LOG OF BORING NO. B-2

OWNER
St. Joseph Water Works

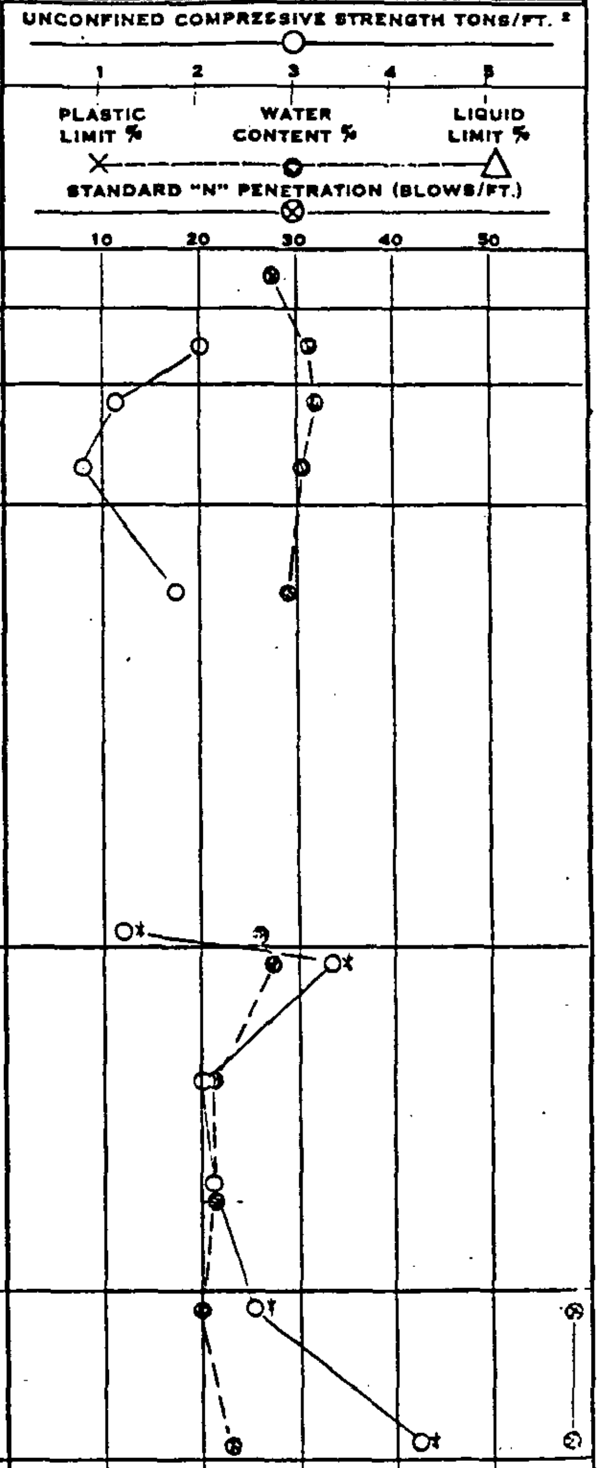
ARCHITECT - ENGINEER
American Water Works

SITE
St. Joseph, Missouri

PROJECT NAME
Proposed Chemical Plant

SURFACE ELEVATION 821.9

DEPTH ELEVATION	SAMPLE NO.	TYPE SAMPLE	SAMPLE DIST.	RECOVERY	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT.³
	1	ST			"A"	93
	2	ST			Silty clay - gray and brown - very tough (CL-CH)	87
	3	ST			Silt, trace clay and fine sand - gray and brown - loose (ML)	86
10.0	4	ST				91
	5	ST			Silty clay - dark brown - tough (CL)	-93
20.0	6	3" ST				
	7	3" ST				
	8	ST				
30.0	8A				Sandy clayey silt with pieces of broken limestone - brown mottled with yellow - medium dense (SC-SM)	
	9	ST				107
40.0	10	ST				90
	11	SS			Silty clay, trace sand and gravel - gray and brown - very tough (CL)	
49.5	12	SS				
					End of Boring	



*Calibrated Penetrometer

"A": Fill, clayey silt, trace sand, cinders, and rubble - dark brown

WATER LEVEL OBSERVATIONS

W.L. 11.5' W.S. OR W.D.

W.L. B.C.R. A.C.R.

W.L. 11.0' A.B.

SOIL TESTING SERVICES
INC.
111 PFINGSTEN ROAD
NORTHBROOK, ILLINOIS

BORING STARTED 11/28/67
BORING COMPLETED 11/28/67
RIG
FOREMAN
DRAWN MP
APPROVED CNB
JOB # 8908-D
SHEET 1 OF 1

LOG OF BORING NO. B-3

OWNER
ST. JOSEPH WATER WORKS

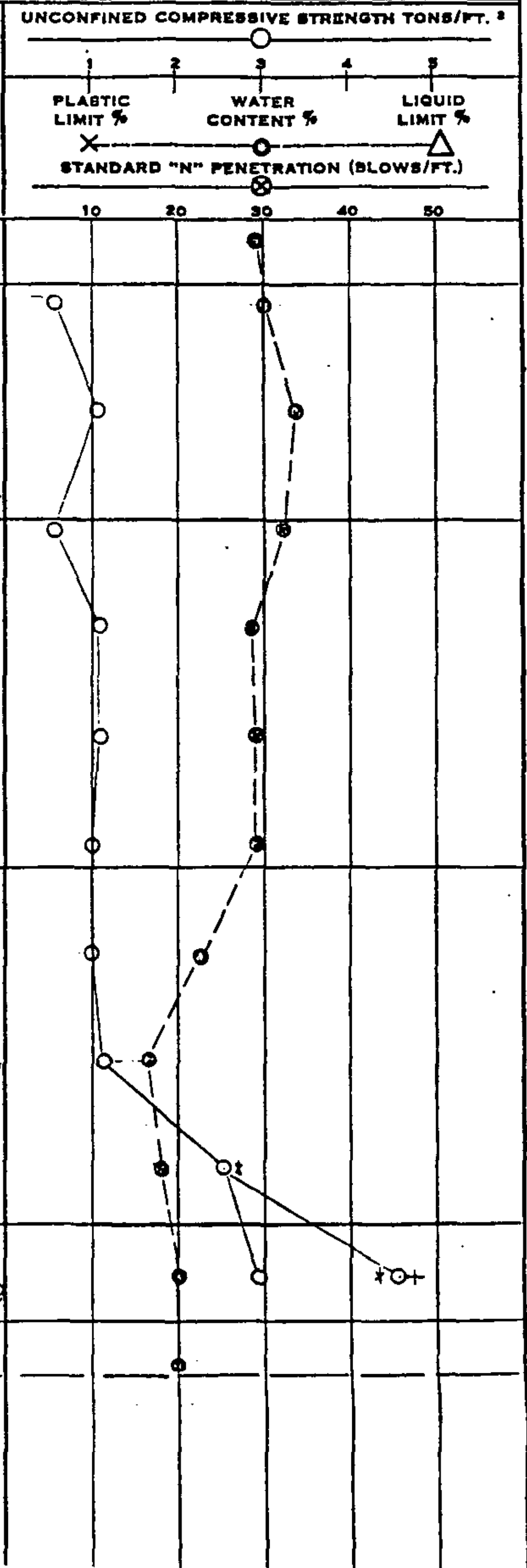
ARCHITECT-ENGINEER
AMERICAN WATER WORKS

SITE
ST. JOSEPH, MISSOURI

PROJECT NAME
PROPOSED CHEMICAL PLANT

SURFACE ELEVATION 821.4

DEPTH ELEVATION	SAMPLE NO.	TYPE SAMPLE	SAMPLE DIST.	RECOVERY	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT.³
	1	ST			FILL, CLAYEY SILT, TRACE SAND, CINDERS AND RUBBLE - DARK BROWN (FILL)	
	2	ST			SILT, TRACE CLAY AND FINE SAND - GRAY AND BROWN - LOOSE (ML)	87
10.0	3	ST				85
	4	ST				
	4A	ST			CLAYEY SILT WITH PIECES OF BROKEN LIMESTONE - GRAY - LOOSE TO MEDIUM DENSE (ML-CL)	84
20.0	5	ST				91
	6	ST				91
30.0	7	ST				94
	8	ST			SANDY CLAYEY SILT WITH PIECES OF BROKEN LIMESTON - BROWN, MOTTLED WITH YELLOW - MEDIUM DENSE TO DENSE (SC-SM)	97
40.0	9	ST				107
	10	ST				
50.0	11	ST			SILTY CLAY, TRACE SAND - GRAY AND BROWN - VERY TOUGH TO HARD (CL)	109
	12	SS			GRAY SHALE	



CONTINUED ON PAGE 2

LOG OF BORING NO. B-3 (CONTINUED)

