2B

PROTECCION TECHNICA ECOLOGICA (PROTECO) INC.
PART B PERMIT APPLICATION
PRD 091018622
PENUELAS, PUERTO RICO

VOLUME 4
REVISION 3

Signifies changes made in

Revision 1, submitted March 17, 1986

Revision 2: June 30,1986

June 30, 1986

(1052B)

Appendix D-6.4

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SUBJECT _____ JOB NO. _____

I. Peak Flow - TR 55
Analysis

SUBJECT Proteco
Peak Flow Analysis
TR 55 Method
JOB NO. B511

Statement of Problem:

To determine peak flows for run-on and run-off system design.

Assumptions:

Assume 25 year, 24 hour storm will be used for design

Drainage areas will be calculated by planimetry.

The entire watershed will be divided into 35 smaller subareas.

Development:

Use U.S.D.A. Soil Conservation Service, Technical Release No. 55

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Procedure:

1) Determine area of watershed subareas, DA, by planimetry, in mi^2

2) Determine runoff curve no, CN from Table 2.2

- for highly plastic, expansive, impervious clays, assume hydrologic soil group D
- for undeveloped portions of the total watershed area assume wood or forest land with poor cover best approximates the landuse areas ∴ CN = 83
- for developed portions of the site assume cultivated land without conservation treatment best approximates the land use areas ∴ CN = 91

3) Determine rainfall frequency, P

Using available data from Puerto Rico and Southern Florida (From Technical Paper No. 40, Rainfall Frequency Altas of U.S. prepared by David M. Hershfield, U.S. Dept. of Commerce, May, 1961.

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3) rainfall frequency (cont.)

	PUERTO RICO	FLORIDA
5 YR 1HR	2.5 IN	3.0 IN
25 YR 2 HR	4.0 IN	5.0 IN.
25 YR 12HR	9.0 IN	9.0 IN
25 YR 24 HR	NOT AVAILABLE	10.5 IN
50 YR 24 HR	12.0 IN.	12.0 IN
100 YR 24 HR	NOT AVAILABLE	14.0 IN

DATO CORRELATES WELL ESPECIALLY FOR LARGER STORMS ∴ USE P = 10.5 IN.

4) Determine runoff depth, Q from Table 2-1 with CN and P known.

5) Determine time of concentration, T_c
   a) scale flow length, L
   b) estimate velocity, V, using Table 1
   c) calculate T_c, $T_c = \frac{L}{V}$, in hrs

6) Determine discharge using computer program which calculates discharge by the following expression:

$$q = q' \, DA \, Q$$

where: q = discharge in cfs

q' = routed discharge in csm/in with T_c known, assume travel time $T_t = 0$, assume type II storm distribution

DA = drainage area in mi^2

Q = runoff depth in inches

The computer tabulates a unit hydrograph (time versus q) for each watershed subarea (pages 22-59)

Watershed subareas were combined, as required to determine peak flows for some channels (pages 60-72)

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SUBJECT Proteco Peak Flow Analysis — JOB NO. BS11

TABLE 2-2

Table 2-2.--Runoff curve numbers for selected agricultural, suburban, and urban land use. (Antecedent moisture condition II, and $I_a = 0.2S$)

LAND USE DESCRIPTION		HYDROLOGIC SOIL GROUP A	B	C	D
Cultivated land[1]: without conservation treatment		72	81	88	91
: with conservation treatment		62	71	78	81
Pasture or range land: poor condition		68	79	86	89
good condition		39	61	74	80
Meadow: good condition		30	58	71	78
Wood or Forest land: thin stand, poor cover, no mulch		45	66	77	83
good cover[2]		25	55	70	77
Open Spaces, lawns, parks, golf courses, cemeteries, etc.					
good condition: grass cover on 75% or more of the area		39	61	74	80
fair condition: grass cover on 50% to 75% of the area		49	69	79	84
Commercial and business areas (85% impervious)		89	92	94	95
Industrial districts (72% impervious).		81	88	91	93
Residential:[3]					
Average lot size	Average % Impervious[4]				
1/8 acre or less	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
Paved parking lots, roofs, driveways, etc.[5]		98	98	98	98
Streets and roads:					
paved with curbs and storm sewers[5]		98	98	98	98
gravel		76	85	89	91
dirt		72	82	87	89

1/ For a more detailed description of agricultural land use curve numbers refer to National Engineering Handbook, Section 4, Hydrology, Chapter 9, Aug. 1972.

2/ Good cover is protected from grazing and litter and brush cover soil.

3/ Curve numbers are computed assuming the runoff from the house and driveway is directed towards the street with a minimum of roof water directed to lawns where additional infiltration could occur.

4/ The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.

5/ In some warmer climates of the country a curve number of 95 may be used.

Table 2-1.--Runoff depth in inches for selected CN's and rainfall amounts

Rainfall (inches)	Curve Number (CN)[1/]								
	60	65	70	75	80	85	90	95	98
1.0	0	0	0	0.03	0.08	0.17	0.32	.56	.79
1.2	0	0	0.03	0.07	0.15	0.28	0.46	.74	.99
1.4	0	0.02	0.06	0.13	0.24	0.39	0.61	.92	1.18
1.6	0.01	0.05	0.11	0.20	0.34	0.52	0.76	1.11	1.38
1.8	0.03	0.09	0.17	0.29	0.44	0.65	0.93	1.29	1.58
2.0	0.06	0.14	0.24	0.38	0.56	0.80	1.09	1.48	1.77
2.5	0.17	0.30	0.46	0.65	0.89	1.18	1.53	1.96	2.27
3.0	0.33	0.51	0.72	0.96	1.25	1.59	1.98	2.45	2.78
4.0	0.76	1.03	1.33	1.67	2.04	2.46	2.92	3.43	3.77
5.0	1.30	1.65	2.04	2.45	2.89	3.37	3.88	4.42	4.76
6.0	1.92	2.35	2.80	3.28	3.78	4.31	4.85	5.41	5.76
7.0	2.60	3.10	3.62	4.15	4.69	5.26	5.82	6.41	6.76
8.0	3.33	3.90	4.47	5.04	5.62	6.22	6.81	7.40	7.76
9.0	4.10	4.72	5.34	5.95	6.57	7.19	7.79	8.40	8.76
10.0	4.90	5.57	6.23	6.88	7.52	8.16	8.78	9.40	9.76
11.0	5.72	6.44	7.13	7.82	8.48	9.14	9.77	10.39	10.76
12.0	6.56	7.32	8.05	8.76	9.45	10.12	10.76	11.39	11.76

1/ To obtain runoff depths for CN's and other rainfall amounts not shown in this table, use an arithmetic interpolation.

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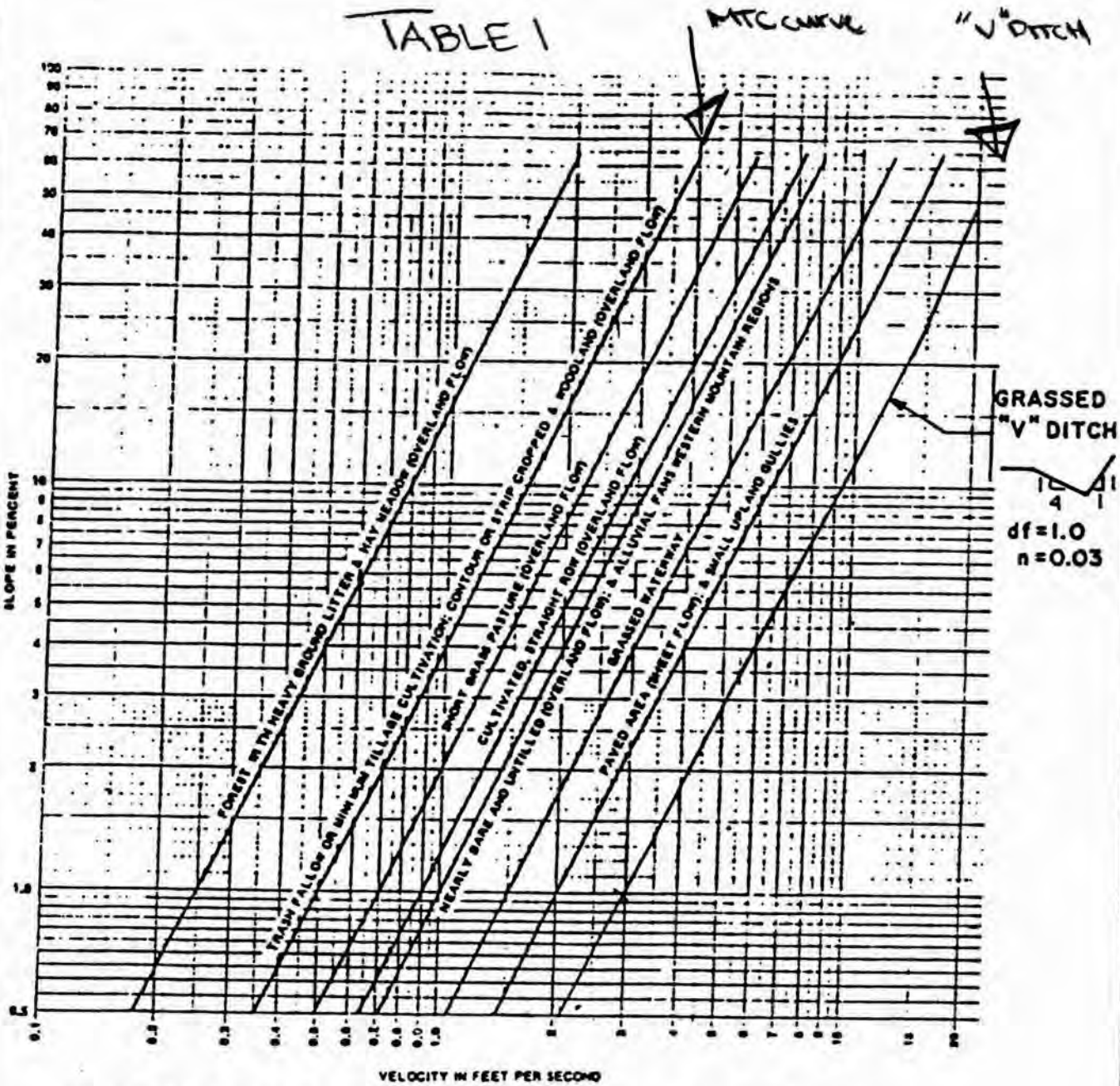
SUBJECT Proteco Peak Flow Analysis TABLE 1 JOB NO. B511



AVERAGE VELOCITIES FOR ESTIMATING TRAVEL TIME FOR OVERLAND FLOW *

Watershed Areas:

The entire Watershed Area is shown on Figure 1, pg. 11

The Watershed subareas, labeled I through XXXV*, are shown on Figures 1-4, pages 11-14.

Note: These figures are only used to show the relative locations of the Watershed subareas and were not used to planimeter areas. Actual areas were planimetered the from 1:100 design drawings and U.S.G.S. Quadrange for Penuelas, P.R.

* Watershed Areas XXXII, XXXIII, XXXIV which represent intermediate stages of development are not shown

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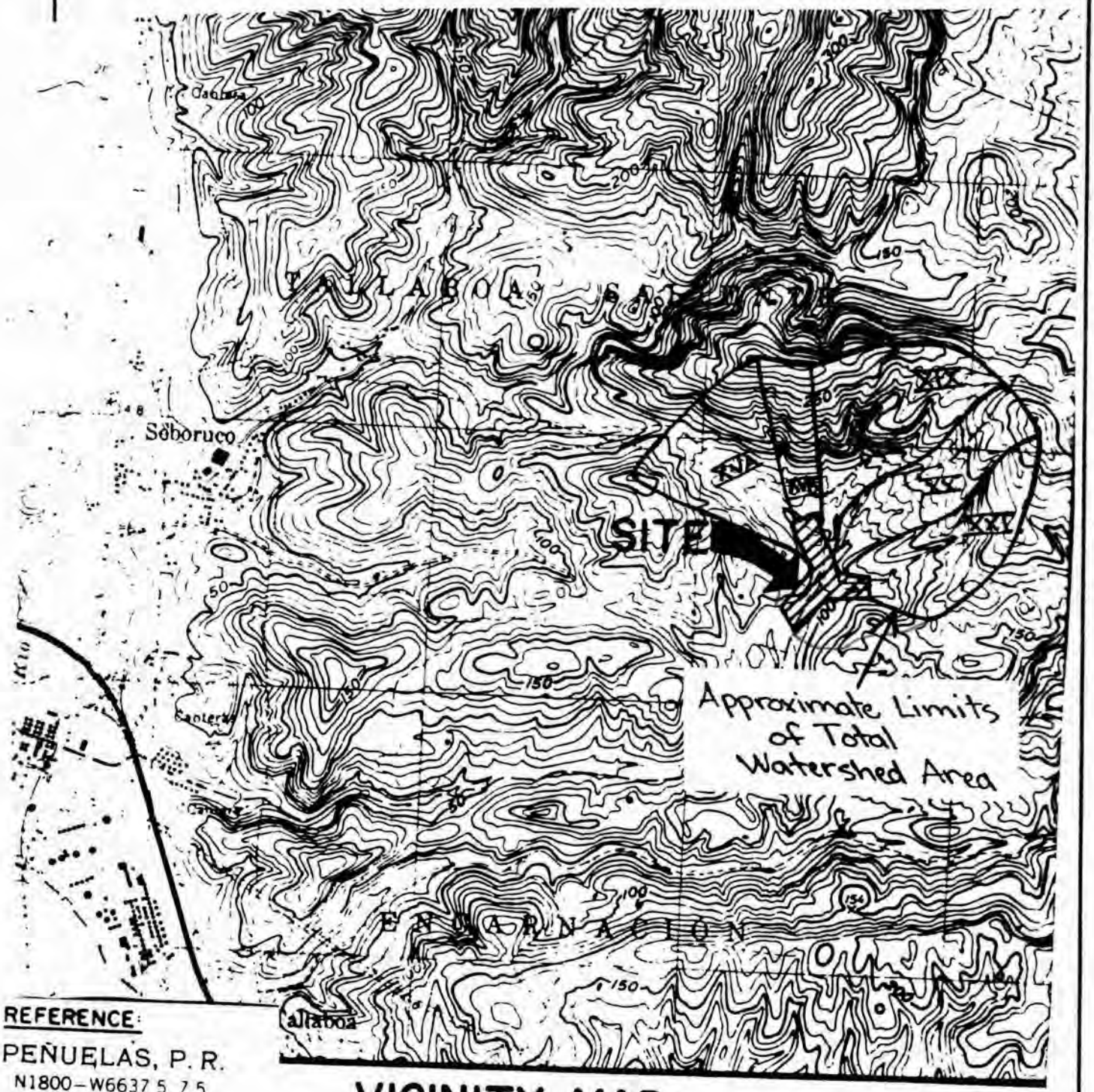
SUBJECT Proteco
Total Watershed Area
FIGURE 1

JOB NO. B511



REFERENCE:

PEÑUELAS, P. R.
N1800–W6637 5 7 5

1972
PHOTOREVISED 1982
MA 1222 II NW-SERIES E835

VICINITY MAP

SCALE

0 2000 4000 6000 FEET

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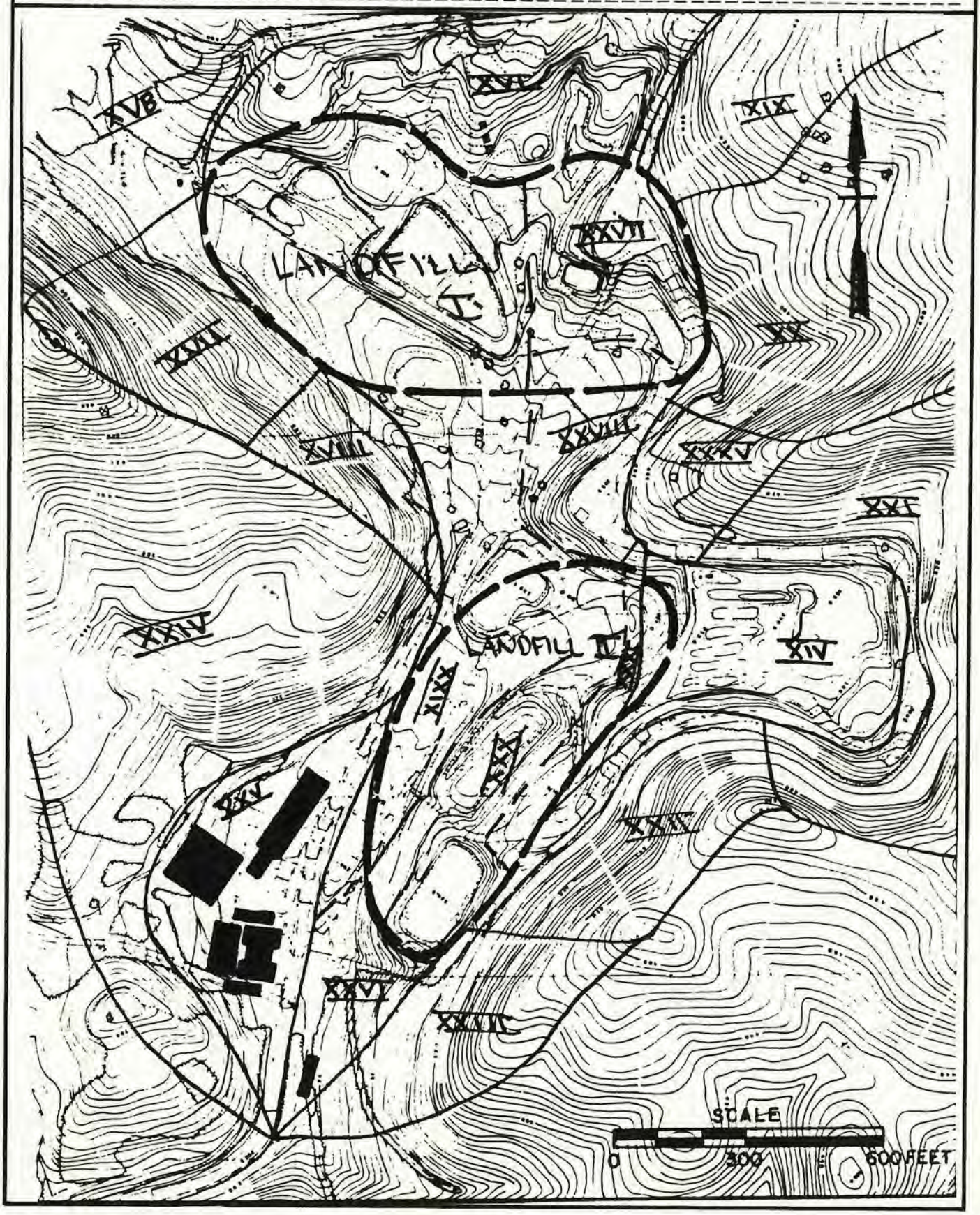
SUBJECT Proteco
Watershed Subareas

JOB NO. B511

FIGURE 2



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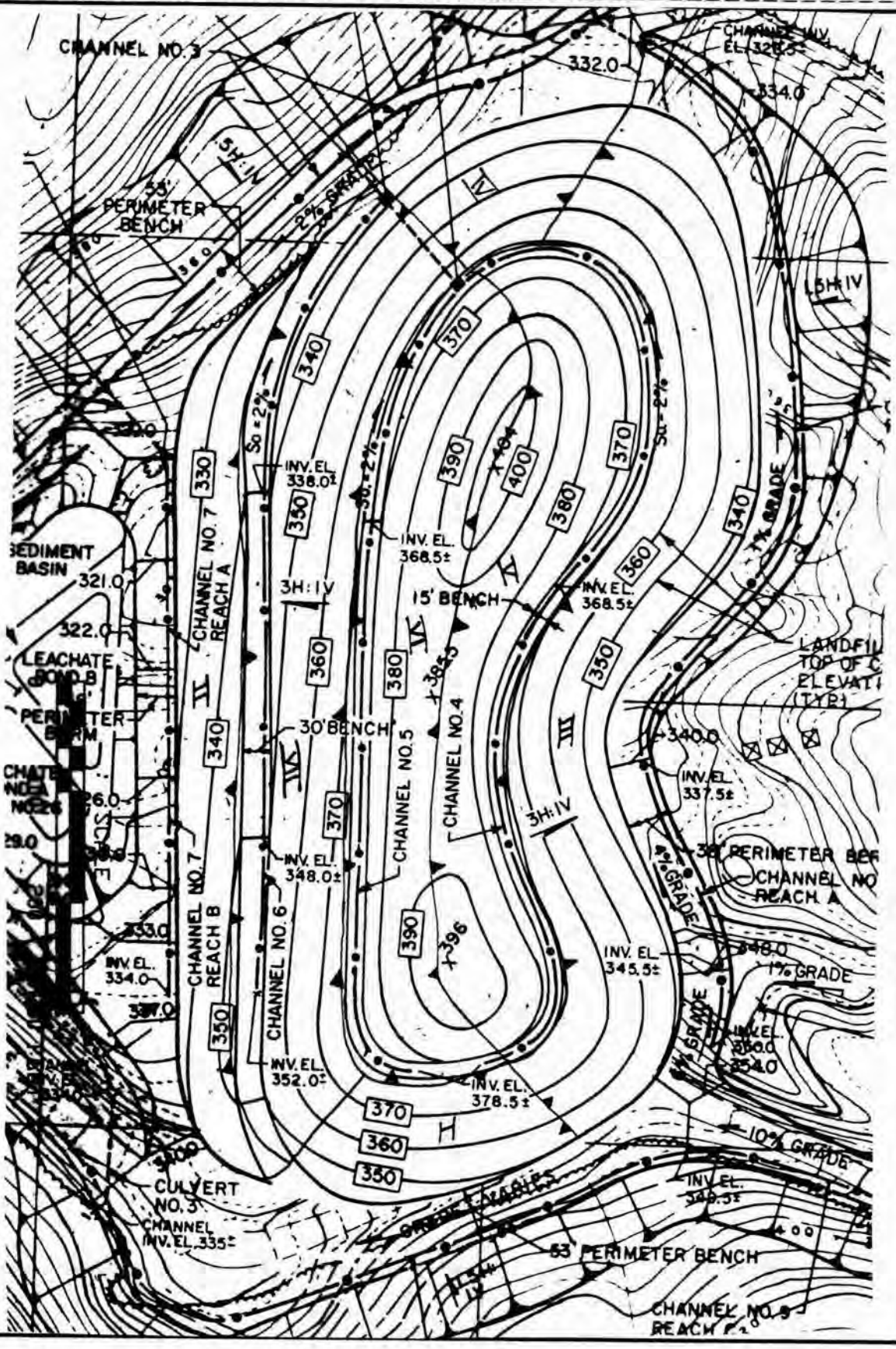
SUBJECT Proteco

Watershed Subareas - Landfill I

FIGURE 3

JOB NO. 8511



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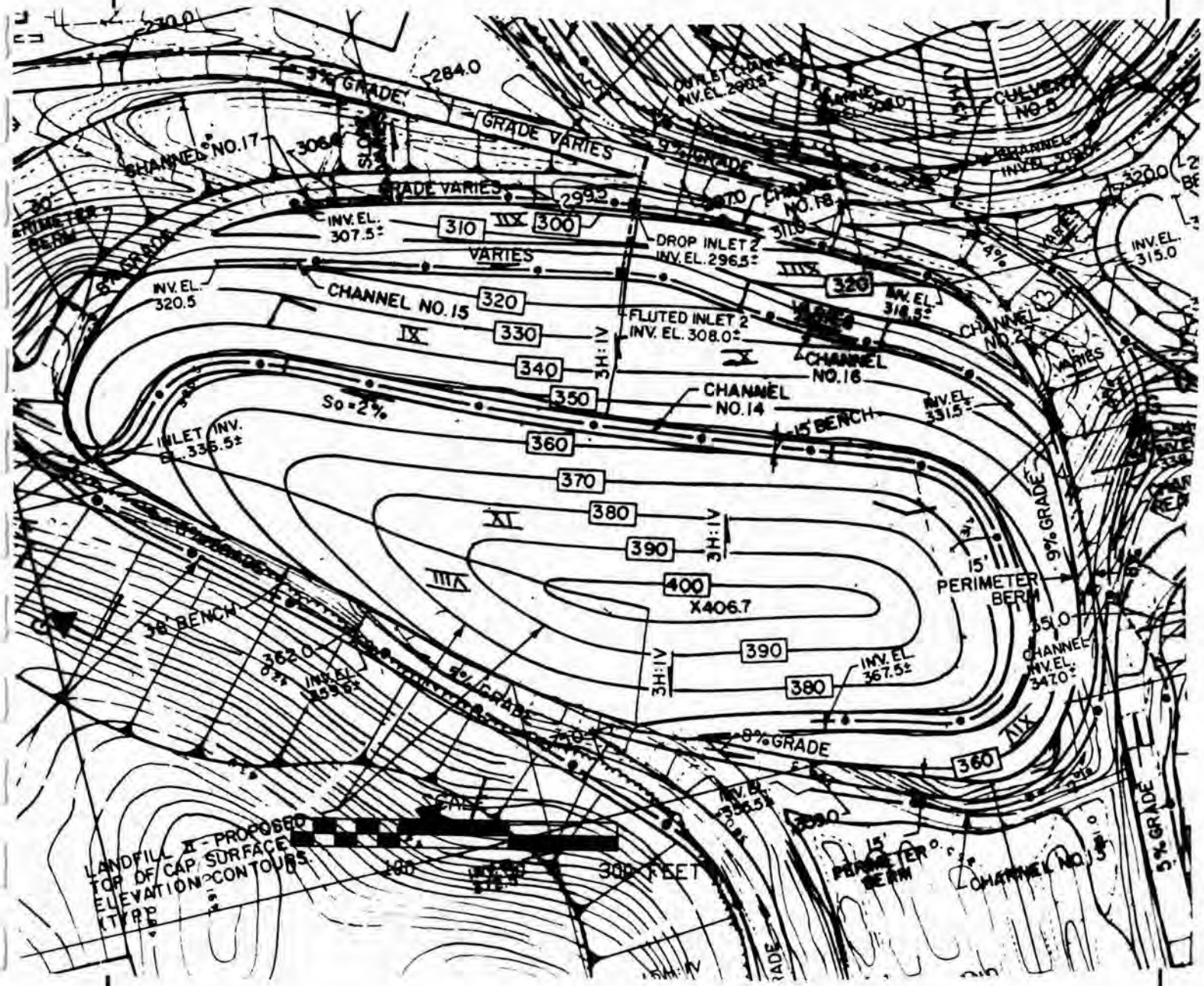
SUBJECT Proteco
Watershed Subareas – Landfill II
FIGURE 4

JOB NO. B511



DRAINAGE AREAS (PLANIMETRY)

COMPLETED LANDFILL

WATERSHED AREA (DRWNG #B511E-L19)	DRAINAGE AREA (FT²)	DRAINAGE AREA (ACRE)	DRAINAGE AREA (MI²)	CN	DP $T_t=0$
I	47510	1.09	0.002	91	E
II	44463	1.02	0.002	91	D
III	130625	3.00	0.005	91	A
IV	32827	0.75	0.001	91	C
V	60390	1.39	0.002	91	B
VI	64912	1.49	0.002	91	B
VII	87998	2.02	0.003	91	C
VIII	66162	1.52	0.002	91	K
IX	129997	2.98	0.005	91	K
X	48232	1.11	0.002	91	M
XI	59099	1.36	0.002	91	M
XII	18615	0.43	0.0007	91	N
XIII	23896	0.55	0.0009	91	N
XIV	289536	6.65	0.01	83	L
(DRWNG #B511-R1)					
XV	3,698,853	84.91	0.13	83	A
XVI	330,700	7.59	0.01	83	A
XVII	116,450	2.67	0.004	83	D

DRAINAGE AREAS (CONT.)

COMPLETED LANDFILL

WATERSHED AREA (DRWNG # B511-R1)	DRAINAGE AREA (FT^2)	DRAINAGE AREA (ACRE)	DRAINAGE AREA (mi^2)	CN	DP(T_t=0)
XVIII	74845	1.72	0.003	83	G
XIX	3,121,250	71.77	0.110	83	T
XX	1,829,073	41.99	0.066	83	F
XXI	2,138,442	49.09	0.077	83	F
XXII	291,182	6.68	0.010	83	J
XXIII	527,800	12.12	0.019	83	J
XXIV	840,879	19.30	0.029	83	J
XXV	133,800	3.07	0.005	91	I
XXVI	118,872	2.73	0.004	83	J
XXXV	53,027	1.22	0.002	83	F

SUBJECT PROTECO JOB NO. B511
TR 55 ANALYSIS

DRAINAGE AREAS

PHASE 1, STAGE 1 CONDITIONS

WATERSHED AREA (PHASE 1, CELL 1 DRWNG)	DRAINAGE AREA (FT²)	DRAINAGE AREA (ACRE)	DRAINAGE AREA (MI²)	CN	DP (T_t=0)
XXVII ~~I~~'	146001	3.35	0.005	83	P
XXVIII ~~II~~'	86748	1.99	0.003	83	L
XXIX ~~III~~'	138037	3.17	0.005	83	R
XXX ~~IV~~'	289541	6.64	0.010	83	R
~~XXXI~~ ~~V~~'	71411	1.64	0.003	83	Q
XXXII ~~VI~~'	46284	1.06	0.002	83	J
XXXIII ~~VII~~'	38066	0.87	0.001	83	J

PHASE 2, STAGE 1 CONDITIONS

WATERSHED AREA (PHASE 2, STAGE 1 DRWNG)	DRAINAGE AREA (FT²)	DRAINAGE AREA (ACRE)	DRAINAGE AREA (MI²)	CN	DP (T_t=0)
XXXIV ~~I~~"	168559	3.87	0.006	83	S

SUBJECT PROTECO — JOB NO. 8511
TR 55 ANALYSIS

TIME OF CONCENTRATION

COMPLETED LANDFILL

* = MTR CURVE
† = "V" DITCH CURVE

WATERSHED AREA I

REACH	L(FT)	ΔH (FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	TOTAL
* A	100	25	0.25	2.5	40	
† B	410	3% GRADE	0.03	5.0	82	122

WATERSHED AREA II

REACH	L(FT)	ΔH (FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
* A	50	15	0.30	2.8	18	
† B	800	20	0.025	4.7	170	188

WATERSHED AREA III

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
* A	100	25	0.25	2.5	40	
† B	1100	20	0.018	4.0	275	315

WATERSHED AREA IV

REACH	L(FT)	ΔH (FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
* A	140	35	0.25	2.5	56	
† B	280	2% GRADE	0.02	4.2	67	123

WATERSHED AREA V

REACH	L(FT)	ΔH (FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
* A	100	16	0.16	2.0	50	
† B	950	15	0.016	3.7	257	307

WATERSHED AREA VI

REACH	L(FT)	ΔH (FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
* A	100	16	0.16	2.0	50	
† B	880	15	0.017	3.9	226	276

WATERSHED AREA VII

REACH	L(FT)	ΔH (FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
* A	120	30	0.25	2.5	48	
† B	1000	10	0.01	3.0	333	381

WATERSHED AREA VIII

REACH	L(FT)	ΔH (FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
* A	100	33	0.33	2.9	34	
† B	550	≈ 15 (GRADE VARIES)	0.027	4.8	115	149

SUBJECT PROTECO JOB NO. 8511
TR 55 ANALYSIS

TIME OF CONCENTRATION
COMPLETED LANDFILL

* = MTC CURVE
† = "V" DITCH CURVE

WATERSHED AREA IX

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	TOTAL
* A	100	33	0.33	2.9	34	323
† B	1300	30	0.023	4.5	289	

WATERSHED AREA X

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
* A	70	27	0.39	3.2	22	
† B	450	33	0.073	8.0	56	178

WATERSHED AREA XI

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
* A	150	20	0.13	1.8	83	
† B	400	12	0.03	5.1	78	161

WATERSHED AREA XII

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
† CHANNEL	360	8	0.022	4.3	84	84

WATERSHED AREA XIII

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
† CHANNEL	420	8% GRADE	0.08	8.5	49	49

WATERSHED AREA XIV

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
* A	330	≈ 10	0.03	0.86	384	444
† B	330	11	0.033	5.5	60	

WATERSHED AREA XV

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
* A	1250	525	0.42	3.4	368	1425
* B	1585	131	0.083	1.5	1057	

WATERSHED AREA XVI

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
* A	580	84	0.14	1.9	305	
† B	1000	16	0.016	3.7	270	575

SUBJECT PROTECC
TR 55 ANALYSIS
JOB NO. B511

TIME OF CONCENTRATION
COMPLETED LANDFILL

* = MTC CURVE
† = "V" DITCH CURVE

WATERSHED AREA XVII

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	TOTAL
* OVERLAND	720	159	0.22	2.3	313	313

WATERSHED AREA XVIII

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
* A	210	72	0.34	2.9	72	131
† B	500	40	0.08	8.5	59	

WATERSHED AREA XIX

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
* OVERLAND	4500	590	0.13	1.8	2500	2500

WATERSHED AREA XX

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
* OVERLAND	3335	550	0.16	2.0	1668	1668

WATERSHED AREA XXI

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
* A	2835	558	0.20	2.3	1233	1331
† B	780	56	0.07	8.0	98	

WATERSHED AREA XXII

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
* A	260	86	0.33	2.9	90	1212
† B	1220	152	0.12	10.0	122	

WATERSHED AREA XXIII

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
* A	1110	227	0.20	2.3	483	483

WATERSHED AREA XXIV

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
* A	1100	235	0.21	2.3	478	668
† B	800	14	0.02	4.2	190	

SUBJECT PROTECO JOB NO. 8511
TRESS ANALYSIS

TIME OF CONCENTRATION
COMPLETED LANDFILL

* = MTC CURVE
† = "V" DITCH CURVE

WATERSHED AREA XXV

	REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
*	A	700	36	0.05	1.1	636	670
†	B	220	12	0.05	6.5	34	

WATERSHED AREA XXVI

	REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
*	A	360	90	0.25	2.5	.144	287
†	B	430	6	0.01	3.0	143	

WATERSHED AREA XXXV

	REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
*	A	310'	76'	0.25	2.5	124	194
†	B	420'	—	0.04	6.0	70	

WATERSHED AREA

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)

WATERSHED AREA

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)

WATERSHED AREA

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)

WATERSHED AREA

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)

WATERSHED AREA

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)

SUBJECT PROTECO JOB NO. B511
TR 55 ANALYSIS

TIME OF CONCENTRATION

* = MTC CURVE
† = "V" DITCH CURVE

PHASE 1, STAGE 1 CONDITIONS

WATERSHED AREA XXVII

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	TOTAL
* A	270	369-344 = 25	0.093	1.5	180	242
† B	440	344 - 319 = 25	0.057	7.1	62	

WATERSHED AREA XXVIII

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
* A	300	344 - 319 = 25	0.083	1.4	214	272
† B	320	319 - 308 = 11	0.034	5.5	58	

WATERSHED AREA XXIX

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
* A	280	324-308=16	0.057	1.2	233	400
† B	1 000	308 - 268 = 40	0.04	6.0	167	

WATERSHED AREA XXX

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
* A	150	327 - 319 = 8	0.053	1.1	136	298
† B	1050	319 - 268 = 51	0.049	6.5	162	

WATERSHED AREA XXXI

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
* A	50	4	0.08	1.3	38	140
† B	640	356 - 327 = 29	0.045	6.3	102	

WATERSHED AREA XXXII

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
* A	280	356 - 268 = 88	0.31	2.8	100	208
† B	430	268 - 260 = 8	0.019	4.0	108	

WATERSHED AREA XXXIII

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)	
† CHANNEL	430	8	0.019	4.0	108	108

WATERSHED AREA

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)

SUBJECT PROTECO TRESS ANALYSIS JOB NO. B511

TIME OF CONCENTRATION

* = MTC CURVE
† = "V" DITCH CURVE

PHASE II, STAGE II

WATERSHED AREA XXXIV

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)
* A	400	380-360=20	0.05	1.1	363
† B	590	360-300=60	0.10	9.5	62

425

WATERSHED AREA

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)

WATERSHED AREA

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)

WATERSHED AREA

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)

WATERSHED AREA

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)

WATERSHED AREA

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)

WATERSHED AREA

REACH	L(FT)	ΔH(FT)	S(ΔH/L)	V(FT/SEC)	T(SEC)

DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

WATERSHED AREA NUMBER..... I @ E
DRAINAGE AREA, SQ. MILES..... .002
CURVE NUMBER..... 91
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 9.399814
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	0
2	11.5	51	1
3	11.7	299	6
4	11.8	991	19
5	11.9	746	14
6	12.0	477	9
7	12.1	233	4
8	12.2	152	3
9	12.3	132	2
10	12.4	121	2
11	12.5	111	2
12	12.6	85	2
13	12.7	74	1
14	12.8	70	1
15	12.9	68	1
16	13.0	65	1
17	13.2	52	1
18	13.5	48	1
19	14.0	39	1
20	14.5	33	1
21	15.0	29	1
22	16.0	24	0
23	18.0	18	0
24	20.0	14	0

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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

WATERSHED AREA NUMBER..... II @ D (CHANNEL 7)
DRAINAGE AREA, SQ. MILES..... .002
CURVE NUMBER..... 91
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 9.399814
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	0
2	11.5	51	1
3	11.7	299	6
4	11.8	991	19
5	11.9	746	14
6	12.0	477	9
7	12.1	233	4
8	12.2	152	3
9	12.3	132	2
10	12.4	121	2
11	12.5	111	2
12	12.6	85	2
13	12.7	74	1
14	12.8	70	1
15	12.9	68	1
16	13.0	65	1
17	13.2	52	1
18	13.5	48	1
19	14.0	39	1
20	14.5	33	1
21	15.0	29	1
22	16.0	24	0
23	18.0	18	0
24	20.0	14	0

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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

WATERSHED AREA NUMBER..... III @ A
DRAINAGE AREA, SQ. MILES..... .005
CURVE NUMBER..... 91
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 9.399814
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	1
2	11.5	51	2
3	11.7	299	14
4	11.8	991	47
5	11.9	746	35
6	12.0	477	22
7	12.1	233	11
8	12.2	152	7
9	12.3	132	6
10	12.4	121	6
11	12.5	111	5
12	12.6	85	4
13	12.7	74	3
14	12.8	70	3
15	12.9	68	3
16	13.0	65	3
17	13.2	52	2
18	13.5	48	2
19	14.0	39	2
20	14.5	33	2
21	15.0	29	1
22	16.0	24	1
23	18.0	18	1
24	20.0	14	1

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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

WATERSHED AREA NUMBER..... IV @ C
DRAINAGE AREA, SQ. MILES..... .001
CURVE NUMBER..... 91
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 9.399814
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	0
2	11.5	51	0
3	11.7	299	3
4	11.8	991	9
5	11.9	746	7
6	12.0	477	4
7	12.1	233	2
8	12.2	152	1
9	12.3	132	1
10	12.4	121	1
11	12.5	111	1
12	12.6	85	1
13	12.7	74	1
14	12.8	70	1
15	12.9	68	1
16	13.0	65	1
17	13.2	52	0
18	13.5	48	0
19	14.0	39	0
20	14.5	33	0
21	15.0	29	0
22	16.0	24	0
23	18.0	18	0
24	20.0	14	0

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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

WATERSHED AREA NUMBER..... V @ B (CHANNEL 4)
DRAINAGE AREA, SQ. MILES..... .002
CURVE NUMBER..... 91
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 9.399814
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	0
2	11.5	51	1
3	11.7	299	6
4	11.8	991	19
5	11.9	746	14
6	12.0	477	9
7	12.1	233	4
8	12.2	152	3
9	12.3	132	2
10	12.4	121	2
11	12.5	111	2
12	12.6	85	2
13	12.7	74	1
14	12.8	70	1
15	12.9	68	1
16	13.0	65	1
17	13.2	52	1
18	13.5	48	1
19	14.0	39	1
20	14.5	33	1
21	15.0	29	1
22	16.0	24	0
23	18.0	18	0
24	20.0	14	0

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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

WATERSHED AREA NUMBER..... VI @ B (CHANNEL 5)
DRAINAGE AREA, SQ. MILES..... .002
CURVE NUMBER..... 91
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 9.399814
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	0
2	11.5	51	1
3	11.7	299	6
4	11.8	991	19
5	11.9	746	14
6	12.0	477	9
7	12.1	233	4
8	12.2	152	3
9	12.3	132	2
10	12.4	121	2
11	12.5	111	2
12	12.6	85	2
13	12.7	74	1
14	12.8	70	1
15	12.9	68	1
16	13.0	65	1
17	13.2	52	1
18	13.5	48	1
19	14.0	39	1
20	14.5	33	1
21	15.0	29	1
22	16.0	24	0
23	18.0	18	0
24	20.0	14	0

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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

WATERSHED AREA NUMBER..... VII @ C (CHANNEL 6)
DRAINAGE AREA, SQ. MILES..... .003
CURVE NUMBER..... 91
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 9.399814
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	1
2	11.5	51	1
3	11.7	299	8
4	11.8	991	28
5	11.9	746	21
6	12.0	477	13
7	12.1	233	7
8	12.2	152	4
9	12.3	132	4
10	12.4	121	3
11	12.5	111	3
12	12.6	85	2
13	12.7	74	2
14	12.8	70	2
15	12.9	68	2
16	13.0	65	2
17	13.2	52	1
18	13.5	48	1
19	14.0	39	1
20	14.5	33	1
21	15.0	29	1
22	16.0	24	1
23	18.0	18	1
24	20.0	14	0

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DESCRIPTION: PROTECO LANDFILL
DRAINAGE AREA
TR 55

WATERSHED AREA NUMBER..... VIII @ K
DRAINAGE AREA, SQ. MILES..... .002
CURVE NUMBER..... 91
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 9.399814
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	0
2	11.5	51	1
3	11.7	299	6
4	11.8	991	19
5	11.9	746	14
6	12.0	477	9
7	12.1	233	4
8	12.2	152	3
9	12.3	132	2
10	12.4	121	2
11	12.5	111	2
12	12.6	85	2
13	12.7	74	1
14	12.8	70	1
15	12.9	68	1
16	13.0	65	1
17	13.2	52	1
18	13.5	48	1
19	14.0	39	1
20	14.5	33	1
21	15.0	29	1
22	16.0	24	0
23	18.0	18	0
24	20.0	14	0

DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

WATERSHED AREA NUMBER..... IX @ K (CHANNEL 14)
DRAINAGE AREA, SQ. MILES..... .005
CURVE NUMBER..... 91
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 9.399814
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	1
2	11.5	51	2
3	11.7	299	14
4	11.8	991	47
5	11.9	746	35
6	12.0	477	22
7	12.1	233	11
8	12.2	152	7
9	12.3	132	6
10	12.4	121	6
11	12.5	111	5
12	12.6	85	4
13	12.7	74	3
14	12.8	70	3
15	12.9	68	3
16	13.0	65	3
17	13.2	52	2
18	13.5	48	2
19	14.0	39	2
20	14.5	33	2
21	15.0	29	1
22	16.0	24	1
23	18.0	18	1
24	20.0	14	1

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DESCRIPTION: PROTECO LANDFILL
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TR 55

WATERSHED AREA NUMBER..... X @ M (CHANNEL 16)
DRAINAGE AREA, SQ. MILES..... .002
CURVE NUMBER..... 91
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 9.399814
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	0
2	11.5	51	1
3	11.7	299	6
4	11.8	991	19
5	11.9	746	14
6	12.0	477	9
7	12.1	233	4
8	12.2	152	3
9	12.3	132	2
10	12.4	121	2
11	12.5	111	2
12	12.6	85	2
13	12.7	74	1
14	12.8	70	1
15	12.9	68	1
16	13.0	65	1
17	13.2	52	1
18	13.5	48	1
19	14.0	39	1
20	14.5	33	1
21	15.0	29	1
22	16.0	24	0
23	18.0	18	0
24	20.0	14	0

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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
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WATERSHED AREA NUMBER..... XI @ M (CHANNEL 15)
DRAINAGE AREA, SQ. MILES..... .002
CURVE NUMBER..... 91
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 9.399814
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	0
2	11.5	51	1
3	11.7	299	6
4	11.8	991	19
5	11.9	746	14
6	12.0	477	9
7	12.1	233	4
8	12.2	152	3
9	12.3	132	2
10	12.4	121	2
11	12.5	111	2
12	12.6	85	2
13	12.7	74	1
14	12.8	70	1
15	12.9	68	1
16	13.0	65	1
17	13.2	52	1
18	13.5	48	1
19	14.0	39	1
20	14.5	33	1
21	15.0	29	1
22	16.0	24	0
23	18.0	18	0
24	20.0	14	0

DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

WATERSHED AREA NUMBER..... XII @ N (CHANNEL 17)
DRAINAGE AREA, SQ. MILES..... .0007
CURVE NUMBER..... 91
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 9.399814
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	0
2	11.5	51	0
3	11.7	299	2
4	11.8	991	7
5	11.9	746	5
6	12.0	477	3
7	12.1	233	2
8	12.2	152	1
9	12.3	132	1
10	12.4	121	1
11	12.5	111	1
12	12.6	85	1
13	12.7	74	0
14	12.8	70	0
15	12.9	68	0
16	13.0	65	0
17	13.2	52	0
18	13.5	48	0
19	14.0	39	0
20	14.5	33	0
21	15.0	29	0
22	16.0	24	0
23	18.0	18	0
24	20.0	14	0

DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

WATERSHED AREA NUMBER..... XIII @ N (CHANNEL 18)
DRAINAGE AREA, SQ. MILES..... .0009
CURVE NUMBER..... 91
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 9.399814
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	0
2	11.5	51	0
3	11.7	299	3
4	11.8	991	8
5	11.9	746	6
6	12.0	477	4
7	12.1	233	2
8	12.2	152	1
9	12.3	132	1
10	12.4	121	1
11	12.5	111	1
12	12.6	85	1
13	12.7	74	1
14	12.8	70	1
15	12.9	68	1
16	13.0	65	1
17	13.2	52	0
18	13.5	48	0
19	14.0	39	0
20	14.5	33	0
21	15.0	29	0
22	16.0	24	0
23	18.0	18	0
24	20.0	14	0

DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

WATERSHED AREA NUMBER..... XIV @ L (CHANNEL 13)
DRAINAGE AREA, SQ. MILES..... .01
CURVE NUMBER..... 83
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 8.38777
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	2
2	11.5	51	4
3	11.7	299	25
4	11.8	991	83
5	11.9	746	63
6	12.0	477	40
7	12.1	233	20
8	12.2	152	13
9	12.3	132	11
10	12.4	121	10
11	12.5	111	9
12	12.6	85	7
13	12.7	74	6
14	12.8	70	6
15	12.9	68	6
16	13.0	65	5
17	13.2	52	4
18	13.5	48	4
19	14.0	39	3
20	14.5	33	3
21	15.0	29	2
22	16.0	24	2
23	18.0	18	2
24	20.0	14	1

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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

WATERSHED AREA NUMBER..... XVA @ A
DRAINAGE AREA, SQ. MILES..... .1
CURVE NUMBER..... 83
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 8.38777
TIME OF CONCENTRATION, HRS..... .4
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	20	17
2	11.5	39	33
3	11.7	103	86
4	11.8	224	188
5	11.9	419	351
6	12.0	558	468
7	12.1	575	482
8	12.2	451	378
9	12.3	331	278
10	12.4	247	207
11	12.5	190	159
12	12.6	155	130
13	12.7	127	107
14	12.8	105	88
15	12.9	90	75
16	13.0	80	67
17	13.2	66	55
18	13.5	53	44
19	14.0	42	35
20	14.5	35	29
21	15.0	30	25
22	16.0	24	20
23	18.0	18	15
24	20.0	14	12

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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

WATERSHED AREA NUMBER..... XVB @ A (CHANNEL 1, REACH A)
DRAINAGE AREA, SQ. MILES..... .04
CURVE NUMBER..... 83
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 8.38777
TIME OF CONCENTRATION, HRS..... .5
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	18	6
2	11.5	36	12
3	11.7	80	27
4	11.8	166	56
5	11.9	301	101
6	12.0	433	145
7	12.1	496	166
8	12.2	474	159
9	12.3	395	133
10	12.4	309	104
11	12.5	242	81
12	12.6	194	65
13	12.7	158	53
14	12.8	130	44
15	12.9	109	37
16	13.0	94	32
17	13.2	75	25
18	13.5	57	19
19	14.0	43	14
20	14.5	36	12
21	15.0	31	10
22	16.0	25	8
23	18.0	18	6
24	20.0	15	5

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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

COMBINED HYDROGRAPH FOR WATERSHED AREA NUMBERS: XVA AND XVB @ A

TIME FRAME	TIME, HRS.	q, CFS
1	11.0	23
2	11.5	45
3	11.7	113
4	11.8	244
5	11.9	452
6	12.0	613
7	12.1	649
8	12.2	537
9	12.3	410
10	12.4	311
11	12.5	241
12	12.6	195
13	12.7	160
14	12.8	132
15	12.9	112
16	13.0	99
17	13.2	81
18	13.5	64
19	14.0	50
20	14.5	41
21	15.0	36
22	16.0	29
23	18.0	21
24	20.0	17

DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

WATERSHED AREA NUMBER..... XV @ A (CHANNEL 1 - REACH B)
DRAINAGE AREA, SQ. MILES..... .13
CURVE NUMBER..... 83
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 8.38777
TIME OF CONCENTRATION, HRS..... .4
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	20	22
2	11.5	39	43
3	11.7	103	112
4	11.8	224	244
5	11.9	419	457
6	12.0	558	608
7	12.1	575	627
8	12.2	451	492
9	12.3	331	361
10	12.4	247	269
11	12.5	190	207
12	12.6	155	169
13	12.7	127	138
14	12.8	105	114
15	12.9	90	98
16	13.0	80	87
17	13.2	66	72
18	13.5	53	58
19	14.0	42	46
20	14.5	35	38
21	15.0	30	33
22	16.0	24	26
23	18.0	18	20
24	20.0	14	15

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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

WATERSHED AREA NUMBER..... XVI @ A
DRAINAGE AREA, SQ. MILES..... .01
CURVE NUMBER..... 83
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 8.38777
TIME OF CONCENTRATION, HRS..... .2
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	23	2
2	11.5	47	4
3	11.7	208	17
4	11.8	509	43
5	11.9	796	67
6	12.0	641	54
7	12.1	424	36
8	12.2	245	21
9	12.3	170	14
10	12.4	138	12
11	12.5	121	10
12	12.6	104	9
13	12.7	85	7
14	12.8	75	6
15	12.9	71	6
16	13.0	68	6
17	13.2	56	5
18	13.5	49	4
19	14.0	40	3
20	14.5	34	3
21	15.0	29	2
22	16.0	24	2
23	18.0	18	2
24	20.0	14	1

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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

WATERSHED AREA NUMBER..... XVII @ D
DRAINAGE AREA, SQ. MILES..... .004
CURVE NUMBER..... 83
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 8.38777
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	1
2	11.5	51	2
3	11.7	299	10
4	11.8	991	33
5	11.9	746	25
6	12.0	477	16
7	12.1	233	8
8	12.2	152	5
9	12.3	132	4
10	12.4	121	4
11	12.5	111	4
12	12.6	85	3
13	12.7	74	2
14	12.8	70	2
15	12.9	68	2
16	13.0	65	2
17	13.2	52	2
18	13.5	48	2
19	14.0	39	1
20	14.5	33	1
21	15.0	29	1
22	16.0	24	1
23	18.0	18	1
24	20.0	14	0

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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

WATERSHED AREA NUMBER..... XVIII @ G
DRAINAGE AREA, SQ. MILES..... .003
CURVE NUMBER..... 83
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 8.38777
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	1
2	11.5	51	1
3	11.7	299	8
4	11.8	991	25
5	11.9	746	19
6	12.0	477	12
7	12.1	233	6
8	12.2	152	4
9	12.3	132	3
10	12.4	121	3
11	12.5	111	3
12	12.6	85	2
13	12.7	74	2
14	12.8	70	2
15	12.9	68	2
16	13.0	65	2
17	13.2	52	1
18	13.5	48	1
19	14.0	39	1
20	14.5	33	1
21	15.0	29	1
22	16.0	24	1
23	18.0	18	0
24	20.0	14	0

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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

WATERSHED AREA NUMBER..... XIX @ T (FOR CHANNEL 9)
DRAINAGE AREA, SQ. MILES..... .11
CURVE NUMBER..... 83
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 8.38777
TIME OF CONCENTRATION, HRS..... .75
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	15	14
2	11.5	29	27
3	11.7	57	53
4	11.8	98	90
5	11.9	163	150
6	12.0	248	229
7	12.1	329	304
8	12.2	375	346
9	12.3	388	358
10	12.4	369	340
11	12.5	325	300
12	12.6	276	255
13	12.7	232	214
14	12.8	195	180
15	12.9	165	152
16	13.0	142	131
17	13.2	107	99
18	13.5	76	70
19	14.0	51	47
20	14.5	39	36
21	15.0	33	30
22	16.0	26	24
23	18.0	19	18
24	20.0	15	14

DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

WATERSHED AREA NUMBER..... XX @ F
DRAINAGE AREA, SQ. MILES..... .066
CURVE NUMBER..... 83
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 8.38777
TIME OF CONCENTRATION, HRS..... .5
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	18	10
2	11.5	36	20
3	11.7	80	44
4	11.8	166	92
5	11.9	301	167
6	12.0	433	240
7	12.1	496	275
8	12.2	474	262
9	12.3	395	219
10	12.4	309	171
11	12.5	242	134
12	12.6	194	107
13	12.7	158	87
14	12.8	130	72
15	12.9	109	60
16	13.0	94	52
17	13.2	75	42
18	13.5	57	32
19	14.0	43	24
20	14.5	36	20
21	15.0	31	17
22	16.0	25	14
23	18.0	18	10
24	20.0	15	8

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DESCRIPTION: PROTECO LANDFILL
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TR 55

WATERSHED AREA NUMBER..... XXI @ F (CHANNEL 11)
DRAINAGE AREA, SQ. MILES..... .077
CURVE NUMBER..... 83
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 8.38777
TIME OF CONCENTRATION, HRS..... .4
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	20	13
2	11.5	39	25
3	11.7	103	67
4	11.8	224	145
5	11.9	419	271
6	12.0	558	360
7	12.1	575	371
8	12.2	451	291
9	12.3	331	214
10	12.4	247	160
11	12.5	190	123
12	12.6	155	100
13	12.7	127	82
14	12.8	105	68
15	12.9	90	58
16	13.0	80	52
17	13.2	66	43
18	13.5	53	34
19	14.0	42	27
20	14.5	35	23
21	15.0	30	19
22	16.0	24	16
23	18.0	18	12
24	20.0	14	9

DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

WATERSHED AREA NUMBER..... XXII @ J
DRAINAGE AREA, SQ. MILES..... .01
CURVE NUMBER..... 83
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 8.38777
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	2
2	11.5	51	4
3	11.7	299	25
4	11.8	991	83
5	11.9	746	63
6	12.0	477	40
7	12.1	233	20
8	12.2	152	13
9	12.3	132	11
10	12.4	121	10
11	12.5	111	9
12	12.6	85	7
13	12.7	74	6
14	12.8	70	6
15	12.9	68	6
16	13.0	65	5
17	13.2	52	4
18	13.5	48	4
19	14.0	39	3
20	14.5	33	3
21	15.0	29	2
22	16.0	24	2
23	18.0	18	2
24	20.0	14	1

DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

WATERSHED AREA NUMBER..... XXIII @ J
DRAINAGE AREA, SQ. MILES..... .019
CURVE NUMBER..... 83
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 8.38777
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	4
2	11.5	51	8
3	11.7	299	48
4	11.8	991	158
5	11.9	746	119
6	12.0	477	76
7	12.1	233	37
8	12.2	152	24
9	12.3	132	21
10	12.4	121	19
11	12.5	111	18
12	12.6	85	14
13	12.7	74	12
14	12.8	70	11
15	12.9	68	11
16	13.0	65	10
17	13.2	52	8
18	13.5	48	8
19	14.0	39	6
20	14.5	33	5
21	15.0	29	5
22	16.0	24	4
23	18.0	18	3
24	20.0	14	2

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DESCRIPTION: PROTECO LANDFILL
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WATERSHED AREA NUMBER..... XXIV @ J
DRAINAGE AREA, SQ. MILES..... .029
CURVE NUMBER..... 83
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 8.38777
TIME OF CONCENTRATION, HRS..... .2
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	23	6
2	11.5	47	11
3	11.7	208	51
4	11.8	509	124
5	11.9	796	194
6	12.0	641	156
7	12.1	424	103
8	12.2	245	60
9	12.3	170	41
10	12.4	138	34
11	12.5	121	29
12	12.6	104	25
13	12.7	85	21
14	12.8	75	18
15	12.9	71	17
16	13.0	68	17
17	13.2	56	14
18	13.5	49	12
19	14.0	40	10
20	14.5	34	8
21	15.0	29	7
22	16.0	24	6
23	18.0	18	4
24	20.0	14	3

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DESCRIPTION: PROTECO LANDFILL
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WATERSHED AREA NUMBER..... XXV @ i
DRAINAGE AREA, SQ. MILES..... .005
CURVE NUMBER..... 91
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 9.399814
TIME OF CONCENTRATION, HRS..... .2
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	23	1
2	11.5	47	2
3	11.7	208	10
4	11.8	509	24
5	11.9	796	37
6	12.0	641	30
7	12.1	424	20
8	12.2	245	12
9	12.3	170	8
10	12.4	138	6
11	12.5	121	6
12	12.6	104	5
13	12.7	85	4
14	12.8	75	4
15	12.9	71	3
16	13.0	68	3
17	13.2	56	3
18	13.5	49	2
19	14.0	40	2
20	14.5	34	2
21	15.0	29	1
22	16.0	24	1
23	18.0	18	1
24	20.0	14	1

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DESCRIPTION: PROTECO LANDFILL
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TR 55

WATERSHED AREA NUMBER..... XXVI @ J
DRAINAGE AREA, SQ. MILES..... .004
CURVE NUMBER..... 83
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 8.38777
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	1
2	11.5	51	2
3	11.7	299	10
4	11.8	991	33
5	11.9	746	25
6	12.0	477	16
7	12.1	233	8
8	12.2	152	5
9	12.3	132	4
10	12.4	121	4
11	12.5	111	4
12	12.6	85	3
13	12.7	74	2
14	12.8	70	2
15	12.9	68	2
16	13.0	65	2
17	13.2	52	2
18	13.5	48	2
19	14.0	39	1
20	14.5	33	1
21	15.0	29	1
22	16.0	24	1
23	18.0	18	1
24	20.0	14	0

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DESCRIPTION: PROTECO LANDFILL
DRAINAGE AREAS
TR 55

WATERSHED AREA NUMBER..... XXVII @ P
DRAINAGE AREA, SQ. MILES..... .005
CURVE NUMBER..... 83
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 8.38777
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	1
2	11.5	51	2
3	11.7	299	13
4	11.8	991	42
5	11.9	746	31
6	12.0	477	20
7	12.1	233	10
8	12.2	152	6
9	12.3	132	6
10	12.4	121	5
11	12.5	111	5
12	12.6	85	4
13	12.7	74	3
14	12.8	70	3
15	12.9	68	3
16	13.0	65	3
17	13.2	52	2
18	13.5	48	2
19	14.0	39	2
20	14.5	33	1
21	15.0	29	1
22	16.0	24	1
23	18.0	18	1
24	20.0	14	1

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DESCRIPTION: PROTECO LANDFILL
DRAINAGE AREAS
TR 55

WATERSHED AREA NUMBER..... XXVIII @ L
DRAINAGE AREA, SQ. MILES..... .003
CURVE NUMBER..... 83
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 8.38777
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	1
2	11.5	51	1
3	11.7	299	8
4	11.8	991	25
5	11.9	746	19
6	12.0	477	12
7	12.1	233	6
8	12.2	152	4
9	12.3	132	3
10	12.4	121	3
11	12.5	111	3
12	12.6	85	2
13	12.7	74	2
14	12.8	70	2
15	12.9	68	2
16	13.0	65	2
17	13.2	52	1
18	13.5	48	1
19	14.0	39	1
20	14.5	33	1
21	15.0	29	1
22	16.0	24	1
23	18.0	18	0
24	20.0	14	0

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WATERSHED AREA NUMBER..... XXIX @ R
DRAINAGE AREA, SQ. MILES..... .005
CURVE NUMBER..... 83
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 8.38777
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	1
2	11.5	51	2
3	11.7	299	13
4	11.8	991	42
5	11.9	746	31
6	12.0	477	20
7	12.1	233	10
8	12.2	152	6
9	12.3	132	6
10	12.4	121	5
11	12.5	111	5
12	12.6	85	4
13	12.7	74	3
14	12.8	70	3
15	12.9	68	3
16	13.0	65	3
17	13.2	52	2
18	13.5	48	2
19	14.0	39	2
20	14.5	33	1
21	15.0	29	1
22	16.0	24	1
23	18.0	18	1
24	20.0	14	1

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DRAINAGE AREAS
TR 55

WATERSHED AREA NUMBER..... XXX @ R
DRAINAGE AREA, SQ. MILES..... .01
CURVE NUMBER..... 83
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 8.38777
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	2
2	11.5	51	4
3	11.7	299	25
4	11.8	991	83
5	11.9	746	63
6	12.0	477	40
7	12.1	233	20
8	12.2	152	13
9	12.3	132	11
10	12.4	121	10
11	12.5	111	9
12	12.6	85	7
13	12.7	74	6
14	12.8	70	6
15	12.9	68	6
16	13.0	65	5
17	13.2	52	4
18	13.5	48	4
19	14.0	39	3
20	14.5	33	3
21	15.0	29	2
22	16.0	24	2
23	18.0	18	2
24	20.0	14	1

