APPENDIX J

STABILITY ANALYSES

CLIENT NAVY, NWS EARLE		JOB NUMBER 7602-0201	
SUBJECT HELP MODEL CALCULATIONS			
BASED ON		DRAWING NUMBER	
BY DCW	CHECKED BY MEA 10/30/97	APPROVED BY	DATE 10/30/97

OBJECTIVE

The objective of this calculation is to estimate the amount of percolation through the low permeability barrier in the landfill caps at Sites 4 and 5. Also the HELP model calculations will be used to determine the amount of head which can be expected to build up on the drainage layer. The depth of the head will then be used in the infinite slope stability calculations. The New Jersey sanitary landfill regulations indicate that the hydrostatic head on the cap should not exceed the thickness of the drainage layer during a 25-yr, 24-hr storm event.

APPROACH

The proposed cap configuration at Site 4 includes a steep portion of the cap (4:1 maximum slope) and the top, plateau portion (3.5-5% slope). The cap configuration of Site 5 will be similar except in the Trap/Skeet range area where the vegetative layers will be replaced with the asphalt paving structure. Figure 1, presents the proposed cap configuration and layers of the cap for the steep portions of the cap (Site 4), and the plateau portion of the caps (Sites 4 and 5). The paved portion of the Site 5 landfill cap is not evaluated with the HELP model because it is assumed that the paved surface will be relatively impervious and the vegetated sections will represent a worst case.

The procedures outlined in the HELP Model Users Guide to Version 3 will be followed in the calculation (ref 1).

The 24-hr, 25-yr will be incorporated into the HELP model by entering the total rainfall amount for a 24-hr, 25-yr storm event (6.0 inches) in to the daily input precipitation input file. The peak daily values presented in the HELP output will represent the 24-hr, 25-yr storm event.

The Site 4 landfill cap has a relatively small plateau portion. Because the amount of area of the plateau portion of the cap which drains toward the steep slope is small, a lateral drain in the drainage layer is not needed at the break in slope between the plateau and the steep portion. The plateau portion and the side slopes will be modeled as with two separate HELP runs with the flow out of the lateral drainage layer in the plateau portion input into the lateral drainage layer in the side slope portion as subsurface inflow. Figures 2 and 3 show the representative flow lengths for Sites 4 and 5, respectively.

ASSUMPTIONS

The following section describes the selection of the assumed soil properties.

TOPSOIL/ SELECT FILL MATERIAL. The topsoil and select cover material are assumed to be similar to soils currently at the sites. The soils at the sites are classified as silty sands. The default soil #7 in the HELP model Users guide was chosen for the these layers. This soil is a silty sand and has a hydraulic conductivity of 5.2×10^{-4} cm/sec. The hydraulic conductivity of the soils in the aquifer at Sites 4 and 5 range between 6.46×10^{-4} and 2.08×10^{-4} cm/sec, as presented in the RI report (ref. 4).

BEDDING SOIL / GAS MANAGEMENT LAYER The gas management layer is assumed to be a poorly graded sand to provide adequate gas flow. An SP soil, as classified by the USCS, represents a poorly graded clean sand. This would correspond to HELP default soil #1 with a hydraulic conductivity of 1×10^{-2} cm/sec.

GRANULAR DRAINAGE MATERIAL The 12 inch thick drainage layer must meet the following gradation requirements based on the New Jersey Administrative Code:

$$D_2 > 0.1 \text{ inch } (2.54 \text{ mm})$$
$$D_{85} > 4\ D_{15}$$

Because of potential puncture of the geomembrane, the maximum size of the drainage material will be

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limited to 1 inch (25.4 mm). Figure 4 from Ref. 2 shows the hydraulic conductivity (coefficient of permeability) of drainage material based on gradation. Curve no. 6 most closely matches the drainage material to be used in the landfill caps. This material has a hydraulic conductivity of 2.08 ft/min (1.0 cm/sec).

The conductivity can also be estimated using the D_{10} of the soil and the following equation proposed by Hazen (REF. 3).

$$k = CD_{10}^2$$

where k is the hydraulic conductivity in cm/sec, C is a constant with the average value being 1, and D_{10} is in mm. Based on the required gradation the D_2 is at least 2.5 mm so the D_{10} would also be at least 2.5 mm. This results in a hydraulic conductivity of 6.25 cm/sec.

To be conservative assume that the hydraulic conductivity of the drainage layer is 1 cm/sec.

GEOMEMBRANE The geomembrane is a 40 mil (0.04 inch) LDPE liner. It is assumed that the membrane has 1 pinhole per acre, good to fair installation with 4 defects per acre, and good placement quality. Assuming a good placement quality is reasonable since the contractor for this project is known and is experienced in this type of construction.

CALCULATIONS

The HELP model outputs are attached for the three cases that were evaluated:

1) Site 5 landfill cap
2) Site 4 plateau
3) Site 4 side slope (with subsurface inflow)

CONCLUSIONS

The yearly average infiltration (inches) and the average peak daily head on the geomembrane is summarized in the following table. The maximum head is assumed to be twice the average head on the geomembrane. The maximum head on the geomembrane during the 24-hr, 25-yr storm event nearly equals the drainage layer thickness of 12 inches but is below.

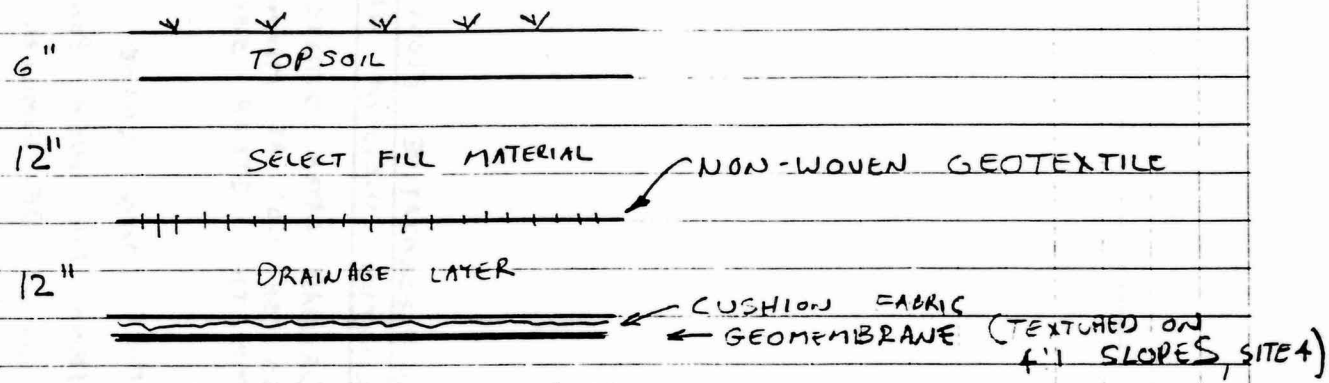
Case	Average yearly percolation through the geomembrane (in)	Average Peak daily head on the geomembrane (in)	Maximum Daily Head on the geomembrane (in)
Site 5	0.15	5.97	11.94
Site 4 Plateau	0.07	3.67	7.34
Site 4 Side Slope	0.01	0.49	0.98

REFERENCES

1) Schroeder, P.R., et al., "The Hydrologic Evaluation of Landfill Performance (HELP) Model: Users guide for Version 3," EPA/600/R-94/168a, U.S. EPA Risk Reduction Engineering Laboratory, Cincinnati OH, 1994.
2) Design Manual-Soil Mechanics, Foundations and Earth Structures, NAVFAC DM-7, March 1971.
3) Holtz, R.D., and Kavacs, W.D., *An Introduction to Geotechnical Engineering*, Prentice -Hall, Englewood Cliffs NJ, 1981.
4) Brown & Root Environmental, Remedial Investigation Report for NWS Earle, Northern Division, Naval Engineering Facilities Command, July 1996.

CALCULATION WORKSHEET Order No. 19116 (01-91)

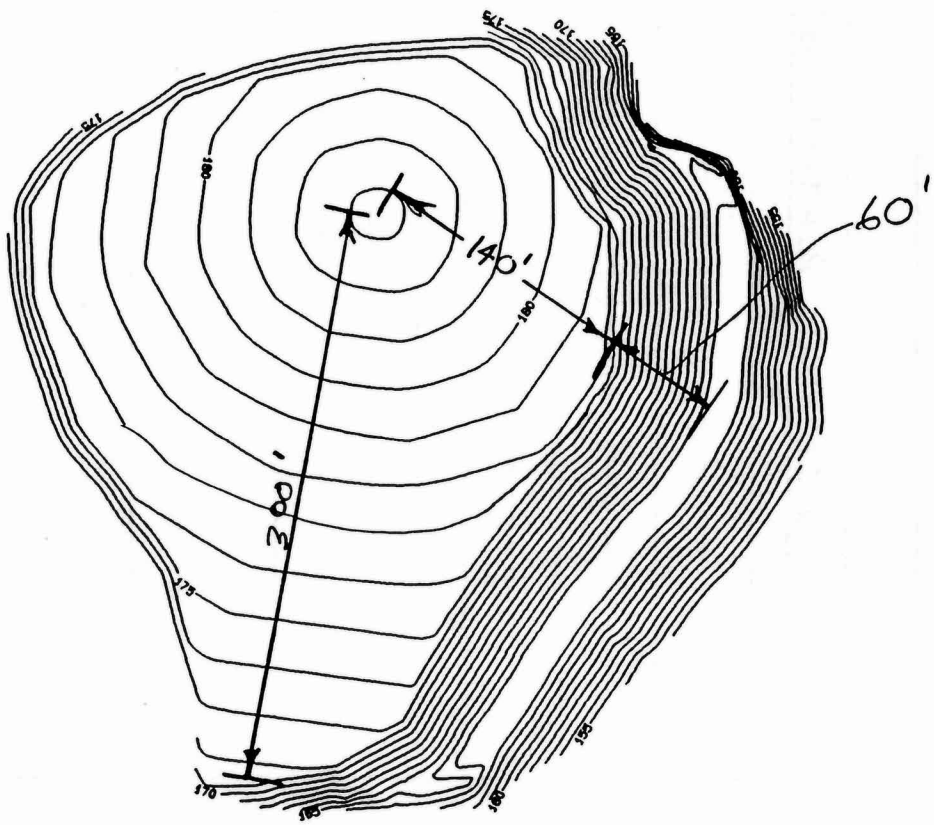
CLIENT		JOB NUMBER	
SUBJECT			
BASED ON		DRAWING NUMBER	
BY	CHECKED BY	APPROVED BY	DATE



VEGETATED PORTION OF CAP

FIGURE 1

SITE 4
FINAL GRADE
1" = 100'

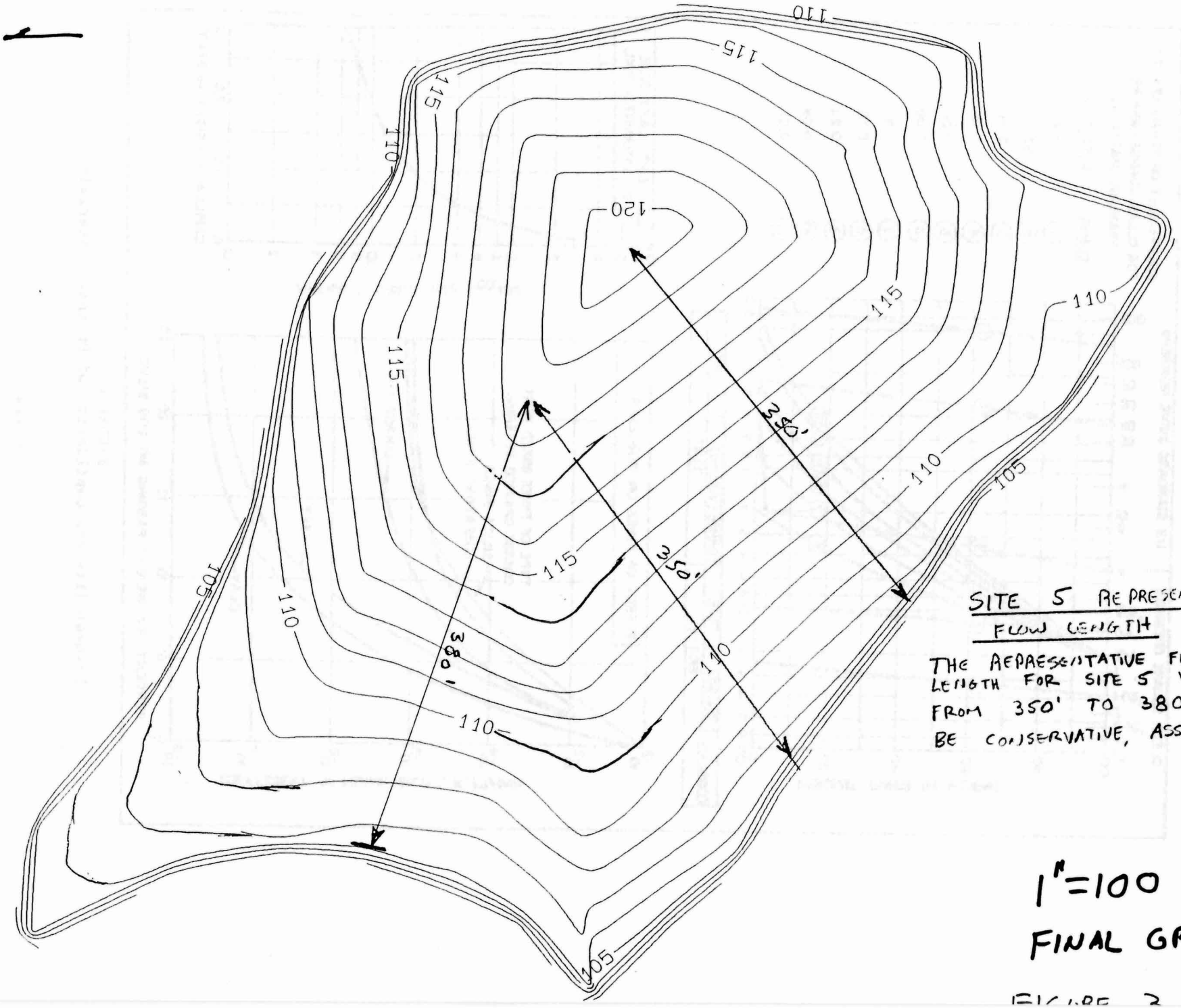


REPRESENTATIVE FLOW LENGTHS USED IN HELP MODEL, SITE 4

(DRAINAGE LAYER OUTLETS TO BENCH SO USE 60' AS MAXIMUM SLOPE LENGTH FOR THE STEEP SECTION)