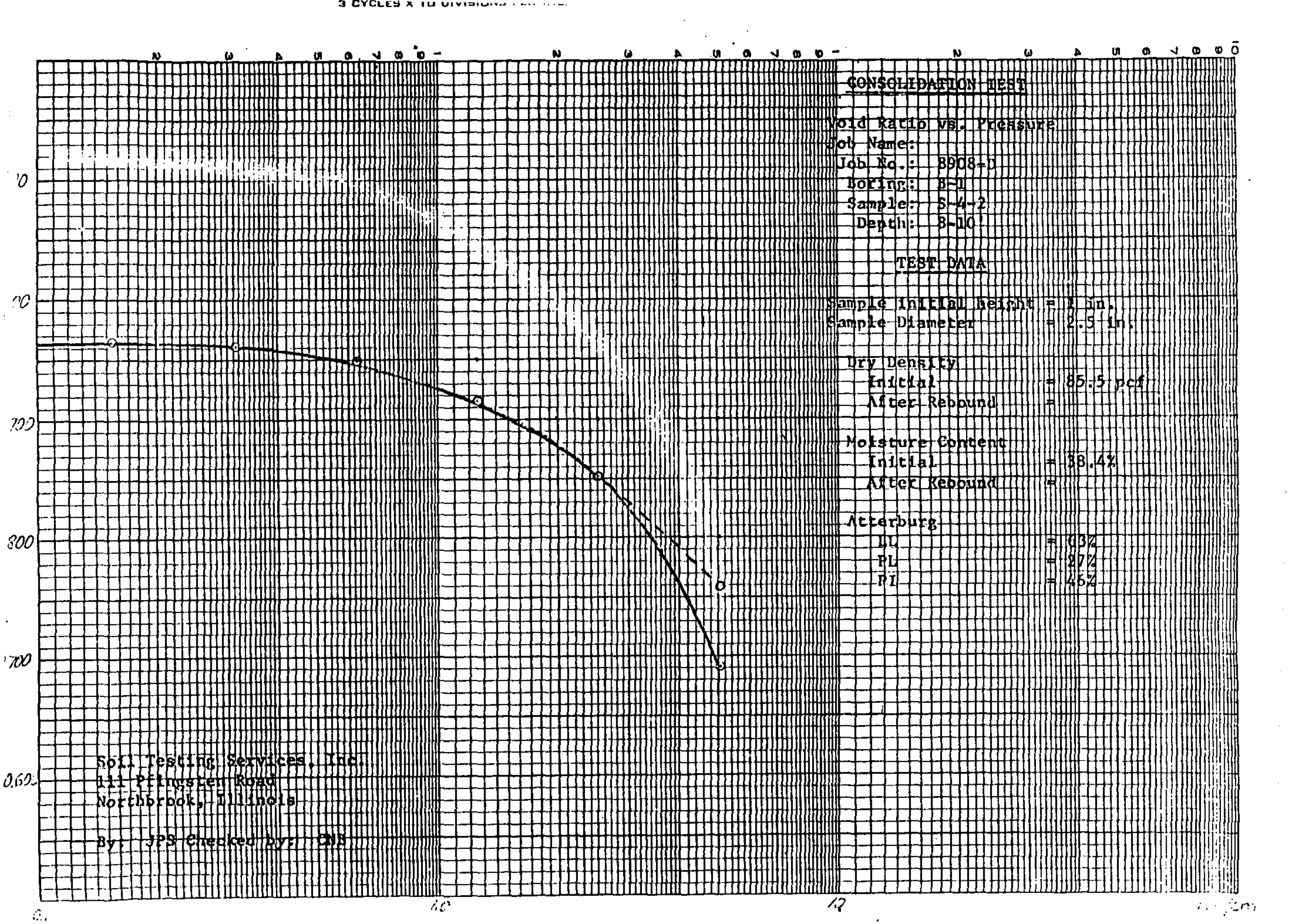
OWNER St. Joseph Water Works	**ARCHITECT - ENGINEER** American Water Works
SITE St. Joseph, Missouri	**PROJECT NAME** Proposed Chemical Plant

DEPTH ELEVATION	SAMPLE NO.	TYPE SAMPLE	SAMPLE DIST.	RECOVERY	DESCRIPTION OF MATERIAL SURFACE ELEVATION	UNIT DRY WT. LBS./FT.³	UNCONFINED COMPRESSIVE STRENGTH TONS/FT.² ○ 1 2 3 4 5 PLASTIC LIMIT % × WATER CONTENT % ● LIQUID LIMIT % △ STANDARD "N" PENETRATION (BLOWS/FT.) ⊗ 10 20 30 40 50
☒							
					Continued from page 1		
		SS			Gray shale		60/1"
60.0							
67.0							
					End of Boring Power Auger Refusal at 67.0'		*Calibrated Penetrometer

WATER LEVEL OBSERVATIONS		
W.L.		W.S. OR W.D.
W.L.	B.C.R.	A.C.R.
W.L.		

SOIL TESTING SERVICES
INC.
111 PFINGSTEN ROAD
NORTHBROOK, ILLINOIS

BORING STARTED 11/29/67	
BORING COMPLETED 11/29/67	
RIG	FOREMAN
DRAWN MP	APPROVED CNB
JOB # 8908-D	SHEET 1 OF 1



CONSOLIDATION TEST

Void Ratio vs. Pressure
Job Name:
Job No.: 8908-D
Boring: B-1
Sample: S-4-2
Depth: 8-10'

TEST DATA

Sample Initial Height = 1 in.
Sample Diameter = 2.5 in.

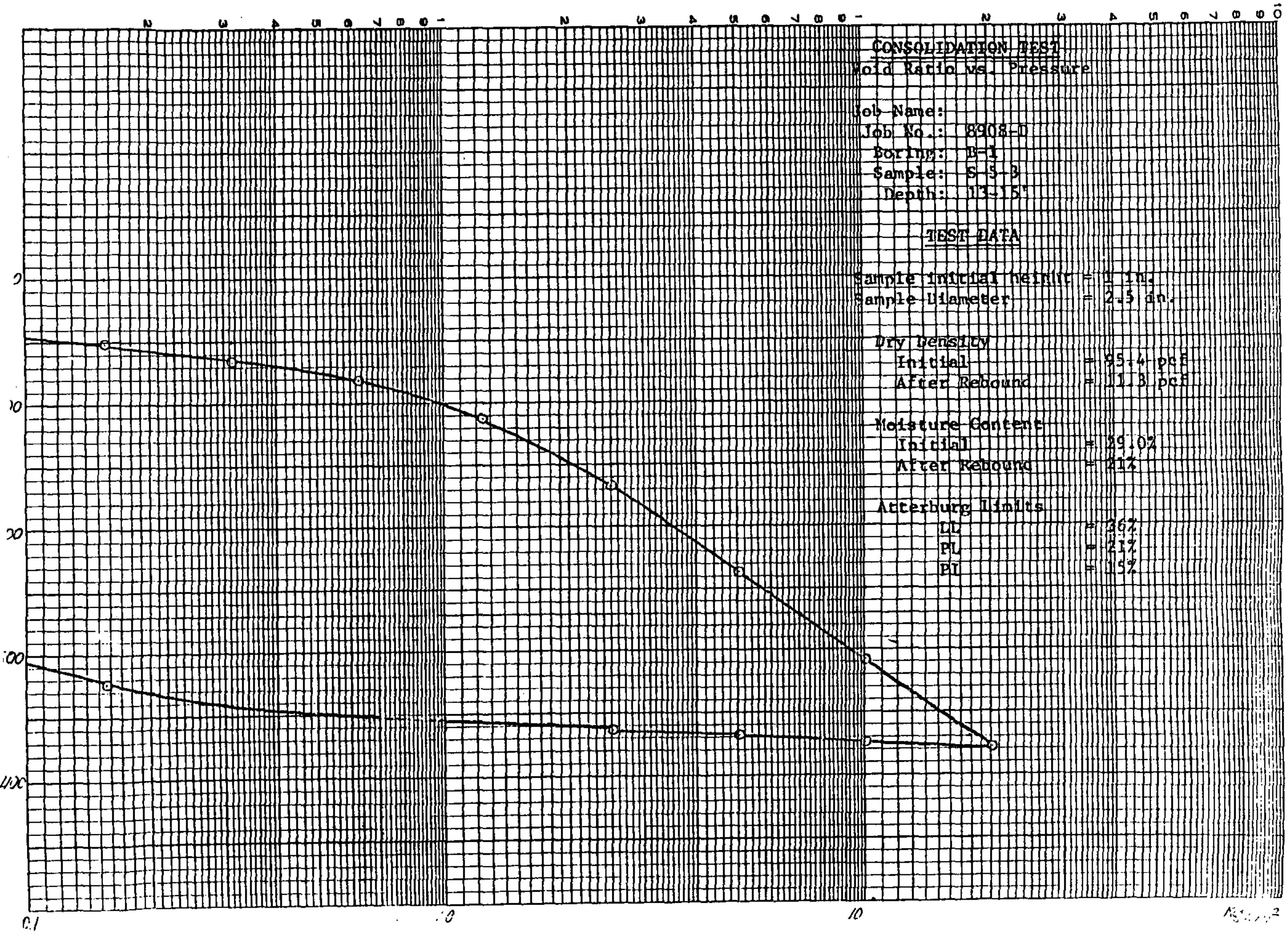
Dry Density
Initial = 85.5 pcf
After Rebound =

Moisture Content
Initial = 38.4%
After Rebound =

Atterburg
LL = 63%
PL = 27%
PI = 46%

Soil Testing Services, Inc.
111 Pfingsten Road
Northbrook, Illinois

By: JPS Checked by: CNB



CONSOLIDATION TEST

Void Ratio vs. Pressure

Job Name:
Job No.: 8908-D
Boring: B-1
Sample: S-5-B
Depth: 13-15'

TEST DATA

Sample initial height = 1 in.
Sample Diameter = 2.5 in.

