investigation.

We would be pleased to answer any questions that you may have regarding the contents of this report.

Yours very truly,

DAMES & MOORE

George D Leal

George D. Leal

GDL:EFG:mf

REPORT

FOUNDATION INVESTIGATION

AND

PRELIMINARY EXPLORATIONS FOR BORROW MATERIALS

PROPOSED NUCLEAR POWER PLANT

MIDLAND, MICHIGAN

FOR

CONSUMERS POWER COMPANY

INTRODUCTION

This report presents the results of our foundation investigation and preliminary explorations for borrow materials at the site of the Proposed Nuclear Power Plant to be constructed in Midland, Michigan for Consumers Power Company. The site is located adjacent to plant facilities of the Dow Chemical Company. The location of the site is shown with respect to certain topographic features on Plate 1, Vicinity Map. The relative locations of the proposed power plant and reservoir facilities are shown with respect to the Tittabawassee River on Plate 2, Site Plan.

SCOPE

The primary purpose of the foundation investigation was to develop sufficient data to permit design to proceed with the assurance that allowable foundation bearing pressures will not be exceeded and that foundation settlements would be within acceptable limits. With respect to the cooling water reservoirs, it was intended that preliminary explorations and testing would be performed to substantiate that suitable fill materials are available within the proposed cooling water reservoir areas. An exhaustive study of the types and quantities of materials available for use as fill was beyond the scope of this study.

The specific program discussed and agreed upon for investigating the site at this time consisted of the drilling and sampling of test borings, the performance of appropriate laboratory tests, and engineering analyses and report preparation.

This report provides the following specific information resulting from our explorations, testing and engineering analyses.

1 - Description of the site.

2 - Soil boring logs and subsurface profiles.

3 - Results of laboratory tests.

4 - Foundation design criteria including the following:

a - Allowable bearing pressures for shallow spread foundations established on the compacted plant fill.

b - Lateral earth pressures against structure walls.

c - Recommended foundation type and estimated settlements for the reactor containment structures.

d - Recommended foundation type and estimated settlements for the turbine building.

e - Recommended foundation type and estimated settlements for the radwaste building.

f - Differential settlement between adjacent structures.

g - Recommended excavation slopes in natural soils and in plant fill.

h - Control of ground water in excavations for the reactor and turbine building.

i - Compaction requirements for the plant fill (i) beneath structures, and (ii) adjacent to the structures.

j - Minimum depth of foundations in compacted soil for frost protection or other reasons.

k - Liquefaction potential of soils at the site.

The results of our field explorations and laboratory tests, which form the basis of our recommendations, are presented in the Appendix of this report.

DESIGN CONSIDERATIONS

We understand that the Proposed Nuclear Power Plant will consist of two reactor containment buildings, a turbine building, a radwaste building certain appurtenant structures, and adjacent cooling water reservoirs. The locations of the power plant and reservoirs are shown on Plate 2. The arrangement of the proposed power plant structure is shown on Plate 3, Plot Plan.

The reactor containment buildings will be tall structures, approximately 130 feet in diameter, with their base at elevation 574. Reactor foundations will impose a uniformly distributed gross pressure on the order of 8,000 pounds per square foot for normal conditions; a maximum gross pressure of approximately 16,000 pounds per square foot, and a minimum gross pressure of approximately zero pounds per square foot under maximum seismic loading.

The turbine building will be approximately 130 feet by 460 feet in plan dimensions, with its base at approximately elevation 604. Turbine building foundations will impose a uniformly distributed gross pressure of approximately 3,000 pounds per square foot for normal conditions; a maximum gross pressure of approximately 5,000 pounds per square foot, and a minimum gross pressure of approximately 1,000 pounds per square foot under maximum seismic loading.

The radwaste building will be located between the two reactor containment buildings. The radwaste building will be separated from the reactor containment structures to allow for possible differential settlement. We understand that the maximum allowable differential settlement between the radwaste building and the adjacent reactor containment building is one inch. 3/4"
The radwaste building will impose a uniformly distributed gross pressure on the order of 5,000 pounds per square foot for normal conditions; a maximum gross pressure of approximately 10,000 pounds per square foot, and a minimum gross pressure of approximately zero pounds per square foot under maximum seismic loading. The foundations for the radwaste building will be established at two elevations, elevation 558 and elevation 580.

The locations and foundation loading data relative to the appurtenant structures have not yet been provided to us.

The final plant grade will be established at approximately elevation 628. The normal ground water was assumed to be at the existing ground surface, approximately elevation 603. The maximum probable flood level has been established at elevation 632.

The bottom of the cooling water reservoirs will be established at approximately elevation 603. The top of the dikes will be established at approximately elevation 628 and the surface of the cooling water will be at approximately elevation 625. The effect of raising the water level to elevation 625 in the reservoirs will cause the normal ground water level in the general plant area to eventually rise to approximately elevation 625. However, a drainage system will be provided to maintain the ground water level in the plant fill at elevation 603.

A schedule of foundation loading during construction is presented on Plate 4, Foundation Loading Sequence.

SITE CONDITIONS

GEOLOGY:

A detailed geologic investigation of the site was beyond the scope of our present investigation. However, we have been provided with the results of geologic studies made by others.

We understand that the soils overlying the bedrock are of predominantly glacial origin and consist of glacial tills, glacial outwash and glacial lake deposits. The bedrock consists of sandstone and shale of the Saginaw Formation.

POWER PLANT AREA:

Surface Conditions - General surface topography in the vicinity of the plant area is shown on Plate 1. The elevation of the ground surface across the power plant site ranged from approximately elevation 604 to 612. Surface vegetation consists of grass, weeds and small trees. A gravel surfaced access road traverses the area. The ground surface along the access road and to the west of the access road is approximately three to five feet higher than the area east of the access road. We understand that the area east of the access road was utilized as a borrow area several years ago. An abandoned borrow pit, approximately ten feet in depth, is located northwest of the plant area.

The immediate plant area contains three shallow marshy areas. The approximate locations and lateral extent of the marshy areas are shown on Plate 3. The marshy areas occur in shallow depressions and contain approximately two to three feet of organic silty soils which pond surface runoff water.

Subsurface Conditions - The subsurface conditions in the plant area were investigated by drilling six exploration test borings to depths ranging from approximately 100 feet to 370 feet below the ground surface. The locations of the borings are shown on Plate 3. The test boring program revealed that the site is blanketed by a layer of topsoil containing roots and other organic material which ranges in thickness from approximately four to eight inches, except in the marshy areas described previously where two to three feet of organic silty soils are present. The topsoil and organic silty soils are underlain by moderately dense sandy soils which extend to depths ranging from approximately 1 to 25 feet.

The sandy soils are underlain by very stiff to hard cohesive soils, predominantly gray silty clay, which extend to depths ranging from approximately 35 feet to 58 feet. The cohesive soils contain numerous discontinuous silt lenses, which vary in orientation from horizontal to approximately 75 degrees with the horizontal. The silt lenses did not contain any free water at the time of our investigation, June 1968, and were in a dry powdery condition.

The deeper soils consist of an extensive underlying stratum of uniformly hard cohesive soils, predominantly brownish gray silty clay containing some sand and gravel. One of the borings, Boring 1, extended to a depth sufficient to penetrate the cohesive materials at a depth of 243 feet. At this depth, very dense sandy soils were encountered which extended to bedrock. The bedrock, black shale of the Saginaw Formation, was encountered at a depth of 358 feet and was cored from 360 to 370 feet

To assist in visualizing the subsurface conditions in the power plant area, two subsurface sections have been prepared and are presented on Plate 5A, Generalized Subsurface Section A-A and Plate 5B, Generalized Subsurface Section B-B. More detailed descriptions of the subsurface conditions are presented on the Log of Borings in the Appendix to this report

Surface Water - The site is subjected to periodic flooding. We understand that maximum probable flood level has been established at elevation 632 feet. A detailed study of surface water fluctuations was beyond the scope of this investigation.

Ground Water - Seepage water entered some of the borings through the sand stratum blanketing the site It is our opinion that this ground water does not necessarily represent the static ground water level at the site, but more probably represents a perched water condition resulting from surface runoff and flood conditions.

The present static ground water level in the cohesive overburden soils could not be determined during the short period of our field investigation. It is likely that the ground water level is at or near the normal surface of the Tittabawassee River. However, long term water level measu e-ments would be required to confirm this condition. For purposes of analysis, it has been conservatively estimated that the static ground water level is at or near the existing ground surface.

Movement of ground water through the cohesive soils underlying the sandy surface soils at the site is extremely slow due to the impervious nature of these materials. At present, the silty clay soils are saturated. The silt lenses within the silty clay soils are discontinuous, appear relatively dry and did not contain free ground water.

The granular soils below a depth of approximately 243 feet contain artesian ground water. Upon completion of Boring 1, water flowed from the boring at a rate of approximately one to two gallons per minute under a pressure of approximately 1.5 pounds per square inch measured at the ground surface.

Frost Penetration - We understand that the maximum depth of frost penetration measured in the vicinity of the site is four feet. Water lines are commonly provided with a minimum of five feet of cover to prevent freezing.

COOLING WATER RESERVOIR AREA:

Surface Conditions - The area slopes down from approximately elevation 625 in the southwest portion to 600 in the northeast portion and is predominantly farmland with some wooded sections. An extensive zone of sand dunes is located south of Gordonville Road. Other less extensive sand dunes are also present within the reservoir area.

Subsurface Conditions - The subsurface conditions were investigated by drilling nine borings to approximately elevation 598. The locations of the borings arr shown on Plate 6, Reservoir Plan. The borings are designated A, B, C, D, E, F, G, H and J. The borings ranged in depth from approximately eight feet to 27 feet below the ground surface. The results of this preliminary boring program reveal that the area is blanketed by a layer of sandy soils except at the locations of Borings C and F. The sandy soils extend to depths ranging from approximately two feet to nine feet below the ground surface. In Borings C and F, silty surface soils were encountered which extend to depths of seven feet and one foot, respectively. The sandy soils and silty soils are underlain by firm cohesive soils to the depths penetrated except at the locations of Borings G and H. Borings G and H terminated in sandy soils.

More detailed descriptions of the soils encountered in the borings are presented on the Log of Borings in the Appendix to this report.

Ground Water - Seepage water entered some of the borings through the sandy surface soils at the depths noted on the Log of Borings.

LABORATORY TESTS

STATIC TESTS:

The results of the laboratory tests performed under static conditions, together with a description of the test procedures, are presented in the Appendix to this report.

A summary of laboratory strength tests, moisture and density tests performed on soil samples extracted from borings drilled in the power plant area are presented on Plate 7, Summary of Test Data.

DYNAMIC TESTS:

The properties of the very stiff to hard cohesive soils were investigated under dynamic loading conditions by performing dynamic triaxial compression tests. Based on the results of these tests, it is our opinion that the strength and compressibility characteristics of the very stiff to hard cohesive soils will not be significantly affected during the application of repetitive dynamic loads within the stress range pertinent to this project. Stress-strain relationships developed during the tests have been utilized to estimate settlements under a maximum earthquake loading. The results of settlement analyses are described in a subsequent section of this report.

LIQUEFACTION POTENTIAL

It is considered that the relatively shallow sand stratum blanketing the site (maximum depth of 25 feet in Boring 5) could possibly be subject to liquefaction under maximum seismic loading. This conclusion is preliminary and has not been substantiated by detailed laboratory testing. On this basis, it is recommended that the sand be removed to the surface of the firm cohesive soils. If replaced as fill, the sand should be compacted to 100 percent of the maximum density as determined by ASTM Compaction Test Designation D 1557-66T. Alternately, cohesive soils may be used as fill if compacted to 95 percent of maximum density.

If subsequent more detailed explorations should disclose that the sand deposits are more extensive than presently anticipated and that complete removal is uneconomical, detailed laboratory testing can be undertaken to more accurately define the in-place density and liquefaction potential of the material. A program of this type could possibly substantiate that somewhat less than complete removal of these materials would be adequate.

The stratum of granular soils below a depth of approximately 240 feet is highly confined and exhibits high densities as determined by laboratory testing and resistance to standard penetration sampling. It is our opinion that these granular soils could not liquefy under any anticipated seismic loading at this site.

DISCUSSION AND RECOMMENDATIONS

GENERAL:

It is our opinion that the site is suitable from a foundation standpoint, for the support of the proposed structures under both static and dynamic loading. It is recommended that the proposed structures be supported on spread and mat foundations in accordance with the recommendations presented in a subsequent section, FOUNDATION DESIGN DATA.

Analyses have been performed to estimate settlement of the proposed structures and the differential settlements which will occur between adjoining structures. The results of the settlement analyses are presented in a subsection, SETTLEMENT.

Preliminary data pertaining to the borrow materials available within the proposed cooling water reservoir areas are presented in the concluding section of this report. The operations associated with site preparation and the earthwork operations required in the attainment of the planned grades within the plant area are discussed in the following sections.

SITE PREPARATION:

Due to the nature of the sandy surface soils, it is recommended that all construction roads, and temporary parking and storage areas be surfaced with a layer of coarse granular material ranging from 6 to 12 inches in compacted thickness. The actual thickness of the coarse granular layer will depend upon the type and frequency of the vehicular traffic.

EARTHWORK:

Clearing, stripping, dewatering, excavating, filling, and backfilling operations will be required in the attainment of the planned grades.

Clearing - It is recommended that all trees and brush, including the major root systems, be removed from the plant area.

Stripping - It is recommended that the topsoil containing roots and other organic material be stripped from all areas to be occupied by structures, pavements, dikes, and reservoirs. It is estimated that the average depth of stripping required will be on the order of six inches, except in marshy areas where up to two to three feet of organic soils are present and should be removed. The stripped soils are not considered suitable for use as fill or backfill.

Dewatering - Dewatering operations will be required in the vicinity of the power plant to control water seepage from the sandy surface soils. It is considered that the amount of this seepage will decrease with time. Only minor water seepage is anticipated through the relatively impervious clay soils underlaying the sandy surface soils.

In order to prevent seepage water from accumulating in the excavation, it is recommended that ground water in the upper sandy soils be controlled either by a well-point system or by a system of peripheral trenches located both inside and outside the excavation. Outside the excavation, a feasible type of perimeter drainage installation would consist of a peripheral trench extending through the sandy soils. The trench should be backfilled with clean gravel or similar pervious material. The trench should be graded to drain away from the plant site. Interception of surface and subsurface ground waters by the peripheral trench will serve to prevent appreciable recharge of ground water into the excavation. Inside the excavation, it is considered that ground water seepage can be adequately controlled by installing shallow peripheral trenches and pumping from sumps.

As an alternate to the above, particularly in areas where the sandy soils are greater than six to eight feet in depth, it may be more economical to install a well-point system to control ground water seepage in the upper sandy soils. In our explorations, sandy soils greater than eight feet in depth were encountered only in Boring 5. However, more extensive shallow explorations will be necessary to properly define the depths of sandy soils around the proposed excavation.

As indicated above, the most essential aspect of dewatering is control of water in the upper sandy soils. Very little seepage into excavations is anticipated through the underlying cohesive soils.

Excavating - Excavation operations will be required in the attainment of the planned grades and for the installation of foundations. The maximum depth of the excavations will be on the order of 30 feet below the existing ground surface for the reactor structures, and on the order of 45 feet below existing ground surface for the radwaste building.

It is recommended that all loose material and water be removed from the bottom of excavations and that the exposed soils be rolled to thoroughly compact soils disturbed by the excavating operations.

Since the cohesive soils are susceptible to loss of strength due to disturbance or the presence of water, it is recommended that a mat of lean concrete be poured, or that other means of protecting the exposed surface of the excavations be provided immediately upon completion of each excavation. The provision of a lean concrete "mud-mat" or similar protection should prevent water from infiltrating into, softening, and disturbing the bearing soils during construction.

It is recommended that banks of excavations through the dewatered sandy surface soils be cut on a slope of one vertical to one and one-quarter horizontal. It is further recommended that the banks of deeper excavations cut through the cohesive soils be cut on a slope of two vertical to one horizontal. Temporary shallow excavations in the cohesive soils which have an unsupported height of 15 feet or less may be cut vertically. It is anticipated that localized sloughing and spalling of the banks of excavations will occur due to drying and shrinking of the banks and also due to the presence of discontinuous lenses and pockets of silt in the cohesive soils.

Sources of Fill Material - Fills up to approximately 25 feet in thickness will be required in the attainment of the proposed final grade of 628 feet. In addition, fills and backfills will be required below and adjacent to structures. Sources of possible fill material are essentially the following:

1 - Materials removed from the plant excavation. These materials will consist of:

a) sandy surface soils, and

b) underlying clay soils.

2 - Materials available from borrow sources within the proposed reservoir area. These materials will consist of:

a) sands present in dune deposits,

b) other sandy surface soils, and

c) underlying clay and silt soils.

3 - Materials imported from off-site sources.

All of the materials mentioned above should be considered suitable for use in the construction of the plant fills. However, it is recommended that preference be given to placement of granular materials in the plant area, if possible, due to the relative ease of compacting these materials. Granular materials can generally be placed and compacted properly under a range of moisture conditions using a variety of compaction equipment. Cohesive clay soils can generally not be placed during periods of wet or freezing weather. In addition, clay soils would be difficult to place in restricted backfill areas because heavy compaction equipment would be required to break-up and compact hard chunk-size pieces that would be removed from on-site excavations.

Filling and Backfilling - It is recommended that fill and backfill materials be placed at or near the optimum moisture content in lifts approximately six to eight inches in loose thickness and that each lift be compacted in accordance with the following criteria:

	RECOMMENDED MINIMUM COMPACTION CRITERIA PERCENT OF MAXIMUM DENSITY*	
PURPOSE OF FILL	ON-SITE COHESIVE SOILS	ON-SITE GRANULAR SOILS
Support of Critical Structures	95	100
Support of Non-Critical Structures	90	95
Adjacent to Structures	90	95

* Maximum density and optimum moisture content should be determined by the ASTM Test Designation D 1557-66T.

Slopes of excavations cut into compacted fill materials should be the same as the recommended slopes provided for excavations into natural soils.

FOUNDATION DESIGN DATA:

General - The reactor containment vessels and the radwaste building will be at elevations such that foundations can be established on the very stiff to hard cohesive soils which underlie the site. These soils will provide excellent foundation support without excessive settlement under both static and dynamic conditions. It is recommended that these structures be established on earth-supported mat foundations.

The turbine building, which will have its base at approximately elevation 604, will not encounter very stiff to hard cohesive soils at all locations. The natural soils at this elevation are sandy soils of variable thickness. It is recommended that these sandy soils be completely removed, that the surface of the underlying clay be exposed, and that foundation grade be attained by the placement of controlled compacted fill soils. The necessity for complete removal of the sandy soils is discussed in a previous section, LIQUEFACTION POTENTIAL. Foundation grade may be attained utilizing either granular or cohesive fill materials; compaction of these fill materials should be in accordance with the recommendations of the EARTHWORK section of this report. It is recommended that the turbine building be supported on a mat foundation established on the controlled compacted fill soils.