THE LONG GRADE FLOWING FROM THE HIGH POINT TO SOUTH WOULD BE SIMILIAR TO SITE 5 (3.5% GRADE), HOWEVER THIS FLOW LENGTH IS SHORTER THAN THE FLOW LENGTHS AT SITE 5. SITE 5 IS CRITICAL FOR THE FLAT PORTION, SO USE SITE 5 RESULTS TO DETERMINE IF A CRITICAL CONDITION EXISTS FOR FLAT PORTIONS AT SITE

2



SITE 5 REPRESENTATIVE FLOW LENGTH

THE REPRESENTATIVE FLOW LENGTH FOR SITE 5 VARIES FROM 350' TO 380'. TO BE CONSERVATIVE, ASSUME 400'

1" = 100

FINAL GRADE

FIGURE 3

5 of 22

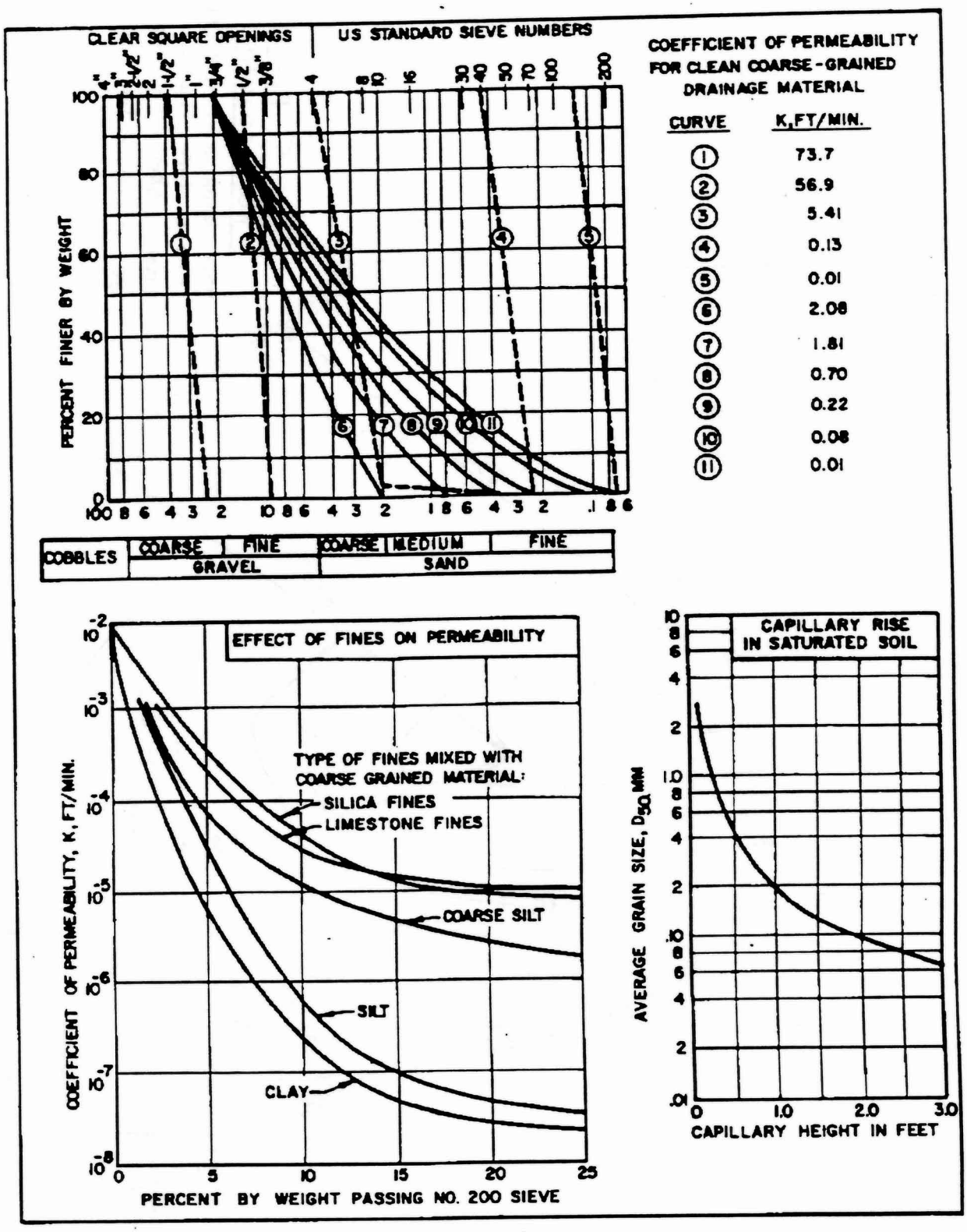


FIGURE 6
Permeability and Capillarity of Drainage Materials

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**               HELP MODEL VERSION 3.03  (31 DECEMBER 1994)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP3\earl2.D4
TEMPERATURE DATA FILE:       C:\HELP3\earle.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\earle.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\earle.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\EARL51.D10
OUTPUT DATA FILE:            C:\HELP3\earl5_24.OUT
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J'd INPUT MOD 10/28/97

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TIME:  14:19     DATE:  10/22/1997


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     TITLE:  NWS EARLE SITE 5

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                LAYER  1
                                --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   7
          THICKNESS                 =      6.00   INCHES
          POROSITY                  =      0.4730 VOL/VOL
          FIELD CAPACITY            =      0.2220 VOL/VOL
          WILTING POINT             =      0.1040 VOL/VOL
          INITIAL SOIL WATER CONTENT =     0.1791 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.520000001000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.63
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                LAYER  2
                                --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   7
          THICKNESS                 =     12.00   INCHES
          POROSITY                  =      0.4730 VOL/VOL
          FIELD CAPACITY            =      0.2220 VOL/VOL
          WILTING POINT             =      0.1040 VOL/VOL
          INITIAL SOIL WATER CONTENT =     0.2431 VOL/VOL
```

EFFECTIVE SAT. HYD. COND. = 0.520000001000E-03 CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3970	VOL/VOL
FIELD CAPACITY	=	0.0320	VOL/VOL
WILTING POINT	=	0.0130	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0471	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	1.00000000000	CM/SEC
SLOPE	=	3.50	PERCENT
DRAINAGE LENGTH	=	400.0	FEET

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 36

THICKNESS	=	0.04	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.399999993000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 1

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4170	VOL/VOL
FIELD CAPACITY	=	0.0450	VOL/VOL
WILTING POINT	=	0.0180	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0555	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999978000E-02	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A GOOD STAND OF GRASS, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	66.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	8.000	ACRES
EVAPORATIVE ZONE DEPTH	=	20.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.208	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	9.308	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.898	INCHES

INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	5.223	INCHES
TOTAL INITIAL WATER	=	5.223	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
EDISON NEW JERSEY

MAXIMUM LEAF AREA INDEX	=	3.50
START OF GROWING SEASON (JULIAN DATE)	=	109
END OF GROWING SEASON (JULIAN DATE)	=	299
AVERAGE ANNUAL WIND SPEED	=	10.20 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	64.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	61.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	66.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	68.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NEWARK NEW JERSEY

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.13	3.05	4.15	3.57	3.59	2.94
3.85	4.30	3.66	3.09	3.59	3.42

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR EDISON NEW JERSEY

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
31.20	32.80	40.60	51.60	61.40	70.20
74.90	73.10	66.70	56.50	45.60	33.90

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR EDISON NEW JERSEY

STATION LATITUDE = 40.50 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.93	3.46	4.30	3.24	4.28	2.73
	3.80	4.46	3.64	2.31	3.11	3.74

STD. DEVIATIONS	1.32	1.40	2.19	1.87	2.36	1.34
	1.81	2.19	1.78	1.10	1.36	1.49

RUNOFF

TOTALS	0.851	1.144	1.129	0.045	0.001	0.000
	0.000	0.011	0.006	0.000	0.000	0.128
STD. DEVIATIONS	1.032	0.777	1.573	0.202	0.006	0.002
	0.001	0.049	0.025	0.000	0.000	0.330

EVAPOTRANSPIRATION

TOTALS	1.104	1.212	2.584	2.947	3.916	3.294
	3.371	3.129	3.167	2.153	1.121	0.882
STD. DEVIATIONS	0.215	0.249	0.325	0.731	1.442	1.413
	1.498	1.265	0.687	0.791	0.267	0.161

LATERAL DRAINAGE COLLECTED FROM LAYER 3

TOTALS	0.6167	0.6504	2.1101	1.3506	0.7312	0.1700
	0.0815	0.3480	0.6813	0.2714	0.6021	1.9840
STD. DEVIATIONS	0.6510	1.1925	1.2064	1.6998	0.8924	0.3412
	0.2330	0.6298	1.0471	0.3661	0.8581	1.4143

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0111	0.0092	0.0309	0.0229	0.0127	0.0030
	0.0014	0.0056	0.0108	0.0052	0.0096	0.0307
STD. DEVIATIONS	0.0103	0.0165	0.0154	0.0224	0.0141	0.0055
	0.0037	0.0090	0.0147	0.0070	0.0123	0.0194

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0120	0.0123	0.0079	0.0100	0.0155	0.0195
	0.0174	0.0133	0.0099	0.0124	0.0096	0.0052
STD. DEVIATIONS	0.0067	0.0053	0.0063	0.0078	0.0082	0.0075
	0.0062	0.0054	0.0041	0.0067	0.0053	0.0051

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ACROSS LAYER 4

AVERAGES	0.0404	0.0522	0.1428	0.0987	0.0476	0.0114
	0.0053	0.0227	0.0463	0.0177	0.0405	0.1293
STD. DEVIATIONS	0.0432	0.1007	0.0828	0.1433	0.0581	0.0230
	0.0152	0.0410	0.0716	0.0238	0.0577	0.0923

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	42.00	(6.841)	1219709.0	100.00
RUNOFF	3.317	(2.4002)	96323.56	7.897

EVAPOTRANSPIRATION	28.880	(3.1331)	838684.62	68.761
LATERAL DRAINAGE COLLECTED FROM LAYER 3	9.59736	(3.79797)	278707.469	22.85032
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.15314	(0.05150)	4447.193	0.36461
AVERAGE HEAD ACROSS TOP OF LAYER 4	0.055	(0.023)		
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.14482	(0.04711)	4205.694	0.34481
CHANGE IN WATER STORAGE	0.062	(0.8955)	1787.72	0.147

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	6.00	174240.000
RUNOFF	2.280	66219.2031
DRAINAGE COLLECTED FROM LAYER 3	1.66816	48443.32420
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.023282	676.09619
AVERAGE HEAD ACROSS LAYER 4	5.971	
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.001656	48.10110
SNOW WATER	3.89	112911.9370

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3810

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0793

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	1.4770	0.2462
2	3.5170	0.2931
3	0.6281	0.0523
4	0.0000	0.0000
5	0.8324	0.0694
SNOW WATER	0.000	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**               HELP MODEL VERSION 3.03  (31 DECEMBER 1994)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\HELP3\earl2.D4
TEMPERATURE DATA FILE:       C:\HELP3\earle.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\earle.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\earle.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\earla.D10
OUTPUT DATA FILE:            C:\HELP3\erl4a24.OUT
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J'd INPUT MEA 10/28/97

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TIME:  14:31     DATE:  10/22/1997


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     TITLE:  NWS EARLE SITE 4
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TOP

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   7
          THICKNESS                  =      6.00   INCHES
          POROSITY                   =      0.4730 VOL/VOL
          FIELD CAPACITY             =      0.2220 VOL/VOL
          WILTING POINT              =      0.1040 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.1791 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.520000001000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.63
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                  LAYER  2
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   7
          THICKNESS                  =     12.00   INCHES
          POROSITY                   =      0.4730 VOL/VOL
          FIELD CAPACITY             =      0.2220 VOL/VOL
          WILTING POINT              =      0.1040 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.2431 VOL/VOL
```

```
EFFECTIVE SAT. HYD. COND.    =  0.520000001000E-03 CM/SEC


                        LAYER  3
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     12.00   INCHES
POROSITY                     =     0.3970 VOL/VOL
FIELD CAPACITY               =     0.0320 VOL/VOL
WILTING POINT                =     0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.0454 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  1.00000000000      CM/SEC
SLOPE                        =      3.50   PERCENT
DRAINAGE LENGTH              =    140.0    FEET


                        LAYER  4
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER 36
THICKNESS                    =      0.04   INCHES
POROSITY                     =     0.0000 VOL/VOL
FIELD CAPACITY               =     0.0000 VOL/VOL
WILTING POINT                =     0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY          =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =      4.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                        LAYER  5
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            TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                    =     12.00   INCHES
POROSITY                     =     0.4170 VOL/VOL
FIELD CAPACITY               =     0.0450 VOL/VOL
WILTING POINT                =     0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.0494 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999978000E-02 CM/SEC


          GENERAL DESIGN AND EVAPORATIVE ZONE DATA
          ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
          AND A SLOPE LENGTH OF  140. FEET.

SCS RUNOFF CURVE NUMBER              =   68.90
FRACTION OF AREA ALLOWING RUNOFF     =   100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE   =     2.800  ACRES
EVAPORATIVE ZONE DEPTH               =    20.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE    =     4.208  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =     9.308  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE   =     1.898  INCHES
```

INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	5.130	INCHES
TOTAL INITIAL WATER	=	5.130	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
EDISON NEW JERSEY

MAXIMUM LEAF AREA INDEX	=	3.50
START OF GROWING SEASON (JULIAN DATE)	=	109
END OF GROWING SEASON (JULIAN DATE)	=	299
AVERAGE ANNUAL WIND SPEED	=	10.20 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	64.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	61.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	66.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	68.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NEWARK NEW JERSEY

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.13	3.05	4.15	3.57	3.59	2.94
3.85	4.30	3.66	3.09	3.59	3.42

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR EDISON NEW JERSEY

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
31.20	32.80	40.60	51.60	61.40	70.20
74.90	73.10	66.70	56.50	45.60	33.90

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR EDISON NEW JERSEY

STATION LATITUDE = 40.50 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.93	3.46	4.30	3.24	4.28	2.73
	3.80	4.46	3.64	2.31	3.11	3.74

STD. DEVIATIONS	1.32	1.40	2.19	1.87	2.36	1.34
	1.81	2.19	1.78	1.10	1.36	1.49

RUNOFF

TOTALS	0.851	1.146	1.132	0.056	0.004	0.002
	0.001	0.018	0.012	0.000	0.000	0.129
STD. DEVIATIONS	1.032	0.774	1.574	0.249	0.014	0.007
	0.005	0.071	0.042	0.000	0.001	0.332

EVAPOTRANSPIRATION

TOTALS	1.104	1.212	2.584	2.947	3.916	3.293
	3.372	3.128	3.167	2.153	1.121	0.882
STD. DEVIATIONS	0.215	0.249	0.325	0.731	1.442	1.411
	1.499	1.266	0.687	0.791	0.267	0.161

LATERAL DRAINAGE COLLECTED FROM LAYER 3

TOTALS	0.6032	0.6647	2.1348	1.3416	0.7371	0.1604
	0.0840	0.3542	0.6763	0.2658	0.6288	1.9989
STD. DEVIATIONS	0.6592	1.2002	1.2258	1.6689	0.9012	0.3262
	0.2306	0.6538	1.0215	0.3620	0.8771	1.4193

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0048	0.0043	0.0143	0.0099	0.0055	0.0012
	0.0006	0.0025	0.0048	0.0022	0.0045	0.0136
STD. DEVIATIONS	0.0047	0.0077	0.0074	0.0099	0.0063	0.0023
	0.0015	0.0042	0.0066	0.0030	0.0057	0.0087

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0050	0.0051	0.0031	0.0035	0.0056	0.0074
	0.0072	0.0060	0.0048	0.0057	0.0046	0.0025
STD. DEVIATIONS	0.0029	0.0024	0.0022	0.0022	0.0033	0.0028
	0.0023	0.0023	0.0022	0.0025	0.0021	0.0023

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ACROSS LAYER 4

AVERAGES	0.0145	0.0219	0.0580	0.0357	0.0171	0.0038
	0.0019	0.0087	0.0173	0.0061	0.0157	0.0462
STD. DEVIATIONS	0.0170	0.0418	0.0367	0.0544	0.0214	0.0077
	0.0053	0.0166	0.0279	0.0082	0.0233	0.0333

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	42.00	(6.841)	426898.2	100.00
RUNOFF	3.351	(2.3966)	34054.89	7.977

EVAPOTRANSPIRATION	28.879	(3.1318)	293530.78	68.759
LATERAL DRAINAGE COLLECTED FROM LAYER 3	9.64987	(3.78612)	98081.234	22.97532
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.06805	(0.02328)	691.650	0.16202
AVERAGE HEAD ACROSS TOP OF LAYER 4	0.021	(0.009)		
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.06046	(0.01994)	614.552	0.14396
CHANGE IN WATER STORAGE	0.061	(0.8887)	616.67	0.144

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	6.00	60984.000
RUNOFF	2.280	23176.7129
DRAINAGE COLLECTED FROM LAYER 3	2.59436	26369.09570
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.015704	159.61461
AVERAGE HEAD ACROSS LAYER 4	3.674	
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000503	5.11752
SNOW WATER	3.89	39519.1797

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3725
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0793

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	1.4770	0.2462
2	3.5170	0.2931
3	0.6049	0.0504
4	0.0000	0.0000
5	0.7449	0.0621
SNOW WATER	0.000	

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**               HELP MODEL VERSION 3.03  (31 DECEMBER 1994)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP3\earl2.D4
TEMPERATURE DATA FILE:       C:\HELP3\earle.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\earle.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\earle.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\earl4b2.D10
OUTPUT DATA FILE:            C:\HELP3\erl4b24.OUT


TIME:  14:39     DATE:  10/22/1997


******************************************************************************

     TITLE:  NWS EARLE SITE 4      SIDE SLOPE

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   7
          THICKNESS                  =      6.00   INCHES
          POROSITY                   =      0.4730 VOL/VOL
          FIELD CAPACITY             =      0.2220 VOL/VOL
          WILTING POINT              =      0.1040 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.1779 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.520000001000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.63
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                  LAYER  2
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   7
          THICKNESS                  =     12.00   INCHES
          POROSITY                   =      0.4730 VOL/VOL
          FIELD CAPACITY             =      0.2220 VOL/VOL
          WILTING POINT              =      0.1040 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.2428 VOL/VOL
```

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EFFECTIVE SAT. HYD. COND.    =  0.520000001000E-03 CM/SEC


                        LAYER  3
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.3970 VOL/VOL
FIELD CAPACITY               =      0.0320 VOL/VOL
WILTING POINT                =      0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0453 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =   1.00000000000      CM/SEC
SLOPE                        =     25.00   PERCENT
DRAINAGE LENGTH              =     60.0    FEET
SUBSURFACE INFLOW            =      9.60   INCHES/YR


                        LAYER  4
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
THICKNESS                    =      0.04   INCHES
POROSITY                     =      0.0000 VOL/VOL
FIELD CAPACITY               =      0.0000 VOL/VOL
WILTING POINT                =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY          =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =      4.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                        LAYER  5
                        --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.4170 VOL/VOL
FIELD CAPACITY               =      0.0450 VOL/VOL
WILTING POINT                =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0459 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999978000E-02 CM/SEC


          GENERAL DESIGN AND EVAPORATIVE ZONE DATA
          ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF 25.%
          AND A SLOPE LENGTH OF   60. FEET.

SCS RUNOFF CURVE NUMBER              =     72.40
FRACTION OF AREA ALLOWING RUNOFF     =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE   =      2.800  ACRES
EVAPORATIVE ZONE DEPTH               =     20.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE    =      4.198  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =      9.308  INCHES
```

LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.898	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	5.076	INCHES
TOTAL INITIAL WATER	=	5.076	INCHES
TOTAL SUBSURFACE INFLOW	=	9.60	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
EDISON NEW JERSEY

MAXIMUM LEAF AREA INDEX	=	3.50
START OF GROWING SEASON (JULIAN DATE)	=	109
END OF GROWING SEASON (JULIAN DATE)	=	299
AVERAGE ANNUAL WIND SPEED	=	10.20 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	64.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	61.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	66.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	68.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NEWARK NEW JERSEY

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.13	3.05	4.15	3.57	3.59	2.94
3.85	4.30	3.66	3.09	3.59	3.42

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR EDISON NEW JERSEY

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
31.20	32.80	40.60	51.60	61.40	70.20
74.90	73.10	66.70	56.50	45.60	33.90

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR EDISON NEW JERSEY

STATION LATITUDE = 40.50 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.93	3.46	4.30	3.24	4.28	2.73
	3.80	4.46	3.64	2.31	3.11	3.74

STD. DEVIATIONS	1.32	1.40	2.19	1.87	2.36	1.34
	1.81	2.19	1.78	1.10	1.36	1.49

RUNOFF

TOTALS	0.842	1.141	1.136	0.072	0.011	0.005
	0.004	0.032	0.026	0.000	0.003	0.131
STD. DEVIATIONS	1.025	0.764	1.585	0.322	0.032	0.021
	0.016	0.108	0.075	0.000	0.010	0.337

EVAPOTRANSPIRATION

TOTALS	1.155	1.250	2.649	2.947	3.994	3.422
	3.499	3.236	3.242	2.237	1.224	0.943
STD. DEVIATIONS	0.194	0.261	0.298	0.779	1.424	1.407
	1.504	1.256	0.673	0.758	0.236	0.125

SUBSURFACE INFLOW INTO LAYER 3

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 3

TOTALS	1.3301	1.3143	3.0374	2.0618	1.4722	0.8274
	0.7724	1.0493	1.3879	0.9783	1.3495	2.7631
STD. DEVIATIONS	0.6969	1.2325	1.2641	1.5763	0.9429	0.3409
	0.2372	0.6668	1.0316	0.4035	0.9123	1.4297

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0009	0.0008	0.0015	0.0012	0.0009	0.0006
	0.0006	0.0007	0.0009	0.0007	0.0008	0.0015
STD. DEVIATIONS	0.0003	0.0004	0.0005	0.0005	0.0004	0.0002
	0.0001	0.0003	0.0004	0.0002	0.0004	0.0006

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0006	0.0006	0.0004	0.0005	0.0006	0.0008
	0.0008	0.0007	0.0006	0.0007	0.0006	0.0004
STD. DEVIATIONS	0.0003	0.0004	0.0003	0.0003	0.0004	0.0003
	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ACROSS LAYER 4

AVERAGES	0.0074	0.0083	0.0177	0.0122	0.0082	0.0047
	0.0043	0.0060	0.0078	0.0054	0.0078	0.0158
STD. DEVIATIONS	0.0040	0.0081	0.0071	0.0094	0.0052	0.0019
	0.0013	0.0040	0.0056	0.0022	0.0051	0.0081

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	42.00	(6.841)	426898.2	100.00
RUNOFF	3.404	(2.4013)	34595.01	8.104
EVAPOTRANSPIRATION	29.796	(3.1993)	302848.50	70.942
SUBSURFACE INFLOW INTO LAYER 3	0.00000		0.000	0.00000
LATERAL DRAINAGE COLLECTED FROM LAYER 3	18.34362	(3.74254)	186444.594	43.67426
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.01093	(0.00146)	111.127	0.02603
AVERAGE HEAD ACROSS TOP OF LAYER 4	0.009	(0.002)		
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00751	(0.00337)	76.282	0.01787
CHANGE IN WATER STORAGE	0.056	(0.8892)	573.06	0.134

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	6.00	60984.000
RUNOFF	2.287	23245.0020
DRAINAGE COLLECTED FROM LAYER 3	2.22173	22581.67190
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000552	5.61136
AVERAGE HEAD ACROSS LAYER 4	0.494	
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000038	0.39108
SNOW WATER	3.89	39519.1797

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3723
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0794

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	1.4753	0.2459
2	3.5157	0.2930

3	0.5932	0.0494
4	0.0000	0.0000
5	0.6191	0.0516
SNOW WATER	0.000	

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CLIENT NAVY, NWS EARLE		JOB NUMBER 7602-0201	
SUBJECT INFINITE SLOPE STABILITY			
BASED ON		DRAWING NUMBER	
BY DCW	CHECKED BY MEA 10/30/97	APPROVED BY	DATE 10/30/97

OBJECTIVE

The objective of this calculation is to determine the factor of safety against sliding of cap components for the proposed cap configuration for the Landfills at Sites 4 and 5 at the Naval Weapons Station Earle in Colts Neck, New Jersey.

APPROACH

The proposed cap configuration at Site 4 includes a steep portion of the cap (4:1 maximum slope) and the top, plateau portion (3.5-5% slope). The cap configuration of Site 5 will be similar except in the Trap/Skeet range area where the vegetative layers will be replaced with the asphalt paving structure. No steep (4:1 slopes) are present at Site 5. The maximum slopes at Site 5 are 3.5 to 5 %. The cap configuration at Site 4 substitutes a textured geomembrane for the smooth geomembrane on the 4:1 side slopes. Figure 1 presents the cap configurations.

An infinite slope type analysis was performed to determine the factor of safety (Ref 1, and 6) of cap components sliding over each other. The equations presented in these references were modified to allow for the analysis of a variable depth of saturation in the cap components.

INFINITE SLOPE EQUATIONS

A typical free body diagram used for an infinite slope analysis and definition of variables are shown in page 9. The Mohr Coulomb strength envelope is used to evaluate the soil parameters c, cohesion, and ϕ, friction angle. The stability analysis involves determination of shear stress along an assumed failure plane and comparing the stress with the shear strength of the soil and/or strength of component interfaces.