Dry Density
Initial = 95.4 pcf
After Rebound = 111.3 pcf

Moisture Content
Initial = 29.0%
After Rebound = 21%

Atterburg Limits
LL = 36%
PL = 21%
PI = 15%

Gannett Fleming
ENGINEERS AND PLANNERS

SUBJECT Mo-American St. Joe's WTP
Prel. Est. Breakdown
BY DATE CHKD. BY DATE

SHEET NO. 1 OF 3
JOB NO. 25512

Electrical -	$ 2,425,000
HVAC -	776,000
Plumbing -	505,000
Instrumentation	1,550,000

Site Work:

Tank & Fdn.	1,940,000	
Bldg Fdns.	2,910,000	
Raw Water Main & Meters	190,000	
Settled Water	285,000	
Transfer Pipe / H.S. Suction	402,000	
H.S. Discharge	52,000	
Waste water Line	102,000	
Overflow	37,000	
Sanitary Facilities	24,000	
Pulsator Drain lines/valves	122,000	
Pre Sed Basin Mods.	58,000	
Chem feed lines to intake	92,000	
Spill Containment System	15,000	
Storm Water System	48,000	
Soil Erosion & Control	19,000	
Utility Relocations	48,000	
Paving	37,000	
Curbs	10,000	
Sidewalks	7,000	
Structural Excavation/Backfill	182,000	
Demolition - Basin #1,2,3 + Filter Bldg	493,000	
Topsoil Seeding	10,000	
Landscaping	48,000	
Site Dewatering - Well Pts	194,000	
Puls. temp flume	25,000	
		7,350,000

SCHEDULE
JSY-5

Total This Page $12,606,000

SUBJECT MO - American St Joe's WTP
Prel. Est Breakdown
BY DATE CHKD. BY DATE

SHEET NO. 2 OF 3
JOB NO.

1. Pulsators

Concrete	1,273,000
Superstructure	754,000
Process	1,600,000
	$ 3,627,000

2. Chemical Bldg

Concrete	836,000
Superstructure	1,051,000
Process	2,448,000
	$ 4,335,000

3. Filter Bldg / Clearwell

Concrete	1,288,000
Superstructure	665,000
Process	2,540,000
	$ 4,493,000

4. Transfer / H.S Pump Station

Concrete	305,000
Superstructure	365,000
Process	899,000
	$ 1,569,000

Total This Page: $ 14,024,000

GRAND TOTAL $ 26,630,000

SUBJECT Mo-American St Joe's WTP
Prel. Est. Breakdown
BY Dem DATE 5/93 CHKD. BY DATE

SHEET NO. 3 OF 3
JOB NO.

Summary of Unit Prices

Concrete	CY	450.–
D.I Fittings	LB	2.00
48" DIP	LF	200.
42" DIP	LF	175
36" DIP	LF	137
Bit. Paving	SY	25.–
Conc. Curbs	LF	20
Conc. Sidewalks	SY	25
Structural Excavation	CY	10
Structural Back fill	CY	15
Superstructure - Pulsators	SF	60
- Filters	SF	60
- Chem. Bldg	SF	80
- Pump Sta	SF	80

SUBJECT
BY DATE CHKD. BY DATE
SHEET NO. 1 OF 1
JOB NO.

Process Breakdown By Est Sheet #

	①	②	③	④	I	
sheet #	Pulsators	Chem	Filters	Pmp St	Instrum.	pg total
1	—	9,000	—	456,000	—	465,000
2	—	—	—	—	316,000	316,000
3	—	115,000	—	—	—	115,000
4	1,360,000	110,000	4,000	—	—	1,474,000
5.	—	401,000	—	—	—	401,000
6	—	549,000	—	—	—	549,000
7	—	105,000	1,698,000	—	—	1,803,000
8	—	373,000	—	32,000	—	405,000
9	74,000	99,000	554,000	320,000	—	1,047,000
10	74,000	—	—	—	—	74,000
11	27,000	400,000	210,000	78,000	—	715,000
12	—	—	—	—	657,000	657,000
13	—	—	—	—	280,000	280,000
14	—	—	—	—	345,000	345,000
15	44,000	30,000	94,000	5,000	—	173,000
16	7,000	162,000	4,000	—	—	173,000 *
17	54,000	46,000	—	—	—	100,000
18	—	25,000	—	—	—	25,000
19	10,000	100,000	54,000	36,000	—	200,000
	1,650,000	2,524,000	2,618,000	927,000	1,598,000	9,317,000
X.97						
=	1,600,000	2,448,000	2,540,000	899,000	1,550,000	

SUBJECT St. Joseph
Preliminary Estimate
BY DATE CHKD. BY DATE

SHEET NO. 1 OF
JOB NO. 28512

Division 11000

11160 Dock Levelar & Bumpers
H. 5488 × 1.38 = 7573 × 1.15 = 8700
B. 7000 × 1.265 = 8855 use $9,000 -(
F 10,750 × 1.3225 = 14,200

~~11202 Sluice Gates~~ see next sheet

11214 Vertical Turbine Pumps

5.0 MGD Transfer Pump	@ 75HP	$33,000
10.0 " " "	@ 125HP	$50,000
15.0 " " "	@ 200HP	$65,000
15.0 " " "	@ 200HP	$65,000
6MGD VFD High Service Pumps.		
Can Pump	600HP	$70,000
VFD		$43,000

326,000
× 1.4
$456,400

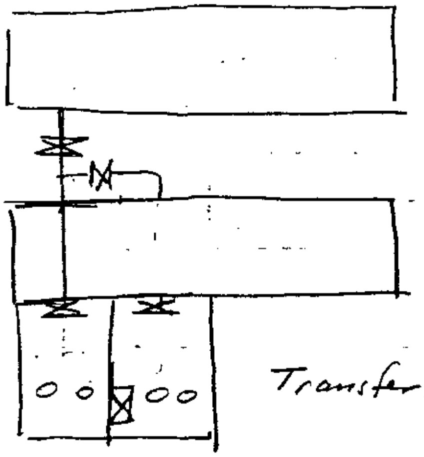
4

$465,000

Sluice Gates

Assume

6 Filter Influent Gates 3'x3' w/ Motor Oper	@ $15,000	=	90,000
6 Filter Waste Gates 2'x3' w/ Motor Oper	@ 14,000	=	84,000
2 Clearwell Gates @ 4'x4' w/ Floor Stand	@ 20000	=	40,000
1 Clearwell Gate @ 3'x3' w/ Floor Stand	@ 15,000	=	12,000
			226,000
			x 1.40
			$ 316,000



316,000

~~11214 Vertical Turbine/Pumps~~

~~Transfer Pumps~~
~~5 MGD~~
~~10 "~~
~~15 "~~
~~15 "~~

see first sheet

~~High Service Pumps w/VFD~~

6 MGD

112 Chemical Transfer Pumps
2 C.S.
2 F
2 A
2 CA
2 WasteWater

10 Pumps @ $11,500 = $115,000

F 7900.00 × 1.3225 = 10,450
13 41,000 (4) × $\frac{1.265}{4}$ = 13,000 use 11,500

$115,000 ②

13 $18,000

11218 Sample Pumps

Pre Sed Basin Effluent
Mixed Water
Filter Influent
Filter Effluent 4 @ 2000 8000 4K (1
4K (3

11223 Fiberglass Stop Gate and Weir Plates

Slow Mix Basin
3 @ 5' × 3'
2 @ 5' × 5'
Pulsator Effluent
3 @ 7' × 2'
3 @ 7' × 4'
11 @ $2,000 w/frame $22,000 10K (3
12K (1

11224 Pulsator Units
3 @ 960,000 × 1.4 = 1,344,000 (

11225 Mixer Equipment Mxer + VFD
1 Rapid Mixer @ $33,600 + 9,500 = 43,100
1 Slow Mixer @ $24,303 + 4,500 = 28,800
$71,900
×1.4
$100,660 (2

1,474,000

11241 Polymer Feed Pumps

4 @ $8,000 x 1.4 = $45,000

11242 Chemical Feed Pumps

4	Series 43	@ 7,000	= 28,000	
16	Series 44	@ 5900	55,000	
1	Series 45	@ 2000	2000	
			85,000 x 1.4 =	120,000

11244 Chlorination Feed System
2 Pre Cl_2
2 Pos Cl_2
2 Evaporators

13 49,000
H (85,000 + 7,000) x 1.025 = 94,300 x = 138,00
F 105,000 x 1.3225 = 139,

say $140,000

11245 Cross Linked High Density Polyethylene Tanks w/ Site Gages

4 – 10,000	Gal	Alum x $1.10 =		$44,000
1 – 6,000	Gal	Fluoride		6,600
1 – 6,000	Gal	Coagulant Aid		6600
1 – 6,000	Gal	Spare Tank		6600
1 – 400	Gal	Alum Tank		440
1	Gal	Coag Aid		440
2	Gal	$KMnO_4$		880
2	Gal	Filter Aid		880
2 800	Gal	Polymer Batch Tanks		1760
1 400	Gal	Lab Wastewater Tank		440