We understand that appurtenant facilities will be supported on spread foundations established in the plant fill. Recommended design data for spread foundations is presented in a subsequent section.

Mat Foundations - We have evaluated the ultimate bearing capacity of the supporting materials which will underlie the major units of the Proposed Nuclear Power Plant on a conservative basis. It is our opinion that the following ultimate bearing capacities can be developed for mat foundations established at the approximate elevations tabulated below:

UNIT	SUPPORTING SOILS	FOUNDATION ELEVATION FEET	ULTIMATE BEARING CAPACITY LBS./SQ.FT.
Reactor Containment Building	Very stiff to hard natural cohesive soils	574	50,000
Radwaste Building	Very stiff to hard natural cohesive soils	580 558	50,000 65,000
Turbine Building	Controlled Compacted Fill*	604	30,000

* Assuming that suitable fill materials are placed and compacted in accordance with the recommendations presented in the EARTHWORK section of this report. Bearing value computation is based on the use of compacted cohesive soils and is conservative in the event that granular soils are used.

The ultimate bearing pressure values tabulated above are gross values and consider the effect of overburden to the surface of the completed plant fill at elevation 628.

The above bearing capacities are ultimate values and suitable factors of safety should be applied. It is our opinion that a minimum factor of safety of three is appropriate for dead loads and frequently applied live loads. We consider that a minimum factor of safety on the order of two is satisfactory for dead, live and seismic loads. The following tabulation presents a summary of the factors of safety which are indicated for the various units which will be supported on mat foundations.

UNIT	DEAD PLUS LIVE LOAD: BEARING PRESSURE LBS./SQ.FT.	DEAD PLUS LIVE LOAD: INDICATED FACTOR OF SAFETY	DEAD, LIVE AND SEISMIC LOAD: MAXIMUM BEARING PRESSURE, LBS./SQ.FT.	DEAD, LIVE AND SEISMIC LOAD: INDICATED FACTOR OF SAFETY
Reactor Containment Buildings	8,000	6.2	16,000	3.1
Radwaste Building				
@ Elevation 580	5,000	10.0	10,000	5.0
@ Elevation 558	5,000	13.0	10,000	6.0
Turbine Building	3,000	10.0	5,000	6.0

Shallow Spread Foundations - We understand that shallow spread foundations established in a controlled compacted fill will be utilized for the support of the appurtenant structures. It is recommended that the foundations be established at a minimum depth of four and one-half feet below the adjacent plant grade to prevent the effect of frost action.

Provided the fill is placed in accordance with the recommendations provided in the EARTHWORK section of this report, spread foundations may be proportioned utilizing the bearing pressures tabulated below. The recommended bearing pressures contain a factor of safety on the order of three and pertain to all design loads, excluding seismic loads. For seismic loads, the recommended net bearing pressures may be increased by 50 percent.

Consolidation tests and detailed settlement analyses were not performed for the purpose of evaluating settlements of shallow spread foundations established in the plant fill. However, it is estimated that shallow spread foundations supporting a total design load of up to 200,000 pounds and proportioned utilizing the bearing pressures presented in the following table will undergo settlement on the order of one-half inch or less.

SUPPORTING SOILS	MINIMUM FOUNDATION DEPTH FEET	ALLOWABLE NET BEARING PRESSURE LBS./SQ.FT.
Controlled Compacted Cohesive Fill	4.5	8,000
Controlled Compacted Granular Fill		
Foundation Width = 2 Feet	4.5	3,000
Foundation Width = 4 Feet	4.5	4,000
Foundation Width = 8 Feet	4.5	5,000
Foundation Width = 12 Feet	4.5	6,000

A higher bearing value may be used for foundations established deeper than 4.5 feet. The tabulated bearing pressures were computed assuming the water level to be at elevation 603 and assuming that foundations are at a relatively shallow depth below elevation 628.

The recommended bearing pressures are net values; therefore, the weight of the foundations and the weight of backfill over the foundations may be neglected in proportioning the foundations.

SETTLEMENT:

Our settlement analyses are based on the results of consolidation tests which indicate that the glacial soils at the site have been preconsolidated under overburden pressures of at least 15,000 to 20,000 pounds per square foot. Data relative to the performance of the consolidation tests are presented in the Appendix.

Based on the results of the consolidation tests, we have estimated settlements and differential settlements of the proposed structures. These settlements include the effects of lowering the ground water level, excavating, placement of plant fill to elevation 628 and the imposed structural loads, including the influence of adjacent structural loads. The approximate scheduling and sequence of the application of these various loading increments is summarized graphically on Plate 4.

The results of our settlement analyses are tabulated below:

UNIT	ESTIMATED MAXIMUM SETTLEMENT INCHES	ESTIMATED MAXIMUM DIFFERENTIAL SETTLEMENT INCHES
Reactor Containment Building	1 to 1½	1/4 to 1/2
Turbine Building	1 to 1½	1/4 to 1/2
Radwaste Building	0 to 1/2	0 to 1/4

It has been further estimated that the maximum differential settlement which will occur between adjacent structures will be as follows:

ADJACENT UNITS	ESTIMATED MAXIMUM DIFFERENTIAL SETTLEMENT INCHES
Radwaste Building and Reactor Containment Buildings	1
Radwaste Building and Turbine Building	1
Reactor Containment Buildings and Turbine Building	1/2

Earthquake loading of short duration should not cause additional settlement of appreciable magnitude. The effects of earthquakes were evaluated by dynamic laboratory tests. Utilizing an approximate value of 3,000,000 pounds per square foot for dynamic modulus of elasticity, we estimate that additional settlements under earthquake loading will be less than one-quarter inch.

LATERAL PRESSURES:

The walls of the structures below final plant grade, elevation 628, will be subjected to horizontal loads imposed by backfill materials, possible hydrostatic pressures during floods, and the horizontal components of adjacent foundation loads. In the design of rigid walls to resist the horizontal loads imposed by a granular backfill, submerged during flood periods, it is recommended that the submerged granular backfill be considered to act as an equivalent fluid with a density of 100 pounds per cubic foot. For a continuously drained granular backfill, an equivalent fluid pressure of 64 pounds per cubic foot is recommended.

The utilization of cohesive backfill is not recommended. However, if it is desired to utilize cohesive backfill, we would be pleased to provide the lateral pressures which would be developed.

The horizontal components of foundation loads which will act against walls can be calculated, if desired, at such time as the magnitude and locations of the loads are provided to us.

UPLIFT PRESSURES:

A consideration of uplift pressures which could develop beneath floor slabs and mat foundations, particularly during flood conditions, should be evaluated.

FLOOR SLABS:

It is recommended that all floor slabs which are not underlain by a lean concrete mud mat, be underlain by a layer of thoroughly compacted granular fill at least six inches in compacted thickness.

COOLING WATER RESERVOIRS:

A preliminary investigation of the cooling water reservoir areas was undertaken to identify the types of materials available for use as fill materials and to develop certain criteria relative to their compaction, strength and permeability characteristics. The results of the Atterberg limits performed are presented on the Log of Borings in the Appendix. The results of the compaction, strength and permeability tests are presented in the Appendix on Plate A-9, Compaction Test Data.

--o0o--

The following Plates and Appendix are attached and complete this report:

Plate 1 - Vicinity Map

Plate 2 - Site Plan (Reservoir and Power Plant Areas)

Plate 3 - Plot Plan (Power Plant Area)

Plate 4 - Foundation Loading Sequence

Plate 5A - Generalized Subsurface Section A-A

Plate 5B - Generalized Subsurface Section B-B

Plate 6 - Reservoir Plan

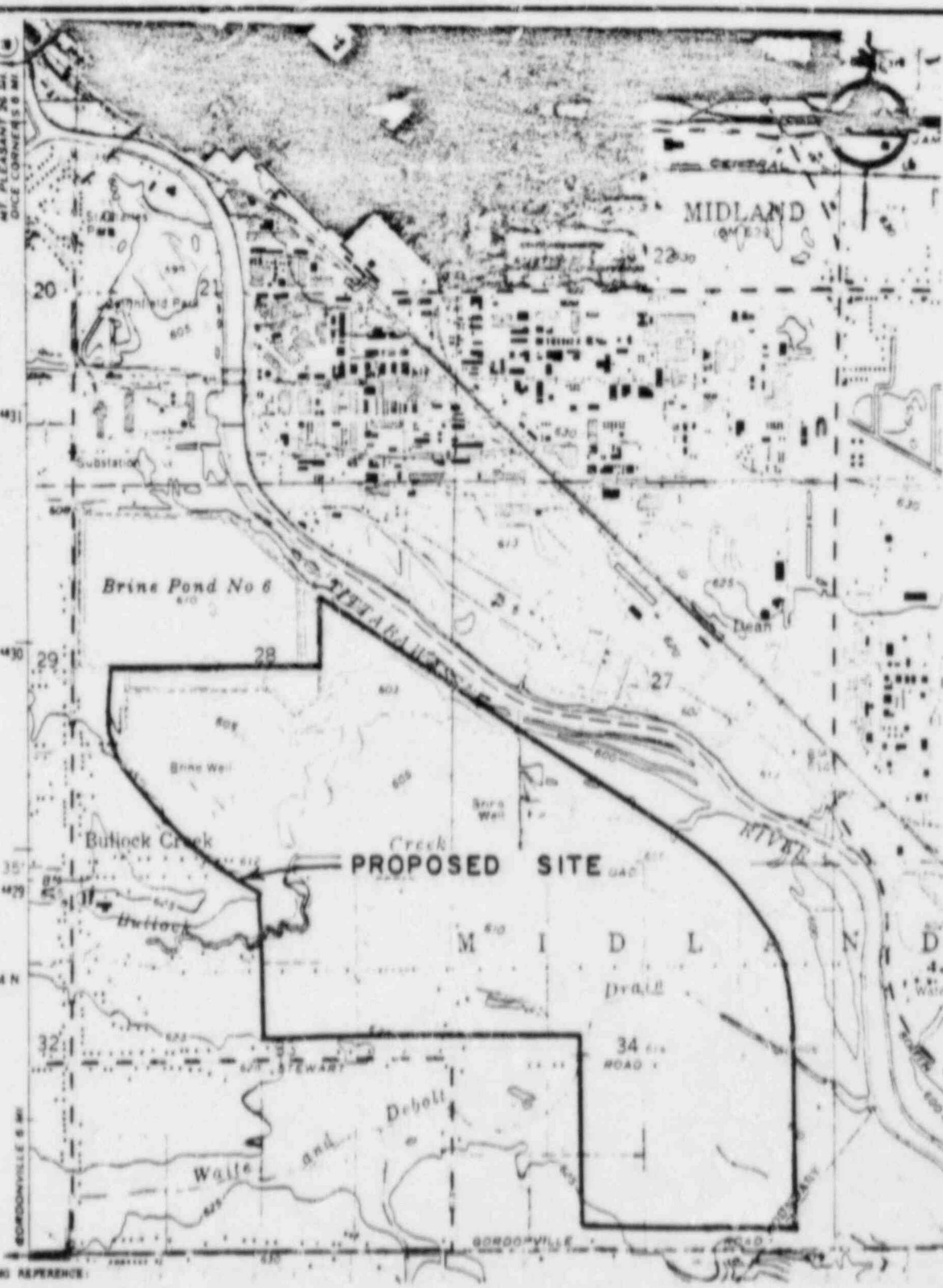
Plate 7 - Summary of Test Data

Respectfully submitted,

DAMES & MOORE

George D. Leal

George D. Leal



DRAWING REFERENCE:

THIS MAP WAS TAKEN FROM A PORTION OF THE U.S.G.S. MIDLAND SOUTH, MICHIGAN QUADRANGLE. DATED: 1962

VICINITY MAP

SCALE 1:24000

CONTOUR INTERVAL 5 FEET
DATUM IS MEAN SEA LEVEL

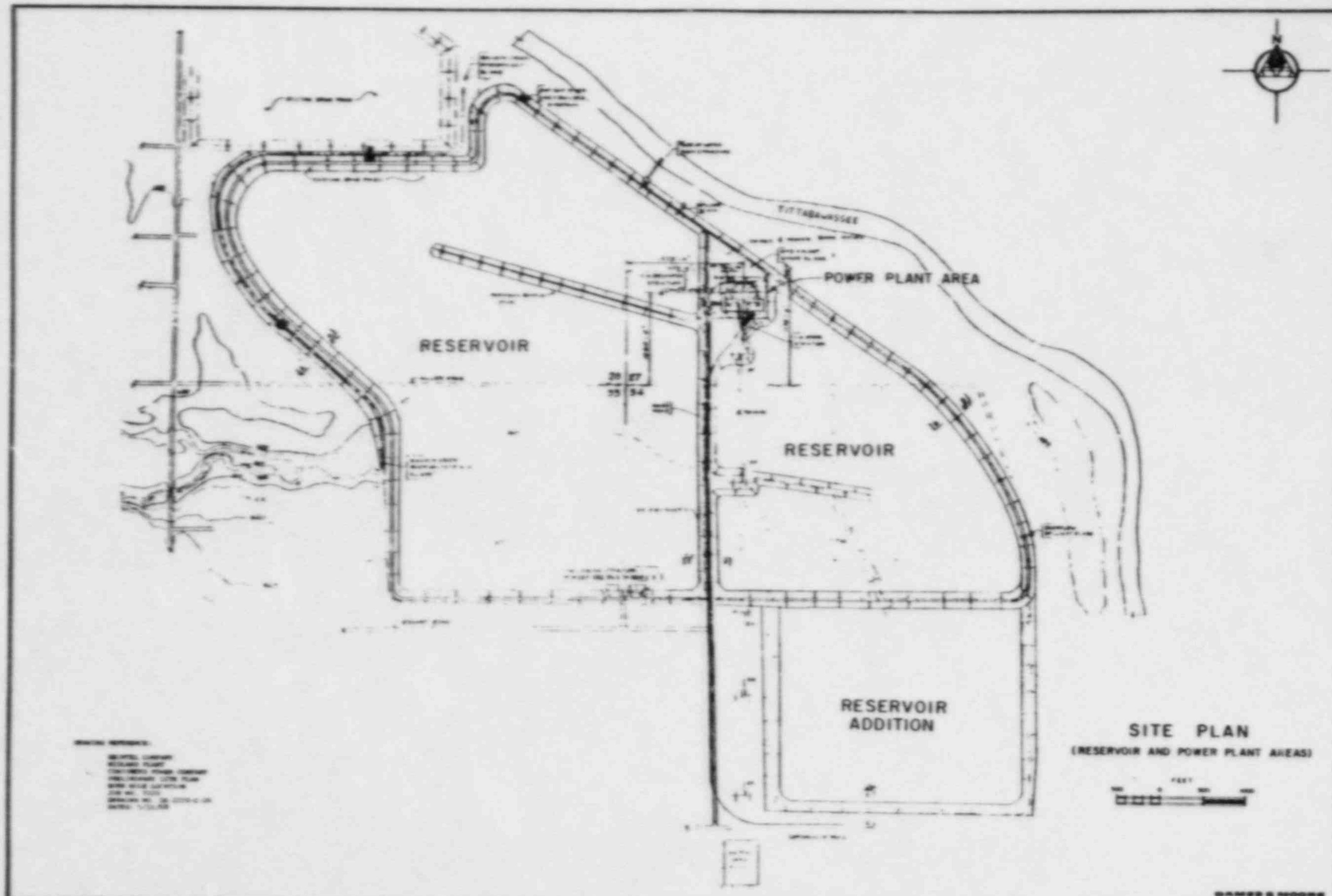
DAMES & MOORE
APPLIED EARTH SCIENCES

PLATE 1

BY ____ DATE ____
CHECKED BY ____

FILE 097-001

REVISIONS
BY ____ DATE ____



N
TITTABAWASSEE
POWER PLANT AREA
RESERVOIR
RESERVOIR
RESERVOIR
ADDITION
SITE PLAN
(RESERVOIR AND POWER PLANT AREAS)
FEET
DAMES & MOORE