From ref # 6 page 242

$$FS = S/\tau$$

and

$$\tau = W \sin\beta \cos\beta$$

$$Weight = W = b\sum_{i=1}^{n}(\gamma_i * h_i)$$

Where n= the number of soil layers

The factor of safety given the shear strength of a material is then (the complete derivation is given on pages 9-11):

$$FS = Sb / (W \sin\beta \cos\beta)$$

The shear strength of the material or interface is given by:

$$S = c + \theta \tan\phi$$

The factor of safety can then be shown to be (the complete derivation is shown on pages 9-11):

$$FS = \frac{c}{W * \cos(\beta)\sin(\beta)} + \frac{W * \cos(\beta)\tan(\phi)}{W * \cos(\beta)\sin(\beta)} - \frac{\gamma_w * h_{sat} * \cos^2(\beta)\tan(\phi)}{W * \cos(\beta)\sin(\beta)}$$

CLIENT NAVY, NWS EARLE		JOB NUMBER 7602-0201	
SUBJECT INFINITE SLOPE STABILITY			
BASED ON		DRAWING NUMBER	
BY DCW	CHECKED BY MEA 10/30/97	APPROVED BY	DATE 10/30/97

Simplifying

$$FS = \frac{c}{W * \cos(\beta) * \sin(\beta)} + \frac{\tan(\phi)}{\tan(\beta)} - \frac{\gamma_w * h_{sat} * \tan(\phi)}{W * \tan(\beta)}$$

ASSUMPTIONS

The following section describes the selection of the assumed soil strengths, interface friction angles, and the level of saturation in the cap configurations.

HEIGHT OF SATURATION IN CAP The height of saturation the cap was calculated in a separate calculation Ref (14) using the HELP model (Ref 15). The HELP model predicts the average peak daily head on the cap (average over the area of the cap). Assume that the maximum head is twice the average head (this assumes a zero head at the highest point in the cap and a uniform gradient in the cap).

Case	Average Peak daily head on the geomembrane (in), ref 14	Maximum Peak daily head on the geomembrane (in)
Site 5	5.97	11.94
Site 4 Plateau	3.67	7.34
Site 4 Side Slope	0.49	0.98

It is assumed that the materials under the geomembrane are unsaturated.

GRANULAR DRAINAGE MATERIAL The 12 inch thick drainage layer must meet the following gradation requirements based on the New Jersey Administrative Code:

$$D_2 > 0.1 \text{ inch } (2.54 \text{ mm})$$
$$D_{85} > 4\ D_{15}$$

Because of potential puncture of the geomembrane the maximum size of the drainage material will be limited to 1 inch (25.4 mm).

The granular drainage material in the cap system is assumed to be a poorly graded gravel based on the above gradation. A GP soil, as classified by the USCS, represents a poorly graded gravel with typical shear strength properties of 0 psf for cohesion and 37 degrees for effective stress friction angle (ref 2, see page 12). A dry unit weight of 120 pcf was judged to be representative for this material (ref 2). The saturated unit weight was calculated using an assumed void ratio of 0.50. Ref 16 gives a range of void ratio for sand and gravel to be between 0.85 and 0.14; the average of these numbers is approximately 0.50. The saturated unit weight was calculated to be 140.8 pcf. The value of 141 pcf was used in the stability analysis for saturated conditions. The saturated unit weight is calculated with the following equation from reference 12.

$$\gamma_{sat} = W_s/V + (e/(1+e))\gamma_{water}$$

Where:

γ_{sat} = saturated unit weight of soil
W_s = dry weight of the soil (pcf)
V = volume of soil (1ft^3)
e = void ratio
γ_{water} = unit weight of water (62.4 pcf)

CLIENT NAVY, NWS EARLE		JOB NUMBER 7602-0201	
SUBJECT INFINITE SLOPE STABILITY			
BASED ON		DRAWING NUMBER	
BY DCW	CHECKED BY MEA 10/30/97	APPROVED BY	DATE 10/30/97

The material will be assumed to be moist above the saturated area with a moisture content of 12% (Ref 2, lists the optimum moisture content for this material as 11% and 14%). This equates to a moist unit weight of 134.4. a unit weight of 135 will be used in the calculations.

SELECT FILL MATERIAL/TOPSOIL The 6 inch layer of topsoil and select fill material are assumed to be similar to the native surface soils surrounding the Sites 4 and 5. From the boring logs of borings in the vicinity of Site 2 the surface soil is primarily silty sand (SM), and some poorly graded sands (SP) and clayey sand (SC). Based on reference 2, typical effective strength parameters for this type of soil (SM) are a cohesion of 420 psf and a friction angle of 34° . Also from ref. 2, a typical dry unit weight is 120 pcf. From Ref. 2 the optimum moisture content for this soil is between 16-11 %. Assume that the moisture content is 12% which results in a moist unit weight of 134.4 pcf. Use 135pcf in the calculations. From reference 3, a typical void ratio for this type of soil is 0.48. This equates to a saturated unit weight of 140 pcf.

GAS MANAGEMENT LAYER/BEDDING LAYER The gas management /bedding layer in the cap system is assumed to be a poorly graded sand to provide adequate gas flow. An SP soil, as classified by the USCS, represents a poorly graded clean sand, sand gravel mix with typical shear strength properties of 0 psf for cohesion and 37 degrees for effective stress friction angle (ref 2, see page 12). A dry unit weight of 110 pcf was judged to be representative for this material (ref 2). From Ref. 2 the optimum moisture content for this soil is between 21-12 %. Assume that the moisture content is 15% which results in a moist unit weight of 126.5 pcf. Use 127 pcf in the calculations. The saturated unit weight was calculated using a typical void ratio for this type of material (0.50, ref. 3, see page 13). The saturated unit weight was calculated to be 130.8 pcf. The value of 131 pcf was used in the stability analysis.

ASPHALT PAVEMENT A portion of the Site 5 landfill cap will be paved to facilitate the removal of debris generated from the skeet/trap shooting activities. The strength parameters of the asphalt paving will be conservatively assumed to be the same as the granular drainage material with a cohesion of 0 pcf and a friction angle of 37°. In reality the asphalt will have a high cohesion, and an assumption of no cohesion will be conservative from a stability standpoint. The unit weight of the compacted asphalt paving is assumed to have a bulk specific gravity of 2.344 and a maximum specific gravity of 2.438 based on a typical pavement design in reference 13. This corresponds to an approximate bulk unit weight of 146 pcf and a maximum unit weight of 152 pcf. A value of 150 pcf was assumed in the analysis.

BASE COURSE/SUBBASE The pavement base course will be an aggregate layer. Assume densities and strength properties similar to that of the granular drainage layer.

<u>INTERFACE FRICTION ANGLES</u> Interface friction angles were conservatively chosen from literature values. The normal stress on the cap materials (due to the weight of the soils) will be in the range of 100-400 psf (roughly corresponding soil depths of 1 to 3 feet). Interface friction angles were chosen with tests using similar normal stress ranges.

<u>Non-Woven Geotextile / Select Fill Material</u> The Select Fill Material will likely be a SM type soil (silty and sands respectively). Reference 5, page 15 (trevira tech note) lists interface strength properties for glacial till and non-woven geotextile as 37° and a cohesion of 32 psf. This same reference lists glacial till as CL-ML type of soil which are inorganic silty fine sands to sandy clays. The select fill material is between a sand material and the glacial till soil types. Assume that the interface friction angle for the non-woven to bedding soil is also between the friction angle for sand and glacial till material. The interface friction angle for the Select Fill Material would be between 25° (for mica schist sand, ref. 4, page 14) and 37°. Use the smallest friction angle in this range to be conservative, $\phi = 25°$.

<u>Non-Woven Geotextile/Granular Drainage Material</u> Assume the non-woven geotextile is needle-punched type similar to Trevira 01114. From reference 5, page, 15 the friction angle and cohesion for this material against Ottawa sand within a normal stress range of 100 to 250 psf are 27° and 68 psf respectively.

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Reference 4, table 5.7 (see page 14) gives friction angles between non-woven geotextile and Ottawa sand, concrete sand, and mica schist sand. Of these three, the lowest friction angle is 25° for mica schist sand. Assume a friction angle of 25° and neglect any cohesion to be conservative.

Granular Drainage Material/ Cushion Fabric This interface will be assumed to be have the same frictional charateristics as the non-woven geotextile/granular drainage material interface, since the cushion fabric is a non-woven geotextile.

Cushion Fabric/ Textured LDPE Interface friction data for textured LDPE is very limited. It is assumed that the friction characteristics of textured HDPE and VLDPE would be similar to the LDPE and can be used in choosing LDPE friction angles. The following table summarizes the friction angles and cohesion values reported in literature.

C (psf)	ϕ (degrees)	Normal stress Range (psf)	Peak or Residual Strength	Backing	Type of Materials (All membranes are textured)	Ref.
18	36	---	---	---	Tex HDPE /Trevira 1155	5
116	28	---	---	---	Friction flex/ NW Polyester Geotextile	11
133	33	----	---	----	Friction flex/ NW polypropylene geotextile	11
55	32	432-1296		----	NSC Friction Seal /NW geotextile	17

To be conservative use the lowest peak friction angle and neglect the cohesion. Use $\phi = 28°$ and $c = 0$ psf.

Textured LDPE / Gas Management/Bedding Layer The following table summarizes the friction angles and cohesion values reported in literature.

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C (psf)	ϕ (degrees)	Normal stress Range (psf)	Peak or Residual Strength	Backing	Type of Materials (All membranes are textured)	Ref.
0	25-45	---	---	---	Gundle HDT/ Sand	7
0	40.5	432	---	clamped to plywood	Rough HDPE / Sand	8
---	25	----	peak	----	TVLDPE/Ott. Sand (sat.)	9
---	21	-----	residual	----	TVLDPE/Ott. Sand (sat.)	9
---	39	432-1296	peak	----	NSC THDPE/Ottawa Sand	10
---	37	432-1296	residual	----	NSC THDPE/Ottawa Sand	10
---	26	244-3000	peak	----	NSC THDPE/Ottawa Sand	10
---	26	244-3000	residual	----	NSC THDPE/Ottawa Sand	10
---	29	244-3000	peak	----	NSC THDPE/Ottawa Sand	10
---	25	244-3000	residual	----	NSC THDPE/Ottawa Sand	10
---	27	244-3000	peak	----	NSC THDPE/Ottawa Sand	10
---	25	244-3000	residual	----	NSC THDPE/Ottawa Sand	10
---	30	---	---	---	FrictionFlex/Ottawa sand	11

To be conservative use the lowest peak friction angle and neglect the cohesion. Use $\phi = 25^o$ and $c = 0$ psf.

Cushion Fabric/ Smooth LDPE Interface friction data for textured LDPE is very limited. It is assumed that the friction characteristics of textured HDPE and VLDPE would be similar to the LDPE and can be used in choosing LDPE friction angles. Reference 4 lists friction angles for two types of non-woven geotextiles with smooth HDPE liners. To be conservative pick the lowest friction angle which is for non-woven needle punched geotextiles with a friction angle of 8° .

Smooth LDPE / Gas Management/Bedding Layer Reference 4 lists friction angles for three types of sands versus a smooth HDPE geomembrane. To be conservative pick the lowest friction angle which is for mica schist sand, with a friction angle of 17° .

Roadway Stabilization Fabric/ Subbase/Select fill The interfaces between the select cover material (silty sand) and the subbase (course aggregate) are assumed to be similar to sand. The roadway stabilization fabric is assumed to be a woven geotextile similar to a monofilament type geotextile. Woven monofilament geotextiles actually produce larger friction angles than a slit film type as can be seen on the table from reference 4, page 14. To be conservative, a slit film type of woven geotextile will be assumed for this calculation. For a mica schist sand to a woven slit film geotextile, the values of $\phi = 23^o$ and $c = 0$ psf (ref. 4) are assumed.

INFINITE SLOPE ANALYSIS Based on the cap configuration and the assumed soil properties discussed above, three possible critical interfaces were evaluated in the infinite slope stability analysis. The first analysis evaluated the interface between the textured LDPE and the Granular Drainage Material for the 4:1 side slopes. The degree of saturation was based on the HELP model calculation (approximately 0.1 foot).

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The saturation in the drainage layer will cause the development of pore pressure at this interface which will have the tendency to lower the factor of safely.

The second analysis evaluated the cushion fabric to smooth geomembrane interface on the flat (5% max) portions of the vegetated cap. The height of saturation again was based on the HELP model calculations and was assumed to be approximately 0.6 ft.

The third interface evaluated was the same as the same as the second case except the paved section of the cap was investigated.

The weight is calculated for the first case as follows:

$$W = (135*2.4)+(141*0.1) = 338 \text{ psf}$$

The factor of safety at the Textured LDPE/Granular Drainage Material interface is calculated by:

$$FS = \frac{0}{338 * \cos(14.03) * \sin(14.03)} + \frac{\tan(25)}{\tan(14.03)} - \frac{62.4 * 0.1 * \tan(25)}{338 * \tan(14.03)}$$

The factor of safety for this interface is 1.83

The factor of safety for the second case (cushion fabric/smooth LDPE interface, vegetated cap) is as follows:

$$W = (135*1.5)+(141*1.0) = 344 \text{ psf}$$

$$FS = \frac{0}{341 * \cos(2.86) * \sin(2.86)} + \frac{\tan(8)}{\tan(2.86)} - \frac{62.4 * 1.0 * \tan(8)}{344 * \tan(2.86)}$$

The factor of safety for this interface is 2.30

The factor of safety for the third case (cushion fabric/smooth LDPE interface, paved cap) is as follows:

$$W = (150*0.167)+(135*1.333)+(141*1.0) = 346 \text{ psf}$$

$$FS = \frac{0}{344 * \cos(2.86) * \sin(2.86)} + \frac{\tan(8)}{\tan(2.86)} - \frac{62.4 * 1.0 * \tan(8)}{346 * \tan(2.86)}$$

The factor of safety for this interface is 2.30

CONCLUSIONS

The overall minimum factor of safety for the infinite slope stability of the cap components for both sites 4 and 5 is 1.8.