68,640 x 1.4 = $96,0
$100,0

11246 Batch Tank Mixers

F 2350 + 3,100

2 $KMnO_4$
2 Polymer Tanks
4 @ 3100 ≈ $12,000

11247 Bulk Chemical Feed System w/

Lime Silo & Feeders B 172,000
Add Weight Transmitter H 23,000 + 32,000
180,000 × 1.4 = 252,000
Carbon Silo & Feeders
Add Weight Transmitter 130,000 × 1.4 = 182,000

11248 Steel Tanks w/ Site Gage & Heat System

B 36,000
6000 Gal Caustic Soda Tank 15,000 +
400 Gal Caustic Soda Day Tank
w/ Heat System + Insul, H ((1706 + 1000) H.15 = 14,600
say 25,000

11250 Chemical Feed System Accessories

~~4 Cl_2 Scales~~

2 Cl_2 Gas Detectors × 1500	3,000
1 Fluoride Scale × 4000	
1 SBP Scale	4000
1 Alum Scale	4000
1 C.A. Scale	4,000
1 KH Scale	4000
2 $KMnO_4$ Scales	8,000
Misc. Equip say	25,000

56,000 × 1.4 = $78,000

549,000

11311 Air Compressor & Related Equipment
B 27,250 × 1.265 = 34,471
F 23,650 × 1.3225 = 31,277 use 33,000 ②

11373 Centrifugal Blower B 70,00 ÷ (2)
40,000 × 1.4 56,000 ③

11450 Kitchenette Unit H 6200 + 300 10,000 ②

13410 Spill Containment Tank F 31,250 + $11,000 +
B 42,000 $54,000 ②
Spill Containment Tank

Spill Containment Valve Manhole 8,000 ②

13521 (a) Filter Underdrain System

13522 (b) Filter Media $\frac{384}{12}$ 15.33 × 34 × 12 × 30 $/CF × 1.°° 1.25 = $742,000 ③

13524 (c) Fiberglass Washwater Troughs

(d) Air Lateral & Distribution System

a+c+d = $\frac{835,00-}{10 × 34 × 17}$ = $144.46/SF × 12 × 15.33 × 34 = 903,56°

say $900,000

$1,807,000

Elevator B 80,000 x 1.265 = $101,000 ②

14300 Hoist & Crane
2 - 2 Ton Chlorine Cylinder Hoists
2@ 6,000 = $12,000 ②

1 - 7½ Ton Pump room Crane $32000 ④
H 18,000 x 1.15 = 20,700 x 1.38 = 28,566
x x 1.15
larger Unit = 32,850

14510 Truck & Lift

1- Fork Lift
1- High Lift Pallet Truck
1- Drum Handler 10,000 ②
B 6000 x 1.265
H 8500

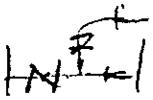
12600 Laboratory B 70,000 x 1.265 = 88,500
H 65,000 x 1.15 x 1.38 = 103,000
use $106,000 (2

Scrubber System B 105,000 x 1.4 $145,000 (

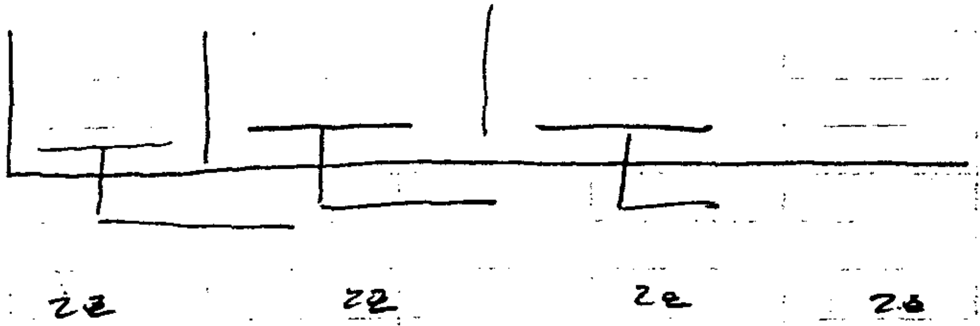
$405000

15100 Process Piping

Presedimentation Basin Effluent D		
Pulsator Influent Piping D		
Process to Filter Piping & Valves L		
Raw Water Vent Pipe?	5000	②
Pulsator Blow-off Piping L	74,000	①
Raw Water Main in Plant 37,721# @ 2.50	94,300	②
Pulsator Drain Piping D		
Filter Air Wash Piping say $50/' × 300	$15,000	③
Filter Face Piping 76,173# @ $4.00	305,000	③
Wash water Piping 39,827# @ 3.00	120,000	③
+ 2828 @ 3.00	8,500	③
Clearwell Interconnection Piping 1 48 BFV = 24,500 1 36 BFV 11200 Fittings & Pipe say 27,995 × 2.50 = 69,990	105,700	③
Transfer Pump Discharge Piping High Service Suction Piping High Service Discharge Piping	93,925 @ 2.50 = 235,000	(
Valves	85000	(
	1047,500	



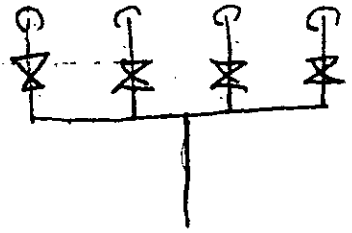
Pulsator Blow-off Piping



4 Valve / Pulsator
x 3

12 - 6" ϕ Plug Valve @ 3,500 = $42,000
x 1.4

58,800



6 6"-90° @ 65 390
3 6" Tees @ 95 = 285

20' 6" ϕ x 22 #/' = 440
8 6" ϕ Flgs x 17 #/flg = 136
1251 x 3 = 3753# @ $4.00 = $15,012

74,000

SUBJECT
BY DATE CHKD. BY DATE
SHEET NO. 11 OF
JOB NO.

Plant Service Piping $10,430^{\#}$ @ 4^{00} –	$42,000	
Valves	18,100	
	$60,000	②
Carbon Removal System Piping 250' @ $40/l	$10,000	③
Chemical Feed Piping & Chemical Feed Connection	200,000	②
Pipe Supports & Hangers say	100,000	30K ② 50K ③ 20K ④
Piping Insulation Both 212,000 x 1.265 = 268,000 say	$250,000	75 ② 125 ③ 50 ④
Modular Seals	50,000	9 15 20 6
Pipe Trays	10,000	6K 4K
Pressure Gauge say 20 @ 400	8000	5K 1 2
Truck Hose Adapters & Vents @ 11 @ $800	8800	
Water Spray Piping System for Pulsator Flume 3 @ say $6000	18,000	

5 H
1 CH
1 CS
1 Sc
1 Sp
1 Wal
1 F

$ 714,800

Gannett Fleming
ENGINEERS AND PLANNERS

SUBJECT
SHEET NO. 12 OF
JOB NO.
BY DATE CHKD. BY DATE

Instrumentation

1.	~~2 - 36" ø~~	~~Magmeters~~		
2.	6 - 18" ø	Filter Effluent Flow Tubes @ 5525		33,150
3.	1. - 24" ø	Washwater Flow Tube		18250
4	1 - 42" ø	Transfer Pump Discharge		30,960
5.	1 - 48" ø	High Service Pump Suction		33,000
6.	1 - 12"	Pitot Tube		2000
7.	2	6" Plant Service Turbine Meters	3000	6000
8.	1	2" Batch Tank Meter	5000	5000
9.	16	Differential Pressure Transmitters	2000	32,000
10	3	Pulsator Conductive Level Probes	1000	3000
11.	6	Filter Conductive Level Probes	2000	12000
12	2	Clearwell Conductive Level Probes	1000	2000
13	1	Rapid Mix Level Probe		1000
14	1	Filter Influent Level Transmitter	4000	4000
15	2	Pump Suction & Discharge Pressure Transmitter	2000	4000
16	8	Tank Capacitance Level Transmitters	4000	32,000
17	4	Batch Tank Capacitance Level Probes	1500	6000
18	4	Day Tank Capacitance Level Probes	1500	6000
19	10	Spill Containment Probes	1500	15000
20	1	Sump Alarm		1000
21	2	High Range Turb.	3000	6000
22	7	Low Range Turb	4000	28,000
23	6	Backwash Turb	@ 2500	15000
24	3	pH Meters	@ 3000	9000
25	1	SCD		10,000
26	3	Chlorine Residual Analyzers	8500	25,500
27	6	Dual FCC w/ DPC	@ 45,000	270,000
28	1	Chemical Storage Room DPC	@	10,000
29	1	Chemical Feed Room DPC		10,000
30	1	Pump Room DPC		10,000
31	1	RW/HS Pump Room DPC		10,000
32	1	UPS system		8,000
33	5	Pump Pressure Switches		3000
34	12 ?	Solenoid Valves	500	6000
35	7	2" Motor Operated Ball Valves	1000	7000
36	1	Temp Transmitter	① 656,260	3000

SUBJECT

BY DATE CHKD. BY DATE

SHEET NO. 13 OF

JOB NO.