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DRAINAGE AREAS
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WATERSHED AREA NUMBER..... XXXI @ Q
DRAINAGE AREA, SQ. MILES..... .003
CURVE NUMBER..... 83
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 8.38777
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	1
2	11.5	51	1
3	11.7	299	8
4	11.8	991	25
5	11.9	746	19
6	12.0	477	12
7	12.1	233	6
8	12.2	152	4
9	12.3	132	3
10	12.4	121	3
11	12.5	111	3
12	12.6	85	2
13	12.7	74	2
14	12.8	70	2
15	12.9	68	2
16	13.0	65	2
17	13.2	52	1
18	13.5	48	1
19	14.0	39	1
20	14.5	33	1
21	15.0	29	1
22	16.0	24	1
23	18.0	18	0
24	20.0	14	0

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DRAINAGE AREAS
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WATERSHED AREA NUMBER..... XXXII @ J
DRAINAGE AREA, SQ. MILES..... .002
CURVE NUMBER..... 83
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 8.38777
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	0
2	11.5	51	1
3	11.7	299	5
4	11.8	991	17
5	11.9	746	13
6	12.0	477	8
7	12.1	233	4
8	12.2	152	3
9	12.3	132	2
10	12.4	121	2
11	12.5	111	2
12	12.6	85	1
13	12.7	74	1
14	12.8	70	1
15	12.9	68	1
16	13.0	65	1
17	13.2	52	1
18	13.5	48	1
19	14.0	39	1
20	14.5	33	1
21	15.0	29	0
22	16.0	24	0
23	18.0	18	0
24	20.0	14	0

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DESCRIPTION: PROTECO LANDFILL
DRAINAGE AREAS
TR 55

WATERSHED AREA NUMBER..... XXXIII @ J
DRAINAGE AREA, SQ. MILES..... .001
CURVE NUMBER..... 83
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 8.38777
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	0
2	11.5	51	0
3	11.7	299	3
4	11.8	991	8
5	11.9	746	6
6	12.0	477	4
7	12.1	233	2
8	12.2	152	1
9	12.3	132	1
10	12.4	121	1
11	12.5	111	1
12	12.6	85	1
13	12.7	74	1
14	12.8	70	1
15	12.9	68	1
16	13.0	65	1
17	13.2	52	0
18	13.5	48	0
19	14.0	39	0
20	14.5	33	0
21	15.0	29	0
22	16.0	24	0
23	18.0	18	0
24	20.0	14	0

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DESCRIPTION: PROTECO LANDFILL
DRAINAGE AREAS
TR 55

WATERSHED AREA NUMBER..... XXXIV @ S
DRAINAGE AREA, SQ. MILES..... .006
CURVE NUMBER..... 83
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 8.38777
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	1
2	11.5	51	3
3	11.7	299	15
4	11.8	991	50
5	11.9	746	38
6	12.0	477	24
7	12.1	233	12
8	12.2	152	8
9	12.3	132	7
10	12.4	121	6
11	12.5	111	6
12	12.6	85	4
13	12.7	74	4
14	12.8	70	4
15	12.9	68	3
16	13.0	65	3
17	13.2	52	3
18	13.5	48	2
19	14.0	39	2
20	14.5	33	2
21	15.0	29	1
22	16.0	24	1
23	18.0	18	1
24	20.0	14	1

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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

WATERSHED AREA NUMBER..... XXXV (CHANNEL 12)
DRAINAGE AREA, SQ. MILES..... .002
CURVE NUMBER..... 83
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 8.38777
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	0
2	11.5	51	1
3	11.7	299	5
4	11.8	991	17
5	11.9	746	13
6	12.0	477	8
7	12.1	233	4
8	12.2	152	3
9	12.3	132	2
10	12.4	121	2
11	12.5	111	2
12	12.6	85	1
13	12.7	74	1
14	12.8	70	1
15	12.9	68	1
16	13.0	65	1
17	13.2	52	1
18	13.5	48	1
19	14.0	39	1
20	14.5	33	1
21	15.0	29	0
22	16.0	24	0
23	18.0	18	0
24	20.0	14	0

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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

COMBINED HYDROGRAPH FOR WATERSHED AREA NUMBERS: XVI AND III @ A FOR (CHANNEL 2)

TIME FRAME	TIME, HRS.	q, CFS
1	11.0	3
2	11.5	6
3	11.7	31
4	11.8	89
5	11.9	102
6	12.0	76
7	12.1	47
8	12.2	28
9	12.3	20
10	12.4	17
11	12.5	15
12	12.6	13
13	12.7	11
14	12.8	10
15	12.9	9
16	13.0	9
17	13.2	7
18	13.5	6
19	14.0	5
20	14.5	4
21	15.0	4
22	16.0	3
23	18.0	2
24	20.0	2

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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

COMBINED HYDROGRAPH FOR WATERSHED AREA NUMBERS:
XV,XVI,III,VI,V,II,IV,VII, AND XVII @ D FOR CHANNEL 3

TIME FRAME	TIME, HRS.	q, CFS
1	11.0	28
2	11.5	55
3	11.7	182
4	11.8	460
5	11.9	654
6	12.0	745
7	12.1	703
8	12.2	539
9	12.3	398
10	12.4	302
11	12.5	237
12	12.6	193
13	12.7	159
14	12.8	133
15	12.9	116
16	13.0	104
17	13.2	86
18	13.5	70
19	14.0	56
20	14.5	47
21	15.0	40
22	16.0	32
23	18.0	24
24	20.0	19

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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

COMBINED HYDROGRAPH FOR WATERSHED AREA NUMBERS:
XV,XVI,III,VI,V,II,IV,VII,XVII, AND XVIII @ G FOR CHANNEL 8

TIME FRAME	TIME, HRS.	q, CFS
1	11.0	29
2	11.5	57
3	11.7	189
4	11.8	485
5	11.9	673
6	12.0	757
7	12.1	709
8	12.2	543
9	12.3	402
10	12.4	305
11	12.5	239
12	12.6	195
13	12.7	160
14	12.8	135
15	12.9	118
16	13.0	106
17	13.2	87
18	13.5	71
19	14.0	57
20	14.5	48
21	15.0	41
22	16.0	33
23	18.0	25
24	20.0	19

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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

COMBINED HYDROGRAPH FOR WATERSHED AREA NUMBERS: XIX, XX, AND I @ F FOR CHANNEL 10

TIME FRAME	TIME, HRS.	q, CFS
1	11.0	24
2	11.5	48
3	11.7	102
4	11.8	201
5	11.9	331
6	12.0	477
7	12.1	583
8	12.2	611
9	12.3	579
10	12.4	514
11	12.5	436
12	12.6	364
13	12.7	303
14	12.8	253
15	12.9	214
16	13.0	184
17	13.2	141
18	13.5	103
19	14.0	72
20	14.5	57
21	15.0	48
22	16.0	38
23	18.0	28
24	20.0	22

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JOB NO. B511 E
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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

COMBINED HYDROGRAPH FOR WATERSHED AREA NUMBERS:
XV, XVI, III, VI, V, II, IV, VII, XVII, XVIII, XIX, XX, XXI, I, AND XIV @ I FOR CHANNEL 19

TIME FRAME	TIME, HRS.	q, CFS
1	11.0	68
2	11.5	134
3	11.7	384
4	11.8	914
5	11.9	1337
6	12.0	1635
7	12.1	1683
8	12.2	1458
9	12.3	1206
10	12.4	989
11	12.5	807
12	12.6	666
13	12.7	552
14	12.8	462
15	12.9	395
16	13.0	347
17	13.2	275
18	13.5	212
19	14.0	159
20	14.5	130
21	15.0	111
22	16.0	89
23	18.0	66
24	20.0	52

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DESCRIPTION: PROTECO LANDFILL
DRAINAGE AREAS
TR 55

COMBINED HYDROGRAPH FOR WATERSHED AREA NUMBERS:
XV, XVI, III, V, VI, IV, VII, II, XVII, XVIII, XIX, XX, I, XIV, XXI, X, XI, XII, XIII, AND XXIV FOR CHANNEL. 20

TIME FRAME	TIME, HRS.	q, CFS
1	11.0	75
2	11.5	148
3	11.7	450
4	11.8	1090
5	11.9	1570
6	12.0	1816
7	12.1	1798
8	12.2	1526
9	12.3	1254
10	12.4	1028
11	12.5	843
12	12.6	695
13	12.7	576
14	12.8	484
15	12.9	416
16	13.0	367
17	13.2	292
18	13.5	227
19	14.0	171
20	14.5	140
21	15.0	119
22	16.0	96
23	18.0	71
24	20.0	56

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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

COMBINED HYDROGRAPH FOR WATERSHED AREA NUMBERS: XXII AND VIII @ K FOR CHANNEL 21

TIME FRAME	TIME, HRS.	q, CFS
1	11.0	2
2	11.5	5
3	11.7	31
4	11.8	102
5	11.9	77
6	12.0	49
7	12.1	24
8	12.2	16
9	12.3	14
10	12.4	12
11	12.5	11
12	12.6	9
13	12.7	8
14	12.8	7
15	12.9	7
16	13.0	7
17	13.2	5
18	13.5	5
19	14.0	4
20	14.5	3
21	15.0	3
22	16.0	2
23	18.0	2
24	20.0	1

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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

COMBINED HYDROGRAPH FOR WATERSHED AREA NUMBERS: XXII, VIII, IX @ J FOR CHANNEL 22

TIME FRAME	TIME, HRS.	q, CFS
1	11.0	4
2	11.5	8
3	11.7	45
4	11.8	148
5	11.9	112
6	12.0	71
7	12.1	35
8	12.2	23
9	12.3	20
10	12.4	18
11	12.5	17
12	12.6	13
13	12.7	11
14	12.8	10
15	12.9	10
16	13.0	10
17	13.2	8
18	13.5	7
19	14.0	6
20	14.5	5
21	15.0	4
22	16.0	4
23	18.0	3
24	20.0	2

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DESCRIPTION: PROTECO LANDFILL
DRAINAGE AREAS
TR 55

COMBINED HYDROGRAPH FOR WATERSHED AREA NUMBERS: FOR CHANNEL 23
XXXII,XXXI,XXX,XXIX, AND XXXIII @ J

TIME FRAME	TIME, HRS.	q, CFS
1	11.0	4
2	11.5	9
3	11.7	53
4	11.8	175
5	11.9	131
6	12.0	84
7	12.1	41
8	12.2	27
9	12.3	23
10	12.4	21
11	12.5	20
12	12.6	15
13	12.7	13
14	12.8	12
15	12.9	12
16	13.0	11
17	13.2	9
18	13.5	8
19	14.0	7
20	14.5	6
21	15.0	5
22	16.0	4
23	18.0	3
24	20.0	2

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DESCRIPTION: PROTECO LANDFILL
DRAINAGE AREAS
TR 55

COMBINED HYDROGRAPH FOR WATERSHED AREA NUMBERS:
XV, XVI, III, VI, V, II, IV, VII, XVII, XVIII, XIX, XX, I, XXI, XIV, X, XI, XII XIII, XXV, AND XXIV FOR CHANNEL 24

TIME FRAME	TIME, HRS.	q, CFS
1	11.0	76
2	11.5	150
3	11.7	460
4	11.8	1114
5	11.9	1607
6	12.0	1847
7	12.1	1818
8	12.2	1537
9	12.3	1262
10	12.4	1035
11	12.5	848
12	12.6	700
13	12.7	580
14	12.8	487
15	12.9	420
16	13.0	370
17	13.2	294
18	13.5	229
19	14.0	173
20	14.5	141
21	15.0	121
22	16.0	97
23	18.0	72
24	20.0	57

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JOB NO.B511 E
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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

COMBINED HYDROGRAPH FOR WATERSHED AREA NUMBERS:
XXXV, XIX, XX, AND I FOR CHANNEL 25

TIME FRAME	TIME, HRS.	q, CFS
1	11.0	25
2	11.5	49
3	11.7	108
4	11.8	218
5	11.9	344
6	12.0	485
7	12.1	586
8	12.2	614
9	12.3	581
10	12.4	516
11	12.5	438
12	12.6	365
13	12.7	304
14	12.8	254
15	12.9	215
16	13.0	185
17	13.2	142
18	13.5	103
19	14.0	72
20	14.5	57
21	15.0	49
22	16.0	39
23	18.0	28
24	20.0	23

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JOB NO.B511 E
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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

COMBINED HYDROGRAPH FOR WATERSHED AREA NUMBERS: XIV AND XXI FOR CHANNEL 26

TIME FRAME	TIME, HRS.	q, CFS
1	11.0	15
2	11.5	29
3	11.7	92
4	11.8	228
5	11.9	333
6	12.0	400
7	12.1	391
8	12.2	304
9	12.3	225
10	12.4	170
11	12.5	132
12	12.6	107
13	12.7	88
14	12.8	74
15	12.9	64
16	13.0	57
17	13.2	47
18	13.5	38
19	14.0	30
20	14.5	25
21	15.0	22
22	16.0	18
23	18.0	13
24	20.0	10

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JOB NO.B511 E
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DESCRIPTION: PROTECO LANDFILL
SITE HYDROLOGY
TR 55

COMBINED HYDROGRAPH FOR WATERSHED AREA NUMBERS:
XIX,XX,I,XIV, AND XXI FOR CHANNEL 27

TIME FRAME	TIME, HRS.	q, CFS
1	11.0	39
2	11.5	77
3	11.7	194
4	11.8	429
5	11.9	664
6	12.0	878
7	12.1	973
8	12.2	915
9	12.3	804
10	12.4	683
11	12.5	568
12	12.6	471
13	12.7	391
14	12.8	327
15	12.9	278
16	13.0	241
17	13.2	188
18	13.5	141
19	14.0	102
20	14.5	82
21	15.0	70
22	16.0	56
23	18.0	41
24	20.0	33

II. Channel Design

II. Design Channels

Assume: 1) Channels will be designed to meet the minimum standards of the

2) Channels will be determined to carry peak flows determined in the previous section for the 25 year, 24 hr. storm.

3) For velocities greater than 6 ft/sec (channel grade 0 to 5%) and 5 ft/sec (channel grade 5 to 10%), riprap lining will be required.

Development: Channels will be located as shown on the plan drawings.

Silt fences will be constructed as required for sedimentation control.

BY MMT DATE 1/31/86
CHK'D _____ DATE _____

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SUBJECT Proteco
Site Hydrology & Hydraulics
Channel Design

JOB NO. B511

Determine Channel Discharges:

Channel No.	Watershed Areas	Q (cfs)
1, Reach A	XVB	166
1, Reach B	XV	627
2	XVI, III	102
3	XV, XVI, III, VI, V, II, IV, VII, XVII *	745
4	V	19
5	VI	19
6	VII	28
7	II	19
8	XV, XVI, III, VI, V, II, IV, VII, XVII, XVIII	757
9	XIX	358
10	XIX, XX, I	611
11	XXI	371
12	XXXV	17
13	XIV	83
14	IX	47
15	XI	19
16	X	19
17	XII	7
18	XIII	8
19 **	XV, XVI, III, VI, V, II, IV, VII, XVII, XVIII, XIX, XX, XXI, I, XIV	1683

SUBJECT Proteco
Site Hydrology & Hydraulics
Channel Design
JOB NO. B511

Channel Discharges (cont.)

Channel. No.	Watershed Areas	Q (cfs)
20**	XV, XVI, III, V, VI, IV, VII, II, XVII, XVIII, XIX, XX, I, XIV, XXI, X, XI, XII, XIII, XXIV	1816
21	XXII, VIII	102
22	XXII, VIII, IX	148
23	XXXII, XXXI, XXX, XXIX, XXXIII	175
24	XV, XVI, III, V, VI, II, IV, VII, XVII, XVIII, XIX, XX, I, XXI, XIV, X, XI, XII, XIII, XXV, XXIV	1847
25	XXXV, XIX, XX, I	614
26	XIV, XXI	400
27**	XIX, XX, I, XIV, XXI	973

* revised 6/26/86 from XVIII to XVII, original TR 55 ok, run w/ XVII
** no design changes necessary, XXXV area included in XXI

Computer printouts for all watershed areas, single and combined, may be found in Section I

Determine Channel Cross Sections:

Using Manning's Equation:

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

where: Q = peak dishcharge

n = roughness coefficient, for design

n = 0.035 for riprap lining

n = 0.030 for grass lining

A = area

R = hydraulic radius

S = channel bottom slope

All channel design information & results (Q, S, n, H, b, V, d, D, F), as well as typical channel cross-sections are shown on Drawing No. B511E-L29.

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JOB NO. B511
BY: MMT
DATE: 12-29-85
PAGE NO 5

DESCRIPTION: PROTECO
CHANNEL DESIGN
CHANNEL 1 - REACH A

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

```
**************************************************
*                                                *
*                                                *
*                                                *
*                                                *
*                                                *
*                                                *
*                                                *
*Left                                        Right*
**************************************************
```

INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 166
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .02
BASE WIDTH IN FEET..... 10
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 6.780713
COMPUTED DEPTH IN FEET..... 1.640625
FREE BOARD IN FEET..... 1.199933
COMPUTED DEPTH + FREE BOARD..... 2.840558
FROUDE NUMBER..... 1.075828

DESIGN CHANNEL DEPTH IN FEET.....= _____

DESCRIPTION: PROTECO LANDFILL
CHANNEL 1
REACH B

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

```
*****************************************************
*                                                   *
*                                                   *
*                                                   *
*                                                   *
*                                                   *
*                                                   *
*                                                   *
*Left                                            Right*
*****************************************************
```

INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 627
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .1
BASE WIDTH IN FEET..... 10
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 17.74609
COMPUTED DEPTH IN FEET..... 2.148438
FREE BOARD IN FEET..... 1.572467
COMPUTED DEPTH + FREE BOARD..... 3.720904
FROUDE NUMBER..... 2.51722

DESIGN CHANNEL DEPTH IN FEET.....= _____

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JOB NO. B51
BY: MMT
DATE: 12-31-85
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DESCRIPTION: PROTECO
CHANNEL DESIGN
CHANNEL 2 - REACH A

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

```
*****************************************************
*                                                   *
*                                                   *
*                                                   *
*                                                   *
*                                                   *
*                                                   *
*                                                   *
*Left                                          Right*
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```

INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 102
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .05
BASE WIDTH IN FEET..... 10
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 8.078154
COMPUTED DEPTH IN FEET..... .9765625
FREE BOARD IN FEET..... 1.200364
COMPUTED DEPTH + FREE BOARD..... 2.176926
FROUDE NUMBER..... 1.59545

DESIGN CHANNEL DEPTH IN FEET.....= _____

FRED C. HART ASSOCIATES.Inc
Penn Center West -II Suite 106
Pittsburgh, PA. 15276

JOB NO.8511
BY:MMT
DATE:12-31-85
PAGE NO 8

DESCRIPTION:PROTECO
CHANNEL DESIGN
CHANNEL 2 - REACH B

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                           Right*
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 102
MANNING'S N VALUE..... .03
SLOPE IN FT/FT..... .01
BASE WIDTH IN FEET..... 10
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 5.147525
COMPUTED DEPTH IN FEET..... 1.396484
FREE BOARD IN FEET..... 1.143841
COMPUTED DEPTH + FREE BOARD..... 2.540326
FROUDE NUMBER..... .8736338

DESIGN CHANNEL DEPTH IN FEET.....= _____

DESCRIPTION:PROTECO
CHANNEL DESIGN
CHANNEL 3

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                           Right*
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 745
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .02
BASE WIDTH IN FEET..... 10
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 10.31354
COMPUTED DEPTH IN FEET..... 3.515625
FREE BOARD IN FEET..... 1.392057
COMPUTED DEPTH + FREE BOARD..... 4.907682
FROUDE NUMBER..... 1.192456

DESIGN CHANNEL DEPTH IN FEET.....= _____

?>2 FRED C. HART ASSOCIATES.Inc
Penn Center West -II Suite 106
Pittsburgh, PA. 15276

JOB NO.B511E
BY:MJV
DATE:1-2-86
PAGE NO 10

B.85

DESCRIPTION:PROTECO LANDFILL
CHANNEL DESIGN
CHANNEL 4

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                           Right*
*****************************************************
```

INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 19
MANNING'S N VALUE..... .03
SLOPE IN FT/FT..... .02
BASE WIDTH IN FEET..... 5
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 4.335316
COMPUTED DEPTH IN FEET..... .6347656
FREE BOARD IN FEET..... 1.093146
COMPUTED DEPTH + FREE BOARD..... 1.727912
FROUDE NUMBER..... 1.083128

DESIGN CHANNEL DEPTH IN FEET.....= _____

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Pittsburgh, PA. 15276

JOB NO.B511E
BY:MJV
DATE:1-2-86
PAGE NO__11_____

DESCRIPTION:PROTECO LANDFILL
CHANNEL DESIGN
CHANNEL 5

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                           Right*
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 19
MANNING'S N VALUE..... .03
SLOPE IN FT/FT..... .02
BASE WIDTH IN FEET..... 5
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 4.335316
COMPUTED DEPTH IN FEET..... .6347656
FREE BOARD IN FEET..... 1.093146
COMPUTED DEPTH + FREE BOARD..... 1.727912
FROUDE NUMBER..... 1.083128

DESIGN CHANNEL DEPTH IN FEET.....= _____

FRED C. HART ASSOCIATES.Inc
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Pittsburgh, PA. 15276

DESCRIPTION:PROTECO LANDFILL
CHANNEL DESIGN
CHANNEL 6

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                            Right*
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 28
MANNING'S N VALUE..... .03
SLOPE IN FT/FT..... .02
BASE WIDTH IN FEET..... 5
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 4.880341
COMPUTED DEPTH IN FEET..... .78125
FREE BOARD IN FEET..... 1.112371
COMPUTED DEPTH + FREE BOARD..... 1.893621
FROUDE NUMBER..... 1.117569

DESIGN CHANNEL DEPTH IN FEET.....= _____

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Pittsburgh, PA. 15276

JOB NO.B511E
BY:MJV
DATE:1-2-86
PAGE NO 13

DESCRIPTION:PROTECO LANDFILL
CHANNEL DESIGN
CHANNEL 7 - REACH A

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                       Right*
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 19
MANNING'S N VALUE..... .03
SLOPE IN FT/FT..... .01
BASE WIDTH IN FEET..... 5
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 3.423892
COMPUTED DEPTH IN FEET..... .7617188
FREE BOARD IN FEET..... 1.078173
COMPUTED DEPTH + FREE BOARD..... 1.839892
FROUDE NUMBER..... .7923891

DESIGN CHANNEL DEPTH IN FEET.....= _____

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Pittsburgh, PA. 15276

JOB NO.B511E
BY:MJV
DATE:1-2-86
PAGE NO 14

DESCRIPTION:PROTECO LANDFILL
CHANNEL DESIGN
CHANNEL 7 - REACH B

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                           Right*
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 19
MANNING'S N VALUE..... .03
SLOPE IN FT/FT..... .045
BASE WIDTH IN FEET..... 5
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 5.735532
COMPUTED DEPTH IN FEET..... .5078125
FREE BOARD IN FEET..... 1.114397
COMPUTED DEPTH + FREE BOARD..... 1.62221
FROUDE NUMBER..... 1.575322

DESIGN CHANNEL DEPTH IN FEET.....= _____

DESCRIPTION:PROTECO
CHANNEL DESIGN
CHANNEL 8

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                       Right*
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 757
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .02
BASE WIDTH IN FEET..... 10
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 10.30573
COMPUTED DEPTH IN FEET..... 3.554688
FREE BOARD IN FEET..... 1.393205
COMPUTED DEPTH + FREE BOARD..... 4.947893
FROUDE NUMBER..... 1.186068

DESIGN CHANNEL DEPTH IN FEET.....= _____

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Pittsburgh, PA. 15276

JOB NO. B511E
BY: MJV
DATE: 1-2-86
PAGE NO. 16

DESCRIPTION: PROTECO LANDFILL
CHANNEL DESIGN
CHANNEL 9 - REACH A

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                           Right*
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 358
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .06
BASE WIDTH IN FEET..... 10
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 12.57403
COMPUTED DEPTH IN FEET..... 1.835938
FREE BOARD IN FEET..... 1.384917
COMPUTED DEPTH + FREE BOARD..... 3.220855
FROUDE NUMBER..... 1.903766

DESIGN CHANNEL DEPTH IN FEET.....= _____

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Pittsburgh, PA. 15276

JOB NO.B511E
BY:MJV
DATE:12-31-85
PAGE NO 17

DESCRIPTION:PROTECO LANDFILL
CHANNEL 9
REACH B

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                          Right*
*****************************************************
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 358
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .07
BASE WIDTH IN FEET..... 10
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 13.33441
COMPUTED DEPTH IN FEET..... 1.757813
FREE BOARD IN FEET..... 1.40232
COMPUTED DEPTH + FREE BOARD..... 3.160132
FROUDE NUMBER..... 2.05572

DESIGN CHANNEL DEPTH IN FEET.....= _____

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Pittsburgh, PA. 15276

JOB NO.B511E
BY:MJV
DATE:1-2-86
PAGE NO 18

DESCRIPTION:PROTECO LANDFILL
CHANNEL DESIGN
CHANNEL 9 - REACH C

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                       Right*
*************************************************
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 358
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .1
BASE WIDTH IN FEET..... 10
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 15.09871
COMPUTED DEPTH IN FEET..... 1.601563
FREE BOARD IN FEET..... 1.441633
COMPUTED DEPTH + FREE BOARD..... 3.043195
FROUDE NUMBER..... 2.41976

DESIGN CHANNEL DEPTH IN FEET.....= _____

DESCRIPTION: PROTECO
CHANNEL DESIGN
CHANNEL 10

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                        Right*
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 611
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .03
BASE WIDTH IN FEET..... 10
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 11.32039
COMPUTED DEPTH IN FEET..... 2.890625
FREE BOARD IN FEET..... 1.403149
COMPUTED DEPTH + FREE BOARD..... 4.293774
FROUDE NUMBER..... 1.419949

DESIGN CHANNEL DEPTH IN FEET.....= _____

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Pittsburgh, PA. 15276

JOB NO.B511E
BY:MJV
DATE:1-2-86
PAGE NO 20

DESCRIPTION:PROTECO LANDFILL
CHANNEL DESIGN
CHANNEL 11 - REACH A

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                          Right*
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 371
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .07
BASE WIDTH IN FEET..... 10
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 13.41528
COMPUTED DEPTH IN FEET..... 1.796875
FREE BOARD IN FEET..... 1.407736
COMPUTED DEPTH + FREE BOARD..... 3.204611
FROUDE NUMBER..... 2.049371

DESIGN CHANNEL DEPTH IN FEET.....= _____

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Pittsburgh, PA. 15276

JOB NO.B511E
BY:MJV
DATE:1-2-86
PAGE NO 21

DESCRIPTION:PROTECO LANDFILL
CHANNEL DESIGN
CHANNEL 11 - REACH B

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                           Right*
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 371
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .035
BASE WIDTH IN FEET..... 10
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 10.50048
COMPUTED DEPTH IN FEET..... 2.148438
FREE BOARD IN FEET..... 1.338732
COMPUTED DEPTH + FREE BOARD..... 3.48717
FROUDE NUMBER..... 1.489456

DESIGN CHANNEL DEPTH IN FEET.....= _____

B.97

DESCRIPTION:PROTECO
CHANNEL DESIGN
CHANNEL 11 - REACH C

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                            Right*
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 371
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .05
BASE WIDTH IN FEET..... 10
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 11.81503
COMPUTED DEPTH IN FEET..... 1.972656
FREE BOARD IN FEET..... 1.370446
COMPUTED DEPTH + FREE BOARD..... 3.343103
FROUDE NUMBER..... 1.736294

DESIGN CHANNEL DEPTH IN FEET.....= _____

FRED C. HART ASSOCIATES.Inc
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Pittsburgh, PA. 15276

JOB NO.B511
BY:MMT
DATE:1-6-86
PAGE NO 23

DESCRIPTION:PROTECO
CHANNEL DESIGN
CHANNEL 12

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                      Right*
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 17
MANNING'S N VALUE..... .03
SLOPE IN FT/FT..... .04
BASE WIDTH IN FEET..... 5
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 5.32006
COMPUTED DEPTH IN FEET..... .4931641
FREE BOARD IN FEET..... 1.10508
COMPUTED DEPTH + FREE BOARD..... 1.598244
FROUDE NUMBER..... 1.479624

DESIGN CHANNEL DEPTH IN FEET.....= _____

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Penn Center West -II Suite 106
Pittsburgh, PA. 15276

JOB NO.B511
BY:MMT
DATE:1-9-86
PAGE NO 24

DESCRIPTION:PROTECO
CHANNEL DESIGN
CHANNEL 13

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                           Right*
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 83
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .02
BASE WIDTH IN FEET..... 0
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 6.104411
COMPUTED DEPTH IN FEET..... 2.128906
FREE BOARD IN FEET..... 1.196322
COMPUTED DEPTH + FREE BOARD..... 3.325228
FROUDE NUMBER..... 1.042684

DESIGN CHANNEL DEPTH IN FEET.....= _____

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Pittsburgh, PA. 15276

JOB NO.B511
BY:MMT
DATE:1-9-86
PAGE NO 25

DESCRIPTION: PROTECO
CHANNEL DESIGN
CHANNEL 14

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                            Right*
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 47
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .02
BASE WIDTH IN FEET..... 0
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 5.303361
COMPUTED DEPTH IN FEET..... 1.71875
FREE BOARD IN FEET..... 1.158817
COMPUTED DEPTH + FREE BOARD..... 2.877566
FROUDE NUMBER..... 1.008166

DESIGN CHANNEL DEPTH IN FEET.....= _____

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Penn Center West -II Suite 106
Pittsburgh, PA. 15276

JOB NO. B511E
BY: MJV
DATE: 1-2-86
PAGE NO. 26

DESCRIPTION: PROTECO LANDFILL
CHANNEL DESIGN
CHANNEL 15

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                           Right*
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 19
MANNING'S N VALUE..... .03
SLOPE IN FT/FT..... .03
BASE WIDTH IN FEET..... 5
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 5.007275
COMPUTED DEPTH IN FEET..... .5664063
FREE BOARD IN FEET..... 1.103574
COMPUTED DEPTH + FREE BOARD..... 1.66998
FROUDE NUMBER..... 1.312794

DESIGN CHANNEL DEPTH IN FEET.....= _____

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Penn Center West -II Suite 106
Pittsburgh, PA. 15276

JOB NO.B511
BY:MMT
DATE:1-9-86
PAGE NO 27

DESCRIPTION:PROTECO
CHANNEL DESIGN
CHANNEL 16

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                      Right*
*************************************************
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 19
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .07
BASE WIDTH IN FEET..... 5
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 6.019017
COMPUTED DEPTH IN FEET..... .4882813
FREE BOARD IN FEET..... 1.118492
COMPUTED DEPTH + FREE BOARD..... 1.606773
FROUDE NUMBER..... 1.68117

DESIGN CHANNEL DEPTH IN FEET.....= _____

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Penn Center West -II Suite 106
Pittsburgh, PA. 15276

JOB NO.B511E
BY:MJV
DATE:1-2-86
PAGE NO 28

DESCRIPTION:PROTECO LANDFILL
CHANNEL DESIGN
CHANNEL 17

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*                                                *
*Left                                        Right*
**************************************************
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 7
MANNING'S N VALUE..... .03
SLOPE IN FT/FT..... .05
BASE WIDTH IN FEET..... 5
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 4.310376
COMPUTED DEPTH IN FEET..... .2783203
FREE BOARD IN FEET..... 1.070356
COMPUTED DEPTH + FREE BOARD..... 1.348677
FROUDE NUMBER..... 1.539417

DESIGN CHANNEL DEPTH IN FEET.....= _____

DESCRIPTION:PROTECO LANDFILL
CHANNEL DESIGN
CHANNEL 18

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*                                                   *
*Left                                           Right*
*****************************************************
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 8
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .08
BASE WIDTH IN FEET..... 5
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 4.73538
COMPUTED DEPTH IN FEET..... .288086
FREE BOARD IN FEET..... 1.078187
COMPUTED DEPTH + FREE BOARD..... 1.366273
FROUDE NUMBER..... 1.665402

DESIGN CHANNEL DEPTH IN FEET.....= _____

FRED C. HART ASSOCIATES.Inc
Penn Center West -II Suite 106
Pittsburgh, PA. 15276

JOB NO.B511E
BY:MJV
DATE:1-2-86
PAGE NO 29

DESCRIPTION:PROTECO LANDFILL
CHANNEL DESIGN
CHANNEL 18

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Lef                                        Right*
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Replaced

INPUT DAT

FLOW	8
MANNI	.03
SLOPE	.08
BASE	5
LEFT	3
RIGHT	3

FREE B .23 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC.....	5.239278
COMPUTED DEPTH IN FEET.....	.2636719
FREE BOARD IN FEET.....	1.083991
COMPUTED DEPTH + FREE BOARD.....	1.347663
FROUDE NUMBER.....	1.916965

DESIGN CHANNEL DEPTH IN FEET.....= _____

FRED C. HART ASSOCIATES.Inc
Penn Center West -II Suite 106
Pittsburgh, PA. 15276

JOB NO.B511
BY:MMT
DATE:1-6-86
PAGE NO 30

DESCRIPTION:PROTECO
CHANNEL DESIGN
CHANNEL 19

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                       Right*
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 1683
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... 9.000001E-02
BASE WIDTH IN FEET..... 10
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 22.16804
COMPUTED DEPTH IN FEET..... 3.632813
FREE BOARD IN FEET..... 1.851952
COMPUTED DEPTH + FREE BOARD..... 5.484764
FROUDE NUMBER..... 2.528211

DESIGN CHANNEL DEPTH IN FEET.....= _____

FRED C. HART ASSOCIATES, Inc
Penn Center West -II Suite 106
Pittsburgh, PA. 15276

JOB NO. B511
BY: BJD
DATE: 1/9/86
PAGE NO 31

DESCRIPTION: PROTECO
CHANNEL DESIGN
CHANNEL 20 - REACH A

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                            Right*
*****************************************************
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 1816
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... 9.000001E-02
BASE WIDTH IN FEET..... 10
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 22.78902
COMPUTED DEPTH IN FEET..... 3.75
FREE BOARD IN FEET..... 1.885135
COMPUTED DEPTH + FREE BOARD..... 5.635135
FROUDE NUMBER..... 2.564746

DESIGN CHANNEL DEPTH IN FEET.....= _____

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Pittsburgh, PA. 15276

JOB NO.B511
BY:BJD
DATE:1/9/86
PAGE NO 32

DESCRIPTION:PROTECO
CHANNEL DESIGN
CHANNEL 20 - REACH B

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                           Right*
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```

INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 1816
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .018
BASE WIDTH IN FEET..... 10
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 12.57538
COMPUTED DEPTH IN FEET..... 5.46875
FREE BOARD IN FEET..... 1.55389
COMPUTED DEPTH + FREE BOARD..... 7.02264
FROUDE NUMBER..... 1.206649

DESIGN CHANNEL DEPTH IN FEET.....= _____

DESCRIPTION:PROTECO
CAHNNEL DESIGN
CHANNEL 21 - REACH A

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                           Right*
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```

INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 102
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .045
BASE WIDTH IN FEET..... 5
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 8.369703
COMPUTED DEPTH IN FEET..... 1.347656
FREE BOARD IN FEET..... 1.231123
COMPUTED DEPTH + FREE BOARD..... 2.578779
FROUDE NUMBER..... 1.528408

DESIGN CHANNEL DEPTH IN FEET.....= _____

DESCRIPTION: PROTECO
CHANNEL DESIGN
CHANNEL 21 - REACH B

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                           Right*
*****************************************************
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 102
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .08
BASE WIDTH IN FEET..... 5
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 10.34269
COMPUTED DEPTH IN FEET..... 1.162109
FREE BOARD IN FEET..... 1.271846
COMPUTED DEPTH + FREE BOARD..... 2.433955
FROUDE NUMBER..... 2.008248

DESIGN CHANNEL DEPTH IN FEET.....= _____

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Pittsburgh, PA. 15276

JOB NO.B511E
BY:MJV
DATE:1-2-86
PAGE NO 35

DESCRIPTION:PROTECO LANDFILL
TR-55
CHANNEL 22

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                           Right*
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 148
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .13
BASE WIDTH IN FEET..... 10
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 12.64127
COMPUTED DEPTH IN FEET..... .9179688
FREE BOARD IN FEET..... 1.307143
COMPUTED DEPTH + FREE BOARD..... 2.225111
FROUDE NUMBER..... 2.563908

DESIGN CHANNEL DEPTH IN FEET.....= _____

Pg. 111

DESCRIPTION:PROTECO LANDFILL
CHANNEL DESIGN
CHANNEL 23

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                           Right*
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 175
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .02
BASE WIDTH IN FEET..... 5
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 7.219098
COMPUTED DEPTH IN FEET..... 2.128906
FREE BOARD IN FEET..... 1.232171
COMPUTED DEPTH + FREE BOARD..... 3.361077
FROUDE NUMBER..... 1.08934

DESIGN CHANNEL DEPTH IN FEET.....= _____

Pg. 112

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Penn Center West -II Suite 106
Pittsburgh, PA. 15276

JOB NO.B511
BY:BJD
DATE:1/9/86
PAGE NO 37

DESCRIPTION:PROTECO
CHANNEL DESIGN
CHANNEL 24

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                          Right*
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 1847
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .04
BASE WIDTH IN FEET..... 0
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 17.01313
COMPUTED DEPTH IN FEET..... 6.015625
FREE BOARD IN FEET..... 1.773543
COMPUTED DEPTH + FREE BOARD..... 7.789168
FROUDE NUMBER..... 1.728745

DESIGN CHANNEL DEPTH IN FEET.....= _____

DESCRIPTION:PROTECO
CHANNEL DESIGN
CHANNEL 25

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                           Right*
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 614
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .045
BASE WIDTH IN FEET..... 0
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 13.54818
COMPUTED DEPTH IN FEET..... 3.886719
FREE BOARD IN FEET..... 1.532536
COMPUTED DEPTH + FREE BOARD..... 5.419255
FROUDE NUMBER..... 1.712681

DESIGN CHANNEL DEPTH IN FEET.....= _____

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Pittsburgh, PA. 15276

JOB NO. B511
BY: MMT
DATE: 1-18-86
PAGE NO. 39

DESCRIPTION: PROTECO
SITE HYDROLOGY AND HYDRAULICS
CHANNEL 26 - REACH A

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                           Right*
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 400
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .08
BASE WIDTH IN FEET..... 0
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 15.12835
COMPUTED DEPTH IN FEET..... 2.96875
FREE BOARD IN FEET..... 1.543571
COMPUTED DEPTH + FREE BOARD..... 4.512321
FROUDE NUMBER..... 2.188224

DESIGN CHANNEL DEPTH IN FEET.....= 4.5'

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Penn Center West -II Suite 106
Pittsburgh, PA. - 15276