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CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT		JOB NUMBER	
SUBJECT			
BASED ON		DRAWING NUMBER	
BY	CHECKED BY	APPROVED BY	DATE

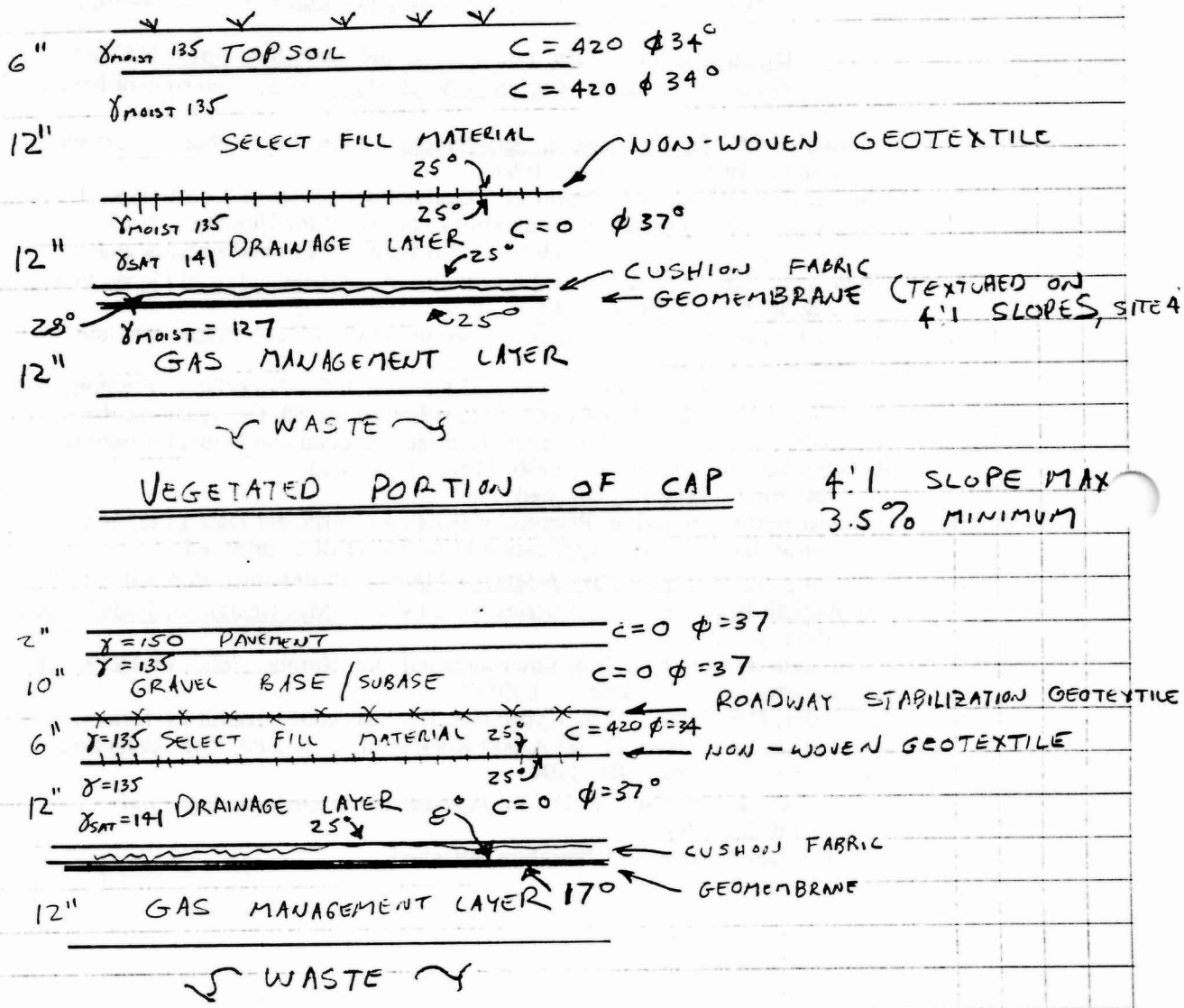

FIGURE 1

CLIENT		JOB NUMBER	
SUBJECT			
BASED ON		DRAWING NUMBER	
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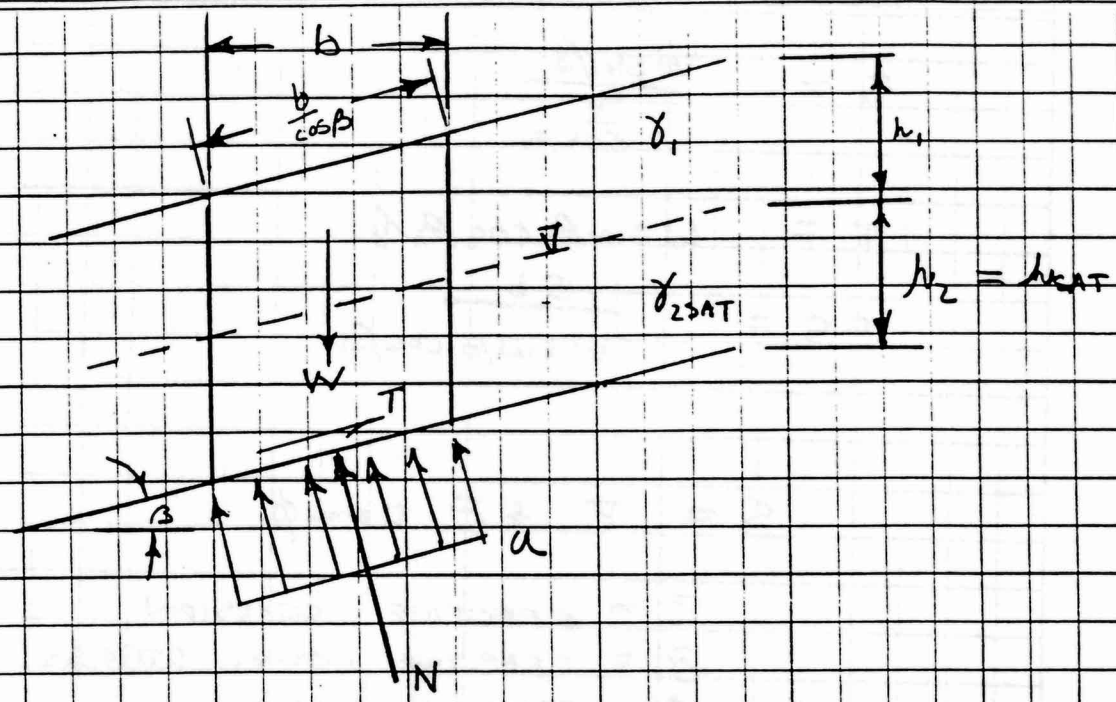

FS = FACTOR OF SAFETY

$$= \frac{S}{\tau}$$

S = SHEAR STRENGTH (PSF)
τ = SHEAR STRESS (PSF)

$$\tau = \frac{T}{\frac{b}{\cos\beta}}$$

T = FORCE = W SIN β
b = WIDTH OF BLOCK = 1 FOOT

$$W = \text{WEIGHT OF BLOCK} = \sum_{i=1}^{n} (\gamma_i h_i)\, b$$

$$= (\gamma_1 h_1 + \gamma_{2SAT} h_2)$$

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$$\tau = \frac{W \sin\beta}{\frac{b}{\cos\beta}}$$

$$\tau = W \sin\beta \cos\beta / b$$

$$FS = \frac{S b}{W \sin\beta \cos\beta}$$

$$S = \bar{c} + \bar{\sigma} \tan\phi$$

$\bar{c}$ = EFFECTIVE COHESION
$\bar{\sigma}$ = EFFECTIVE NORMAL STRESS
ϕ = FRICTION ANGLE

$$\bar{\sigma} = \frac{\bar{N}}{\frac{b}{\cos\beta}}$$

$\bar{N}$ = EFFECTIVE NORMAL FORCE

$$\bar{N} = N - U$$

N = NORMAL FORCE = $W \cos\beta$
U = FORCE OF WATER = $\frac{u b}{\cos\beta}$

u = PORE PRESSURE $\gamma_w h_2 \cos^2\beta$
γ_w = UNIT WIEGHT OF WATER

$$\bar{N} = W \cos\beta - \left[\gamma_w h_2 \cos^2\beta \, b / \cos\beta\right]$$

CLIENT		JOB NUMBER	
SUBJECT			
BASED ON		DRAWING NUMBER	
BY	CHECKED BY	APPROVED BY	DATE

$$\bar{\sigma} = \left[W - \gamma_w h_2 \cos\beta b\right]\frac{\cos\beta}{b}$$

$$S = \bar{c} + \left[W - \gamma_w h_2 \cos\beta b\right]\frac{\cos\beta}{b}\tan\phi$$

$$FS = \frac{\bar{c} + \left[W - \gamma_w h_2 \cos\beta b\right]\frac{\cos\beta}{b}\tan\phi}{W\sin\beta\cos\beta/b}$$

$$= \frac{\bar{c}b + W\cos^2\beta\tan\phi - \gamma_w h_2\cos^2\beta\tan\phi\, b}{W\sin\beta\cos\beta}$$

$$= \frac{\bar{c}b}{W\sin\beta\cos\beta} + \frac{\tan\phi}{\tan\beta} - \frac{\gamma_w h_2\tan\phi\, b}{W\tan\beta}$$

ASSUME $b = 1$

$$\boxed{FS = \frac{\bar{c}}{W\sin\beta\cos\beta} + \frac{\tan\phi}{\tan\beta} - \frac{\gamma_w h_2\tan\phi}{W\tan\beta}}$$

EQUATION USED TO CALCULATE INFINITE SLOPE FS GIVE $\bar{c}$ AND ϕ OF INTERFACE AND A SATURATED THICKNESS.

TABLE 1
Typical Properties of Compacted Soils

Group Symbol	Soil Type	Range of Maximum Dry Unit Weight, pcf	Range of Optimum Moisture, Percent	Typical Value of Compression: At 1.4 tsf (20 psi)	Typical Value of Compression: At 3.6 tsf (50 psi)	Typical Strength Characteristics: Cohesion (as compacted) psf	Typical Strength Characteristics: Cohesion (saturated) psf	Typical Strength Characteristics: ϕ (Effective Stress Envelope Degrees)	Typical Strength Characteristics: Tan ϕ	Typical Coefficient of Permeability ft./min.	Range of CBR Values	Range of Subgrade Modulus k lbs/cu in.
				Percent of Original Height								
GW	Well graded clean gravels, gravel-sand mixtures.	125 - 135	11 - 8	0.3	0.6	0	0	>38	>0.79	5×10^{-2}	40 - 80	300 - 500
GP	Poorly graded clean gravels, gravel-sand mix	115 - 125	14 - 11	0.4	0.9	0	0	>37	>0.74	10^{-1}	30 - 60	250 - 400
GM	Silty gravels, poorly graded gravel-sand-silt.	120 - 135	12 - 8	0.5	1.1	.....	.....	>34	>0.67	$>10^{-6}$	20 - 60	100 - 400
GC	Clayey gravels, poorly graded gravel-sand-clay.	115 - 130	14 - 9	0.7	1.6	.....	.....	>31	>0.60	$>10^{-7}$	20 - 40	100 - 300
SW	Well graded clean sands, gravelly sands.	110 - 130	16 - 9	0.6	1.2	0	0	38	0.79	$>10^{-3}$	20 - 40	200 - 300
SP	Poorly graded clean sands, sand-gravel mix.	100 - 120	21 - 12	0.8	1.4	0	0	37	0.74	$>10^{-3}$	10 - 40	200 - 300
SM	Silty sands, poorly graded sand-silt mix.	110 - 125	16 - 11	0.8	1.6	1050	420	34	0.67	$5 \times >10^{-5}$	10 - 40	100 - 300
SM-SC	Sand-silt clay mix with slightly plastic fines.	110 - 130	15 - 11	0.8	1.4	1050	300	33	0.66	$2 \times >10^{-6}$	5 - 30	100 - 300
SC	Clayey sands, poorly graded sand-clay-mix.	105 - 125	19 - 11	1.1	2.2	1550	230	31	0.60	$5 \times >10^{-7}$	5 - 20	100 - 300
ML	Inorganic silts and clayey silts.	95 - 120	24 - 12	0.9	1.7	1400	190	32	0.62	$>10^{-5}$	15 or less	100 - 200
ML-CL	Mixture of inorganic silt and clay.	100 - 120	22 - 12	1.0	2.2	1350	460	32	0.62	$5 \times >10^{-7}$	.....	
CL	Inorganic clays of low to medium plasticity.	95 - 120	24 - 12	1.3	2.5	1800	270	28	0.54	$>10^{-7}$	15 or less	50 - 200
OL	Organic silts and silt-clays, low plasticity.	80 - 100	33 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	50 - 100
MH	Inorganic clayey silts, elastic silts.	70 - 95	40 - 24	2.0	3.8	1500	420	25	0.47	$5 \times >10^{-7}$	10 or less	50 - 100
CH	Inorganic clays of high plasticity	75 - 105	36 - 19	2.6	3.9	2150	230	19	0.35	$>10^{-7}$	15 or less	50 - 150
OH	Organic clays and silty clays	65 - 100	45 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	25 - 100

Notes:

1. All properties are for condition of "Standard Proctor" maximum density, except values of k and CBR which are for "modified Proctor" maximum density.
2. Typical strength characteristics are for effective strength envelopes and are obtained from USBR data.
3. Compression values are for vertical loading with complete lateral confinement.
4. (>) indicates that typical property is greater than the value shown.
   (..) indicates insufficient data available for an estimate.