Main Control Console		15,000	
Unloading Dock Panel (Highland		10,000	
Computers	2 @ 5000	10,000	
Printers	2 @ 2000	4,000	
CRT	2 @ 5000	10,000	
			49,000
Labor	3,000 hours @ $65/hr	195,000	
	30 days field @ 1000	30,000	
	6 Trips @ 1000	6000	
			231,000

$280,000 Ⓘ

Butterfly Valve

2 - 36" ϕ	Raw Water Control Valves	× 15,000	=	30,000
12 - 18"	Filter Effluent Valve	× 4,600	=	55,200
12 - 12"	Airwash Valve	× 4,000	=	48,000
6 - 24"	Wash Valves	× 6500	=	39,000
6 - 18"	Filter Effluent Flow Control Valve	× 5600	=	33,600
6 - 16"	Filter Rinse Flow Control Valve	× 5400	=	32,400
1 - 24"	Washwater Flow Control Valve	× 8000	=	8000

246,200
× 1.4

$344,680 (I)

Access Hatches

1	Rapid Mix		
1	Slow Mix		
4	Split Box		
6	Pulsator		
3	Vacuum Box		
1	Pipe Gallery		
2	Clearwell		
1	Pump Pipe Gallery		27K (
19	@ $3000 =	$57,000	18K (
			9K (
			3K

Manways to Pulsator

2 @ end of Flumes × 3 = 6 × $3000 9,000 (

1 @ 8'-c-c 10 × 3 = 30 along influent flume @ 2000 $20,000 (

4 into clearwell sections @ 3000 12000 (

Ladders @ $65/l.f.

1	Rapid Mix	22
1	Slow Mix	22
4	Split Boxes	88
12	Pulsators	192
1	Pumproom	15
2	Clearwell	40
2	Roof	30

409 × 65 = 26,585
Add for safety Climb
say $35,000 17, 12, 4, 2

173,000

Al. Grating

2'x 7' for 3 pulsators 42 SF @ $48/SF
2 x 1.5 x 15 for Slow Mix Room 45
87 + 48 = 4176

Mixer Stands 4 @ 2000 say $6000 3K (
3K (
8,000 (2

FRP Grating
Cl2 60 SF
SBP/A - 360 SF
CA 360 SF
K 225 SF
FA 225 SF
F 150 SF
CS 150 SF

1530 SF @ $72/SF = 110,160 110,000 (

FRP Stair
Flouride Room say $5,000 (

Al. Stair & Platforms

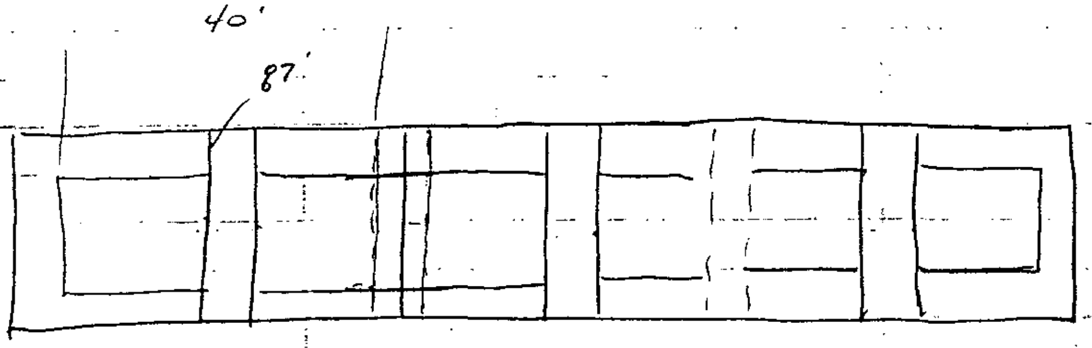
C S.		say 4000		(
Polymer		4000		(
Polymer Mix System		8000		(
Chemical/Admin Bldg	2 Towers	23R x 2 $270/R = 12420		(
End of Filter Bldg	1 Tower	14R x 270	= 4000	(
End of Process Bldg	1 Tower	14R x 270	= 4000	
Scrubber Room		4000	4000	
Unloading Dock		4000	4000	

$157,000 +
173

* Not in orig total

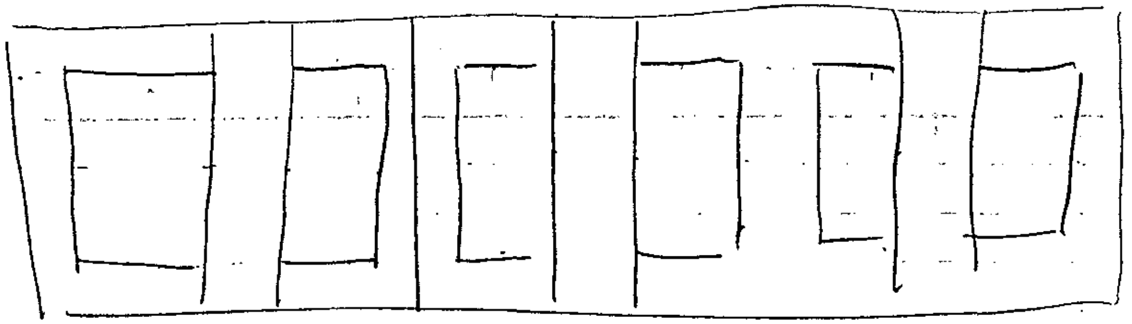
Aluminum Handrail

Process Room



6 × 87 = 522
2 × 120 = 240

Filter



2 × 12 × 26 = 624
2 × 12 × 12 = 288

1674 l.f. @ $\$60^{\underline{00}}$ = 100,000:$^{46}_{54}$

Containment Area Liners

Feed Area

A -	18 x 20	=	360
CA	18 x 20	=	360
K	13 x 15	=	195
FA	13 x 15	=	195
Fd.	10 x 15	=	150

Storage Area

A	67 x 20	1340
F	19 x 19	361
CS	19 x 18	342
Scrub.	19 x 25	475
Sp	18 x 19	342
Lab Waste	10 x 8	80

4200 SF x 4^{00} = 16,800

say $17,000

Mats

A	67 x 8 =	536
F	19 x 8	152
CS	19 x 8	152
Scrub	19 x 8	152
Sp	19 x 8	152
LabW	10 x 8	80

1224 x 6^{00} = 7344 say $8000

$25,000

Structural steel say part of unit price per sq foot of superstructure

Painting say 200,000

10 ①
100 ②
54 ③
36 ④

MISSOURI-AMERICAN WATER COMPANY
ST. JOSEPH DISTRICT
ST. JOSEPH WATER TREATMENT PLANT IMPROVEMENTS

GEOTECHNICAL DESIGN MEMORANDUM

APRIL 1993

Prepared by

Gannett Fleming, Inc.
Harrisburg, Pennsylvania

SCHEDULE
JSY-6

MISSOURI-AMERICAN WATER COMPANY
ST. JOSEPH DISTRICT
ST. JOSEPH WATER TREATMENT PLANT IMPROVEMENTS

GEOTECHNICAL DESIGN MEMORANDUM

INTRODUCTION

This memorandum summarizes the geotechnical investigation and preliminary analyses performed for the proposed facility improvements of the St. Joseph, Missouri Water Treatment Plant. The proposed plant improvements consist of a Process Building, Filter Building, Chemical Building, and Pumping Station to be located within the footprint of existing Sediment Basin No. 1. An additional storage tank will be located north of existing Sediment Basin No. 2, and a garage to the east of existing Sediment Basin No. 2. The results of the subsurface investigation and laboratory testing are summarized below. Preliminary design analyses and recommendations are also presented for the proposed facility improvements.

The plant site is located on the east shore of the Missouri River, approximately two miles upstream of the city of St. Joseph, Missouri. The site is situated within the flood plain of the river, and terrain surrounding the plant is relatively flat. Existing ground elevation at the site varies from approximately 820 to 836 feet. The topographic relief indicated by these ground elevations is primarily the result of 10 to 15 foot earthen embankments surrounding most of the existing plant structures. These embankments were placed as part of the original plant construction.

It is noted that several alternates are currently under consideration with regard to the precise locations and elevations of proposed structures. Once established, final foundation design and recommendations will be made with regard to the proposed plant improvements. It is the intent of this memorandum to present the results of the current subsurface investigations and laboratory testing, and discuss their relevance with regard to the feasible foundation types anticipated for the proposed structures. The analyses upon which the recommendations presented herein are based were performed using preliminary structure location and loading information. As process and structural design progresses and more precise information is made available, additional geotechnical analyses will be performed as warranted.

SUBSURFACE INVESTIGATION

Subsurface conditions in the general vicinity of the proposed facilities were evaluated by performance of seven Standard Penetration Test (SPT) borings, identified as Borings GF-1, 2, 3, 5, 7, 8 and 9. These borings were located in accessible areas around the perimeter of the existing sediment basins. Proposed Borings GF-4 and GF-6 were deleted from the boring program when it was determined their proposed locations were not accessible. In general, subsurface information directly beneath the proposed structures was not obtained since their locations were within the existing sediment basins, which are currently in service. The locations of the borings are shown on the Site Plans of Figures 1 and 2. The locations of available borings performed during earlier phases of plant development in areas adjacent to the currently proposed facilities are also shown on the Site Plans. Subsurface conditions encountered in these borings were also reviewed as part of the current evaluation. Logs of all borings shown on Figures 1 and 2 are attached as Appendix A.