JOB NO. B511
BY: MMT
DATE: 1-18-86
PAGE NO 40

DESCRIPTION: PROTECO
CHANNEL DESIGN
CHANNEL 26 - REACH B

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                           Right*
*****************************************************
```

INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 400
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .14
BASE WIDTH IN FEET..... 0
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 18.62248
COMPUTED DEPTH IN FEET..... 2.675781
FREE BOARD IN FEET..... 1.64634
COMPUTED DEPTH + FREE BOARD..... 4.322122
FROUDE NUMBER..... 2.837261

DESIGN CHANNEL DEPTH IN FEET.....= 4.5'

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Pittsburgh, PA. 15276

JOB NO.B511
BY:MMT
DATE:1/17/86
PAGE NO. 41

DESCRIPTION:PROTECO
SITE HYDROLOGY AND HYDRAULICS
CHANNEL 27

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                           Right*
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```

INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 973
MANNING'S N VALUE..... .035
SLOPE IN FT/FT..... .04
BASE WIDTH IN FEET..... 10
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 14.17696
COMPUTED DEPTH IN FEET..... 3.398438
FREE BOARD IN FEET..... 1.532864
COMPUTED DEPTH + FREE BOARD..... 4.931301
FROUDE NUMBER..... 1.662493

DESIGN CHANNEL DEPTH IN FEET.....= _____

III. Drop & Fluted Inlets

Design Drop & Fluted Inlets

Assume: A total of 4 inlets will be used in the drainage plan:

Fluted Inlet 1 will collect runoff from Channels 4 & 5 and discharge into Drop Inlet 1 at the toe of the perimeter berm.

Drop Inlet 1 will collect runoff from Channel 6 and Fluted Inlet 1 and will discharge into Channel 3.

Fluted Inlet 2 will collect runoff from Channels 15 & 16 and discharge into Drop Inlet 2 at the toe of the perimeter berm.

Drop Inlet 2 will collect runoff from Channels 17 & 18 and Fluted Inlet 2 and will discharge into Channel 20.

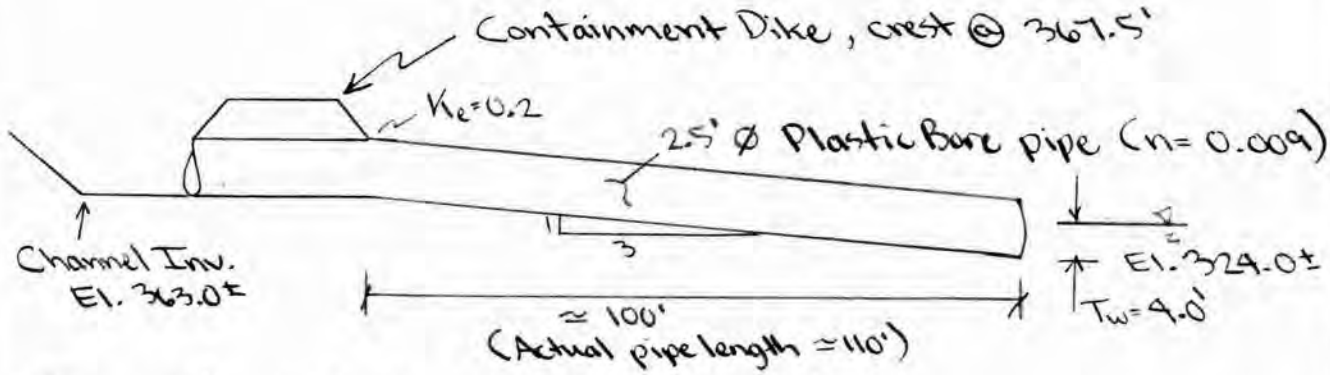
Development: PlasticBore pipe (Corrugated Metal Pipe w/smooth plastic interior) will be used in in conjunction with containment dikes to serve as the fluted inlets. PlasticBore pipe will be used in conjunction with rectangular concrete catch basins to serve as the drop inlet structures. Pipes will be sized to carry combined peak flows; the containment dikes and catch basins will be sized to contain required headwater conditions.

SUBJECT Proteco Landfill
Site Hydrology & Hydraulics
Drop & Fluted Inlet Design
JOB NO. B511

Fluted Inlet 1

Peak Q = $Q_{channel\ 4}$ + $Q_{channel\ 5}$
= 19.0 cfs + 19.0 cfs
= 38 cfs

Assume the following cross section:



For inlet control, Hw @ 366.6'
Outlet control does not come into effect

∴ Use 2.5' Ø Plastic Bore pipe
Containment Dike Crest @ 367.5'

FRED C. HART ASSOCIATES, Inc.
CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
PAGE NO: #3

JOB NO: B511L
RUN BY: AEB
DATE: 01-13-1986
CHECKED BY: mmT

TITLE: PROTECO
FLUTED INLET NO. 1

INLET CONTROL
****

Q(CFS)	HEAD(FT)	HEADWATER ELEVATION (FT)
16.88	1.99	364.99
17.50	2.04	365.04
18.13	2.08	365.08
18.75	2.12	365.12
19.38	2.16	365.16
20.00	2.20	365.20
20.63	2.24	365.24
21.25	2.28	365.28
21.88	2.32	365.32
22.50	2.36	365.36
23.13	2.41	365.41
23.75	2.45	365.45
24.38	2.49	365.49
25.00	2.53	365.53
25.63	2.57	365.57
26.25	2.62	365.62
26.88	2.66	365.66
27.50	2.71	365.71
28.13	2.75	365.75
28.75	2.80	365.80
29.38	2.84	365.84
30.00	2.89	365.89
30.63	2.94	365.94
31.25	2.99	365.99
31.88	3.04	366.04
32.50	3.09	366.09
33.13	3.14	366.14
33.75	3.19	366.19
34.38	3.24	366.24
35.00	3.30	366.30
35.63	3.35	366.35
36.25	3.41	366.41
36.88	3.47	366.47
37.50	3.52	366.52
38.13	3.58	366.58
38.75	3.64	366.64
39.38	3.70	366.70
40.00	3.76	366.76

Q design →

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CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
PAGE NO: 04

JOB NO: B511L
RUN BY: AEB
DATE: 01-13-1986
CHECKED BY: MMT

TITLE: PROTECO
FLUTED INLET NO. 1

OUTLET CONTROL
****

Hf = [(2.5204(1+K)/D^4) + (466.18(n^2)L/D^(16/3))] (Q/10)^2

WHERE Hf = FRICTION LOSS (FT)
K = SUM OF MINOR LOSS FACTORS
D = PIPE DIAMETER (FT)
n = MANNING'S VALUE FOR PIPE ROUGHNESS
Q = FLOW (CFS)

HEADWATER = TAILWATER + Hf + EXIT INVERT ELEVATION
TAILWATER = 4

ENTRANCE LOSS COEFFICIENT = .2

Q(CFS)	Hf(FT)	HEADWATER ELEVATION (FT)
.....	.....	.....

OUTLET CONTROL DOES NOT COME INTO EFFECT WITHIN THIS ELEVATION INTERVAL

$$q = \frac{a\sqrt{2gH}}{\sqrt{1 + k_e + k_f + k_c L}} = \frac{4.91\left(\sqrt{2(32.2)(327.5 - 326.7)}\right)}{\sqrt{1 + .5 + 0 + (.0179)(35)}}$$

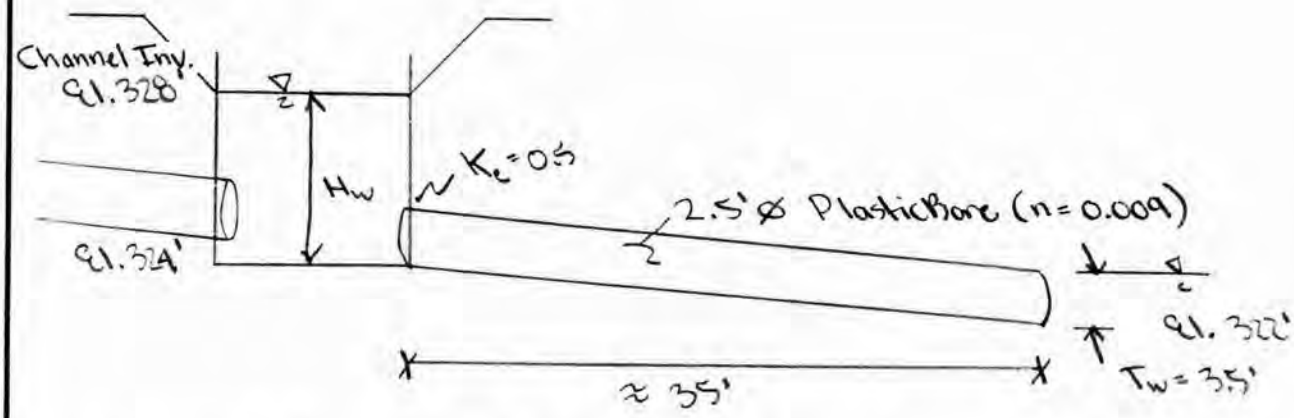
$= 24.17$ ~~[illegible]~~ won't even handle flow from channel 6, much less both!

SUBJECT Proteco Landfill
Site Hydrology & Hydraulics
Drop & Fluted Inlet Design
JOB NO. B511

Drop Inlet 1

Peak Q = $Q_{\text{Fluted Inlet 1}} + Q_{\text{Channel 6}}$
= 38.0 cfs + 28.0 cfs
= 66.0 cfs

Assume the following cross section:



For inlet control, H_w @ 327.5'
For outlet control, H_w @ 326.7'

∴ Use 2 @ 2.5' ø PlasticBore pipe

FRED C. HART ASSOCIATES, Inc.
CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
PAGE NO: #6

JOB NO: B511
RUN BY: MMT
DATE: 01-03-1986
CHECKED BY: B

TITLE: PROTECO
SITE HYDROLOGY
DROP INLET 1

INLET CONTROL
****

Q(CFS)	HEAD(FT)	HEADWATER ELEVATION (FT)
23.13	2.57	326.57
23.75	2.62	326.62
24.38	2.67	326.67
25.00	2.72	326.72
25.63	2.77	326.77
26.25	2.83	326.83
26.88	2.88	326.88
27.50	2.94	326.94
28.13	2.99	326.99
28.75	3.05	327.05
29.38	3.11	327.11
30.00	3.17	327.17
30.63	3.23	327.23
31.25	3.29	327.29
31.88	3.35	327.35
32.50	3.42	327.42
½ Qdesign → 33.13	3.48	327.48
33.75	3.55	327.55
34.38	3.62	327.62
35.00	3.69	327.69
35.63	3.76	327.76
36.25	3.83	327.83
36.88	3.90	327.90
37.50	3.98	327.98
38.13	4.05	328.05

FRED C. HART ASSOCIATES, Inc.
CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
PAGE NO: Ø 7

JOB NO: B511
RUN BY: MMT
DATE: 01-03-1986
CHECKED BY: B

TITLE: PROTECO
SITE HYDROLOGY
DROP INLET 1

OUTLET CONTROL
****

Q(CFS)	HEAD(FT)	HEADWATER ELEVATION (FT)
23.13	0.57	326.07
23.75	0.60	326.10
24.38	0.63	326.13
25.00	0.67	326.17
25.63	0.70	326.20
26.25	0.74	326.24
26.88	0.77	326.27
27.50	0.81	326.31
28.13	0.84	326.34
28.75	0.88	326.38
29.38	0.92	326.42
30.00	0.96	326.46
30.63	1.00	326.50
31.25	1.04	326.54
31.88	1.08	326.58
32.50	1.13	326.63
½ Q design → 33.13	1.17	326.67
33.75	1.22	326.72
34.38	1.26	326.76
35.00	1.31	326.81
35.63	1.36	326.86
36.25	1.40	326.90
36.88	1.45	326.95
37.50	1.50	327.00
38.13	1.55	327.05

$$q = \frac{4.91\sqrt{2(32.2)(311.6-297.5)}}{\sqrt{1+.2+0+(.0179)(60)}} = 98.12 \text{ cfs}$$

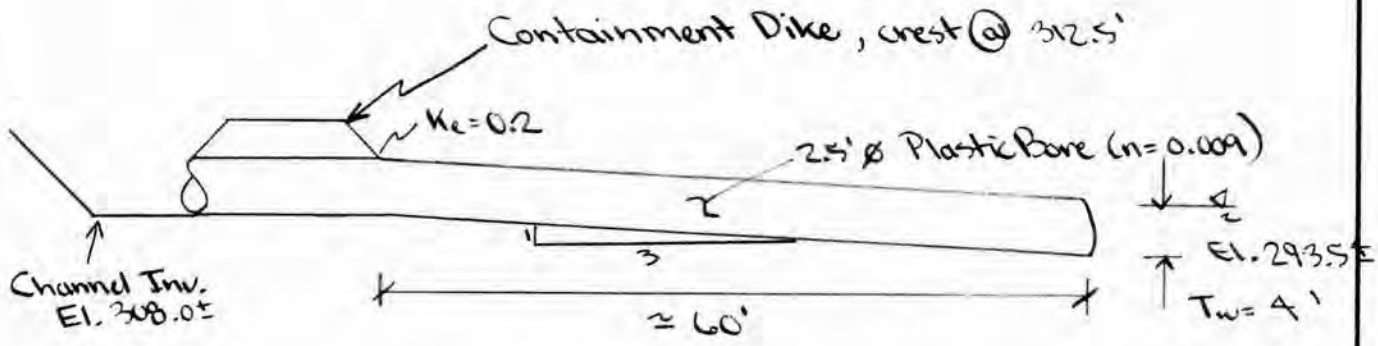
sufficient

SUBJECT Proteco Landfill
Site Hydrology & Hydraulics
Drop & Fluted Inlet Design
JOB NO. B511

Fluted Inlet 2

Peak Q = $Q_{channel15}$ + $Q_{channel16}$
= 19 cfs + 19 cfs
= 38 cfs

Assume the following cross section:



For Inlet Control, H_w @ 311.6'
Outlet control does not come into effect

∴ Use 2.5' ø Plastic Bore pipe
Containment Dike Crest @ 312.5'

FRED C. HART ASSOCIATES, Inc.
CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
PAGE NO: #9

JOB NO: B511L
RUN BY: AEB
DATE: 01-13-1986
CHECKED BY: MMT

TITLE: PROTECO
FLUTED INLET NO. 2

INLET CONTROL
****

Q(CFS)	HEAD(FT)	HEADWATER ELEVATION (FT)
16.88	2.01	310.01
17.50	2.05	310.05
18.13	2.09	310.09
18.75	2.13	310.13
19.38	2.17	310.17
20.00	2.21	310.21
20.63	2.25	310.25
21.25	2.30	310.30
21.88	2.34	310.34
22.50	2.38	310.38
23.13	2.42	310.42
23.75	2.46	310.46
24.38	2.51	310.51
25.00	2.55	310.55
25.63	2.59	310.59
26.25	2.64	310.64
26.88	2.68	310.68
27.50	2.73	310.73
28.13	2.77	310.77
28.75	2.82	310.82
29.38	2.87	310.87
30.00	2.91	310.91
30.63	2.96	310.96
31.25	3.01	311.01
31.88	3.06	311.06
32.50	3.12	311.12
33.13	3.17	311.17
33.75	3.22	311.22
34.38	3.28	311.28
35.00	3.33	311.33
35.63	3.39	311.39
36.25	3.45	311.45
36.88	3.51	311.51
37.50	3.57	311.57
Q_{DESIGN} → 38.13	3.63	311.63
38.75	3.69	311.69
39.38	3.76	311.76
40.00	3.82	311.82

FRED C. HART ASSOCIATES, Inc.
CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
PAGE NO: B 10

JOB NO: B511L
RUN BY: AEB
DATE: 01-13-1986
CHECKED BY: MMT

TITLE: PROTECO
FLUTED INLET NO. 2

OUTLET CONTROL
****

Hf = [(2.5204(1+K)/D^4) + (466.18(n^2)L/D^(16/3))] (Q/10)^2

WHERE Hf = FRICTION LOSS (FT)
K = SUM OF MINOR LOSS FACTORS
D = PIPE DIAMETER (FT)
n = MANNING'S VALUE FOR PIPE ROUGHNESS
Q = FLOW (CFS)

HEADWATER = TAILWATER + Hf + EXIT INVERT ELEVATION
TAILWATER = 4

ENTRANCE LOSS COEFFICIENT = .2

Q(CFS)	Hf(FT)	HEADWATER ELEVATION (FT)
.....	.....	.....

OUTLET CONTROL DOES NOT COME INTO EFFECT WITHIN THIS ELEVATION INTERVAL

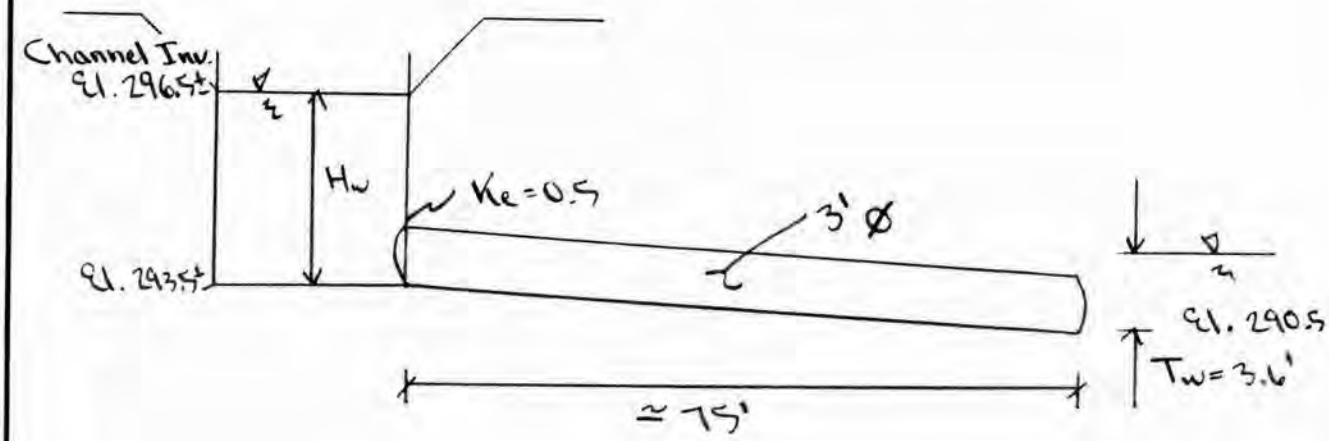
Drop Inlet 2

Peak Q = $Q_{Fluted\ Inlet\ 2}$ + $Q_{channel\ 17}$ + $Q_{channel\ 18}$

= 38 cfs + 7 cfs + 8 cfs

= 53 cfs

Assume the following cross-section:



For inlet control, Hw = 296.0'

For outlet control, Hw = 296.5'

∴ Use 2@3' Ø PlasticBore pipe

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FRED C. HART ASSOCIATES, INC.
CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
PAGE NO: A 12

JOB NO: B511
RUN BY: MMT
DATE: 01-07-1986
CHECKED BY: B

TITLE: PROTECO
SITE HYDROLOGY AND HYDRAULICS
DROP INLET 2

OUTLET CONTROL
****

Hf = [(2.5204(1+K)/D^4) + (466.18(n^2)L/D^(16/3))] (Q/10)^2

WHERE Hf = FRICTION LOSS (FT)
K = SUM OF MINOR LOSS FACTORS
D = PIPE DIAMETER (FT)
n = MANNING'S VALUE FOR PIPE ROUGHNESS
Q = FLOW (CFS)

HEADWATER = TAILWATER + Hf + EXIT INVERT ELEVATION
TAILWATER = 3.6

ENTRANCE LOSS COEFFICIENT = .5

Q(CFS)	Hf(FT)	HEADWATER ELEVATION (FT)
0.00	0.00	296.10
1.50	0.00	296.10
3.00	0.00	296.10
4.50	0.01	296.11
6.00	0.02	296.12
7.50	0.03	296.13
9.00	0.04	296.14
10.50	0.06	296.16
12.00	0.08	296.18
13.50	0.10	296.20
15.00	0.12	296.22
16.50	0.15	296.25
18.00	0.18	296.28
19.50	0.21	296.31
21.00	0.24	296.34
22.50	0.28	296.38
24.00	0.32	296.42
25.50	0.36	296.46
27.00	0.40	296.50
28.50	0.44	296.54

½ Q design

RED C. HART ASSOCIATES, INC.
CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
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JOB NO: B511
RUN BY: MMT
DATE: 01-07-1986
CHECKED BY: B

TITLE: PROTECO
SITE HYDROLOGY AND HYDRAULICS
DROP INLET 2

NLET CONTROL
****

EAD=DY

WHERE D = DIAMETER OF PIPE (FT)
Y = A + BX + CX^2 + DX^3 + EX^4 + FX^5
WHERE A,B,C,D,E,F ARE EXPERIMENTALLY
DERIVED COEFFICIENTS
A= 8.748299E-02 B= .706578
C=-.253295 D= .0667001
E=-6.61651E-03 F= 2.50619E-04
X = Q/D^2.5

Q(CFS)	HEAD(FT)	HEADWATER ELEVATION (FT)
0.00	0.00	293.50
1.50	0.46	293.96
3.00	0.64	294.14
4.50	0.82	294.32
6.00	0.98	294.48
7.50	1.13	294.63
9.00	1.27	294.77
10.50	1.40	294.90
12.00	1.53	295.03
13.50	1.65	295.15
15.00	1.76	295.26
16.50	1.87	295.37
18.00	1.97	295.47
19.50	2.07	295.57
21.00	2.17	295.67
22.50	2.26	295.76
24.00	2.35	295.85
25.50	2.44	295.94
½ Q Design → 27.00	2.53	296.03
28.50	2.61	296.11

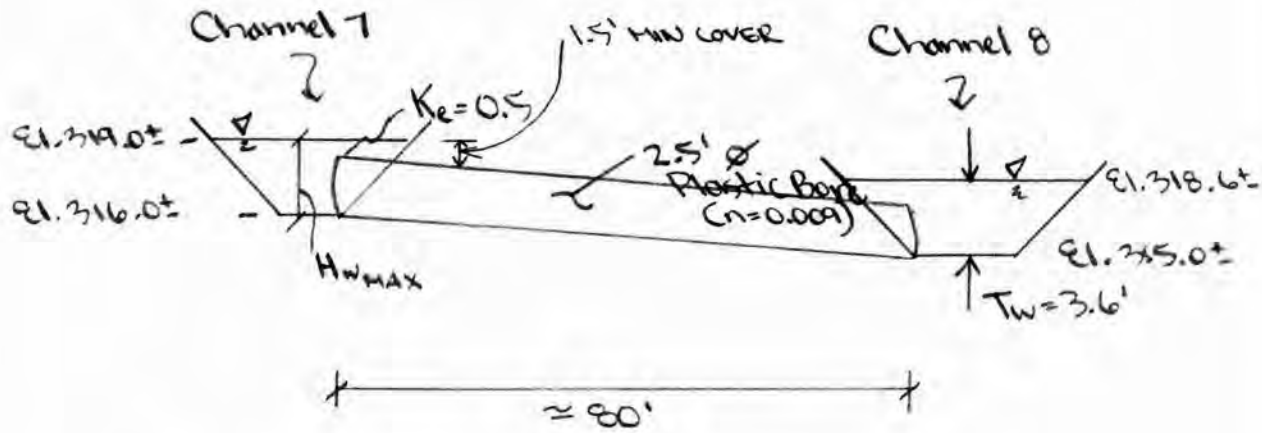
IV Culvert Hydraulic Design

SUBJECT Proteco Landfill
Site Hydrology & Hydraulics
Culvert Design
JOB NO. B511

Culvert 2

Peak Q = Q channel 7
= 19 cfs

Assume the following cross section:



For inlet control, H_W @ 318'
For outlet control, H_W @ 319'

∴ Use 2.5' Ø Plastic Bore Pipe

FRED C. HART ASSOCIATES, Inc.
CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
PAGE NO: # 2

JOB NO: B511
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TITLE: CULVERT 2

OUTLET CONTROL
****

Hf = [(2.5204(1+K)/D^4) + (466.18(n^2)L/D^(16/3))] (Q/10)^2

WHERE Hf = FRICTION LOSS (FT)
K = SUM OF MINOR LOSS FACTORS
D = PIPE DIAMETER (FT)
n = MANNING'S VALUE FOR PIPE ROUGHNESS
Q = FLOW (CFS)

HEADWATER = TAILWATER + Hf + EXIT INVERT ELEVATION
TAILWATER = 3.6

ENTRANCE LOSS COEFFICIENT = .5

Q(CFS)	Hf(FT)	HEADWATER ELEVATION (FT)
0.00	0.00	318.60
1.25	0.00	318.60
2.50	0.01	318.61
3.75	0.02	318.62
5.00	0.03	318.63
6.25	0.05	318.65
7.50	0.07	318.67
8.75	0.09	318.69
10.00	0.12	318.72
11.25	0.15	318.75
12.50	0.19	318.79
13.75	0.23	318.83
15.00	0.27	318.87
16.25	0.32	318.92
17.50	0.37	318.97
Q Design → 18.75	0.42	319.02

FRED C. HART ASSOCIATES, Inc.
CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
PAGE NO: 3

JOB NO: B511
RUN BY: MMT
DATE: 01-08-1986
CHECKED BY: B

TITLE: CULVERT 2

INLET CONTROL
****

HEAD=DY

WHERE D = DIAMETER OF PIPE (FT)
Y = A + BX + CX^2 + DX^3 + EX^4 + FX^5
WHERE A,B,C,D,E,F ARE EXPERIMENTALLY DERIVED COEFFICIENTS
A= .167287 B= .558766
C=-.159813 D= .0420069
E=-3.69252E-03 F= 1.25169E-04
X = Q/D^2.5

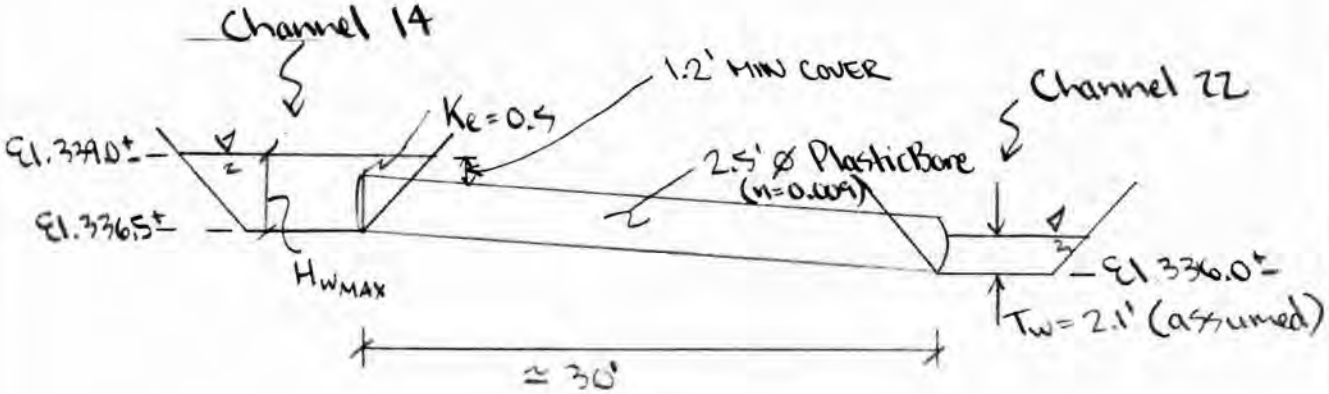
Q(CFS)	HEAD(FT)	HEADWATER ELEVATION (FT)
0.00	0.00	316.00
1.25	0.59	316.59
2.50	0.75	316.75
3.75	0.90	316.90
5.00	1.04	317.04
6.25	1.17	317.17
7.50	1.29	317.29
8.75	1.41	317.41
10.00	1.52	317.52
11.25	1.63	317.63
12.50	1.74	317.74
13.75	1.84	317.84
15.00	1.94	317.94
16.25	2.04	318.04
17.50	2.14	318.14
Qdesign → 18.75	2.24	318.24

SUBJECT Protecc
Site Hydrology & Hydraulics
Culvert Design
JOB NO. B511

Culvert 6

Peak Q = Q channel 14
= 47 cfs

Assume the following cross section:



For inlet control, Hw @ 338.9'
For outlet control, Hw @ 338.5'

∴ Use 2@2.5 ø PlasticBore pipe

FRED C. HART ASSOCIATES, INC.
CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
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JOB NO: B511
RUN BY: MMT
DATE:01-08-1986
CHECKED BY: B

TITLE: Culvert 6

INLET CONTROL
****

	Q(CFS)	HEAD(FT)	HEADWATER ELEVATION (FT)
	23.75	2.62	338.92
½ Q design →	24.38	2.67	338.97
	25.00	2.72	339.02

FRED C. HART ASSOCIATES, INC.
CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
PAGE NO: 6

JOB NO: B511
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TITLE: Culvert 6

OUTLET CONTROL
****

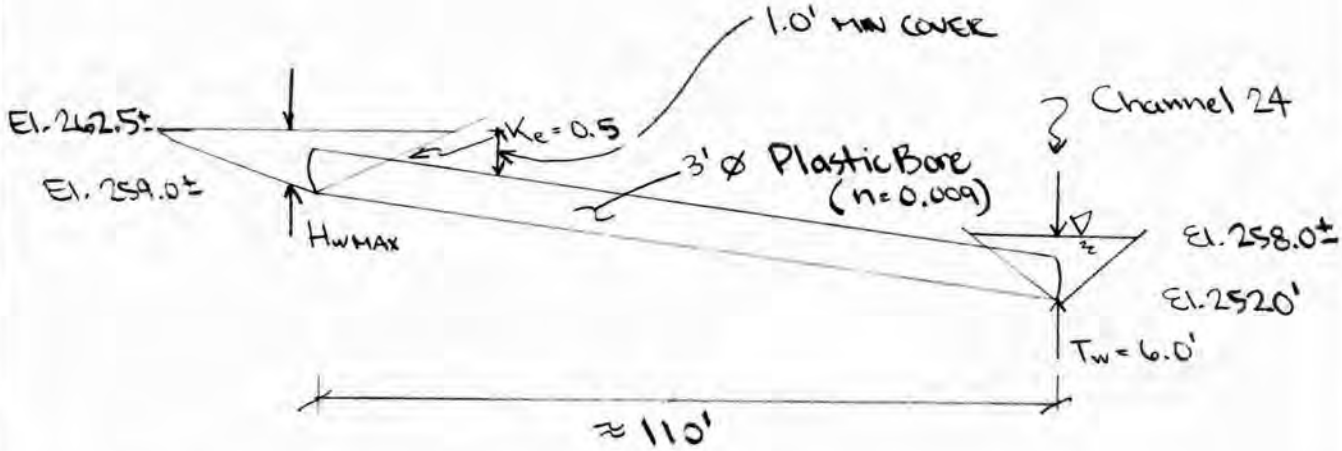
	Q(CFS)	HEAD(FT)	HEADWATER ELEVATION (FT)
½ Qdesign →	23.75	0.59	338.52
	24.38	0.63	338.55
	25.00	0.66	338.58

SUBJECT Proteco Landfill
Site Hydrology & Hydraulics
Culvert Design
JOB NO. B511

Culvert 9

Peak Q = Q_{WA} ~~XXV~~
= 37.0 cfs

Assume the following cross section:



For inlet control, Hw @ 262.2'
Outlet control does not come into effect.

∴ Use 3' ⌀ Plastic Bore

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CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
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TITLE:

OUTLET CONTROL
****

Hf = [(2.5204(1+K)/D^4) + (466.18(n^2)L/D^(16/3))] (Q/10)^2

WHERE Hf = FRICTION LOSS (FT)
K = SUM OF MINOR LOSS FACTORS
D = PIPE DIAMETER (FT)
n = MANNING'S VALUE FOR PIPE ROUGHNESS
Q = FLOW (CFS)

HEADWATER = TAILWATER + Hf + EXIT INVERT ELEVATION
TAILWATER = 6

ENTRANCE LOSS COEFFICIENT = .5

Q(CFS)	Hf(FT)	HEADWATER ELEVATION (FT)
42.00	1.03	259.03
42.75	1.07	259.07

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CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
PAGE NO: #9

TITLE: Culvert 9

JOB NO:
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INLET CONTROL
****

Q(CFS)	HEAD(FT)	HEADWATER ELEVATION (FT)
20.25	2.12	261.12
21.00	2.16	261.16
21.75	2.21	261.21
22.50	2.26	261.26
23.25	2.30	261.30
24.00	2.35	261.35
24.75	2.39	261.39
25.50	2.44	261.44
26.25	2.48	261.48
27.00	2.53	261.53
27.75	2.57	261.57
28.50	2.62	261.62
29.25	2.66	261.66
30.00	2.71	261.71
30.75	2.75	261.75
31.50	2.80	261.80
32.25	2.85	261.85
33.00	2.89	261.89
33.75	2.94	261.94
34.50	2.98	261.98
35.25	3.03	262.03
36.00	3.08	262.08
36.75	3.13	262.13
37.50	3.17	262.17
38.25	3.22	262.22
39.00	3.27	262.27
39.75	3.32	262.32
40.50	3.37	262.37
41.25	3.42	262.42
42.00	3.47	262.47
42.75	3.52	262.52

Qdesign → 37.50

SUBJECT Proteco
Site Hydrology and Hydraulics
Culvert Design
JOB NO. B511

Temporary Culvert 10
Landfill I

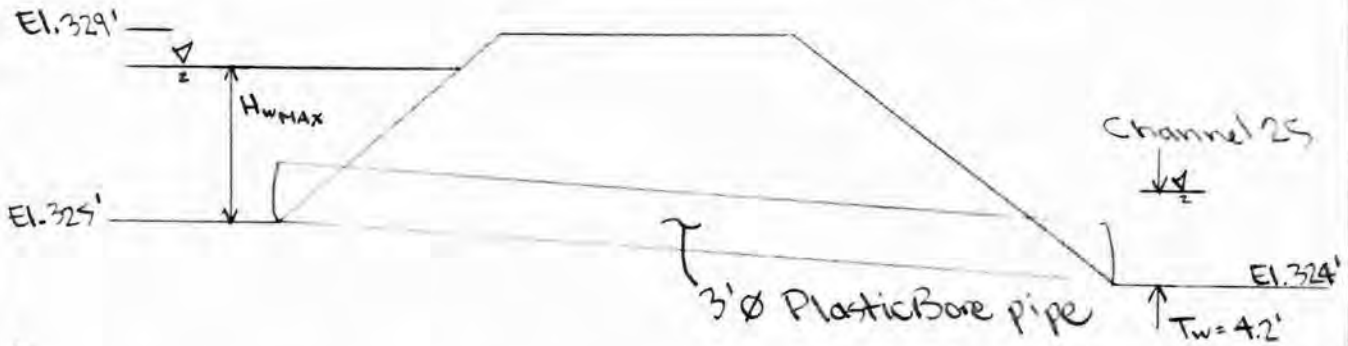
$Q_{Design} = 42$ cfs

Assume: $L \cong 100$ ft

$S \cong 0.01$ ft/ft

$d_{TW} = 4.2$ ft — corresponds to flow depth, Channel 25 (see previous calculations)

Max. H_w elev. = 329 ft — to avoid overtopping roadway embankment & temporary diversion dikes



For inlet control, $H_w = 328.5'$

For outlet control, $H_w = 329.2'$

∴ Use 3' Ø PlasticBore

$$q = \frac{7.07\sqrt{2(32.2)(329-328.2)}}{\sqrt{1+.5+0+.0140(100)}} = 29.8$$

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FRED C. HART ASSOCIATES, Inc.
CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
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TITLE: PROTECO
TEMPORARY CULVERT 10
LANDFILL I

INLET CONTROL
****

Q(CFS)	HEAD(FT)	HEADWATER ELEVATION (FT)
40.50	3.37	328.37
42.00	3.47	328.47
43.50	3.58	328.58
45.00	3.68	328.68
46.50	3.79	328.79
48.00	3.91	328.91
49.50	4.02	329.02
51.00	4.14	329.14
52.50	4.26	329.26
54.00	4.39	329.39
55.50	4.51	329.51
57.00	4.65	329.65

FRED C. HART ASSOCIATES, Inc.
CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
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JOB NO: B511
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TITLE: PROTECO
TEMPORARY CULVERT 10
LANDFILL I

OUTLET CONTROL
****

Q(CFS)	HEAD(FT)	HEADWATER ELEVATION (FT)
40.50	0.94	329.14
42.00	1.01	329.21
43.50	1.09	329.29
45.00	1.16	329.36
46.50	1.24	329.44
48.00	1.32	329.52
49.50	1.41	329.61
51.00	1.49	329.69
52.50	1.58	329.78
54.00	1.68	329.88
55.50	1.77	329.97
57.00	1.87	330.07

Qpeak

SUBJECT Proteco
Site Hydrology and Hydraulics
Culvert Design
JOB NO. B511

Temporary Culvert 11
Landfill II

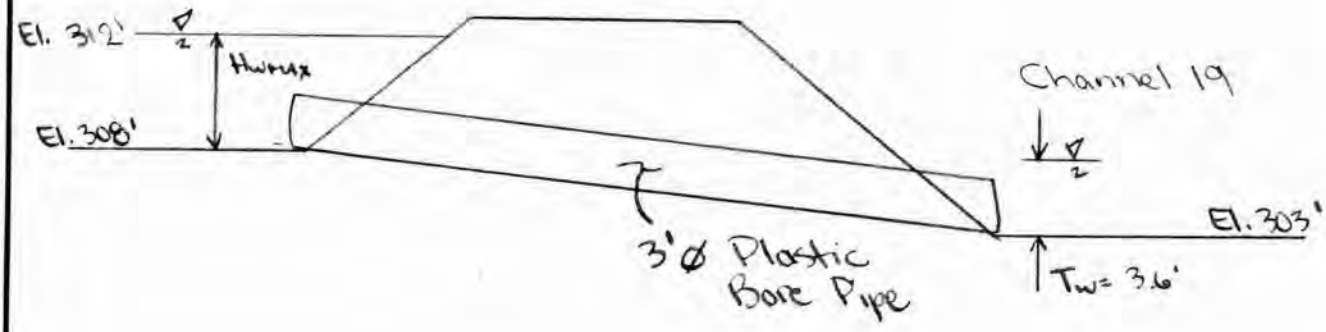
$Q_{Design} = 50$ cfs

Assume: $L \cong 150$ ft

$S \cong 0.03$ ft/ft

$d_{Tw} = 3.6'$ corresponds to flow depth, Channel 19 (see previous calcs)

Max. H_w elev. = 312' to avoid overtopping roadway embankment & temporary diversion dike



For inlet control, $H_w = 312.0'$

For outlet control, $H_w = 308.0'$

∴ Use 3' Ø Plastic Bore

$$q = \frac{7.07\sqrt{2(32.2)(312-306.6)}}{\sqrt{1+.5+0+.014(150)}} = 69.5 \text{ cfs}$$

47.25	3.85	311.85
48.00	3.91	311.91

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FRED C. HART ASSOCIATES, Inc.
CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
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RUN BY: MMT
DATE: 01-20-1986
CHECKED BY: AB

TITLE: PROTECO
TEMPORARY CULVERT 11
LANDFILL II

INLET CONTROL
****

	Q(CFS)	HEAD(FT)	HEADWATER ELEVATION (FT)
	48.75	3.96	311.96
≈ Qdesign	49.50	4.02	312.02

FRED C. HART ASSOCIATES, Inc.
CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
PAGE NO: 15

JOB NO: B511
RUN BY: MMT
DATE: 01-20-1986
CHECKED BY: AB

TITLE: PROTECO
TEMPORARY CULVERT 11
LANDFILL II

OUTLET CONTROL
****

Hf = [(2.5204(1+K)/D^4) + (466.18(n^2)L/D^(16/3))] (Q/10)^2

WHERE Hf = FRICTION LOSS (FT)
K = SUM OF MINOR LOSS FACTORS
D = PIPE DIAMETER (FT)
n = MANNING'S VALUE FOR PIPE ROUGHNESS
Q = FLOW (CFS)

HEADWATER = TAILWATER + Hf + EXIT INVERT ELEVATION
TAILWATER = 3.6

ENTRANCE LOSS COEFFICIENT = .5

Q(CFS)	Hf(FT)	HEADWATER ELEVATION (FT)
47.25	1.40	308.00
48.00	1.45	308.05
48.75	1.49	308.09
49.50	1.54	308.14

V. Culvert Structural Design

SUBJECT Proteco
Site Hydrology & Hydraulics
Culvert Structural Design
JOB NO. B511

Assume all culverts (both CMP & Plastic Bore) will be 16 gage with $2^2/_3$ in x 1/2 in Corrugations.

Check structural capacity based on worst case conditions:

- 3' Ø pipe
- 1' minimum soil cover
- backfill soil density = 125 pcf
- 85% AASHTO compaction
- Highway H 20 Loading

Structural analysis (see pg. 2) shows 16 gage with $2^2/_3$ in x 1/2 in corrugations is adequate.

BY MMT DATE 1/14/86	FRED C. HART ASSOCIATES, INC.	SHEET 2 OF 2	149 PAGE
CHK'D B DATE 1/31/86			

SUBJECT Proteco JOB NO. BS11
Site Hydrology & Hydraulics
Culvert Structural Design

Input Data :

BACKFILL SOIL DENSITY (PCF)	= 125
DEPTH OF COVER (FT)	= 1
DIAMETER OF PIPE (FT)	= 3
BACKFILL COMPACTION (%)	= 85
LIVE LOAD AT SURFACE	=HIGHWAY H 20 LOADING

Design Pressure = Load Factor * (Live Load + Dead Load)

DEAD LOAD (PSF)	= 125
LIVE LOAD (PSF)	= 1800
LOAD FACTOR	= 1
DESIGN LOAD (PSF)	= 1925

Ring Compression = Design Pressure * (Diameter/2)

RING COMPRESSSION (LB/FT)	= 2887.5

****Corrugation and Gage Used For Solution****

GAGE USED	= 16
GALVANIZED THICKNESS (IN)	= 0.0640
SIZE OF CORRUGATIONS	= 2 2/3 in x 1/2 in

Section Properties :

CROSS SECTIONAL AREA (IN^2/FT)	= .775
MOMENT OF INERTIA (IN^4/FT)	= .0227
RADIUS OF GYRATION (IN)	= .1711442

Design Stress = Ultimate Stress/2

ULTIMATE STRESS (PSI)	= 33000
DESIGN STRESS (PSI)	= 16500

Required Cross Sectional Area =Ring Compression/Design Stress

REQUIRED CROSS SECTIONAL AREA (IN^2/FT)= 0.1750

Flexibility Factor = (Diameter * 12 IN/FT)/
(30E+06 PSI * Moment of Inertia / 12 IN/FT)

FLEXIBILITY FACTOR	= 0.0228
MAXIMUM VALUE ALLOWED	= 0.0433

16 GAGE WITH 2 2/3 in x 1/2 in CORRUGATION, AS SPECIFIED BY THE USER, SATISFIES THE DESIGN CRITERIA.

REFERENCE : Handbook of Steel Drainage & Highway Construction Products, Chapter 3, by the American Iron and Steel Institute.

VI. Riprap Design

SUBJECT Proteco JOB NO. B511
Site Hydrology & Hydraulics
Riprap Design

Puerto Rican Standards require that flow velocities in grasslined channels will not exceed 6 ft/sec (channel grade 0 to 5%) and 5 ft/sec (channel grade 5 to 10%). Therefore based on previous calculations the following channels require rip rap lining (bottom & sideslopes):

- Channel 1 (Reach A & B)
- Channel 2 (Reach A)
- Channel 3
- Channel 8
- Channel 9 (Reach A, B, C)
- Channel 10
- Channel 11 (Reach A, B, C)
- Channel 13
- Channel 14
- Channel 16
- Channel 19
- Channel 20 (Reach A & B)
- Channel 21 (Reach A & B)
- Channel 22
- Channel 23
- Channel 24
- Channel 25
- Channel 26 (Reach A, B)
- Channel 27

Using the tractive force method presented in the Puerto Rican Standards, pg. 110:

<u>For straight channel sections:</u>

1) For trapezoidal channels:
   a) calculate b/d
   b) determine P/R from Curve 2

2) Calculate d_{so}:

for trapezoidal channels,

$$d_{so} = 12\left(118\, Q S_b^{13/6}\, R/P\right)^{2/5}$$

for triangular channels,

$$d_{so} = 12\left(64.4\, Q S_b^{13/6} \frac{z}{z^2+1}\right)^{2/5}$$

where: Q = peak flow (cfs)

S_b = channel bottom slope, ft/ft

z = 3 (horizontal component, channel sideslope ratio)

3) Check actual "n" value using the equation

$$n = 0.0395\,(d_{so})^{1/6}$$ where: d_{so} is in feet

If the estimated and actual n values are not in reasonable agreement another trial must be made

$n = 0.035$ was used in design to find b & d

BY MMT DATE 1/12/86
CHK'D DATE 2/7/86
SUBJECT Proteco Site Hydrology & Hydraulics Riprap Design
JOB NO. 8511
FRED C. HART ASSOCIATES, INC.
SHEET 3 OF 13
PAGE 153

Riprap Design for Straight Channels

Channel	b (ft)	d (ft)	b/d	P/R*	S_b (ft/ft)	Q (cfs)	d_{50} (in)	n
1, Reach A	10	1.6	6.3	17.0	0.02	166	6.8	0.036
1, Reach B	10	2.1	4.8	15.9	0.10	627	47.8	
2, Reach A	10	1.0	10.0	20.5	0.05	102	11.5	0.039
3	10	3.5	2.9	14.5	0.02	745	13.2	0.040
8	10	3.6	2.8	14.5	0.02	757	13.3	0.040
9, Reach A	10	1.8	5.6	16.5	0.06	358	24.2	
9, Reach B	10	1.8	5.6	16.5	0.07	358	27.6	
9, Reach C	10	1.6	6.3	17.0	0.10	358	37.2	
10	10	2.9	3.4	14.9	0.03	611	17.1	0.042
11, Reach A	10	1.8	5.6	16.5	0.07	371	28.0	
11, Reach B	10	2.1	4.8	16.0	0.035	371	15.6	0.041
13	0	2.1	—	—	0.02	83	7.7	0.037
14	0	1.7	—	—	0.02	47	6.2	0.035
16	5	0.5	10	20.5	0.07	19	7.8	0.038
19	10	3.6	2.8	14.5	0.09	1683	67.2	
11, Reach C	10	2.0	5.0	16.0	0.05	371	21.2	

* Computed for 3H:1V Sideslopes

BY MMT DATE 1/12/86
CHK'D JR DATE 2/7/86

FRED C. HART ASSOCIATES, INC.

SUBJECT Proteco Site Hydrology & Hydraulics Riprap Design

JOB NO. BS11

SHEET 4 OF 13

15A PAGE

Riprap Design for Straight Channels (cont.)

Channel	b (ft)	d (ft)	b/d	P/R*	S_b (ft/ft)	Q (cfs)	d_{50} (in)	n
20, Reach A	10	3.8	2.6	14.3	0.09	1816	69.7	
20, Reach B	10	5.5	1.8	13.8	0.018	1816	17.5	0.042
21, Reach A	5	1.3	3.8	15.2	0.045	102	11.8	0.039
21, Reach B	5	1.2	4.2	15.5	0.08	102	19.3	
22	10	0.9	11.1	21.5	0.13	148	29.9	
23	5	2.1	2.4	14.2	0.02	175	7.4	0.036
24	0	6.0	—	—	0.04	1847	48.8	
25	0	3.9	—	—	0.045	614	34.8	
			—	—				
26, Reach A	0	3.0	—	—	0.08	400	48.2	
26, Reach B	0	2.7	—	—	0.14	400	78.4	
27	10	3.4	2.9	14.5	0.04	973	26.7	
18	5	0.3	16.7	27.0	0.08	8	5.6	0.035

* computed for 3H:1V Sideslopes

Checking "n" value:

Determine "reasonable agreement for $n_{assumed}$ & n_{actual}.

for Channel 10:

$n_{assumed} = 0.035$
$b = 10'$
$d = 2.9'$
$\therefore d_{50} = 17.1''$
$n_{actual} = 0.042$

w/ $n_{assumed} = 0.042$
$b = 10'$
$d = 2.9'$
$\therefore d_{50} = 17.2'' \approx d_{50\,n=0.035} = 17.1''$

$\therefore$ 1st trial w/ $n = 0.035$ is adequate

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Penn Center West -II Suite 106
Pittsburgh, PA. 15276

JOB NO.
BY:
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PAGE NO 6

DESCRIPTION: PROTECO
CHANNEL 10
CHECKING "n" VALUE

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