REF. 2

certainties that arise from sampling fluctuations, and they tend to vary from the true averages more widely if the number of observations is small. The plus or minus limits given are determined mathematically from the number of observations and from the standard deviation of the data used to determine the average. These limits imply that the true average, obtained by securing and testing more and more samples under the same essential conditions, lies within the plus or minus values 9 chances

r liquid limits than these will have inferior engineering properties.

(b) *Permeability.*—The voids in the soil mass provide passages through which water may move. Such passages are variable in size and the paths of flow are tortuous and interconnected. If, however, a sufficiently large number of paths of flow are considered as acting together, an average rate of flow for the soil mass can be determined under controlled conditions that will represent a property of the

TABLE 8.—*Average properties of soils*

Soil classification group	Proctor compaction		Void ratio, e.	Permeability, k, feet per year	Compressibility		Shearing strength		
	Maximum dry density in pounds per cubic foot	Optimum water content, percent			@ 20 p.s.i., percent	@ 50 p.s.i., percent	C_o p.s.i.	C_{sat} p.s.i.	tan ϕ
GW	>119	<13.3	(*)	27,000±13,000	<1.4	(*)	(*)	(*)	>0.79
GP	>110	<12.4	(*)	64,000±34,000	<0.8	(*)	(*)	(*)	>0.74
GM	>114	<14.5	(*)	>0.3	<1.2	<3.0	(*)	(*)	>0.67
GC	>115	<14.7	(*)	>0.3	<1.2	<2.4	(*)	(*)	>0.60
SW	119±5	13.3±2.5	0.37±*	(*)	1.4±*	(*)	5.7±0.6	(*)	0.79±0.02
SP	110±2	12.4±1.0	0.50±0.03	>15.0	0.8±0.3	(*)	3.3±0.9	(*)	0.74±0.02
SM	114±1	14.5±0.4	0.48±0.02	7.5±4.8	1.2±0.1	3.0±0.4	7.4±0.9	2.9±1.0	0.67±0.02
SM-SC	119±1	12.8±0.5	0.41±0.02	0.8±0.6	1.4±0.3	2.9±1.0	7.3±3.1	2.1±0.8	0.66±0.07
SC	115±1	14.7±0.4	0.48±0.01	0.3±0.2	1.2±0.2	2.4±0.5	10.9±2.2	1.6±0.9	0.60±0.07
ML	103±1	19.2±0.7	0.63±0.02	0.59±0.23	1.5±0.2	2.6±0.3	9.7±1.5	1.3±*	0.62±0.04
ML-CL	109±2	16.8±0.7	0.54±0.03	0.13±0.07	1.0±0.2	2.2±0.0	9.2±2.4	3.2±*	0.62±0.06
CL	108±1	17.3±0.3	0.56±0.01	0.08±0.03	1.4±0.2	2.6±0.4	12.6±1.5	1.9±0.3	0.54±0.04
OL	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
MH	82±4	36.3±3.2	1.15±0.12	0.16±0.10	2.0±1.2	3.8±0.8	10.5±4.3	2.9±1.3	0.47±0.05
CH	94±2	25.5±1.2	0.80±0.04	0.05±0.05	2.6±1.3	3.9±1.5	14.9±4.9	1.6±0.86	0.35±0.09
OH	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)

The ± entry indicates 90 percent confidence limits of the average value. * Denotes insufficient data, > is greater than, < is less than.

REFERENCE 3

13 OF 22

REFERENCE 4

nts at the corresponding
following equation:

(5.6)

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surface, and
sing surface.

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b, which results in the

(5.7)

lculated in the standard

(5.8)

(5.9)

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n in Table 5.7.
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mbranes (CSPE-R and

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geotextile friction values
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of textured HDPE and
ese roughened surfaces
This is particularly the
. the surface pattern of

14 OF 2

Table 5.7 Friction values and efficiencies (in parentheses) for (a) soil-to-geomembrane, (b) geomembrane-to-geotextile, and (c) soil-to-geotextile combinations*

(a) Soil-to-Geomembrane Friction Angles

	Soil Types		
Geomembrane	*Concrete Sand* (ϕ = 30°)	*Ottawa Sand* (ϕ = 28°)	*Micha Schist Sand* (ϕ = 26°)
EPDM-R	24° (0.77)	20° (0.68)	24° (0.91)
PVC			
Rough	27° (0.88)	—	25° (0.96)
Smooth	25° (0.81)	—	21° (0.79)
CSPE-R	25° (0.81)	21° (0.72)	23° (0.87)
HDPE	18° (0.56)	18° (0.61)	17° (0.63)

(b) Geomembrane-to-Geotextile Friction Angles

	Geomembrane				
		PVC			
Geotextile	*EPDM-R*	*Rough*	*Smooth*	*CSPE-R*	*HDPE*
Nonwoven, needle punched	23°	23°	21°	15°	8°
Nonwoven, heat bonded	18°	20°	18°	21°	11°
Woven, monofilament	17°	11°	10°	9°	6°
Woven, slit film	21°	28°	24°	13°	10°

(c) Soil-to-Geotextile Friction Angles

	Soil Types		
Geotextile	*Concrete Sand* (ϕ = 30°)	*Ottawa Sand* (ϕ = 28°)	*Mica Schist Sand* (ϕ = 26°)
Nonwoven, needle punched	30° (1.00)	26° (0.92)	25° (0.96)
Nonwoven, heat bonded	26° (0.84)	—	—
Woven, monofilament	26° (0.84)	—	—
Woven, slit film	24° (0.77)	24° (0.84)	23° (0.87)

*Efficiency values in parentheses are based on the relationship $E = (\tan \delta)/(\tan \phi)$.

Source: After Martin et al. [14].

The frictional behavior of geomembranes placed on clay soils is of considerable importance in the composite liners of waste landfills. Current requirements are for the clay to have a hydraulic conductivity equal to or less than 2×10^{-7} ft./min. (1×10^{-7} cm/sec.) and for the geomembrane to be placed directly on the clay. While an indication of the shear strength parameters has been investigated (e.g., reference 15), the data are so sensitive to the variables listed previously that site-specific and material-specific tests should always be performed. In such cases, literature values should never be used for final design purposes.

5.1.3.9 Geomembrane Anchorage In certain problem situations a geomembrane might be sandwiched between two materials and then tensioned by an external force. The termination of a geomembrane liner within an anchor trench is such a situation. To simulate this behavior in a laboratory environment, one can use an 8.0-in. (200-mm)-wide geomembrane sandwiched between back-to-back channels.

REFERENCE 5

15 OF 22

TREVIRA SPUNBOND

TECH NOTE

006-90 (CJS)

Hoechst Celanese Corporation P.O. Box 5887 Spartanburg, SC 29304

SOIL/GEOSYNTHETIC INTERFACE FRICTION by DIRECT SHEAR

Test Procedure: The coefficient of friction between a geosynthetic and soil (see Table 1) or between any combination of geosynthetics selected by the user is determined by placing the geosynthetic and one or more contact surfaces within a 12" x 12" direct shear box. A constant, normal compressive stress is applied to the specimen and a tangential (shear) force is applied to the apparatus so that one section of the box moves in relation to the other section. The shear force is recorded as a function of the deflection of the moving section of the shear box. The test is performed for a minimum of three different, normal stresses selected by the user (100, 200, and 250 psf were used here) to model appropriate field conditions. The peak (or residual) shear stresses recorded are plotted against the applied, normal compressive stresses used for testing. The test data generally forms a straight line whose slope is the coefficient of friction, μ, between the two materials where the shearing occurred. The y-intercept of the plot is the adhesion, a. The equivalent friction angle, δ, is calculated as: $\delta = \tan(\mu)$.

Related Test: Interlock Friction by Pullout is a related test used primarily with geogrids. Generally, for geotextiles, the direct shear test provides more conservative (lower) results than the pullout test.

Results of Tests Performed by Georgia Institute of Technology

SLIDING SURFACE	μ	δ(deg.)	a(psf)
Ottowa Sand/TREVIRA®1114	0.51	27	68
Ottowa Sand/Trevira 1155	0.68	34	21
Glatial Till/Trevira 1114	0.76	37	32
Glatial Till/Trevira 1155	0.75	37	10
Gulf Coast Clay/Trevira 1114	0.96	43	62
Gulf Coast Clay/Trevira 1155	1.26	52	45
MDPE Geonet*/Trevira 1114	0.46	25	29
HDPE Geonet*/Trevira 1114	0.32	18	39
HDPE Geomembrane/Trevira 1155	0.17	10	0
Embossed HDPE Geomembrane/Trevira 1155	0.72	36	18
TREVIRA® 1155/Trevira 1155**	0.33	18	13
Typar 3401/Typar 3401**	0.19	11	44
Mirafi 600X/Mirafi 600X**	0.29	16	60

*Avg. of three different confining soils. **Glatial Till used as confining soil.

TABLE 1 -- PROPERTIES of CONFINING SOIL

CONFINING SOIL	USCS CLASSIFICATIONS	ATTERBURG LIMITS			COMPACTION CHAR.			SHEAR TEST RESULTS		
		LL	PL	PI	γ Max. (pcf)	W opt. (%)	D100	μ	δ(deg)	a(kPa)
Ottowa Sand	SP	-	-	NP	-	-	104	0.78	38	0
Glatial Till	CL-ML	15-33	15-20	0-13	138†	8†	-	0.73	36	31
Gulf Coast Clay	CL	42	28	14	115†	16††	-	0.38	20	57

† Modified Proctor ††Standard Proctor

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Hoechst

TABLE 1
GEOSYNTHETIC VS. SAND INTERFACE FRICTION (EFFICIENCY)

INTERFACE WITH SAND	NORMAL STRESS (PSI)			
	3	5	7	9
SAND	45° (1.0)	35° (1.0)	33° (1.0)	32° (1.0)
NONWOVEN, NEEDLEPUNCHED	40° (0.88)	32.5° (0.92)	30.5° (0.92)	30° (0.93)
NONWOVEN, HEAT BONDED	37° (0.82)	32.5° (0.92)	32.4° (0.98)	32° (1.0)
MONOFILAMENT	31° (0.68)	29° (0.82)	28° (0.84)	28° (0.87)
MULTIFILAMENT	40° (0.88)	33.5° (0.95)	32° (0.96)	31.5° (0.98)
SLIT FILM	34° (0.75)	30.5° (0.87)	30° (0.90)	30° (0.93)
HDPE - SMOOTH	28° (0.62)	27° (0.77)	26° (0.78)	26° (0.81)
HDPE - ROUGH	40.5° (0.90)	33° (0.94)	31.5° (0.95)	30° (0.93)
CSPE	33° (0.73)	31° (0.88)	31° (0.93)	31° (0.96)
VLDPE	28° (0.62)	23° (0.65)	21.5° (0.65)	21.5° (0.67)
PVC	33° (0.73)	30° (0.85)	30° (0.90)	30° (0.93)
FLEXIBLE GRID	42° (0.93)	33° (0.94)	32° (0.96)	31.5° (0.98)

Note: Efficiency (Eff=δ/ϕ) values are indicated in parenthesis. Friction values (δ°) were found from the equation $\tau_f = C_a + \sigma_n \tan\delta$ assuming $C_a = 0$ for cohesionless soils.

POLYFEX LIT.
REF 9

TABLE 2

Interface Direct Shear Test Results
Measured Peak Strengths

Test Number	Interface Tested	Coefficient of Friction	Interface Friction Angle	Adhes (ps
1	Saturated Ottawa sand/60-mil Poly-Flex Textured VLDPE Geomembrane	0.47	25°	26

NOTE: (1) The reported value of adhesion may not be the "true adhesion" of the interfa caution should be exercised in using this adhesion value for applications inv normal stresses outside the range of stresses covered by the test.

TABLE 3

Interface Direct Shear Test Results
Measured Residual Strengths

Test Number	Interface Tested	Coefficient of Friction	Interface Friction Angle	Adhe (
1	Saturated Ottawa sand/60-mil Poly-Flex Textured VLDPE Geomembrane	0.38	21°	

NOTE: (1) The reported value of adhesion may not be the "true adhesion" of the interf caution should be exercised in using this adhesion value for applications ir normal stresses outside the range of stresses covered by the test.

Date Tested
11/25/87

Project Reference
R&D

Testing Laboratory
GRI

Geosynthetic Manufacturer
NSC

Upper Interface Material
OTTAWA SAND

Lower Interface Material
NSC TEX HDPE (KNOBS)

Test Normal Stresses (psi)
5.5, 10.9, 16.4

Test Speed (in/min)
0.005

Test Area in Plan (inches)
4X4

Existence of Report
Yes

Reported Peak Angle
27

Reported Residual Angle
0

D-Base Memo
Water Content = 0%

Date Tested
11/25/87

Project Reference
R&D

Testing Laboratory
GRI

Geosynthetic Manufacturer
NSC

Upper Interface Material
OTTAWA SAND

Lower Interface Material
NSC TEX HDPE (KNOBS)

Test Normal Stresses (psi)
5.5, 10.9, 16.4

Test Speed (in/min)
0.005

Test Area in Plan (inches)
4X4

Existence of Report
Yes

Reported Peak Angle
33

Reported Residual Angle
0

D-Base Memo
Water Content = 100 %

Date Tested
8/31/91

Project Reference
R&D

Testing Laboratory
GEOSYNTECH

Geosynthetic Manufacturer
NSC

Upper Interface Material
OTTAWA SAND

Lower Interface Material
NSC TEX HDPE (80)

Test Normal Stresses (psi)
3, 6, 9

Test Speed (in/min)
0.04

Test Area in Plan (inches)
12X12

Existence of Report
Yes

Reported Peak Angle
39

Reported Residual Angle
37

D-Base Memo
Tested under dry conditions.