Alpha-Omega Geotech, Inc. of Kansas City, Kansas, performed the current borings in December of 1992. Gannett Fleming, Inc., provided a geotechnical engineer to inspect and supervise boring and sampling operations during the subsurface investigation. Standard split-spoon samples were taken continuously in the upper ten feet of each boring with sampling intervals of five feet thereafter to bedrock. With the exception of Boring GF-7, bedrock was cored in all borings. Cores were obtained in order to determine the condition and engineering qualities of site bedrock. In addition, undisturbed tube samples were taken for the purpose of classification, consolidation and strength testing.

Classification tests were also performed on soil samples taken from the split-spoon.

LABORATORY TESTING

Samples collected from the subsurface investigation were tested to confirm visual classifications obtained in the field and to determine other relevant engineering properties of the soils. All laboratory testing was performed in Gannett Fleming's Geotechnical Laboratory. Laboratory testing included determinations of natural moisture content, dry density, Atterberg limits, and gradation analyses. A consolidation test and triaxial compression test were also performed on undisturbed samples. Copies of laboratory testing results are attached as Appendix B.

SUBSURFACE CONDITIONS

Existing ground surface at current boring locations varied from approximately Elevation 820 at Boring GF-1 to Elevation 823 at Boring GF-9. In general, borings performed at the eastern side of the plant encountered significantly different soil conditions than those borings located to the west. Boring information indicates that the western portion of the site is underlain by silty sands and sandy silts, whereas the eastern side is underlain by moderate to highly plastic clays. It is not presently known with any certainty where the boundary between these two differing soil profiles occurs. Because the central portion of the site was inaccessible due to the existing basins it was not possible to perform intermediate borings to better define the limits of the two different soil strata.

In the western portion of the site, Borings GF-1, GF-3 and GF-5 encountered a layer of silt and sandy silt overlying sandy material. The silt was approximately 20 feet thick and classifies as an "ML" (low plasticity silt) in the Unified Soil Classification System (USCS). The sandy material consisted of an upper layer of loose to medium dense silty sand and a lower strata of much denser sand with some gravel content. The upper sands exhibited SPT N-values (blows per foot of penetration) ranging from 5 to 13 blows per foot, with an average value of 9 blows per foot. The underlying dense to very dense poorly graded sand exhibited N-values ranging from 19 to 121 blows per foot, with an average value of 34 blows per foot. Laboratory tests performed on the sands indicate USCS classifications of SP (poorly graded sand) and SP-SM (poorly graded, to silty, sand) for these materials. Gravel content of the sands increased with depth, and the sand stratum was typically underlain by a 2 to 6 foot thick layer of boulders and cobbles overlying bedrock.

The clay strata encountered in the easternmost borings contained an upper zone of soft to medium stiff, highly plastic clay. N-values for this material ranged between 2 and 19 blows per foot, with an average value of 8 blows per foot. This upper clay strata extended to depths between 30 and 35 feet, and was underlain by a layer of medium to stiff highly plastic clay containing some gravel. This clay strata exhibited N-values ranging between 12 and 49 blows per foot, with an average value of 25 blows per foot. This stratum extended to bedrock, and varied in thickness from 18 to 26 feet. Laboratory tests performed on the clay soils indicate a USCS classification of CH (highly plastic clay).

An unconsolidated-undrained (UU) strength test was performed on a tube sample representative of the softer clay soils present at the site. That test obtained an unconfined compressive strength of 0.8 ksf, which is indicative of a relatively weak material. A consolidation test was also performed, which indicated the clays had been subjected at some point in the past to vertical pressures greater than those presently existing. Such soils are categorized as "overconsolidated", and typically experience lesser settlement than would otherwise occur under application of a vertical load. The results of strength and consolidation testing were incorporated into the geotechnical analyses discussed later in this memorandum.

Bedrock was encountered at depths ranging from 56 to 89 feet at the boring locations, corresponding to top of rock elevations of about 766 to 733 feet. In general, bedrock slopes downward from east to west at the site.

Bedrock at the water treatment plant consists of gray shale, which is soft and highly weathered to a depth of approximately 5 feet below the top of rock. Bedrock was sampled to depths of 3 to 10 feet below the point of split spoon or auger refusal. Recovery of rock cores ranged from 87 to 100 percent and rock quality designation (RQD) varied from 0 to 86 percent.

Measurements taken during the course of drilling indicated groundwater levels varied between Elevation 800 and Elevation 810 across the site. It is believed likely that groundwater levels at the site will vary with seasonal fluctuations of the Missouri River.

Subsurface profiles depicting representative conditions across the area of proposed construction are presented in Appendix C. These profiles were used in evaluating the probable performance of several foundation types, as discussed in the following section of this report.

PRELIMINARY ANALYSES

The feasibility and performance of both shallow and deep foundation systems was evaluated using the preliminary structure loads and foundation elevations currently available. Given the presence of competent bedrock at moderate depth, and the fact that several of the existing plant structures are supported on deep foundations, it is assumed that caisson or driven pile foundations could be successfully used if warranted. The analyses performed for preparation of this report therefore dealt primarily with the feasibility of shallow foundations. It was also assumed that the characteristics of the soft clays present at the site would control allowable bearing capacity and settlement analyses.

Bearing capacity and settlement of shallow structural slab foundations were evaluated using the strength and consolidation characteristics obtained from current laboratory testing. The relevant strength and consolidation parameters obtained from the testing are:

Unconfined Compressive Strength, $q_u = 0.8$ ksf
Compression Index, $C_c = 0.47$
Re-Compression Index, $C_r = 0.05$
Pre-Consolidation Pressure, $P_p = 2.8$ ksf

A preliminary estimate of the bearing pressures associated with the proposed structures was also required to perform the analyses. An estimated bearing pressure of 2.5 ksf was provided by the project structural designers as representative of a typical process structure loading.

Using the Terzaghi bearing capacity equation, an ultimate bearing capacity of 2.5 ksf was calculated for the soft to medium clays present at the site. If typical safety factors of 2.5 to 3 are applied to this value, an allowable bearing capacity ranging from 0.8 to 1.0 ksf is thereby obtained. In light of the estimated 2.5 ksf which will be applied by the proposed structures, bearing capacity of the clay soils present beneath the eastern portion of the site will not be adequate for support of anticipated structure loads.

The magnitude of anticipated consolidation settlements associated with shallow foundations on clay soils was calculated, assuming that bearing capacity deficiencies could somehow be mitigated. Using the re-compression index to calculate settlement (i.e., making the "best case" assumption that only re-compression, rather than virgin consolidation, would occur), consolidation settlements on the order of 2 to 3 inches were obtained. If any virgin consolidation were to occur, the magnitude of observed settlement would likely increase several fold. In addition, because of the difference in soil conditions across the site it is expected that significant differential settlements would occur beneath any structure spanning the juncture of the clay soils to the east of the site and the sands to the west. The sandy soils would not be expected to experience any appreciable consolidation settlement, and therefore virtually all consolidation settlement occurring in clay soils would be expressed as differential settlement across the structure.

CONCLUSIONS AND DISCUSSION

Based on the results of the analyses discussed above, it is concluded that the use of shallow foundations will probably not be feasible for any structure founded in or above the clay soils present at the site. It is anticipated that some form of deep foundation bearing on bedrock will be required for those structures. As mentioned previously, it is anticipated that either caissons or driven pile foundations could be utilized to support proposed structures. Subsequent foundation design will consider which of these foundation types, as well as other possible types, will provide the most cost effective foundation system for the proposed facilities.

It is possible that some structures, such as the garage building being considered, may be relatively lightly loaded as well as relatively insensitive to post-construction settlements. If the garage building is retained in its current location to the east of the existing plant, it may therefore be feasible to found it on shallow foundations bearing on clays. If so, it is likely a significant cost savings could be achieved by avoiding installation of a relatively expensive deep foundation system for this, or any similar, structure.

In order to better delineate the limits and properties of the sandy soils and clay soils in the areas of proposed structures it is recommended that additional borings and laboratory testing be performed. Because the area in question is within the limits of existing Sediment Basin No. 1, it will be necessary to drain the basin and remove any significant sediment deposits to allow performance of the borings. While it is recognized that performing additional borings and testing will entail additional expense, it is believed the potential cost savings associated with utilization of shallow foundations for even one of the proposed structures would more than offset that expense. Specific recommendations regarding boring locations and laboratory testing will be submitted to Missouri-American in the immediate future.

In the event it can be determined that one or more of the proposed structures will be underlain entirely by sands, it is possible that such structures may be founded on shallow foundations without adverse consequences. A critical consideration in such cases will be the potential for differential movements between adjacent structures on dissimilar foundation types. These situations will be evaluated following final location of the proposed facilities.

Additional items to be addressed during subsequent design work include support and stability of required excavations, dewatering of excavations, flotation resistance, and protection of existing facilities during construction of adjacent structures. A final geotechnical report addressing these issues will be provided during the latter stages of facilities design.