```
**************************************************
*                                                *
*                                                *
*                                                *
*                                                *
*                                                *
*                                                *
*                                                *
*Left                                        Right*
**************************************************
```

INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 611
MANNING'S N VALUE..... .042
SLOPE IN FT/FT..... .03
BASE WIDTH IN FEET..... 10
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 9.90685
COMPUTED DEPTH IN FEET..... 3.164063
FREE BOARD IN FEET..... 1.3636
COMPUTED DEPTH + FREE BOARD..... 4.527663
FROUDE NUMBER..... 1.196842

DESIGN CHANNEL DEPTH IN FEET.....= _____

For channel bends:

1. Calculate B_s, the channel surface width

$$B_s = b + 2(z)d$$

where: $z = 3$ (horizontal component, channel sideslope ratio)

2. Measure bend radius, R_o (ft)
3. Calculate B_s/R_o and determine the bend factor, F_B from Curve 4
4. If $F_B < 1.1$, then the riprap size for the straight channel is sufficient

   If $F_B > 1.1$, then the riprap size for the channel bend shall be,

$$d_{50}(\text{bend}) = F_B \times d_{50}(\text{straight})$$

Riprap Design for Channel Bends

Channel	b(ft)	d(ft)	B_s(ft)	R_o(ft)	B_s/R_o	F_B	d_{50}
2, transition from Reach A to B	10	1.2*	17.2	100	0.17	1.03<1.1	same
10	10	2.9	27.4	60	0.46	1.15≈1.1	same
11, Reach B	10	2.1	22.6	100	0.23	1.03<1.1	same
13	0	2.1	12.6	100	0.13	1.01<1.1	same
14, Bend A	0	1.7	10.2	70	0.15	1.01<1.1	same
14, Bend B	0	1.7	10.2	65	0.16	1.02<1.1	same
20, Reach B	10	5.5	43.0	150	0.29	1.1≈1.1	same
21, Reach A	5	1.3	12.8	150	0.09	1.01<1.1	same

∴ NO CHANGE IN RIPRAP SIZE REQUIRED FOR BENDS

* avg. value for Reaches A & B

BY: DMMT DATE: 1/12/86
CHK'D: [illegible] DATE: 2/7/86
SUBJECT: Rootes Site Hydrology & Hydraulics Riprap Design
JOB NO. 8511
FRED C. HART ASSOCIATES, INC.
SHEET 8 OF 13
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SUBJECT Proteco
Site Hydrology & Hydraulics
Riprap Design

JOB NO. BS11

- Determine Maximum riprap size:

$$d_{MAX} = (1.5)\, d_{50}$$

- Minimum riprap size = 6"
- Determine thickness of riprap layer:

$$T = (1.5)\, d_{max}$$

- In cases where $d_{50} > 18"$ a Fabriform grout mat (or approved equal) will be used to line the channels
- As shown on Drawing No. BS11-L29, the Fabriform will be keyed into the channels so as to prohibit its movement. Fabriform is essentially a form for casting-in-place concrete erosion revetments. Fabriform's deeply cobbled concrete surface is well suited to attenuation of hydraulic energy and exhibits similar erosion resistant characteristics as a concrete lined channel.
- To minimize construction problems caused by too many riprap sizes only three riprap sizes (denoted d_{50} construction in Channel Protection Summary) will be used:

8", 14" & 18".

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SUBJECT Proteco
Site Hydrology & Hydraulics
Riprap Design

JOB NO. B511

Channel Protection Summary

Channel	Reach	Lining	d_{50} (calc.)	d_{50} (construction)	d_{MAX}	T
1	A	riprap	6.8"	8"	12"	18"
1	B	Fabriform	—	—	—	—
2	A	riprap	11.5"	14"	21"	32"
2	B	grass	—	—	—	—
3	—	riprap	13.2"	14"	21	32"
4	—	grass	—	—	—	—
5	—	grass	—	—	—	—
6	—	grass	—	—	—	—
7	A	grass	—	—	—	—
7	B	grass	—	—	—	—
8	—	riprap	13.3"	14"	21"	32"
9	A	Fabriform	—	—	—	—
9	B	Fabriform	—	—	—	—
9	C	Fabriform	—	—	—	—
10	—	riprap	17.1"	18"	27"	41"
11	A, C	Fabriform	—	—	—	—
11	B	riprap	15.6"	18"	27"	41"
12	—	grass	—	—	—	—
13	—	riprap	7.7"	8"	12"	18"
14	—	riprap	6.2"	8"	12"	18"
15	—	grass	—	—	—	—
16	—	riprap	7.8"	8"	12"	18"
17	—	grass	—	—	—	—
18	—	grass	—	—	—	—

SUBJECT Proteco
Site Hydrology & Hydraulics
Riprap Design
JOB NO. 8511

Channel Protection Summary (cont.)

Channel	Reach	Lining	d_{50} (calc.)	d_{50} (construction)	d_{MAX}	T
19	—	Fabriform	—	—	—	—
20	A	Fabriform	—	—	—	—
20	B	riprap	17.5"	18"	27"	41"
21	A	riprap	11.8"	14"	21"	32"
21	B	Fabriform	—	—	—	—
22	—	Fabriform	—	—	—	—
23	—	riprap	7.4"	8"	12"	18"
24	—	Fabriform	—	—	—	—
25	—	Fabriform	—	—	—	—
		Fabriform	—	—	—	—
26	A	Fabriform	—	—	—	—
26	B	Fabriform	—	—	—	—
27	—	Fabriform	—	—	—	—

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SUBJECT Proteco Riprap Design CURVE 2

JOB NO. B511

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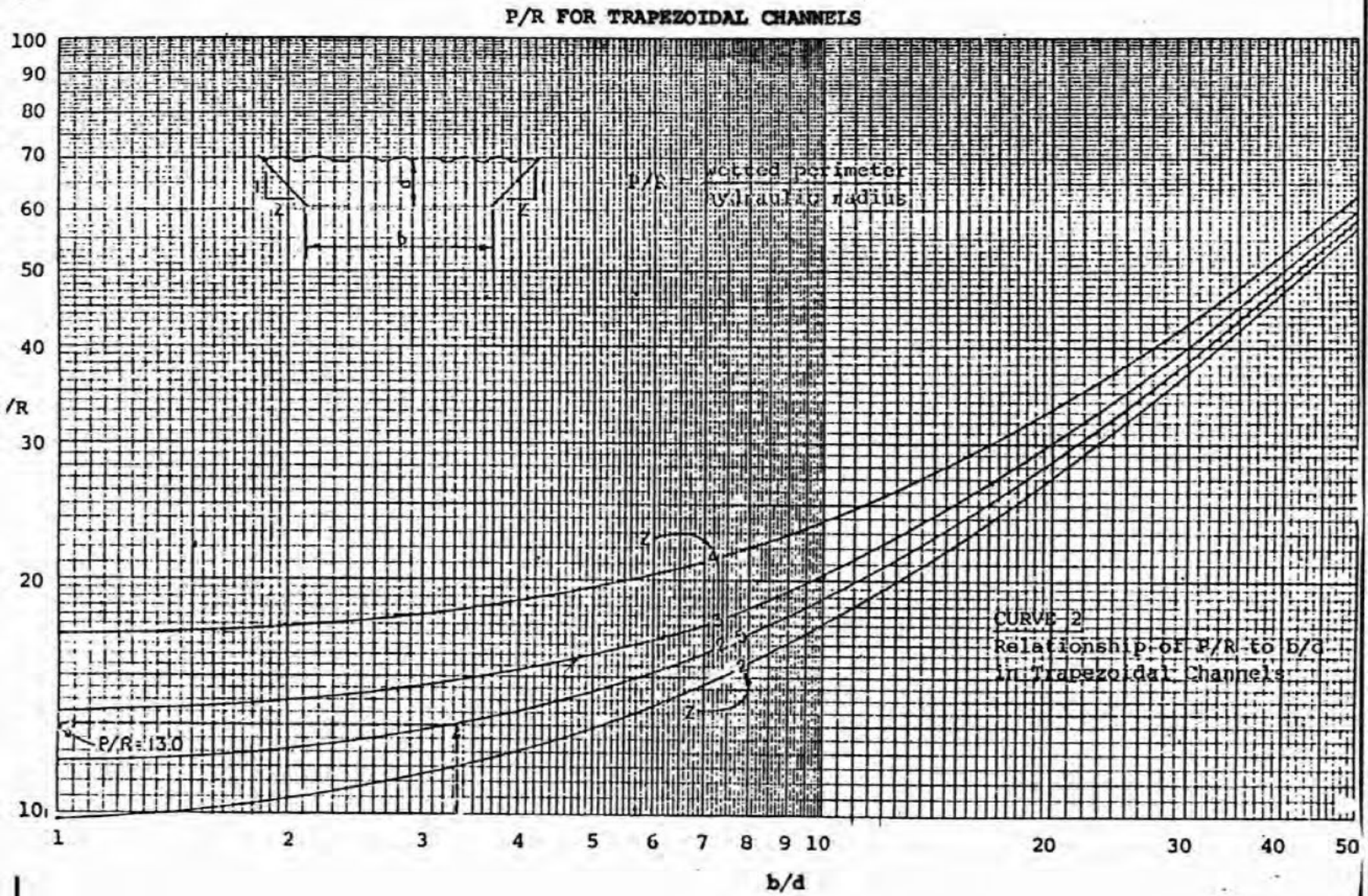
P/R FOR TRAPEZOIDAL CHANNELS



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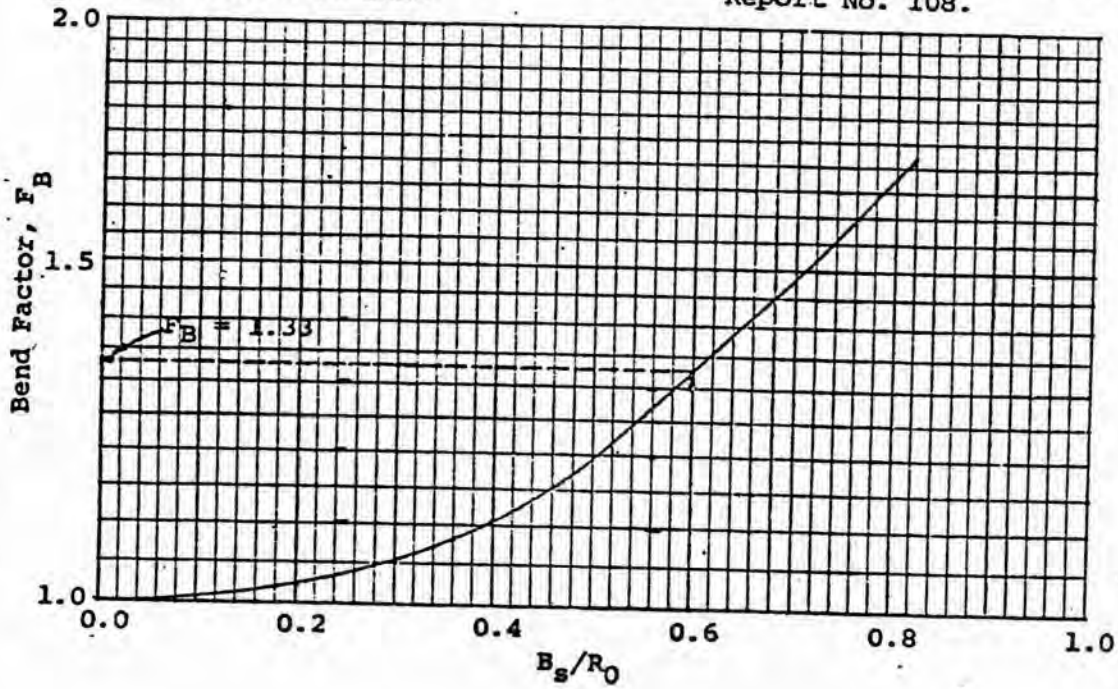
SUBJECT Proteco Riprap Design CURVE 4 JOB NO. B511

CURVE 4 - RIPRAP SIZE CORRECTION FACTOR FOR FLOW IN CHANNEL BENDS

d_{50}(for bend) = d_{50}(for straight) X F_B
B_s = channel surface width
R_o = mean radius of bend

Adapted from Highway Research Report No. 108.



VII. Conduit Outlet Protection

BY MMT DATE 1/13/86	FRED C. HART ASSOCIATES, INC.	SHEET 1 OF 165 PAGE
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SUBJECT Proteco
Site Hydrology & Hydraulics
Conduit Outlet Protection

JOB NO. B511

Puerto Rican Standards require outlet protection to convert pipe flow to channel flow and reduce the velocity of the water consistent with the channel lining in order to convey the flow of water to a stable downstream channel without causing erosion.

Consider protection requirements of the following pipe outlets:

- Drop Inlet 1 discharging into Channel 3
- Drop Inlet 2 discharging into Channel 19
- Culvert 2 discharging into Channel 8
- Culvert 6 discharging into Channel 22
- Culvert 10 discharging into Channel 25
- Culvert 11 discharging into Channel 19
- Culverts 1, 3, 4, 5, 7, 8, (Roadway/Channel Crossings)
- Culvert 9 discharging into Channel 24

SUBJECT Proteco
Site Hydrology & Hydraulics
Conduit Outlet Protection
JOB NO. 8511

For pipe outlets, determine apron size and minimum d_{50} size for the riprap:

1) Determine Q (cfs), pipe diameter, d (inches) and tailwater condition.

   Maximum T_w condition: $T_w \geq 0.5$ pipe diameter

   Minimum T_w condition: $T_w < 0.5$ pipe diameter

2) Enter appropriate curve, Curve 5 (max T_w) or Curve 6 (Min T_w) with Q & d to find riprap size and apron length. (L_{apron})

3) Calculate apron width (W_{Apron})

   $W_{Apron} = d + L_{Apron}$ for minimum tailwater condition

   $W_{Apron} = d + 0.4 L_{Apron}$ for maximum tailwater condition

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SUBJECT Proteco Site Hydrology & Hydraulics Conduit Outlet Protection

JOB NO. B511

Outlet Protection Design

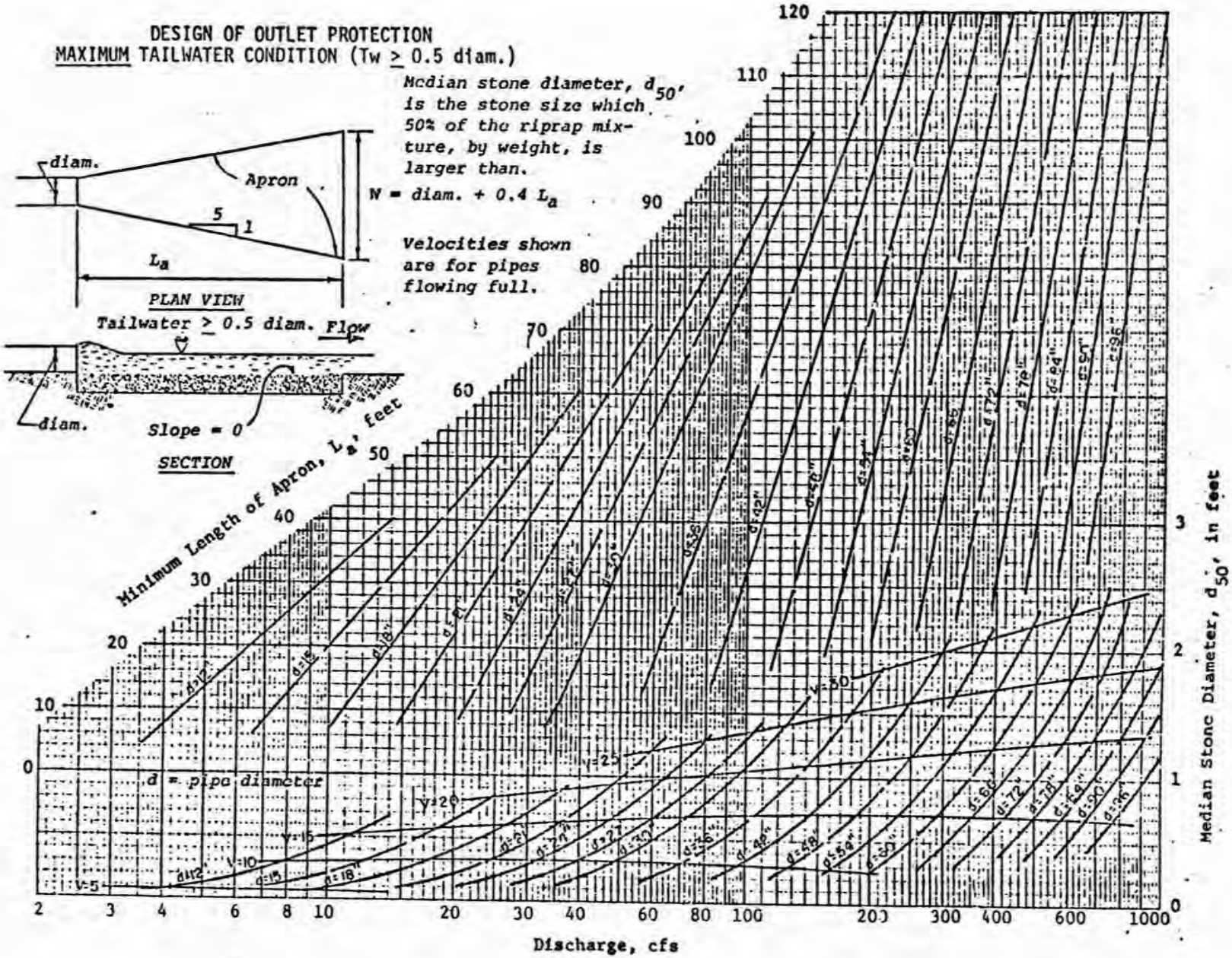
Discharge Outlet Structure	Q (cfs)	d (inches)	T_w	d_{50} (ft)	L_{Apron} (ft)	W_{Apron} (ft)
Drop Inlet 1	33 *	30"	3.5' Max. cond.	0.1	8	6
Drop Inlet 2	27 *	36"	3.6' Max. cond.	0.1	0	3
Culvert 2	19	30"	3.6' Max cond.	0.1	0	3
Culvert 6	24 *	30"	0.9' Min. cond.	0.65	6	8.5
Culvert 10	42	36"	4.2' Max. cond.	0.1	4	4
Culvert 11	50	36"	3.6' Max cond.	0.1	7	6
Culverts 1,3,4,5,7,8 associated w/ Roadway/Channel Crossings	4.5 **	12"	Min.	0.25	11	12
Culvert 9	37	36"	6.0' Max cond.	0.1	10'	13.0

* These flows are for one-half of the total flow because there are two pipes at each location.

** This flow was determined using computer program CULVERT to determine Q for 1' ø culvert, 100' long at 2% grade, assuming no tailwater

Summary:

Calculation of d_{50} for all outlets was less than the d_{50} riprap of the downstream channels. Therefore the erosion protection of the downstream channels is adequate for dissipating the energy of the water from the conduits. Although the length and width of an outlet apron was calculated, no aprons need to be constructed.



BY MMT DATE 1/13/86

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SUBJECT Proteco Conduit Outlet Protection CURVE 5

JOB NO. B511

FRED C. HART ASSOCIATES, INC.

SHEET 5 OF

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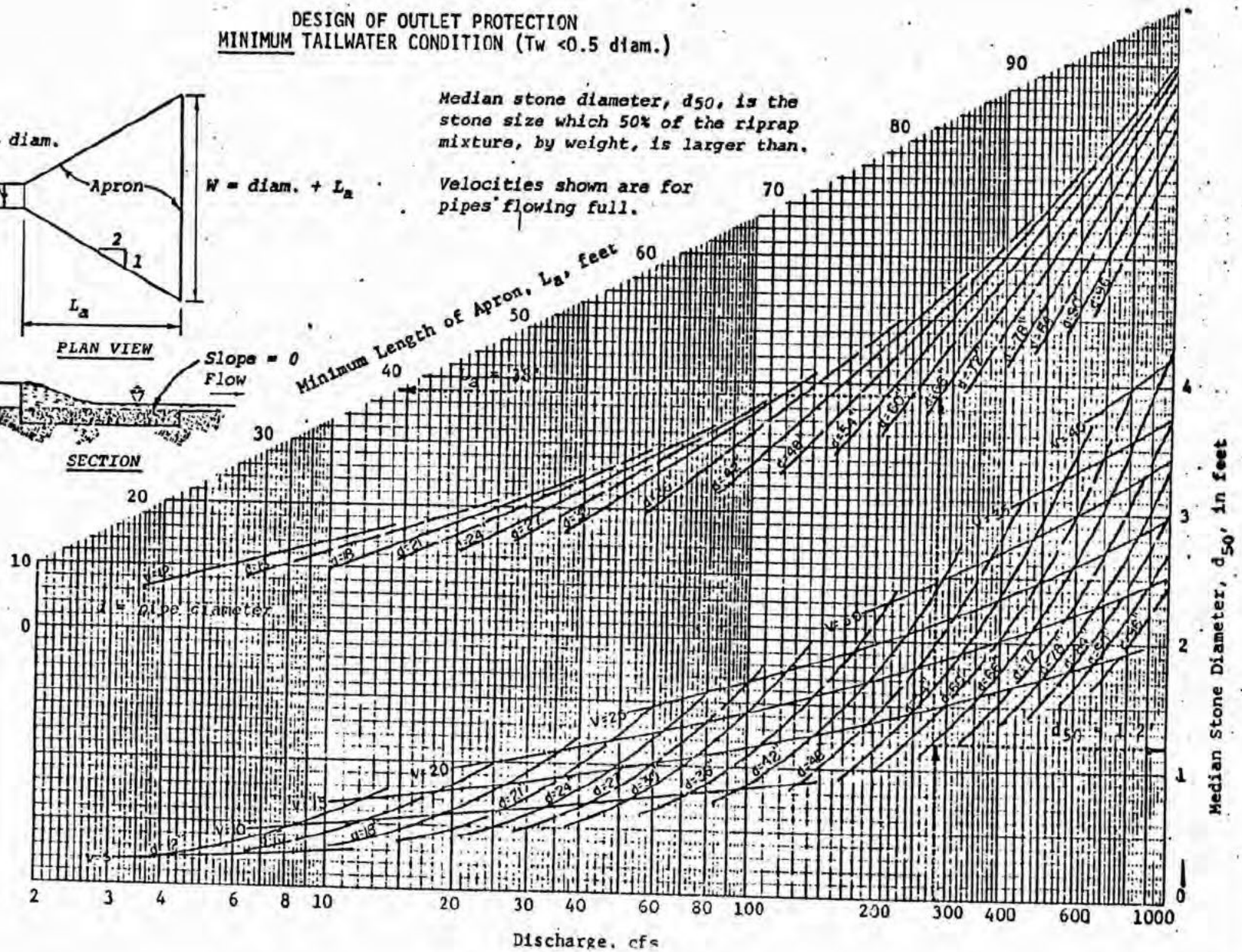
DESIGN OF OUTLET PROTECTION
MINIMUM TAILWATER CONDITION (Tw <0.5 diam.)

Median stone diameter, d_{50}, is the stone size which 50% of the riprap mixture, by weight, is larger than.

Velocities shown are for pipes flowing full.



BY MMT DATE 2/7/86
CHK'D DATE
SUBJECT Proteco Conduit Outlet Protection Curve 6
JOB NO B511
FRED C. HART ASSOCIATES, INC.
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✓ JR 2-3-86

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FRED C. HART ASSOCIATES, Inc.
CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
PAGE NO: 1

JOB NO: B511
RUN BY: MMT
DATE:01-13-1986
CHECKED BY:

TITLE: PROTECO
CULVERTS 1 - 6 ASSOCIATED WITH ROADWAY/CHANNEL CROSSINGS

NUMBER OF NODES = 2

DEPTH OF TAILWATER ABOVE EXIT INVERT ELEVATION = .85

TYPE OF ENTRANCE = PROJECTING

NODE	DESCRIPTION	DISTANCE (FEET)	ELEVATION (FEET)	DIAMETER (FEET)	MATERIAL	n VALUE
1	ENTRANCE		312			
		100		1	CMP	0.024
2	EXIT		310			

✓JR 2-3-86

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CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
PAGE NO: 2

JOB NO: B511
RUN BY: MMT
DATE:01-13-1986
CHECKED BY:

TITLE: PROTECO
CULVERTS 1 - 6 ASSOCIATED WITH ROADWAY/CHANNEL CROSSINGS

MINOR LOSSES
****

REACH 1 - 2	DESCRIPTION	LOSS FACTOR
	.....	.....
	NO MINOR LOSSES IN THIS REACH	

✓ JR 2-3-86
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CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
PAGE NO: 3

JOB NO: B511
RUN BY: MMT
DATE:01-13-1986
CHECKED BY:

TITLE: PROTECO
CULVERTS 1 - 6 ASSOCIATED WITH ROADWAY/CHANNEL CROSSINGS

INLET CONTROL
****

HEAD=DY

WHERE D = DIAMETER OF PIPE (FT)
Y = A + BX + CX^2 + DX^3 + EX^4 + FX^5
WHERE A,B,C,D,E,F ARE EXPERIMENTALLY
DERIVED COEFFICIENTS
A= .187321 B= .56771
C=-.156544 D= .0447052
E=-3.43602E-03 F= 8.9661E-05
X = Q/D^2.5

Q(CFS)	HEAD(FT)	HEADWATER ELEVATION (FT)
0.00	0.00	312.00
0.25	0.32	312.32
0.50	0.44	312.44
0.75	0.54	312.54
1.00	0.64	312.64
1.25	0.73	312.73
1.50	0.82	312.82
1.75	0.91	312.91
2.00	1.00	313.00
2.25	1.10	313.10
2.50	1.20	313.20
2.75	1.31	313.31
3.00	1.43	313.43
3.50	1.70	313.70
4.00	2.03	314.03
4.50	2.40	314.40

✓ JL 2-3-86
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CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
PAGE NO: 4

JOB NO: B511
RUN BY: MMT
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CHECKED BY:

TITLE: PROTECO
CULVERTS 1 - 6 ASSOCIATED WITH ROADWAY/CHANNEL CROSSINGS

OUTLET CONTROL
****

Hf = [(2.5204(1+K)/D^4) + (466.18(n^2)L/D^(16/3))] (Q/10)^2

WHERE Hf = FRICTION LOSS (FT)
K = SUM OF MINOR LOSS FACTORS
D = PIPE DIAMETER (FT)
n = MANNING'S VALUE FOR PIPE ROUGHNESS
Q = FLOW (CFS)

HEADWATER = TAILWATER + Hf + EXIT INVERT ELEVATION
TAILWATER = .85

ENTRANCE LOSS COEFFICIENT = .9

Q(CFS)	Hf(FT)	HEADWATER ELEVATION (FT)
2.00	1.27	312.12
2.25	1.60	312.45
2.50	1.98	312.83
2.75	2.39	313.24
3.00	2.85	313.70
3.50	3.88	314.73
4.00	5.06	315.91
4.50	6.41	317.26

VIII Sedimentation Pond

SUBJECT SEDIMENTATION POND DESIGN JOB NO. B511L

PURPOSE: TO DESIGN A SEDIMENTATION BASIN CAPABLE OF REMOVING THE SEDIMENT WHICH COLLECTS IN RUNOFF WITHIN THE LANDFILL CELLS ASSUMING THE RUNOFF IS DETERMINED TO BE NONHAZARDOUS

NOTE: THIS SEDIMENTATION BASIN IS INTENDED FOR USE DURING THE CONSTRUCTION PHASE OF THE LANDFILLS, I.E. ONLY THAT TIME BETWEEN EXCAVATION AND FINAL CAPPING OF THE CELL. THEREFORE, ONLY A PORTION OF THE LANDFILL WILL CONTRIBUTE RUNOFF TO THE SEDIMENTATION BASIN AT ANY ONE TIME.

CONTRIBUTORY CELLS	AREA* (ft^2)	AREA (acres)
PHASE 1 Stage 1	138,500 ft^2	3.2
PHASE 1 Stage 2	113,500 ft^2	2.6
PHASE 1 Stage 3	153,200 ft^2	3.5
PHASE 2 Stage 1	105,100 ft^2	2.4
PHASE 2 Stage 2	106,400 ft^2	2.4
PHASE 2 Stage 3	124,000 ft^2	2.8

* AREAS TAKEN FROM INTERIM BERM DESIGN CALCS.

DUE TO THE CONSTRUCTION SEQUENCE THE MAXIMUM RUNOFF WILL OCCUR WHEN STAGE 3 IS ACTING AS A HOLDING BASIN FOR RUNOFF FROM STAGES 1 AND 2.

∴ MAX CONTRIBUTORY AREA FOR

PHASE 1: 3.2 + 2.6 + 3.5 = 9.3 ACRES ⟸ MOST STRINGENT CONDITION

PHASE 2: 2.4 + 2.4 + 2.8 = 7.6 ACRES

SUBJECT SEDIMENTATION POND DESIGN JOB NO. B511L

USING THE DESIGN METHOD FROM "STANDARDS AND SPECIFICATIONS FOR SOIL EROSION AND SEDIMENT CONTROL IN DEVELOPING AREAS (USDA SOIL CONSERVATION SERVICE · CARIBBEAN AREA)"

BASIN DESIGN:

MINIMUM VOL. = $67\ yd^3 \times$ (# acres drained)
(BELOW PRINCIPAL SPILLWAY CREST) $= 67\ yd^3 \times 9.3 = 624\ yd^3$

MINIMUM VOL. BEFORE CLEANOUT = $27 yd^3 \times$ (# acres drained)
$= 27 yd^3 \times 9.3 = 252\ yd^3$

∴ MINIMUM VOL. FOR SEDIMENT = $624 yd^3 - 252 yd^3 = 372$

FROM AREA2 PROGRAM CALCULATIONS:

Elev.	Area (ft^2)	Cum. Vol. (yd^3)
316	4818	364
317	6071	565

THEREFORE FOR ELEV. 316.5

AVG. AREA = $\frac{4818 + 6071}{2} = 5444\ ft^2$

VOLUME = $(5444\ ft^2) \times (.5\ ft) = 2722.25\ ft^3 = 100\ yd^3$

CUMULATIVE VOL. = $364 + 100 = 464\ yd^3$

∴ USE ELEVATION 316.5 FOR THE SEDIMENTATION CLEANOUT LEVEL

TO KEEP RISER HEIGHT AS LOW AS POSSIBLE TO ALLOW FOR AS MUCH FREEBOARD AS POSSIBLE USE THE MINIMUM DISTANCE BETWEEN SEDIMENT CLEANOUT LEVEL AND RISER CREST = 1.0 ft.

∴ RISER CREST = 316.5 ft + 1 ft = 317.5 ft.
(AVAILABLE VOLUME BELOW PRINCIPLE SPILLWAY = 682 yd^3 > 624 yd^3 ∴ o.k.)

FROM THE INTERIM BERM DESIGN CALCULATIONS THE MAXIMUM RUNOFF VOLUME FOR THE 25 YR 24 HR. STORM IS 12,223 yd^3. (This occurs when cell 3 is acting as a holding pond for cells 1 + 2.)

ASSUMING THAT THE HOLDING POND IS PUMPED OUT OVER A 24 HR. PERIOD (into the sedimentation pond):

$$Q = \frac{12223\ yd^3}{24\ hrs} \times \frac{27\ ft^3}{yd^3} \times \frac{hr}{60\ min} \times \frac{min}{60\ sec} = 3.82\ cfs$$

WHICH REPRESENTS PEAK FLOW CONDITIONS.

USING THE CULVERT PROGRAM Q = 4.0 WHEN THE POOL ELEV. = 317.91 ft. (Weir Control)

Note: NO ANTI-SEEP COLLARS ARE REQUIRED SINCE THE HEIGHT OF THE EMBANKMENTS > 10 ft AND WILL BE CONSTRUCTED OF CLAY MATERIALS

BY JAR DATE 1/8/86
CHK'D MMT DATE 1/10/86

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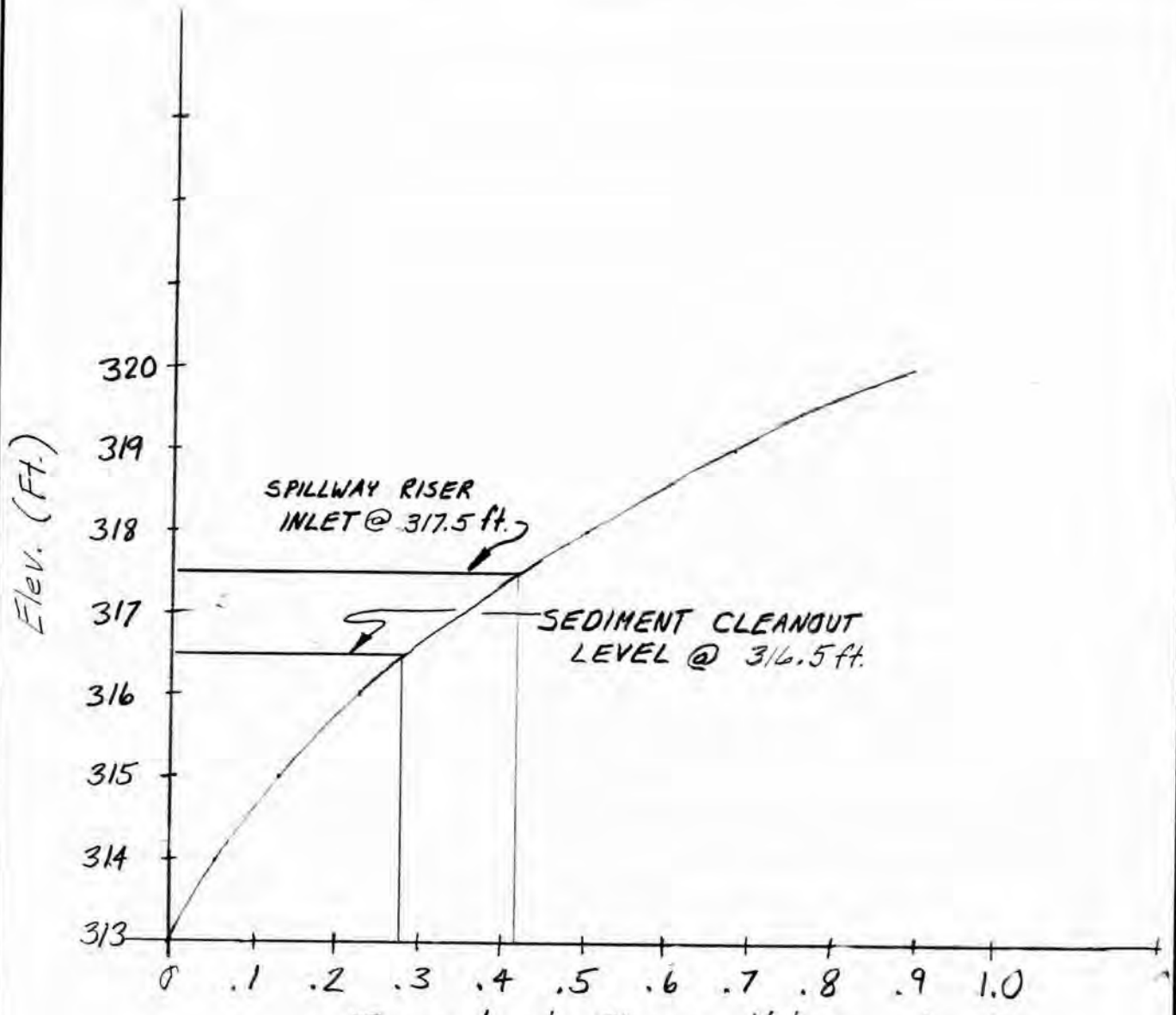
SUBJECT SEDIMENTATION POND DESIGN JOB NO. B511L



ELEVATION vs. STORAGE VOLUME

SEDIMENT BASIN

BY JAR DATE 1/8/86
CHK'D MMT DATE 1/10/86

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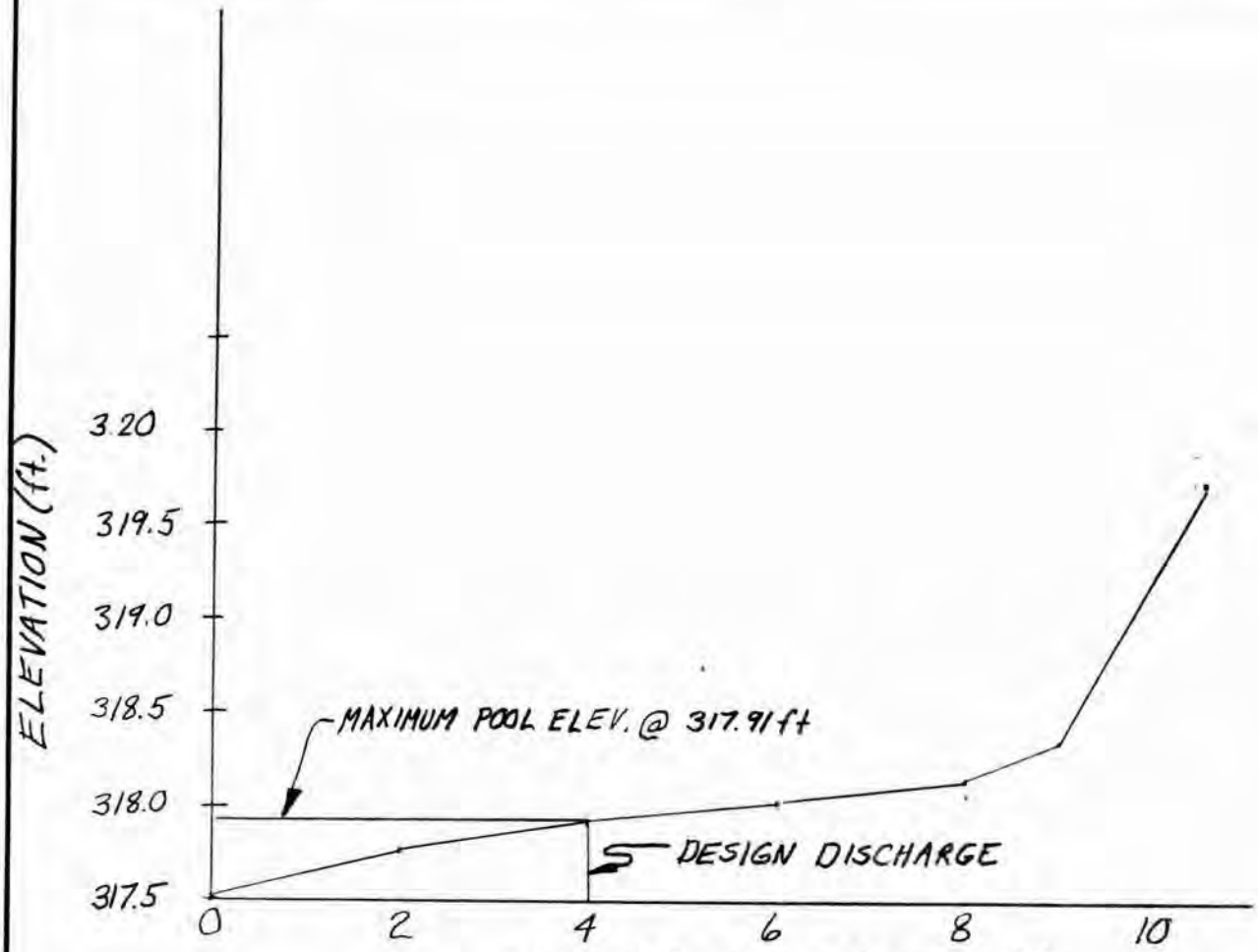
SUBJECT SEDIMENTATION POND DESIGN JOB NO. B-511L



ELEVATION VS DISCHARGE
SEDIMENT BASIN

FRED C. HART ASSOCIATES - PITTSBURGH, PA.
PLANIMETERING PROGRAM VERSION 2.0
PAGE NO: 1
TITLE: SED. POND
PROTECO

JOB NO: B511
RUN BY: JAR
DATE:01-09-1986

FRAME	ELEVATION	AREA(SQ.IN)
1	313.00	0.74
1	314.00	1.11
1	315.00	1.49
1	316.00	1.93
1	317.00	2.43
1	318.00	2.87
1	319.00	3.42
1	320.00	4.04

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FRED C. HART ASSOCIATES - PITTSBURGH, PA.
PLANIMETERING PROGRAM VERSION 2.0
PAGE NO: 1
TITLE: SED. POND
PROTECO

JOB NO: 8511
RUN BY: JAR
DATE:01-09-1986

SCALE= 1INCH: 50 FT
AVERAGE AREA IS CALCULATED BY (A+B)/2

ELEV	DIGITIZER READING (SQ.IN.)	AREA (SQ.FT.)	AVERAGE AREA (SQ.FT.)	DELTA ELEV	VOLUME (CU.YDS)	cum vol zero @	CUMULATIVE VOLUME (CU.YDS)
313.00	0.74	1840.8					
314.00	1.11	2764.89	2302.86	1.00	85.29	.053	85.29
315.00	1.49	3734.13	3249.51	1.00	120.35	.127	205.64
316.00	1.93	4818.12	4276.12	1.00	158.37	.226	364.02
317.00	2.43	6071.78	5444.95	1.00	201.66	.351	565.68
318.00	2.87	7174.07	6622.93	1.00	245.29	.502	810.98
319.00	3.42	8559.57	7866.82	1.00	291.36	.683	1102.34
320.00	4.04	10096.44	9328.00	1.00	345.48	.897	1447.82

By interpolation the cum volume below el. 317.5:

$$\frac{6072\,ft^2 + 6623\,ft^2}{2} \; .5\,ft. = 3173.75\,ft^3 \times \frac{yd^3}{27\,ft^3} = 117\,yd^3$$

$$565\,yd^3 + 117\,yd^3 = 682\,yd^3$$

FRED C. HART ASSOCIATES, INC.
ULVERT HYDRAULICS ANALYSIS - VERSION 1.0
AGE NO: 1

JOB NO: B51!
RUN BY: JAR
DATE:05-17-1984
CHECKED BY:

ITLE: SED. POND SPILLWAY DESIGN
PROTECO

NUMBER OF NODES = 2

EPTH OF TAILWATER ABOVE EXIT INVERT ELEVATION = 3.6

TYPE OF ENTRANCE = RISER
HEIGHT OF RISER = 4.5 FT
RISER DIAMETER = 1.5 FT

ODE	DESCRIPTION	DISTANCE (FEET)	ELEVATION (FEET)	DIAMETER (FEET)	MATERIAL	n VALUE
1	ENTRANCE		313			
		110		1.5	CMP	0.024
2	EXIT		311			

note: Design calculations using 1.5' Ø riser are adequate however a 2' Ø riser will be used for constructability. The hydraulic analysis for 1.5' Ø riser is conservative.

Pg 184

RED C. HART ASSOCIATES, INC.
CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
PAGE NO: 3

JOB NO: B511
RUN BY: JAR
DATE: 05-17-1984
CHECKED BY:

TITLE: SED. POND SPILLWAY DESIGN
PROTECO

WEIR CONTROL
****

Q=CLH^(3/2)

WHERE Q = FLOW (CFS)
C = WEIR COEFFICIENT = 3.293333
L = WEIR LENGTH (FT)
H = HEAD (FT)

Q(CFS)	HEAD(FT)	HEADWATER ELEVATION (FT)
0.00	0.00	317.50
1.00	0.16	317.66
2.00	0.26	317.76
3.00	0.33	317.83
4.00	0.40	317.91
5.00	0.47	317.97
6.00	0.53	318.03
7.00	0.59	318.09
8.00	0.64	318.14
9.00	0.70	318.20
9.75	0.73	318.23
10.50	0.77	318.27
11.25	0.81	318.31

Weir Control Ends Here

Pg 185

FRED C. HART ASSOCIATES, INC.
CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
PAGE NO: 4

JOB NO: B511
RUN BY: JAR
DATE: 05-17-1984
CHECKED BY:

TITLE: SED. POND SPILLWAY DESIGN
PROTECO

INLET CONTROL
****

HEAD=DY

WHERE D = DIAMETER OF PIPE (FT)
Y = A + BX + CX^2 + DX^3 + EX^4 + FX^5
WHERE A,B,C,D,E,F ARE EXPERIMENTALLY DERIVED COEFFICIENTS
A= .167433 B= .538595
C=-.149374 D= .0391543
E=-3.43974E-03 F= 1.15882E-04
X = Q/D^2.5

Q(CFS)	HEAD(FT)	HEADWATER ELEVATION (FT)
0.00	0.00	313.00
1.00	0.52	313.52
2.00	0.74	313.74
3.00	0.93	313.93
4.00	1.11	314.11
5.00	1.28	314.28
6.00	1.45	314.45
7.00	1.62	314.62
8.00	1.81	314.81
9.00	2.02	315.02
9.75	2.19	315.19
10.50	2.38	315.38
11.25	2.58	315.58

FRED C. HART ASSOCIATES, INC.
CULVERT HYDRAULICS ANALYSIS - VERSION 1.0
PAGE NO: 5

JOB NO: B511
RUN BY: JAR
DATE: 05-17-1984
CHECKED BY:

TITLE: SED. POND SPILLWAY DESIGN
PROTECO

OUTLET CONTROL
****

H = [(2.5204(1+K)/D^4) + (466.18(n^2)L/D^(16/3))] (Q/10)^2

WHERE Hf = FRICTION LOSS (FT)
K = SUM OF MINOR LOSS FACTORS
D = PIPE DIAMETER (FT)
n = MANNING'S VALUE FOR PIPE ROUGHNESS
Q = FLOW (CFS)

HEADWATER = TAILWATER + Hf + EXIT INVERT ELEVATION
TAILWATER = 3.6

ENTRANCE LOSS COEFFICIENT = 1.5

Q(CFS)	Hf(FT)	HEADWATER ELEVATION (FT)
0.00	0.00	314.60
1.00	0.05	314.65
2.00	0.19	314.79
3.00	0.42	315.02
4.00	0.74	315.34
5.00	1.16	315.76
6.00	1.67	316.27
7.00	2.28	316.88
8.00	2.97	317.57
9.00	3.76	318.36
9.75	4.41	319.01
10.50	5.12	319.72
11.25	5.88	320.48

Outlet Control Begins Here

IX. Interim Berm Design

SUBJECT Proteco Landfill I — JOB NO. B511

Interim Berm Design - Temporary Stormwater Basin

Stage 1 - Landfill Development:

Determine volume of water to be contained in Stage 2 area. Consider runoff from developed portion of landfill and direct rainfall into temporary stormwater basin (for 25 yr 24 hr storm).

Runoff from Stage 1:

Vol. Runoff = (Area Stage 1)(9.40" runoff)

$= (129548\ ft^2)(9.40\ in)(\frac{1\ ft}{12\ in})$

$= 101479\ ft^3$

Direct rainfall into basin:

Vol. rainfall = (Area Stage 2)(10.5" rainfall)

$= (113128\ ft^2)(10.5\ in)(\frac{1\ ft}{12\ in})$

$= 98987\ ft^3$

Total Storage Volume Required:

Vol. req'd = Runoff + Rainfall

$= 101479\ ft^3 + 98987\ ft^3$

$= 200466\ ft^3$

$= 7425\ yd^3$

BY MMT DATE 10/31/85
CHK'D JL DATE 12/20/85

FRED C. HART ASSOCIATES, INC.

SHEET 2 OF 5 — 189 PAGE

SUBJECT PROTECO
Landfill I

JOB NO. B511E

Determine storage volume available in Stage 2. Planimeter "top of primary liner" contours shown on Figure 1

Total Storage Available:

FRED C. HART ASSOCIATES - PITTSBURGH, PA.
PLANIMETERING PROGRAM VERSION 2.0
PAGE NO: 1
TITLE: PROTECO
PHASE 1 LANDFILL
INTERIM BERM DESIGN

JOB NO: B511
RUN BY: MMT
DATE: 11-02-1985

SCALE= 1INCH: 50 FT
AVERAGE AREA IS CALCULATED BY (A+B)/2

ELEV	DIGITIZER READING (SQ.IN.)	AREA (SQ.FT.)	AVERAGE AREA (SQ.FT.)	DELTA ELEV	VOLUME (CU.YDS)	CUMULATIVE VOLUME (CU.YDS)
301.50	0.00	0.0				
302.50	0.99	2478.71	1239.36	1.00	45.90	45.90
303.50	4.20	10495.84	6487.28	1.00	240.27	286.17
304.50	9.29	23234.10	16864.97	1.00	624.63	910.80
305.50	14.56	36410.38	29822.24	1.00	1104.53	2015.33
306.50	19.49	48729.40	42569.89	1.00	1576.66	3591.99
307.50	23.53	58815.00	53772.20	1.00	1991.56	5583.55
308.50	25.96	64894.40	61854.70	1.00	2290.91	7874.47
309.50	26.98	67449.05	66171.72	1.00	2450.80	10325.27
310.50	27.93	69833.68	68641.36	1.00	2542.27	12867.54
311.50	28.58	71439.82	70636.75	1.00	2616.18	15483.72
312.00	28.36	70900.28	71170.05	0.50	1317.96	16801.68
312.50	28.32	70810.55	70855.41	0.50	1312.14	18113.82
313.50	28.16	70393.08	70601.81	1.00	2614.88	20728.70
314.50	28.07	70166.03	70279.55	1.00	2602.95	23331.65

With 2' freeboard:

Min. berm height = El. 310.5

Stage 2 Landfill Development:

Determine volume of water to be contained in Stage 3 area. Consider runoff from developed portion of landfill (Stages 1 & 2) and direct rainfall into temporary stormwater basin (for 25 yr 24 hr storm)

Runoff from Stages 1 & 2:

Vol. runoff = (Area Stages 1 & 2)(9.40" runoff)
= $(129548\ ft^2 + 113128\ ft^2)(9.40\ in)(\frac{1\ in}{12\ ft})$
= $190096\ ft^3$

Direct rainfall into basin:

Vol. rainfall = (Area Stage 3)(10.5" rainfall)
= $(150769\ ft^2)(10.5\ in)(1\ in/12\ ft)$
= $131923\ ft^3$

Total Storage Volume Required:

Vol. req'd = Runoff + Rainfall
= $190096\ ft^3 + 131923\ ft^3$
= $322019\ ft^3$
= $11927\ yd^3$

BY MMT DATE 10/31/85
CHK'D JR DATE 12/26/85

FRED C. HART ASSOCIATES, INC.

SHEET 4 OF 5 PAGE 191

SUBJECT PROTECO Landfill I JOB NO. B511E

Determine storage volume available in Stage 3. Planimeter "top of primary liner" contours shown on figure 1

Total Storage Available:

FRED C. HART ASSOCIATES - PITTSBURGH, PA.
PLANIMETERING PROGRAM VERSION 2.0
PAGE NO: 1
TITLE: PROTECO
PHASE I LANDFILL
INTERIM BERM DESIGN

JOB NO: B511
RUN BY: MMT
DATE: 11-02-1985

SCALE= 1INCH: 50 FT
AVERAGE AREA IS CALCULATED BY (A+B)/2

ELEV	DIGITIZER READING (SQ.IN.)	AREA (SQ.FT.)	AVERAGE AREA (SQ.FT.)	DELTA ELEV	VOLUME (CU.YDS)	CUMULATIVE VOLUME (CU.YDS)
304.50	0.00	0.0				
305.50	1.20	2989.20	1494.60	1.00	55.36	55.36
306.50	4.42	11062.16	7025.68	1.00	260.21	315.57
307.50	8.95	22373.96	16718.06	1.00	619.19	934.75
308.50	14.40	36001.59	29187.77	1.00	1081.03	2015.78
309.50	20.28	50694.58	43348.08	1.00	1605.48	3621.27
310.50	24.04	60090.94	55392.76	1.00	2051.58	5672.85
311.50	24.73	61821.90	60956.42	1.00	2257.65	7930.50
312.50	24.76	61907.35	61864.63	1.00	2291.28	10221.78
313.50	24.55	61371.46	61639.41	1.00	2282.94	12504.72
314.50	24.80	61995.85	61683.66	1.00	2284.58	14789.30
315.50	24.79	61975.10	61985.48	1.00	2295.76	17085.06
316.50	24.59	61480.10	61727.60	1.00	2286.21	19371.26

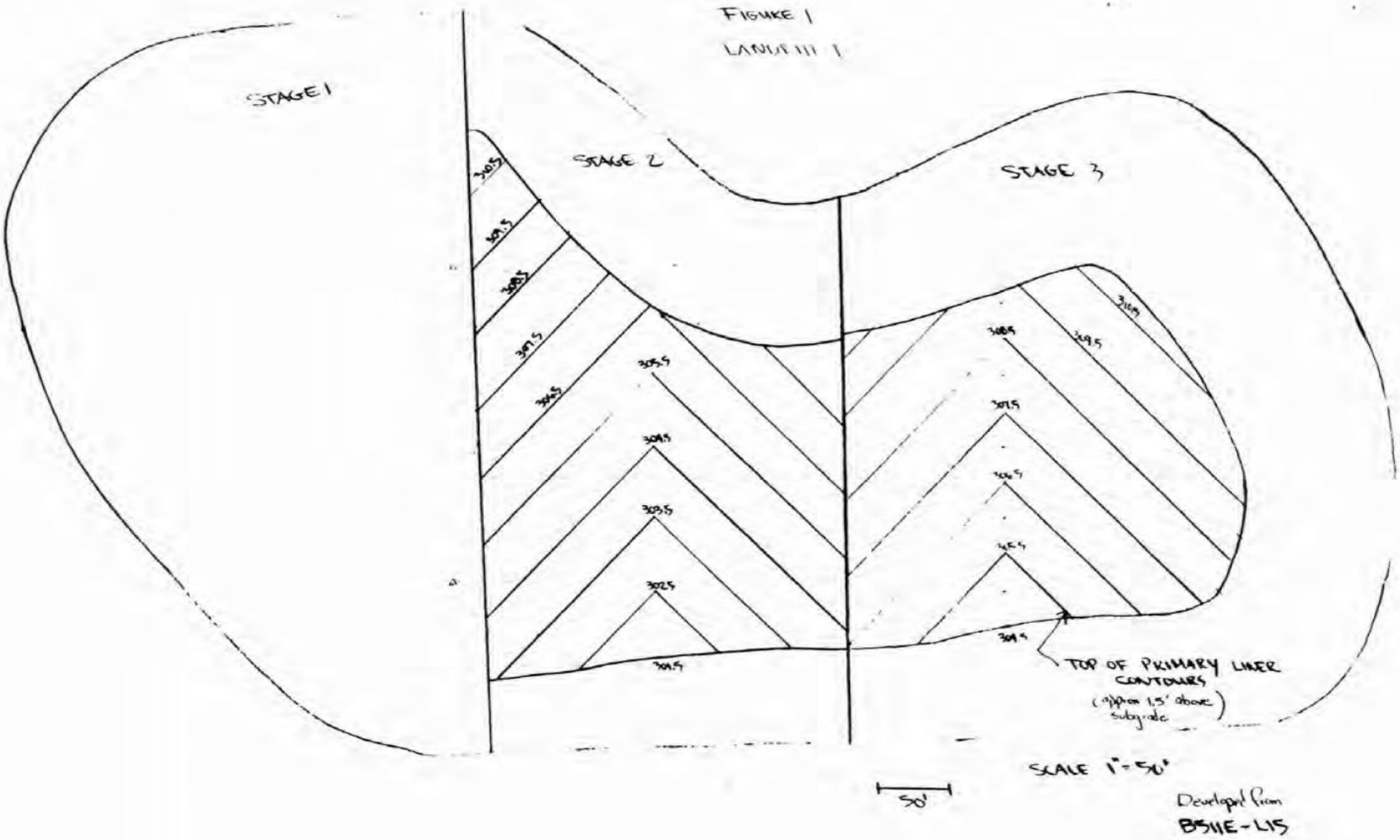
with 2' freeboard:

Min. berm height = El 315.5

Dwg. #2

FIGURE 1

LANDFILL 1



SCALE 1" = 50'

Developed from
BS11E-L15

BY MMT DATE 10/31/85	FRED C. HART ASSOCIATES, INC.	SHEET 1 OF 5	193 PAGE
CHK'D JL DATE 12/20/85			

SUBJECT Proteco JOB NO. B511 E

Landfill II

Interim Berm Design - Temporary Stormwater Basin

Stage 1 Landfill Development:

Determine volume of water to be contained in Stage 2 area. Consider runoff from developed portion of landfill and direct rainfall into temporary stormwater basin (for 25yr 24hr storm).

Runoff from Stage 1:

Vol. Runoff = (Area Stage 1)(9.40" runoff)*

$= (103083.5\ ft^2)(9.4\ in)(\frac{1\ ft}{12\ in})$

$= 80749\ ft^3$

Direct rainfall into basin:

Vol. rainfall = (Area Stage 2)(10.5" rainfall)*

$= (103934.9\ ft^2)(10.5\ in)(\frac{1\ ft}{12\ in})$

$= 90943\ ft^3$

Total Storage Volume Required:

Vol. Req'd = Runoff + Rainfall

$= 80749\ ft^3 + 90943\ ft^3$

$= 171692\ ft^3$

$= 6359\ yd^3$

* See B511E-L17

BY MMT DATE 10/31/85
CHK'D JL DATE 12/20/85

FRED C. HART ASSOCIATES, INC.

SHEET 2 OF 5 — 194 PAGE

SUBJECT PROTECO Landfill II — JOB NO. B511E

Determine storage volume available in Stage 2. Planimeter "top of primary liner" contours shown on Figure 2

Total Storage Available:

FRED C. HART ASSOCIATES, INC.
PLANIMETERING PROGRAM VERSION 1.0
PAGE NO: 1
TITLE: PROTECO
PHASE II LANDFILL
INTERIM BERM DESIGN - TEMPORARY STORMWATER BASIN

JOB NO: B511
RUN BY: MMT
DATE:10-31-1985

SCALE= 1INCH: 100 FT
AVERAGE AREA IS CALCULATED BY (A+B)/2

ELEV	DIGITIZER READING (SQ.IN.)	AREA (SQ.FT.)	AVERAGE AREA (SQ.FT.)	DELTA ELEV	VOLUME (CU.YDS)	CUMULATIVE VOLUME (CU.YDS)
288.00	0.00	0.0				
289.00	0.23	2252.96	1126.48	1.00	41.72	41.72
290.00	0.90	9037.93	5645.45	1.00	209.09	250.81
291.00	1.86	18559.11	13798.52	1.00	511.06	761.87
292.00	2.98	29750.37	24154.74	1.00	894.62	1656.49
293.00	3.64	36379.40	33064.88	1.00	1224.63	2881.11
294.00	3.92	39194.64	37787.02	1.00	1399.52	4280.63
295.00	3.87	38655.40	38925.02	1.00	1441.67	5722.30
296.00	3.95	39516.60	39086.00	1.00	1447.63	7169.93
297.00	3.89	38941.65	39229.13	1.00	1452.93	8622.86

With 2' freeboard:

Min. Berm Height = El 298.0

Stage 2 Landfill Development:

Determine volume of water to be contained in Stage 3 area. Consider runoff from developed portion of landfill (Stages 1 & 2) and direct rainfall into temporary stormwater basin (for 25 yr 24 hr storm)

Runoff from Stages 1 & 2:

Vol. Runoff = (Area Stage 1 + Area Stage 2)(9.40" runoff)

$= (103083.5\ ft^2 + 103934.9\ ft^2)(9.4\ in)\left(\frac{1\ ft}{12\ in}\right)$

$= 162164\ ft^3$

Direct rainfall into basin:

Vol. Rainfall = (Area Stage 3)(10.5" rainfall)

$= (120900.0\ ft^2)(10.5\ in)\left(\frac{1\ ft}{12\ in}\right)$

$= 105788\ ft^3$

Total Storage Volume Required:

Vol. req'd = Runoff + Rainfall

$= 162164\ ft^3 + 105788\ ft^3$

$= 267952\ ft^3$

$= \underline{\underline{9924\ yd^3}}$

BY MMT DATE 10/31/85
CHK'D JR DATE 12/20/86

FRED C. HART ASSOCIATES, INC.

SHEET 4 OF 5 PAGE 196

SUBJECT PROTECO Landfill II JOB NO. B511E

Determine storage volume available in Stage 3. Planimeter "top of primary liner" contours shown on Figure 2

Total Storage Available:

FRED C. HART ASSOCIATES, INC.
PLANIMETERING PROGRAM VERSION 1.0
PAGE NO: 1
TITLE: PROTECO
PHASE II LANDFILL
INTERIM BERM DESIGN - TEMPORARY STORMWATER BASIN

JOB NO: B511
RUN BY: MMT
DATE: 11-02-1985

SCALE= 1INCH: 100 FT
AVERAGE AREA IS CALCULATED BY (A+B)/2

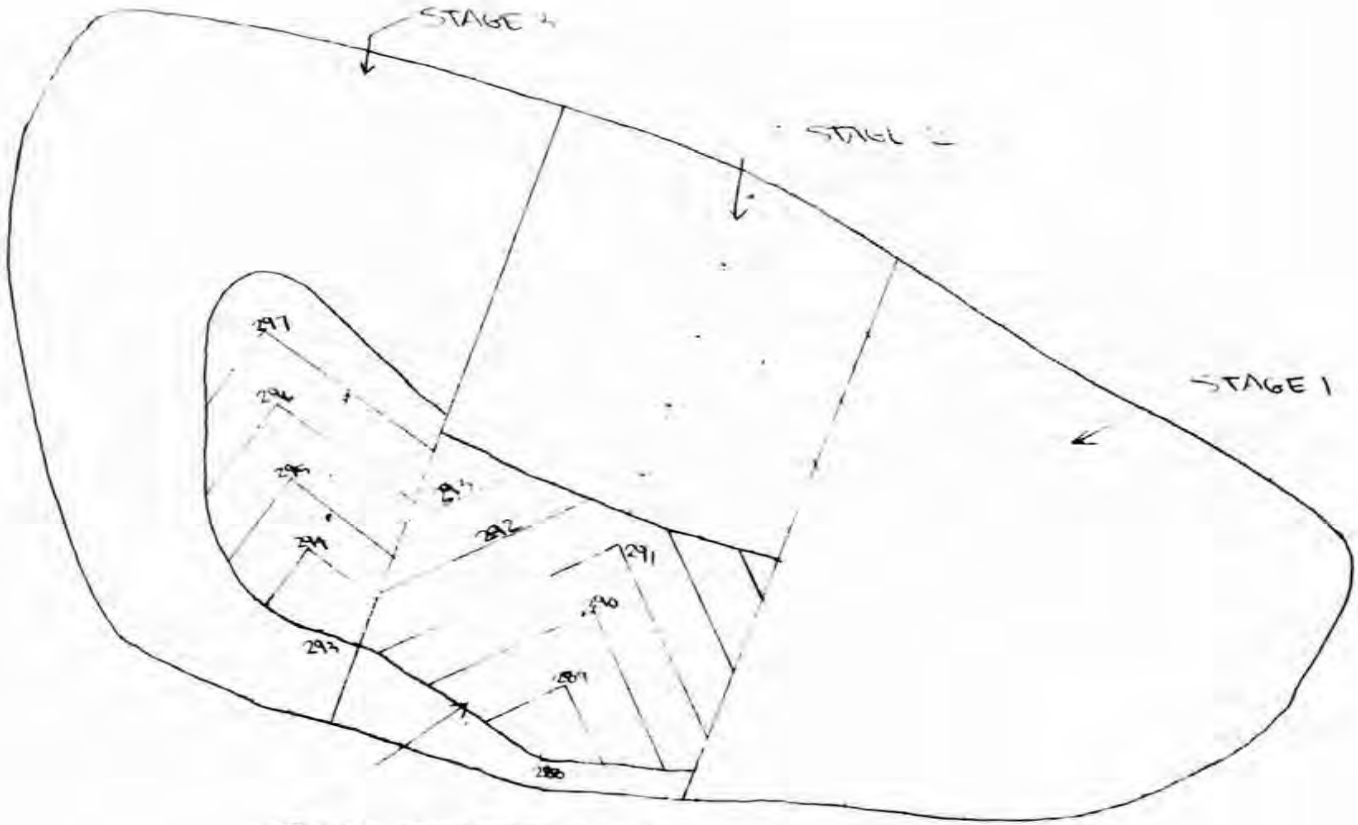
ELEV	DIGITIZER READING (SQ.IN.)	AREA (SQ.FT.)	AVERAGE AREA (SQ.FT.)	DELTA ELEV	VOLUME (CU.YDS)	CUMULATIVE VOLUME (CU.YDS)
293.00	0.00	0.0				
294.00	0.27	2683.95	1341.97	1.00	49.70	49.70
295.00	0.70	6989.21	4836.58	1.00	179.13	228.84
296.00	1.36	13629.46	10309.34	1.00	381.83	610.66
297.00	2.04	20392.61	17011.04	1.00	630.04	1240.70
298.00	2.74	27356.87	23874.74	1.00	884.25	2124.95
299.00	2.75	27483.22	27420.05	1.00	1015.56	3140.51
300.00	2.72	27244.57	27363.90	1.00	1013.48	4153.99
301.00	2.68	26750.95	26997.76	1.00	999.92	5153.90
302.00	2.81	28108.83	27429.89	1.00	1015.92	6169.82
303.00	2.76	27564.70	27836.77	1.00	1030.99	7200.82
304.00	2.74	27448.58	27506.64	1.00	1018.76	8219.58
305.00	2.73	27280.12	27364.35	1.00	1013.49	9233.07
306.00	2.73	27300.96	27290.54	1.00	1010.76	10243.84

with 2' freeboard:

Min. Berm Height = EL. 308.0

Figure 2

LANDFILL II



TOP OF PRIMARY LINER CONTOURS

(approx 1.5' above subgrade)

100'

Developed from B511E-L15

X. Total Runoff Volume

SUBJECT Proteco
Total Runoff Volume Calculation
Landfill I & II
JOB NO. B511

Calculate Total Runoff Volume from Landfills I & II:

Total area Landfill I = 393445 ft^2 (from Interim Berm Design Calcs, Section IX)

Total area Landfill II = 327918 ft^2 (from Interim Berm Design Calcs. Section IX)

Total area Landfills I & II = 721363 ft^2
= 16.6 acres

Total rainfall amount for 25yr, 24 hr storm = 10.5"

Obtain runoff depth, in inches, from Table 2.1 (from TR 55 Manual) with CN = 91 (see Peak Flow Analysis, Section I)

Runoff depth = 9.4"

∴ Total Runoff Volume = $(16.6 \text{ acres})(9.4 \text{ in})\left(\frac{1 \text{ ft}}{12 \text{ in}}\right)$
= 13.0 acre-ft

XI Sediment Disposal Areas

BY mmt DATE 2/7/86	FRED C. HART ASSOCIATES, INC.	SHEET 1 OF 2	201 PAGE
CHK'D ____ DATE ____			

SUBJECT Proteco
Site Hydrology & Hydraulics
Sediment Disposal Areas

JOB NO. 8511

Two sediment disposal areas are shown on Figure 1.

Sediment placed in these areas will be graded so as surface water flow to the permanent stormwater diversion channels will not be impeded. These areas will be properly vegetated and maintained.

BY MMT DATE 2/7/86

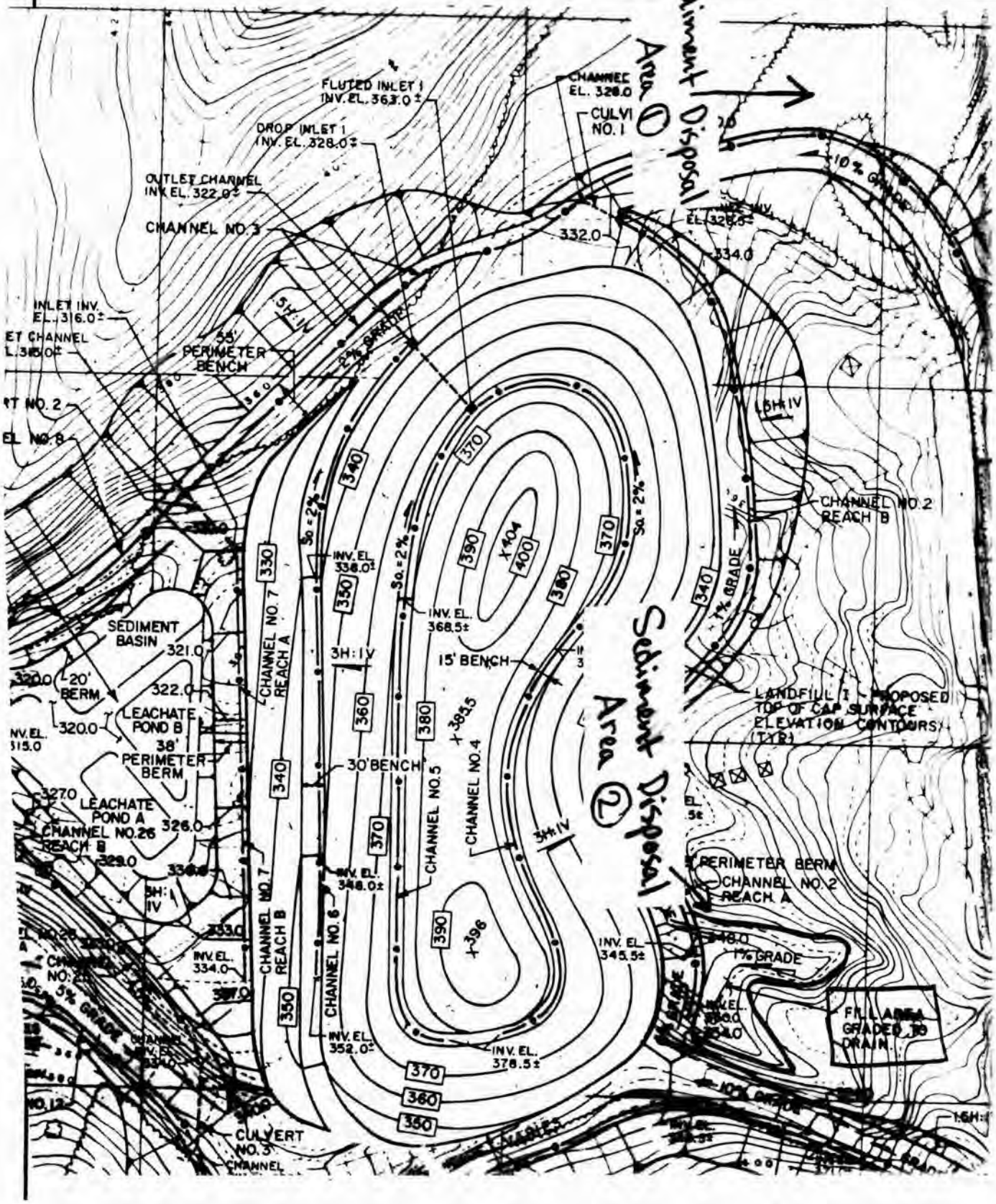
CHK'D _____ DATE _____

FRED C. HART ASSOCIATES, INC.

SHEET 2 OF 2 — PAGE 202

SUBJECT Proteco
Site Hydrology & Hydraulics
Sediment Disposal Areas - FIGURE 1

JOB NO. B511



ITEM XII

PROTECO PART B

REVISION 2

AMMENDMENTS

BY MJV DATE 6-11-86	FRED C. HART ASSOCIATES, INC.	SHEET 1 OF 1	203 PAGE
CHK'D MMT DATE 6/24/86			

SUBJECT PROTECO JOB NO. B511
RIPRAP DESIGN
CHANNEL #18

DESIGN DATA;

b(ft)	d(ft)	b/d	S_o	Q
5	0.3	16.7	0.08	8

FOR TRAPAZOIDAL CHANNELS

$$d_{50} = 12\left(118.0\ Q\ S_b^{13/6}\ R/P\right)^{2/5}$$

DETERMINE R/P

FROM CURVE 2, PAGE 162

WITH $b/d = 16.7$

$z = 3$

$P/R = 27$

$\therefore \frac{R}{P} = 0.037$

$$d_{50} = 12\left(118(8)(0.08)^{13/6}(0.037)\right)^{2/5} = 5.6'' \text{ SAY } 8''$$

Check "n" value:

$n = 0.0395\,(d_{50})^{1/6}$ where d_{50} is in feet

$n = 0.0395\left(\frac{5.6}{12}\right)^{1/6}$

$n = 0.035 = n_{used} = 0.035$ ∴ ok

∴ use $d_{50} = 8''$

$d_{max} = 12''$

$T = 1.5'$

SUBJECT PROTECO JOB NO. B511

DROP INLET GRATING COVER ANALYSIS

CALCULATION OF SIZE ADEQUACY FOR DESIGN STORM PEAK

PROCEDURE: SHOW THE ADEQUACY OF THE HEAVY DUTY GRATING COVERS (DWG. NO. B511E-L30) TO COLLECT THE CHANNEL DESIGN STORM PEAK DISCHARGE. ORIFICE AND WEIR FLOW ANALYSIS WILL BE USED IN THE CALCULATION.

DROP INLET 1 - ORIFICE FLOW

$$Q = CA\sqrt{2gh}$$

REF.; HANDBOOK OF HYDRAULICS, KING AND BRATER, McGRAW-HILL BOOK CO., NEW YORK, 1963, P 4-3.

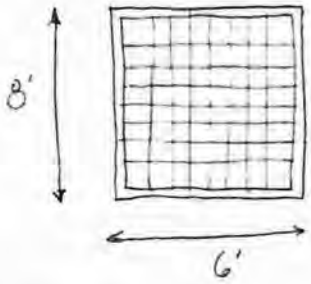
where

C = coeff of discharge = 0.61 from FIG 4-6, p.4-6 for 1" orifice head = 0'

A = x-sec area = 1 in² / OPENING = 0.0069 ft²

g = gravity acceleration (32.2 ft/sec²)

h = head = Design flow depth



ASSUME GRATING HAS 1" SQUARE OPENING WITH 1/4" ϕ STEEL RODS

THEREFORE, ONE OPENING = $1\frac{1}{4}$" SPACING

$\frac{8' \times 12''}{1.25''}$ = 77 SQUARES $\frac{6' \times 12''}{1.25''}$ = 58 SQUARES

77 X 58 = 4466 HOLES IN GRATING

DETERMINE THE FLOW THAT ONE OPENING CAN HANDLE.

$$Q_{MAX} = 0.61(0.0069\ ft^2)\sqrt{2(32.2)(h)}$$

where h = DESIGN FLOW DEPTH FROM CHANNEL 6

h = 0.8'

Q_{MAX} = 0.030 CFS / OPENING

TOTAL Q_{MAX} = 0.030 x 4466 = 133 CFS

(FOR ENTIRE GRATING SURFACE AREA)

SUBJECT PROTECO JOB NO. B511
DROP INLET GRADING COVER ANALYSIS
CALCULATION OF SIZE ADEQUACY FOR DESIGN STORM PEAK

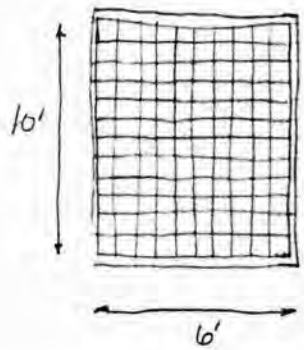
DROP INLET 1- ORIFICE FLOW (cont.)

DESIGN FLOW FROM CHANNEL 6 = 28 CFS

THEREFORE; $\frac{28}{133} = 0.21$

1 - 0.21 = 79% OF THE GRATING CAN BE CLOGGED WITH DEBRIS AND STILL FACILITATE A FLOW OF 28 CFS. 2

DROP INLET 2- ORIFICE FLOW



$\frac{10' \times 12''}{1.25''}$ = 96 SQUARES

$\frac{6' \times 12''}{1.25''}$ = 58 SQUARES

96 x 58 = 5568

DESIGN h FOR CHANNEL #17 & #18 = 0.30'

$Q_{MAX} = 0.61\ (0.0069\ ft^2)\ \sqrt{2(32.2)\ 0.30}$

= 0.018 CFS / OPENING

= 0.018 x 5568 OPENINGS = 100 CFS (ENTIRE GRATING)

DESIGN FLOW FOR CHANNEL 17 + 18
= 7 CFS + 8 CFS = 15 CFS

THEREFOR; $\frac{15}{100} = 0.15$

SUBJECT PROTECO JOB NO. B511
DROP INLET GRADING COVER ANALYSIS
CALCULATION OF SIZE ADEQUACY FOR DESIGN STORM PEAK

DROP INLET 2 - ORIFICE FLOW (cont.)

$1 - 0.15 =$ 85 % OF THE GRATING CAN BE CLOGGED WITH DEBRIS AND STILL FACILITATE A FLOW OF 15CFS

WEIR FLOW ANALYSIS - DROP INLET 1

$Q = CLh^{3/2}$ p5-23 HANDBOOK OF HYRAULICS

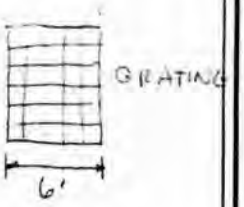
where

C= coeff of vel. for rectangular sharp-crested weir

$\simeq 3.47$ when $h = 0.8'$ & $H_d = 2'$

REF; WATER RESOURCES ENGINEERING, LINSLEY AND FRANZINI, McGRAW-HILL INC., 1979, p262.

L= Length of Weir Opening = 6'



h= head = design flow depth

$Q = 3.47\ (28)\ 0.8^{3/2} = 70$ CFS > 28CFS

OK

WEIR FLOW ANALYSIS - DROP INLET 2

C= 3.45 when $h = 0.3$ & $H_d = 1.5$

$Q = 3.45\ (\ )\ 0.30^{3/2} = 16$ CFS > 15CFS

OK

BY MJV DATE 6/16/86	FRED C. HART ASSOCIATES, INC.	SHEET 1 OF 4	207 PAGE
CHK'D MMT DATE 6/29/86			

SUBJECT PROTECO JOB NO.

DETERMINATION OF ADEQUACY OF 3-FOOT-HIGH TEMPORARY DIVERSION DIKE (DWG. BS11E-L11 AND L17)

SHOW THAT THE 3-FOOT-HIGH LANDFILL TEMPORARY DIVERSION DIKES ARE ADEQUATE TO CONTROL PEAK DISCHARGE FROM THE 25-YEAR 24-HOUR STORM EVENT:

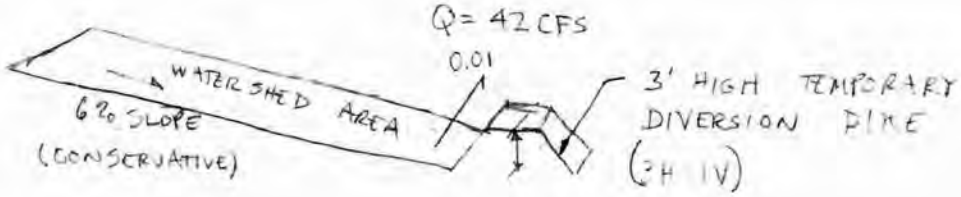
RAINFALL FREQUENCY = 10.5"

(PAGE 5, APPENDIX D-6.4)

LANDFILL #1 {DIVERSION DIKE}

ACCORDING TO TR 55 ANALYSIS (PAGE 53) THE PEAK q FOR THIS AREA IS 42 CFS

THE FOLLOWING SECTION OF WATERSHED AREA XXVII CAN BE DRAWN; 2



ASSUME THE WATERSHED AREA AND 3' DIVERSION IS A CHANNEL

THE CHANNEL PROGRAM CAN BE USED TO DETERMINE THE DESIGN DEPTH **WHERE**: Q = 42 CFS

S = 0.01 (conservative - deepest cond.)

H_1 = 15 (5 or 6% slope)

H_2 = 3

n = 0.03 (grass)

LANDFILL # 2

ACCORDING TO TR 55 ANALYSIS (PAGE 60) THE PEAK DISCHARGE q IS 50 CFS

THE CHANNEL PROGRAM CAN BE USED TO DETERMINE THE DESIGN DEPTH. **WHERE**: Q = 50 CFS

S = 0.01

H_1 = 8

H_2 = 3

n = 0.03

DESCRIPTION: PROTECO
3' DIVERSION DIKE - L.F. 1
DESIGN DEPTH DETERMINATION

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                       Right*
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 42
MANNING'S N VALUE..... .03
SLOPE IN FT/FT..... .01
BASE WIDTH IN FEET..... 0
LEFT SLOPE H VALUE..... 15
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 3.455515
COMPUTED DEPTH IN FEET..... 1.162109
FREE BOARD IN FEET..... 1.090824
COMPUTED DEPTH + FREE BOARD..... 2.252934
FROUDE NUMBER..... .7988704

DESIGN CHANNEL DEPTH IN FEET.....= _____

2

? FRED C. HART ASSOCIATES.Inc
Penn Center West -II Suite 106
Pittsburgh, PA. 15276

JOB NO.B511
BY:MMT
DATE:6-24-86
PAGE NO 209
SHEET 3/4

DESCRIPTION:PROTECO
3' DIVERSION DIKE - L.F. 2
DESUGN DEPTH DETERMINATION

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*Left                                        Right*
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 50
MANNING'S N VALUE..... .03
SLOPE IN FT/FT..... .01
BASE WIDTH IN FEET..... 0
LEFT SLOPE H VALUE..... 8
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 4.019442
COMPUTED DEPTH IN FEET..... 1.503906
FREE BOARD IN FEET..... 1.115128
COMPUTED DEPTH + FREE BOARD..... 2.619034
FROUDE NUMBER..... .8168503

DESIGN CHANNEL DEPTH IN FEET.....= _____

2

BY MMT DATE 6/29/86
CHK'D _____ DATE _____

FRED C. HART ASSOCIATES, INC.

SHEET 4 OF 4 PAGE 310

SUBJECT PROTECO JOB NO. _____
DETERMINATION OF ADEQUACY OF 3-FOOT-HIGH
TEMPORARY DIVERSION DIKE (DWG BSHE-L11 AND L17)

FROM THE CHANNEL PROGRAM, THE DESIGN DEPTH FOR LANDFILL I = 2.3'
LANDFILL II = 2.6'

IN EACH CASE THE DESIGN DEPTH, WHICH INCLUDES FREEBOARD, IS LESS THAN 3'

∴ THE 3' HIGH DIVERSION DIKES ARE ADEQUATE

2

SUBJECT PROTECO JOB NO. B511
STORMWATER COLLECTION AND PUMPING
RUN-ON BETWEEN INTERIM BERM & DIVERSION DIKE

DESIGN COLLECTION AND PUMPING SYSTEM TO BE INSTALLED TO REMOVE RUN-ON COLLECTED BETWEEN THE INTERIM BERM AND LANDFILL TEMPORARY DIVERSION DIKES:

2

LANDFILL I:

DETERMINE RUN-ON VOLUME: (Area by planimetry)

VOL. RUN-ON = (Area)(10.5" rainfall for 25yr 24 hr storm)

$= (34{,}000\ ft^2)(10.5\ in)\left(\frac{1\ ft}{12\ in}\right)$

$= 29750\ ft^3$

$= 1100\ YD^3$

$1100\ YD^3 / 24\ HR$ PUMPING PERIOD $= 46\ YD^3/HR$

$= 9270\ GAL/HR$

$= 155\ GAL/MIN$

SINCE THE REQUIRED PUMPING DISCHARGE RATE IS LESS THAN THE RATE OF DISCHARGE TO BE PUMPED FROM THE TEMPORARY STORMWATER RETENTION CELL, LANDFILL I, STAGE 2 THE PUMP CAPACITY CALCULATIONS DONE FOR THE TEMPORARY STORMWATER RETENTION CELL MAY BE USED CONSERVATIVELY.

BASED ON CALCULATIONS FOR SECTION D-6h (3), PAGE C:

ONE (1) - SIZE 4" x 4" 40 CCGW CONTINUOUS PUMP, 2000 RPM IS SUFFICIENT

SUBJECT PROTECO JOB NO. B54
STORMWATER COLLECTION AND PUMPING
RUN-ON BETWEEN INTERIM BERM & DIVERSION DIKE

LANDFILL II:

DETERMINE RUN-ON VOLUME: (Area by planimetry)

VOL. RUN-ON = $(37000\ ft^2)(10.5\ in)\left(\frac{1\ ft}{12\ in}\right)$

$= 32375\ ft^3$

$= 1200\ YD^3$

$1200\ YD^3 / 24$ HR PUMPING PERIOD $= 50\ YD^3/HR$

$= 10092$ GAL/HR

$= 168$ GAL/MIN

2

AS BEFORE, BASED ON CALCULATIONS FOR SECTION D-6h(3), PAGE ( ):

ONE (1) - SIZE 4" x 4" 40 CCGW CONTINUOUS PUMP, 2000 RPM IS SUFFICIENT

THEREFORE, ONE OF THE PUMPS USED FOR THE REMOVAL OF WATER FROM THE TEMPORARY STORMWATER RETENTION CELLS WILL BE USED TO REMOVE RUN-ON BETWEEN THE INTERIM BERM & DIVERSION DIKE.