PLATE 2

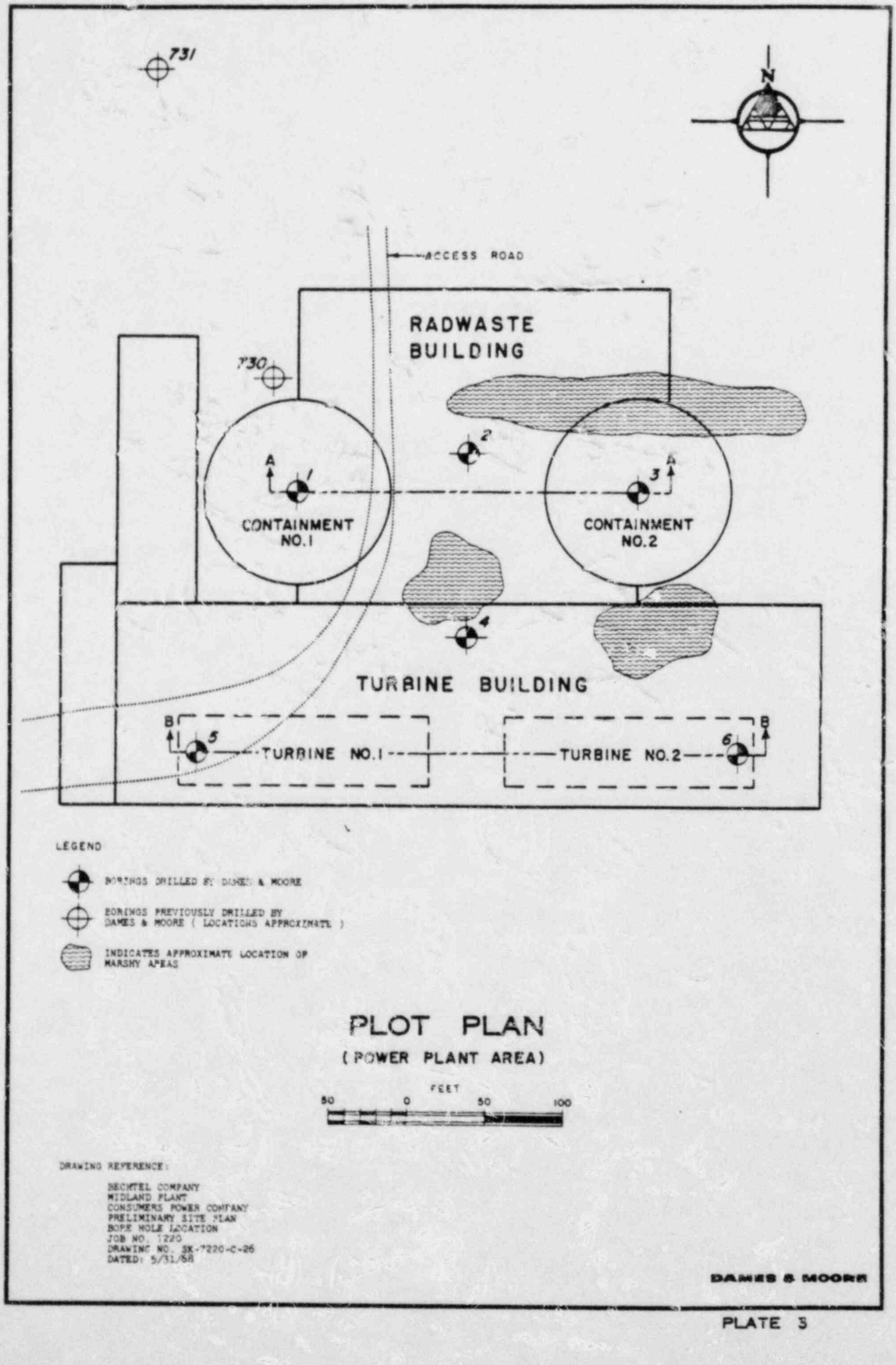
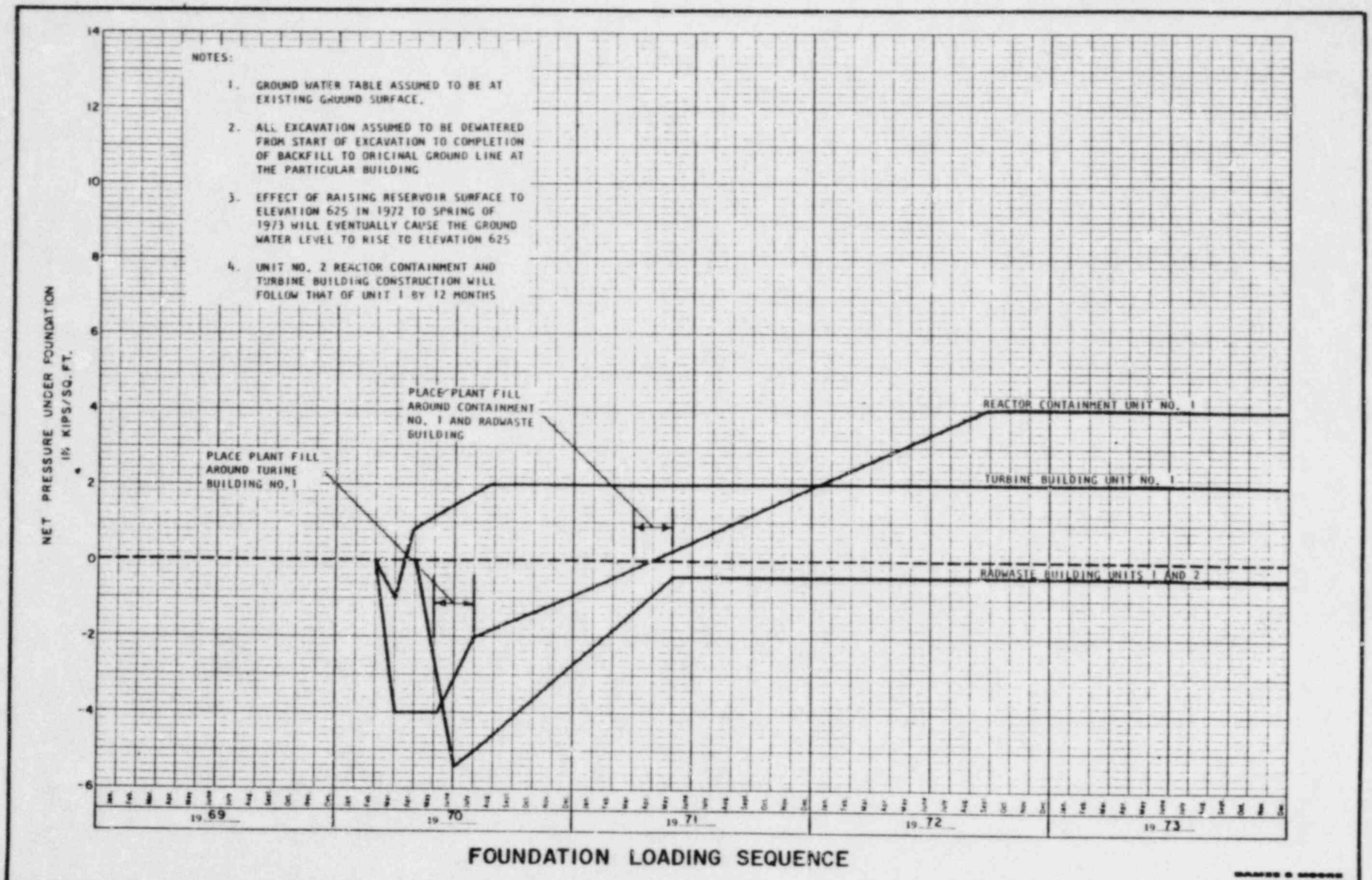

731
N
ACCESS ROAD
RADWASTE BUILDING
730
2
A
1
3
A
CONTAINMENT NO.1
CONTAINMENT NO.2
4
TURBINE BUILDING
B
5
TURBINE NO.1
TURBINE NO.2
6
B
LEGEND
BORINGS DRILLED BY DAMES & MOORE
BORINGS PREVIOUSLY DRILLED BY DAMES & MOORE (LOCATIONS APPROXIMATE)
INDICATES APPROXIMATE LOCATION OF MARSHY AREAS
PLOT PLAN
(POWER PLANT AREA)
FEET
50
0
50
100
DRAWING REFERENCE:
BECHTEL COMPANY
MIDLAND PLANT
CONSUMERS POWER COMPANY
PRELIMINARY SITE PLAN
BORE HOLE LOCATION
JOB NO. 7220
DRAWING NO. SK-7220-C-26
DATED: 5/31/68
DAMES & MOORE

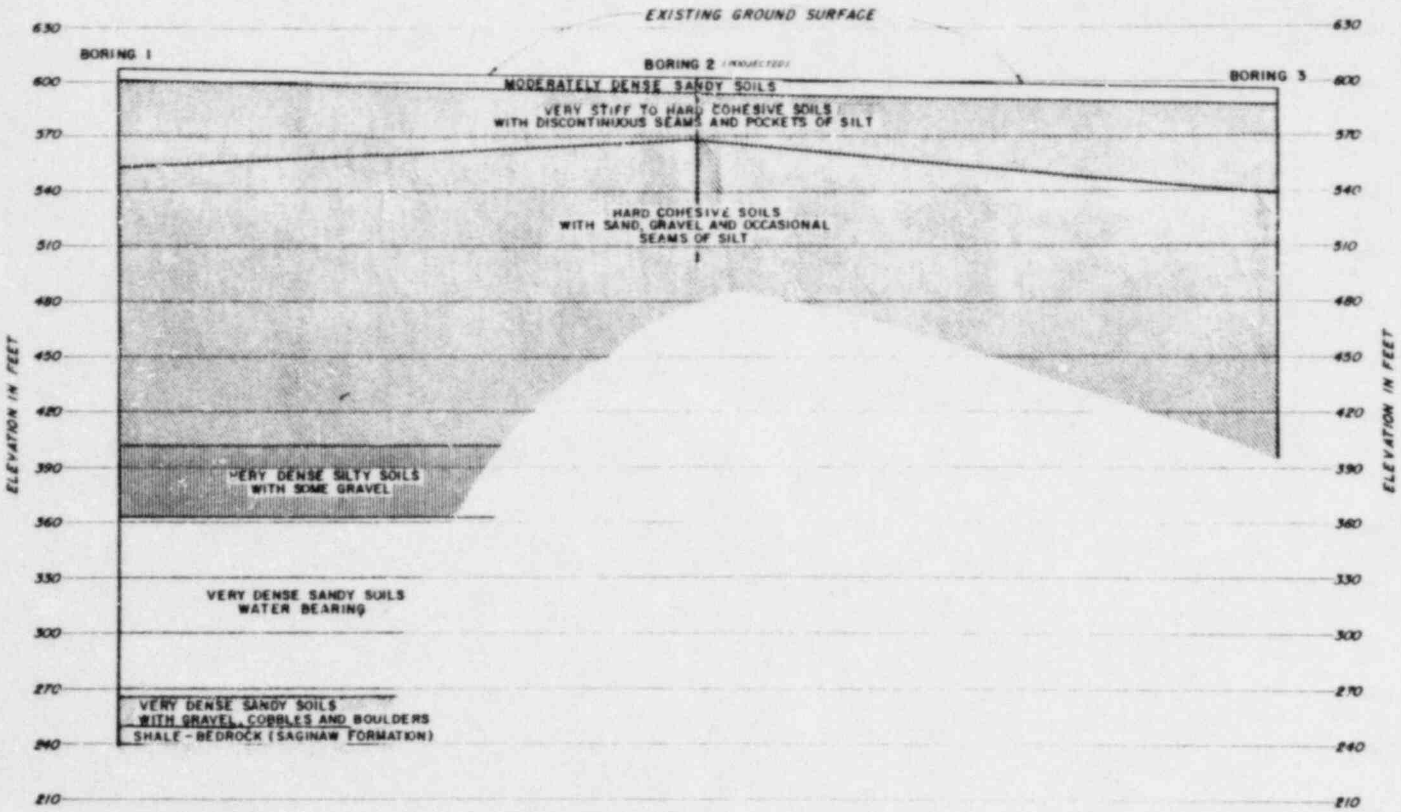
PLATE 3



FOUNDATION LOADING SEQUENCE

DAMES & MOORE

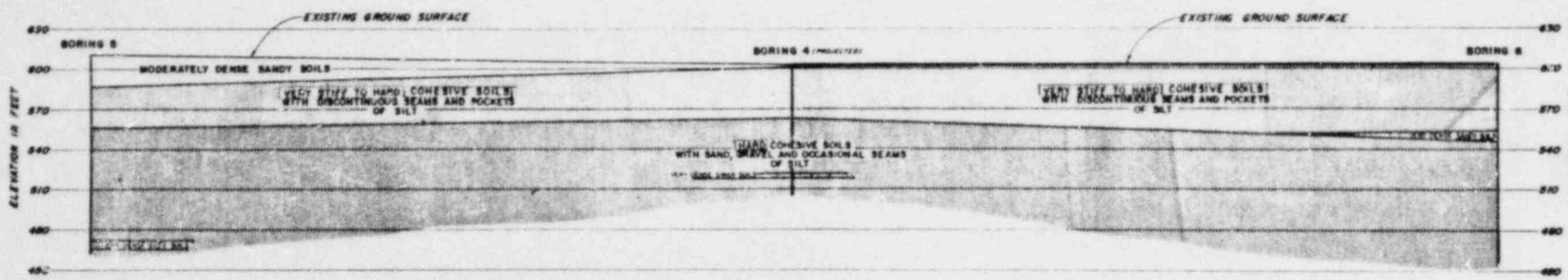
PLATE 4



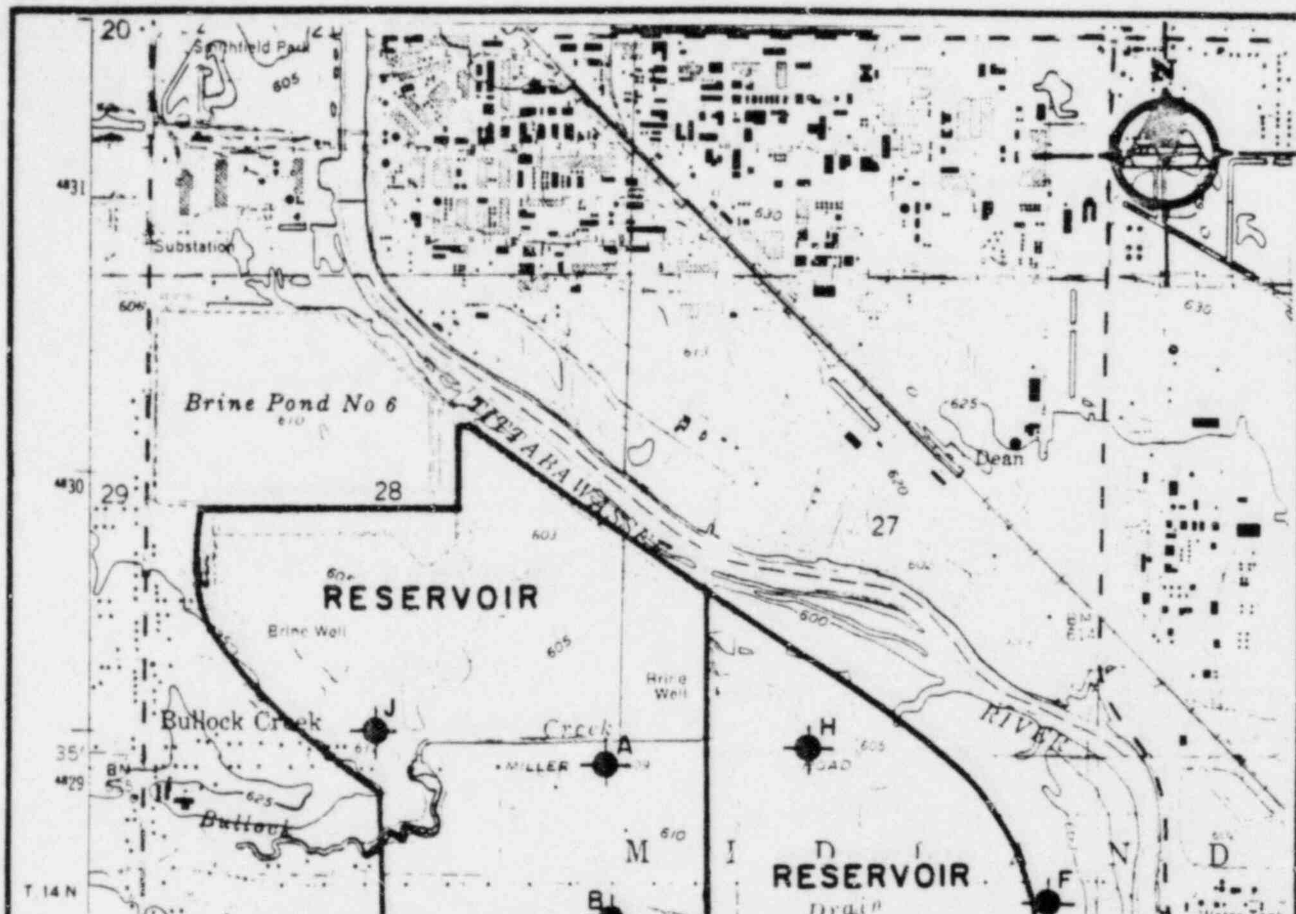
GENERALIZED SUBSURFACE SECTION A-A

DAMES & MOORE

PLATE 5-A



GENERALIZED SUBSURFACE SECTION B-B



DRAWING REFERENCE:

THIS MAP WAS TAKEN FROM A PORTION OF THE U.S.G.S. MIDLAND SOUTH, MICHIGAN QUADRANGLE. DATED: 1962

RESERVOIR PLAN

SCALE 1:24 000

1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 KILOMETER

CONTOUR INTERVAL 5 FEET

DATUM IS MEAN SEA LEVEL

DAMES & MOORE

APPLIED EARTH SCIENCES

PLATE 6

BY ______ DATE ______

CHECKED BY ______

FILE 197-001

REVISIONS BY ______ DATE ______

APPENDIX

FIELD EXPLORATIONS AND LABORATORY TESTS

FIELD EXPLORATIONS

Power Plant Area - The subsurface conditions at the site of the Proposed Nuclear Power Plant were investigated by drilling six four-inch diameter exploration test borings to depths ranging from approximately 100 feet to 370 feet below the existing ground surface utilizing truck-mounted rotary wash and rotary auger type drilling equipment.

The drilling operations were supervised by our field engineers who maintained logs of the borings, obtained undisturbed samples of the various soil strata penetrated utilizing Dames & Moore Soil Samplers, supervised the performance of Standard Penetration Tests performed in granular soils, and supervised the diamond core drilling operations performed to extract cores of the underlying bedrock. Graphical representations of the soils and rock penetrated by the borings are shown on Plates A-1A through A-1C, Log of Borings. The method utilized in classifying the soils is defined on Plate A-2, Unified Soil Classification System.

Undisturbed samples of the soils penetrated by the borings were obtained in Dames & Moore Soil Samplers of the type illustrated on Plate A-3, Soil Sampler Type U. The Dames & Moore soil samplers were driven approximately 18 inches into the soil with a hammer weighing approximately 340 pounds falling approximately 24 inches. The Standard Penetration Tests were performed in granular materials utilizing a split spoon sampler having an outside diameter of two inches and an inside diameter of one and three-eighths of an inch. The split spoon sampler was driven 18 inches into the ground with a hammer weighing 140 pounds falling 30 inches. The number of blows required to drive the

Dames & Moore soil samplers and the split spoon sampler for the second and third six inches of penetration are recorded on the Log of Borings. The rock was cored in Boring 1 utilizing a NX size core barrel with a diamond bit.

The boring locations and the elevations of the ground surface were provided to us by a survey crew from the firm of Hunter, Whittier and Solberg located in Midland, Michigan. The ground surface elevation is shown above the log of each boring. These elevations refer to the U.S.G.S. Datum.

Cooling Water Reservoir Areas - The subsurface conditions in the area to be occupied by the Proposed Cooling Water Reservoirs were investigated by drilling nine, four-inch diameter exploration test borings to depths ranging from approximately 8 to 27 feet below the existing ground surface utilizing truck-mounted auger type drilling equipment.

The drilling operations were supervised by one of our field engineers, who maintained logs of the borings drilled, and obtained disturbed samples of the soils from the augers. Graphical representations of the soils penetrated by the borings are shown on Plate A-1D, Log of Borings. The method utilized in classifying the soils is defined on Plate A-2, Unified Soil Classification System. Disturbed samples of the soils penetrated by the borings were obtained in sufficient quantity to perform the tests required.

The borings locations were determined from available maps and local topography by our field engineers. Ground surface elevations were interpolated from contours presented on the Midland South, Michigan U.S.G.S. Quadrangle Map dated 1962. The interpolated ground surface elevation is presented above the log of each boring.

LABORATORY TESTS:

Strength Tests - Direct shear, unconfined compression, triaxial compression, and dynamic triaxial compression tests were performed on selected undisturbed samples to evaluate the strength characteristics of the various soils penetrated by the borings.

The direct shear tests were performed in the manner described on Plate A-4, Method of Performing Direct Shear and Friction Tests. Unconfined compression and triaxial compression tests were performed in the manner described on Plate A-5, Methods of Performing Unconfined and Triaxial Compression Tests. Stress-strain curves were plotted for each static strength test. For the direct shear tests, the shear strength is either a peak strength or the strength at a deflection of one-tenth of an inch whichever occurs first. For the unconfined compression and triaxial compression tests, shearing strengths were chosen assuming that the angle of internal friction of the cohesive soils was equal to zero. The shear strengths presented are either peak strengths or the strengths at an axial deflection of twenty percent of the sample height, whichever occurred first. Determination of the moisture content and dry density were made in conjunction with each strength test. The results of the strength tests, together with the associated moisture-density determinations are presented to the left of the Log of Borings in the manner described by the Key to Test Data shown on Plate A-2.