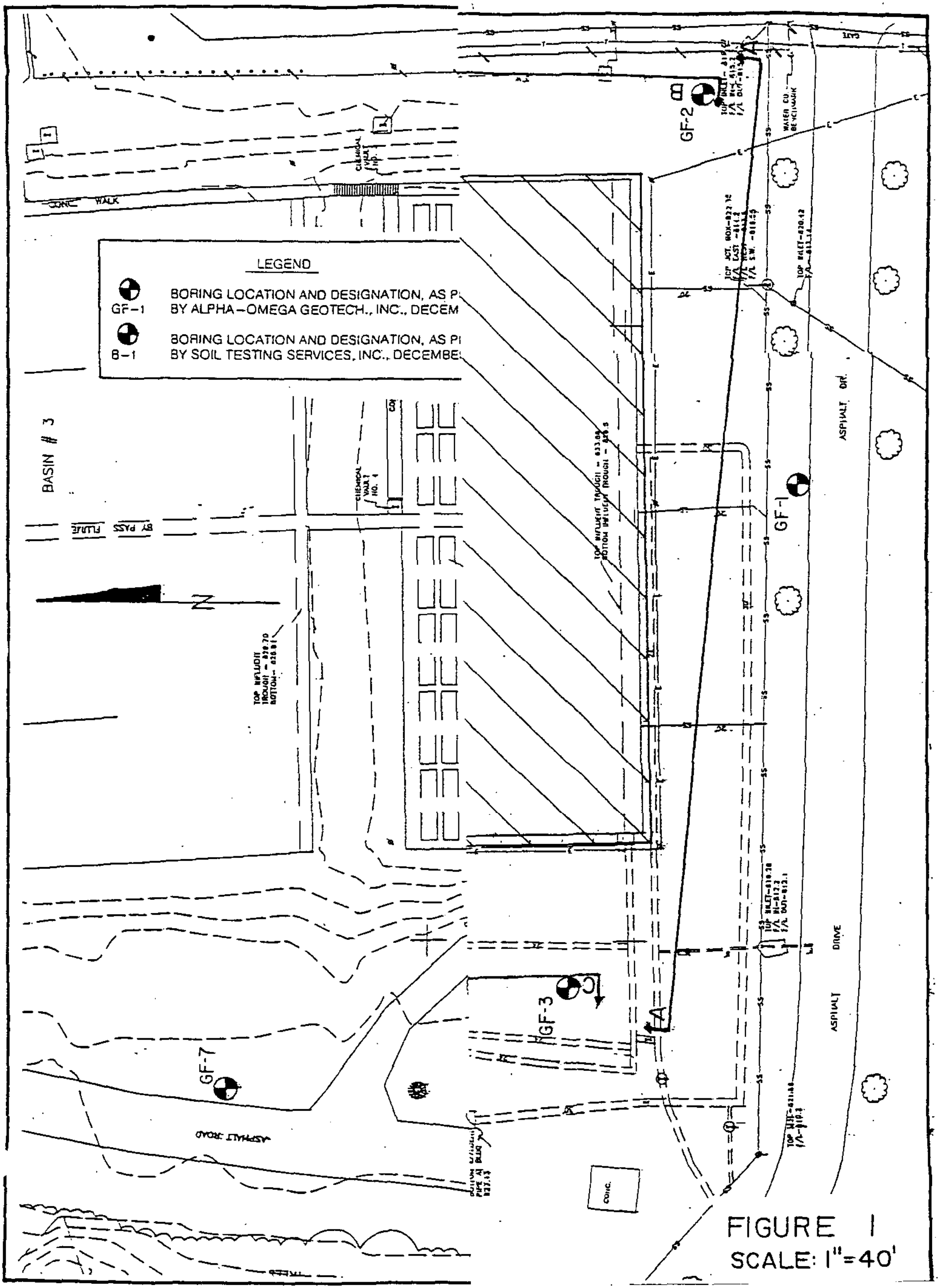


FIGURE 1

SCALE: 1"=40'

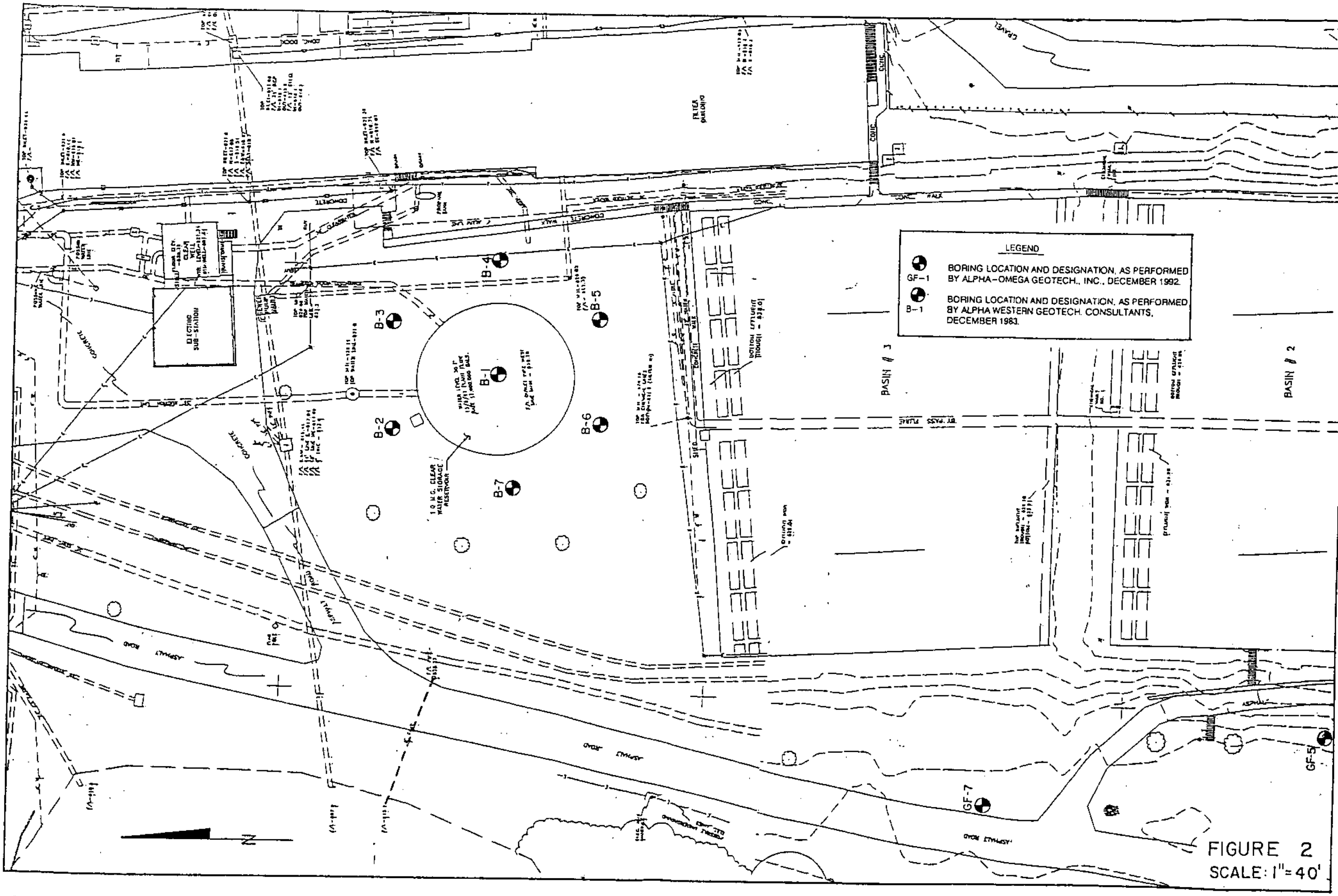


FIGURE 2
SCALE: 1"=40'

APPENDIX A

• BORING LOGS •

Date Started	12/7/92	**DRILLING LOG**	Hole No.	GF-1
Date Finished	12/8/92	GANNETT FLEMING, INC. Harrisburg, PA 17105	Sheet	1 of 3
Soil Sampling	64 Ft.		Line & Station	-
Rock Sampling	10 Ft.	Project St. Joseph Water Treatment Plant	Offset	-
Total Depth of Hole	74 Ft.		N Coordinate	16144.4
No. of Undist. Sample	0	Drilling Agency Layne Western	E Coordinate	17747.3
Total Number of Core Boxes	1	Driller Randy Crowl	Elev. Top of Hole	820.72

Groundwater Observations
At 26.7 Ft. After 0 Hrs.
At 20.2 Ft. After 36 Hrs.

Elev. 800.5 After 36 Hrs.

Size and Bit Type NX
Casing Size
Hollow-Stem 6" O.D.
Drilling Fluid

Spoon Size 2" O.D.
Hammer Wt. 140#
Hammer Drop 30"

Inspector T. L. Dreese

Direction of Hole
x Vertical ___Inclined
______Deg. From Vertical

	Elev. Depth	Legend	Description of Materials	Sample Depth	Blows or RQD	Recovery	Box or Sample No.	Remarks
			Dark Brown Lean CLAY; Medium; Moist.	0.0-2.0	2-4			
					4-4	0.8	S-1	
				2.0-4.0	3-3			PPR = 0.85 tsf
					4-4	0.8	S-2	
	4.2			4.0-6.0	3-3			
5			Gray SILT with Sand; Damp. (ML)		4-3	N.R.	S-3	
				6.0-8.0	4-4			
					4-5	2.0	S-4	
				8.0-10.0	4-3			
					4-4	2.0	S-5	
10								
				14.0-16.0	5-8			
			Same except medium dense, moist.		7-6	1.8	S-6	
15								
				19.0-21.0	3-3			
	20.0				2-4	2.0	S-7	
20			Gray Poorly Graded Fine SAND with Silt; Loose to Medium Dense, Wet.					
				24.0-26.0	4-4			
					4-6	1.9	S-8	
25								

REMARKS:

Water Table encountered at 20'.
Drilled through thin clay seam at ≈ 12.5' (return on augers).