BY MHV DATE 6-17-86 CHK'D ____ DATE ____	FRED C. HART ASSOCIATES, INC.	SHEET 1 OF 3	213 PAGE

SUBJECT PROTECO JOB NO. B511

DESIGN STORM PEAK DISCHARGE CALCULATION

TEMPORARY STORMWATER DIVERSION CHANNELS

THE FOLLOWING IS THE DESIGN STORM DISCHARGE CALCULATION AND CHANNEL DESIGN FOR THE TEMPORARY STORMWATER DIVERSION CHANNELS. WORST CASE CONDITIONS WERE USED IN DESIGN.

FOR TR 55 ANALYSIS FOR PEAK DISCHARGE:

AREA = 250,000 FT^2
= 0.0089 MI^2 } area of Landfill I, top of refuse surface elevation contours, Stage 2, Dwg. No. B511E-L12 2

RAINFALL = 10.5" (25 yr, 24 hr storm)

CURVE NO. = 83 (

TIME OF CONCENTRATION = 0.1 hr

TIME OF TRAVEL = 0

FOR CHANNEL DESIGN:

Q = 75 cfs from TR 55 analysis

n = 0.03

H_1 = 3
H_2 = 3 } assumed

B = 0

S = 0.01 conservative, gives deepest channel

?E FRED C. HART ASSOCIATES, Inc.
Penn Center West II, Suite 106
Pittsburgh, PA. 15276

JOB NO. B511
BY: MMT
DATE:
PAGE NO 214
CKd By. MIY

DESCRIPTION: PROTECO
TEMPORARY STORMWATER DIVERSION CHANNEL

WATERSHED AREA NUMBER..... TEMPORARY STORMWATER DIVERSION
DRAINAGE AREA, SQ. MILES..... 8.999999E-03
CURVE NUMBER..... 83
PRECIPITATION, INCHES..... 10.5
DIRECT RUNOFF, INCHES..... 8.38777
TIME OF CONCENTRATION, HRS..... .1
TIME OF TRAVEL, HRS..... 0

TIME FRAME	TIME, HRS.	q, CSM/IN	q, CFS
1	11.0	24	2
2	11.5	51	4
3	11.7	299	23
4	11.8	991	75
5	11.9	746	56
6	12.0	477	36
7	12.1	233	18
8	12.2	152	11
9	12.3	132	10
10	12.4	121	9
11	12.5	111	8
12	12.6	85	6
13	12.7	74	6
14	12.8	70	5
15	12.9	68	5
16	13.0	65	5
17	13.2	52	4
18	13.5	48	4
19	14.0	39	3
20	14.5	33	2
21	15.0	29	2
22	16.0	24	2
23	18.0	18	1
24	20.0	14	1

2

FRED C. HART ASSOCIATES.Inc
Penn Center West -II Suite 106
Pittsburgh, PA. 15276

JOB NO.B511
BY:MMT
DATE:1-10-86
PAGE NO 215
Chd By: MJV

DESCRIPTION:TEMPORARY STORMWATER DIVERSION CHANNEL

MANNING'S EQUATION IS USED IN THIS ANALYSIS

SKETCH OF THE CHANNEL SECTION

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*                                                *
*                                                *
*Left                                       Right*
**************************************************
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INPUT DATA FOR THIS ANALYSIS:

FLOW IN CFS..... 75
MANNING'S N VALUE..... .03
SLOPE IN FT/FT..... .01
BASE WIDTH IN FEET..... 0
LEFT SLOPE H VALUE..... 3
RIGHT SLOPE H VALUE..... 3

FREE BOARD= 1+0.025 * V * Y^.333

SOLUTION FOR THIS ANALYSIS:

VELOCITY IN FT/SEC..... 5.13243
COMPUTED DEPTH IN FEET..... 2.207031
FREE BOARD IN FEET..... 1.167058
COMPUTED DEPTH + FREE BOARD..... 3.374089
FROUDE NUMBER..... .8610056

DESIGN CHANNEL DEPTH IN FEET.....= _____

2

BY MJV DATE 6-16-86
CHK'D DATE

FRED C. HART ASSOCIATES, INC.

SUBJECT PROTECO
STORMWATER COLLECTION AND PUMPING SYSTEM DESIGN

SHEET 1 OF 4 — 216 PAGE

JOB NO.

SUMMARY:

- DESIGN PUMPING SYSTEM USING 25 YR, 24 HR STORM
- DESIGN PUMPING SYSTEM FOR LANDFILL 1 & 2
- RUNOFF (STORMWATER) FROM STAGES 1 & 2 THAT FLOW INTO STAGE 3 IS THE WORSE CASE CONDITION, AND THE SYSTEM WILL BE DESIGNED ACCORDING TO THESE CONDITIONS. (PLUS DIRECT RAINFALL)
- ASSUME A 24 HOUR PUMPING PERIOD

PROCEDURE:

LANDFILL #1

FROM PAGE 190 OF APPENDIX D-6.4, THE TOTAL RUNOFF + DIRECT RAINFALL = 11927 YD^3

11927 YD^3 / 24 HR PUMPING PERIOD = 497 YD^3/HR

= 100394 GAL/HR

= 1673 GAL/MIN

= 3.72 CFS

2

DETERMINATION OF ENERGY HEAD FROM THE PLANT (h_p)

$$h_p = h_L + h_{L_m} + Z_B + \frac{V^2}{2g}$$

where:

h_{Lm} = Minor losses

h_L = friction loss

Z_B = distance to 1 ft water (vertical)

$\frac{V^2}{2g}$ = velocity head.

REF: WATER RESOURCES ENGINEERING RAY LINSLEY & JOSEPH FRANZINI McGRAW HILL BOOK COMPANY, 1979, PAGE 283.

$$h_L = f \frac{L}{D} \frac{V^2}{2g}$$

where L and D = Length & Diameter of Pipe

f = friction f.

PROCEDURE (cont.)

L (CONSERVATIVE) = 400'

D = Assume 4" = 0.33'

$\frac{V^2}{2g}$ = Q = 3.72 CFS / 3 (ASSUME 3 PUMPS) = 1.24

$V = \frac{Q}{A} = \frac{1.24'}{\pi (0.17)^2} = 13.7$ FPS

$\frac{V^2}{2g} = \frac{(13.7)^2}{2(32.2)} = 2.91$

f = FOR $2\frac{1}{2}$" ϕ UNLINED CANVAS FIRE HOSE @ 15 FPS = 0.035

REF: HANDBOOK OF HYDRAULICS, KING AND BRATER McGRAW-HILL BOOK COMPANY, 1963, PAGE 6-27.

$h_L = 0.035 \frac{400'}{0.333'} 2.91 = 122'$

$Z_B = 321 - 340 = -19$

DETERMINATION OF h_p FOR L.F. #1

$h_p = h_L + h_{LM} + Z_B + \frac{V^2}{2g}$

assuming no minor losses,

$h_p = 122 + 0 - 19 + 2.91 = 106$

PUMP

USE THREE (3) - SIZE 4" x 4" 40 CCGW CONTINUOUS PUMPS

2000 RPM

PROCEDURE (cont.)

GIVEN 106' OF HEAD AND A 2000 RPM CONTINUOUS DUTY PUMP, THE RESULTANT PUMPING RATE IS 600 GPM (FROM PERFORMANCE CURVE, NEXT PAGE)

THE REQUIRED PUMPING RATE IS

1673 GAL/MIN ÷ 3 PUMPS = 560 GPM

2

600 GPM > 560 GPM

THEREFORE, THE DESIGN IS ADEQUATE

LANDFILL 2

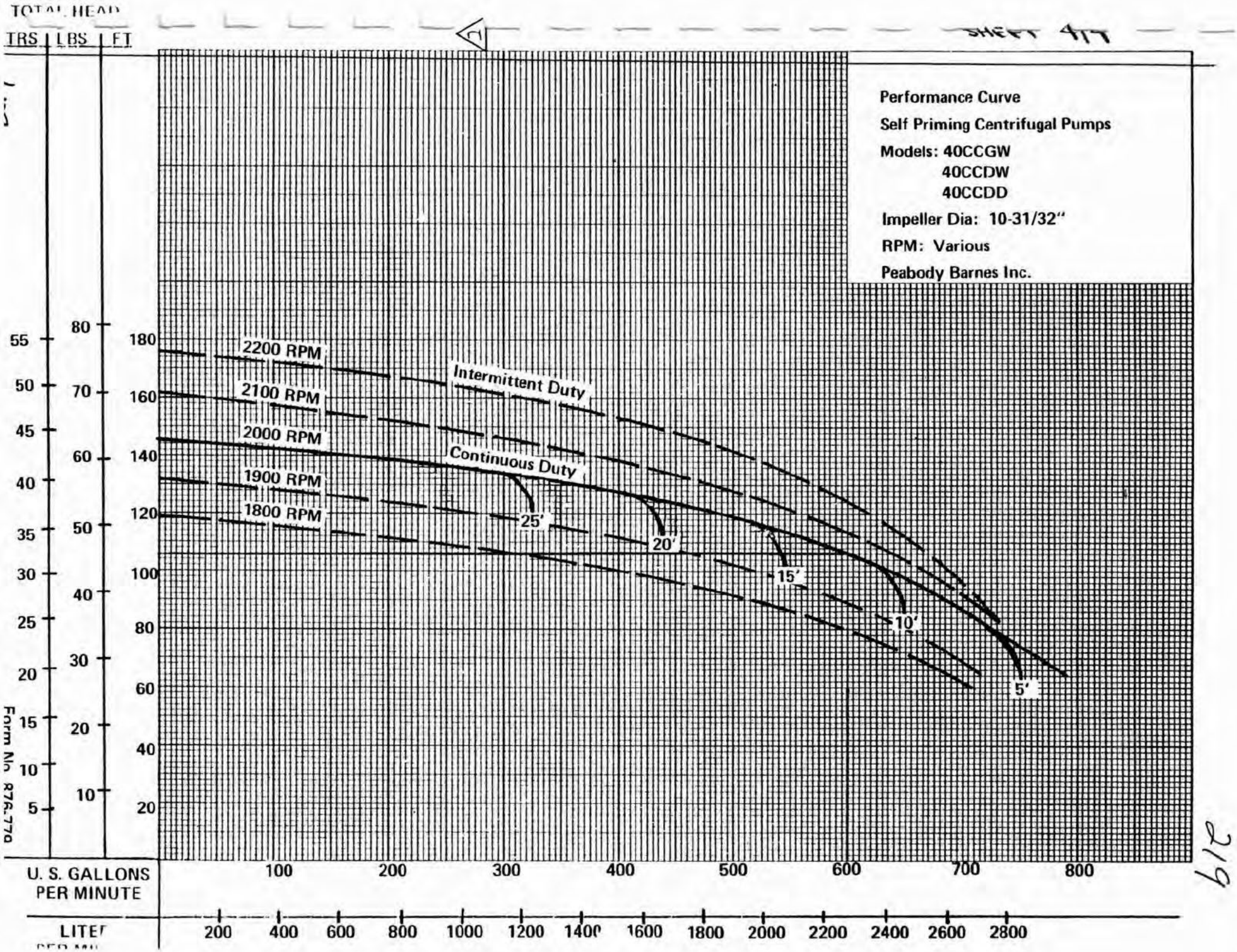
FROM PAGE 195 OF APPENDIX D-6.4 THE TOTAL RUNOFF + DIRECT RAINFALL = 9924 YD³

L & Z_B ARE APPROXIMATELY THE SAME AS LANDFILL 1. BECAUSE THE TOTAL RAINFALL TO BE PUMPED FROM LANDFILL 2 IS LESS THAN LANDFILL 1 THE DESIGN CRITERIA (SHOWN ABOVE FOR LANDFILL 1) IS SUFFICIENT.

9924 YD³/24 HR = 413.5 YD³/HR
= 83527 GAL/HR
= 1392 GAL/MIN

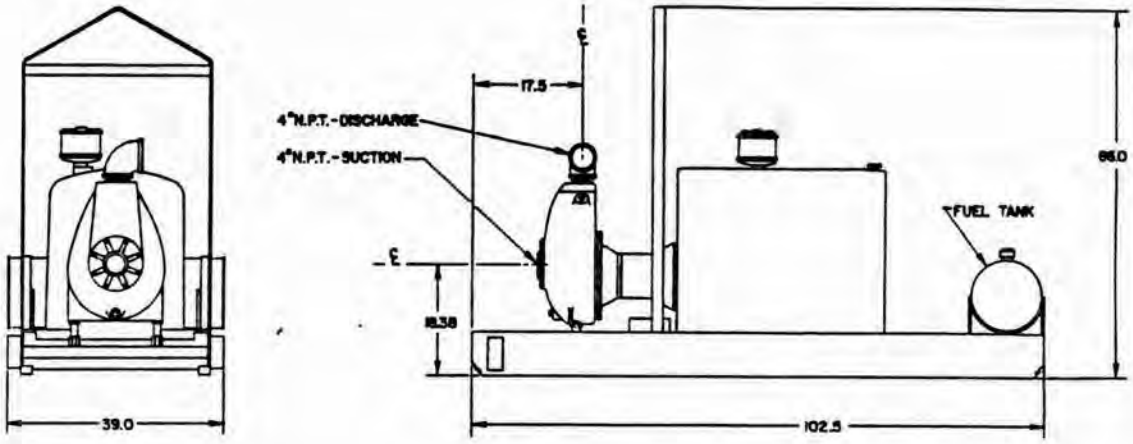
1392 GPM ÷ 3 PUMPS = 464 GPM < 600 GPM ∴ OK

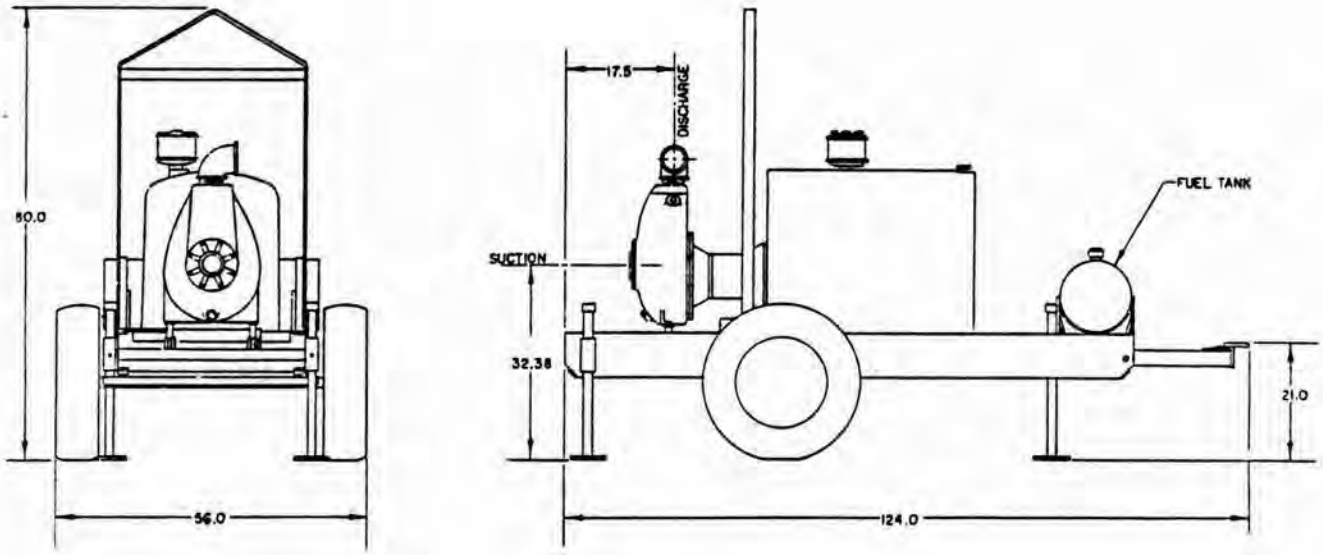
THEREFORE, THREE (3) OF THE PUMPS SPECIFIED ABOVE CAN ADEQUATELY REMOVE THE STORED RAINFALL


TOTAL HEAD
TRS
LBS
FT
Performance Curve
Self Priming Centrifugal Pumps
Models: 40CCGW
40CCDW
40CCDD
Impeller Dia: 10-31/32"
RPM: Various
Peabody Barnes Inc.
2200 RPM
2100 RPM
2000 RPM
1900 RPM
1800 RPM
Intermittent Duty
Continuous Duty
25'
20'
15'
10'
5'
55
50
45
40
35
30
25
20
15
10
5
80
70
60
50
40
30
20
10
180
160
140
120
100
80
60
40
20
U. S. GALLONS PER MINUTE
100
200
300
400
500
600
700
800
LITE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
Form No. 876-770

Self Priming Centrifugal Pumps

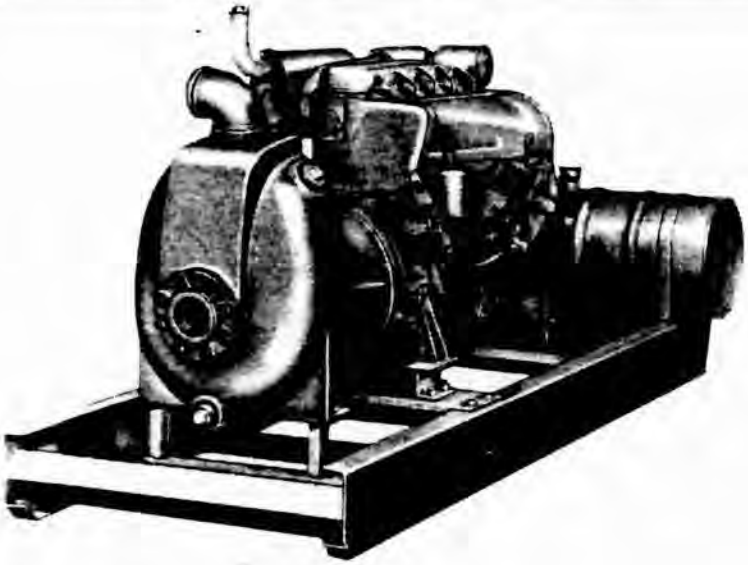
Model: 40CCGW





Self Priming Centrifugal Pumps

Engine Driven

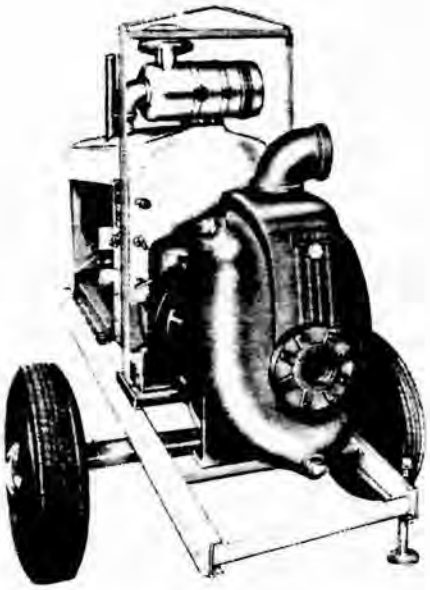


Models
40CCGW
40CCDW
40CCDD

Size 4" X 4"

CERTIFIED PERFORMANCE
CONTRACTORS PUMP BUREAU
cpb

40M



Pump Specifications

Size Suction and Discharge: 4" x 4"
Body Material: Cast Iron, No. 30ASTM
Volute Material: Cast Iron, No. 30ASTM
Wear Plate: Cast Iron, No. 30ASTM and Removable
Impeller: Open Trash Type, Cast Iron, No. 30ASTM
Seal: Double Grease Seal, Mechanical Face Type and Lip Seal
Intermediate Material: Cast Iron, No. 30ASTM
Standard Equipment: Discharge Elbow; Suction Nipple Faced One End; Suction Strainer; Lifting Bail; Suction Flange; Suction Check Valve
Optional Equipment: Hi-Speed Trailer w/7.75 x 15 Pneumatic Tires; Adjustable Support Stands, Front and Rear; Ring Type Towing Hitch (see Price List)
Ordering Information by Model:

40CCGW	On Base, Electric Start
40CCGW-1	On Hi-Speed, Electric Start
40CCDW	On Base, Electric Start
40CCDW-1	On Hi-Speed, Electric Start
40CCDD	On Base, Electric Start
40CCDD-1	On Hi-Speed, Electric Start

BY MMT DATE 6/26/86	FRED C. HART ASSOCIATES, INC.	SHEET 1 OF 11	220 PAGE
CHK'D ____ DATE ____			

SUBJECT Proteco JOB NO. B520

Purpose:

- To provide addition design information for the run-off control system.
- To define the size of the final substage for Stage 3 to provide adequate storage capacity for run-off from uncapped portions of the landfill and direct rainfall into the substage.

SUBJECT Proteco Landfill I Substaging Design JOB NO. B5206

Landfill I:

Stage 3 - Landfill Development:

Determine volume of water to be contained in Stage 3 substage area. Consider run-off from uncapped portion of landfill and direct rainfall into Stage 3 area (See area outlined on Figure 1, sheet 8/11)

Assume no infiltration, all direct runoff/rainfall for most conservative design.

Vol. req'd = (Area)(10.5" Rainfall) where Area is determined by planimetry

$= (201953\ ft^2)(10.5")\left(\frac{1ft}{12in}\right)$

$= 176709\ ft^3$

$= 6545\ yd^3$

Determine volume available in final substage to store run-off/rainfall. By trial and error determined required area of final substage; planimeter "top of protective cover contours in area shown on Figure 2, sheet 9/11

BY MMT DATE 6/26/86 | FRED C. HART ASSOCIATES, INC. | SHEET 3 OF 11 | PAGE 222

CHK'D _____ DATE _____

SUBJECT Proteco JOB NO. B520

Total Storage Available:

SCALE= 1INCH: 50 FT
AVERAGE AREA IS CALCULATED BY (A+B)/2

ELEV	DIGITIZER READING (SQ.IN.)	AREA (SQ.FT.)	AVERAGE AREA (SQ.FT.)	DELTA ELEV	VOLUME (CU.YDS)	CUMULATIVE VOLUME (CU.YDS)
306.50	0.00	0.0				
307.50	1.38	3458.86	1729.43	1.00	64.05	64.05
308.50	4.83	12063.60	7761.23	1.00	287.45	351.51
309.50	8.90	22238.77	17151.18	1.00	635.23	986.74
310.50	11.37	28433.84	25336.31	1.00	938.38	1925.12
311.50	13.56	33889.16	31161.50	1.00	1154.13	3079.25
312.50	13.99	34986.57	34437.87	1.00	1275.48	4354.72
313.50	14.45	36115.11	35550.85	1.00	1316.70	5671.42
314.50	14.36	35893.56	36004.34	1.00	1333.49	7004.91
315.50	15.49	38723.15	37308.35	1.00	1381.79	8386.71

With 1' freeboard below the interim berm crest (el. 315.5), all run-off/rainfall could be safely contained in the area.

As shown of Drawing No. B511E-L33, the run-off/rainfall will be stored in the area between the temporary clay key and the permanent leachate collection manhole. This area is also shown in Sections AA + BB.

BY WMT DATE 6/26/86 | FRED C. HART ASSOCIATES, INC. | SHEET 4 OF 11 | 223 PAGE

CHK'D _____ DATE _____

SUBJECT Proteco JOB NO. 8520

Landfill II:

Vol. req'd = (Area)(10.5" Rainfall)

$= (183213 ft^2)(10.5")\left(\frac{1 ft}{12 in}\right)$

$= 160311 ft^3$

$= 5937 yd^3$

Area is determined by planimetry from Figure 3 sheet 10/11

Total Storage Available:

Area shown on Figure 4 sheet 11/11

SCALE= 1INCH: 50 FT
AVERAGE AREA IS CALCULATED BY (A+B)/2

ELEV	DIGITIZER READING (SQ.IN.)	AREA (SQ.FT.)	AVERAGE AREA (SQ.FT.)	DELTA ELEV	VOLUME (CU.YDS)	CUMULATIVE VOLUME (CU.YDS)
295.00	0.00	0.0				
296.00	0.91	2267.46	1133.73	1.00	41.99	41.99
297.00	2.60	6500.85	4384.16	1.00	162.38	204.37
298.00	4.53	11315.31	8908.08	1.00	329.93	534.30
299.00	5.36	13389.89	12352.60	1.00	457.50	991.80
300.00	5.99	14967.65	14178.77	1.00	525.14	1516.94
305.00	7.71	19265.75	17116.70	5.00	3169.76	4686.70
307.00	8.74	21843.26	20554.50	2.00	1522.56	6209.25

With 1' freeboard below the interim berm crest (el. 308.0), all run-off / rainfall could be safely contained in the area.

DESCRIPTION: PROTECO
SUBSTAGING DESIGN
STORAGE VOLUME REQUIRED

HORIZONTAL SCALE: 1 INCH = 100 **VERTICAL SCALE:** 1 INCH = 100

AREA IDENTIFICATION	AREA, SQ. IN.	AREA, SQ. FT.	AREA, ACRES
LF I	20.20	201953.10	4.64
LF II	18.32	183212.90	4.21

SHEET 6 OF 11 PAGE 225

FRED C. HART ASSOCIATES, INC.

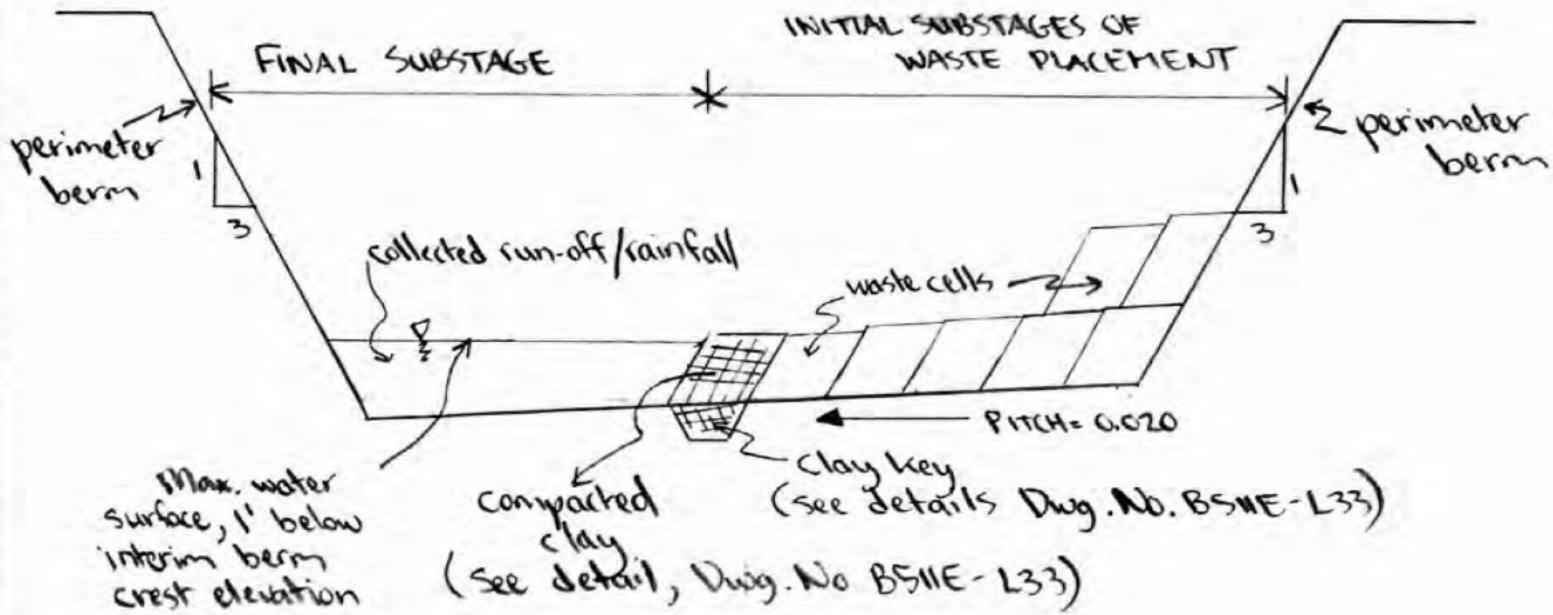
JOB NO. B520

BY MMT DATE 6/26/86

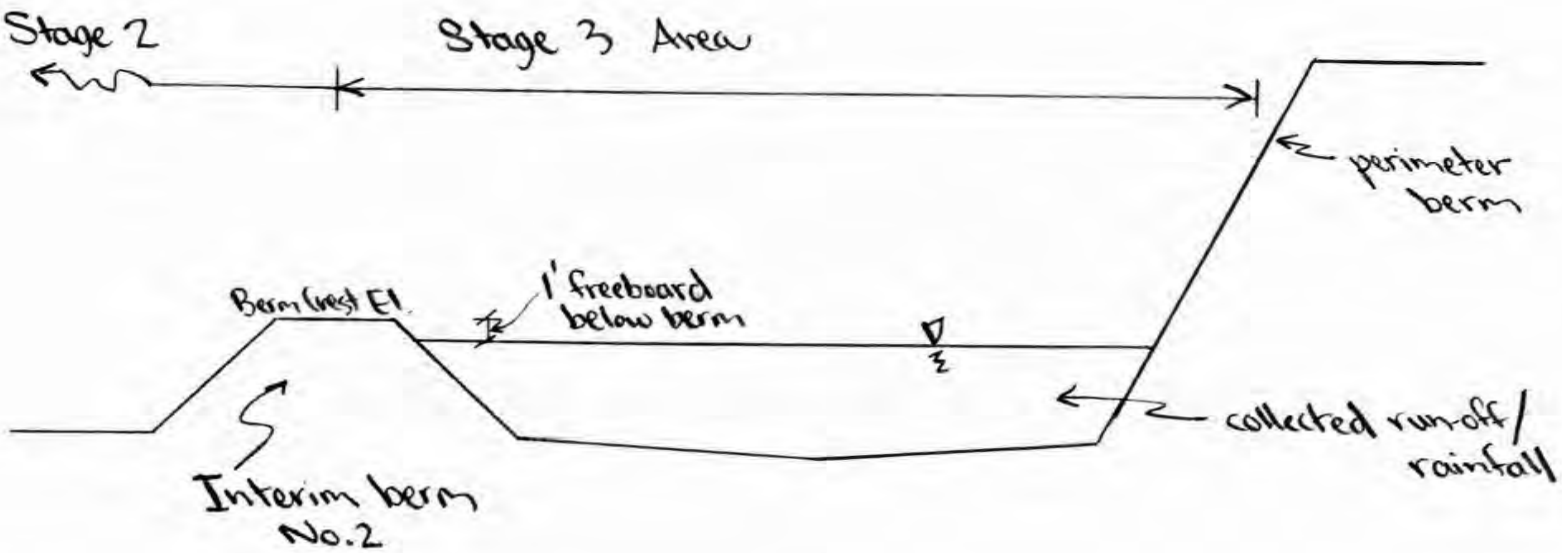
CHK'D DATE

SUBJECT Proteco

SECTION A-A
N.T.S.



SECTION B-B
N.T.S.



FRED C. HART ASSOCIATES, INC.

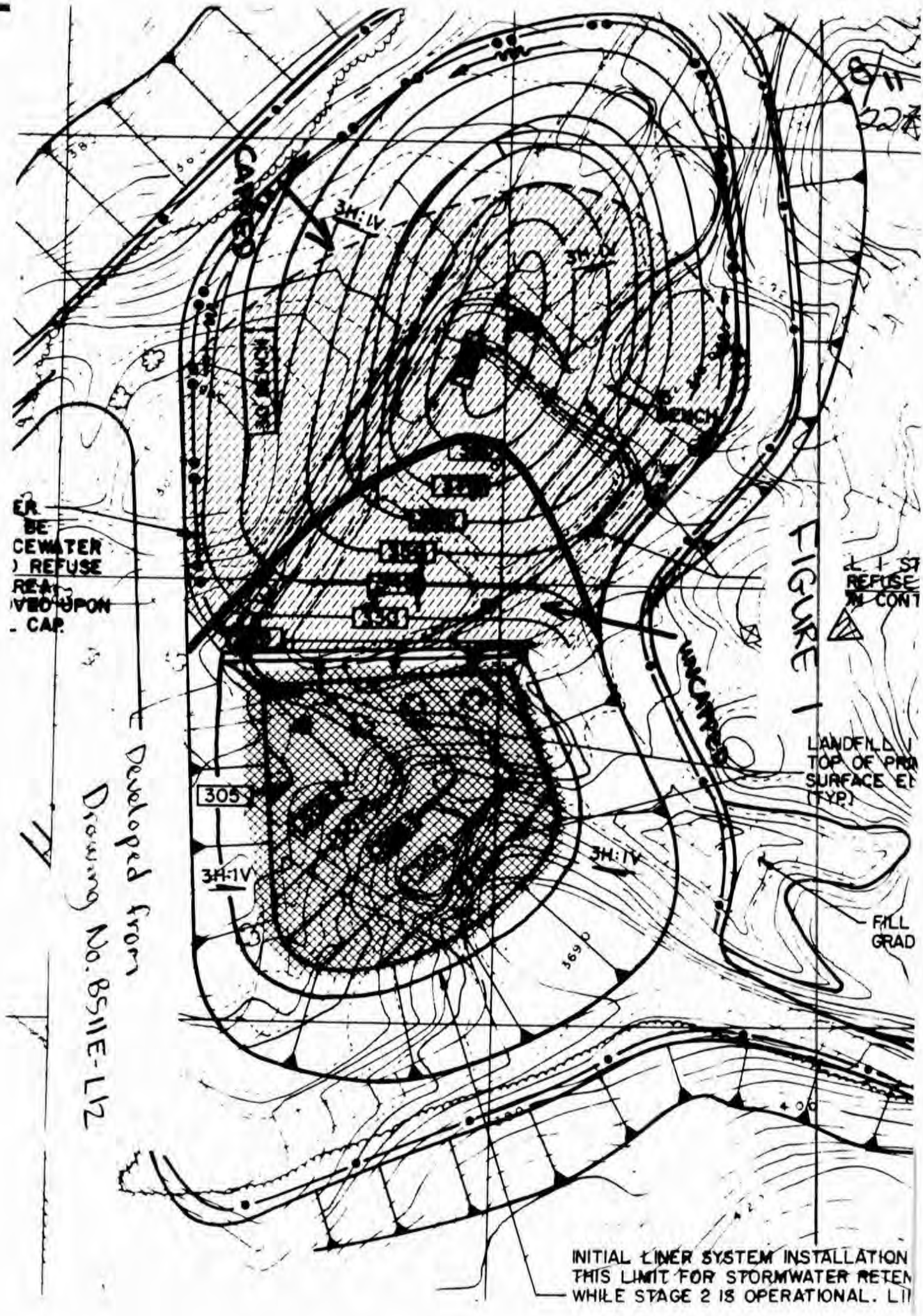
SHEET 7 OF 11 PAGE 226

BY MMT DATE 6/26/86

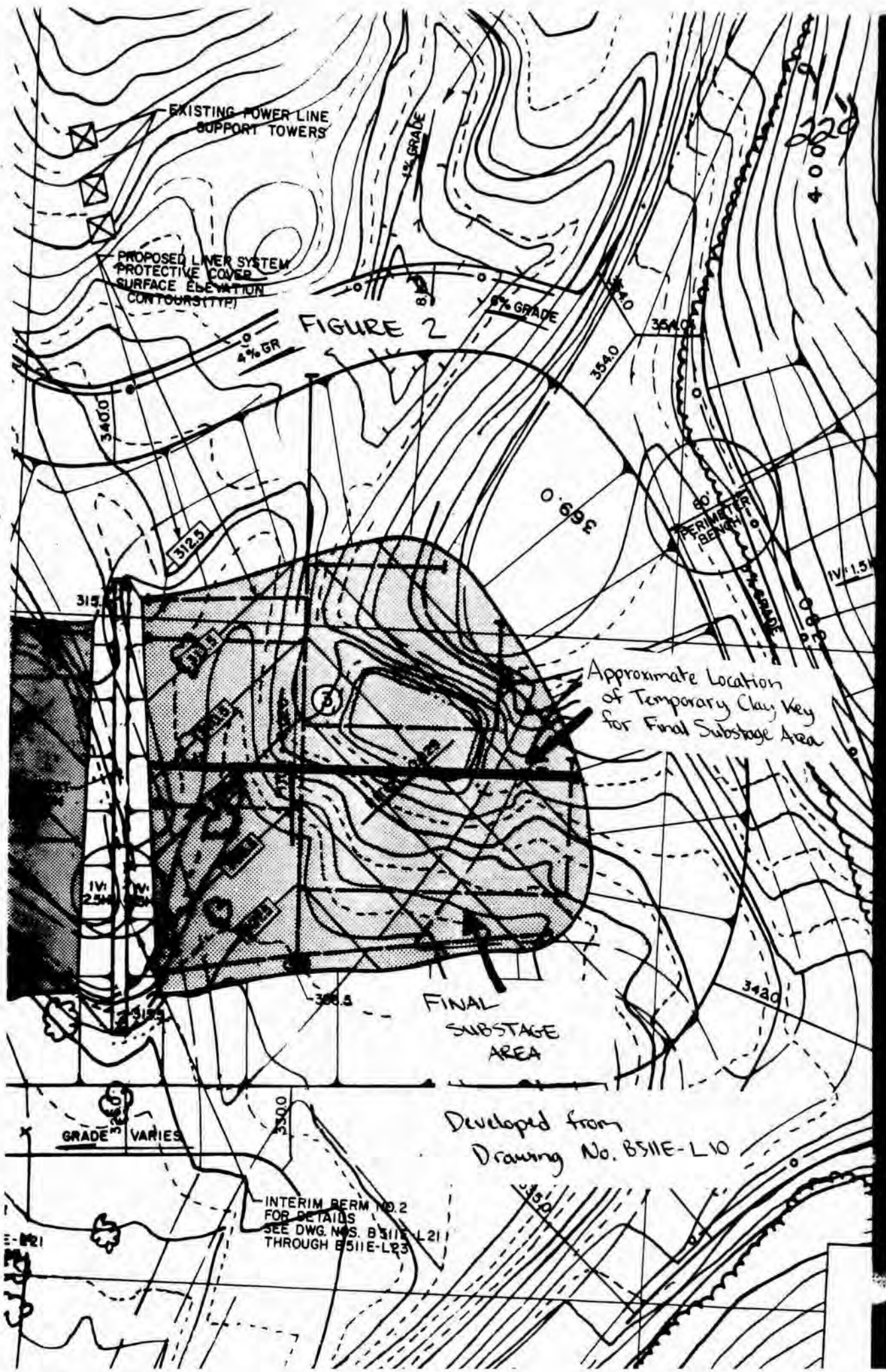
CHK'D DATE

SUBJECT Proteco.

JOB NO. 8520



Developed from Drawing No. B511E-L12


EXISTING POWER LINE SUPPORT TOWERS
PROPOSED LINER SYSTEM PROTECTIVE COVER SURFACE ELEVATION CONTOURS (TYP)
FIGURE 2
4% GR
6% GRADE
1% GRADE
340.0
354.0
312.5
315.
369.0
PERIMETER BENCH
Approximate Location of Temporary Clay Key for Final Substage Area
FINAL SUBSTAGE AREA
342.0
GRADE VARIES
330.0
Developed from Drawing No. B511E-L10
INTERIM BERM NO. 2 FOR DETAILS SEE DWG. NOS. B511E-L21 THROUGH B511E-L23

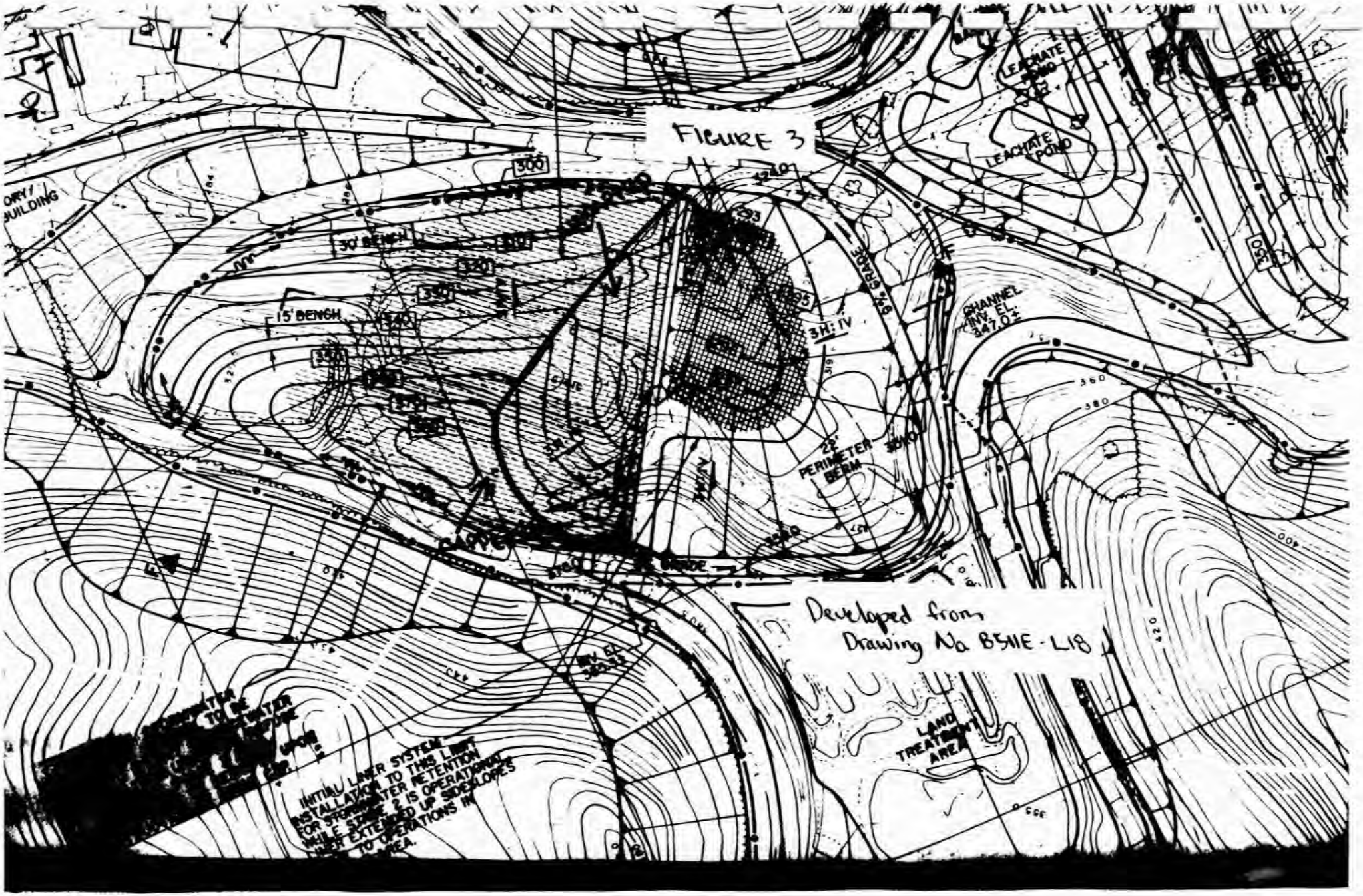
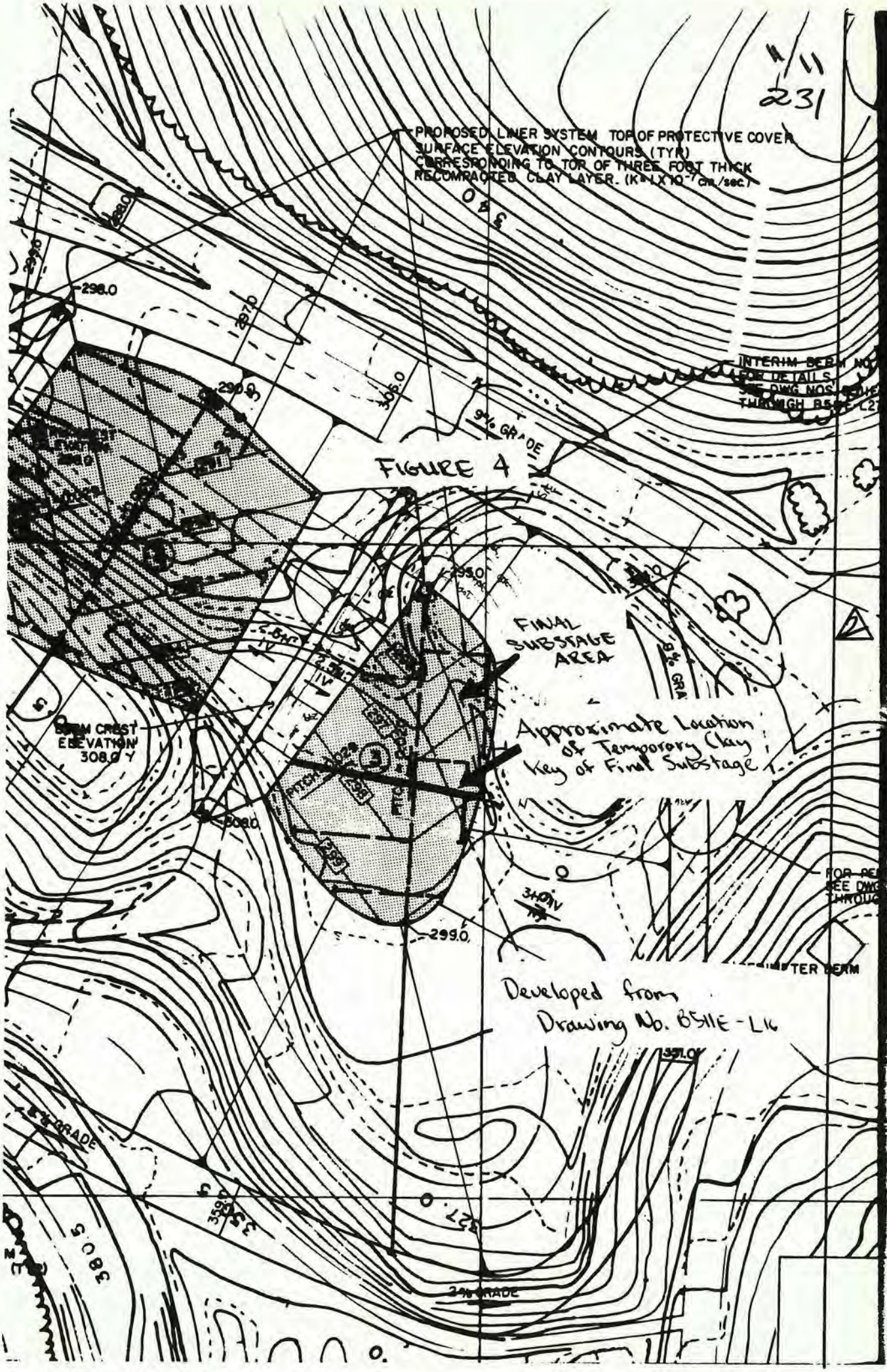


FIGURE 3
Developed from
Drawing No B511E-L18
LEACHATE POND
LEACHATE POND
CHANNEL INV. EL. 347.0±
22' PERIMETER BERM
3H:1V
15' BENCH
30' BENCH
300
350
LAND TREATMENT AREA
INITIAL LINER SYSTEM INSTALLATION TO THIS LIMIT FOR STORMWATER RETENTION WHILE STAGE 2 IS OPERATIONAL LINER EXTENDED UP SIDESLOPES TO OPERATIONS IN AREA.

10/11
230



11/11
231
PROPOSED LINER SYSTEM TOP OF PROTECTIVE COVER
SURFACE ELEVATION CONTOURS (TYP)
CORRESPONDING TO TOP OF THREE FOOT THICK
RECOMPACTED CLAY LAYER. (K=1X10^-7 cm/sec)
298.0
297.0
305.0
9% GRADE
FIGURE 4
295.0
FINAL SUBSTAGE AREA
Approximate Location of Temporary Clay Key of Final Substage
BERM CREST ELEVATION 308.0
308.0
299.0
Developed from Drawing No. B511E-L16
351.0
8% GRADE
380.5
327.0
2% GRADE

APPENDIX D-6.5

SURFACE IMPOUNDMENT

SIZING CALCULATIONS

BY FCM DATE 3/11/86	FRED C. HART ASSOCIATES, INC.	SHEET 1 OF 5 PAGE
CHK'D ____ DATE ____		

SUBJECT PROTECO — JOB NO. 8511

LEACHATE POND ADEQUACY DETERMINATION

APPENDIX D-6.5

PROBLEM STATEMENT

Determine if the primary and secondary leachate ponds (A & B respectively) have sufficient capacities.

DESIGN ASSUMPTIONS

- Assume 10.5 inches for a design storm of 25 years.

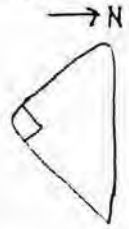
SOLUTION

- LAGOONS A AND B EACH HAVE CAPACITIES > 100,000 GALLONS PLUS 2 FEET OF FREEBOARD (A. LEDINS TELEPHONE CONVERSATION, SUPPORTING CALCS. W/A. L.)
- LAGOON A SURFACE AREA

2 LONG SIDES = 130 FT
2 SHORT SIDES = 50 FT & 67 FT } LEDINS TELEPHONE CONV.

$$\text{AREA} = \left(\frac{50+67}{2}\right)130$$
$$\text{AREA} = 7605 \text{ FT}^2$$

- LAGOON B SURFACE AREA



2 EQUAL LEGS OF TRIANGLE = 104 FT. } LEDINS TEL. CONV.

$$\text{AREA} = 0.5(104)(104)$$
$$\text{AREA} = 5408 \text{ FT}^2$$

- TRUCK WASH AREA

19 FT x 102.5 FT

$$\text{AREA} = 19(102.5)$$
$$\text{AREA} = 1948 \text{ FT}^2$$

SUBJECT PROTECO
LEACHATE POND ADEQUACY DETERMINATION
APPENDIX D-6.5
JOB NO. B511

SOLUTION

① CALCULATE THE INFLOW TO PRIMARY POND A FROM LANDFILLS, TRUCK WASH, AND DIRECT RAINFALL INTO THE POND.

- WORST CASE FOR LANDFILL LEACHATE PRODUCTION IS WHEN LANDFILL 1 CELL 1 IS CAPPED, CELL 2 IS FILLED TO 80 FT W/NO CAP, AND CELL 3 HAS 108 FT. LIFT. THE LEACHATE PRODUCED IS EQUAL TO 8589 GAL/DAY. NOTE THAT THIS VOLUME IS THE MAXIMUM DAILY VOLUME PRODUCED FOR A STUDY PERIOD OF 5 YEARS (HELP). CALCULATIONS ARE SHOWN ON PG. 2 OF 10, RCM WORK, 3/11/86, APPENDIX D-6.2, ITEM 9 QUESTION REPLY. (HELP PROGRAM)

- THE TRUCK WASH INFLOW ASSUMING THE 25 YEAR DESIGN STORM IS AS FOLLOWS:

TRUCK WASH SURFACE AREA X 25 YEAR DESIGN STORM

$= (1948\ FT^2)(10.5\ IN/12)$

$= 1705\ FT^3 \left(\frac{7.482\ GAL}{1\ FT^3}\right)$

$= 12{,}757\ GAL/DAY$

- THE DIRECT RAINFALL INTO LAGOON A ASSUMING THE 25 YEAR DESIGN STORM IS AS FOLLOWS:

LAGOON A SURFACE AREA X 25 YEAR DESIGN STORM

$= 7605\ FT^2 (10.5\ IN/12)$

$= 6654\ FT^3 (7.482\ GAL/1\ FT^3)$

$= 49{,}785\ GAL/DAY$

- TOTAL INFLOW INTO LAGOON A

$= 8{,}589 + 12{,}757 + 49{,}785$

$= 71{,}131$ U.S. GALLONS/DAY

CONCLUSION THE PRIMARY LEACHATE POND A HAS SUFFICIENT CAPACITY TO HOLD ALL OF THE ASSUMED WORST CASE RUNOFF AND LEACHATE PRODUCTION.

CAPACITY OF 100,000+ GAL > 71,131 GAL/D OK

NOTE THAT OPERATIONS WATER WILL BE RESTRICTED TO SECONDARY LEACHATE POND B, AND THAT THE SECONDARY LEACHATE POND WILL NOT BE USED FOR THIS PURPOSE WHEN THE PRIMARY POND IS FULL.

SUBJECT PROTECO JOB NO. B511
LEACHATE POND ADEQUACY DETERMINATION
APPENDIX D-6.5

② CALCULATE THE INFLOW TO PRIMARY POND A FROM TRUCK WASH, AND DIRECT RAINFALL INTO THE POND.

- ASSUME THE SAME LEACHATE PRODUCTION SCENARIO AS IN ① ON PAGE 2, BUT USE THE 25 YEAR STORM GENERATED FLOW OF 9664 GALLONS FOR LANDFILL 1, CELL 3. SEE ATTACHED KGI, 1/6/86, PAGE 4 OF 4 CALCULATIONS.

- DIRECT RAINFALL AND TRUCK WASH REMAIN THE SAME.

- TOTAL INFLOW INTO LAGOON A

$= 9664 + 12,757 + 49785$

$= 72206$ GAL/DAY

CONCLUSION THE PRIMARY LEACHATE POND A HAS SUFFICIENT CAPACITY TO HOLD ALL OF THE ASSUMED WORST CASE RUNOFF AND LEACHATE PRODUCTION.

CAPACITY OF 100,000+ GAL > 72206 GAL/DAY OK

SUBJECT LEACHATE VOLUME GENERATED JOB NO. B511-I
LANDFILL 1
CELL 3

DETERMINE MAXIMUM VOLUME OF LEACHATE TO BE GENERATED IN A 24 HOUR PERIOD.

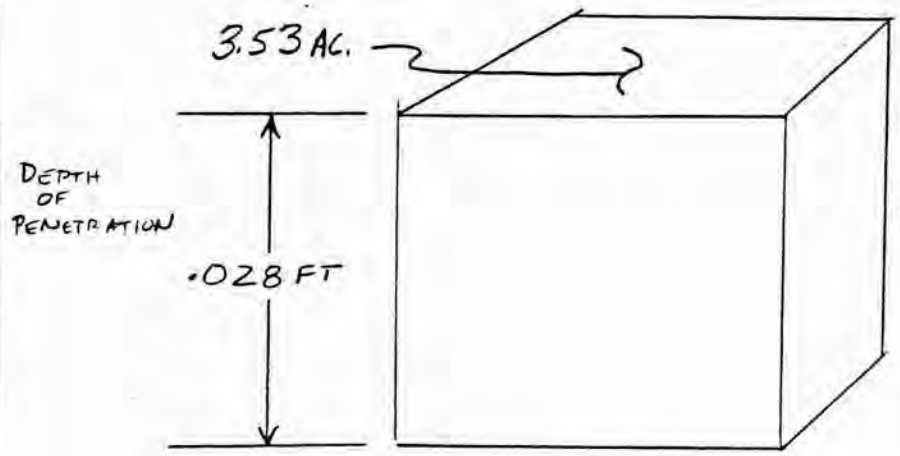
25 YEAR, 24 HOUR STORM = 10.5 INCHES

ASSUME → POROSITY = n = 0.30

→ $K = 10^{-5} \frac{cm}{SEC} = \left(\frac{.00001\,cm}{SEC}\right) \times \frac{86{,}400\,SEC}{24\,HOUR} \times \frac{1\,IN}{2.54\,cm} \times \frac{1\,FT}{12\,IN}$

$= \frac{.028\,FT}{24\,HOUR}$

AREA = 3.53 ACRES = 153,767 FT^2 (CONSERVATIVE)



= MAXIMUM VOLUME, ASSUMING 100% POROSITY

= 4305.5 FT^3

= 32,214 gal.

→ ASSUMING 30% POROSITY MAX LEACHATE GENERATION = (MAX.) × (0.30)

= (32,214 gal.) × (0.30)

= 9,664 gal.

FRED C. HART ASSOCIATES, INC.
PITTSBURGH, PENNSYLVANIA

RECORD OF TELEPHONE CONVERSATION

ROUTE

FILE

Date: 11 March 1986 Time: 11:10 a.m. Job No. B511

Re: PROTECO - LAGOON SURFACE AREA

Call placed by: R Mertz of HART

To: ANDY LEDINS of HART (212) 840-3990

Notes: SURFACE AREA OF LAGOONS

TRIANGULAR LAGOON (SECONDARY):

2 EQUAL LEGS OF TRIANGLE = 104 FT

PARALLELOGRAM LAGOON (PRIMARY):

2 LONG SIDES (∥ TO BERM) = 130 FT

2 SHORT SIDES ARE 50 FT AND 67 FT

CAPACITY OF LAGOONS EXCEEDS 100,000 GALLONS (NOT INCLUDING 2 FEET OF FREEBOARD)

Signed: Robert Mertz

APPENDIX D-6.6

LANDFILL AND

SURFACE WATER MANAGEMENT FACILITIES

This material was previously submitted January 31, 1986; PROTECO PROJECT MASTER DOCUMENTS LIST - Plans and Specifications.

APPENDIX D-6.3

LANDFILL AND

SURFACE WATER MANAGEMENT FACILITIES

QUALITY ASSURANCE MANUAL

FOR THE INSTALLATION OF HDPE GEOMEMBRANES

AND

SOIL COMPONENTS QUALITY ASSURANCE MANUAL

This material was previously submitted January 31, 1986; PROTECO PROJECT MASTER DOCUMENTS LIST - Plans and Specifications.

APPENDIX D-6.4

LANDFILL AND

SURFACE WATER MANAGEMENT FACILITIES

HAZARDOUS WASTE LANDFILL AND

SURFACE WATER MANAGEMENT FACILITIES

Technical Specification

This material was previously submitted January 31, 1986; PROTECO PROJECT MASTER DOCUMENTS LIST - Plans and Specifications.

June 30, 1986

PROTECO PROJECT

MASTER DOCUMENTS LIST

Plans and Specifications

I. Specifications

A. "Technical Specifications Container Storage Building and Site Work" dated August 18, 1985

1. Addendum No. 1 dated October 1985 (Section A only and Contractor Questions)

* 2. Addendum No. 2 dated January 31, 1986

3. Addendum No. 3, dated June 30, 1986

NOTE: "Technical Specifications Tank Farm Storage Facility" dated September 9, 1985 are VOID and Replaced with B, below.

* B. "Technical Specifications Tank Farm" dated January 31, 1986

1. Addendum No. 1, dated June 30, 1986

* C. "Technical Specifications Stabilization Building and Related Equipment" dated January 31, 1986

1. Addendum No. 1, dated June 30, 1986

* D. "Quality Assurance Manual for the Installation of High Density Polyethylene Geomembranes" dated January 31, 1986

1. Addendum No. 1, dated June 30, 1986

* E. "Quality Assurance Manual for Installation of the Soil Component of Liner and Final Cover Systems" dated January 31, 1986

1. Addendum No. 1, dated June 30, 1986

* F. "Technical Specifications, Proposed Hazardous Waste Landfill and Surfacewater Management Facilities" dated January 31, 1986

1. Addendum No. 1, dated June 30, 1986

* G. "Surface Water Management Calculations" dated February 13, 1986

** H. "Landfill and Surface Water Management Facilities - Addendum to Geotechnical Evaluation" dated February 19, 1986, Revised in Item I June 30, 1986

I. "Part B Permit Application - Volumes I and II - General Revision Number 2," dated June 30, 1986

J. Technical Specifications for Leachate Management System, Surface Impoundment, Truck Washing Facilities", dated April 18, 1986

K. "Geotechnical Evaluation for Proteccion Tecnica Ecologica (PROTECO) Inc." dated August 30, 1985

* Indicates items in January 31, 1986 submittal to EPA.
** Submitted as Appendix in Part B Permit Application

II. Drawings

Revision No. / Date

A. Container Storage Building and Tank Farm Drawings

*	B511C	G1	Title Sheet	2/1-31-86
	B511C	SL1	Site Layout Drawings	VOID/1-31-86
	B511C	SL2	Site Layout Drawings	VOID/1-31-86
	B511C	SL3	Site Layout Drawings	0/8-18-85
	B511C	SL4	Site Layout Drawings	0/8-18-85
	B511C	SL5	Site Layout Drawings	0/8-18-85
	B511B	SL1	Site Layout Drawings	0/8-18-85
	B511B	SL2	Site Layout Drawings	2/1-31-86
	B511C	BL1	Facility Layout and Details	0/8-13-85
	B511C	BL2	Facility Layout and Details	0/8-17-85
	B511C	BL3	Facility Layout and Details	0/7-31-85
*	B511B	BL1	Tank Farm and Tank Schedule	1/1-31-86
	B511B	BL2	Tank Farm Cross Section	1/10-03-85
	B511B	BL3	Tank Farm Cross Section	1/10-03-85
	B511B	BL4	Tank Farm Cross Section	1/10-3-85
	B511B	BL5	Tank Farm Cross Section	1/10-3-85
	B511B	BL6	Tank Farm Details	2/1-31-86
*	B511B	T1	Tank Details - Tank T1	4/6-20-86
*	B511B	T2	Tank Details - Tank T2	3/4-03-86
*	B511B	T3	Tank Details - Tank T3	3/4-03-86
*	B511B	T4	Tank Details - Tank T5	4/6-20-86
*	B511B	T5	Tank Details - Tank T6	4/6-20-86
*	B511B	T6	Tank Details - Tank T8	4/6-20-86
*	B511B	T7	Tank Details - Tank T4	4/6-20-86
*	B511B	T8	Tank Details - Tank T7	4/6-20-86
	B511C	P1	Piping Drawings	0/8-12-85
	B511C	P2	Piping Drawings	1/10-10-85
	B511B	P1-4	Tank Farm Storage Piping Drawings Void; Refer to DWGS B511 D P20 to P30	VOID/1-31/86

A. Container Storage Building and Tank Farm Drawings (Cont.)

				Revision No. / Date
	B511C	S1	Structural Plans, Sections and Details	1/10-3-85
	B511C	S2	Structural Plans, Sections and Details	1/10-3-85
	B511C	S3	Structural Plans, Sections and Details	1/10-3-85
	B511C	S4	Structural Plans, Sections and Details	1/10-3-85
	B511C	S5	Structural Plans, Sections and Details	0/8-17-85
	B511B	S1	Structural Plans, Sections and Details	0/8-17-85
	B511B	S2	Structural Plans, Sections and Details	0/8-17-85
	B511B	S3	Structural Plans, Sections and Details	0/8-17-85
	B511B	S4	Structural Plans, Sections and Details	0/8-17-85
	B511B	S5	Structural Plans, Sections and Details	1/10-1-85
*	B511B	S6	Structural Plans, Sections and Details	2/1-31-86
	B511C	SB1	Structural Building Plans, and Details	0/8-7-85
	B511C	SB2	Structural Building Plans, and Details	0/8-7-85
	B511C	SB3	Structural Building Plans, and Details	0/8-7-85
	B511C	SB4	Structural Building Plans, and Details	0/8-7-85
	B511C	SB5	Structural Building Plans, and Details	0/8-7-85

A. Container Storage Building and Tank Farm Drawings (Cont.)

				Revision No. / Date
	B511C	SB6	Structural Building Plans, and Details	0/8-7-85
	B511C	SB7	Structural Building Plans, and Details	0/8-7-85
*	B511C	E1	Electrical Drawings	1/1-31-86
*	B511C	E2	Electrical Drawings	1/1-31-86
	B511B	E3	Electrical Drawings	VOID/1-31-86
	B511B	E4	Electrical Drawings	VOID/1-31-86
	B511C	E5	Electrical Drawings	0/8-17-85
	B511B	E6	Electrical Drawings	VOID/1-31-86
*	B511C	E7	Electrical Drawings	1/1-31-86
*	B511C	E8	Electrical Drawings	2/1-31-86
	B511B	E9	Electrical Drawings	VOID/1-31-86
	B511C	FP1	Fire Protection Plans	0/8-11-85
	B511C	FP2	Fire Protection Plans	0/8-18-85

B. Stabilization/Fixation Facility and Tank Farm/Treatment Facility.

				Revision No. / Date
*	B511D	G1	Title Sheet	1/6-30-86
*	B511D	A20	Architectural - Floor and Roof Plans	0/1-31-86
*	B511D	A21	Elevations and Details	0/1-31-86
*	B511D	BL20	Equipment Arrangements Plan Views	1/6-20-86
*	B511D	BL21	Equipment Arrangements Plan Views	0/1-31-86
*	B511D	BL22	Equipment Arrangements Sections	1/6-20-86
	B511D	E20	Relay Interlocks Schematic Diagram	0/3-31-86
	B511D	E21	Relay Interlocks Schematic Diagram	0/3-31-86
	B511D	E22	Relay Interlocks Schematic Diagram	1/6-18-86
	B511D	E23	Relay Interlocks Schematic Diagram	1/6-23-86
	B511D	E24	Annunciator Schematic Diagram	0/4-4-86
	B511D	E25	Annunciator Schematic Diagram	1/6-20-86
	B511D	E26	Control Schematic Diagram	0/3-31-86
	B511D	E27	Control Schematic Diagram	1/6-23-86
	B511D	E28	Control Schematic Diagram	1/6-23-86
	B511D	E29	Annunciator Panels Details	1/4-9-86
	B511D	E30	Relay Panels Details	1/6-19-86
	B511D	E31	Pushbutton Stations Details	0/4-14-86
	B511D	E32	Pushbutton Stations Details	0/4-14-86
	B511D	E33	Pushbutton Stations Details	0/4-14-86
	B511D	E34	Pushbutton Stations Details	0/4-14-86

B. Stabilization/Fixation Facility and Tank Farm/Treatment Facllity. (Cont.)

				Revision No. / Date
	B511D	E35	Panel Arrangements	1/6-20-86
	B511D	E36	Alarm Index	0/5-06-86
	B511D	E43	Instrument Loops/Cable Block Diagram	0/6-23-86
	B511D	E44	Instrument Loops	0/4-17-86
	B511D	E45	Cable Block Diagram	1/6-23-86
	B511D	E46	Cable Block Diagram	1/6-23-86
	B511D	E47	Cable Block Diagram	1/6-23-86
*	B511D	F20	Foundation Plan and Anchor Bolt Schedule	1/6-20-86
*	B511D	F21	Grade Slab Plan	0/1-31-86
	B511D	F22	Foundation and Slab, Sections and Details	0/1-31-86
*	B511D	F23	Foundation and Slab, Sections and Details	0/1-31-86
*	B511D	F24	Conveyor Pit - Plan, Sections and Details	0/1-31-86
*	B511D	M20	Outline - Inclined Solids Conveyor C-1	1/6-23-86
*	B511D	M21	Outline - Conveyors C-2 and C-3	1/6-23-86
*	B511D	M22	Outline - Conveyor C-4	1/6-23-86
*	B511D	M23	Drip Plan Details	1/6-23-86
*	B511D	P20	Piping Plan	1/6-23-86
*	B511D	P21	Piping Section A-A	1/6-23-86
*	B511D	P22	Piping Section B-B	1/6-23-86
*	B511D	P23	Piping Section C-C	1/6-23-86
*	B511D	P24	Piping Section D-D	1/6-23-86
*	B511D	P25	Loading and Unloading Area - North End Details	1/6-23-86

B. Stabilization/Fixation Facility and Tank Farm/Treatment Facility. (Cont.)

				Revision No. / Date
*	B511D	P26	Loading and Unloading Area - South End Details	1/6-23-86
*	B511D	P27	Piping Arrangement - Plan Views Elevations 0'-0" and 20'-0"	1/6-23-86
*	B511D	P28	Piping Arrangement Plan View Elevations 34'-0"	1/6-23-86
*	B511D	P29	Piping Arrangement Elevations	1/6-23-86
*	B511D	P30	Piping Arrangement Yards Piping	1/6-23-86
*	B511D	S20	Pipe Rack and Catwalk	0/1-31-86
*	B511D	S21	Silo Support Framing and Roof Plans	0/1-31-86
*	B511D	S22	2nd and 3rd Level Platforms Plans	0/1-31-86
*	B511D	S23	Building Elevations	0/1-31-86
*	B511D	S24	Sections and Details	0/1-31-86
*	B511D	S25	Intermediate Platform Plan and Sections	0/1-31-86
*	B511D	SK20	Process and Instrumentation Details - Tanks T1 and T2	1/6-20-86
*	B511D	SK21	Process and Instrumentation Details - Tanks T7 and T3	1/6-20-86
*	B511D	SK22	Process and Instrumentation Details - Tanks T4 and T5	1/6-20-86
*	B511D	SK23	Process and Instrumentation Details - Tanks T6 and T8	1/6-20-86
*	B511D	SK24	Process and Instrumentation Details - Tanks T9 and T13	1/6-20-86
*	B511D	SK25	Process and Instrumentation Details - Silo/Dry Feed Systems	1/6-20-86
*	B511D	SK26	Process and Intrumentation Details - Stabilization Process	1/6-20-86
*	B511D	SK27	Process and Intrumentation Details - Potable Water and Air	1/6-20-86

B. Stabilization/Fixation Facility and Tank Farm/Treatment Facility. (Cont.)

				Revision No. / Date
*	B511D	SK28	Process and Intrumentation Details - Symbol Schedule	1/6-20-86
*	B511D	T20	Tank T9 - Outline	0/1-31-86
*	B511D	T21	Tank T13 - Outline	1/6-20-86
*	B511D	T22	Silo Outlines	0/1-31-86
			Instrument Index Sheets 1-97	0/6-20-86

C. Landfill Facilities

				Revision # / Date
*	B511E	L1	Title Sheet	0/1-31-86
*	B511E	L2	Existing Site Arrangement Plan	0/1-31-86
*	B511E	L3	Property Landfill Arrangement Plan	0/1-31-86
*	B511E	L4	Base Map - Monitoring Well Locations	0/1-31-86
*	B511E	L5	Geological Cross-Section A-A'	0/1-31-86
*	B511E	L6	Geological Cross-Section B-B'	0/1-31-86
*	B511E	L7	Geological Cross-Section C-C'	0/1-31-86
*	B511E	L8	Geological Cross-Section D-D'	0/1-31-86
*	B511E	L9	Layout/Grading Plans - LF1	0/1-31-86
*	B511E	L10	Layout/Grading Plans - LF1	1/6-30-86
*	B511E	L11	Layout/Grading Plans - LF1	1/6-30-86
*	B511E	L12	Layout/Grading Plans - LF1	1/6-30-86
*	B511E	L13	Layout/Grading Plans - LF1	0/1-31-86
*	B511E	L14	Cap Surface Elevation - LF1	1/6-30-86
*	B511E	L15	Layout/Grading Plans - LF2	0/1-31-86
*	B511E	L16	Layout/Grading Plans - LF2	1/6-30-86
*	B511E	L17	Layout/Grading Plans - LF2	1/6-30-86
*	B511E	L18	Layout/Grading Plans - LF2	1/6-30-86
*	B511E	L19	Layout/Grading Plans - LF2	0/1-31-86
*	B511E	L20	Cap Surface Elevation - LF2	1/6-30-86
*	B511E	L21	LF1 - Section A-A and Details	0/1-31-86
*	B511E	L22	LF1 - Section B-B and Details	0/1-31-86
*	B511E	L23	LF1 - Section C-C and Details	1/6-30-86
*	B511E	L24	LF1 - Section D-D and Details	0/1-31-86
*	B511E	L25	LF2 - Section E-E and Details	0/1-31-86
*	B511E	L26	LF2 - Section F-F and Details	0/1-31-86
*	B511E	L27	LF2 - Section G-G and Details	1/6-30-86
*	B511E	L28	LF2 - Section H-H and Details	0/1-31-86
*	B511E	L29	Typical Channel Sections and Schedule	1/6-30-86

C. Landfill Facilities (Cont.)

				Revision # / Date
*	B511E	L30	Slope Drain Profiles and Details	0/1-31-86
*	B511E	L31	Culvert and Channel Crossings Section Details and Schedules	0/1-31-86
*	B511E	L32	Sediment Basin Plan, Profiles and Details	0/1-31-86
*	B511E	L33	Isometric View	1/6-30-86

D. Leachate Management System, Surface Impoundment, Truck Washing Facilities

B511-I-1	Title Sheet	0/03-12-86
B511-I-2	Site Plan	0/03-12-86
B511-I-3	Contract Limits Landfill I, State I Liner Contours, Stage II	0/03-12-86
B511-I-4	Leachate Pond Leak Detection Piping & Leachate Pond Mechanical	0/03-12-86
B511-I-5	Leachate Pond Cross Sections	0/03-12-86
B511-I-6	Leachate Pond Details	0/03-12-86
B511-I-7	Grit Chamber	0/03-12-86
B511-I-8	Leachate Pond Pump Station Details	0/03-12-86
B511-I-9	Catwalk Structural Details	0/03-12-86
B511-I-10	Standard Structural Details	0/03-12-86
B511-I-11	Landfill Pump Stations	0/03-12-86
B511-I-12	Civil Details 1	0/03-12-86
B511-I-13	Truck Washing Facility	0/03-12-86
B511-I-14	Control Schematics.	0/03-12-86

June 30, 1986

Other Non-Part B Application Reports

A. "Study of Existing Wastes and Suitability of Proposed Closure Method for PROTECO Land Treatment Facility AC2 (Unit 14)" dated February 24, 1986.

B. "Proteccion Tecnica Ecologica (PROTECO) Inc. Existing Unit Closure Plan" Revised May 1, 1986.

C. "Assessment of Hydrogeological Data for Proteccion Tecnica Ecologica (PROTECO) Inc.", dated October, 1985.

APPENDIX D-6.5

SURFACE IMPOUNDMENT

SIZING CALCULATIONS

SUBJECT PROTECO JOB NO. B511
LEACHATE POND ADEQUACY DETERMINATION
APPENDIX D-6.5

PROBLEM STATEMENT

Determine if the primary and secondary leachate ponds (A&B respectively) have sufficient capacities.

DESIGN ASSUMPTIONS

- Assume 10.5 inches for a design storm of 25 years.

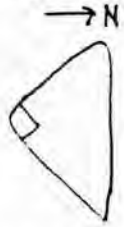
SOLUTION

- LAGOONS A AND B EACH HAVE CAPACITIES > 100,000 GALLONS PLUS 2 FEET OF FREEBOARD (A. LEDINS TELEPHONE CONVERSATION, SUPPORTING CALCS. W/A. L.)
- LAGOON A SURFACE AREA

2 LONG SIDES = 130 FT
2 SHORT SIDES = 50 FT & 67 FT } LEDINS TELEPHONE CONV.

$$\text{AREA} = \left(\frac{50+67}{2}\right)130$$
$$\text{AREA} = 7605 \text{ FT}^2$$

- LAGOON B SURFACE AREA



2 EQUAL LEGS OF TRIANGLE = 104 FT. } LEDINS TEL. CONV.

$$\text{AREA} = 0.5(104)(104)$$
$$\text{AREA} = 5408 \text{ FT}^2$$

- TRUCK WASH AREA

19 FT x 102.5 FT

$$\text{AREA} = 19(102.5)$$
$$\text{AREA} = 1948 \text{ FT}^2$$

SUBJECT PROTECO
LEACHATE POND ADEQUACY DETERMINATION
APPENDIX D-6.5
JOB NO. B511

SOLUTION

① CALCULATE THE INFLOW TO PRIMARY POND A FROM LANDFILLS, TRUCK WASH, AND DIRECT RAINFALL INTO THE POND.

- WORST CASE FOR LANDFILL LEACHATE PRODUCTION IS WHEN LANDFILL 1 CELL 1 IS CAPPED, CELL 2 IS FILLED TO 80 FT W/NO CAP, AND CELL 3 HAS 108 FT. LIFT. THE LEACHATE PRODUCED IS EQUAL TO 8589 GAL/DAY. NOTE THAT THIS VOLUME IS THE MAXIMUM DAILY VOLUME PRODUCED FOR A STUDY PERIOD OF 5 YEARS (HELP). CALCULATIONS ARE SHOWN ON PG. 2 OF 10, RCM WORK, 3/11/86, APPENDIX D-6.2, ITEM 9 QUESTION REPLY. (HELP PROGRAM)

- THE TRUCK WASH INFLOW ASSUMING THE 25 YEAR DESIGN STORM IS AS FOLLOWS:

TRUCK WASH SURFACE AREA X 25 YEAR DESIGN STORM
$= (1948\ FT^2)(10.5\ IN/12)$
$= 1705\ FT^3 \left(\frac{7.482\ GAL}{FT^3}\right)$
$= 12{,}757\ GAL/DAY$

- THE DIRECT RAINFALL INTO LAGOON A ASSUMING THE 25 YEAR DESIGN STORM IS AS FOLLOWS:

LAGOON A SURFACE AREA X 25 YEAR DESIGN STORM
$= 7605\ FT^2 (10.5\ IN/12)$
$= 6654\ FT^3 (7.482\ GAL/1\ FT^3)$
$= 49{,}785\ GAL/DAY$

- TOTAL INFLOW INTO LAGOON A
$= 8589 + 12{,}757 + 49{,}785$
$= 71{,}131$ U.S. GALLONS/DAY

CONCLUSION THE PRIMARY LEACHATE POND A HAS SUFFICIENT CAPACITY TO HOLD ALL OF THE ASSUMED WORST CASE RUNOFF AND LEACHATE PRODUCTION.

CAPACITY OF 100,000+ GAL > 71,131 GAL/D OK

NOTE THAT OPERATIONS WATER WILL BE RESTRICTED TO SECONDARY LEACHATE POND B, AND THAT THE SECONDARY LEACHATE POND WILL NOT BE USED FOR THIS PURPOSE WHEN THE PRIMARY POND IS FULL.

SUBJECT PROTECO JOB NO. B511
LEACHATE POND ADEQUACY DETERMINATION
APPENDIX D-6.5

② CALCULATE THE INFLOW TO PRIMARY POND A FROM TRUCK WASH, AND DIRECT RAINFALL INTO THE POND.

- ASSUME THE SAME LEACHATE PRODUCTION SCENARIO AS IN ① ON PAGE 2, BUT USE THE 25 YEAR STORM GENERATED FLOW OF 9664 GALLONS FOR LANDFILL 1, CELL 3. SEE ATTACHED KGI, 1/6/86, PAGE 4 OF 4 CALCULATIONS.

- DIRECT RAINFALL AND TRUCK WASH REMAIN THE SAME.

- TOTAL INFLOW INTO LAGOON A

$= 9664 + 12,757 + 49785$

$= 72206$ GAL/DAY

CONCLUSION THE PRIMARY LEACHATE POND A HAS SUFFICIENT CAPACITY TO HOLD ALL OF THE ASSUMED WORST CASE RUNOFF AND LEACHATE PRODUCTION.

CAPACITY OF 100,000+ GAL > 72206 GAL/DAY OK

SUBJECT LEACHATE VOLUME GENERATED LANDFILL 1 CELL 3 JOB NO. R511-I

DETERMINE MAXIMUM VOLUME OF LEACHATE TO BE GENERATED IN A 24 HOUR PERIOD.

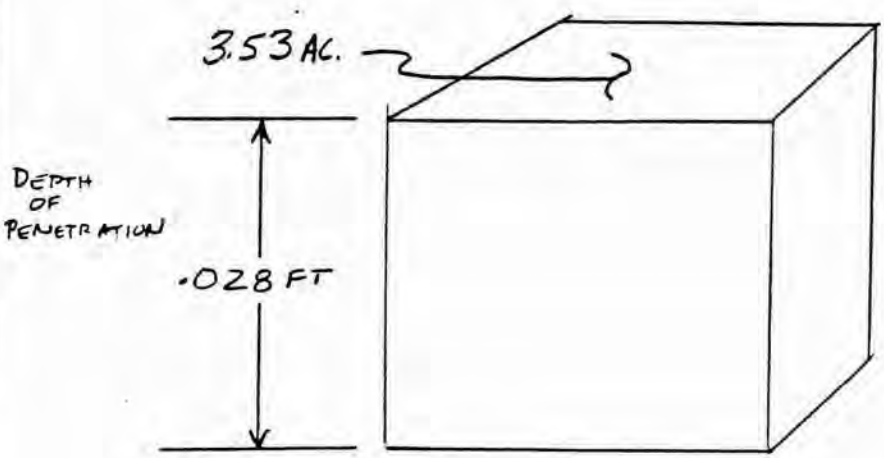
25 YEAR, 24 HOUR STORM = 10.5 INCHES

ASSUME → POROSITY = n = 0.30

$$\rightarrow K = 10^{-5}\frac{cm}{SEC} = \left(\frac{.00001\,cm}{SEC}\right) \times \frac{86{,}400\,SEC}{24\,HOUR} \times \frac{1\,IN}{2.54\,cm} \times \frac{1\,FT}{12\,IN}$$

$$= \frac{.028\,FT}{24\,HOUR}$$

AREA = 3.53 ACRES = 153,767 FT^2 (CONSERVATIVE)



= MAXIMUM VOLUME, ASSUMING 100% POROSITY

= 4305.5 FT^3

= 32,214 gal.

→ ASSUMING 30% POROSITY MAX LEACHATE GENERATION = (MAX.) × (0.30)

= (32,214 gal.) × (0.30)

= 9,664 gal.

FRED C. HART ASSOCIATES, INC.
PITTSBURGH, PENNSYLVANIA

RECORD OF TELEPHONE CONVERSATION

ROUTE

FILE

Date: 11 March 1986 Time: 11:10 a.m. Job No. B511

Re: PROTECO - LAGOON SURFACE AREA

Call placed by: R Mertz of HART

To: ANDY LEDINS of HART (212) 840-3990

Notes: SURFACE AREA OF LAGOONS

TRIANGULAR LAGOON (SECONDARY):

2 EQUAL LEGS OF TRIANGLE = 104 FT

PARALLELOGRAM LAGOON (PRIMARY):

2 LONG SIDES (∥ TO BERM) = 130 FT

2 SHORT SIDES ARE 50 FT AND 67 FT

CAPACITY OF LAGOONS EXCEEDS 100,000 GALLONS (NOT INCLUDING 2 FEET OF FREEBOARD)

Signed: Robert Mertz

APPENDIX D-6.6

LANDFILL AND

SURFACE WATER MANAGEMENT FACILITIES

This material was previously submitted January 31, 1986; PROTECO PROJECT MASTER DOCUMENTS LIST - Plans and Specifications.

APPENDIX D-6.7

ASSESSMENT OF HYDROGEOLOGIC DATA

FOR PROTECCION TECHNICA ECOLOGICA (PROTECO), INC.

Previously Submitted in October 1985

(0655B-12)

Appendix D-6.8

Temporary Stormwater Retention Cell Water Testing Program

The following water testing program has been developed to determine if the run-off collected in the temporary stormwater retention cells is contaminated. The cells will be constructed to contain run-off from the landfills during the construction phases.

The stormwater in each cell will be tested prior to removal from the cell. If the water is found to be contaminated it will be pumped into the Leachate Pond for treatment. If uncontaminated it will be pumped into the Sedimentation Basin. Upon issuance of a NPDES permit, this basin will discharge into the surface water drainage channel.

All sampling and testing methods used in this testing program will follow EPA SW-846: Test Methods for Evaluating Solid Waste, Second Edition. These methods include the following:

- At least two composite samples will be taken from the cell, the actual number of samples depends on the volume of water contained in the cell. These composites will consist of water samples taken from locations displaced both vertically and horizontally throughout the cell.

- Sampling protocol includes use of a COLIWASA, a weighted bottle and a dipper, depending on sampling location and depth. All sampling equipment will be properly decontaminated prior to use .

- Samples will be placed in glass containers and these containers will be stored and transported back to the PROTECO laboratory in a cooler.

- Samples will be treated for the parameters listed on Table D-6.8-1 using the same methods as outlined in Section C, Waste Analysis Plan.

- Contamination will be determined using the criteria given in the NPDES permit, upon issuance.

TABLE D-6.8-1

STORMWATER TESTING PROGRAM PARAMETERS

pH

Specific Conductance

Total Dissolved Solids

Sulfate

D-7 Land Treatment