The dynamic triaxial compression tests were performed on two samples of the cohesive soils. The samples were subjected to a confining pressure and loaded in cycling compression to evaluate the dynamic modulus of elasticity within a certain range of cycling strain amplitude. The results of the tests are presented in the text of the report.

Direct shear tests were performed on saturated, remoulded, compacted samples extracted from borings drilled in the reservoir area. The results of the tests are presented with the compaction curves on Plate A-9, Compaction Test Data.

Consolidation Tests - Consolidation tests were performed on representative undisturbed samples of the soils penetrated by the borings to provide data for estimating settlements of fill and foundations. The consolidation tests were performed in accordance with the method described on Plate A-6, Method of Performing Consolidation Tests. Several special loading procedures were utilized to help define the stress history of the soil. Some samples were loaded to the overburden pressure and rebonded at the field moisture content prior to performing the standard consolidation test under submerged conditions. Other samples were loaded to pressures in excess of the overburden pressure and rebounded at field moisture content prior to performing the standard consolidation tests under submerged conditions. The results of the consolidation tests are presented on Plates A-7A through A-7E, Consolidation Test Data.

Moisture-Density Tests - Moisture-density tests were performed in conjunction with each strength and consolidation test. Additional moisture-density tests were performed on undisturbed samples for correlation purposes. The results of the moisture-density tests are presented to the left of the Log of Borings in the manner described by the Key to Test Data shown on Plate A-2.

Compaction Tests - Compaction tests were performed on samples of soils extracted from borings drilled in the Proposed Cooling Water Reservoir area to define the moisture-density relationship which is required to develop criteria for the placement and compaction of fill materials. The compaction tests were performed in accordance with the ASTM Compaction Test Designation D1557-66T as defined on Plate A-8, Method of Performing Compaction Tests. The results of the compaction tests are presented on Plate A-9, Compaction Test Data.

Atterberg Limits - Atterberg limits, consisting of the liquid limits, plastic limit and plasticity index, were determined to facilitate classification of the soils according to the Unified Soil Classification System. The liquid limit and plastic limit tests was performed in accordance with the ASTM-D423 Test Designation and D424. The tests were performed on selected samples extracted from Boring 1 drilled in the power plant area and on disturbed samples extracted from the borings drilled in the reservoir area. The results of the Atterberg limits are presented to the left of the Log of Borings.

Permeability Tests - Falling head type permeability tests were performed on remoulded soil samples extracted from borings drilled in the reservoir area. The remoulded soil samples were compacted to a dry density equal to approximately 95 percent of the maximum dry density attainable by the ASTM Compaction Test Designation D1557-66T, prior to testing. The results of the permeability tests are presented with the compaction curves on Plate A-9.

Particle Size Distribution - A determination of the particle size distribution of selected samples of granular soils extracted from borings drilled in the reservoir area was made to facilitate classification of these soils. The results of the mechanical analyses performed to determine the particle size distribution are presented on Plate A-10, Grain Size Analyses.

Rock Compression Tests - Rock compression tests were performed on selected samples of the gray shale bedrock which underlies the site of the power plant. These tests were performed utilizing standard ASTM procedures. The results of the rock compression tests are presented to the left of the Log of Boring 1.

--oOo--

The following Plates are attached and complete this Appendix:

Plate A-1A - Log of Borings (Boring 1)

Plate A-1B - Log of Borings (Borings 2 and 3)

Plate A-1C - Log of Borings (Borings 4, 5, and 6)

Plate A-1D - Log of Borings (Borings A, B, C, D, E, F, G, H, and J)

Plate A-2 - Unified Soil Classification System

Plate A-3 - Soil Sampler Type U

Plate A-4 - Method of Performing Direct Shear and Friction Tests

Plate A-5 - Method of Performing Unconfined Compression and Triaxial Compression Tests

Plate A-6 - Method of Performing Consolidation Tests

Plate A-7A - Consolidation Test Data

Plate A-7B - Consolidation Test Data

Plate A-7C - Consolidation Test Data

Plate A-7D - Consolidation Test Data

Plate A-7E - Consolidation Test Data

Plate A-8 - Method of Performing Compaction Tests

Plate A-9 - Compaction Test Data

Plate A-10 - Grain Size Analyses

Amendment No 3.
dtd 8-13-69

SUPPLEMENT TO REPORT

FOUNDATION INVESTIGATION AND
PRELIMINARY EXPLORATIONS FOR BORROW MATERIALS
PROPOSED NUCLEAR POWER PLANT
MIDLAND, MICHIGAN

FOR

CONSUMERS POWER COMPANY

5697-004-07

DAMES & MOORE

CONSULTING ENGINEERS IN THE APPLIED EARTH SCIENCES

EARTH SCIENCES

ATLANTA NEW YORK
CHICAGO PORTLAND
DENVER SALT LAKE CITY
HONOLULU SAN FRANCISCO
HOUSTON SEATTLE
LOS ANGELES

LONDON ENGLAND SYDNEY AUSTRALIA
MADRID SPAIN TEHRAN IRAN
TORONTO CANADA

309 WEST JACKSON BOULEVARD · CHICAGO, ILLINOIS 60606 · 312 922-1772 · TELEX 2-5227

PARTNERS JAMES B THOMPSON · GEORGE D LEAL

ASSOCIATE WILLIAM G PARATORE

CHIEF ENGINEER JAMES V TOTO

March 15, 1969

Bechtel Corporation
P.O. Box 3965
San Francisco, California 94119

Attention: Mr. J. H. Blasingame,
Project Engineer

Gentlemen:

This letter transmits fifteen copies of our "Supplement to Report, Foundation Investigation and Preliminary Explorations for Borrow Materials, Proposed Nuclear Power Plant, Midland, Michigan for Consumers Power Company," dated March 15, 1969.

The scope of this investigation was planned in collaboration with Messrs. Flach, Martinez, Kulesza and Cherrington of Bechtel Corporation.

The data and recommendations presented in this report are intended to supplement those presented in our "Report of Foundation Investigation, and Preliminary Explorations for Borrow Materials," dated June 28, 1968, and are considered appropriate for final plant design.

It has been a pleasure to be of service to Consumers Power Company and Bechtel Corporation on this project, and we trust that you will contact us if you should have any questions or comments.

Yours very truly,

DAMES & MOORE

George D Leal

George D. Leal

GDL:WWM:mf

SUPPLEMENT TO REPORT

FOUNDATION INVESTIGATION AND

PRLIMINARY EXPLORATIONS FOR BORROW MATERIALS

PROPOSED NUCLEAR POWER PLANT

MIDLAND, MICHIGAN

FOR

CONSUMERS POWER COMPANY

INTRODUCTION

This report presents the results of a supplementary foundation investigation performed at the site of the Proposed Nuclear Power Plant to be constructed in Midland, Michigan for Consumers Power Company.

An initial foundation investigation was performed by Dames & Moore and the results presented in our "Report, Foundation Investigation and Preliminary Explorations for Borrow Materials, Proposed Nuclear Power Plant, Midland, Michigan," dated June 28, 1968. Subsequent to the initial investigation, the plant structures were relocated 150 feet to the east and 60 feet to the north of the original location. Because of subsurface conditions encountered at the new location, the plant structures were relocated a second time to a position 40 feet south and 20 feet east of the original location. The data and recommendations presented in this supplementary report are appropriate for the final plant location.

SCOPE

The purpose of the supplementary foundation investigation was to develop data and recommendations appropriate for final plant design. The specific program discussed and agreed upon for investigating the site consisted of the drilling and sampling of exploration test borings, the performance of a limited number of supplementary laboratory tests, the performance of appropriate engineering analyses, and the preparation of final recommendations and substantiating data.

This report is intended to be supplementary in nature and does not repeat discussion of items covered in the initial report unless required. Emphasis is given to the following specific information:

1 - Modified site description as necessitated by the additional explorations.

2 - Soil boring logs which include information on ground water levels at the time of drilling.

3 - Results of supplementary laboratory tests.

4 - Final foundation design criteria, including:

a) Allowable bearing pressure for shallow spread foundations on the compacted plant fill as a function of width for an allowable total settlement of 3/4 inch.

b) Lateral earth pressure against structure walls as a function of depth. In developing these data, the maximum probable flood has been assumed at elevation 632 feet, and the top of plant fill has been assumed at elevation 634 feet. For normal conditions, the ground water level has been assumed at elevation 625 feet, the reservoir water surface elevation.

c) Recommended foundation type for the reactor buildings, the turbine building, and for the turbine generators. The estimated total settlement and maximum differential settlement are provided for recommended foundation types.

d) Recommended foundation type and estimated total settlement for the auxiliary building which is located between the two reactor buildings. Its structure and foundation will be separate from those of the adjacent three buildings to allow for possible differential settlement which must not exceed 3/4 inch.

e) Differential settlements between auxiliary building, reactor, and turbine buildings.

5 - Review of recommendations regarding site preparation and earthwork, as follows:

a) Recommended excavation slopes in natural soils and in plant fill.

b) Control of ground water in excavations for the reactor and turbine buildings.

c) Compaction requirements for the plant fill (I) beneath structures, and (II) adjacent to structures.

d) Minimum depths of footings in compacted soil for frost protection or other reasons.

The results of our supplementary field explorations and laboratory tests are presented in the Appendix to this report.

DESIGN CONSIDERATIONS

Subsequent to the completion of the initial investigation, planned foundation elevations of all the major structures have been modified and more detailed structural design data has become available. A summary of pertinent structural data is given below.

The reactor building foundations will be established at elevation 582.5. They will be structurally separated from the adjacent auxiliary building, and the maximum allowable differential settlement between auxiliary building and reactor buildings has been established at three-quarters of an inch.

The auxiliary building plan dimensions will be 166 feet by 161 feet. This building abuts both of the reactor buildings and the turbine building. The central portion of the auxiliary building, 76 feet by 131 feet in plan dimensions, will be founded at elevation 562.0 feet; both parts of the auxiliary building abutting the reactor buildings will be founded at elevation 580. The remainder of the auxiliary building, located adjacent to the turbine building, and between it and the reactor buildings, will be founded at elevation 610.

Plan dimensions of the turbine building will be approximately 132 feet by 436 feet with a base elevation of 610. This building will house two turbine-generators supported on mat foundations established at approximately elevation 602 feet. The turbine-generator mat foundations will have plan dimensions of 145 feet by 45 feet and 185 feet by 45 feet.

Foundation loads imposed by th
operating conditions and under seismic lo
below.

STRUCTURE	FOUNDATION ELEVATION, FEET	DEA		
Reactor Building	582.5	[illegible]		
Auxiliary Building	562.0	6,		
	580.0	5,0	[illegible]	0
	610.0	3,50	7,000	0
Turbine Building	610.0	3,000	5,000	1,000
Turbine Generator Mat Foundations	602.0	4,500	9,000	0

The locations and foundation loading data relative to the appurtenant structures have not been provided to us.

Final plant grade has been raised approximately six feet and will be established at approximately elevation 634. Normal ground water level as in the initial investigation, is assumed to be at the existing ground surface, approximately elevation 603. However, this may be a perched water level. The water level in the cooling pond reservoir will be at approximately elevation 625. The underdrainage system considered in the initial report has been eliminated; consequently, it is assumed that the ground water level in the plant area will rise concurrently to approximately elevation 625. The maximum probable flood level will remain at elevation 632.

SITE CONDITIONS

SUBSURFACE CONDITIONS

General geologic conditions, and surface conditions at the site have been discussed in our initial report.

The subsurface conditions at the site were further investigated by drilling 11 supplementary exploration test borings and 22 probings to depths ranging from 10 to 80 feet at the locations shown on Plate 2.

The supplementary borings and probings provided more detailed information regarding the sandy soils, which generally underlie the topsoil and/or organic silty soils. These sandy soils consist of brown and gray fine sands which grade from loose near the surface to very dense with increasing depth. Although there is little or no sand within the central part of the plant area, the sand stratum does extend to approximately elevation 585 feet at both the east and west ends of the turbine building. Similarly, the bottom of the sand stratum varies from approximately elevation 600 in the vicinity of the west reactor building area to approximately elevation 575 feet near the north-eastern edge of the east reactor building area and along a part of the northern edge of the auxiliary building area.

The presence of very stiff to hard cohesive soils, predominantly gray silty clay, underlying the surface sand deposits was confirmed by the supplementary boring program.

More detailed descriptions of the subsurface soil penetrated by the supplementary borings are presented on the Log of Borings in the Appendix to this report.

SURFACE WATER

The site is presently subjected to periodic flooding. We understand that maximum probable flood level has been estimated at elevation 632 feet, which is the same elevation assumed in our initial report.

GROUND WATER

Seepage water entered some of the borings through the sand stratum blanketing the site. Ground water observations in the supplementary borings were consistent with those discussed in the initial report. A perched water condition probably exists in the sandy surface soils, and it has been conservatively estimated that the perched ground water level is at or near the existing ground surface. The underlying silty clay soils are saturated, but the present ground water level in these impervious materials could not be determined during the short term of our field investigations.

LABORATORY TESTS

The results of the laboratory tests performed in connection with the supplemental investigation, together with a description of the test procedures, are presented in the Appendix to this report.

A summary of all laboratory strength tests, and moisture and density tests, performed on soil samples extracted from borings drilled in the power plant area are presented on Plate 5, Summary of Test Data.

DISCUSSION AND RECOMMENDATIONS

GENERAL:

The results of our supplementary investigation confirm that the site is suitable, from a foundation standpoint, for the support of the proposed plant structures. Initial recommendations regarding suitable foundation types for various structures are considered applicable. These recommendations are summarized below.

It is recommended that the reactor buildings and the lower portion of the auxiliary building be supported on mat foundations established at the planned elevations, in the very stiff to hard cohesive soils.

It is recommended that the turbine building, the higher south portion of the auxiliary building, and the turbine-generators be supported on mat foundations established in controlled compacted fill at the planned elevations. Prior to the placement of fill, it is recommended that all topsoil, loose sand and other unsuitable soils be excavated from the turbine building area and the south portion of the auxiliary building area. The exposed natural soils should be thoroughly proof-rolled prior to commencing filling operations.

It is recommended that appurtenant structures be supported on spread foundations established in the controlled compacted fill.

The more detailed structural design data and the additional subsurface data available at this time permit a final analysis of total and differential settlements. Foundation design data and the results of the settlement analysis are presented in subsequent sections of this report.

Recommendations regarding earthwork operations are presented in the following section.

EARTHWORK:

The supplementary investigation requires certain modifications in our initial recommendations regarding dewatering, excavating, filling and backfilling.

Dewatering - The supplementary investigation has indicated that more extensive dewatering operations will be required than originally anticipated due to the greater amount of sandy surface soils encountered in the immediate plant area.

Plant excavations will extend into sandy surface soil below the ground water level and into relatively impervious clay soils. The depth of the sandy surface soils in the vicinity of the plant structures ranges from 0 to approximately 35 feet, with the maximum depth of sand occurring near the south western corner of the turbine building. The maximum depth of excavation will be on the order of 40 feet, to elevation 562.0, for the auxiliary building.

Only minor water seepage is anticipated in the lower clay soils. However, dewatering operations will be required in connection with excavations into the upper sandy soils. The ground water level, presently assumed to be at approximately elevation 603, may vary during the construction period in response to rainfall, surface runoff conditions, and the water level in the adjacent Tittabawasse River.

We understand that a seepage cutoff wall will be installed which will minimize the flow of seepage water through the sandy soils into the plant excavations. The location of the seepage cut off wall is shown on Plate 2, Site Plan. In order to supplement ground water control in the excavations, it is recommended that the ground water level inside the seepage cutoff wall be lowered as required by a well-point or deep-well dewatering system.

The subsurface conditions at the site have been discussed with a representative of the Griffin Wellpoint Corporation, a qualified dewatering contractor. After having been familiarized with the soil conditions, the following schemes were proposed by the Griffin Wellpoint Corporation.

1 - A single stage well-point system would be installed to lower the water level in the sandy soils inside the seepage cutoff wall to approximately elevation 575. In areas where the depth of sandy soils exceeds approximately elevation 575, a second stage of well-points would be installed to lower the water level to approximately elevation 560. It is anticipated that well-points will have to be installed with vertical sand filter-wicks to maintain the required drainage and draw-down. A copy of correspondence from Griffin Wellpoint Corporation and their sketch of proposed locations of the upper and lower dewatering systems is attached to the Appendix of this report.

2 - As an alternative to the above, particularly in areas where the sandy soils extend to depths below the bottom of excavations, it may be more economical to install several peripheral wells to depths below the plant excavations. These deep wells should be designed and operated such that the ground water level in the vicinity of the plant excavations is maintained below the bottom of the excavations.

The dewatering schemes outlined above are considered suitable, but appropriate field pumping tests should be performed prior to selecting a dewatering contractor. The field pumping tests would provide data to allow the choice of the most suitable type of dewatering system (well-points or deep wells), and would provide additional data for contractor bidding purposes. We would be pleased to provide guide specifications and technical supervision during the performance of field pumping tests, if required.

The dewatering system should maintain the water level in the sandy soils at least three to five feet below exposed excavated surface. Piezometers should be installed and monitored to insure that the water level in the sandy soils is continuously maintained at the recommended level.

In peripheral areas where the sandy surface soils are shallow, and surface water is not intercepted by other means, it is recommended that a peripheral drainage trench system be installed around the outside of excavations. The perimeter drainage system should consist of trenches excavated through the sandy surface soils and graded to drain away from the plant area. The trenches should be backfilled with clean gravel or other pervious material. Inside the excavation it is recommended that ground water seepage be controlled by a system of shallow peripheral trenches and sumps. Pumps will be required to remove water which accumulates in the trench-sump system.

Excavating - This section presents recommendations pertaining to excavating operations required to attain the modified planned grades and to prepare soils for the support of foundations or fill materials.

The maximum depth of excavation will be on the order of 40 feet in the vicinity of the auxiliary building.

Providing stripping is carried out in the manner recommended in our previous report and stripped soils are wasted, all remaining soils to be excavated will be suitable for use as fill or backfill. Detailed recommendations for the use of these soils are given in a subsequent section.

In addition to the excavation required to attain foundation levels, it is recommended that all on-site sands be excavated from below foundation level in the reactor building and auxiliary building areas, and that these soils be replaced by either compacted sand or clay fill soils. Based on the results of our field explorations, we anticipate that only very minor amounts of in-situ sands may be encountered at the foundation level of these structures. Where over-excavation is required, subgrade preparation and the backfilling to attain foundation levels should be carried out in the manner outlined in subsequent sections.