DRILLING LOG (Continuation Sheet)	GANNETT FLEMING, INC.	Hole No. GF-1
		Sheet 2 of 3
	Project St. Joseph Water Treatment Plant	Elev. Top of Hole 820.72

Elev. Depth	Legend	Description of Materials	Sample Depth	Blows or RQD	Recovery	Box or Sample No.	Remarks
		Gray Poorly Graded Fine SAND with Silt; Loose to Medium Dense; Wet.	29.0-31.0	4-4			
30				5-12	2.0	S-9	
			34.0-36.0	2-4			
35				9-11	2.0	S-10	
			39.0-41.0	4-8			
40				13-19		S-11	
			44.0-46.0	5-7			Sand ran into augers to ≈42' on first attempt for S-12
45				13-22		S-12	
			49.0-51.0	17-11			
50				12-14		S-13	
			54.0-56.0	16-12			
55				7-10		S-14	Augers bouncing from 56.0' to 59.0'
			59.0-60.5	20-48			
60				60/0.5		S-15	

DRILLING LOG (Continuation Sheet)	GANNETT FLEMING, INC.	Hole No. GF-1
		Sheet 3 of 3
	Project St. Joseph Water Treatment Plant	Elev. Top of Hole 820.72

Elev. Depth	Legend	Description of Materials	Sample Depth	Blows or RQD	Recovery	Box or Sample No.	Remarks
60.5		Rock fragments in last 0.5' of S-15					
62.5		Cobbles and boulders.					
74.0		SHALE; Gray; Very Soft; Highly Weathered; Intensely Bedded, RD 0°-5°.	64.0-74.0	78%	100%	R-1	Augered to 64.0'
		End of Boring					

Date Started 12/10/92
Date Finished 12/11/92
Soil Sampling 55 Ft.
Rock Sampling 10 Ft.
Total Depth of Hole 65 Ft.
No. of Undist. Sample 1
Total Number of Core Boxes 1

Groundwater Observations
At 31 Ft. After 0 Hrs.
At Ft. After Hrs.

Elev. After Hrs.

DRILLING LOG

GANNETT FLEMING, INC.
Harrisburg, PA 17105

Project St. Joseph Water Treatment Plant

Drilling Agency Layne Western
Driller Randy Crowl
Size and Bit Type NX
Casing Size
Hollow-Stem 6" O.D.
Drilling Fluid
Spoon Size 2" O.D.
Hammer Wt. 140#
Hammer Drop 30"
Inspector T. L. Dreese

Hole No. GF-2
Sheet 1 of 3
Line & Station -
Offset -
N Coordinate 16169.8
E Coordinate 17875.0
Elev. Top of Hole 821.15

Direction of Hole
x Vertical ___Inclined
______Deg. From Vertical

Elev. Depth	Legend	Description of Materials	Sample Depth	Blows or RQD	Recovery	Box or Sample No.	Remarks
		Dark Brown Fat CLAY; Moist; Very Soft to Soft.	0.0-2.0	3-3			
				3-5	0.3	S-1	
			2.0-4.0	4-9			
				7-9	0.7	S-2	PPR = 1.9 tsf
			4.0-6.0	4-3			
5				3-4	1.4	S-3	PPR = 0.5 tsf
			6.0-8.0	3-6			PPR = 0.2 tsf
8.0				5-7	1.3	S-4	
			8.0-10.0	2-3			PPR = 0.1 tsf
				3-4		S-5	
10		Brown Fat CLAY with Sand; Very Soft to Medium; Moist to Wet.	10.0-12.0	-	1.3/2.0	U-1	PPR = 1.0 tsf
		Same except Wet.					
			14.0-16.0	1-1			
15				1-2	1.5	S-6	PPR = 0.2 tsf
			19.0-21.0	8-2			
20				1-2	1.7	S-7	PPR = 0.1 tsf
			24.0-26.0	2-2			
25		Gravel Chip caught in spoon.		4-27	1.0	S-8	PPR = 0.25 tsf

REMARKS:

DRILLING LOG (Continuation Sheet)	GANNETT FLEMING, INC.	Hole No. GF-2
		Sheet 2 of 3
	Project St. Joseph Water Treatment Plant	Elev. Top of Hole 821.15

Elev. Depth	Legend	Description of Materials	Sample Depth	Blows or RQD	Recovery	Box or Sample No.	Remarks
26.0							Auger Jumping 26.0' - 27.0'
		Brown Fat CLAY with Gravel; Soft to Medium; Wet.					
			29.0-31.0	6-5			
30				7-33	1.3	S-9	PPR = 0.5 tsf
		Boulder or Cobble from 32.0' - 32.5'					
			34.0-36.0	5-8			PPR = 1.0 tsf
35				9-23	0.8	S-10	
37.0							
		Brown Gravelly Fat CLAY; Medium to Stiff; Wet.	39.0-39.8	7-50/0.3	0.7	S-11	Gravel caught in spoon
40							
			44.0-46.0	13-12			PPR = 0.8 tsf
45				15-13		S-12	
			49.0-51.0	12-18			PPR = 1.2 tsf
50				13-21	0.4	S-13	
53.0							
		Gray SHALE; Very Soft to Soft; Highly Weathered; Intensely to Very Intensely Bedded, RD 0°-5°; Very Widely Spaced Fractures, RD 35°-40°.	54.0-54.75	44-50/0.25		S-14	Augered to 55.0'
55			55.0-65.0	79%	100%	R-1	
60							

DRILLING LOG (Continuation Sheet)	GANNETT FLEMING, INC.	Hole No. GF-2
		Sheet 3 of 3
	Project St. Joseph Water Treatment Plant	Elev. Top of Hole 821.15

Elev. Depth	Legend	Description of Materials	Sample Depth	Blows or RQD	Recovery	Box or Sample No.	Remarks
65.0		Gray SHALE; Very Soft to Soft; Highly Weathered; Intensely to Very Intensely Bedded, RD 0°-5°; Very Widely Spaced Fractures, RD 35°-40°.					
		End of Boring					

65
70
75
80
85
90
60

Date Started 12/11/92	DRILLING LOG GANNETT FLEMING, INC. Harrisburg, PA 17105	Hole No. GF-3
Date Finished 12/16/92		Sheet 1 of 3
Soil Sampling 89.0 Ft.		Line & Station -
Rock Sampling 3.0 Ft.	Project St. Joseph Water Treatment Plant	Offset -
Total Depth of Hole 92.0 Ft.		N Coordinate 16220.1
No. of Undist. Sample 0	Drilling Agency Layne Western	E Coordinate 17585.1
Total Number of Core Boxes 1	Driller Randy Crowl	Elev. Top of Hole 822.07
Groundwater Observations At Ft. After Hrs. At 22.5 Ft. After 36 Hrs.	Size and Bit Type NX Casing Size Spoon Size 2" O.D. Hollow-Stem 6" O.D. Hammer Wt. 140# Drilling Fluid Quick Gel Hammer Drop 30"	Direction of Hole _x_ Vertical ___ Inclined
Elev. 779.6 After 36 Hrs.	Inspector T. L. Dreese	________ Deg. From Vertical

Elev. Depth	Legend	Description of Materials	Sample Depth	Blows or RQD	Recovery	Box or Sample No.	Remarks
		Dark Brown Fat CLAY with Sand; Medium; Moist.	0.0-2.0	2-4 4-5	1.0	S-1	PPR = 1.1 tsf
			2.0-4.0	4-4			PPR = 1.5 tsf
				6-7	1.0	S-2	
			4.0-6.0	3-4			
5.0				5-5	1.0	S-3	
		Gray Silt with Sand; Damp. (ML)	6.0-8.0	6-12			
				7-14	1.5	S-4	
			8.0-10.0	6-6			
				7-7	N.R.	S-5	
			14.0-16.0	4-8			
				9-8	1.3	S-6	
			19.0-21.0	5-6			
				4-7	1.4	S-7	
		Same, Wet at 20.5'					
		Clay seam penetrated with auger from 21.0'-24.0'					
			24.0-26.0	3-3			
25.0				3-5		S-8	

REMARKS:

DRILLING LOG (Continuation Sheet)	GANNETT FLEMING, INC.	Hole No. GF-3 Sheet 2 of 3
	Project St. Joseph Water Treatment Plant	Elev. Top of Hole 822.07

Elev. Depth	Legend	Description of Materials	Sample Depth	Blows or RQD	Recovery	Box or Sample No.	Remarks
		Gray Poorly Graded Fine SAND with Silt; Loose to Medium Dense; Wet.					
			29.0-31.0	3-3			
30				5-8		S-9	
			34.0-36.0	6-6			
35				7-14		S-10	
38.0							
		Gray Poorly Graded Fine SAND; Dense to Very Dense; Wet.	39.0-41.0	11-19			
40				20-20	1.5	S-11	
			44.0-46.0	14-19			
45				19-25	1.0	S-12	
		Gray Poorly Graded SAND; Wet. (SP)	49.0-51.0	20-29			
50				27-35	1.7	S-13	
			54.0-56.0	17-24			
55				32-43	1.0	S-14	
			59.0-61.0	49-60			
60				61-57	1.1	S-15	