There are no land treatment facilities proposed.

D-8 Waste Piles

There will be no waste piles at the Proteco Facility

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D-9 STABILIZATION/FIXATION FACILITY

D-9a General

The PROTECO facility will include a process to stabilize/fix incoming wastes whose physical form, i.e., containing free liquids, (per the "paint filter test" criteria method 9095 of SW-846" Test Methods for Evaluating Solid Waste delineated on Table C-8) would exclude direct burial in the secure landfills under 40 CFR 264.314, or for wastes which must be treated prior to land disposal.

This process will be conducted in the Stabilization/Fixation Facility located northwest of the entrance gate within the same area allotted for the Tank Storage and Treatment and Container Storage facilities, as shown on Drawing B511-C-SL3.

The Stabilization/Fixation Facility technical specification and drawing set are referred to as necessary, and can be found in Appendices D-9.1 and A respectively. Supporting tank calculations are provided in Appendix D-9-1. |Δ

D-9b Facility Description

The facility will occupy approximately one-third of an acre. This area allows for a future "twin" to the proposed unit to be built adjacent to the initial facility as shown on Drawing 511-D-F20. This Part B Application is for both units.

The proposed facility design incorporates personnel safety features, prevention of fire, sudden and non-sudden releases of hazardous which could threaten human health or the environment, and administrative and process control procedures to assure process operation resulting in a stabilized/fixed product suitable for land disposal. The facility description follows.

The technical specifications require construction in accordance with the local building codes. The stabilization/fixation process will be conducted in a building. Overall building dimensions are approximately 50' wide by 50' long by 51' high. The building foundation consists of a 1' reinforced concrete slab (as shown on Drawings B511-D-F20 to F22).

The building roof decking slopes down directing rainfall to a gutter and down spout. The roof extends around and over the lower section of the stabilizing/fixing material silos at the southern end of the building with flashing provided as a seal. This section of the roof also has a gutter and downspout to direct rainfall away from the facility. The aluminum coated steel siding extends down to within 5' of grade. Four ventilators are provided on the roof (as shown on the architectural Drawings, numbers B511-D-A20 and A21).

The steel building structure is designed per AISC codes with cross-bracing for the wind loading per local codes. The internal structure consists of three elevations; grade, 20' and 34'. The upper platforms are constructed of steel grating. Floor drains are directed to a double lined sump with leak detection.

The roof drainage design, curbing around the facility and internal drainage sump design prevent run-off of spills to the environment and run-on of rainfall into the facility. Spill containment and cleanup procedures are discussed in Section D-9f below.

Personnel and equipment safety considerations have been incorporated into the design. Personnel entrances/exists are located at either end of the silo wing, at the rear of the eastern side of the building, at the 20' platform via stairs dropping down off the silo area, and through the truck tipping and discharge bays. A stairwell extends up to the 34' platform from the truck discharge bay area (all stairs and walkways conform to OSHA codes). Four (4) eyewash/shower stations are provided at the facility.

A sprinkler system over the process unit is central to the facilities fire protection fixing additives. The facility's safety and fire protection is discussed in Section D-9g below.

D-9c Process Description

The proposed Stabilization/Fixation Facility is capable of mixing fly ash or cement kiln dust, with dry limestone to sludge, solids, or liquid waste streams. Figure 1 presents a simplified block flow diagram of the stabilization/fixation process indicating design and maximum flows of all streams. This process, referred to as a modified "pozzolanic" process, utilizes the hydration of silicate compounds (typified by the common cement reaction) to improve the waste characteristics and produce a matrix constituting a stabilized/fixed product suitable for landfilling in accordance with the regulations cited above.

D-9c(1) General. The following process description is depicted on the P & ID Drawings B511-D-SK24, 25, and 26.

The ratio of waste to stabilizing/fixing agents additives will vary for each waste per the pre-acceptance waste stabilization/fixation testing, described under administrative/process controls below. The anticipated range and design throughputs are as follows:

	Hourly Range*	Hourly Design*
Sludges/Solids	0 - 5 tons	2.5 tons
Liquids	0 - 3 (700 gallons) tons	2.0 tons (500 gallons)
Stabilizing/Fixing Additives	0 - 9 tons	7.5 tons
Total to Landfill	0 - 16.5 tons	12.0 tons

*Per Facility - Two facilities are proposed in this Part B Application.

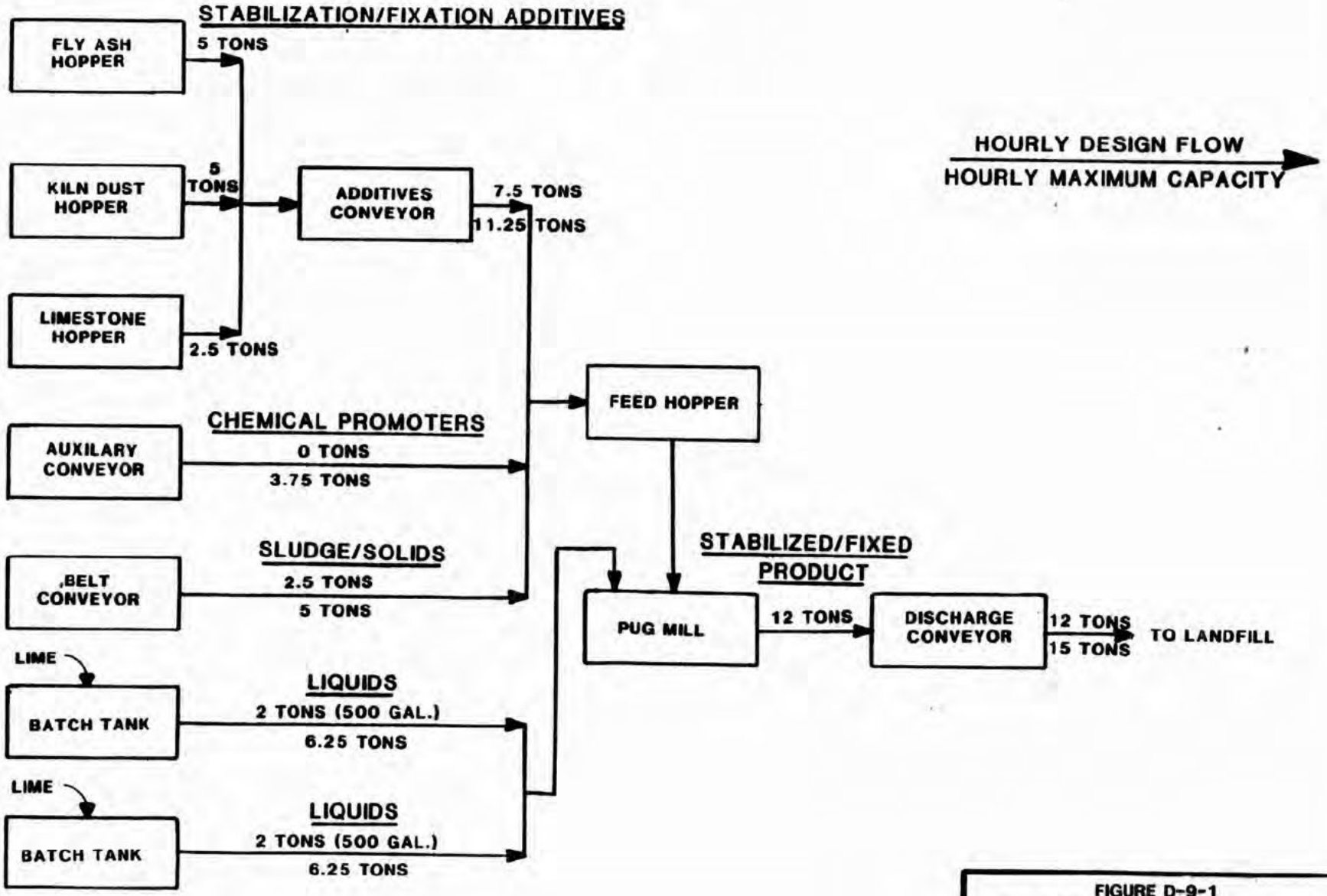

FIGURE D-9-1
STABILIZATION FACILITY
SIMPLIFIED FLOW DIAGRAM
PROTECO

FRED C. HART ASSOCIATES, INC.

The system can be operated to stabilize/fix sludges, solids and/or liquids.

The hourly design throughput, 12.0 tons corresponds to approximately 24 cubic feet per hour. The system is capable of achieving a waste to stabilizing/fixing additive ratio of 1:3. While the operating equipment provides for variable feed flowrates, normal operating conditions are expected to be within the mixture ratio range of 1:1 to 1:3.

All the feeds converge at the pug mill which is the center of the system. The pug mill is a high speed, low residence time, mixer/granulator. Waste liquids are fed from tanks to distributers located in top of the pug mill. Waste sludges/solids and the additives are conveyed into a feed hopper situated over the screw feeder on the pug mill. The pug mill discharges through another screw conveyer which serves to drop the stabilized/fixed product into a dump truck for transport to the landfill.

The system operates as a semi-continuous process; sludge/solids can be continuously unloaded and fed to the pug mill while liquids can be batch fed from the Tank Farm Storage/Treatment Facility through the batch tanks described below. Liquid feeds to the batch tanks can also be delivered by tanker truck or pumped from the liquids drainage sump in the Stabilization/Fixation Facility.

The system provides for the conditioning and feeding of liquid wastes for stabilization/fixation through two (2) 2,000 gallon batch tanks. Batch tank T-9 is to be used for solvents (both non-halogenated and halogenated), oil sludge, or oil wastes from the Tank Farm. Batch tank T-13 is to be used for aqueous wastes, or alkali and acid wastes neutralized in the neutralization tank. The waste characteristics of the batch wastes in these tanks would either be mixtures or the same wastes as described for each tank in the Tank Farm (see Section D-4d). The batch

tanks both have mechanical mixers and provisions for lime slurry addition for pH conditioning. The feed flow rate from these tanks is manually adjusted by the operator, at a throttling value upstream of a flow meter, on the discharge end of the transfer pump. (The pre-acceptance waste stabilization/fixation testing described under Administrative/Process controls below, serves to establish the formulation ratios for the process.) The maximum flowrate is 1,500 pounds per hour (1,500 gph) or three times the design throughput of 500 gallons per hour, feeding under normal conditions from one batch tank.

Sludges and solid wastes to be stabilized/fixed by the treatment additives are delivered by dump truck to the tipping area. The sludge/solids are dropped on to the tipping floor and loaded, into a conveyor feed-hopper, by a front end loader to be stationed in the tipping area. The belt conveyor, referred to as the inclined solids conveyor (C-1), has a variable speed in order to allow for adjustments of the delivery rate to the pug mill feed hopper for density and consistency of each sludge/solids feed. At full capacity, this conveyor can deliver 10,000 pounds (5 tons) per hour to the process or two times the design throughput of 5,000 pounds (2.5 tons) per hour. The sludge/solids drop into the pug mill feed hopper where, at the treatment additives inlet, a grinder extends off the additives conveyor drive shaft to inhibit clumping or bridging of the feeds in the hopper.

The treatment additives; dry limestone, fly-ash, and cement kiln dust, are fed from their storage hoppers, T-10, T-11, and T-12 respectively, by screw feeders. These screw feeders are operated by variable speed motors to allow for control of the flowrates and proportional mixing as required by the specified waste stabilization/fixation formulation. The fly-ash, and kiln dust screw feeders (C1-T11 and C1-T12) have a 10,000 pounds per hour capacity, while the limestone screw feeder capacity (C1-T10) is 5,000 pounds per hour. These feeds drop onto the pug mill feed transfer conveyor (C-2) rated at 22,500 pounds (11.25 tons) per hour, or one and a

half capacity over the design throughput, and also driven by a variable speed motor. This conveyor feeds in turn, into the pug mill feed hopper where it is assisted by the sludge grinder at its discharge end.

The pug mill serves as the mixer/treatment vessel for the stabilizing/fixing process. The proposed pug mill is a rotary solids/ liquids mixer employing pins extending off the rotor shaft to mix and transport the material. The high speed, 600 rpm, rotation of the shaft creates vortices of high mixing behind the pins. The helical positioning of the pins serves to transport the material. The dry feed, waste sludge/solids and the stabilizing/fixing additives, are fed to the pug mill through the feed hopper located overhead of the pug mill's screw feeder. Waste liquids are piped directly to the pug mill housing and atomized by the pug mill action, rather than by spray nozzles prone to plugging. Feed rates are controlled upstream of the pug mill as described above.

The pug mill design capacity defines the overall system process rate at 10 dry tons per hour, or 12 tons per hour total. The unit has a high turn-down ratio and could be operated at rates as low as five tons per hour.

Discharge from the pug mill drops into the discharge conveyor which transfers the stabilized/fixed product to the location overhead of the discharge floor for loading the trucks destined for the landfill. The discharge conveyor is a screw conveyor of fixed speed 30,000 pounds per hour or one quarter capacity over the design throughput capacity of 24,000 pounds per hour.

An auxiliary conveyor is provided overhead of the pug mill feed hopper to allow for the addition of stabilizing/fixing promoting chemicals, if needed. This screw conveyor is to have a capacity of 7,500 pounds per hour.

D-9c(2) Stabilization/Fixation Chemistry and Formulations. The proposed facility utilizes a modified "pozzolanic process", similar to the setting of cement, to improve the waste characteristics and chemically treat and stabilize/fix the hazardous waste into a matrix suitable for land disposal.

This chemical treatment chemically transforms the liquid portion of the waste into a solid and the hazardous constituents into less soluble and/or less toxic forms. The liquids and hazardous constituents are directly incorporated into or encapsulated between the resulting crystal structure, thereby limiting their mobility, solubility or toxicity, and rendering them less amenable to environmental mobility.

The "pozzolanic process" involves hydration, neutralization, precipitation, and crystalization reactions. The composition of the waste, the fly ash or cement kiln dust, pH of the waste, and mixture ratios (formulations) are factors effecting the extent and type of each reaction and therefore the properties of the stabilized/fixed product.

D-9c(2)a Stabilization/Fixation Chemistry. The following discussion outlines the chemistry of the "pozzolanic process", as it relates to the wastes and additives to be stabilized/fixed at the site, and the range of mixture formulations provided for in the process design.

The hydrolysis-crystalization reactions are the primary processes responsible for water dissipation resulting in the formation of a solid matrix suitable for landfilling. The hydrolysis reactions of calcium oxide compounds with silicates, aluminates and aluminoferrite are typical cement setting processes. The calcinated silicates or aluminates are then in a suitable form for direct fixation reactions with heavy metals, hydration or for fixation of non-metal compounds encapsulated within the crystals matrix.

Neutralization reactions are necessary to promote the formation of both the more readily hydrated calcium silicates and the metal precipitates to be fixed or bound with the silicate crystals, where sulfates, metal oxides, and alkaline silicates (e.g., alumino, cadmium, and potassium silicates) are present. These precipitation reactions and the subsequent crystallizations are favored in the pH range 9 to 11.

These competing and inhibiting compounds may be present in the fly ash and/or cement kiln dust as these materials are not specification products. Fly ash, being the oxidized metal compounds, silicates, alumina, inerts, and any miscellaneous compounds carried off as remaining ash during the combustion of fossil fuel, is expected to display a wide variety of both the calcium silicates and other compounds mentioned above.

The composition of the fly ash may also vary from batch to batch. The composition of fly ash regarding its pozzolanic properties is characterized by the "lime saturation factor;" the ratio of calcium oxide to silicates, aluminum and iron oxides. The quantity of dry limestone to be added to the fly ash would be determined during the pre-stabilization/fixation testing. The "lime saturation factor" relates to the limestone addition as the limestone provides calcium oxide for combination with the silicates and aluminates and to precipitate the heavy metals for incorporation into the pozzolanic matrices.

Cement kiln dust, while generally having better pozzolanic properties than fly ash, is a by-product of cement manufacturing and tends to contain alkaline silicates that inhibit the "pozzolanic" reactions. Therefore, dry limestone is added per the pre-stabilization/fixation testing, to provide the calcium oxide.

In general, since the metal precipitation reactions for the metals contained in the fly ash, kiln dust or wastes are favored by pH conditions in the range 9 to 11, a preliminary guideline for an acceptable pH range

of wastes for stabilization/fixation processing would be 6.5 to 11. This guideline will be refined during the pre-stabilization/fixation testing for each waste.

Where the sludge/solids wastes to be stabilized/fixed are acidic, the dry limestone in the stabilizing/fixing additive mixture would result in a neutralized mixture of a pH promoting the precipitation reactions described above. The batch tanks, having provisions for pH adjustment by lime slurry addition, would serve to condition acidic liquid wastes up to the desired pH range prior to stabilization/fixation processing.

The presence of metal sulphate (e.g., iron, cadmium or magnesium sulfate) or chloride compounds in the wastes or fly ash represent specific known inhibitors of the "pozzolanic" reactions. These compounds are very soluble, therefore, in order to precipitate them for incorporation into the stabilized/fixed matrix, further lime addition or the use of a chemical promoting agent may be necessary to react them to insoluble compounds.

The chemical additions conveyor allows for the addition of "pozzolanic" promoting chemicals to the mixture in the event of a waste exhibiting very poor stabilization/fixation; in particular, the granulated sodium silicates. Granulated sodium silicate is readily available and relative to most commercial chemicals, inexpensive. It reacts with all polyvalent metal ions, acids, and some organics and does note require the alkaline pH conditions. As an additive, it broadens the chemical and pH conditions tolerance of the "pozzolanic" reactions. Due to its higher cost over cement kiln dust, fly-ash, or limestone, sodium silicate is not intended for addition to the process under normal conditions. As an additive in waste stabilization/fixation processing, sodium silicate is currently being used by the speciality contractors providing these services and can be used at PROTECO if needed for specific formulations.

Organics also tend to have an adverse effect on the "pozzolanic" reactions. Depending on the organic content and character, the process could satisfactorily encapsulate them, but may require the addition of a chemical-promoting agent. Where the sodium silicate additives are not

sufficient to accommodate the wastes containing organics, proprietary polymer additives will be obtained from specialty contractors (e.g., Dow markets such an additive).

D-9c(2)b Stabilization/Fixation Formulations. The term formulation is used herein to describe the waste to stabilization/fixation additive to chemical additive, if necessary, mixture ratios to achieve a product suitable for landfilling per the "paint filter test" mentioned above.

The site laboratory will perform stabilization/fixation tests on wastes designated for stabilization/fixation processing as part of the waste pre-acceptance testing. These tests will be performed on samples delivered by the generator with the waste preacceptance sheets. In addition, prior to actual processing the laboratory will perform verification tests on the specified waste stabilization/fixation formulations as necessary where the composition has been altered due to mixing in storage facilities, pH conditioning, etc.

The possible formulations are bounded by the system process flowrates. However, the system has been designed to allow a range of formulations under normal operating conditions from 1:3 to 1:1/2 waste to stabilizing/fixing additives. This range is expected to provide adequate processing conditions for most wastes suited for stabilization/fixation. In addition, the chemical additions conveyor allows for addition of hydrolysis-crystalization promoting chemicals, if necessary. Excessive addition of stabilizing/fixing additives will result in a product that will pass the "paint filter test" but is uneconomical. Insufficient addition of stabilizing/fixing additives could result in an end product not suitable for landfill disposal and requiring reprocessing or other special handling resulting in additional labor costs and lost time. The laboratory, in specifying formulations reflective of actual process capabilities, will add a safety factor to the laboratory determinations to accommodate the scale up to the full size process where variables such as homogeneous mixing may not be achievable to the degree possible in the laboratory.

In the case where the chemical additive is needed, its mixture proportions would be included in the formulation. Typical applications by the hazardous waste stabilization/fixation processing speciality contractors have utilized this additive in proportions of approximately one to two tenth parts per part waste.

D-9c(3) Stabilization/Fixation Procedures and Control. The following section describes the procedures for stabilizing/fixing liquid and sludge/solid wastes and the related administrative and process controls.

D-9c(3)a Waste Stabilization/Fixation Processing Controls. Both administrative and process controls have been provided for the stabilization/fixation facility to assure processing to achieve a product suitable for landfilling and to prevent damage to equipment or inadvertent processing circumstances requiring implementation of the Contingency Plan and Emergency Procedures (Section G).

Administrative controls include the site wide use of the waste movement form to assure operator knowledge of the waste composition and inventory, pre-stabilization/fixation testing as required to either confirm or develop pre-acceptance test or redevelop stabilization/fixation formulations, and product discharge testing per the "paint filter test".

The site wide waste movement form would be applicable to any deliveries of sludge/solids to the Stabilization/Fixation Facility or any transfers of waste liquids to the Stabilization/Fixation Facility's batch tanks, including delivery from the Tank Farm tanks, tanker truck or liquid sump in the Stabilization/Fixation Facility. These forms are maintained in the laboratory, thereby resulting in cognizance of both the laboratory and plant operations personnel of any waste movements and providing a double administrative check.

The pre-stabilization/fixation testing serves as an administrative control to verify the generator waste pre-acceptance stabilization/fixation testing results. The originally developed formulations would be verified where, due to storage, mixing, conditioning, or intended mixing

with another waste matrix (sludge/solids or liquid), the laboratory personnel determines the waste stabilization/formulation may need to be revised. Liquid waste samples would be taken from the sample ports provided on the recycle lines of the storage tanks in the Tank farm prior to transfer to the batch tanks in the Stabilization/Fixation Facility (adequate mixing time corresponding to a minimum of one turnover of the tank contents shall be employed prior to sampling to ensure collection of a representative sample). A sludge/solid waste sample would be taken from the delivery truck as per the facility's Waste Analysis Plan.

Prior to transfer to the landfill, a representative sample of the stabilized/fixed waste batch being processed would be collected and subjected to the "paint filter test" to assure proper stabilization/ fixation processing has been achieved.

Through the collection and maintenance of the pre-acceptance stabilization/fixation test logs, pre-stabilization/fixation test logs, and the "paint filter test" logs, a data bank would be compiled that would serve as a basis for administrative decision and control and operation of the process for each type of waste or waste mixture to be processed to assure achievement of a product suitable for landfilling.

The operation of transferring liquid waste from the sumps or from tank trucks to the batch tanks is controlled with the use of the site waste movement forms, as described above. In addition, at the tank truck fill station, the administrative control measure of individually keyed locking caps is employed as discussed in the Tank Farm Section D-4e.

The process controls on the system can be grouped into equipment protection controls and feed controls to achieve specified mixture formulations. The equipment operation controls are automatic functions interlocking to shut-off motors, pumps or mixers to automatically protect the equipment from damage. The feed controls require operator adjustment.

The process control for setting waste to stabilizing/fixing additive mixture formulation consists of variable drives on the additive hopper feed screws and throttling valves on the liquid feed lines from the batch tanks. These controls are local and accessible to the operator from the personnel walkways at the respective equipment. It is intended to vary the additive hopper feed screw drive speeds and the liquid feedrate, if feeding liquids, around a preset sludge/solids feedrate from the belt conveyor. The variable speed controller on the belt conveyor is intended for adjustments based on actual sludge/solids density, not for adjustments to vary formulation ratios. All screw conveyors and the pug mill feed screw operate at single speeds suitable for transporting materials adequately over the variable feedrate ranges.

In addition, the lime feed to the batch tanks is a manual control loop for pH conditioning of the liquid waste in the batch tank. If necessary, to achieve the pH conditions discussed in Section D-9c(2) favoring the "pozzolanic" process, lime would be added to the tanks from the recirculating lime slurry system. Local pH indication is provided at the tanks along with high pH level alarm.

The equipment protection controls on the batch tanks are: high level alarm and shut-off of the feed pumps at the Tank Farm and low level alarm and shut-off of mixers and discharge pumps.

The low level alarm and pump/mixer shut-off is intended to both protect the equipment and alert the operator to make a decision as to whether an additional batch of the same liquid waste should be transferred from the Tank Farm Storage/Treatment Tanks or the batch tank should be emptied by use of a deadman switch on the pumps.

Speed monitoring instrumentation is provided on the motors driving all the screw conveyors, the belt conveyor and the pug mill screw feeder. These serve to shut down the entire system, including any liquid on low speed at any motor reflective of plugging of the screw by the material being transported. Specifically, this shut-down is to be performed in reverse sequential order from the discharge conveyor, i.e., sequential

shut-down in reverse to assure discharge of the waste inventory in the conveyors and pug mill. High temperature monitoring is provided on pug mill to shut down the system in the above same manner in the event of an excessive heat generation due to an improper neutralization reaction.

The procedures for responding to these circumstances are described in Section G, Contingency Plan and Emergency Procedures.

D-9c(3)b Operating Procedures Outline. The following outlines operating procedures for start-up, shut-down and batch tank filling and conditioning. This outline is not intended to serve as operating procedures; actual procedures would be developed during equipment purchase and construction, along with the associated operator log sheets. Manual operating steps are employed extensively to require the operator to interact with the processing, thereby introducing further administrative control.

Start-Up

Prior to start-up, the following prechecks shall be performed:

- Waste movement forms have been completed indicating the volume of wastes to be processed;
- Stabilization/fixation formulations have been specified;
- Liquid wastes, if any, mixers in the batch tanks are active, any feeding to the tanks has ceased, and the p^H is in the range 6.5 to 11;
- Sufficient stabilization/fixation additive(s) are available;
- All associated alarms are operative;
- Truck(s) for removal of discharge are available;
- The front-end loader is operable and active; and
- The laboratory is prepared to test the initial batch per the "paint filter test".

The stabilization/fixation additive(s) are then transferred from the hoppers to the local receivers. The formulations ratios are set at the

batch tank discharge and the receiver screw feeds; these formulations are set around a fixed sludge/solids feedrate from the belt conveyor.

All conveyors and screw feeders are then set active including the chemical additive auxiliary conveyor, if necessary. The belt conveyor speed is adjusted if the sludge/solids consistency varies significantly from the previous operations setting.

Stabilization/fixation additive feeding is started just prior to sludge/solids or liquid feeding to assure a mixture is discharged. Samples are composited from the initial discharge and subjected to paint filter test.

Shut-Down

When liquid wastes are being processed and the low level interlock alarms and shuts down the mixers and discharge pumps, or the waste inventory to be stabilized/fixed has been completely processed, manual shutdown is performed.

Shut-down is performed in a manner to empty the pug mill, conveyors and batch tanks so as to reduce residual holdup that could cake upon equipment surfaces requiring down-time for cleaning.

Where liquids are being processed and the batch tanks have shut down, the system shall be shut-down while the operations personnel evaluates if additional liquid wastes shall be transferred to the batch tanks.

The feeds are shut down first, all sludge/solids are removed from the tipping area and belt conveyor feeder hopper. Processing can continue without liquid feed sufficient to discharge this residual material.

Conveying equipment is shut down in the following order: belt conveyor, auxiliary conveyor, pug mill feed transfer conveyor, pug mill and discharge conveyor.

Were a batch to not pass the "paint filter test", the system would be shut down in accordance with the above-outlined procedures. The discharged material would then be delivered to the tipping area or sediment pit for reprocessing if it exhibited a liquid content requiring dewatering.

Visual inspection would serve to provide advance warning of a batch not appearing to have consistency suitable to pass the "paint filter test".

Batch Tank Filling and Conditioning

Prior to batch tank filling, the following prechecks shall be performed:

- Waste movement forms have been completed indicating the volume of waste to be processed and assuring compatibility
- Mixer and vent blower active
- Associated alarms are operable.

Valving is then aligned between the Tank Farm Storage/Treatment Tank tank, tanker truck or liquid pit. All other transfer line valving is closed to prevent backflow or any vapors. With the transfer pump active, the operator monitors the tank level indicator. Prior to activating the transfer pump, the inventory to be transferred is checked against available capacity; where filling is from tanker truck or liquid pit, an estimate of the transfer pumping time is established as a check. Monitoring of the truck meter is also employed to prevent overfilling.

Prior to batch tank conditioning, the following prechecks shall be performed:

- Verify the inventory of lime slurry in lime slurry tank T-14;
- Mixer active in lime slurry tank and system is on recirculation mode; and
- pH indication instrumentation and alarm active, flush if necessary.

Subsequent to inspection of the pH of the waste being treated and determination of the estimated volume of lime required for conditioning, the three-way valve on the recirculation system is set to bleed in lime. Consideration shall be given to the type of lime utilized in the lime slurry tank; high calcium hydrated lime will result in more rapid neutralization, while dolomitic lime will require a lag time of up to half an hour prior to recording pH change. In any event, the lime slurry addition would be performed in batches. Both the leveling out of the typical buffer curve and the high level pH alarm would provide operational flexibility to prevent pH adjustment over 11.

D-9d Materials Handling

The following section describes the stabilization/fixation additives and sludge/solids storage, handling and conveying. Quality control procedures for additives are also discussed.

D-9d(1) Sludge/Solids Handling. The sludge/solids are to be delivered by dump trucks in 10 cubic yard loads, to the Stabilization/Fixation Facility through the northeast truck bay (see Drawings B511-D-BC-20 through 22). The trucks will drop the load onto the tipping area floor where a front-end loader will serve to feed the sludge/solids into the belt conveyor feed hopper. ⚠

The feed hopper rests over the belt conveyor and is designed with a side feeding chute with an adjustable damper to assist in uniform feeding to the belt conveyor (see Drawing B5611-D-M22 for detail). Conveyor bottom pulley assembly rests over the conveyor pit to allow for the belt to be fed at grade and to contain any residuals spillage. ⚠

This arrangement protects the belt conveyor from receiving dropped loads directly, potentially overburdening and damaging it. In addition, the front-end loader will provide a materials checkpoint; large objects would be set aside for special handling.

The floor dimensions of the tipping area are approximately 16-1/2 feet wide by 24 ft long. The clearance over the tipping area extends to the roof. The truck bay height is 30 ft. An additional four foot by 16-1/2 foot triangular area extends off the feed hopper.

This area and the roof clearances are sufficient for the trucks to back in partially, raise the bed for unloading and drive out while leaving an area for the load and front-end loader maneuvering. The feed hopper has doors that extend out to the concrete barriers which serve to both contain the sludge/solids and protect the building structure from the truck traffic. Cement-filled pipe posts are located around the exterior of the building columns at the truck bays and the stairs and columns exposed in the interior for the same reasons.

The sludge/solids belt conveyor has cleats and sidewalls to facilitate conveying and is covered with a shroud after the feed hopper area.

The discharged stabilized/fixed solids drop off the discharge conveyor through a flex duct over the discharge area truck bay. This truck bay has a clearance of approximately 21 feet suitable for dump trucks with the bed in the down, load position.

D-9d(2) Stabilization/Fixation Additives Storage and Handling. The stabilization/fixation storage and transfer systems consists of three bulk storage silos located on the southern wall of the Stabilization/Fixation Facility building, each with pneumatic transfer to three receivers dropping to screw feeders overhead of the pug mill feed transfer conveyor (see Drawing B511D-SK25 for system diagram). The use of three bulk storage silos and receiver hoppers allow for segregation of fly ash, cement kiln dust and dry limestone. The bulk silos have capacities of 80, 100 and 80 cubic meters, respectively. Larger capacity is provided for cement kiln dust, as this is expected to be the primary additive used for stabilization/fixation. The bulk storage silos are to be filled from pressure differential trucks, which will pneumatically convey their load into the silos. The silo capacities are approximately one-third over capacity to the typical truck load of 60 cubic meters (2,000 cubic feet). The bulk silos have redundant level indicators.

Pneumatic transfer to the receiver hoppers is proposed. The pneumatic transfer of additives from the bulk silos to the receivers is to be performed by the use of blow tanks which fluidize batches of material under pressure, then on release of pressure, the suspended holdup is delivered to the receivers. The sequence is automatically controlled. This arrangement is more dependable and is expected to require less maintenance for these abrasives than the alternative rotary valve-pneumatic conveying. Level transmitters at the receivers interlock with the blowers to start-up or shut down the transfer on empty or full receivers.

Clumping and bridging is prevented by the use of vibrating bins dropping to the blow tanks on the silos and to the screw feeders on the receivers. In addition, the air delivered to the dust control fabric filters overhead each of the silos and receivers is dried to prevent moisture absorption and plugging of these vents. The blowers on the pneumatic transfer systems would introduce a sufficient temperature rise to vaporize any moisture in the transfer air.

The stabilization/fixation promoting chemicals (granular sodium silicate or polymer additives), if necessary, would be purchased in the 50 or 100 pound bags and be stored on the 34 foot elevation platform in the vicinity of the chemical additions auxiliary conveyor. The anhydrous form (Na_2 SiO_3) of sodium silicate should be used when this additive is desirable.

D-9e Equipment Description

This section describes the primary equipment items. Tables are included summarizing the fabrication and design specifications. A discussion of major process equipment follows. The equipment arrangement drawing series provides an overview of size and location of these equipment items (Drawings B511-BL20 to BL22).