All loose in-situ sands, soft or compressible clay soils, and organic soils should be excavated in the turbine building area. Based on the results of the supplementary field explorations, it is anticipated that the depth of excavation of unsuitable soils will vary from one to five feet with an average over the area of approximately three feet. The excavation of these unsuitable soils, and subsequent backfilling with controlled compacted fill where required, is necessary in order to provide uniform foundation support for the turbine building and turbine-generator foundations. The plan dimensions of the excavated area should include the "zone of influence" of the mat foundations established in the controlled compacted fill. For purposes of excavation and filling, the "zone of influence" of a foundation is defined as the zone within planes extending downward and outward from the bottom outside edge of a foundation at an angle of 45 degrees with the horizontal.

Engineering studies have been performed to evaluate the stability of slopes constructed through the upper dewatered sandy soils and the underlying very stiff to hard clay soils. Based on the results of these studies, it is recommended that the banks of excavations through the dewatered sandy soil be cut on a slope of one vertical to one and one-half horizontal or flatter. Banks of excavations cut through the clay soils may be cut on a slope of two vertical to one horizontal or flatter. Banks of temporary excavations within the clay soils which are not subject to surcharge loading may be cut vertically with an unsupported height of up to 15 feet. It is anticipated that localized sloughing and spalling of the banks of excavations will occur due to drying and shrinking of the banks and also due to the presence of discontinuous lenses and pockets of silt in the clay soils.

Subgrade Preparation - Following stripping and excavating it is recommended that the exposed surfaces be thoroughly proof-rolled under the supervision of a qualified soils engineer. Where practical both foundation and fill subgrades should be proof-rolled to compact the exposed surfaces and to detect any localized zones of soft soils. As a guide, the proof-rolling operation could be considered equivalent to making approximately two passes over the entire exposed subgrade with a 20-cubic yard capacity loaded motor scraper. In deep excavations or limited access areas, smaller equipment making more passes would be suitable for proof-rolling.

Zones of loose or soft soils delineated by proof-rolling should be compacted if possible or removed and replaced with controlled compacted fill.

Upon attainment of final foundation grade in each area, it is recommended that a working mat of lean concrete be poured. The installation of a lean concrete "mud mat" or similar protection should minimize disturbance of the subgrade soils due to water seepage and construction operations. The mud mat will not provide protection against freezing and thawing of the subgrade soils.

The clay soils are susceptible to loss of strength due to frost action, disturbance and/or the presence of water. If the construction schedule requires that foundation excavations be left open during the winter, it is recommended that excavating operations be performed such that at least three and one-half feet of natural soils or similar cover remain in place over the final subgrade or overlying the "mud mat." This layer of protective material is necessary to prevent the softening and disturbance of the subgrade soils due to frost action.

Mud mats or similar means of protection should also be installed on the banks of excavations which lie within the building areas. The mud mat will provide protection against drying and resaturation which could lead to weakening and spalling of slopes.

Filling and Backfilling - Fills up to approximately 35 feet in thickness will be required in the attainment of the final plant grade elevation 634. In addition, fills and backfills will be required below and adjacent to structures.

As previously mentioned, on-site excavated soils, both sands and clay soils are considered suitable fill materials. Provided either soil type is placed and compacted in accordance with the criteria recommended below, it is considered unnecessary, from performance considerations, to specify the selective use of one or other of these soil types for any of the fills or backfills which will be required; however, as sands are more readily compacted with small equipment such as hand operated vibratory equipment it is recommended that sand fill be used in areas of limited access.

All fill and backfill materials should be placed at or near the optimum moisture content in nearly horizontal lifts approximately six to eight inches in loose thickness. Each lift should be compacted in accordance with the following criteria for the construction of controlled compacted fill and backfill.

In addition, no compacted soils should be allowed to freeze. If filling or backfilling operations are discontinued during periods of cold weather, it is recommended that all frozen soils be removed or recompacted prior to the resumption of operations.

Engineering studies have been performed to evaluate the stability of slopes constructed through the plant fill. Based on the results of these studies, it is recommended that the banks of temporary excavations through dewatered sand fill soils be cut on a slope of one vertical to one and one-half horizontal or flatter. Banks of temporary excavations through compacted clay fill soils which are not subject to surcharge loading may be cut vertically with an unsupported height of up to ten feet.

It is recommended that permanent slopes through granular compacted fill soils be constructed on slopes of one vertical to four horizontal or flatter. Permanent slopes through cohesive compacted fill soils may be constructed on slopes of one vertical to two horizontal.

Filling operations should be performed under the continuous technical supervision of a qualified soils engineer who would perform in-place density tests in the compacted fill to verify that all materials are placed and compacted in accordance with the recommended criteria.

RECOMMENDED MINIMUM COMPACTION CRITERIA

PURPOSE OF FILL	ON-SITE SAND SOILS PERCENT RELATIVE DENSITY*	ON-SITE CLAY SOILS PERCENT OF MAXIMUM DENSITY**
Support of Structures	85	100
Adjacent to Structures	75	95
Areal Fill (Not supporting or adjacent to structures)	70	90

* Maximum and Minimum density of sand soils should be determined in accordance with A.S.T.M. Test Designation D-2049-64T.

** Maximum dry density and optimum moisture content should be determined in accordance with A.S.T.M. Test Designation D-698, modified to require 20,000 foot-pounds of compactive energy per cubic foot of soil.

∴ = 95% of Standard ASTM 1557 method D

FOUNDATION DESIGN DATA

General - Foundation design data presented in this section assumes that individual building areas will be prepared in the manner previously recommended. It is our opinion that the major plant structures may be satisfactorily supported on mat foundations established at the presently planned elevations. Similarly, shallow spread foundations founded on controlled compacted fill soils will provide satisfactory support for the appurtenant structures.

Mat Foundations - The ultimate bearing capacity of the supporting soils underlying each of the major structures has been re-evaluated to reflect modified foundation elevations. The results of these analyses are tabulated below:

UNIT	SUPPORTING SOILS	FOUNDATION ELEVATION (FEET)	ULTIMATE BEARING CAPACITY LBS./SQ.FT.
Reactor Building	Very stiff to hard natural clay soils	582.5	45,000
Auxiliary Building	Very stiff to hard natural clay soils	562.0 580.0	50,000 45,000
	Controlled compacted fill	610.0	30,000
Turbine Building	Controlled compacted fill	610.0	30,000
Turbine-Generators	Controlled compacted fill	602.0	30,000

The above tabulation assumes that fill will be composed of compacted clay soils; if compacted sand fill is used the ultimate bearing capacities listed above will be greater than the tabulated values. The tabulated ultimate bearing pressures are gross values; thus the weight of foundations should be included in computing the foundation loads. The effects of overburden to elevation 634, and the effects of ground water at elevation 625 have been considered in the bearing capacity analysis.

The following tabulation presents a summary of the factors of safety revised to reflect the modified loading conditions and ultimate bearing capacities for the various units:

UNIT	FACTOR OF SAFETY DEAD AND LIVE LOADS	 DEAD, LIVE AND SEISMIC LOADS
Reactor Buildings	5.6	2.8
Auxiliary Building		
@ Elevation 562.0	7.7	3.8
@ Elevation 580	9.0	4.5
@ Elevation 610	8.6	4.3
Turbine Building	10.0	6.0
Turbine-Generators	6.7	3.3

Shallow Spread Foundations

The recommended bearing pressures for shallow spread foundations have been calculated assuming the ground water level to be at elevation 625 and assuming that the supporting compacted fill materials may be either clay or sand soils.

FOUNDATION WIDTH	ALLOWABLE NET BEARING PRESSURES (POUNDS PER SQUARE FOOT) CLAY SOILS	 SAND SOILS
2	5,000	2,800
4	5,000	3,100
8	5,000	3,700
12	5,000	4,300

The factor of safety and allowable increase for seismic loads are the same as previously recommended.

SETTLEMENT

General - Settlement analyses are based on the results of consolidation tests performed on undisturbed and recompacted soil samples. Consolidation test data are presented in the Appendix of this report. The consolidation tests performed in connection with the supplemental investigation confirm that the very stiff to hard clay soils have been preconsolidated under overburden pressures of at least 15,000 to 20,000 pounds per square foot.

The settlement analyses consider the effects of lowering the ground water level, excavating, placement of areal fill, subsequent raising of ground water level and the associated time considerations.

Mat Foundations

The results of our settlement analyses for structures supported on mat foundations are tabulated below:

UNIT	ESTIMATED MAXIMUM SETTLEMENT INCHES	ESTIMATED MAXIMUM DIFFERENTIAL SETTLEMENT INCHES
Reactor Buildings	1 - 1½	¼ - ½
Auxiliary Building		
@ Elevation 562	½ - 1	¼ - ½
@ Elevation 580	½ - 1	¼ - ½
@ Elevation 610	1½ - 2	¼ - ½
Turbine Building	1½ - 2	¼ - ½
Turbine-Generator Mats	1½ - 2	¼ - ½

It has been further estimated that the maximum differential settlement which will occur between adjacent structures will be as follows:

ADJACENT UNITS	ESTIMATED MAXIMUM DIFFERENTIAL SETTLEMENTS BETWEEN STRUCTURES INCHES
Auxiliary @ Elevation 562 and @ Elevation 580	1/2
Auxiliary @ Elevation 562 and @ Elevation 610	1
Auxiliary @ Elevation 580 and Reactor	1/2
Auxiliary @ Elevation 610 and Reactor	3/4
Auxiliary @ Elevation 610 and Turbine Building	1/2
Turbine Building and Turbine Mat	1/2

The results of the dynamic settlement analysis presented in the initial report are considered applicable to the revised plant design and final location. Additional settlement under dynamic loading should not exceed one-quarter inch. The appropriate range of values for modulus of elasticity for dynamic settlement analysis is discussed in the Appendix to this report.

Appurtenant Structures - The total and differential settlements of buildings supported on shallow-spread foundations will depend on (1) the surface settlement of the areal fill and (2) the settlement caused by the individual foundations imposing bearing pressures on the order of the allowable bearing pressures previously recommended.

Neither building locations nor the individual column loads have been made available to us at this time. Analysis shows that the areal fill ~~will undergo long term settlements~~ on the order of $1\frac{1}{2}$ to 2 inches. It is estimated that shallow spread foundations supporting a total design load of up to 30,000 pounds and proportioned utilizing the bearing pressures presented above will undergo settlement on the order of one-half inch or less.

If necessary, the long term total and differential settlement of each appurtenant structure will be analyzed when the locations and structural loads of these structures are known.

Time-Rate of Settlement - It is estimated that one-~~third~~ tenth to one-half of the maximum settlements tabulated previously will occur as elastic recompression, essentially simultaneously with the load application. The remaining one-half to two-thirds of the maximum settlements will occur in accordance with the time-rates estimated from consolidation test data and presented below.

APPROXIMATE PERCENT OF SETTLEMENT, AFTER RECOMPRESSION	TIME YEARS
20	2
50	10
90	50

Settlement of conventional spread foundations, established on an appreciable thickness of controlled compacted granular fill will occur essentially as the load is applied to the foundation.

LATERAL PRESSURES

The walls of structures below final plant grade. elevation 634, will be subjected to horizontal loads imposed by backfill materials, hydrostatic pressures, and the horizontal components of adjacent foundation loads. Excluding the horizontal components of adjacent foundation loads, it is recommended that long term lateral pressures against rigid and non-rigid walls be computed using the equivalent fluid unit weights tabulated below:

	BACKFILL MATERIAL ADJACENT TO STRUCTURE	EQUIVALENT FLUID UNIT WEIGHT (LBS./CU.FT.)	
		ABOVE WATER LEVEL	BELOW WATER LEVEL
NON-RIGID WALLS:	Sand Soils	40	80
	Clay Soils	50	90
RIGID WALLS:	Sand Soils	60	100
	Clay Soils	80	110

Lateral pressures developed adjacent to rigid walls immediately following placement and compaction of backfill materials may exceed the long term pressures in the portion of the wall near the ground surface. Therefore, we recommend that rigid walls be designed for the equivalent fluid unit weights presented above or a uniformly distributed pressure of 600 pounds per square foot, whichever is greater at any particular depth.

The above recommended equivalent fluid pressures assume backfill soils will be placed in a carefully controlled manner. The stiff to hard on-site clay soils should not be placed as layers of chunky soil which require excessive compactive effort to obtain a homogeneous compacted fill. Such a procedure would increase the equivalent fluid pressure on the order of 50 percent. The use of clay backfill in any areas of limited access is not recommended.

Substructure walls which are established below adjacent foundations should also be designed to resist the horizontal components of adjacent foundation loads. For preliminary analysis of lateral foundation pressures we suggest the method of analysis presented in Spangler and Mickle's* paper "Lateral Pressures on Retaining Walls Due to Backfill Surface Loads." For final analysis, after the final arrangement of facilities, type of backfill, and final loading conditions are known, it is suggested that horizontal components of foundation loads acting on adjacent walls be evaluated by finite element analysis.

UPLIFT PRESSURES

Uplift loads will be resisted by the dead weight of the structures, the weight of the backfill materials, directly overlying the foundations, if any, and the frictional resistance between the structure and the adjacent backfill materials. The unit weight of the backfill materials may be taken as 120 pounds per cubic foot above the assumed ground water level, and 60 pounds per cubic foot below the assumed ground water level. The frictional resistance may be computed by assuming a coefficient of lateral earth pressure equal to 0.35 and a coefficient of friction between soil and concrete of 0.35.

These values apply to backfill soils composed of clean sand and pertain to ultimate frictional resistance to uplift. An appropriate factor of safety on the order of 1.5 for normal operating conditions and 1.2 for maximum probable flood conditions should be applied to the ultimate values.

---

* Spangler, M.G. and Jack L. Mickle, "Lateral Pressures on Retaining Walls Due to Backfill Surface Loads," Proceedings of the International Conference on Soil Mechanics and Foundation Engineering, Vol. 3, P. 155, 1936.

If clay backfill soils are used, the ultimate frictional resistance to uplift may be computed in a similar manner, except that the coefficient of friction between soil and concrete should be reduced to 0.25.

Floor slabs established below the design floor level should be designed for full hydrostatic pressure or should be provided with adequate drainage facilities.

--oOo--

The following Plates and Appendix are attached and complete this report:

Plate 2 - Site Plan (Revised Reservoir and Power Plant Areas)

Plate 3 - Plot Plan (Power Plant Area, Revised)

Plate 4B - Generalized Subsurface Section B-B (Revised)

Plate 5 - Summary of Test Data (Revised)

Appendix - Field Explorations and Laboratory Tests

Respectfully submitted,

DAMES & MOORE

George D. Leal

George D. Leal
Registered Professional Engineer
State of Michigan
Certificate No. 17383

M

5.2 Non-Seismic Category I

Non-Seismic Category I structures, systems and equipment are those whose failure would not result in the release of radioactivity and would not prevent reactor shutdown. The failure of non-Seismic Category I structures, system and equipment may interrupt power generation. 9

Typical Non-Seismic Category I Structures are:

Evaporator Building 6
Turbine Building
Turbine Generator Pedestal
3 Cooling Tower
Intake and Discharge Structures (except service water) 6
Administration Building
Shop and Warehouse
Primary Storage, Condensate and Domestic Water Tanks
Buttress Access Shafts
Radwaste Building 9 6

6.0 CIVIL REQUIREMENTS

6.1 Earthwork

6.1.1 Filling operations shall be performed under the technical supervision of a qualified soils engineer who will perform in-place density tests in the compacted fill to verify that all materials are placed and compacted in accordance with the recommended criteria. 3

RECOMMENDED MINIMUM COMPACTION CRITERIA

PURPOSE OF FILL	ON-SITE SAND SOILS PERCENT RELATIVE DENSITY*	ON-SITE CLAY SOILS PERCENT OF MAXIMUM DENSITY**
Support of Structures	85	-
Adjacent to Structures	75	-
Area Fill (Not supporting or adjacent to structures)	75 7	90

3

* Maximum and Minimum density of sand soils should be determined in accordance with A.S.T.M. Test Designation D 2049-69. 3

** Maximum dry density and optimum moisture content should be determined in accordance with A.S.T.M. Test Designation D1557-70, Method D, as modified by the "Bechtel modified Proctor Test." 6

C-120 - action taken for 9/21/76

Bechtel Power Corporation

Interoffice Memorandum

To: Training File

Subject: Job 7220 Midland Project
Training Session BT 94
Earthwork Backfill Procedures

Date: October 28, 1976

From: D. P. Tanner

Construction

Midland, MI 362

Copies to: R. Ward
D. Perkins
D. Horn
C. Nelson

References: 1) Specification C-210 Rev. 4
2) Specification C-211 Rev. 2

On Wednesday, September 15, 1976, Don Perkins, Civil Superintendent (Yard), gave a training session to Bechtel construction craft personnel. The session lasted approximately ten minutes.

The instruction concerned uncompacted lift thicknesses for soil placement in backfill areas. D. Perkins gave an explanation of Specification C-210 Rev. 4 (Plant Foundation Excavation and Cooling Pond Dikes), Sections 12.5.2, 12.5.3 and 12.5.4 which state, in part, "The uncompacted lift thickness shall not be more than 12 inches. In areas not accessible to roller equipment the material shall be placed in lifts not to exceed 4 inches in uncompacted thickness". D. Perkins also gave an explanation of Specification C-211 Rev. 2 (Structural Backfill), Section 5.2.2 which states, in part, "The uncompacted lift thickness of the backfill material shall be determined by field personnel after evaluation of the proposed compaction equipment. However, in no case shall the uncompacted lift thickness exceed 12 inches".

Those in attendance were:

Laborer General Foreman: K. Parsons
Laborer Foreman: P. McQuire
D. Perkins - Civil Supt

D. P. Tanner
D. P. Tanner

DPT/CHN/dlh

5024-(2-74)

To Midland File: B3.0.3

From GSKeeley/TCCooke, P-14-408B

Date December 4, 1978

Subject MIDLAND PROJECT - DIESEL GENERATOR BUILDING SETTLEMENT MEETING - FILE: B3.0.3 SERIAL: 6175

CC DBMiller/TCCooke, Midland
CAHunt, P-14-209B
DEHorn, Midland

Consumers Power Company

Internal Correspondence

RECEIVED DEC 8 1978
FIELD QUALITY ASSURANCE
MIDLAND, MICHIGAN

On Thursday, November 2, 1978, a meeting was held in Ann Arbor between Bechtel and Consumers Power Company technical people to review the situation on the settlement of the diesel generator foundation. An agenda and names of personnel in attendance are attached (Attachments A and B).

During this meeting the following discussion took place:

I. A. <u>See Attachment C for Listing of Inconsistencies</u>

1. Tuveson of Bechtel stated the following:

C-501 is an AA design guide. Bechtel feels that Geo Tech, although not there full time, performed technical supervision. They did not have a man full time for either dike work or power block backfill.