Date Tested
11/15/92

Project Reference
R&D

Testing Laboratory
GEOSYNTECH

Geosynthetic Manufacturer
NSC

Upper Interface Material
OTTAWA SAND

Lower Interface Material
NSC TEX HDPE (60)

Test Normal Stresses (psi)
1.7, 6.9, 20.8

Test Speed (in/min)
0.04

Test Area in Plan (inches)
12X12

Existence of Report
Yes

Reported Peak Angle
26

Reported Residual Angle
26

Base Memo
sted under dry Conditions.

Date Tested	Project Reference	Testing Laboratory	Geosynthetic Manufacturer
11/15/92	R&D	GEOSYNTECH	NSC

Upper Interface Material	Lower Interface Material	Test Normal Stresses (psi)
OTTAWA SAND	NSC TEX HDPE (60)	1.7, 6.9, 20.8

Test Speed (in/min)	Test Area in Plan (inches)	Existence of Report
0.04	6X6	Yes

Reported Peak Angle	Reported Residual Angle
29	25

D-Base Memo
Tested under dry conditions.

Date Tested	Project Reference	Testing Laboratory	Geosynthetic Manufacturer
11/15/92	R&D	GEOSYNTECH	NSC

Upper Interface Material	Lower Interface Material	Test Normal Stresses (psi)
OTTAWA SAND	NSC TEX HDPE (60)	1.7, 6.9, 20.8

Test Speed (in/min)	Test Area in Plan (inches)	Existence of Report
0.04	4X4	Yes

Reported Peak Angle	Reported Residual Angle
27	25

Base Memo
sted under dry conditions.

Date Tested	Project Reference	Testing Laboratory	Geosynthetic Manufacturer
11/15/92	R&D	GEOSYNTECH	NSC

Upper Interface Material	Lower Interface Material	Test Normal Stresses (psi)
OTTAWA SAND	NSC TEX HDPE (60)	35, 70, 100

Test Speed (in/min)	Test Area in Plan (inches)	Existence of Report
0.04	12X12	Yes

Reported Peak Angle	Reported Residual Angle
27	26

D-Base Memo
Tested under dry conditions.

Date Tested	Project Reference	Testing Laboratory	Geosynthetic Manufacturer
4/23/93	92777	NSC	NSC

Upper Interface Material	Lower Interface Material	Test Normal Stresses (psi)
OTTAWA SAND	NSC TEX HDPE (60)	35, 70, 87

Date	Project I.D.	Testing Laboratory	Geosynthetic Manuf.
8/16/93	93164W	NSC	NSC

Top of Interface	Bottom of Interface
BENTOFIX (ELEPHANT)	NSC TEX HDPE (60)

Normal Stress (in psf)	Displacement Rate (inches/minute)	Existence of Report	Test Size in Plan
3.5, 7, 14	0.04	Yes	12X12

Peak Friction Angle	Residual Friction Angle
34	23

Memo for Database

Date	Project I.D.	Testing Laboratory	Geosynthetic Manuf.
8/31/93	SALES	GEOSYNTECH	NSC

Top of Interface	Bottom of Interface
BENTOFIX (WOVEN)	NSC SMOOTH HDPE (60)

Normal Stress (in psf)	Displacement Rate (inches/minute)	Existence of Report	Test Size in Plan
1.5, 4, 10	0.04	Yes	12X12

Peak Friction Angle	Residual Friction Angle
9	9

Memo for Database

REF. 11 21 OF 22

FrictionFlex® Application Data

Textured

SLT's FrictionFlex® process provided the industry's first textured liner. It is the only geomembrane texturing process ever to be granted a U.S. Patent. It, in fact, has been awarded two*. In direct contrast to blown-film geomembranes which are textured or made rough by a process which actually erodes the sides of the sheet, the FrictionFlex process is additive. SLT begins with 24-foot wide SLT HyperFlex® or UltraFlex® sheet manufactured to the industry's most exacting standards. Only after the sheet passes all QC, is texturing added to one or both sides as required by the application. When the engineer utilizes SLT geomembranes textured by the FrictionFlex process, increased facility design capacity, service life and total revenue potential can be obtained. Containment slopes, vertical expansions and perimeter slopes in closures share the benefits of greater air-space and superior cover stability.

Most importantly, the advantages of FrictionFlex are available without compromise of any performance property or other issue of secure containment. The patented manufacturing process enables SLT to produce a textured liner exhibiting similar mechanical and chemical properties demanded of SLT's premium grades of smooth geomembrane liners, whether HyperFlex, UltraFlex, or other Polyethylene.

An added feature of SLT's process is that an edge, 6-to-8 inches wide, is left smooth to aid in welding and field quality control. This allows standard installation equipment and procedures to ensure expedient construction.

The following reflects independent data confirming superior FrictionFlexed liner performance in contact with soils and synthetics:

- **High coefficient of friction with soils**
- **High coefficient of friction with synthetics**
- **Premium grade mechanical and chemical properties**
- **Excellent Strength Elongation**

SLT Textured Liner Materials				Typical Smooth HDPE
Material	Coefficient of Friction	Adhesion (per square foot)	Average Friction Angle (degrees)	Comparable Friction Angle
Sandy Glacial Till	0.74	27	36	20
Sandy Clay	0.70	65	35	18
Smooth Clay	0.62	39	32	16
Ottawa Sand	0.59	21	30	19
Non-woven Polyester Geotextile	0.54	116	28	11
Non-woven Poly-propylene Geotextile	0.65	133	33	12

NOTE: The above data is approximate. SLT recommends that specific data be developed for all application designs. Shear box testing of the specific geosynthetic and natural components of the composite is necessary to establish an appropriate design basis. SLT will be pleased to provide any necessary material samples for such purposes and invites comparative procedures.

*U.S. Patent No. 4,885,201
5,075,135

This data is provided for informational purposes only and is not intended as a warranty or guarantee. SLT assumes no liability in connection with the use of this data.

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09-93.SLT

FRICTION SEAL — FEATURES AND BENEFITS

VERSATILITY

	Stress Crack Resistance	Puncture Properties	Ultraviolet Resistance	Chemical Resistance	Multi-Axial Seam Properties
FRICTION SEAL HD	2	3	1	1	3
FRICTION SEAL VL	1	1	3	3	2
FRICTION SEAL CX*	1	2	1	2	1

1 = Highly Recommended 2 = Excellent 3 = Good with Proper Design

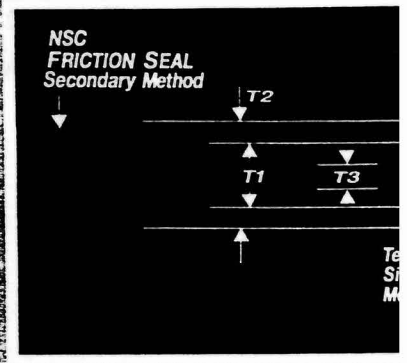
*CX = COEX SEAL, a coextruded geomembrane consisting of a VLDPE core layered between HDPE.

The chart above can assist in selecting the best liner material depending on which physical properties are most critical.

National Seal Company's manufacturing process adds a friction coating to HDPE, VLDPE, or COEX SEAL, a coextruded geomembrane. This capability allows the design engineer to select the textured sheet most suitable for the application at hand. Depending on the application, FRICTION SEAL can be textured on one or both sides of any of NSC's polyethylene geomembranes.

QUALITY CON ASSURANCE

Base Sheet Measurement vs. Peak to Pea



T1: Compares FRICTION SEAL's minimu (base sheet thickness) to the minimu the textured sheet by single coextrus (total sheet thickness)

T2: Overall FRICTION SEAL thickness

T3: Actual textured sheet base thickness coextrusion method

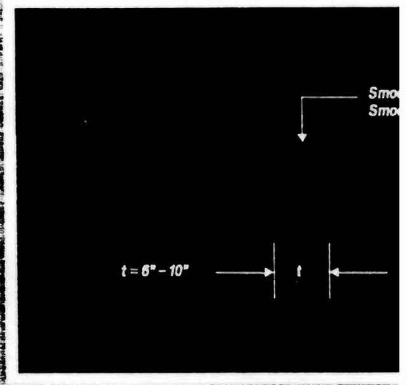
HIGHEST COEFFICIENT OF FRICTION

FRICTION SEAL AGAINST	FRICTION ANGLE (degrees)	ADHESION (pounds per sq. ft.)
DRAINAGE SAND	37°	25psf
CLAY	29°	150psf
NONWOVEN GEOTEXTILE	32°	55psf

Test was run on a 12" x 12" direct shear box at strain rates of 0.04 in./min. on the soil profiles and 0.20 in./min. on the geotextile profile. Normal compressive loads of 3psi, 6psi, and 9psi were used.

FRICTION SEAL offers a superior coefficient of friction with soils and geosynthetics. By using FRICTION SEAL with a geocomposite, the adhesion between the various layers can be greatly increased. As a result, the critical failure plane can be pushed into the soil improving slope stability. This allows engineers to design steeper slopes while maintaining high safety factors. The added safety measure provides extra assurance that material slippage will not occur.

HIGH QUALIT SEAMING



CALCULATION WORKSHEET Order No. 19116 (01-91)

PAGE _____ OF _____

CLIENT NWS EARLE		JOB NUMBER 7602	
SUBJECT STABILITY ANALYSES			
BASED ON		DRAWING NUMBER	
BY T Allen	CHECKED BY MJA 8/28/97	APPROVED BY	DATE 8/25/97

STABILITY ANALYSES

SITE 4

NWS EARLE

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT NWS EARLE		JOB NUMBER 7602	
SUBJECT STABILITY ANALYSES SITE 4			
BASED ON		DRAWING NUMBER	
BY T Allen	CHECKED BY MEA	APPROVED BY	DATE 8/25/97

PURPOSE ASSESS LONG TERM STABILITY OF FINAL LANDFILL CONFIGURATION

APPROACH USE COMPUTER MODEL PCSTABL5 TO EVALUATE CRITICAL FAILURE SURFACES

PROCEDURE

1) DEVELOP SECTION REPRESENTING WORST CASE CONDITIONS (SEE SHEET 2)

2) DEVELOP SOIL PARAMETERS BASED ON LABORATORY DATA, CLASSIFICATION, AND CORRELATIONS (SEE SHEET 3)

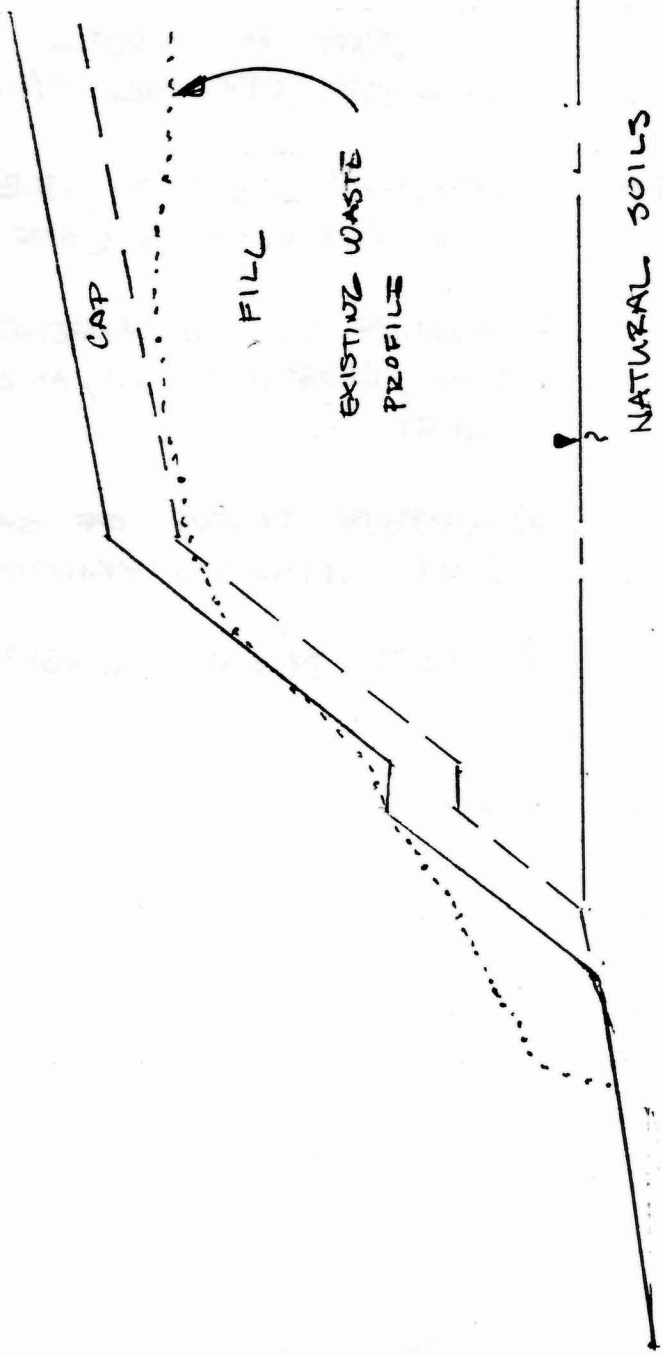
3) COMPUTE FACTOR OF SAFETY FOR WORST CASE (SEE ATTACHED PRINTOUT)

4) ACCEPT DESIGN WHEN FS ≥ 2.0

RESULTS O.K.