D-9e(1) Inclined Sludge/Solids (Belt) Conveyor C-1. The Stabilization/Fixation Facility system will have an inclined belt conveyor

to transfer sludge/solid wastes to be stabilized/fixed to the pug mill. Table D-9-1 provides a summary of the fabrication and operating specifications. Drawing B511-D-M20 (Outline - Inclined Solids Conveyor C-1) provides a mechanical depiction of the unit. Section 6040, subsection 2.01, of the technical specifications provides detailed specifications for this item.

The belt conveyor extends 32 feet from the front-end loader feed hopper at grade elevation, where it is seated in the conveyor sump, to the pug mill feed hopper located at the intermediate platform on elevation 27 feet. Just above the front-end loader feed hopper, the belt is entirely enclosed by a shroud. The conveyor is inclined at approximately a 2 on 1 slope.

The materials of construction are as follows: structural components are carbon steel; belt housing and shroud are galvanized steel; the belt is oil-resistant rubber.

The 2' wide belt has 3-1/2" cleats and a 4" flexible sidewall to facilitate the sludge/solids transfer. The belt is driven by a variable speed five horsepower explosion-proof motor acting on the head pulley to provide a maximum 270 foot per minute belt travel. Lubrication fittings are provided for idlers and pulleys.

D-9e(2) Screw Conveyors. The Stabilization/Fixation Facility system employs three (3) screw conveyors to transport solids; the pug mill feed transfer conveyor C-2, the chemical additions conveyor C-3, and the pug mill discharge conveyor C-4. These items are depicted on Drawings B511-D-M21 and M22 and specified in Section 6040, subsection 2.02, of the technical specifications. Tables D-9-2 through D-9-4 summarize the fabrication and operating specifications for these conveyors.

TABLE D-9-1

PROPOSED INCLINED SLUDGE/SOLIDS CONVEYOR (C-1)

Conveyor C-1:	Belt Sludge/Solids conveyor
Design Functions:	Inclined conveyor for sludge/solids feed to pug mill
Materials of Construction:	Belt: oil resistant rubber (with cleats and sidewalls) Covers: galvanized steel Structure: carbon steel
Fabrication Standards:	See Section 6040 of Stabilization/Fixation Facility technical specification
Dimensions:	4'-6" x 32'4", 2' wide belt (see drawing B511-D-M20)
Capacity:	Design: 3 tons/hour Maximum: 5 tons/hour (100 cubic foot/hour of maximum 100 pound/cubic foot, 60-70% moisture material)
Power:	5 hp - 270 rpm
Location:	Elevation 0 to 20'

TABLE D-9-2

PROPOSED PUG MILL SCREW CONVEYOR (C-2)

Conveyor C-2	Screw Pug mill feed transfer conveyor
Design Functions	stabilization/fixation additives transfer from receivers to pug mill
Materials of Construction	316L SS
Fabrication Standards	See Section 6040 of Stabilization/Fixation Facility Technical Specification
Dimensions	1'-2" x 14'10", 9" diameter screw (see drawing B511-D-M20)
Capacity	Design: 7.5 tons/hour Maximum: 11.25 tons/hour (300 cubic foot/hour of maximum 75 pound/cubic foot material)
Power	3 hp - 60 rpm
Location	Elevation 20'

TABLE D-9-3

PROPOSED CHEMICAL ADDITIONS CONVEYOR (C-3)

Conveyor C-3:	Screw conveyor
Design Function:	Manual feed at additives chemical additives
Materials of Construction:	316 SS
Fabrication Standards:	See Section 6040 of Stabilization/Fixation Facility Technical specification
Dimensions:	1'-2" x 7'-10", 9" diameter screw (see drawing B511-D-M21)
Capacity:	Maximum: 3.7.5 tons/per hour (100 cubic foot/hour of 75 pounds/cubic foot material)
Power:	0.5 hp - 25 rpm
Location:	Elevation 34'

TABLE D-9-4

PROPOSED PUGMILL DISCHARGE CONVEYOR (C-4)

Conveyor C-4:	Screw conveyor
Design Function:	Transfer of stabilized/fixed material from pugmill discharge to landfill truck overhead position
Materials of Construction:	316 L SS
Fabrication Standards:	See Section 6040 of Stabilization/Fixation Facility Technical specification
Dimensions:	1'-5" x 19'-11", 12" diameter screw (see drawing B511-D-M22)
Capacity:	Design: 12 tons/hour maximum capacity: 15 tons/hour (300 cubic foot/hour of maximum 100 pounds/foot material)
Power:	5 hp - 30 rpm
Location:	Elevation 20'

The screw conveyors are all fabricated of 316L stainless steel. The screw are standard pitch, solid flight, right-hand orientation. Bronze bearings with external lubrication fittings are employed. The screw diameters are 9", excepting the discharge conveyor which as a 12" screw for the higher duty service.

The covers are flat bolt on and are provided with a limit switch at the discharge end to serve as a relief lid safety mechanism.

The conveyors are belt-driven by explosion-proof motors of capacity 1/2 horsepower for the auxiliary conveyor C-3, 3 horsepower for the additives conveyor C-2, and 5 horsepower for the discharge conveyor C-4.

D-9e(3) Pug Mill PM-1. The proposed pug mill is an all-welded and machined, skid-mounted unit, intended to be purchased as a pre-designed unit from a specialty vendor. Table D-9-5 summarizes the fabrication and operating specifications for these conveyors.

The unit is a horizontal, stationary shell, solids/liquids mixer with a rotating rotor. The rotor is a shaft with 3/4" diameter pins extending from it for a total 3' outer diameter. A constant speed feed screw, driven by a 3/4 horsepower motor, feeds the solids/sludges additives into the mill. Liquid feeds enter through a pipe in the shaft housing, overhead of the rotor. The overall unit is driven by a 15 horsepower motor to achieve 600 rpm. The shaft is supported by roller bearings at either side, outfitted with lubrication fittings.

The shaft on the housing is lined with a 1/2" thick, resilient, wear-resistant polyurethane based lining. The pins, which will have the most contact with the feeds, are constructed of an abrasion-resistant alloy with tungsten carbide tips.

The shaft and all other items that contact the feeds are constructed of heat-hardened steel for abrasion-resistance. The 1/16" clearance between the pin tips and the housing prevent buildup of material and reduce the holdup to an amount readily discharged during the winding down

TABLE D-9-5

PROPOSED PUGMILL PM-1

Conveyor PM-1:	Rotary mixer
Manufacturer:	Ferro-Tech Industries
Model No:	18T59
Design Function:	Receives waste sludge/solids and liquid feeds and stabilization/fixation additives; mix and discharge stabilized/fixed material
Materials of Construction:	1/2 inch lined carbon steel shell; hardened steel rotor; tungston-carbide tipped alloy mixers
Fabrication Standards:	See Section 6050 of Stabilization/Fixation Facility Technical specification
Dimensions:	Skid 6'x 4', 3' diameter rotor 12 tons/hour
Capacity:	12.0 tons/hour
Power:	15 hp - 600 rpm
Location:	Elevation 20'

of the motor on shutdown. The shaft housing has a bolted on cover fabricated in sections for ease of removal for inspection or cleaning of the shaft.

The pug mill is specified in Section 6050 of the Stabilization/Fixation Facility technical specification. △

The pug mill is located on elevation 20', entirely within the Stabilization/Fixation Facility building, wherein any spillage would be contained.

D-9e(4) Bulk Storage Silos and Receivers. The three bulk storage silos, S-1, S-2 and S-3 provide for bulk storage of the stabilization/fixation additives. The capacities of the fly ash (S-3), cement kiln dust (S-2) and dry limestone silos, are 80, 100 and 80 cubic meters, respectively.

The silos, pneumatic transfer system, and receivers are intended to be purchased as a pre-designed system from the materials handling/storage specialty vendors. This proposed system is depicted on Drawing B511-D-SK25. Table D-9-6 summarizes the fabrication and operating specifications for the silos.

The silos are to be constructed of welded or bolted mild steel with a primer and external coat of paint. The diameter of all three silos is 12 feet, while the heights are 24 feet for the 80 cubic meter silos S-1 and S-3, and 32 feet for the 100 cubic meter silo S-2. The silos are erected above dedicated 50 cubic foot blow tanks, each served by a 30 horsepower motor. Pneumatic transfer is automated to sequence as follows; slide gate valve opens to drop material to blow tank, blow tank is pressurized to fluidize material, butterfly valve opens causing blow tank holdup to transfer to receivers. This sequence is continued until the high level switch on the receivers shut off the blowers.

The silos are completely outfitted with access manholes, top and side-mounted level indicators, continuous cleaning pulse jet design filter

TABLE D-9-6

PROPOSED STABILIZATION BULK STORAGE SILOS S-1, S-2, S-3

Silos S-1, S-2, S-3:	Vertical bulk solids silos
Design Function:	Bulk storage of fly ash S-3 cement kiln dust S-2, dry limestone S-3
Materials of Construction:	Mild steel with primer and exterior coat, welded or bolted construction
Fabrication Standards:	See Section 6010 of Stabilization/Fixation Facility Technical specification
Dimensions:	12' diameter, 24'long for S-1 and S-3, 32'long for S-2; conical bottom. (see drawing B511-D-T22r
Capacity:	S-1 and S-3, 80 cubic meters S-2, 100 cubic meters
Location:	Elevation 0'
Transfer and Dust Control Accessories	Pneumatic transfer by line bottom bins to 50 cubic feet blow tanks; blower - 30 hp. Bon vent filter using filter tubes and continuous cleaning pulse jet design

tube bin vent filters for dust control, and live bottom bins for feed to blow tanks. Bin vent filters are fed dry compressed air to prevent clogging of the dust control vents.

All silos are filled by pressure differential truck through individually keyed locked caps adjacent to the Stabilization/Fixation Facility building near the silos. The silos are capable of holding approximately one and one-third volume of a truck, allowing for filling of a one-third full silo.

All silos, including the fly ash silo, are contained within the Stabilization/Fixation Facility floor slab with its curbing for spillage containment. The lower sections of the silos are enclosed in the Stabilization/Fixation Facility structure. The silos are accessed either at the grade level directly, at elevation 20 by the stairs leading around the silos on the root extension platform. Ladders extend up the silos for access to the top. The silos are supported by the Stabilization/Fixation Facility building's steel structure.

An outline of the silos is provided in Drawing B511-D-T22. The enclosure and location of the silos is depicted in Drawing B511-D-A21.

The stabilization/fixation additive receivers, T-10, T-11 and T-12, serve as local hoppers to provide an operating holdup over the additives feed conveyor. The capacity of each of the receivers is 75 cubic foot. The units are round vertical hoppers with conical bottoms, constructed of welded carbon steel with live bottom bms. The additive drops to a variable rate screw feeder, where the processing additives feedrate is set, which in turn drops to the pug mill additives feed conveyor C-2.

Each receiver is outfitted with bin vent filters with the same filter tube and continuous cleaning pulse jet design as the bulk storage silos.

The receivers are located on the intermediate platform at elevation 27 feet, which serves to provide access to their feeding mechanisms. The receivers, including the fly ash receiver, are located entirely within the

Stabilization/Fixation Facility building, and as such, any possible spillage would be contained by the building curbing. Table D-9-7 summarizes the technical and operating specifications for the receivers.

D-9e(5) Batch Tanks. The two batch tanks, T-9 and T-13, serve to provide a local quantity of waste liquid for processing. Both tanks have 2,000 gallons capacity and can be filled from their respective compatible waste feed storage tanks in the Tank Farm Storage/Treatment Facility, from the liquid pit in the building or from a tanker truck if special waste handling is needed.

The batch tank system is depicted on Drawing B511-D-SK24 and summarized in Tables D-9-8 and D-9-9.

Two tanks are provided to segregate the waste liquid feeds according to equipment fabrication material suitability and compatibility. T-9, serving to hold batches of solvents, oils and oil sludges in a 316L stainless steel vessel. T-13, serving to hold batches of aqueous waste and neutralized solutions of alkali and acid wastes delivered from the Tank Farm Storage/Treatment Facility's neutralization tank (T-3), is constructed of FRP.

Tank T-9 is to be fabricated in accordance with ASME Boiler and Pressure Vessel Code Section VIII for 15 pounds pressure as indicated on Drawing No. B511-B-T20. The calculated minimum wall thickness for the tank, assuming waste liquid contents of specific gravity 1.5, is 1/4 inch (see calculations in Appendix D-9.1). ⚠

Tank T-13 is to be fabricated in accordance with the applicable FRP code, ASTM D40-97 as indicated on Drawing No. B511-B-T21. The calculated minimum wall thickness for the tank, conservatively assuming waste liquid contents of specific gravity 1.5, is 1/4" and 3/8" for the dished bottom (see calculations in Appendix D-9.1).

These tanks are double-walled, with the second wall to serve as secondary containment. Liquid sensors in the annular space will alarm to

TABLE D-9-7

PROPOSED STABILIZATION/FIXATION ADDITIVES
RECEIVERS T-10, T-11, T-12

Receivers T-10, T-11, T-12:	Vertical batch operation hoppers
Design Function:	Provide local stabilization/fixation additive holdup for processing. Feed to additives feed conveyor
Materials of Construction:	Carbon steel, all welded
Fabrication Standards:	See Section 6010 of Stabilization/Fixation Facility Technical specification
Dimensions:	4' diameter, 7 1/2 long conical bottom
Capacity:	75 cubic feet
Location:	Intermediate platform at elevation 27'
Transfer and Dust Control Accessories:	Live bottom bin to screw feeders (5 tons/hour for T-11 and T-12, 2.5 tons (hour for T-10). Bin vent filter using filter tubes and continuous cleaning pulse jet design

TABLE D-9-8

PROPOSED BATCH TANK T-9

Tank No. T-9:	Batch tanks for solvents, oil sludge, oil
Design Function:	Provide for local holdup and conditioning of waste liquids to be stabilized/fixed (e.g. 1.0)
Materials of Construction:	316 SS
Fabrication Standards:	ASME Boiler and Pressure Vessel Code Section VIII
Maximum Pressure:	Atmospheric/design 15 pounds per sq. inch
Shell thickness:	a minimujm 1/4 inch
Corrosion Allowance:	1/32 inch
Capacity:	2,000 gallons

TABLE D-9-9

PROPOSED BATCH TANK T-13

Tank No. T-13:	Batch tanks for aqueous waste, solutions neutralized of the alkali and acid wastes
Design Function:	Provide for local holdup and conditioning of waste liquids to be stabilized/fixed (e.g. 1.5)
Materials of Construction:	FRP
Fabrication Standards:	ASTM D40-97
Shell thickness:	1/4 inch, 3/8 inch bottom shell
Corrosion Allowance:	10-20 miles synthetic surfacing mat (e.g. Dynel)
Maximum Pressure:	Atmospheric
Capacity:	2,000 gallons

indicate any leakage of the tank contents. The jacket and sensor act as a dedicated leak detection system on the tanks. Drainage is provided through the outer wall to allow for controlled collection of leakage. The tank would be taken out of service for repair in the event of detecting a leak.

D-9f Spill Containment

The Stabilization/Fixation Facility design incorporates spill containment capacity. A complete perimeter system of curbs and ramps surrounds the facility and interior drainage is controlled by floor drains and sumps.

Keyed into the grade slab is a six-inch curb, installed with water stop. At the truck bays and personnel exits, a six-inch ramp is provided.

The grade slab is epoxy-coated, diked and sloped to floor drains draining to a sump. The batch tanks have dedicated secondary containment in the form of the double-walled tanks described in Section D-9e, above.

The grade slab plan is depicted on Drawing B511-D-F21, with the curbing, ramp and other details shown on B511-D-F22. The surface is to be coated with a total 40 mils epoxy. The curbs and ramping serve to contain spillage, i.e., prevent run-off and prevent run-on.

A total of four (4) floor drains are located in subsections of the floor, each sloped to direct spillage to the drain. Drainage piping is to be HDPE pipe connected to the sump pit. The truck sludge/solids unloading area has a drainage ditch routed directly to the sump.

The sump design is a baffled pit with a grated cover depicted on Drawing B511-D-F23. The maximum total capacity of the pit is approximately 3,500 gallons.

The grating cover, and use of grating for the building elevation walkways allows for any spillage from the upper floors to drop down to the floor drains or directly to the sediment/liquid pit.

The design is intended to promote the separation of the liquid fraction of any spillage to allow this material to be pumped to the batch tank for stabilization/fixation. In addition, this arrangement allows for clarification of a waste sludge load, if necessary. These flow paths are depicted on Drawing B511-D-SK26, stabilization building P&I diagram. All waste movements from trucks into the pit or pumped out of the pit would be handled similar to any waste intended for stabilization/fixation processing as discussed in Section C.

The design of the sediment/liquid pit incorporates an HDPE lining, below the epoxy coated concrete surface, along with sampling wells constructed in the leak drainage section. This overall design results in a double barrier against leakage from the pit, which with inspection per Section F, will serve as a leak detection system. Thus, the sump system has been designed to meet Part B standards.

D-9g Personnel Safety/Fire Protection

Personnel safety protection has been included in the overall design of the Stabilization/Fixation Facility. This includes fire protection, eyewash/shower stations and walkway/exit designs facilitating emergency evacuation.

Fire protection is provided by a sprinkler system, dry chemical fire extinguishers, flammable gas detectors, and fire hose cabinets. These items and their locations are depicted on the equipment arrangement Drawings B511-D-BL20 and BL21.

A sprinkler system is to be installed over the pug mill equipment area. Two extinguishers are located at readily accessable locations on each of the three elevations; total 6. Flammable gas detectors/alarms are situated in the vicinity of the batch tanks and in sediment and conveyor sumps. In the latter locations they serve to alert personnel to any unnoticed holdup of solvent spills. The fabrication and installation of the fire protection system devices is specified in Section 6060 of the Tank Storage/Treatment facility.

In addition, equipment motors are protected from spark generation by an explosion-proof (NEC class 1, division 1, group C) specification on the latter).

Four (4) eyewash/shower stations, fed from the dedicated water tank system described in Section D-4 of the Tank form, are located at personnel traffic locations. Two are on the grade elevations, at the truck bay and to the rear of the sump, and one is on each of the other two levels at the stairwell exits. Drawings B511-C-P2 provides a detail of the eyewash/shower stations.

APPENDIX D-9.1

STABILIZATION/FIXATION FACILITY

Tank Calculations

Proteco, Inc.
Structural Calculations - Batch Tank
Dwg. # BS11-D-T20

Allstates Design &
Development Co., Inc.
One Oxford Valley, Suite 609
2300 East Lincoln Highway
Langhorne, PA 19047

A. Ziegler 1-30-86

I-9 Organic Batch Tank

S.G. = 1.5

Dia = 7'-0"
Straight Hgt = 7'-0"
Working Capacity = 2,000 gallons

Mat'l 316L SS

Design requirements are based on ASME Boiler and Pressure Vessel Code Section 8, Paragraph UG-27 "Thickness of Shells Under Internal Pressure."

The minimum thickness of cylindrical shells shall be the greater thickness as given by (1) or (2):

(1) $$t = \frac{PR}{SE - 0.6P}$$

(2) $$t = \frac{PR}{2SE + 0.4P}$$

Where:

t = minimum required thickness of shell, in.
P = design pressure, psig
R = inside radius of shell, in.
S = max. allowable stress value, psi
E = joint efficiency

Use a joint efficiency, E = 0.7 (from part UW-12).

S = 25,000 psi (from table UHA-23).

Using a design pressure of 15 psi:

(1) $$t = \frac{15 \times 42}{25{,}000\ (.7) - 0.6\ (15)}$$

t = 0.036"

(2) $$t = \frac{15 \times 42}{2\ (25{,}000)\ .7 + 0.4\ (15)}$$

t = 0.018"

The minimum required wall thickness using the ASME pressure vessel calculations with a 15 psi internal design pressure is 0.036".

However, due to external loading and rigidity considerations the tank minimum shell and head thickness should be 1/4".

Dwg # 8511-D-T21

I-13 Aqueous Batch Tank s.g. = 1.5

Dia. = 7'-0" (84")
Straight Hgt. = 7'-0" (84")
Working Capacity = 2,000 gallons

Design requirements are based on ASTM D4097-82, Section 6:

Straight shell wall thickness:

$$t = \frac{0.036\ \gamma\ HD}{2S_h}$$

where:

- t = wall thickness, in.
- S_h = allowable hoop tensile stress
- p = pressure, psig
- H = fluid head, in.
- γ = specific gravity
- D = inside dia. of tank, in.

$$t = \frac{0.[illegible](1.5)\ (84)\ (84)}{[illegible](1500)}$$

t = 0.127" < 3/16"

According to ASTM D4097, the straight shell wall thickness shall not be less than 3/16". Therefore, use 1/4" wall thickness.

Top Head - From ASTM D4097, Section 6.2.1: The minimum thickness of the top head shall be 3/16 in. Use 1/4"

Elevated dished bottom thickness:

From ASTM D4097 Section 6.3.4

Dwg. # B511-D-T21 cont'd.

$t = 0.885\ (0.036\ \gamma\ HR)/S$

$t = 0.885\ [0.036\ (1.5)\ (108 \times 84)]\ /\ 1500$

$t = 0.289"$ use 3/8" bottom thickness.

APPENDIX D-9.2

STABILIZATION/FIXATION FACILITY

Technical Specifications

This material was previously submitted on January 31, 1986; PROTECO PROJECT MASTER DOCUMENTS LIST - Plans and Specifications.

SECTION E - GROUNWATER MONITORING PLAN

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SECTION E

GROUNDWATER MONITORING PROGRAM
SAMPLING AND ANALYSIS PLAN

I. INTRODUCTION

This document was prepared in accordance with the requirements set forth by the United States Environmental Protection Agency (USEPA) and the Puerto Rico Environmental Quality Board (EQB), pursuant to the Resource Conservation and Recovery Act (RCRA). This document was specifically designed in compliance with paragraphs 265.91 and 265.92 of the Act and describes the Groundwater Monitoring Program and Sampling and Analysis Plan for proposed new disposal units for the Proteccion Tecnica Ecologica, Inc. (PROTECO) Facility in Penuelas, Puerto Rico.

The water-bearing zones at PROTECO are not well defined at this time. Lateral extent of the zones needs to be determined. A work plan outlining additional tasks to define the extent of water bearing zones is being prepared and will be submitted by February 11, 1986. For these reasons, the locations of proposed wells in this report are subject to relocation after obtaining more hydrogeologic information.

The primary objective of the PROTECO Groundwater Monitoring Program and Sampling Analysis Plan is to evaluate the impact of individual regulated units on the quality of groundwater underlying the facility. This Groundwater Monitoring Program was developed to monitor the uppermost aquifer or water-bearing geologic unit beneath proposed new regulated units at the facility. This general approach to groundwater monitoring is appropriate because the uppermost water-bearing geologic unit is the most probable route for contaminant migration from individual regulated units. Monitoring of this zone would therefore provide the earliest possible detection of leakage from regulated units.

The PROTECO Groundwater Monitoring Program consists of point of compliance monitoring wells located downgradient from each regulated unit. Regulated unit specific water quality parameters have been established for each existing unit based upon the type of waste(s) expected to be placed in the subject unit. In this way, the groundwater monitoring network in conjunction with procedures described in the Sampling and Analysis Plan, should be capable of detecting leakage from regulated units.

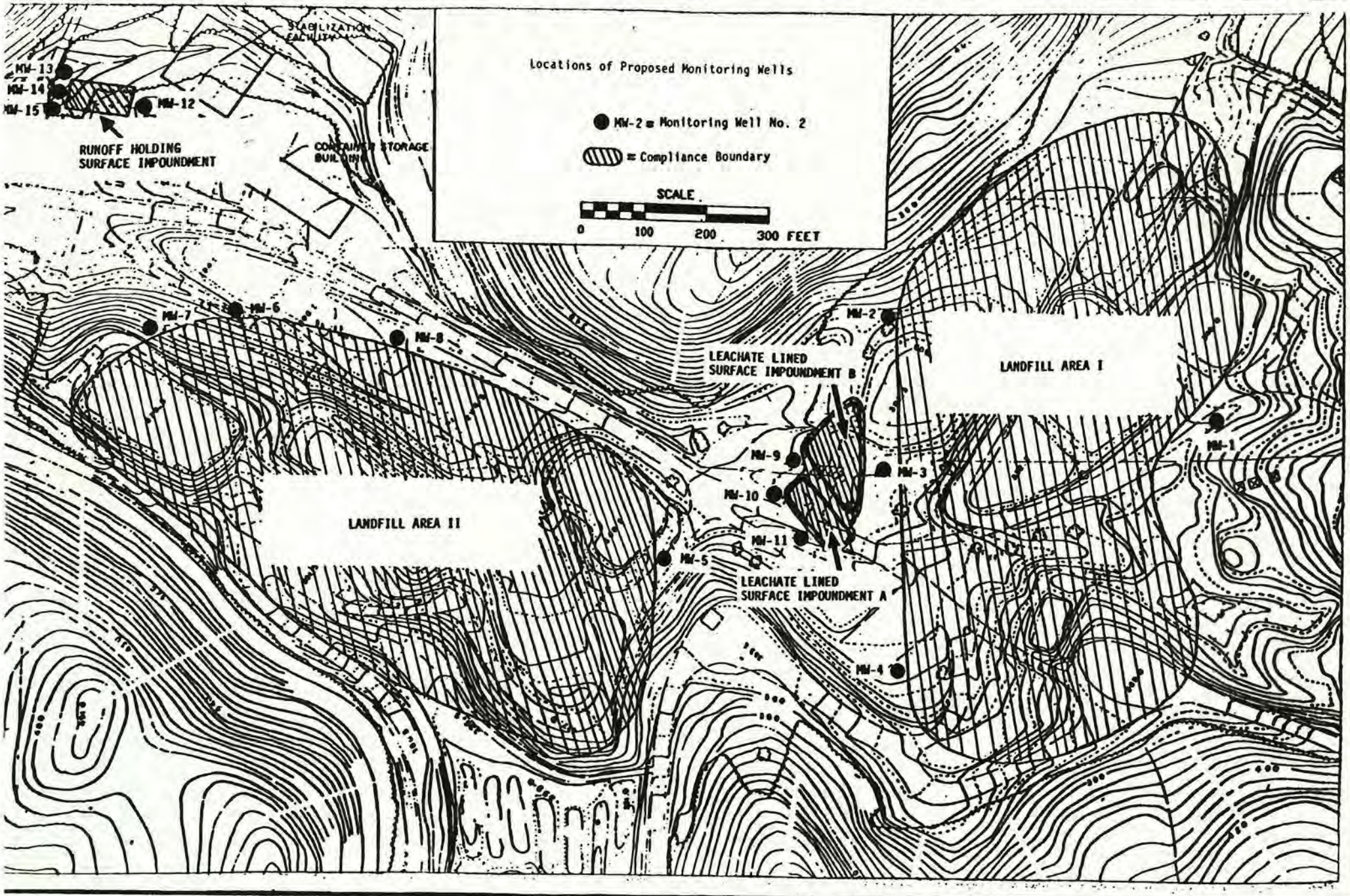
This Groundwater Monitoring Program applies to the monitoring of four (4) proposed regulated units. These are Landfill Area 1, Landfill Area 2, two (2) Leachate Lined Surface Impoundments and a Runoff Holding Surface Impoundment associated with the tank farm storage and treatment facility. The location of these proposed regulated units is illustrated on Figure E-1.

II. DESCRIPTION OF GROUNDWATER MONITORING NETWORK

In accordance with Subpart F - Groundwater Monitoring, paragraph 265.91, the Groundwater Monitoring Network for each regulated unit at the PROTECO facility will consist of three (3) hydraulically downgradient monitoring wells installed at the limit of the waste management area or by definition, the point of compliance. Furthermore, monitoring wells (downgradient and upgradient wells) are located in compliance with paragraph 264.97 to yield groundwater samples from the uppermost water-bearing geologic unit. These samples are representative of the quality of groundwater passing the point of compliance for each regulated unit and representative of background groundwater that has not been affected by leakage from a regulated unit. A description of the groundwater monitoring network for each regulated unit, existing and proposed, is listed below.

Proposed Units:

Landfill Area I:


Locations of Proposed Monitoring Wells
MW-2 = Monitoring Well No. 2
= Compliance Boundary
SCALE
0
100
200
300 FEET
STABILIZATION FACILITY
MW-13
MW-14
MW-15
MW-12
RUNOFF HOLDING SURFACE IMPOUNDMENT
CONTAINER STORAGE BUILDING
MW-7
MW-6
MW-8
MW-2
LEACHATE LINED SURFACE IMPOUNDMENT B
LANDFILL AREA I
MW-1
MW-9
MW-3
MW-10
LANDFILL AREA II
MW-11
MW-5
LEACHATE LINED SURFACE IMPOUNDMENT A
MW-4

Landfill Areas 1 and 2 will be double lined according to the Minimum Technology Guidance on Double Liner Systems draft generated by the EPA. Each landfill will have its own monitoring network. The individual monitoring networks are described in the following sections.

The groundwater monitoring network for this regulated unit consists of three (3) downgradient point of compliance monitoring wells and one (1) upgradient monitoring well. The proposed location of each monitoring well in this network is illustrated in Figure E-1. Each monitoring well will be completed to yield samples from the uppermost water-bearing geologic unit underlying Landfill Area 2. The downgradient monitoring wells are identified as MW-6, MW-7 and MW-8. The upgradient monitoring well is identified as MW-5. Well construction specifications for each well are described in Section III and a table summarizing the details of construction of each well is presented in Table E-1. Specifications such as elevation, depth and screened interval were estimated based on existing hydrogeologic knowledge of the area and will be updated after well installation.

Leachate Surface Impoundments:

Two (2) lined surface impoundments, Leachate Impoundment A and Leachate Impoundment B have been designed for the storage and treatment of leachate generated from the landfills. The impoundments will be double lined according to the Minimum Technology Guidance on Double Liner Systems EPA draft. Due to space restrictions, the two impoundments will share one monitoring network consisting of three (3) downgradient point of compliance monitoring wells and one (1) upgradient monitoring well. The locations of the impoundments and the proposed monitoring wells are illustrated in Figure E-1. As is made evident by Figure E-1; the two impoundments are in close proximity to one another. Additionally, the sediment basin is located adjacent to the southwestern edge of Leachate Impoundment B, although the sediment basin is not a regluated unit. Dikes access roads will separate the Leachate Impoundments and the sediment basin.

PROPOSED REGULATED UNIT MONITORING WELL SPECIFICATIONS

Well No.	Monitored Unit	Approx. Ele. TOC (FT)	Est. Total Depth (FT)	Est. Screened Internal (FT)	Screen Length (FT)	Slot Size (IN)	Well Diameter (ID)(IN)	Casing Material	Hydrogeologic Position Relative to Regulated Monitored Unit
MW - 1 (I)	Landfill Area I	347	95	85-95	10	0.01	2	Teflon	Upgradient
MW - 2 (I)	Landfill Area I	316	45	35-45	10	0.01	2	Teflon	Downgradient
MW - 3 (I)	Landfill Area I	295	50	40-50	10	0.01	2	Teflon	Downgradient and upgradient for Surface Impoundment
MW - 4 (I)	Landfill Area I	300	60	50-60	10	0.01	2	Teflon	Downgradient
MW - 5 (II)	Landfill Area II	318	70	60-70	10	0.01	2	Teflon	Upgradient
MW - 6 (II)	Landfill Area II	280	45	35-45	10	0.01	2	Teflon	Downgradient
MW - 7 (II)	Landfill Area II	308	70	60-70	10	0.01	2	Teflon	Downgradient
MW - 8 (II)	Landfill Area II	274	50	40-50	10	0.01	2	Teflon	Downgradient
MW - 9	Leachate Surface Impoundment	306	50	40-50	10	0.01	2	Teflon	Dowgradient
MW - 10	Leachate Surface Impoundment	310	50	40-50	10	0.01	2	Teflon	Downgradient
MW - 11	Leachate Surface Impoundment	318	60	50-60	10	0.01	2	Teflon	Upgradient
MW - 12	Runoff Holding Surface Impoundment	280	55	45-55	10	0.01	2	Teflon	Downgradient
MW - 13	Runoff Holding Surface Impoundment	274	55	45-55	10	0.01	2	Teflon	Downgradient
MW - 14	Runoff Holding Surface Impoundment	262	55	45-55	10	0.01	2	Teflon	Downgradient
MW - 15	Runoff Holding Surface Impoundment	258	50	40-50	10	0.01	2	Teflon	

(0597B-1)

One monitoring network, instead of two was chosen because in order to design two points of compliance monitoring networks downgradient of each Leachate Impoundment, it would be necessary to install some of the monitoring wells in too close proximity to the impoundments, in the way of maintenance roadways. Further, the depth to groundwater compared to the horizontal segregation distance between the units makes unit-specific monitoring technically questionable at best.

Each monitoring well will be completed to yield samples from the uppermost water-bearing geologic unit underlying the leachate impoundments. The downgradient monitoring wells are designated as MW-9, MW-10 and MW-11. The upgradient monitoring well is designated as MW-3. Well construction specifications for each well are described in Section III and a data table summarizing the construction details is presented in Table E-1. Specifications such as elevation, depth and screened interval are estimates based on existing hydrogeologic knowledge of the area and will be updated after well installation.

Runoff Holding Surface Impoundment:

This impoundment has been designed to collect any significant spills that would occur in the tank containment area. The impoundment will be double-lined according to the Minimum Technology Guidance on Double Liner Systems EPA draft. The groundwater monitoring network for this regulated unit consists of three (3) downgradient point of compliance monitoring wells and one (1) upgradient monitoring well. The proposed location of each monitoring well in this network is illustrated in Figure E-1. Each monitoring well will be completed to yield samples from the uppermost water-bearing unit underlying the Runoff Holding Surface Impoundment. The downgradient monitoring wells are identified as MW-13, MW-14 and MW-15. The upgradient monitoring well is identified as MW-12. Well construction specifications for each well are described in Section III and a table summarizing the construction details is presented in Table E-1. Specifications such as elevation, depth and screened interval are estimates based on existing hydrogeologic knowledge of the area and will be updated after installation.

III. MONITORING WELL CONSTRUCTION

Monitoring wells installed as a part of the groundwater monitoring network for each regulated unit have been and will be constructed of 2 inch inside diameter (ID) teflon or PVC riser pipe (threaded flush joint) and 2 inch ID machine slot well screen (Teflon or PVC). To insure the compatibility of monitoring well materials with the types of wastes present in existing and proposed regulated units, all permanent monitoring wells installed for the groundwater monitoring of proposed regulated units will be constructed of teflon well screen and riser pipe. PVC well construction materials will be phased out of service and existing monitoring wells constructed with PVC materials will only be utilized to obtain water level data. The annular space around the well screen will be backfilled with chemically inert sand to a depth two feet above the top of each screen. A two foot bentonite seal will be placed above the sand and the remainder of the annulus will be backfilled to the surface with a mixture of six (6) parts Portland Type I cement to three (3) parts water and one (1) part bentonite. The monitoring well installation will be protected at the surface by the placement of a one (1) foot cement seal at the top of the cement-bentonite slurry to prevent the leakage of fluids from the surface into the annulus and ultimately the monitoring detection zone.

Each monitoring well will be fitted with an outer protective casing with a locking cap to prevent tampering. The protective casing is 4 inch ID steel and is installed to a minimum depth of two feet below the ground surface.

Each monitoring well is to be developed by surging and bailing to clear the well screen of fines and induce groundwater flow into the well. Each monitoring well is to be developed a minimum of two times to insure that each well yields groundwater with a minimum concentration of suspended solids. Diagrams illustrating the construction of existing regulated unit monitoring wells is presented in Appendix E.1

IV. MONITORING PARAMETERS

The Groundwater Monitoring Program For Proposed Facilities is designed to monitor the water quality of the individual regulated units. A list of parameters will be developed as the leachate is produced in the landfills. At this time, the exact wastes to be placed in each of the proposed facilities are not known. For this reason, the following list of general indicator parameters will be monitored until the wastes leachate can be further monitored.

Non-Priority Pollutants - Volatile Organic Compounds

Pesticides - PCB's
Total Organic Carbon (TOC)
Total Petroleum Hydrocarbons
Total Dissolved Solids (TDS)
Total RCRA Metals
pH
Specific Conductance

This list of parameters will be modified when leachate monitoring data is available. The specific parameteres will then be based upon the analyses of samples from the leachate collection system along with consideration of wastes sliced in the unit. The parameters will be selected in order to characterize those contaminants present in the subject wastes which are the most mobile and persistent in the system. A semi-annual review of waste streams and leachate will be conducted and monitoring parameters updated as necessary.

V. SAMPLING AND ANALYTICAL PROCEDURES

GENERAL - The purpose for sampling groundwater monitoring wells at the PROTECO Facility is to collect valid representative groundwater quality data from the geologic materials underlying each regulated unit. In order to accomplish this, a number of steps must be taken to assure proper sample collection and hence the collection of valid comparable data. All samples will be collected and handled in accordance with accepted USEPA Standard procedures, as described below.

All groundwater monitoring wells which are included as part of the monitoring program will be sampled within a short time period (1 day) during each sampling campaign. This will help provide an overall understanding of the groundwater quality throughout the hydrogeologic regime underlying the facility at the time of sampling. When conducting each sampling campaign, work will always begin at the background location and proceed downgradient. This is an added precautionary measure which helps assure that the background sample will not be affected by any materials from the downgradient locations. Protecting the integrity of the background sample is critical because these values will be used to set the standards for comparisons with downgradient values.