Geo Tech only reviewed data if field requested them to review and only if field had problems. Bechtel feels that field engineers' personnel involved in compaction were qualified soils engineers and could interpret tests and correlation of tests. CP Co does not feel that they were qualified soils engineers on site (most were right out of school). Bechtel (PAMartinez) had said in July 1974 they would have a man full time on the job, but not the site.

2. Bechtel feels that relaxation of Dames & Moore recommendations is supported by field testing on compaction and the D&M Report does not specify the type of equipment to be used. 1973 testing showed that it varied depending on equipment and material. Would have used different compaction if lifts were 6" - 8". CP Co talked to Rexford about difficulty of monitoring spreading and compaction especially in small areas. Bechtel says they feel as comfortable with 12" lifts as 6" - 8". See J L Corley letter to Connolly, 7/23/74. Don Horn says there were areas around containment where they went above mark. During July 1974 PAM committed to CAH that JWanzek would be on job full time - affected by slowdown.

3. Bechtel does not feel there is any conflict. If backfill froze and then thawed, it should be removed. It was all scraped off (usually 2") and then tested with a pickax.

FEB 8 1979

4. C-501 - On-site sand.

   C-211 - Structural backfill so does not have to be too high a percentage (bought off-site sand). CP Co feels that the Bechtel C-210 specification did not require sand soil to be compacted to 85%. Bechtel feels that whether it is 80% or 85% it has no structural effect assuming the sand meets the gradation for structural sand (imported off-site).

5. Bechtel says that they requested that more borings be done before diesel generator problem and they have now demonstrated that we do have adequate compaction of material in sand lens area questioned.

6. Bechtel says that, in some cases, the wrong standards could be followed and that this was the problem with grade beam. There have been times when inexperienced man could have selected the wrong coorelation. Since the diesel building problem, Bechtel has gone to running proctors as soil is being placed although they had taken some borings after grade beam, but did not see any problems. How many proctors were run as material was removed from borrow pit - none. This would have shown whether technicians were utilizing the correct proctors. Present practices require higher density which is more difficult to obtain watching wheel action in small areas was assumed to be impractical.

7. Should Bechtel modify proctor vs ASTM (see NRC Exit #6 below)?

B. <u>NRC Exit (See Attachment D for Listing of Findings)</u>

1. During construction, we are doing every week on diesel and every 60 days on others. We see no need to change from FSAR commitment.

2. Use of random fill was identified as okay in Dames & Moore and PSAR and as long as adequately compacted is okay. Will change FSAR to indicate random fill will be used. In addressing judgment on area and non-uniformity of soil, we should also cover conservatism of structure design to settlements. The building is a stiff structure and can span settlements.

   DSFR 5-7 Change sand is acceptable not "random fill"

3. Due to various types of equipment, acceptance was performance rather than procedure. Copied from dike work, but not applicable to backfill. The table should be modified.

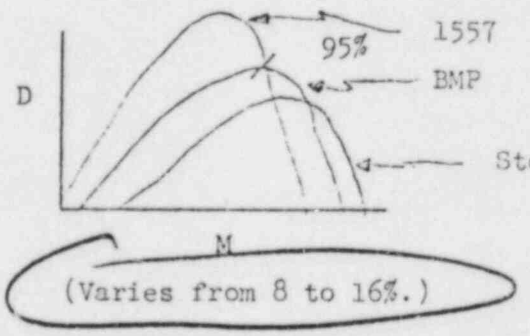
4. Cover this in compaction explanation. Review and change the FSAR. The PSAR said 1/2" is a ballpark figure.

5. Typo; grade instead of actual.

6. C-10 specification in 1969 used four-pass performance specification and test to 20,000 foot pounds Bechtel Modified Proctor (BMP). On restart in 1973, C-10 became C-210 for dike (methods) and performance for rest of fill (testing to BMP with modified - 95% of 1557D). Was added to Section 13 - testing is still based on BMP per Section 12.

   In 1977, Revision 5 was rewritten to 1557 for placement (was rewritten for type of materials - sand). On clays said 95% of 1557. Q-List dike was tested to 95%, but rest was accepted on 4-pass. Test in these areas shown less than 95%. There were 3,000 tests taken.

1557	BMP
95%	100%



*BMP was originally implied to be used for dikes. 20,000 ft lb vs 56,000 ft lb of effort on BMP vs 1557. On other jobs Bechtel uses 95% of 1557. Dames & Moore recommended 95% of 1557 or 100% of BMP. Bechtel does not know why 95% BMP was used - possibly 56,000 ft lb was accidently copied out of the D&M Report. As it ended up, Bechtel used 95% of BMP for everything.

	Referenced 1557 (1968)	BMP (1969)
Under & Support Of	95	100
Adjacent to Structure	90	95
Nonsupportive & Adjacent	90	90

7. Working on. Continue monitoring. The elastic foundation question has not yet been analyzed for the worst case.

8. Will discuss utilities and random fill calculations which are major concerns.

9. Feels no problem and could close up later. It is under observation. 0.02" maximum allowable under ACI architectural.

10. Okay.

11. Will be monitoring. Initial calculations did consider variations on water level.

12. Okay. Check consultant on preload.

13. Okay.

14. Mat foundations not used normally over random fill or in diesel building; Bechtel disagrees.

    Bechtel disagrees on blow count question and noted that tests may have been taken at planes.

    O.K.

15. Does not believe material was placed as indicated (low blow counts).

II. A. <u>Planned Future Actions</u>

1. Start monitoring underground utilities prior to other activities.

    a. Condensate lines - measure gaps and survey (elevation).

    b. Other pipes - measure sleeve gaps - do additional excavation as required.

    c. Get initial readings on adjacent underground pipes.

2. Release the duct banks.

3. Grout gaps between building footings and soil for more uniformity in soil pressure and avoidance of building stress.

4. Check the relative displacement between duct bank and footings - include the off-set duct bank.

5. Run a profile along the bore of pipe beneath the building before and after preloading. Include horizontal and vertical measurements on center line.

6. Monitor condensate pipes and duct banks and check continuity on one duct per bank.

7. Install soils instrumentation.

    a. Building settlement markers.

    b. Piezometer for pore water pressure (in and out).

c. Settlement monitoring of existing fill at varying elev[illegible]

d. Inclinometers.

8. Preparation for surcharge.

a. Three feet of sand will be placed approximately 20' ar[illegible] the outside of the Diesel Generator Building and inside [illegible] Diesel Generator Building for frost protection.

b. Manholes may be utilized in the approximately 2,000 cubic feet of sand.

c. Excavate both sides of duct banks.

d. Protect the turbine generator basement wall, if a surcharge is required in that area.

9. Resolve what will be done in the transformer areas.

B. <u>Scheduling</u>

The duct bank should be cut loose on November 6, 1978. This operation will take approximately 2½ weeks. On November 24, 1978 start [illegible] operation (1½ weeks maximum time estimate). The pond should be [illegible] by January 1, 1979 if at all possible. Instrument preparation sh[illegible] start immediately to complete in 2-2½ weeks. The meeting with consultants will be held on November 7, 1978 in Champaign, Ill. Decision on surcharge will be made November 14, 1978.

It is anticipated that cribbing for the surcharge will be complete by mid-December. NRC confirmation of the planned course of action may be required. Once fill has been started, it will take approximately [illegible] weeks to complete. The surcharge will then remain until approximately [illegible], 1979 (assumption). Removal would take about 2 weeks. It is assumed that work would continue where possible in mechanical and electrical areas. Civil work on Diesel Generator Building would probably continue from March 1, 1979 through May 1979 and complete June 1, 1979. The machine must be turned over on March 1, 1980 for hot functional.

Monitoring operations should start as soon as possible prior to cutting the building loose (initial work has been completed).

The NRC, Darl Hood, will be contacted on November 7, 1978 and a meeting will be set up with Messrs Hood and Lyman Heller.

GSK/cg

Attachment A

Bechtel Power Corporation

MEETING AGENDA

Midland Units 1 and 2
Consumers Power Company
Bechtel Job 7220

DATE: Thursday, November 2, 1978, 10 a.m.

PLACE: Ann Arbor Office, 4 D 5

SUBJECT: DIESEL GENERATOR REVIEW MEETING

ATTENDEES: Consumers Power Company / Bechtel

DISCUSSION ITEMS: (I) CPCo/NRC Questions & Concerns

(A) "Inconsistencies Discovered to Date"

(B) NRC Exit Meeting October 27, 1978

(II) Future Activities

(A) Releasing Duct Banks

(B) Grouting Gaps Under Footing

(C) Utilities Monitoring During Release of Duct Banks

(D) Soil Settlement Instrumentation and Monitoring of Utilities During Surcharging

(E) Preparation for Surcharge

(1) Protective Measures

(2) Frost Protection

(F) Schedule

PP

Attachment B 11/2/7?

Diesel Generator Review Meeting

Attendees:

P. Martinez	BECHTEL
N. Swanberg	"
KARL NIEDNER	"
MO ROTHWELL	✓
B.C. McConnel	—
J.P. Betts	"
M. R Williams	" QA
J.O WANZECK	BECHTEL
STAN BLUE	Bechtel
RN Wheeler	CPCO
DE Sibbald	CPCO
D.E. HORN	CPCo
G.S. Keeley	CPCo.
T.C. COOKE	CPCo.
C. A. Hunt	CPCo
G A TUVESON	Bechtel

ATTACHMENT C

INCONSISTENCIES DISCOVERED TO DATE

1) References:

a. Dames & Moore Report (Page 15)

b. Standard No 7220-C-501, "Civil & Structural Design Criteria" (Page 8)

"Filling operations shall be performed under the technical supervision of a qualified Soils Engineer who will perform in-place density tests in compacted fill to verify that all materials are placed and compacted in accordance with recommended criteria."

Bechtel Field did not have a Soils Engineer on site.

2) References:

a. Dames & Moore Report (Page 14)

b. Bechtel Specifications C-210 and C-211

Dames & Moore - "All fill and backfill materials should be placed at or near the optimum moisture content in nearly horizontal lifts approximately six to eight inches in loose thickness."

Bechtel Specs - C-211, Section 5.2.2 - "However, in no case shall the uncompacted lift thickness exceed 12 inches."

Obviously, these two requirements conflict.

3) References:

a. Dames & Moore Report (Page 15)

b. Bechtel Specification C-211

Dames & Moore - "In addition, no compacted soils should be allowed to freeze. If fill or backfilling operations are discontinued during periods of cold weather, it is recommended that all frozen soils be removed or recompacted prior to resumption of operations."

Bechtel Spec - "No backfill shall be placed upon frozen surface nor shall any frozen material be incorporated in backfill."

This does not address the question of removal or recompaction upon resumption of work.

4) References:

a. Bechtel Design Standard C-501

b. Bechtel Specification C-211

Bechtel Design Standard - Table of Minimum Compaction Criteria

Purpose of Fill -	On Site
Support of Structure	Sand Soil
	Percent Relative Density
	85% (D2049-69)

Spec C-211, Section 5.5.1 - "Cohesionless (sand) material shall be compacted to not less than 80% relative density...by ASTM D. 2049."

Specification and Design Standard conflict.

5) References:

a. Dames & Moore Report (Page 14)

b. FSAR Pages 2-7

c. Drawing C-44

Dames & Moore - "It is recommended that all areas in which the final grade will be raised by placement of fill be stripped of all topsoil and other unsuitable soil if any and be thoroughly proof rolled."

FSAR - "All loose in-site sands, soft or compressible clay soils and organic soils will be excavated in the Turbine Building area."

Bechtel Drawing C-44, Note #4 - "Within the excavation area shown, all loose surficial sands with relative density less than 75% shall be removed."

Added to this drawing 8/23/75.

Boring logs show us that the soil was not removed; however, it may be greater than 75%.

Discussion

The question of whether the loose sands as described in the PSAR were ever removed is a good example of why there should be mechanisms to insure that commitments are properly conveyed to the Construction Group and that the outlined work is successfully concluded. When the note to Drawing C-44 was added, it was too late to economically excavate the loose sand since they had for the most part been covered by backfill.

The attached boring logs and locations confirm existance of the sands, although the blow counts look very good.

6) We question the method used to select the proctors. Errors in reported compaction probably resulted in selection of lower maximum density proctors. See Bechtel letter to US Testing dated February 1, 1978.

Attachment 1

TO RWMarguglio, JSC-220A

FROM DEHorn, Midland DEH

DATE October 31, 1978

SUBJECT MIDLAND PROJECT - NRC EXIT INTERVIEW OF OCTOBER 27, 1978
File: 0.4.2 Serial: 280FQA78

Consumers Power Company

INTERNAL CORRESPONDENCE

CC SAfifi, Bechtel - Ann Arbor
WRBird, JSC-216B
RLCastleberry, Bechtel - Ann Arbor
TCCooke, Midland
JLCorley, Midland
GSKeeley, P14-408B
DBMiller, Midland
JFNewgen, Bechtel

The following people were in attendance at the subject exit interview which was conducted at the end of G. J. Gallagher's inspection of October 24-27, 1978:

CPCo	Bechtel	NRC
RCBauman	WLBarclay	RJCook
TCCooke	ABoos	GJGallagher
JLCorley	RLCastleberry	
DEHorn	LADreisbach	
GSKeeley	PAMartinez	
DBMiller		
BHPeck		
RMWheeler		

Mr. Gallagher stated that the visit was a follow-up on 50.55(e) report of the diesel generator settlement and that it was also a fact finding visit. The inspection consisted of a review of past data, activities in progress and planned activities for future work. Inspection was performed by review of the FSAR commitments; Specification C-210; Specification C-211; PQCI/IR C-1.02; Dames and Moore Report of Foundation Investigation and Preliminary Explorations for Borrowed Materials dated June 28, 1968 and supplement to this report dated March 15, 1969; preliminary data on diesel generator settlement problem including boring plan, cross sections of fill, blow count versus the elevation graphs, lab data, settlement data, boring logs, dutch cone logs, weather data and penetrameter readings in test pits; design drawings C-45, C-109, C-117 and C-1001; soil tests taken in the diesel generator building area during construction compiled by B. T. Cheek, Bechtel QC; observation of soil testing at the test lab and in the field; and discussions with Bechtel Geo-Tech, Project Engineering, Field Engineering, Quality Control Engineering, U.S. Testing, Consumers Power Company, PMO and QA personnel. Mr. Gallagher stated that he would not handle the findings as noncompliances, however, they could become items of noncompliance when they are reviewed by his management.

His findings/observations were as follows:

1. The FSAR states that during operation, settlement readings will be taken every 90 days. Because of the diesel generator settlement problem, this frequency should be re-evaluated for adequacy.

2. FSAR Table 2.5-14 "Summary of Foundation Supporting Seismic Category I Structures" identifies the supporting soil materials under the diesel generator building as being controlled, compacted cohesive soils. However, construction drawing C-109, Rev. 9 and C-117, Rev. 6 identifies the material in this area as Zone 2 material. Zone 2 material is identified as random fill described as any material free of organic or other deleterious materials. In the field a variety of materials have been used for the diesel generator foundation material, in particular, sands, clay, and lean concrete, silty sands and clayey sands. The apparent conflict is that Table 2.5-14 identifies cohesive soils where, in actuality, cohesionless sands have been utilized. A review of the records indicate that sands have been used between elevation 594'-608', areas of elevation 611'-613' and areas between 616'-623'. This indicates the extent of the variability of the material placed under the diesel generator building foundation. Mr. Gallagher did not feel it was good judgement to use random material under the support of a structure.

3. FSAR Table 2.5-21 "Summary of Compaction Requirements" identify random fill to require a compaction effort of a minimum of 4 passes with the specified equipment in this table. This requirement has not been an imposed requirement of Bechtel Specification C-210 nor an inspection requirement of Bechtel Quality Control Instruction C-1.02 for backfill.

4. FSAR section 3.8.5.5 states that settlements of shallow spread footings founded on compacted fill are estimated to be on the order of ½" or less. Site Survey Program has identified settlements in the diesel generator building foundation on spread footings to range from 0.55 inches to 2.30 inches and in excess of 3.0 inches for the diesel generator pedestal.

5. FSAR figure 2.5-47 indicates the foundation of the diesel generator building to be at elevation 634', according to design drawings C-1001, Rev. 5 it is indicated for the diesel generator spread footings and pedestal foundation to be at 628'.

6. A. Specification C-210, section 13.7.1 requires all cohesive backfill in the plant area to be compacted to not less than 95% maximum density as determined by ASTM D1557 method D which requires an effective compactive effort of 56,000 foot-pounds of energy per cubic foot of soil. However, section 13.4 Testing requires testing of the materials placed in the plant area to be performed in accordance with tests listed in section 12.4. This section, in particular section 12.4.5.1, "Cohesive Soils," requires maximum lab densities to be determined using ASTM D1557 Method D provided a compactive energy equal to 20,000 foot-pounds per cubmic foot is applied (Bechtel Modified Proctor Density). To date, the Bechtel Modified Proctor Density for determining maximum proctor density versus optimum moisture content has been utilized. This conflict results in an unconservative method of determining the maximum proctor density and method of assuring that the required percent compaction is achieved. In particular, the actual in-place compaction would be less using the Bechtel Modified Proctor Density as a reference than using the standard ASTM D1557 method D. This is due to the fact that the compactive energy exerted using the Bechtel Modified Method is less than the effort exerted by the standard method D - example: 20,000 foot-pounds versus 56,000 foot-pounds.

6. B. Bechtel Quality Control Instruction C-1.02 section 2.4 testing identifies the applicable inspection criteria and includes Specification C-210, section 13.7 and 12.4 which includes the apparent conflict as described in detail in Part A above.

C. A further review of the original subsurface investigation performed by Dames and Moore and documented in report supplement dated March 15, 1969 page 16 indicates that the recommended minimum compaction criteria for support of structures be 100% of maximum density using a compactive effort of 20,000 foot-pounds (resulting from Bechtel Modified Proctor determination). However, this 100% of Bechtel Modified Proctor corresponds to 95% compaction according to the standard ASTM D1557 method D and not 95% compaction according to Bechtel Modified Proctor method which has been utilized for the entire plant fill area to date. Furthermore, Dames and Moore Report, page 15 states that all fill and backfill material should be placed at or near the optimum moisture content in near horizontal lifts approximately 6-8" in loose thickness. Bechtel specification permits a maximum of 12 inches which affects the compactability of the material.

7. Piping, condensate lines, duct banks, and other utilities under the diesel generator building may also be affected and must be evaluated.

8. Mr. Gallagher stated he was leaving not having seen ~~design~~ settlement calculations and will be discussing design calculations, assumptions made, and conflicts with the FSAR with Licensing.

9. The inspector observed the structural concrete crack that has developed in the east exterior wall. The crack was observed with members from Bechtel Geo-Tech and Consumers Power Company. The crack extended full height of the wall and continued down through the spread footing as seen from the inside of the building. The crack is expected to have been induced flexurally caused by differential settlement. Discussion with Bechtel design staff has indicated that this crack is under study and is currently being evaluated. ACI-318-71 in the commentary section 10.6.4 limits flexural crack exposed to the outside to 0.013". Corrective action may be required if this limit is exceeded.

10. The following tests were observed to be performed in accordance with the applicable tests standards by U.S. Testing:

A. Lab Test ASTM D1557-70

B. Field Test ASTM D/1556-64

11. Calculations should be evaluated on the increase and the rate of increase of the pond fill and the effects of the water in other areas.

12. Mr. Gallagher stated that the NRC does not view preloading of the structure to be a fix or resolution of the problem at this time.

13. Seismic loading calculations should be determined for the type of material existing in its present condition.

DATE December 4, 1978   AA 10/4 ... CONSUMERS POWER

DIESEL GENERATOR BUILDING SETTLEMENT MEETING - FILE: B3.0.3 SERIAL: 6175

CONSUMERS POWER CO. RECEIVED DEC 11 AM

INTERNAL CORRESPONDENCE

CC DBMiller/TCCooke, Midland

DEHorn, Midland

Midland Project

On Thursday, November 2, 1978, a meeting was held in Ann Arbor between ... of Consumers Power Co. ... technical people to review the situation on the settlement of the diesel generator building. An agenda and names of those in attendance are attached (Attachment A & B)

During this meeting the following discussion took place.

1. Tuveson of Bechtel stated the following:

C-501 is an AA design guide. Bechtel feels that Geo Tech, although not there full time, performed technical supervision. They did not have a man full time for either dike work or power block area fill.

Geo Tech only reviewed data if field requested them to review and only if field had problems. Bechtel feels that field engineer personnel involved in compaction were qualified soils engineers and could interpret tests and correlation of tests. CP Co does not feel that they were qualified soils engineers on site (most were right out of school). Bechtel (TJMartinez) had said in ... they would have a man full time on the job, but not the site.

2. Bechtel feels that relaxation of Dames & Moore recommendation is supported by field testing on compaction and the D&M Report does not specify the type of equipment to be used. 1973 testing showed that it varied depending on equipment and material. Would have used different compaction if lifts were 6" - 8". CP Co talked to Bechtel about difficulty of monitoring spreading and compaction especially in small areas. Bechtel says they feel as comfortable with 12" lifts as 6" - 8". See J L Corley letter to Connolly, 7/23/74. Don Horn says there were areas around containment where they went above mark. During July 1974 PAM committed to GAH that JWanzek would be on job full time -- affected by slowdown.

3. Bechtel does not feel there is any conflict. If backfill froze and then thawed, it should be removed. It was all scraped off (usually 2") and then tested with a pickax.

[illegible] CONSUMERS POWER

[illegible]

FILE: B3.0.3 SERIAL: [illegible]

INTERNAL CORRESPONDENCE

DEC 1 1 A.M.

cc [illegible]/TCCooke, Midland

DFHorn, Midland

Midland Project

On Thursday, November 2, 1978, a meeting was held in Ann Arbor between Bechtel & Consumer Power Co. technical people to review the situation on the settlement of the diesel generator foundation. An agenda and names of personnel in attendance are attached (Attachment A & B).

During this meeting the following discussion took place.

I. A. See Attachment C for [illegible]

1. [illegible] of Bechtel stated the following:

C-501 is an AA design guide. Bechtel feels that Geo Tech, although not there full time, performed technical supervision. They did not have a man full time for either dike work or power block backfill.

Geo Tech only reviewed data if field requested them to review and only if field had problems. Bechtel feels that field engineers' personnel involved in compaction were qualified soils engineers and could interpret tests and correlation of tests. CP Co does not feel that they were qualified soils engineers on site (most were right out of school). Bechtel (PAMartinez) had said in July 1974 they would have a man full time on the job, but not the site.

2. Bechtel feels that relaxation of Dames & Moore recommendations is supported by field testing on compaction and the D&M Report does not specify the type of equipment to be used. 1973 testing showed that it varied depending on equipment and material. Would have used different compaction if lifts were 6" - 8". CP Co talked to Rexford about difficulty of monitoring spreading and compaction especially in small areas. Bechtel says they feel as comfortable with 12" lifts as 6" - 8". See J L Corley letter to Connolly, 7/23/74. Don Horn says there were areas around containment where they went above mark. During July 1974 PAM committed to CAH that JWanzek would be on job full time -- affected by [illegible].

3. Bechtel does not feel there is any conflict. If backfill froze and then thawed, it should be removed. It was all scraped off (usually 2") and then tested with a pickax.

[illegible] IDENTIFIED TO DATE

1. References

a. [illegible] & Moore Report (Page 15)

b. Standard No. 7220-G-001, "Civil & Structural Design Criteria" (Page [illegible])

"[illegible] operations shall be performed under the technical supervision of a qualified Soils Engineer who will perform in place density tests in compacted fill to verify that all materials are placed and compacted in accordance with recommended criteria."

Bechtel Field did not have a Soils Engineer on site.

2) References:

a. Dames & Moore Report (Page 14)

b. Bechtel Specs C-210 and C-211

Dames & Moore - "All fill and backfill materials should be placed at or near the optimum moisture content in nearly horizontal lifts approximately [illegible] inches in loose thickness."

Bechtel Specs - C-211, Section 5.2.2 - "However, in no case shall the un[compacted] lift thickness exceed 12 inches."

Obviously, these two requirements conflict.

3) References:

a. Dames & Moore Report (Page 15)

b. Bechtel Specification C-211

Dames & Moore - "In addition, no compacted soils should be allowed to f[reeze]. If fill or backfilling operations are discontinued during periods of cold weather, it is recommended that all frozen soils be removed or recompacted prior to resumption of operations."

Bechtel Spec - "No backfill shall be placed upon frozen surface nor shall any frozen material be incorporated in backfill."

This does not address the question of removal or recompaction upon resumption of work.

Written By
RM Wheeler (CPCo)
@ FOE Meeting
on 11/2/78 -

INCONSISTENCIES DISCOVERED TO DATE

1. References.

a. Dames & Moore Report (Page 13)

b. Standard No. 7220-C-302, "Civil & Structural Design Criteria" (Page 8)

"Filling operations shall be performed under the technical supervision of a qualified Soils Engineer who will perform in-place density tests in compacted fill to verify that all materials are placed and compacted in accordance with recommended criteria."

Bechtel Field did not have a Soils Engineer on site.

2) References:

a. Dames & Moore Report (Page 14)

b. Bechtel Specs C-210 and C-211

Dames & Moore - "All fill and backfill materials should be placed at or near the optimum moisture content in nearly horizontal lifts approximately six to eight inches in loose thickness."

Bechtel Specs - C-211, Section 5.2.2 - "However, in no case shall the uncompacted lift thickness exceed 12 inches."

Obviously, these two requirements conflict.

3) References:

a. Dames & Moore Report (Page 15)

b. Bechtel Specification C-211

Dames & Moore - "In addition, no compacted soils should be allowed to freeze. If fill or backfilling operations are discontinued during periods of cold weather, it is recommended that all frozen soils be removed or recompacted prior to resumption of operations."

Bechtel Spec - "No backfill shall be placed upon frozen surface nor shall any frozen material be incorporated in backfill."

This does not address the question of removal or recompaction upon resumption of work.

Written By:
RM Wheeler (CPCO)
For Meeting
ON 11/2/78-

3. Lab Density per ASTM D-1557 Method D for each in-place density test -

Note - the one point proctor may be used in this case

* The location and test frequency will be as directed by Bechtel - Geotech

If you have any questions please contact me x 389

[signature]

MEMORANDUM

R. K. Siple

B. T. Cheek — DATE 9-29-78

Soils Testing — 7220

- Plant Area Fill -

CC W. L. Barclay
J. Betts
A. Marshall

Per direction of Project Engineering Meeting 9-28-78 and discussion with Messrs J. Betts, A. Marshall and B. Cheek the followings tests are to be performed for the plant area fill.

* Structural Backfill (Sand)

1. In-Place Density per Nuclear Device ASTM D 2922
2. In-Place Density per ASTM D-1556
3. Relative Density per ASTM D 2049 for each in-place density test.

* Random Fill (Clay)

1. In-Place Density per Nuclear Device ASTM D 2922
2. In-Place Density per ASTM D-1556

   Note - When excavating material for in-place test retain enough material to perform a one point proctor @ in-place moisture and enough material for moisture determination

Bechtel Power Corporation

Interoffice Memorandum

To	R. L. Castleberry	File No.	
Subject	Job 7220 Midland Project Foundation Settlement Plan BCBE-1990	Date	July 26, 1978
		From	J. F. Newgen
		Of	Construction
Copies to		At	Midland, MI Ext.

Enclosed are the existing settlement readings as of July 22, 1978.

J. F. Newgen

JFN/CLW/sa

Enclosure

RECEIVED AUG 09 1978 BECHTEL A.A. 7220

JOB 7220	ACT.	INFO.	COPY	INIT.
PROJ. ENGR.		2		—
ASST. P. E. T		1		mol
ASST. P. E. T				
ASST. P. E. P				
ASST. P. E. P				
MECH.				
ELECT.				
CS				
CIVIL			✓	wpatt
P.D.				
ARCH.				
Q.A.				
PROJ. MGR.				
FIELD				
CONST. COORD.				
FSAR				
ADMIN.				
FILE NO. 0275 w/o				

Midland Units 1 & 2
Job 7220-101

MEETING NOTES

DATE: 28 September 1978

LOCATION: Midland Jobsite
Midland, Michigan

SUBJECT: Settlement Observations Some Fill Supported Structures

ATTENDEES:

CPCo.	Bechtel	Consultant
T. C. Cooke	S. S. Afifi	Dr. R. B. Peck
D. E. Horn	J. Betts	
A. S. Pratt	A. J. Boos	
O. E. Sibbald	R. Castleberry	
R. M. Wheeler	B. J. Cheek	
	W. R. Ferris	
	O. H. Holman	
	T. Johnson	
	B. T. LeFevre	
	B. C. McConnel	
	G. Tuveson	
	K. Wiedner	
	A. S. Marshall	

DISCUSSION:

Purpose

The meeting was held to discuss settlements of structures south of the turbine building which are founded on fill. Dr. R. B. Peck was met by W. R. Ferris, S. S. Afifi and G. T. LeFevre on Thursday morning and all drove to the site. Enroute, Dr. Peck was briefed on the general site conditions, settlement observations and preliminary findings of the exploration and testing program. Upon arrival at the site, Dr. Peck was further briefed by client and Bechtel personnel. All parties then toured the site and inspected the buildings where settlements have been reported.

General

1. The reference benchmark for the plant is located outside the plant area and has been checked every six months since 1977.

2. Salt wells in the area are completely capped and monitored. Brine production started in the early 1900's. The salt is located at about 4000 ft. depth.

3. The major settlements noted to date are in structures founded on the fill south of the turbine building. These settlements are based on measurements made on construction scribe marks as reference which should be accurate within 1/4 inch.

a. The diesel building settlements were first noted in July 1978. They now range between 1/2 and 3 inches.

b. The southwest corner of the turbine building has settled 3/4" since May 1977. It may have been influenced by the adjacent excavation for the administration building.

c. West transformer pads settled 2-1/4 inches. Since this measurement was made about 5 feet of crushed stone was placed in the large area surrounding the pads and no settlement of the pads was noted.

d. The service water valve pits (added weight near zero) have settled about 2 inches (1-7/8" and 1-3/8"). No settlement of these pits occurred in the past month.

4. No long term records of ground water table are available for the Midland site.

5. The sand layer below the clay till is located at 150 ft. depth and has a piezometric pressure at elevation 605±. Original ground water surface was assumed at the same elevation.

6. The pond operating level will be between 618 and 627. The pond was filled in March 1978 to about elevation 622. Now the water table in the vicinity of the diesel generator building is at elevation 622.

7. Circulating water lines buried in the plant fill are backfilled with sand and permit water table to rise to pond level in the plant area.

<u>Diesel Generator Building</u>

1. Building dimensions are 70' x 155'. The present foundation pressure is about 2 ksf except under the pads where the pressure is 1 ksf. The expected maximum pressure is 4 ksf static, 5.5 ksf dynamic.

2. Backfill under the building was done during the latter months of 1975 and 1977. Most fill was placed in 1977 which was a dry year (starting in May - latest placed in October). Most fill was placed with rolling equipment. The material was brought in by trucks, spread by a dozer and compacted with a vibratory sheepsfoot roller. Duct banks were put into the fill by digging trenches and backfilling.

3. Construction scribe marks were used to check settlement. Dates when these marks were set is not precisely known. However, the concrete was poured in the period March-May 1978, first pour in October 1977. The settlement was first noted in July 1978. Initial values are referred to the initial elevation of construction

scribe marks which are accurate within $\pm 1/4"$. The monitoring is being continued.

4. At the east end of the building, there are places where the foundation is separating from the mud mat below. This indicates that the building may be arching over hard spots or the fill may be settling under its own weight.

5. A trench along the east end of the building was excavated to a level below the foundation to install electrical duct bank.

6. The clay fill under the building came from the pond and the sand fill around the piping is imported. No on-site sand was used. The clay fill is random with varying sand content. It came from a stock pile that was used between 1975 and 1977.

7. The first footing was placed in October 1977. It was covered and heated.

Exploration and Testing

1. The exploration program consists of borings to conduct standard penetration tests, obtain Shelby tube samples (3" to 5" diameter), and obtain information on ground water table. Also Dutch cone measurements are being made to correlate with test samples.

2. The laboratory testing consists of unconfined compression tests, unconsolidated-undrained triaxial tests, consolidation tests, classification tests, Atterberg limit and grain size tests, and clay mineral analyses. Compaction tests will also be made to develop Proctor curves and conduct strength and consolidation tests on samples dry and wet of optimum. Samples prepared dry of optimum will also be tested for strength and consolidation after saturation. Consolidation samples will be first loaded to 1 ksf without water, then they will be flooded to determine the corresponding settlement.

3. Test pits will be made to determine in-situ density, obtain sufficient samples for Proctor tests and conduct pocket penetrometer tests.

Comments by Dr. Peck

1. Make test pits at a number of locations and carve large size samples for density and Proctor testing.

2. Look carefully at tes pit walls. Take pocket penetrometer readings along the sides of the test pits on a grid pattern.

3. Plot settlement of the building at different times and show contours of equal settlement to see if the building is equalizing. This will indicate how stiff the building is. Add settlement points if necessary.

4. The fill is probably settling under its own weight in combination with settlement due to the building weight. The till material may have been placed in dry chunks with some voids. When the material is dry the top will get well compacted and the bottom will not. Following this, a small change in moisture will probably result in increased compressibility.

6. Settlement may not be related to applied loads. It will be helpful to monitor light structures on the fill near pond.

7. Regional subsidence.

   a. Make sure external benchmarks are satisfactory.

   b. Obtain the Dow records of settlement.

8. Install borros settlement gages at several depths to determine rate and seat of settlement.

9. Install observation wells around the fill in the plant area.

Dr. Peck said that it was too early to discuss a fix as all of the exploration testing and observational data were not yet available. He also said that he will read and digest the preliminary data given to him and may have some additional comments to make on the investigation.

S. S. Afifi

SSA/lap

—ephone call

BECHTEL

CC:
XXXXX S. Rao-AAO

G. Tuveson-AAO
G. Richardson
F. Teague
A. Boos
W. Barclay
File

BY J. Hook OF QA - Site

TO S. Rao OF AAO

DATE October 7, 77 TIME 2:00

JOB NO 7220

SUBJECT Bechtel Modified Proctor

QUESTION:

Is the intent of para. 13.7 of spec. 7220-C-210 that the test be run to the "Bechtel" modified proctor test as is indicated in the FSAR para. 2.5.4.5.3 and in the response to NCR-88.

10/7/77 @ 3:25 pm

ANSWER

Yes

Jon G. Hook

0046 (12-67)

BECHTEL CORPORATION
POWER DIVISION

Telephone call

Route J. HOOK
C. RICHARDS
B. CHEEK
B. WARD

By F. G. TEAGUE Of SITE

To S. RAO Of AZ

Date 10/7 19 71 Time [illegible]

Subject: SPEC C-210 BACKFILL TESTING Job No. 7220

TEAGUE Q.A. HAS ASKED FOR CLARIFICATION OF SUBJECT SPECIFICATION, SECTION 13, FOR PLANT AREA + BERM BACKFILL. SECTION 13.4 FOR TESTING OF MATERIALS REFERS TO SECTION 12.4 AND THEREFORE REQUIRES THE BECHTEL MODIFIED PROCTOR DENSITY TEST FOR COMPACTION OF COHESIVE BACKFILL. SECTION 13.7 FOR COMPACTION OF THE SAME MATERIALS REFERS TO TESTING IN ACCORDANCE WITH THE ASTM D-1557, METHOD D PROCTER, WITHOUT SPECIAL REFERENCE TO THE BECHTEL MODIFICATION.

RAO THIS APPARENT CONFLICT IS CLARIFIED BY SPEC. C-208 SECTION 9.1.9, DIRECTIONS TO THE TESTING SUBCONTRACTOR, WHICH CALLS FOR THE ASTM-D155 TEST FOR THESE MATERIALS AND ALSO ALLOWS BECHTEL FIELD (THE CONTRACTOR) TO CALL FOR THE BECHTEL MODIFICATION OF THAT TEST. EITH METHOD IS THEREFORE ACCEPTABLE TO PROJECT ENGINEERING.

[signature]

Telephone call

BY R. Grote OF B. Midland ROUTE Valenzano

TO R. Rixford OF B.A.A.O. Church

DATE Sept. 18, 74 TIME 2:15 P.M. File C-210

SUBJECT Compaction Requirements in Q-list Fills JOB NO. 7220

I called R. Rixford concerning compaction requirements for specification C-210. He was in agreement with the following summarization of compaction requirements:

"1-Q Dikes (method spec)

Compaction ~~is~~ acceptance is based on moisture conditioning and 4 passes with a 50-ton rubber tired roller (or equivalent roller)

Q-list Plant Area Fill ("end product" spec)

Compaction acceptance is based on meeting an "end product" requirement, i.e. 95% of maximum density only. No method of acheiving this "end product" is specified or is required. The subcontractor can use any equipment he chooses as long as he acheives 95% maximum density.

Rixford fully agrees with the above summarization.

R. Grote
9/18/74

JLC	
REW	
DRK	
DFH	
FILE	
RETURN	

Bechtel Power Corporation

Interoffice Memorandum

To J. P. Connolly

Date October 1, 1974

Subject Job 7220 Midland Project
Geotechs Responsibility on
Earthwork Subcontract
0-817

From T. C. Valenzano

Of Construction

At Midland, Michigan

Copies to

This is in response to your request for clarification of Geotech's responsibilities during summer 1973: Geotech's responsibilities were that of providing design assistance to project engineering and assistance to field engineering and QC. Furthermore, Geotech has the responsibility for being cognizant of all phases of the soils work in both engineering and construction. It is their responsibility to be assured that the design is properly interpreted, construction properly performed, and the specified testing requirements properly implemented, and if they are not satisfied, to advise appropriate management personnel. It was within this context that Geotech was allowed to perform acceptance validation for both field engineering and quality control.