DETERMINATION OF WELL EVACUATION REQUIREMENTS - Before any groundwater samples are collected for chemical analysis, great care will be taken to assure that the sample is representative of groundwater quality in the geologic materials in the vicinity of the well, and not of standing water in the well. In order to make such an assurance, each well will be properly prepared prior to sample collection. Preparation involves removing water from the well until all standing water which is present in the well has been evacuated.

The first step of the well evacuation process is to determine the actual volume of standing water that is present in the well. This will be accomplished by solving the following equation:

$$V = 5.88\ D^2\ (Lwc - Ldtw)$$

where: V = Standing Volume of Water in the Well (Gallons)
D = Diameter of the Well Casing (Feet)
Lwc = Total Length of the Well Casing (Feet)
Ldtw = Depth to Water in the Well (Feet)

Once the volume of standing water in each well has been calculated, the total volume of water that must be removed prior to sample collection is determined by multiplying the standing volume by the number of volumes to be evacuated. A minimum of three (3) well volumes will be evacuated prior to sampling, if possible. If three well volumes are not available within a reasonable time period, as many volumes as possible will be evacuated.

In addition to enabling a calculation of the standing volume of water in the well, precise water level measurements (to 0.1 inch accuracy) will provide the necessary information to construct a potentiometric surface contour map. Such a map will indicate both the direction and gradient of groundwater flow, and help define the particular hydrogeologic site conditions existing at the time of sampling. This type of information is very important for comparing the hydrogeologic conditions (i.e. seasonal affects) existing from one quarterly sampling campaign to another, and is necessary when interpreting sampling analysis data.

For the above mentioned reasons, and given the fact that confined conditions with anticipated low horizontal flow gradients are expected at the PROTECO Facility it is very important that precise groundwater elevations be measured. As such, a complete round of water level measurements will be made at the start of each sampling campaign prior to the evacuation of any water. A transistorized water level indicator calibrated in feet will be used w/refined measurements to 0.1 inch obtained manually with a mechanical rule. The depth-to-water measurements will be used to determine 1) the volume of standing water in each of the wells which were described earlier and 2) groundwater flow rate and direction as outlined below. A weighted line will also be used to sound the wells in order to verify the total well depths as listed on Table E-1.

DETERMINATION OF GROUNDWATER FLOW DIRECTION - The most important factor for determining the direction of groundwater flow within a given aquifer, is the gradient of the water table or potentiometric surface. This gradient is interpreted from water level measurements which are taken from the groundwater monitoring wells that are screened within this interval (upper most water bearing geologic unit) below the site. The resulting groundwater elevations, or potentiometric surface, is then plotted on a base map and equipotential lines are drawn, resulting in the construction of a potentiometric surface contour map. The direction of groundwater flow is then indicated as being perpendicular to the equipotential lines in a direction from higher to lower head.

In order to gather the needed groundwater elevation data, it is important to know the elevation, above mean sea level, of the measuring point at each well, and to make precise depth-to-water measurements in each well. The elevation of the top of the casings (TOC) at the PROTECO Facility have been determined by a licensed surveyor to 0.01 foot accuracy. Accurate depth-to-water measurements will be made with a transistorized water level indicator calibrated in feet aided by mechanical rule, measurements to 0.1 inch prior to quarterly well sampling. Once the depth to water in the well has been measured, this value is subtracted from the known elevation of the measuring point at the top of the well casing. The resulting value is the elevation above mean sea level of the water in each well. These values are then used to construct the potentiometric surface map. A potentiometric surface map of this kind will be produced from data collected at the PROTECO Facility and will be updated annually.

DETERMINATION OF GROUNDWATER FLOW RATE - The rate at which groundwater flows through any given geologic material can be estimated by the use of a modified form of Darcy's Law. The resulting equation is as follows:

$$V = \frac{-KI}{n}$$

where: V = the average linear velocity of the groundwater (ft/day)

K = the hydraulic conductivity of the geologic material through which the groundwater is flowing (ft/day)

I = the hydraulic gradient [the difference in height (ft) of the potentiometric surface between the two measuring points, divided by the horizontal distance (ft) between the two measuring points].

n = the effective porosity of the geologic material through which the groundwater is flowing.

Laboratory grain size analyses have been conducted on samples collected during the drilling of test borings at the PROTECO Facility. Such analyses have provided information which is useful in determining a (K) value for the above equation.

The movement of groundwater, its rate as well as direction, is controlled to a large extent by permeability contrasts. Several measurements of the permeability of different lithologies encountered were made during the construction of the test holes. There are two generally accepted techniques for determining permeability. A pump-in test is used for unsaturated deposits in the vadose zone above the water table (Bouwer, 1978, p. 129). A rate-of-rise (or fall) test, also known as a bailer of slug test, is used for saturated deposits below the water table (Freeze, 1979, p. 339; and Bouwer, 1978, p. 113). In-situ tests such as these provide more representative data than laboratory tests of cores because they can be used to evaluate the properties of a greater volume of undisturbed section of material. Pump-in tests require the addition of water to a borehole until a constant rate of inflow results in a constant head build-up in order to be able to calculate permeability.

WELL EVACUATION METHOD - Given the small diameter of the wells and the associated low yield characteristics of each well, the proposed method for well evacuation is manual bailing. Pumping methods are not feasible due to the extremely rapid drawdown rates observed in the monitoring wells. The elimination of introducing pump materials into the wells is helpful in

reducing the risk of cross-contamination from inadequate pump decontamination efforts. Manual bailing will be accomplished with the use of a 1 1/2 inch diameter, bottom-loading, teflon bailers with a teflon check valve. Each bailer will be three feet in length and each well will have a dedicated bailer to help prevent cross-contamination between wells.

When bailing a well, an attempt will be made to remove the standing water from the top of the water column to the bottom. In this way, the possibility of any standing water remaining in the well is drastically reduced. Furthermore, bailing will proceed at a rapid enough pace to draw the water down and cause the well to go dry. In order to facilitate this effort, a tripod for lowering and raising the bailer into and out of the well should be utilized. Such apparatus will also help keep the teflon cord clean by coiling it on a spool, rather than on the ground, and reduce the risk of introducing contaminants into the well.

SAMPLE COLLECTION - Once the groundwater monitoring wells have been adequately evacuated, they are ready to be sampled. All groundwater samples will be collected with the same bailer used to evacuate the well from which the samples are obtained. Prior to use for initial evacuation and sampling, each bailer will be prepared and stored in the following manner:

1. Each bailer will be rinsed with tap water.
2. The bailers are then washed with methanol.
3. After being rinsed with acetone, they are allowed to air dry.
4. The bailer will then be rinsed with distilled water and again be allowed to dry.
5. Cleaned bailers will be dedicated to each well. They will be stored in the wells in a manner to prevent cross contamination.

Because the groundwater monitoring wells at the PROTECO Facility are so slow to recover, a considerable amount of time may be allowed to pass between the completion of well evacuation and the commencement of sample collection. For this reason, it is possible that recharged water resting at the top of the water column may go through a slight chemical alteration

as a result of contact with air in the well casing. To minimize this effect, where possible three bails of water will be wasted onto the ground before any groundwater samples are retained. Where this is unfeasible due to lack of water, only one bail of water will be wasted. This practice will also tend to rinse out any water which remains in the bailer after well evacuation. A minimum of seven liters should be sampled from each groundwater monitoring well. The groundwater samples are poured from the bailers directly into one liter wide mouth glass and plastic bottles provided by the laboratory. In accordance with current EPA guidance, one of these samples is filtered through a 0.45 um membrane for use in the Total Dissolved Metals Analysis. The sample bottles are sterilized at the laboratory by washing in HNO_3 and then rinsed with distilled water. The samples are preserved at the laboratory within twenty-four hours of sample collection. All sample analyses are performed in the laboratory. A description of the bottle types and preservation requirements for the various parameters are listed in Section IV.

CHAIN-OF-CUSTODY AND SAMPLE SHIPMENT PROCEDURES - Proper chain-of-custody procedures will be followed for all groundwater sample handling from the time of collection through final analyses at the laboratory. These procedures are necessary to insure the integrity of the sample through its various phases of possession transfer. It accomplishes this by providing a mechanism to trace the possession of the sample until the final analyses results have been reported. In order to achieve this, the sample must be in the responsible parties' physical possession and secured in a manner that prevents tampering by unauthorized personnel. A number of mechanisms will be followed to guarantee that the above-mentioned criteria have been met, and include the following elements: (1) sample labels, (2) chain-of-custody seals, (3) a chain-of-custody record form, (4) a sample analysis request sheet, and (5) sample shipment procedures.

1. Sample Labels - Sample labels are very important for identifying where each sample has been collected. The labels will be made from gummed paper and will be filled out and affixed to the bottle in the field just prior to sample collection. It is important that this order be followed for label application, because once the cool groundwater is placed into

the sample bottle, water will begin to condense on the bottle, making it difficult to affix the label at that time. It may also be helpful to cover the label with transparent tape to assure that the label does not come off during sample shipment. The sample label will contain the following information: (1) sample number, (2) the collection date, (3) the name of the collector, and (4) the sampling location (i.e., well number).

2. Chain-of Custody Seals - These seals will be placed over the lid of the coolers containing the samples for shipment to the lab. The seals will be placed in a location where they will have to be broken in order to reach the samples. Each cooler being used to ship samples will have its own seal. The seal should have the collector's signature and the sampling date written on it. It is also important that this seal be placed onto the coolers before the samples leave the custody of the sample collector.

3. Chain-of-Custody Record Form - Chain-of-custody record forms will be filled out for each sample and will accompany the sample as it changes possession. The purpose for maintaining such documentation is to allow a trace to be made of sample possession. A copy of the chain-of-custody record form, showing all the information that will be required on the form, appears as Figure E-2.

4. Sample Analyses Request Sheet - Sample analyses request sheets will be supplied by the laboratory and will serve as the major communication mechanism between the sample collector and the laboratory. They indicate which analyses are required for the samples. There will be at least two copies of each form; one will remain at the lab while the other will be returned to PROTECO and be retained as part of the PROTECO records. A portion of the form will be filled out by the person collecting the sample in the field and will contain information pertaining to sample collection details (i.e., sample number and analysis is requested, sample location, collection date and time, collector's name and phone number, etc.). The remaining portion of the form will be filled out by laboratory personnel and will contain the following information: name of person receiving the sample, laboratory sample number, date of sample receipt and analyses to be performed.

FIGURE E-2

PROTECCION TECNICA ECOLOGICA, INC. (PROTECO)

FIRM DELIVERY

PONCE, PUERTO RICO

CHAIN OF CUSTODY RECORD FOR
GROUNDWATER MONITORING PROGRAM

Lab Sample No. _____
_____
_____
_____
_____

Sampling Locations: _____

Collector's Name: _____ Telephone: (___) _____
SIGNATURE

Date Sampled: _____ Time Sampled: _____ hours _____

Field Information: _____
_____
_____

Sample Receiver:

1. _____
name and address of organization receiving sample

2. _____
3. _____

Chain of Possession:

1. _____ _____ _____
signature title inclusive dates

2. _____ _____ _____
signature title inclusive dates

3. _____ _____ _____
signature title inclusive dates

(0597B-10)

5. Sample Shipment Procedures - As indicated earlier, all samples will be shipped to the laboratory in coolers. The coolers will be packed at the site in a manner which assures safe transport of all sample bottles within. This will be accomplished by packing the properly labeled and filled sample bottles in vermiculite to prevent the bottles from falling over and/or breaking. Ice-filled plastic bags will be placed around the bottles within the vermiculite. Once the samples and the ice have been placed in the coolers, all excess space will be filled with additional vermiculite to hold the bottles in place. The chain-of-custody record forms and sample analyses request forms will be placed inside the coolers. The coolers will then be sealed with heavy-duty tape and fitted with custody seals over the lid. All samples will be delivered to the lab within 20 hours of collection.

Recordkeeping - Thorough and detailed records will be kept of all groundwater monitoring well sampling procedures performed at PROTECO including both well evacuation and sample collection details. This information will primarily be recorded in two places; prepared field work sheets and a field log book. The field work sheet will primarily contain information pertaining to well preparation prior to sample collection. (Note: sample collection details will be kept on the chain-of-custody forms, the analyses request sheets, and in the field log book). This sheet will be filled out in the field to allow for a determination of the volume of water which must be removed from the well prior to sample collection. A copy of this work sheet appears as Figure E-3.

In addition to the field work sheet, a detailed account of all groundwater sampling procedures will be kept in a field log book. The primary purpose for utilizing such a book is to record enough information about the sampling procedures, so the entire event can be reconstructed without the need to rely on the sample collector's memory. The log book should consist of bound pages which are consecutively numbered. At a minimum, the following information will be included in the field log book for work done at each well:

FIGURE E-3

PROTECO
GROUNDWATER MONITORING WELL SAMPLING
FIELD WORK SHEET

1. Date: _____/ _____/ _____.
2. Personnel Present: _____, _____, _____, _____
3. Well ID: # _____
4. Does the well show any sign of tampering? Yes _____ No _____

   If yes, describe:

5. Depth of well (L_{wc}): _____ feet.

6. Depth to water (L_{dtw}): _____ feet.
7. Height of water column in well: _____ feet (Item 5 less Item 6).
8. Diameter of well: _____ inches or _____ feet.
9. Volume of standing water in well: _____ gallons
10. Amount of water removed from well prior to sampling.

Date:	Time Start:	Time Stop:	# of Gallons Removed:

* Total Gallons Removed: _____

* (This value must at least be equal to the volume noted in Table E-5.)

(0597B-11)

- Sampling location (well number)
- Date and personnel present
- Purpose for sampling (i.e., quarterly sampling for detection monitoring background determination)
- Depth-to-water measurement
- Well evacuation method and volumes removed prior to sample collection
- Name of sample collector
- Time of sampling
- Sampling method
- Sample I.D. number (from lab analyses request sheets)
- Type of preservation used
- Appearance of each sample including the results of any analyses done in the field
- Sample shipment details (i.e., when shipped, by whom, to where)
- Analyses to be performed

The log book will be kept in a safe location at the PROTECO office when not being used in the field, and will always be available for inspection. All records pertaining to the groundwater monitoring program will be retained at the PROTECO office for the life of the facility and during the post-closure care period.

ANALYTICAL PROCEDURES - PROTECO is presently using Environmental Quality Laboratories, Inc. (EQLab) in Santurce, Puerto Rico to analyze groundwater samples taken in conjunction with the groundwater monitoring program. Other laboratories that could be used for these analyses include Caribtec in San Juan, Envirolab in Ponce, and Omni Research in San German. EQlab maintains a log book of records documenting the chain of custody of each sample, and the status of each samples analysis.

For metals, except where the analytical techniques requires otherwise, each sample will be split into two aliquots. One aliquot will be filtered and analyzed for dissolved metals. The other aliquot will not be filtered and will be analyzed for "total recoverable" metals. These procedures,

outlined in Methods for Chemical Analysis of Water and Wastes, are designed to yield "total" concentrations of "dissolved recoverable" metals before acidification. Sample preparation for other inorganic parameters should also be based on measuring the total effect of each parameter on the sample.

Specific conductance, pH and temperature will be analyzed in the field by PROTECO using portable test meters after January 1, 1986. Exposure to the atmosphere, temperature change, and the addition of preservatives can initiate changes in these parameters.

Table E-2 describes the test methods that are used by the laboratory (i.e., (EQLab) to measure each of the analytical parameters used in the groundwater detection monitoring program at PROTECO. The table also lists a reference source for each method. Under normal circumstances, the time elapsed between receipt of a sample and analysis is dependent on the holding time for the various tests, between 24 hours and 20 days. Holding times for several parameters such as Phenols, Total Organic Carbon and specific conductance, and pH are as short is 6 to 24 hours. These holding times are based on Table 1 of Manual of Groundwater Sampling Procedures by Marion R. Scalf, James F. McNabb et al, NWWA/EPA Series, 1981. Table E-3 indicates holding times for individual constituents to be analyzed. Complete analyses including quality assurance/quality control results will be available to PROTECO within two months of sampling date.

STATISTICAL PROCEDURES - The use of statistical procedures in groundwater monitoring programs is to compare groundwater quality data from downgradient wells that have been potentially or actually affected by a subject facility with groundwater quality data from background wells. These comparisons are based on statistical tests which determine if significant differences exist between the two sets of water quality data for individual parameters.

For detection monitoring, the USEPA has recommended that a specific statistical test be used for comparison of data between background and downgradient wells. This statistical test, Cochran's Approximation to the

PARAMETERS AND TEST METHODS

Parameter	Test Method	Reference
Arsenic	Atomic Absorption	Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, March 1983.
Barium	Atomic Absorption	Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, March 1983.
Cadmium	Atomic Absorption	Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, March 1983.
Fluoride	Colorimetric or Potentiometric	Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, March 1983.
Lead	Atomic Absorption	Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, March 1983.
Mercury	Atomic Absorption	Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, March 1983.
Selenium	Atomic Absorption	Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, March 1983.
Silver	Atomic Absorption	Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, March 1983.
Lindane	Gas Chromatograph	Methods for Benzidine, Chlorinated Organic Compounds, Pentachlorophenol and Pesticides in Water and Wastes

PARAMETERS AND TEST METHODS

Parameter	Test Method	Reference
Phenols	Chloroform Extraction Method 510B	Standard Methods For the Examination of Water & Wastewater 16th edition, 1985.
pH	Electrometric	Test Methods for Evaluating Solid Waste. Physical/Chemical Methods, USEPA SW-846.
Specific Conductivity	Method 120.1	Methods for Chemical Analysis of Water and Wastes, EPA-600/4-790020, March 1983.
Total Organic Carbon	Combustion, Methods 415.1	Methods for Chemical Analysis of Water and Wastes, EPA-600/4-790020, March 1983.
Volatile Organics	Gas Chromatograph/ Mass Spectrometer	Federal Register, Volume 49, 209 October 26, 1984. USEPA Method 624.

HOLDING TIMES FOR LABORATORY ANALYSIS

Parameter	Holding Time
Arsenic	6 Mos.
Barium	6 Mos.
Cadmium	6 Mos.
Chromium	6 Mos.
Fluoride	7 Days
Lead	6 Mos.
Mercury	28 Days
Selenium	6 Mos.
Silver	6 Mos.
Lindane	7 Days
Phenols	24 Hrs.
pH	6 Hrs.
Specific Conductivity	24 Hrs.
Total Organic Carbon	24 Hrs.
Volatile Organics	14 Days

Behrens-Fisher (CABF) Students' t-test, specified in Part 264 Appendix IV, is applicable to those parameters that display approximately normal distributions. Normal distributions are those where the sample data have estimated coefficients of variations less than 1.0. This criteria is intended to eliminate grossly non-normal data from being used in the test.

If the background data show an estimated coefficient of variation less than 1.0 for all monitoring parameters, then the statistical test specified by EPA may be applied. In accordance with Section 264.98(c)(2), PROTECO will present the background data in a form necessary for determination of statistically significant increases. The following is required for each parameter:

n_b - the number of measurements
x_b - the mean of the measurements calculated by

$$\bar{X}_b = \quad Xi/n \quad i = 1$$

in which X_i is the measurement i of parameter X

S_b - the standard deviation of the measurements calculated by

$$Sb = i = 1 \; (X_i - X)^2 \quad n_b - 1$$

CV_b - coefficient of variation of the measurement calculated by

$$CV_b = s_b \quad X_b$$

Once the background values have been established, the statistical test is performed on each parameter with data obtained from each downgradient monitoring well for samples collected at least semi-annually according to Section 264.97(1)(i). This is done to determine whether the difference between the mean of the constituent at each well and the mean background value is significant at the 0.05 level.

CABF statistical test procedure is outlined in Appendix IV of 40 CFR Part 264. The procedure is as follows:

Using all the available background data (n_b readings), calculate the background mean (X_b) and background variance (s_b2). For the single

monitoring well under investigation (n_m reading), calculate the monitoring mean (X_m) and monitoring variance (s_m^2).

For any set of data (X_1, X_2 ... X_n) the mean is calculated by:

$$X = \frac{X_1 + X_2 \ldots + X_n}{n}$$

and the variance is calculated by:

$$S^2 = \frac{(X_1 - X)^2 \ldots + (X_n - X)^2}{n}$$

Where "n" denotes the number of observations in the set of data.

The test uses these data summary measures to calculate a t-statistic (t*) and a comparison t-statistic (T_c). The T* value is compared to the t_c value and a conclusion reached as to whether there has been a statistically significant change in any indicator parameter.

The t-statistic for all parameters except pH and similar monitoring parameters is:

$$t^* = \frac{\bar{X}_m - \bar{X}_b}{\frac{s_m^2}{n_m} + \frac{s_b^2}{n_b}}$$

If the value of this t-statistic is negative, then there is no significant difference between the monitoring data and background data. it should be noted that significantly small negative values may be indicative of a failure of the assumption made for test validity or errors have been made in collecting the background data.

T-statistic (t_c), which t* will be compared, necessitates finding t_b and t_m from standard (one-tailed) tables where,

t_b = t-tables with (n_b-1) degrees of freedom, at the 0.05 level of significance.

t_m = t-tables with (n_m-1) degrees of freedom, at the 0.05 level of significance.

Finally, the special weightings W_b and W_m are defined as:

$$W_b = \frac{s_b^2}{n_b} \text{ and } W_m = \frac{s_m^2}{n_m}$$

and so the comparison t-statistic is:

$$t_c = \frac{W_b t_b + W_m tm}{W_b + W_m}$$

The t-statistic (t*) is now compared with the comparison t-statistic (t_c) using the following decision-rule:

If t* is equal to or larger than t_c, then conclude that there most likely has been a significant increase in this specific parameters.

If f* is less than t_c, then conclude that most likely there has not been a change in this specific parameter.

The t-statistic for testing pH and similar monitoring parameters is constructed in the same manner as previously described except the negative sign (if any) is discarded and the caveat concerning the negative value is ignored. The standard (two-tailed) tables are used in the construction t_c for pH and similar monitoring parameters.

If t* is equal to or larger than t_c, then conclude that there most likely has been a significant increase (if the initial t* had been negative, this would imply a significant decrease). If t* is less than t_c, then conclude that there most likely has been no change.

A standard table for t-values in one and two-tailed tests is provided in Table E-4.

BACKGROUND VALUE ESTABLISHMENT - Background values for each regulated unit list of parameters will be established through a quarterly sampling

Values of t-Statistic for One- and Two-Tailed Tests at a Level of Significance of 0.05 (from Fisher and Yates).

DEGREES OF FREEDOM	t-values (one - tail)	t-values (one - tail)
1	6.314	12.706
2	2.920	4.303
3	2.353	3.182
4	2.132	2.776
5	2.015	2.571
6	1.943	2.447
7	1.895	2.365
8	1.860	2.306
9	1.833	2.262
10	1.812	2.228
11	1.796	2.201
12	1.782	2.179
13	1.771	2.160
14	1.761	2.145
15	1.753	2.131
16	1.746	2.120
17	1.740	2.110
18	1.734	2.101
19	1.729	2.093
20	1.725	2.086
21	1.721	2.080
22	1.717	2.074
23	1.714	2.069
24	1.711	2.064
25	1.708	2.060
30	1.697	2.042
40	1.684	2.021

program conducted at the background monitoring location. At each quarterly sampling, four replicate samples will be collected from the background location and analyzed for each listed parameter to account for any variations as a result of analytical procedures. The four values obtained for each parameter will then be averaged to arrive at one average value for each parameter for that sampling campaign. A similar procedure will be followed for each quarterly sampling, resulting in the generation of four (4) average quarterly values for each parameter. These four values will then be averaged to produce one average annual value for each parameter. This procedure is designed to take into account any seasonal variations which may occur in the vicinity of the PROTECO Facility.

Once these values have been established, they will be used in the specified statistical procedure to determine if statistically significant increases in background are occurring in the downgradient wells. This procedure will be repeated each year in order to update background values on an annual basis. In establishing background levels for a detection monitoring program, certain procedures have been followed that are described in the previous section under Statistical Procedures.

APPENDIX E.1

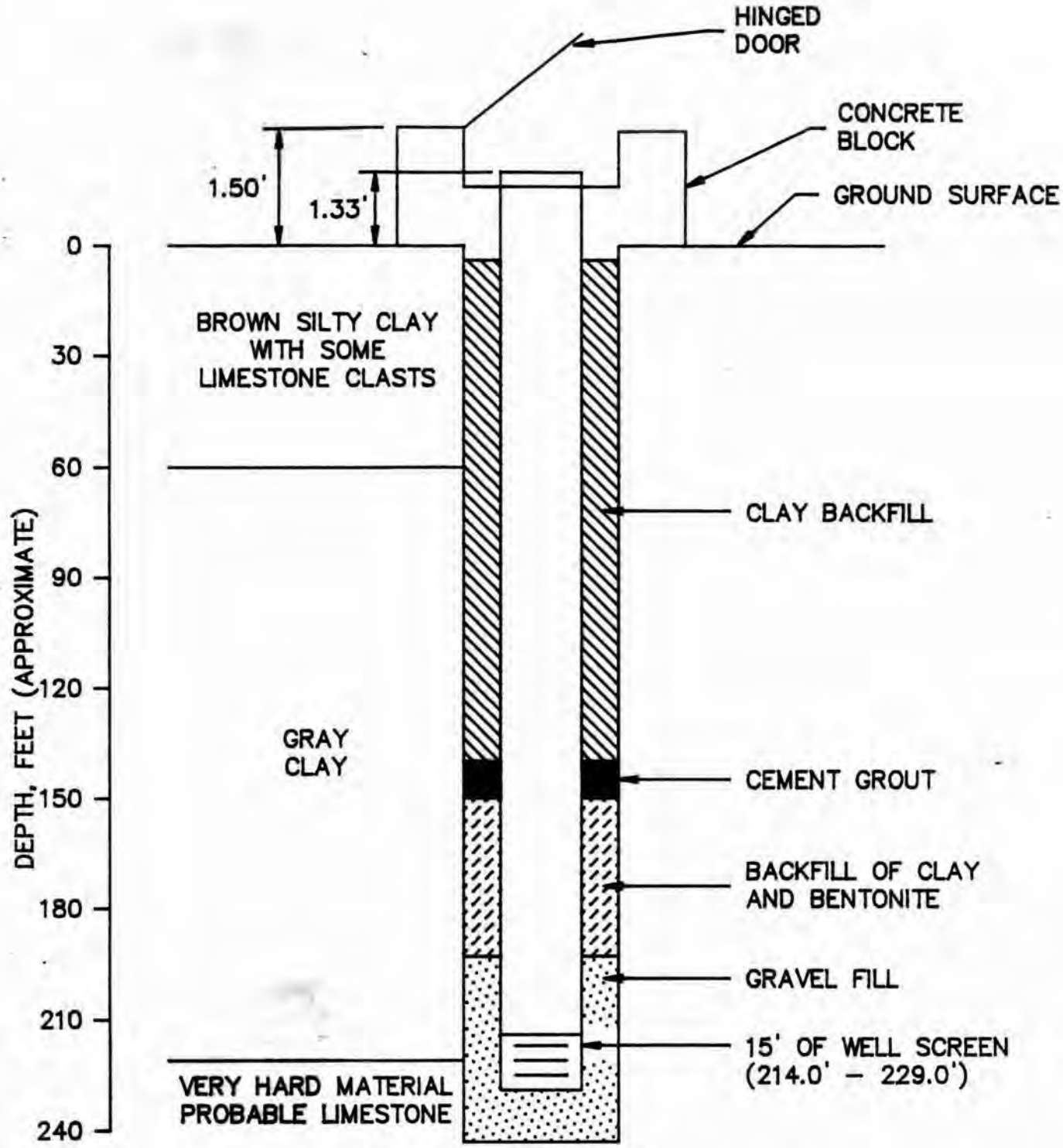


FIGURE 1

MONITORING WELL 1W81
CONSTRUCTION SPECIFICATIONS

PROTECO SITE
PEÑUELAS, PUERTO RICO

FRED C. HART ASSOCIATES, INC.

NOT TO SCALE

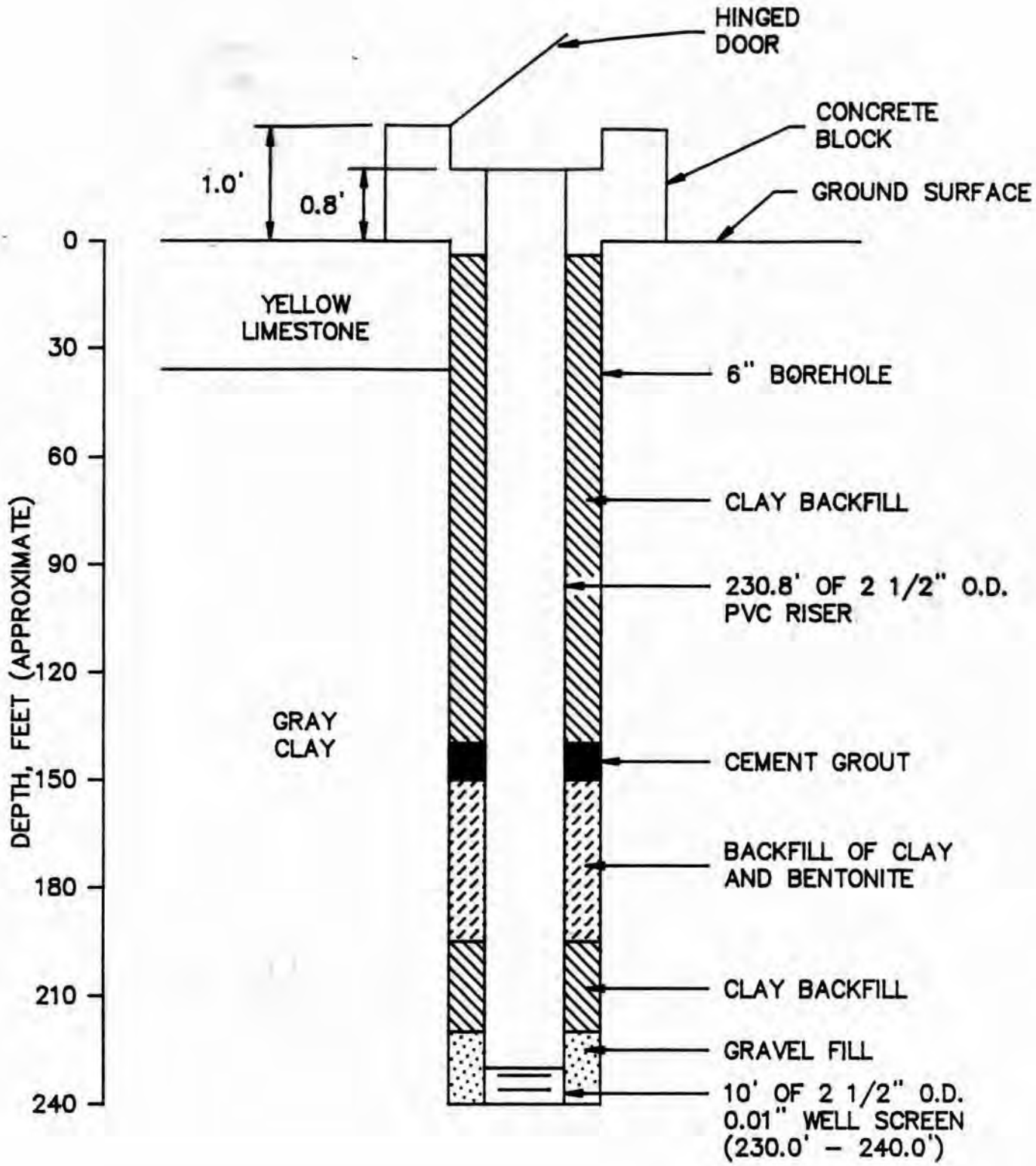


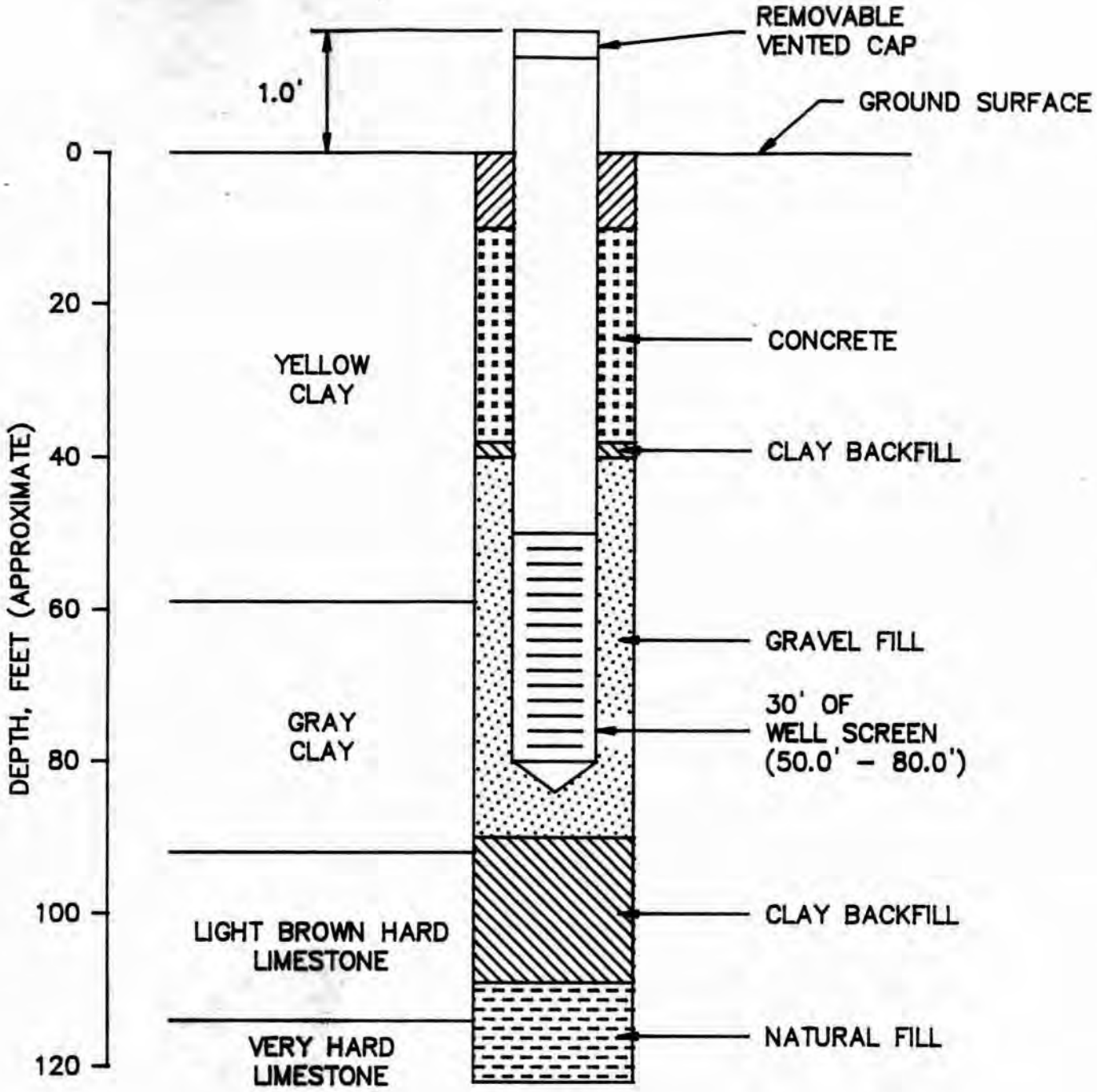
FIGURE 2

MONITORING WELL 2W81
CONSTRUCTION SPECIFICATIONS

PROTECO SITE
PEÑUELAS, PUERTO RICO

FRED C. HART ASSOCIATES, INC.

NOT TO SCALE



NOTE:

a–ALL PVC CONNECTIONS MADE WITH 3 STAINLESS STEEL SELF TAPPING SCREWS.

b–HOLE COLLAPSED BELOW 107' AFTER ATTEMPED PUMP IN TEST.

NOT TO SCALE

FIGURE 3

MONITORING WELL 3W81
CONSTRUCTION SPECIFICATIONS

PROTECO SITE
PEÑUELAS, PUERTO RICO

FRED C. HART ASSOCIATES, INC.

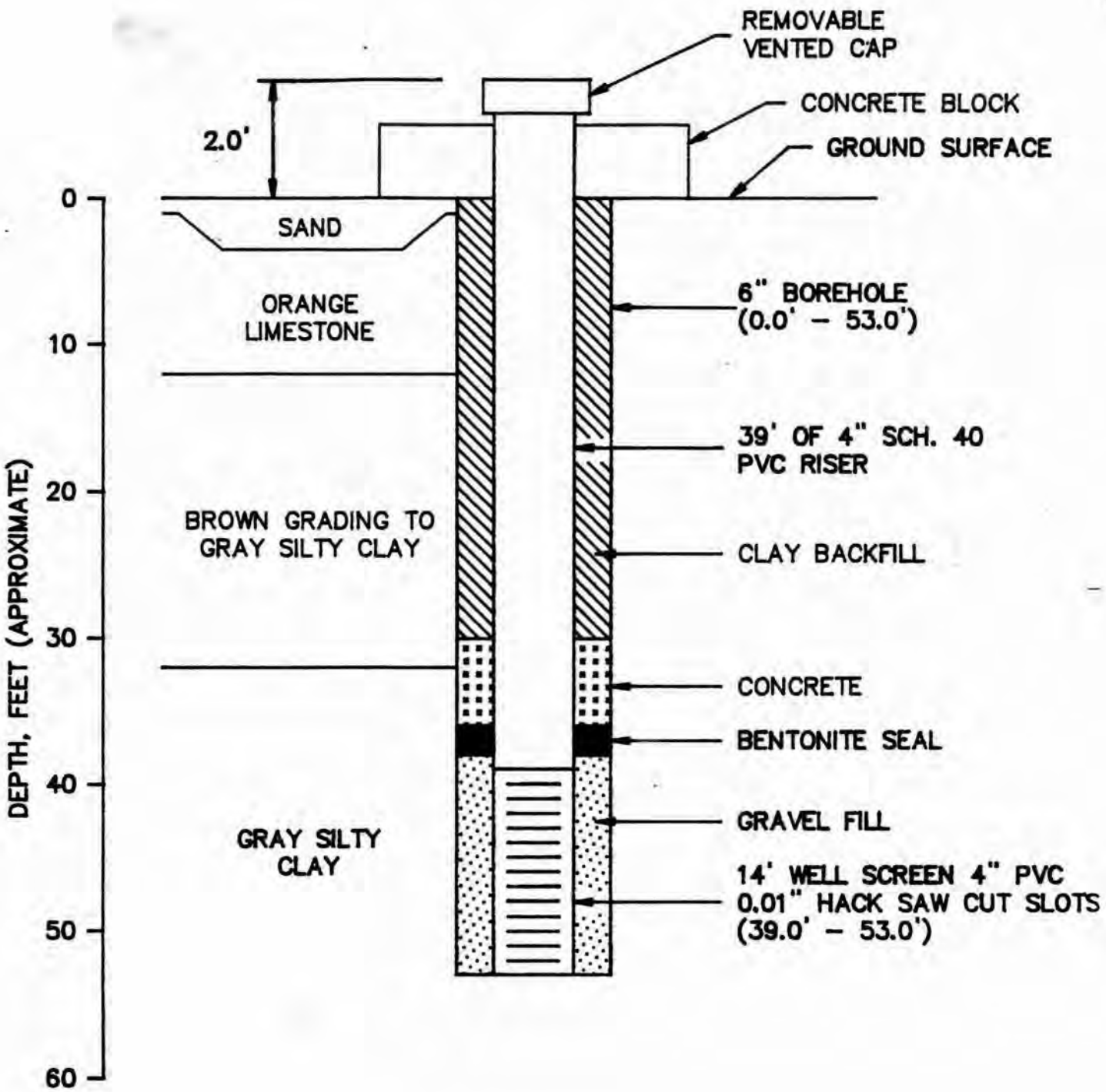


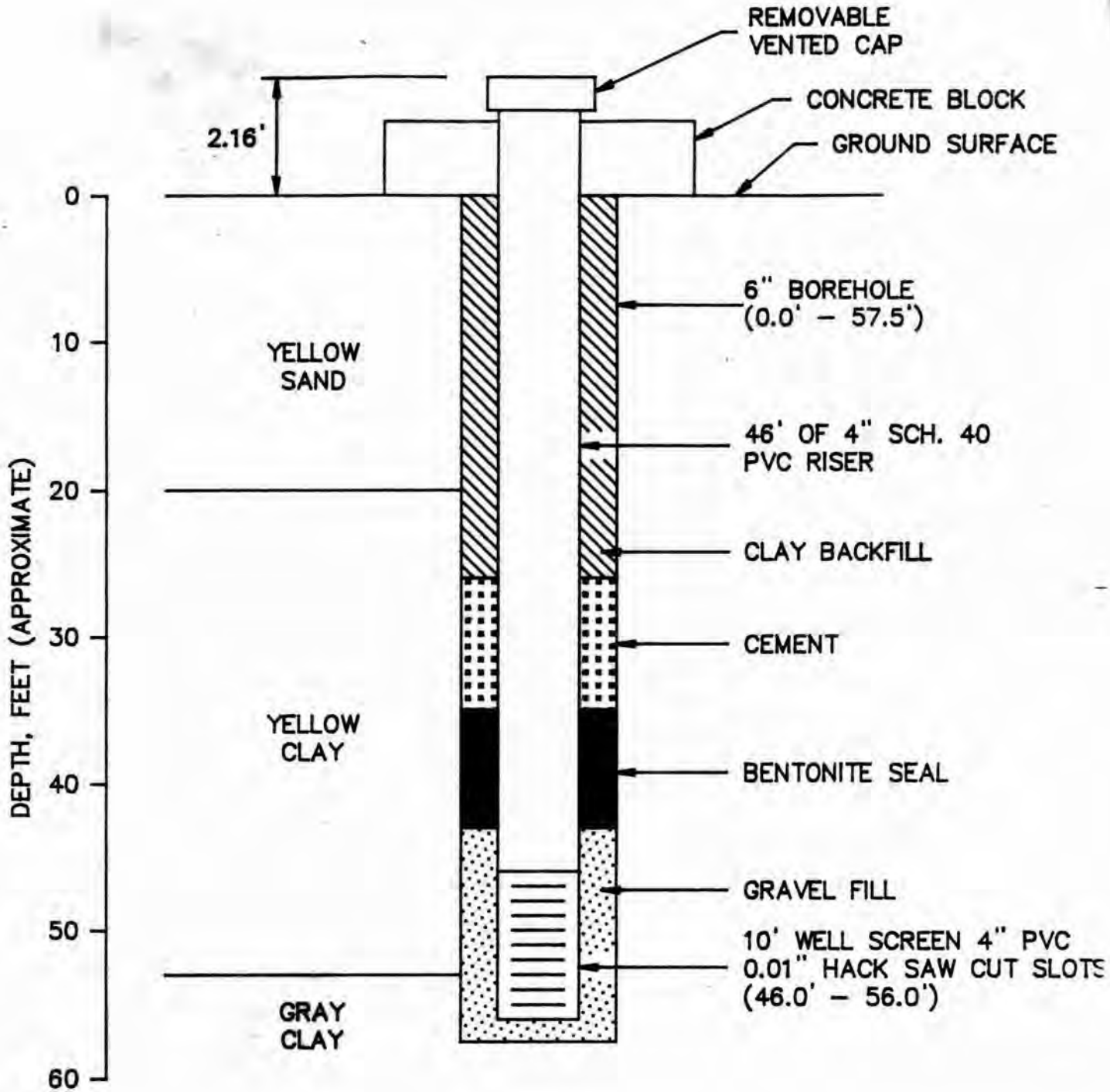
FIGURE 4

MONITORING WELL 4W81
CONSTRUCTION SPECIFICATIONS

PROTECO SITE
PEÑUELAS, PUERTO RICO

FRED C. HART ASSOCIATES, INC.

NOT TO SCALE



NOTE:
SINCE THIS CONSTRUCTION DIAGRAM WAS DRAWN 7.76 ADDITIONAL FEET OF PVC WERE ADDED TO THE TOP OF THE CASING; NEW SURVEYED ELEVATION IS 335.86 FEET.

NOT TO SCALE

FIGURE 5

MONITORING WELL 9W81
CONSTRUCTION SPECIFICATIONS

PROTECO SITE
PEÑUELAS, PUERTO RICO

FRED C. HART ASSOCIATES, INC.

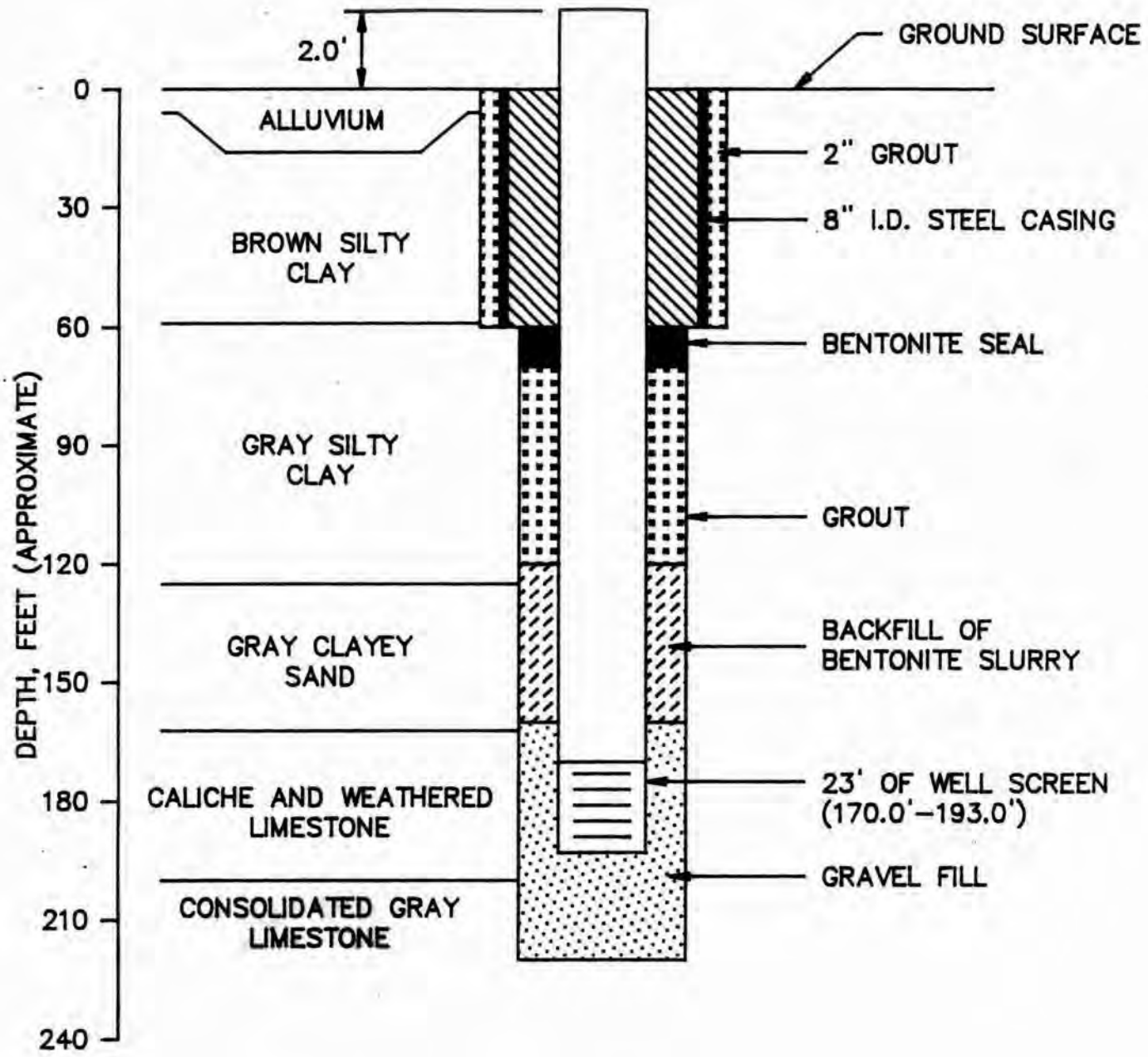


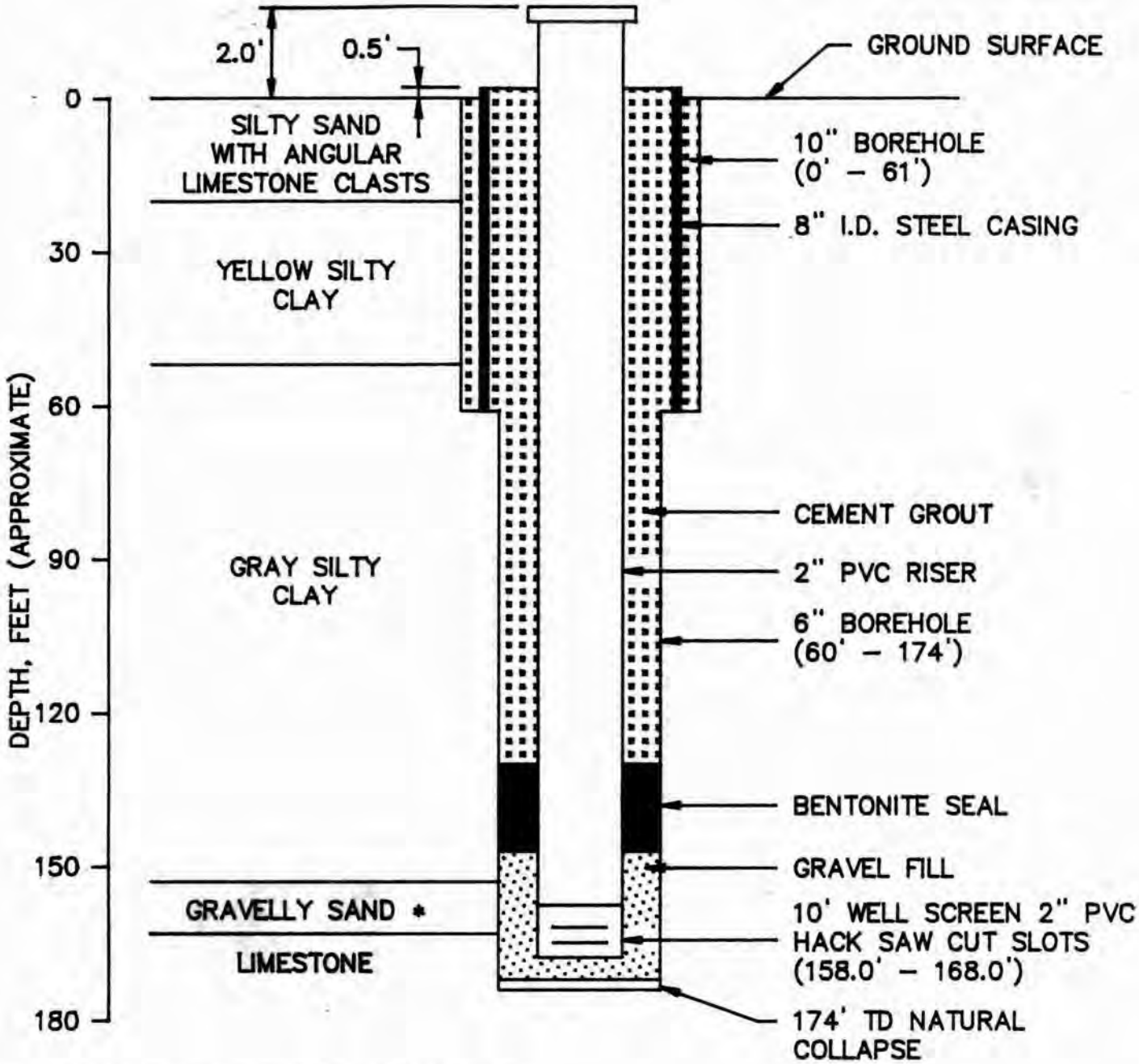
FIGURE 6

MONITORING WELL 11W83
CONSTRUCTION SPECIFICATIONS

PROTECO SITE
PEÑUELAS, PUERTO RICO

FRED C. HART ASSOCIATES, INC.

NOT TO SCALE



* PROBABLY GYPSUM AND LIMESTONE FRAGMENTS IN CLAY MATRIX.

FIGURE 7

MONITORING WELL 12W83
CONSTRUCTION SPECIFICATIONS

PROTECO SITE
PEÑUELAS, PUERTO RICO

FRED C. HART ASSOCIATES, INC.

NOT TO SCALE

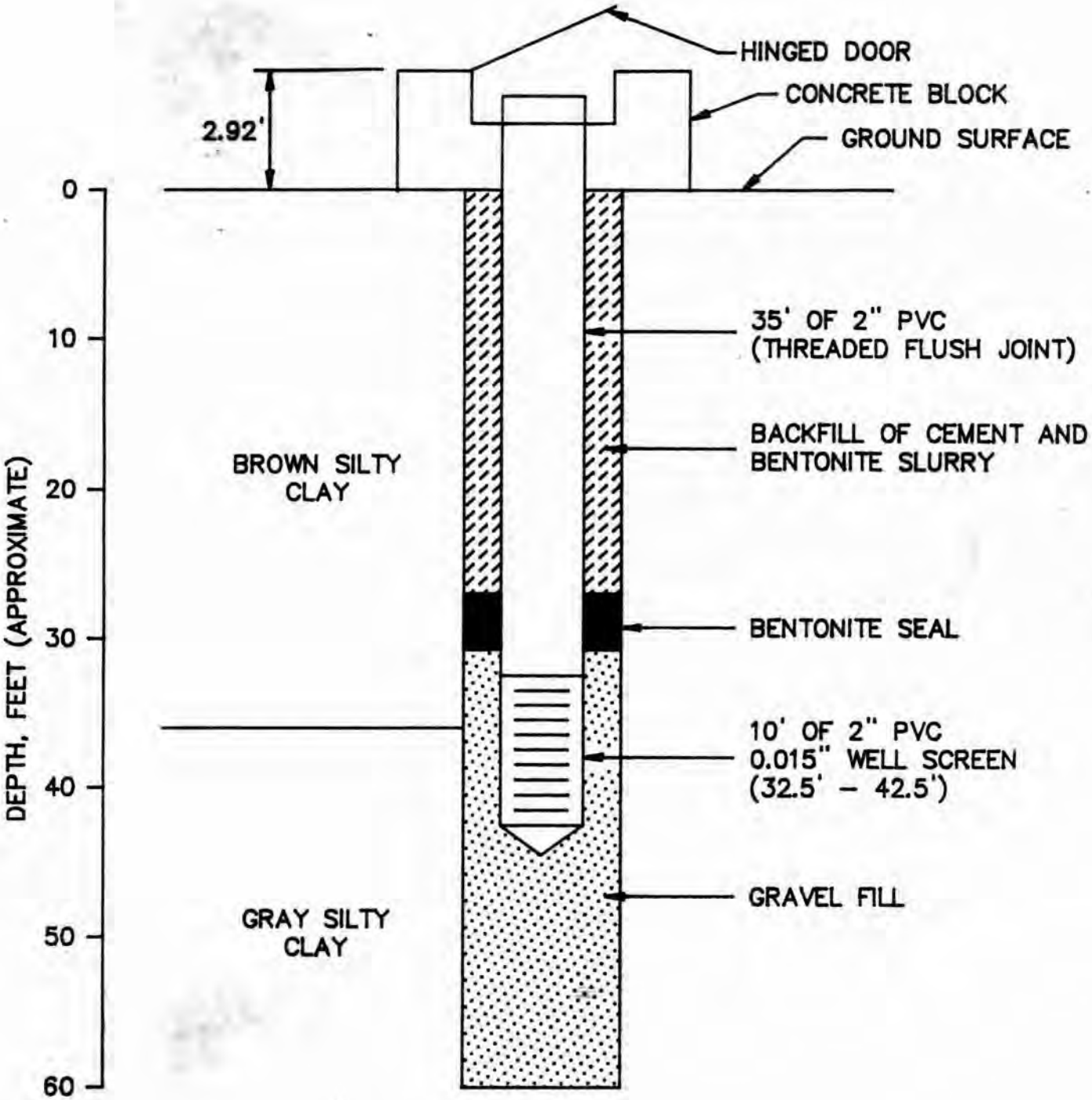


FIGURE 8

MONITORING WELL 14W85
CONSTRUCTION SPECIFICATIONS

PROTECO SITE
PEÑUELAS, PUERTO RICO

FRED C. HART ASSOCIATES, INC.

NOT TO SCALE

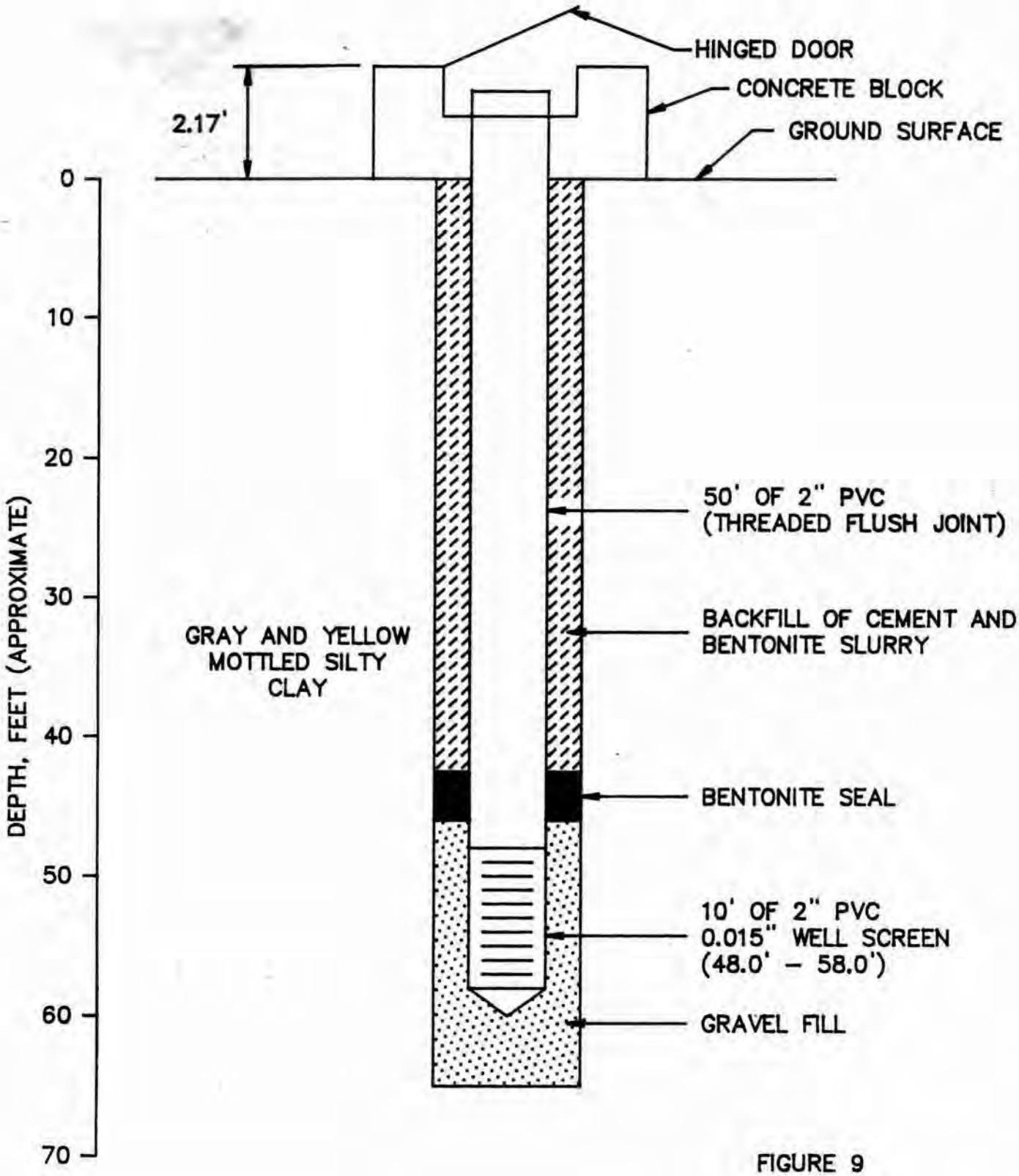


FIGURE 9

MONITORING WELL 15W85
CONSTRUCTION SPECIFICATIONS

PROTECO SITE
PEÑUELAS, PUERTO RICO

FRED C. HART ASSOCIATES, INC.

NOT TO SCALE

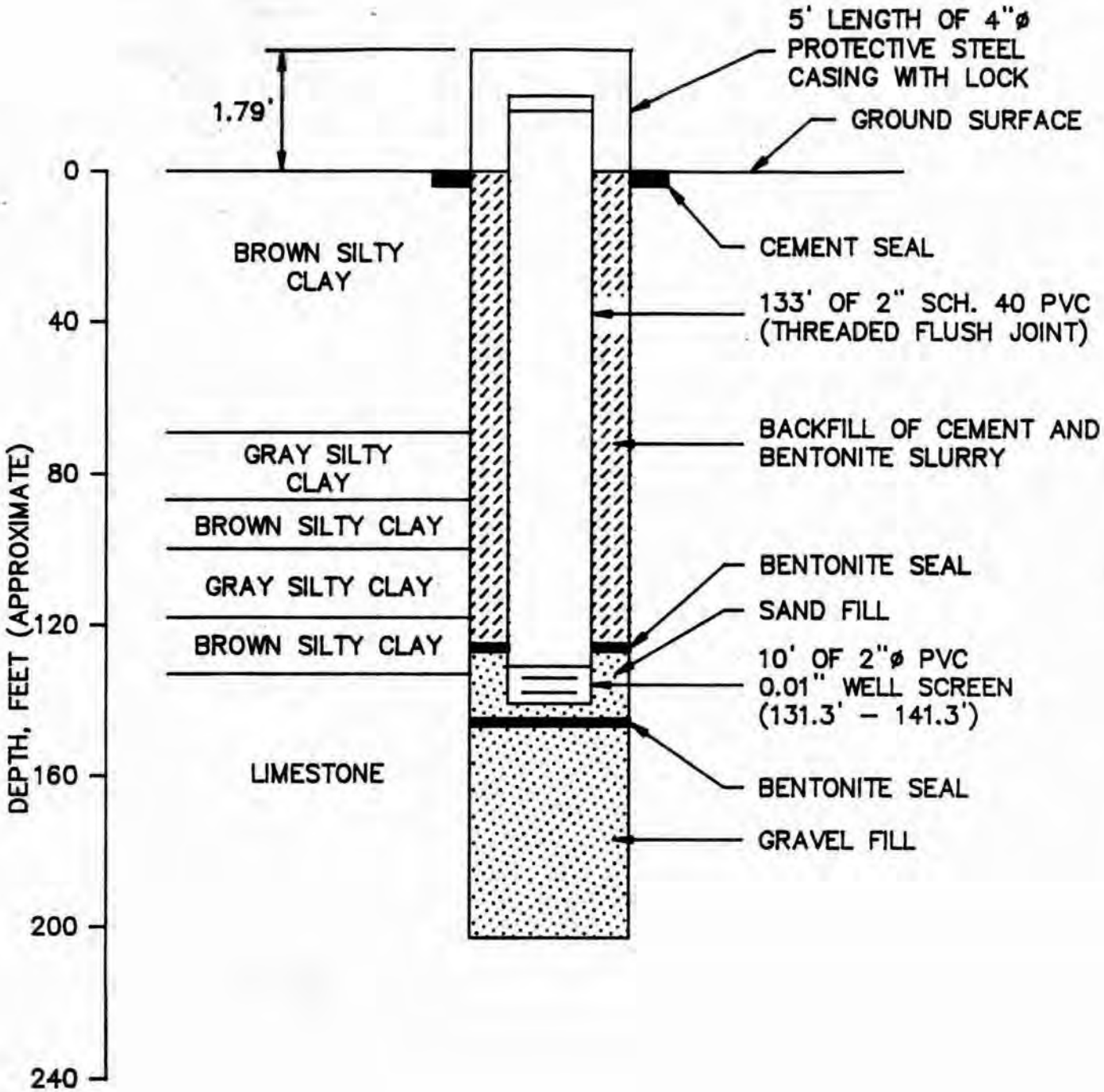


FIGURE 10

MONITORING WELL 16W85
CONSTRUCTION SPECIFICATIONS

PROTECO SITE
PEÑUELAS, PUERTO RICO

FRED C. HART ASSOCIATES, INC.

NOT TO SCALE

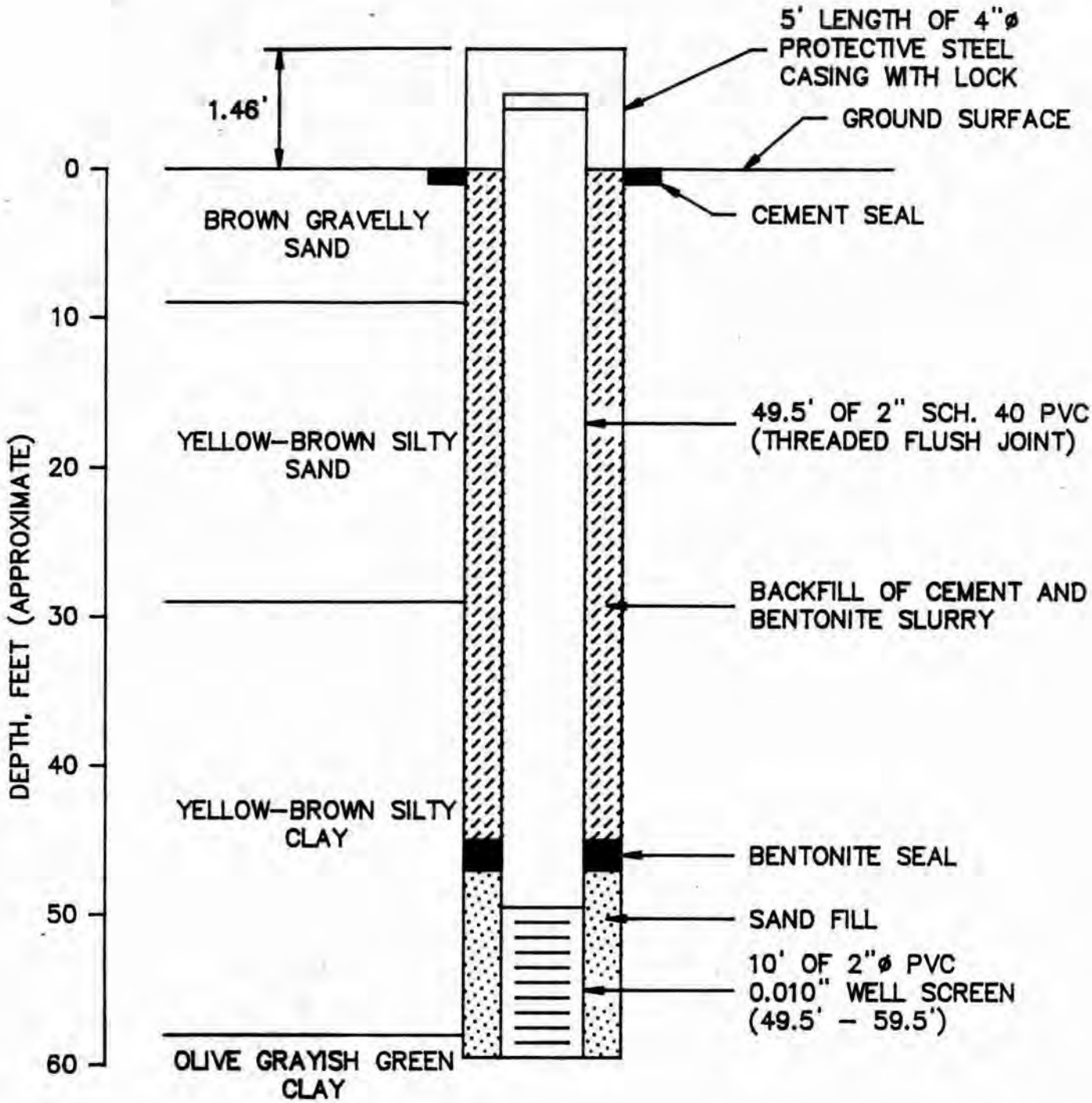


FIGURE 11

MONITORING WELL 18W85
CONSTRUCTION SPECIFICATIONS

PROTECO SITE
PEÑUELAS, PUERTO RICO

FRED C. HART ASSOCIATES, INC.

NOT TO SCALE

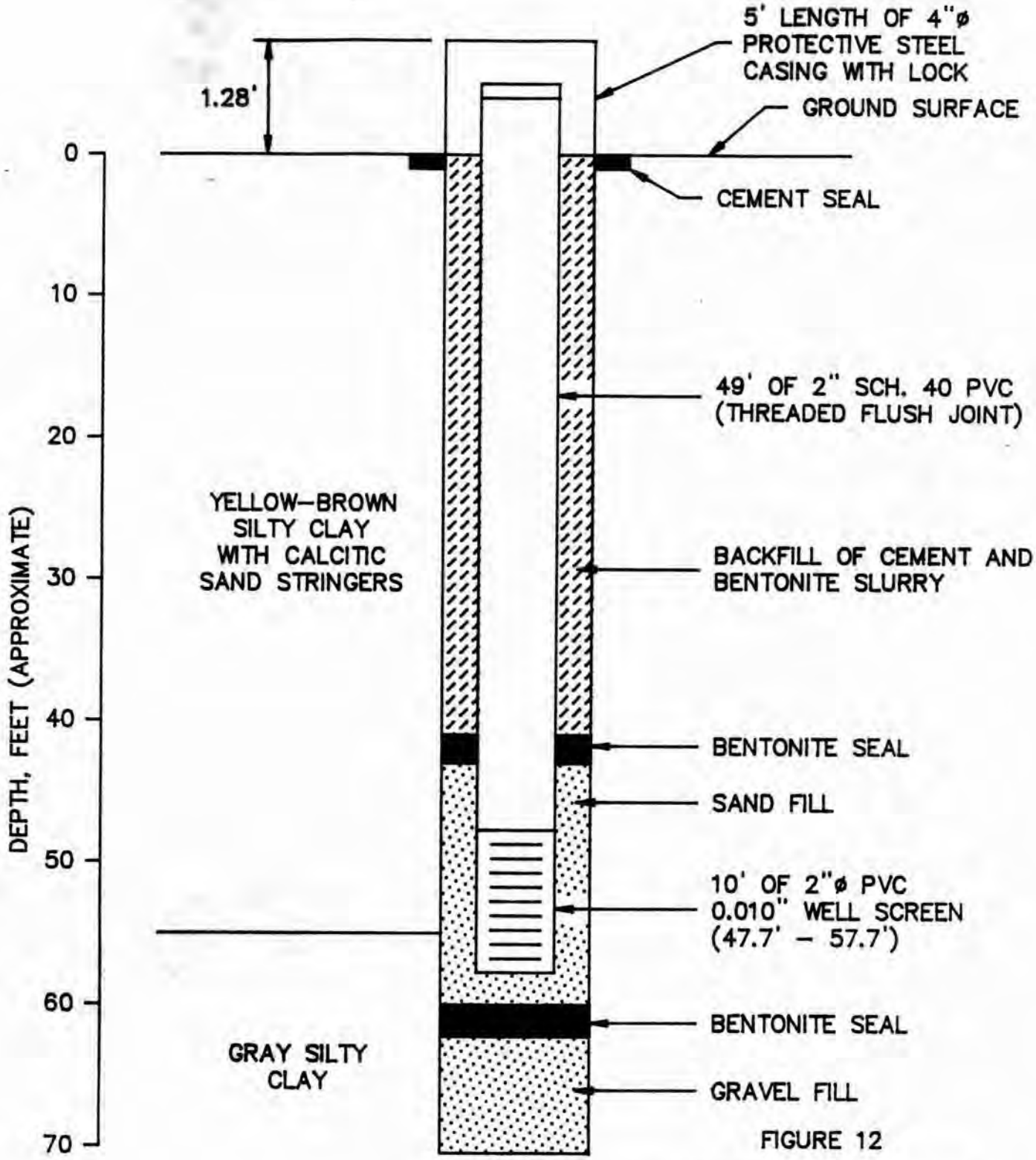


FIGURE 12

MONITORING WELL 21W85
CONSTRUCTION SPECIFICATIONS

PROTECO SITE
PEÑUELAS, PUERTO RICO

FRED C. HART ASSOCIATES, INC.

NOT TO SCALE

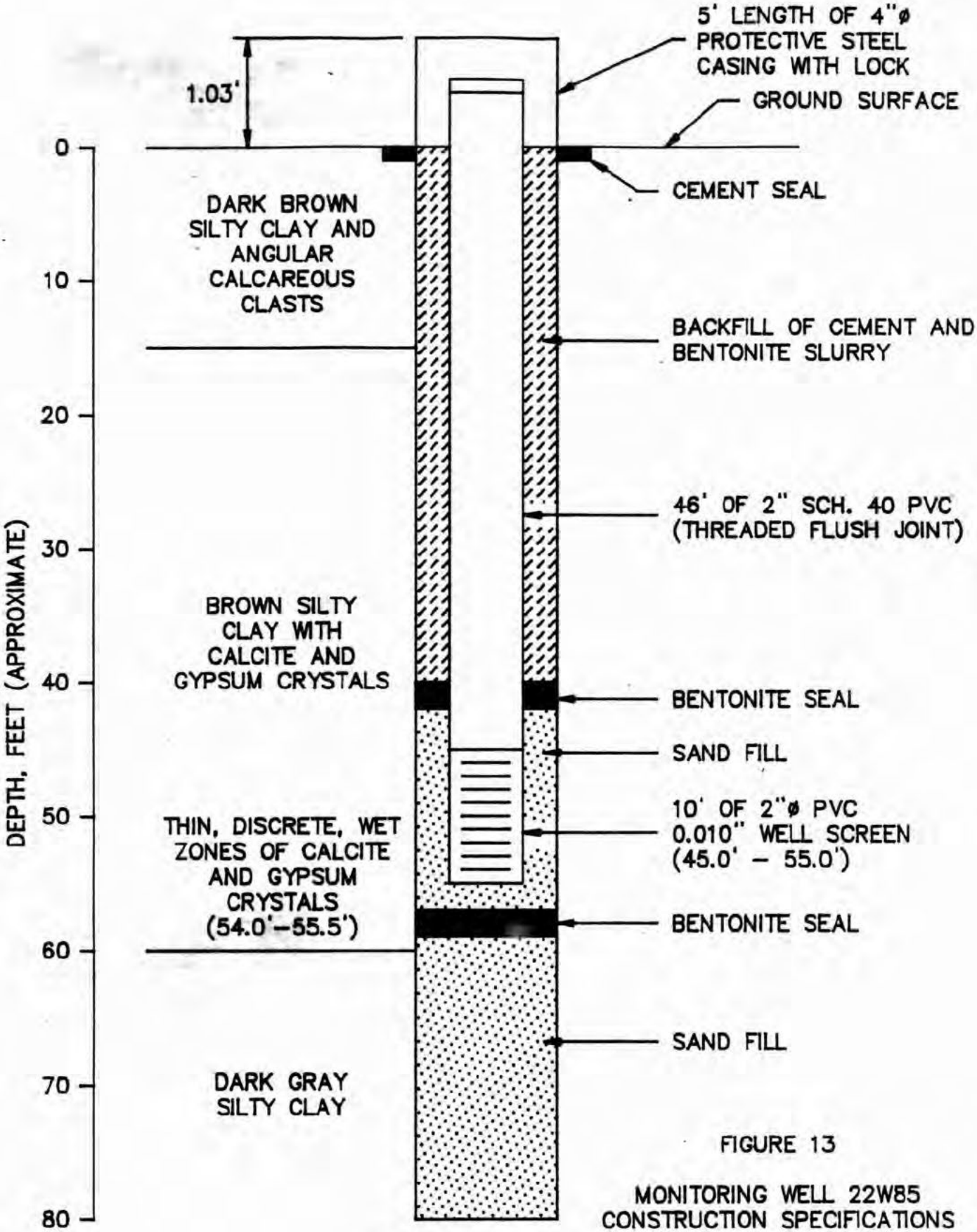


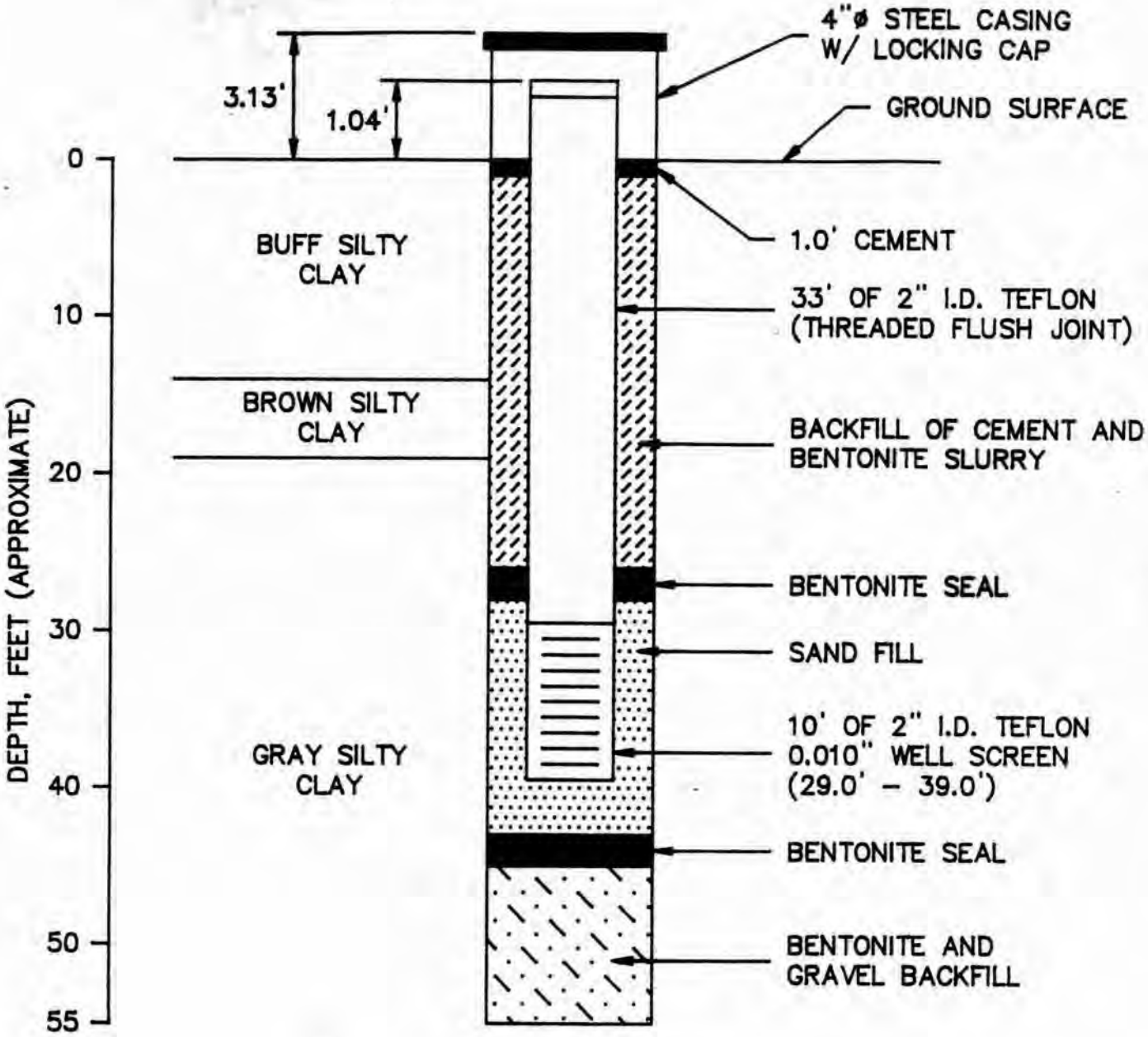
FIGURE 13

MONITORING WELL 22W85
CONSTRUCTION SPECIFICATIONS

PROTECO SITE
PEÑUELAS, PUERTO RICO

FRED C. HART ASSOCIATES, INC.

NOT TO SCALE



NOTES:

1. CONSTRUCTION COMPLETED ON 11-3-85.
2. DEVELOPED ON 11-3-85.

FIGURE 14

MONITORING WELL 23W85
CONSTRUCTION SPECIFICATIONS

PROTECO SITE
PEÑUELAS, PUERTO RICO

FRED C. HART ASSOCIATES, INC.

NOT TO SCALE

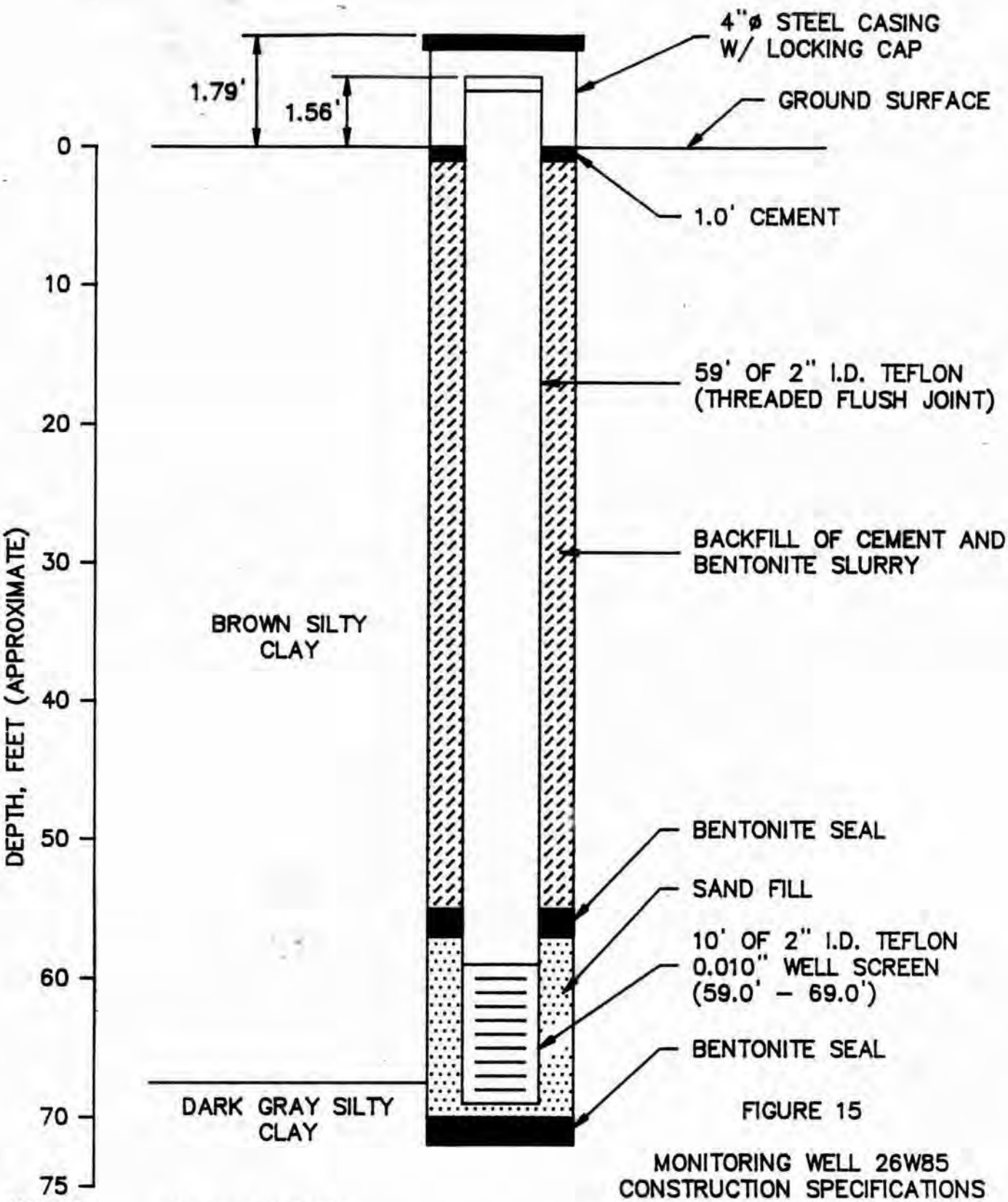


FIGURE 15

MONITORING WELL 26W85
CONSTRUCTION SPECIFICATIONS

NOTES:

NOT TO SCALE

1. CONSTRUCTION COMPLETED ON 11-3-85.

2. DEVELOPED ON 11-3-85.

PROTECO SITE
PEÑUELAS, PUERTO RICO

FRED C. HART ASSOCIATES, INC.

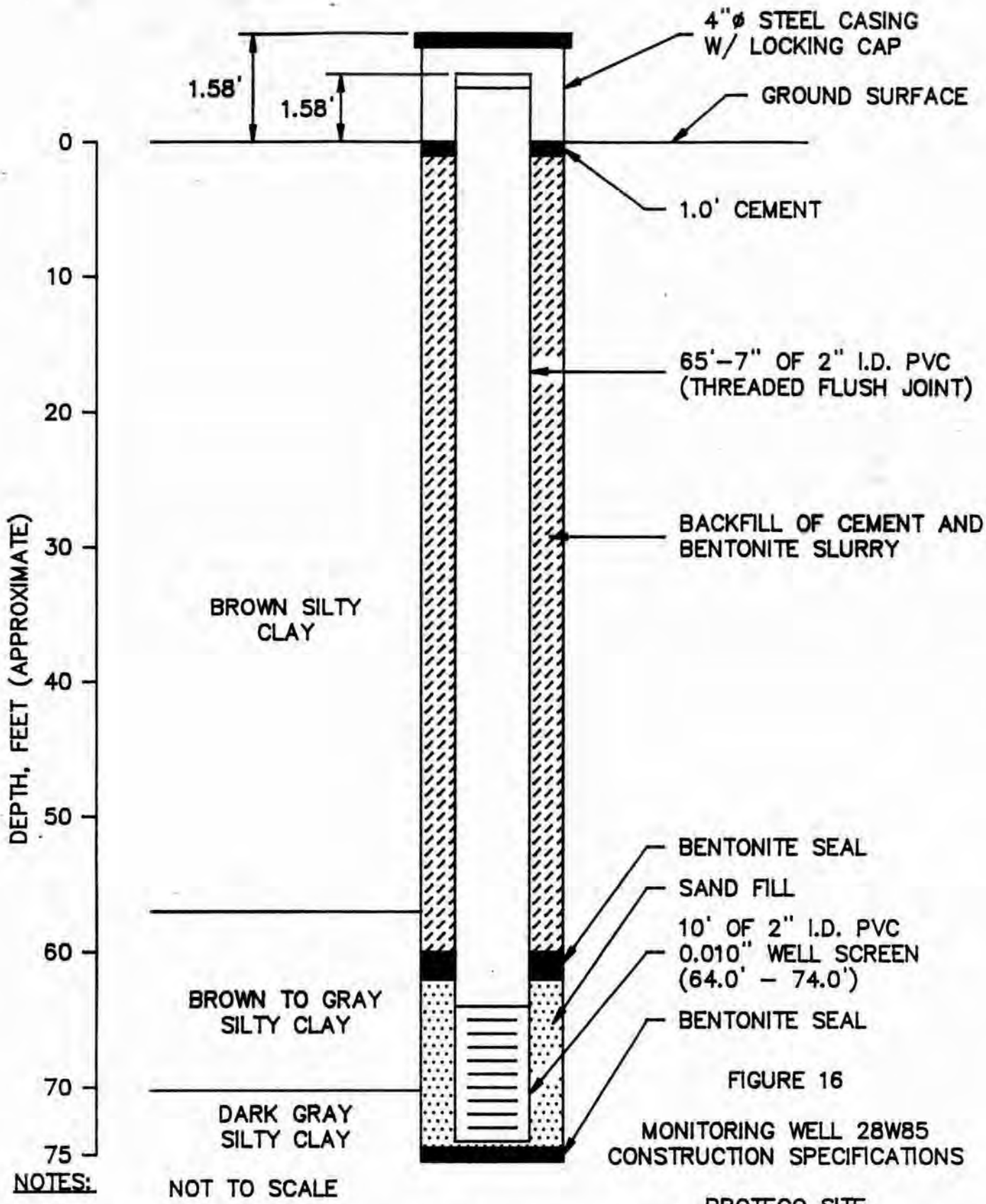


FIGURE 16

MONITORING WELL 28W85
CONSTRUCTION SPECIFICATIONS

NOTES:

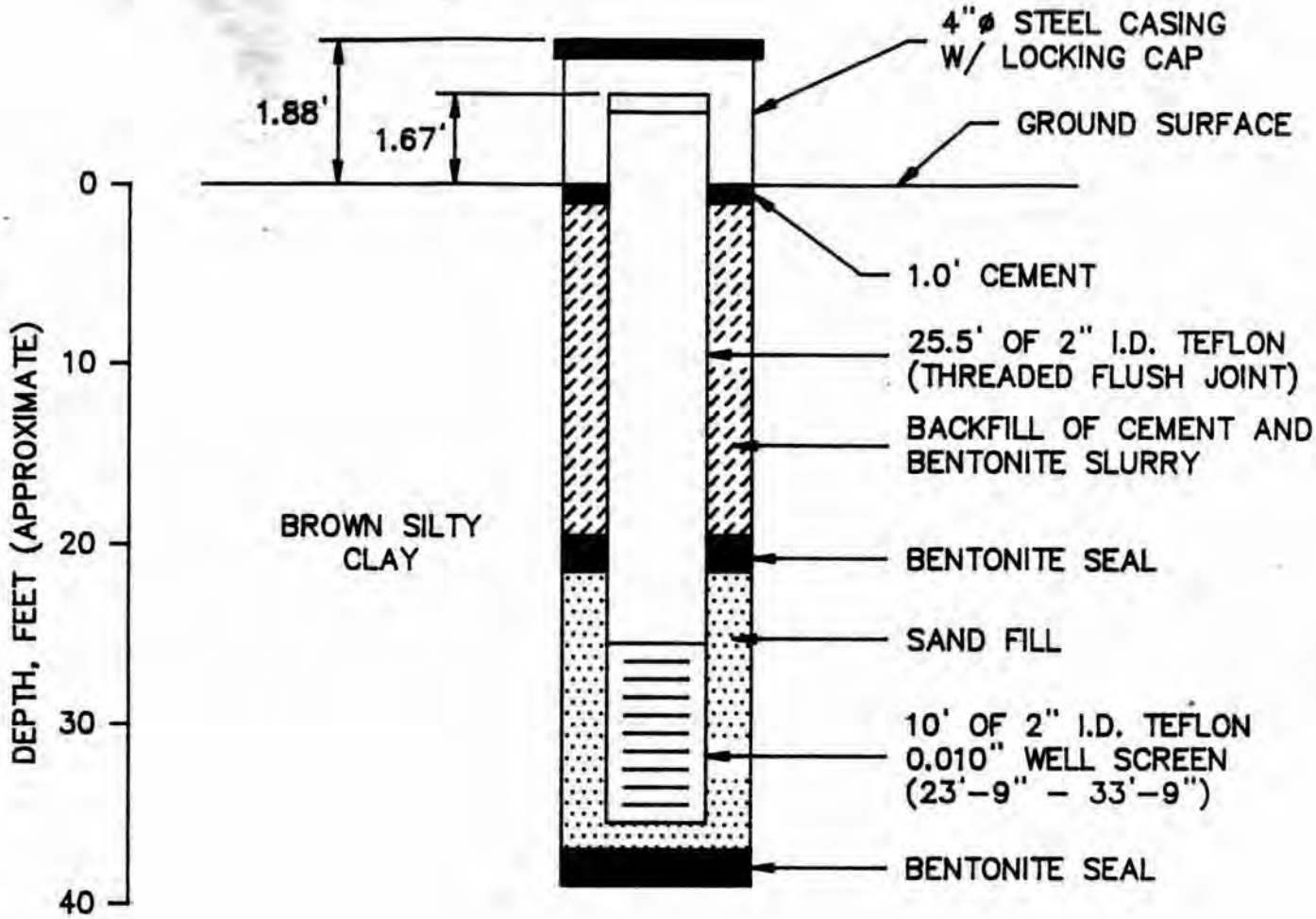
NOT TO SCALE

1. CONSTRUCTION COMPLETED ON 11-6-85.

2. DEVELOPED ON 11-7-85.

PROTECO SITE
PEÑUELAS, PUERTO RICO

FRED C. HART ASSOCIATES, INC.



NOTES:

1. CONSTRUCTION COMPLETED 11-2-85.
2. DEVELOPED ON 11-3-85.

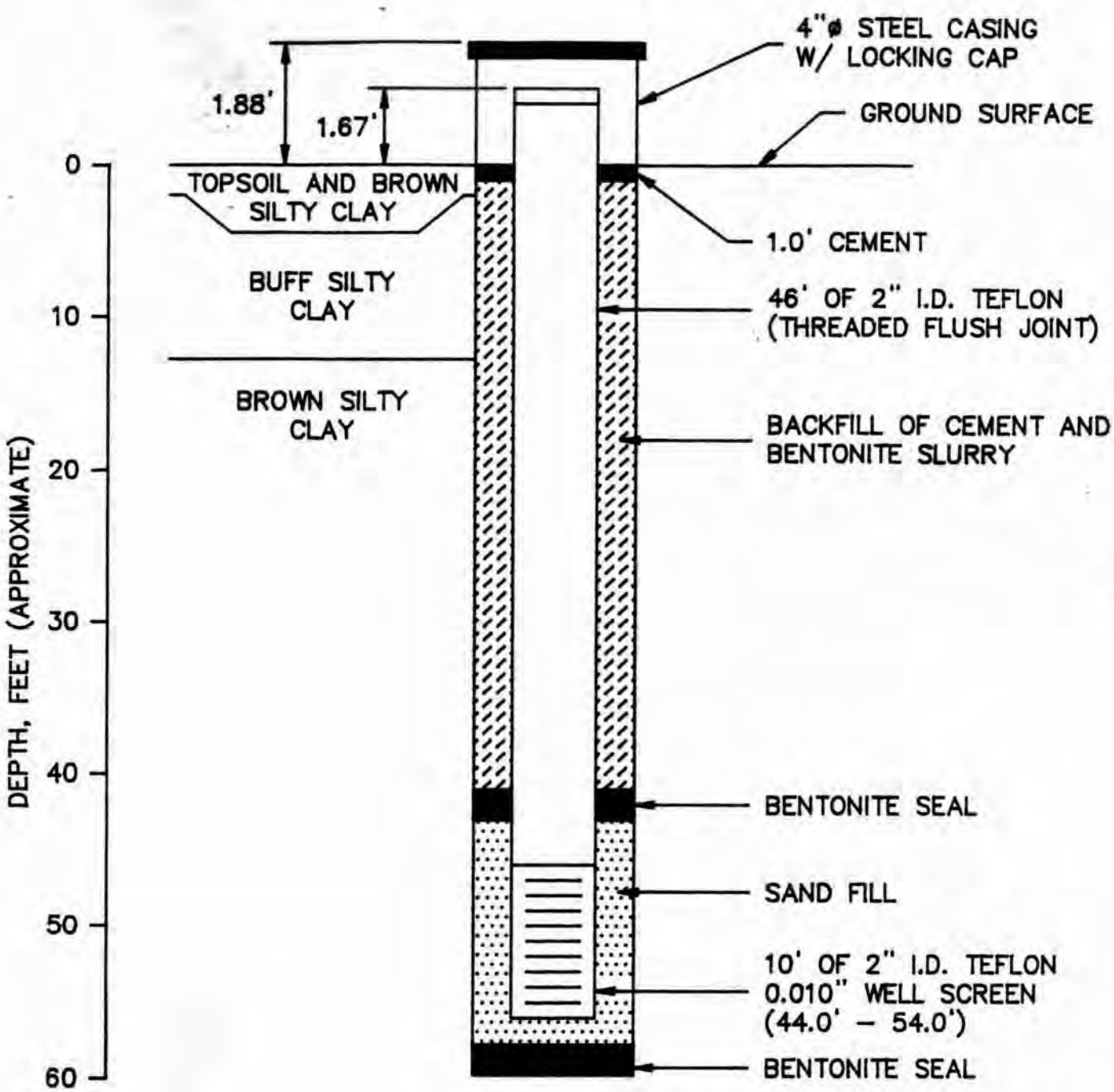
FIGURE 17

MONITORING WELL 29W85
CONSTRUCTION SPECIFICATIONS

PROTECO SITE
PEÑUELAS, PUERTO RICO

FRED C. HART ASSOCIATES, INC.

NOT TO SCALE



NOTES:

1. CONSTRUCTION COMPLETED ON 11–1–85.
2. DEVELOPED ON 11–3–85.

FIGURE 18

MONITORING WELL 30W85
CONSTRUCTION SPECIFICATIONS

PROTECO SITE
PEÑUELAS, PUERTO RICO

FRED C. HART ASSOCIATES, INC.

NOT TO SCALE

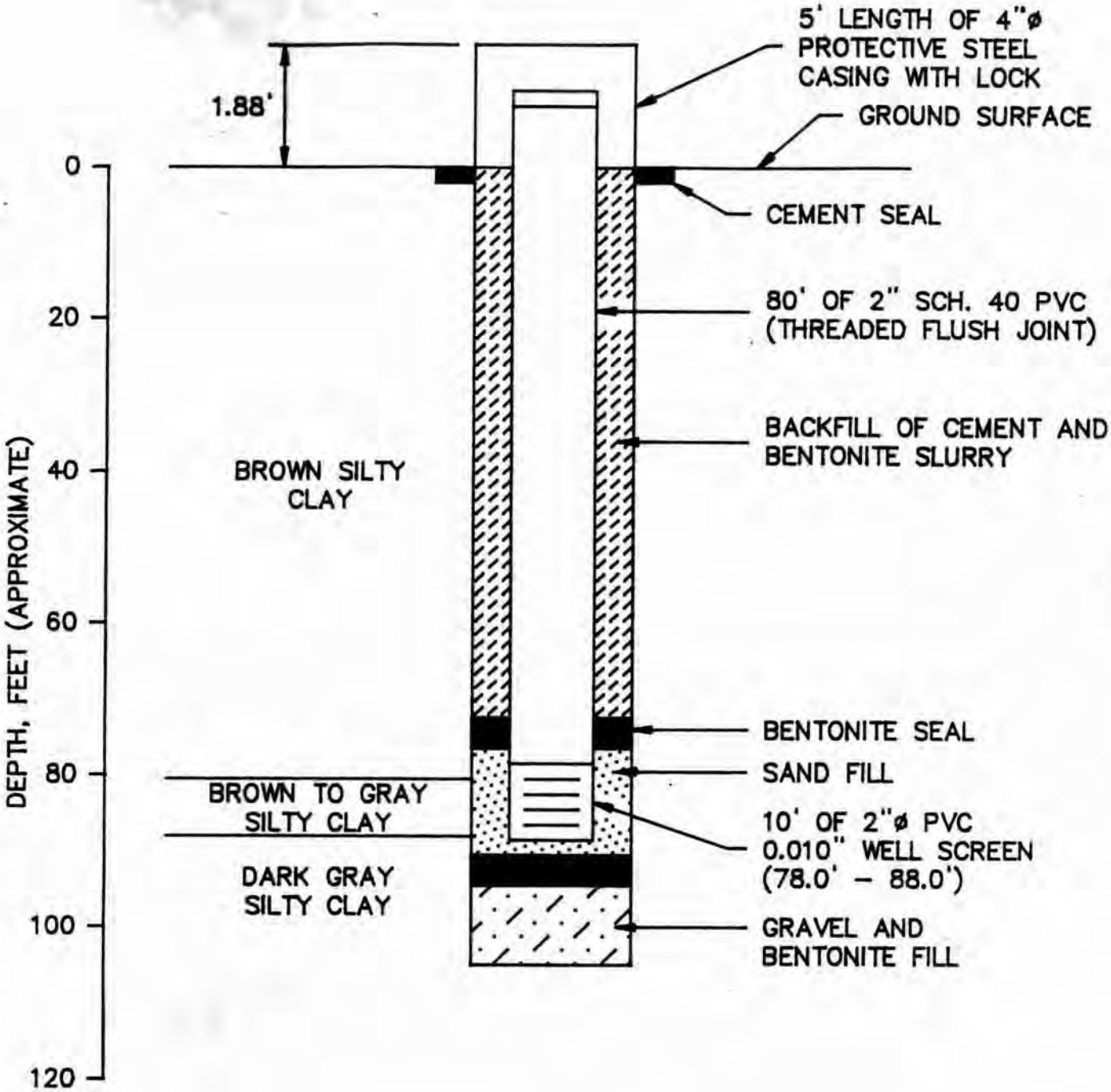


FIGURE 19

MONITORING WELL 32W85
CONSTRUCTION SPECIFICATIONS

PROTECO SITE
PEÑUELAS, PUERTO RICO

FRED C. HART ASSOCIATES, INC.

NOT TO SCALE

TABLE 1

MONITORING WELL CONSTRUCTION SPECIFICATIONS

Well No.	Surveyed Top of Casing Elevation (TOC)	Total Depth	Screened (depth Internal in ft.)	Screen Length	Screen Slot Size	Well Diameter	Casing & Screen Material	Notes
1WB1	268.54	229.0'	214-229'	15'	0.01"	2"ID	PVC	1
2WB1	283.81	240.0'	230-240'	10'	0.01"	2"ID	PVC	1
3WB1	295.50	80.0'	50-80'	30'	0.005"	4"ID	PVC	1
4WB1	342.71	53.0'	39-53'	14'	0.001"	4"ID	PVC	1
9WB1	335.86	57.5'	46-56'	10'	0.001"	4"ID	PVC	1
11WB3	348.53	193.0'	170-193'	23'	0.01"	2"ID	PVC	2
12WB3	287.17	174.0'	158-168'	10'	0.001"	2"ID	PVC	1
14WB5	327.09	62.5'	32.5-42.5'	10'	0.015"	2"ID	PVC	3
15WB5	335.93	66.0	48-58'	10'	0.015"	2"ID	PVC	3
16WB5	358.25	202.5'	131'4"-141'4"	10'	0.01"	2"ID	PVC	3.5
17WB5	413.11	200.0'	--------	---	------	-----	----	4
18WB5	271.71	59.5'	49.5'-59.5'	10'	0.01"	2"ID	PVC	3.5
19WB5	387.19	100.0'	--------	---	------	-----	----	4
20WB5	341.60	210.0'	--------	---	------	-----	----	4
21WB5	257.83	57'8"	47'8"-57'8"	10'	0.01'	2"ID	PVC	3.5
22WB5	304.07	55.0'	45'-55'	10'	0.01'	2"ID	PVC	3.5

KEY:

Note

1. Field constructed well screen made by cutting PVC Pipe with a hacksaw.
2. Well screen located at an incorrect stratigraphic position
3. Commercially manufactured machine slotted well screens.
4. Dry borehole, no well screen or riser piper installed.
5. Monitoring well installed in accordance with phase I work slope well construction specifications.

TABLE 1

REGULATED UNIT MONITORING WELL SPECIFICATIONS

WELL NO.	MONITORED UNIT	SURVEYED ELEVATION (FT) TOP OF CASING	TOTAL DEPTH	SCREENED INTERVAL (FT.)	SCREEN LENGTH (FT.)	SCREEN SLOT SIZE (IN.)	WELL DIAMETER (INSIDE)	CASING MATERIAL	HYDROGEOLOGIC POSITION RELATIVE TO MONITORED UNIT
18W-85	Immobilization Unit TI_3	271.71	59.5	49.5 to 59.5	10	0.01	2 in.	PVC	Downgradient
23W-85	Immobilization Unit TI_3	276.67	39.0	29.0 to 39.0	10	0.01	2 in.	Teflon	Downgradient
30W-85	Immobilization Unit TI_3	279.54	54.0	44.0 to 54.0	10	0.01	2 in.	Teflon	Downgradient
26W-85	Rainwater Lagoon	296.83	69.0	59.0 to 69.0	10	0.01	2 in.	Teflon	Downgradient
28W-85	Rainwater Lagoon	297.33	74.0	64.0 to 74.0	10	0.01	2 in.	PVC	Downgradient
29W-85	Rainwater Lagoon	295.99	33.8	23.8 to 33.8	10	0.01	2 in.	Teflon	Downgradient
22W-85	Rainwater Lagoon and TI_3	304.07	55.0	45.0 to 55.0	10	0.01	2 in.	PVC	Upgradient

HART

Fred C. Hart Associates, Inc.