This was done because sufficient numbers of experienced Bechtel field engineering and quality control personnel were not available on the site. Geotech's assistance was requested for this reason.

Sufficient numbers were later made available and Geotechs services as an acceptance authority was delegated to QC and field engineers for Q and non-Q work respectively.

T. C. Valenzano
T. C. Valenzano

TCV/sw

FSAR-
sect 2.5.4.2.6
Corp. Testing

5024 (10-72)

C-67-50

Telephone call

BY C. A. Hunt	OF CPCo - Jackson	ROUTE J. C. Hink	R. L. Castleberry
TO F. L. Rixford	OF B-Ann Arbor	xc: J. H. Allen	
DATE 9-19-74	TIME 9:30	File xc: C-210PL, C-1140	
SUBJECT Method of Compaction of Plant Area Fill		JOB NO 7220	

Chuck called to express a concern on the part of Consumers' personnel about what they feel is a lack of control of compaction in the plant area fill.

Chuck asked why Canonie was not using a roller for compaction in the plant area. I told him the specification required only that the end result be 95% of ASTM 1557 - there was no restriction on the equipment used to attain it. After a lengthy discussion on this point, we addressed the added responsibility this lack of control places upon the inspector. Chuck wanted to know where the inspector was instructed how to assure adequate compaction in the absence of a formal compaction procedure. I told Chuck that this was the inspector's job - to make sure we get proper placement, compaction, etc.

Chuck finally agreed that a phone call (followed up by an IOM) to the field, reminding them that increased vigilance on the part of the inspectors would be required in areas where compaction methods aren't specified, would satisfy CPCo's concern about control of compaction in the plant area.

This is ridiculous. Very slow routing or mail system.

RECEIVED

BECHTEL GEOTECH

12

BECHTEL

Telephone call

BY ______ OF ______

TO ______ OF ______

DATE ______ 19 ______ TIME ______

SUBJECT ______

ROUTE Valenzano
Church
File C-210

JOB NO. ______

I made an analogy (an exaggeration admittedly, but applicable) that if the compaction could be acheived with a herd of mules walking over the fill it would be acceptable as long as I got the required 95% compaction. Rixford agreed.

R. Brotz
9/18/79

0046 (12-67)

BECHTEL

MEMORANDUM

TO J. C. CHURCH LOCATION MIDLAND NUCLEAR PL

FROM J.C WANZECK GEOTECH DATE SEPT 18 19 74

SUBJECT COMPACTION REQUIREMENTS JOB NO. 7220

PLANT ZONE II FILL FILE

SPECIFICATION 7220-C-210 REV 2

SECTION 13.0 PLANT AREA BACKFILL & BERM BACKFILL.

HEREIN WE ADDRESS 13.7 COMPACTION REQUIREMENTS ONLY

IT IS OUR OPINION THAT ALL THE COMPACTION REQUIREMENTS THAT ARE NEEDED FOR ZONE II MATERIAL IN THE PLANT FILL IS AS STATED IN 13.7 WITH THE EXCEPTION THAT ZONE 4, 4A, 5, 5A AND 6 MATERIALS NEED NO SPECIAL COMPACTIVE EFFORT OTHER THAN DESCRIBED IN SECTION 13.8.1

J.C. Wanzeck

CC: J ALLEN
SS AFIFI
FILE ANN ARBOR

Bechtel Associates Professional Corporation

Inter-office Memorandum

BEBC - 456

To E. E. Felton

Date August 1, 1974

Subject Midland Plant Units 1 & 2
Job No. 7220
Structural Backfill
File: C-211, 0274, C-1140

From R. L. Castleberry

Of Engineering

At Ann Arbor

RECEIVED
AUG - 6 1974
BECHTEL POWER CORP.
JOB 7220
PER________

Copies to
J. C. Hink
J. H. Allen
S. S. Afifi

Reference: A) BCBE-370, 7-25-74

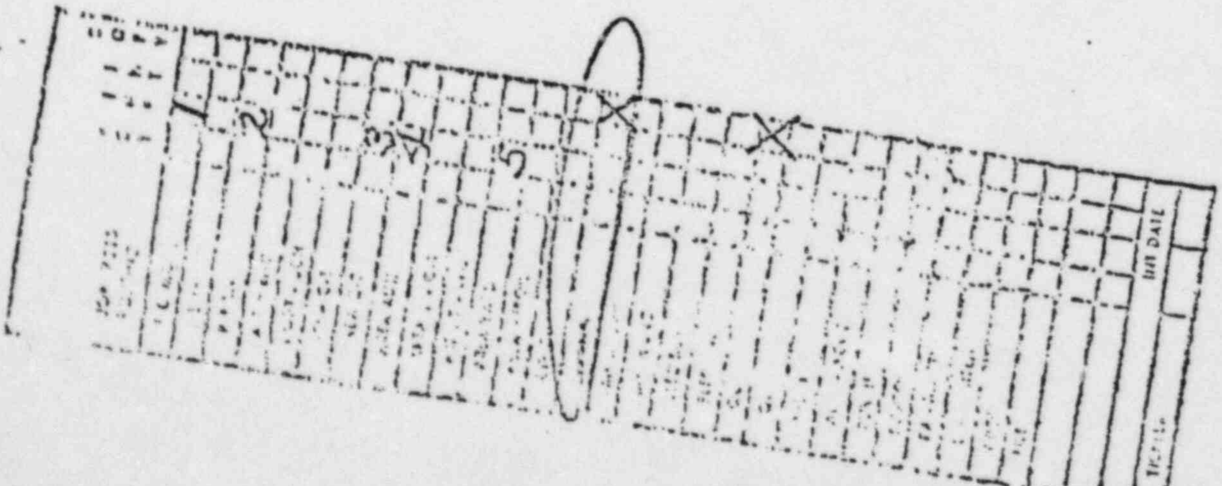
Field Engineering's understanding of the intent of the Structural Backfill specification, as expressed in reference A, is correct in all respects - with one minor clarification.

The last sentence of paragraph 3 of reference A states, "Only backfill against Class 1 structures is 'Q' listed." To be accurate this statement should be, "Only structural backfill against Class 1 structures is 'Q' listed." This would prevent a future attempt to wrongly apply this statement to other non-structural backfill, such as backfill over a Q-listed electrical duct bank.

Work is continuing on the three outstanding items, requiring project engineering action mentioned in reference A. Item 1 is being prepared within the Civil group, items 2 and 3 are being addressed by Geotech.

R. L. Castleberry

RLR/jef



by the Contractor. The rolling requirements for each zone of the dikes and embankment are as follows:

Zone	Type of Compaction Equipment	Minimum Number of Passes per Lift
1	50-ton Rubber Tired Roller	4
1A	50-ton Rubber Tired Roller	4
2	50-ton Rubber Tired Roller	4
3	50-ton Rubber Tired Roller or Vibr. Roller	4
4	Construction Equipment routed over the zone or additional rolling as directed by Contractor	-
4A	50-ton Rubber Tired Roller as directed by Contractor.	-
5	Not Required	-
5A	Not Required	-
6	Not Required	-

A pass shall consist of the entire coverage of the area with at least one trip of the equipment specified. In order to effect complete coverage of the area being rolled, each trip of the roller shall overlap the adjacent trip by not less than 2 feet. Dumping, spreading, sprinkling, disking, or harrowing, and compacting may be performed at the same time at different points along the section where there is sufficient area to permit these operations to proceed simultaneously.

12.8.2 Additional Rolling

If, as determined by the Contractor, the desired compaction of any portion of embankment is not obtained by the minimum passes specified, additional passes shall be made over the surface area of such designated portions of the embankment until the desired degree of compaction has been attained. However, where lift thickness is greater than specified, or moisture content at time of rolling is improper or specified rolling has not been performed, such rolling shall be by and at the expense of the Subcontractor.

13.6 Moisture Control

Moisture control of the plant area and berm material shall conform to Section 12.6.

13.7 Compaction Requirements

All backfill in the plant area and the berm shall be compacted to not less than 95 per cent of maximum density as determined by modified Proctor method (ASTM 1557, Method D), with the exception that Zone 4, 4A, 5, 5A, and 6 materials need no special compactive effort other than as described in Section 12.8.1.

13.8 Slides and Winter Protection

All provisions for slides and winter protection shall be similar to requirements in Sections 12.9 and 12.10

13.9 Measurement & Payment

13.9.1 Measurement

Embankment will be measured in place to the nearest cubic yard of embankment material of the various zones, satisfactorily placed and compacted in the plant area and the berm. Such measurement will be made between the foundation lines as determined by survey in the field and the neat fill lines, grades and slopes shown. No allowance will be made for settlement of the foundation or of the embankment during construction.

13.9.2 Payment

Embankment will be paid for at the applicable contract price stated in the Price Schedule for the items listed below.

P. A. Martinez

July 25, 1974

Job 7220 Midland Project
Structural Backfill
Specification 7220-C-211, Rev. 0
BCBE-370

E. E. Felton

Construction

Midland, Michigan

M. M. Krout
K. A. Lawes
J. C. Hink
J. H. Allen
J. F. Newgen

On July 23, 1974, R. Grote contacted R. Rixford for clarification of structural backfill requirements per Specification 7220-C-211, Rev. 0. The following discussion confirms that conversation and outlines how the field will proceed with construction.

The structural backfill material required by Specification 7220-C-211, Revision 0, is required to be placed only within three feet of the exterior wall of any plant area structure. This material is not required under a structure. Beyond the three feet line and under Class 1 structures, Zone 2 material at 95% compaction is all that is required. This does not prevent the field from placing the cohesionless material required by C-211 beyond the three feet line if we choose to do so. It would be permissable to use the cohesionless material for all backfill, however, it is not required.

Specification 7220-C-211 is to be followed for placing all backfill within three feet of exterior walls of all plant area structures. This requirement, however, does not make all structural backfill Q-Listed. Only backfill against Class 1 structures is "Q" Listed.

Outstanding items requiring project engineering action are as follows:

1. Drawing SK-C-355 which is referenced in Section 7.0 of Specification 7220-C-211 has not been transmitted to the field.

2. Response to BCBE-319 is required. (Letter transmitted 6/5/74.)

3. Is the 95% compaction required in the plant area to be 95% of Bechtel Modified or 95% of ASTM 1557, Method D?

Please reply by July 31, 1974 if you have any questions on the above. We have been attempting to resolve this matter for many months and hope this letter serves that end.

ORIGINAL SIGNED BY E. E. FELTON

E. E. Felton

EEF/RAG/al

Church
SERAFIN
ISSLEMAN

Bechtel Power Corporation

Interoffice Memorandum

To	J. C. Church	Date	June 24, 1974
Subject	Job 7220 Midland Project Specification 7220-C-210 Paragraph 13.7 7220-C-210-23	From	T. C. Valenzano
		Of	Construction
Copies to		At	Midland, Michigan

We have reviewed your June 10, 1974 ICM concerning compactive effort required on Zones 1 and 2 in the plant and berm backfill areas. We agree with your interpretation; i.e., a 95% of maximum density is the acceptance criteria, and the number of roller passes listed in Paragraph 12.8.1 does not apply to plant and berm backfill. We feel that the specification is now clear, and no FCR is required.

T. C. Valenzano

T. C. Valenzano

TCV/RAG/bk

NOTE
June 10, 74 memo
To John Church

5024 (10-72)

Bechtel Power Corporation

Interoffice Memorandum

To T. C. Valenzano

Date June 10, 1974

Subject Job 7220 Midland Project
Subcontract 7220-C-210
Item 13.7 Compaction Requirements
7220-C-210-17

From J. C. Church

Of Subcontracts

At Midland, Michigan

Copies to J. P. Connolly

There has been some confusion as to the interpretation of the following item.

13.7 COMPACTION REQUIREMENTS

All backfill in the plant area and the berm shall be compacted to not less than 95 percent of maximum density as determined by modified Proctor method (ASTM 1557, Method D), with the exception that Zone 4, 4A, 5, 5A, and 6 Materials need no special compactive effort other than as described in Section 12.8.1.

The question that has been posed by the Quality Control people is: does the exception stated above apply only to Zone 4, 4A, 5, 5A, and 6 or do we also have to abide by Section 12.8.1 for Zones 1 and 2? Our interpretation is that for the plant and berm areas, all we need to obtain is a compaction of not less than 95 per cent of maximum density as determined by modified Proctor method (ASTM 1557, Method D), with no restrictions as to the method used to obtain these results.

Attached find a memo from Quality Control and a Field Change Request on the above subject. Because of time element for this item, your immediate action on this would be appreciated.

John C. Church

John C. Church

JCC/JRS/ja

Attachment

5024 (10-72)

BECHTEL P[illegible] ER CORPORATION

FIELD CHANGE REQUEST

PROJECT NO 7220

1. P[illegible] 1 OF 1

Q No.

2. No.

3. DATE MO DAY YR 6 10 7[illegible]

4. REF. DWG. OR SPEC. 210, 13.7

REV. 0

5. TITLE Baffle and Cooling Pond Dikes

DESIGN ORIGIN. ENGRG [X] VENDOR [ ] (IDENTIFY) NAME

7. EXISTING CONDITION:

Compaction requirements of Specification 13.7

8. CHANGE REQUEST/SKETCH

Clarify Specification 13.7 as to whether or not four (4) equipment passes are additionally required for Zones 1 and 2 along with 95% maximum density.

Section 13.7 should read as follows:

> All backfill in the plant area and the berm shall be compacted to not less than 95% of maximum density as determined by modified Proctor method (ASTM 1557, Method D) regardless of compactive method. The exception shall be that Zone 4, 4A, 5, 5A, and 6 Materials need no special compactive effort other than as described in Section 12.8.1.

10. REVIEWED BY: Date

CIVIL

ELECT.

PLANT DESIGN

INSTRUMENTATION & CONTROL

MECH.

WELDING

9. PREPARED BY: [signature]

11. APPROVAL OF FIELD DISPOSITION:

Project Field Engineer Date

12. PROJECT ENG'R'G APPROVAL: YES [ ] NO [ ] PROJ. ENGR.: Date

REMARKS:

Bechtel Power Corporation

Interoffice Memorandum

To John Church

Subject Roller Passes in "Q" Area
QCFM-194

Copies to L. Albert
D. Horn

Date June 6, 1974

From J. P. Connolly

Of Quality Control

At Midland, Michigan
Job 7220

Letters signed by you on September 18, 1973 and October 5, 1973 indicate that four (4) machine or equipment passes should be made by either the Hyster C455A No. 1125 or the Caterpillar 835 sheepsfoot roller to attain the proper compaction requirements stated in paragraph 12.8.1 of Spec. C-210, Rev. 2.

Robert Haney of Canonie Construction Company feels that under paragraph 13.7 of Spec. C-210 Rev. 2, he is not held to any specified number of passes as long as he achieves 95% of maximum density.

Don Horn of Consumers Power Company feels that they are held to the four (4) passes and 95% of maximum density. Quality Control is also of the opinion that four (4) equipment passes are required because of existing documentation. The situation could be clarified with an F.C.R. to the effect that in the Q-Listed areas. No specified number of passes would be required as long as 95% of maximum density was achieved.

Please resolve this situation as soon as possible.

J.P. Connolly

J. P. Connolly

JPC/LVH/jmw

5024 (10-72)

canonie CONSTRUCTION COMPANY / P.O. BOX 509 / U.S. 31 & M 3 / SOUTH HAVEN, MICHIGAN 49090 / (616) 637 1171

Relevant to your request for compaction equipment clarification, Canonie Construction proposes to furnish the following equipment for compaction:

Zones 1, 1A, and 2	-	Cat 835 Compactor or Hyster C-455A
Zone 3	-	CF43 Vibro Plus Compactors Tri-plex Arrangement
Proof Rolling	-	Raygo Rumbler Compactor

We propose to utilize the above compaction equipment on monitored test fills within the embankment and will employ the contractors testing lab to perform the necessary tests to certify the subject equipment and method as satisfactory to meet the contractors compaction spec.

We are presently preparing, at your request, revised hourly, daily, weekly, and monthly equipment rental rates for your review. We will transmit these on June 18, 1973.

We trust we have clarified the subject items and hope to hear from you at your earliest convenience.

Very truly yours,

CANONIE CONSTRUCTION COMPANY

Arnold Palanca
Vice President

AP:jkb

Enclosures

8.2 Mechanical Splices

Samples of mechanical splices shall be taken and tested as specified in Technical Specification 7220-C-255. Samples of the splices, including a length of reinforcing bar on each side of the splice, will be removed from the work by the Contractor for testing. The samples shall be tested to failure and reports of the tensile strengths submitted to the Contractor within 7 days after the test samples are furnished. **Tensile tests** shall meet the requirements specified in Technical Specification 7220-C-39. Arrangements for the off-site testing shall be made by the Subcontractor. Test specimens shall be kept by the Subcontractor.

Same from Rev 1 to Rev 14

9.0 TESTING OF SUBGRADE, EMBANKMENTS, AND STRUCTURAL BACKFILL

The following tests on embankments and subgrade fills and structural backfill shall be made by the Subcontractor; frequencies shall be in accordance with Table 9-1 attached.

9.1 On-Site Field and Laboratory Tests

a. Compaction tests in accordance with ASTM Test Designation D1557. When directed by the Contractor, these tests shall be modified by preparing the sample in four layers, each compacted with 25 blows of a 10 lb. rammer falling 18 inches giving compactive energy equal to 20,000 ft. lbs/cu ft. ("Bechtel Test"). The mold to be used shall have a diameter of 6 inches.

b. Relative density of cohesionless materials in accordance with ASTM D2049.

c. Field Density Tests for sands and fine material in accordance with ASTM D1556, and on gravels with the above as modified by USBR E 24 as described in USBR Earth Manual. Other methods of field density determination such as a nuclear density device may be used in accordance with ASTM D 2922 and using manufacturer's instructions provided that the the results are compactible with those obtained by the specified procedure. Compatability of other methods will be determined by the Field Engineer. 3 13

UNCONTROLLED NOT TO BE USED FOR CONSTRUCTION

d. Atterberg Limit Tests for Liquid and Plastic Limits in accordance with ASTM D423 and 424.

e. Grain Size Analysis in accordance with ASTM Designation D422, except that the hydrometer test is not required 11

f. California Bearing Ratio Tests in accordance with ASTM Designation D1883 shall be made by the Subcontractor on embankment and subgrade fills to determine the relative bearing values required for the design of asphalt concrete pavement.

A

Note:

The contents of this package are maintained in a three-ring notebook by Eugene Gallagher which is labeled "Midland Soils Investigation" - Volume 2.

B