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT NWS EARLE	JOB NUMBER 7602
SUBJECT STABILITY ANALYSES SITE 4	
BASED ON	DRAWING NUMBER
BY T Allen / CHECKED BY MEA	APPROVED BY / DATE 8/25/97



REPRESENTATIVE SECTION

SCALE 1" = 50' H
1" = 10' V

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT NWS EARLE	JOB NUMBER 7602
SUBJECT STABILITY ANALYSES SITE 4	
BASED ON	DRAWING NUMBER
BY T Allen / CHECKED BY MEA	APPROVED BY / DATE 8/25/97

SOIL PARAMETERS

CAP - CLAYS - $\gamma^T = 110$ pcf
$\gamma^s = 115$ pcf
$c = 0$
$\phi = 25°$

FILL - HETEROGENEOUS - PRIMARILY SANDY MATERIAL WITH UNKNOWN PLACEMENT RECORD

$\gamma^T = 110$ pcf
$\gamma^s = 115$ pcf
$c = 0$
$\phi = 20°$

NATURAL SOILS - MEDIUM DENSE SILTY SANDS TO SANDS & GRAVEL, SOME CLAYEY SAND

$\gamma^T = 110$ psf
$\gamma^s = 115$ psf
$c = 0$
$\phi = 30°$

Earle44

** PCSTABL5M **

by
Purdue University

√'d MEA
8/28/97

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:	82597
Time of Run:	tja
Run By:	tja
Input Data Filename:	earle4-4.in
Output Filename:	earle44.out

PROBLEM DESCRIPTION general stability phi=20 waste, phi=25 c ap, phi=30 base

BOUNDARY COORDINATES

5 Top Boundaries
11 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	100.00	95.00	103.00	3
2	95.00	103.00	140.00	113.00	1
3	140.00	113.00	150.00	113.00	1
4	150.00	113.00	210.00	128.00	1
5	210.00	128.00	350.00	133.00	1
6	95.00	103.00	107.00	103.00	3
7	107.00	103.00	140.00	109.50	2
8	140.00	109.50	150.00	109.50	2
9	150.00	109.50	210.00	124.50	2
10	210.00	124.50	350.00	129.50	2
11	107.00	103.00	350.00	103.00	3

1

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	110.0	115.0	.0	25.0	.00	.0	1
2	110.0	115.0	.0	20.0	.00	.0	1
3	110.0	115.0	.0	30.0	.00	.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	.00	100.00
2	350.00	100.00

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

300 Trial Surfaces Have Been Generated.

30 Surfaces Initiate From Each Of 10 Points Equally Spaced Along The Ground Surface Between X = 50.00 ft.
and X = 100.00 ft.

Each Surface Terminates Between X = 180.00 ft.
and X = 300.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 25.00 ft.

10.00 ft. Line Segments Define Each Trial Failure Surface.

1

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	100.00	104.11
2	110.00	104.05
3	120.00	104.35
4	129.97	105.02
5	139.92	106.05
6	149.82	107.45
7	159.67	109.21
8	169.44	111.33
9	179.13	113.81
10	188.72	116.63
11	198.20	119.81
12	207.56	123.34
13	216.78	127.20
14	219.22	128.33

Circle Center At X = 106.8 ; Y = 376.2 and Radius, 272.2

*** 1.808 ***

Individual data on the 18 slices

Slice No.	Width Ft(m)	Weight Lbs(kg)	Water Force Top Lbs(kg)	Water Force Bot Lbs(kg)	Tie Force Norm Lbs(kg)	Tie Force Tan Lbs(kg)	Earthquake Force Hor Lbs(kg)	Earthquake Force Ver Lbs(kg)	Surcharge Load Lbs(kg)
1	10.0	1257.1	.0	.0	.0	.0	.0	.0	.0
2	2.7	768.2	.0	.0	.0	.0	.0	.0	.0
3	7.3	2799.5	.0	.0	.0	.0	.0	.0	.0

4	10.0	5463.8	.0	.0	.0	.0	.0	.0	.0
5	9.9	6937.2	.0	.0	.0	.0	.0	.0	.0
6	.1	61.2	.0	.0	.0	.0	.0	.0	.0
7	9.8	6743.7	.0	.0	.0	.0	.0	.0	.0
8	.2	108.6	.0	.0	.0	.0	.0	.0	.0
9	9.7	6231.7	.0	.0	.0	.0	.0	.0	.0
10	9.8	6845.4	.0	.0	.0	.0	.0	.0	.0
11	9.7	6930.6	.0	.0	.0	.0	.0	.0	.0
12	9.6	6605.3	.0	.0	.0	.0	.0	.0	.0
13	9.5	5883.1	.0	.0	.0	.0	.0	.0	.0
14	9.4	4781.4	.0	.0	.0	.0	.0	.0	.0
15	2.4	1033.0	.0	.0	.0	.0	.0	.0	.0
16	.4	143.4	.0	.0	.0	.0	.0	.0	.0
17	6.4	1602.5	.0	.0	.0	.0	.0	.0	.0
18	2.4	139.5	.0	.0	.0	.0	.0	.0	.0

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	100.00	104.11
2	109.98	104.73
3	119.95	105.55
4	129.90	106.56
5	139.82	107.76
6	149.73	109.16
7	159.60	110.76
8	169.44	112.55
9	179.24	114.53
10	189.00	116.70
11	198.71	119.07
12	208.38	121.63
13	218.00	124.37
14	227.56	127.31
15	232.06	128.79

Circle Center At X = 73.5 ; Y = 612.1 and Radius, 508.7

*** 1.903 ***

1

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)

1	100.00	104.11
2	109.95	103.08
3	119.94	102.65
4	129.94	102.83
5	139.90	103.61
6	149.81	105.01
7	159.61	107.00
8	169.27	109.59
9	178.75	112.76
10	188.03	116.50
11	197.05	120.79
12	205.81	125.63
13	209.23	127.81

Circle Center At X = 122.0 ; Y = 266.9 and Radius, 164.3

*** 2.077 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	88.89	102.81
2	98.87	102.22
3	108.87	101.99
4	118.87	102.12
5	128.86	102.61
6	138.82	103.45
7	148.75	104.64
8	158.63	106.19
9	168.45	108.10
10	178.19	110.35
11	187.85	112.95
12	197.40	115.89
13	206.85	119.17
14	216.17	122.79
15	225.36	126.73
16	229.51	128.70

Circle Center At X = 110.3 ; Y = 381.3 and Radius, 279.3

*** 2.087 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	100.00	104.11
2	109.94	105.20
3	119.87	106.39
4	129.79	107.67
5	139.69	109.05
6	149.58	110.53
7	159.46	112.11
8	169.31	113.79
9	179.16	115.56
10	188.98	117.43
11	198.78	119.40
12	208.57	121.46
13	218.33	123.63
14	228.07	125.88
15	237.79	128.24
16	241.28	129.12

Circle Center At X = -4.8 ; Y = 1107.6 and Radius, 1008.9

*** 2.129 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	66.67	102.11
2	76.65	101.48
3	86.64	101.20
4	96.64	101.26
5	106.64	101.67
6	116.61	102.42
7	126.55	103.51
8	136.44	104.95
9	146.29	106.72
10	156.06	108.83
11	165.76	111.28
12	175.36	114.06

Earle44

13	184.87	117.16
14	194.26	120.60
15	203.53	124.35
16	211.87	128.07

Circle Center At X = 89.8 ; Y = 391.6 and Radius, 290.4

*** 2.166 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	77.78	102.46
2	87.73	101.49
3	97.71	100.87
4	107.71	100.61
5	117.71	100.70
6	127.70	101.15
7	137.67	101.95
8	147.60	103.10
9	157.49	104.60
10	167.31	106.45
11	177.07	108.65
12	186.74	111.19
13	196.32	114.07
14	205.79	117.28
15	215.14	120.83
16	224.35	124.71
17	233.25	128.83

Circle Center At X = 110.1 ; Y = 383.4 and Radius, 282.8

*** 2.302 ***

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)

1	88.89	102.81
2	98.85	101.95
3	108.85	101.67
4	118.84	101.98
5	128.80	102.87
6	138.70	104.34
7	148.48	106.39
8	158.14	109.00
9	167.62	112.17
10	176.90	115.89
11	185.95	120.15
12	192.20	123.55

Circle Center At X = 108.6 ; Y = 272.3 and Radius, 170.6

*** 2.318 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	77.78	102.46
2	87.68	101.03
3	97.62	100.02
4	107.61	99.43
5	117.61	99.25
6	127.60	99.50
7	137.58	100.16
8	147.52	101.24
9	157.41	102.74
10	167.23	104.64
11	176.95	106.96
12	186.58	109.69
13	196.07	112.81
14	205.43	116.33
15	214.64	120.24
16	223.67	124.53
17	231.72	128.78

Circle Center At X = 116.8 ; Y = 337.9 and Radius, 238.7

*** 2.433 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	66.67	102.11
2	76.52	100.37
3	86.43	99.09
4	96.40	98.26
5	106.39	97.88
6	116.39	97.96
7	126.38	98.50
8	136.33	99.48
9	146.22	100.92
10	156.04	102.81
11	165.77	105.14
12	175.38	107.92
13	184.85	111.13
14	194.16	114.76
15	203.30	118.82
16	212.25	123.28
17	220.98	128.15
18	221.39	128.41

Circle Center At X = 109.7 ; Y = 317.5 and Radius, 219.6

*** 2.471 ***

1

```
          Y            A     X     I     S            F     T

          .00     43.75     87.50    131.25    175.00    218.75

X       .00 +---------+---------+--*------+---------+---------+
            -
            -
            -
            -
            -
      43.75 +
            -                     .
            -                    ..
            -                  ...6
            -                 ....0
```

Earle44

```
                -                  .....6
A      87.50 +                   .......4
                -                  ......06*
                -                 ........41
                -                 .......04*
                -                ........031
                -                .........96
X     131.25 +                ..........415
                -               ..........71**
                -               ..........94
                -               ..........03**
                -               ..........9315
                -               ...........712
I     175.00 +                ...........946.
                -               ............016.
                -               ............7418
                -                ............413.
                -                ............413
                -                ............9**
S     218.75 +                  ............21
                -                  ............92
                -                  ............2
                -                   ............55
                -                    ............
                -                     ............
      262.50 +                      ...........
                -                      ..........
                -                        ........
                -                         .......
                -                           .....
                -                              ..
F     306.25 +
                -
                -
                -
                -
                -
T     350.00 +                        W*      *
```

CALCULATION WORKSHEET Order No. 19116 (01-91)

PAGE _____ OF _____

CLIENT NWS EARLE	JOB NUMBER 7602
SUBJECT SETTLEMENT ANALYSES SITE 4	
BASED ON	DRAWING NUMBER
BY T Allen / CHECKED BY NWS 8/20/97	APPROVED BY / DATE 8/25/97

SETTLEMENT ANALYSES

SITE 4

NWS EARLE

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT NWS		JOB NUMBER 7602	
SUBJECT SETTLEMENT ANALYSES			
BASED ON		DRAWING NUMBER	
BY T Allen	CHECKED BY MEA	APPROVED BY	DATE 8/25/97

PURPOSE: DETERMINE SETTLEMENT EFFECTS ON LANDFILL CAP

APPROACH: DETERMINE SETTLEMENT AT HIGH POINT OF FILL. ASSUMING NO SETTLEMENT AT EDGE, RECALCULATE SLOPE BASED ON FINAL ELEVATION

PROCEEDURE: FROM PROFILE USED FOR STABILITY ANALYSES ADDITIONAL LOADING DUE TO FILL AND CAP PLACEMENT

MAXIMUM ADDITIONAL HEIGHT = 8'

8' x 110 pcf = 880 pcf

ASSIGN COMPRESSIBILITY TO FILL AND NATURAL SOILS

FILL - ELASTIC (DURING CONSTRUCTION)

NATURAL SOILS - ELASTIC (DURING CONSTRUCTION)

RESULTS: NEGLIGIBLE LONG TERM SETTLEMENT THEREFORE NO DETRAMENTAL EFFECTS TO SLOPES

CALCULATION WORKSHEET Order No. 19116 (01-91)

PAGE _____ OF _____

CLIENT NWS EARLE	JOB NUMBER 7602
SUBJECT STABILITY ANALYSES SITE 5	
BASED ON	DRAWING NUMBER
BY T Allen / CHECKED BY MA 8/20/97	APPROVED BY / DATE 8/25/97

STABILITY ANALYSES

SITE 5

NWS EARLE

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT NWS EARLE		JOB NUMBER 7602	
SUBJECT STABILITY ANALYSES SITE 5			
BASED ON		DRAWING NUMBER	
BY T Allen	CHECKED BY MKA	APPROVED BY	DATE 8/28/97

PURPOSE ASSESS LONGTERM STABILITY OF FINAL LANDFILL CONFIGURATION

APPROACH USE COMPUTER MODEL PCSTABL5 TO EVALUATE CRITICAL FAILURE SURFACES

PROCEDURE

1) DEVELOP SECTION REPRESENTING WORST CASE CONDITIONS (SEE SHEET 2)

2) DEVELOP SOIL PARAMETERS BASED ON LABORATORY DATA, CLASSIFICATION, AND CORRELATIONS. (SEE SHEET 3)

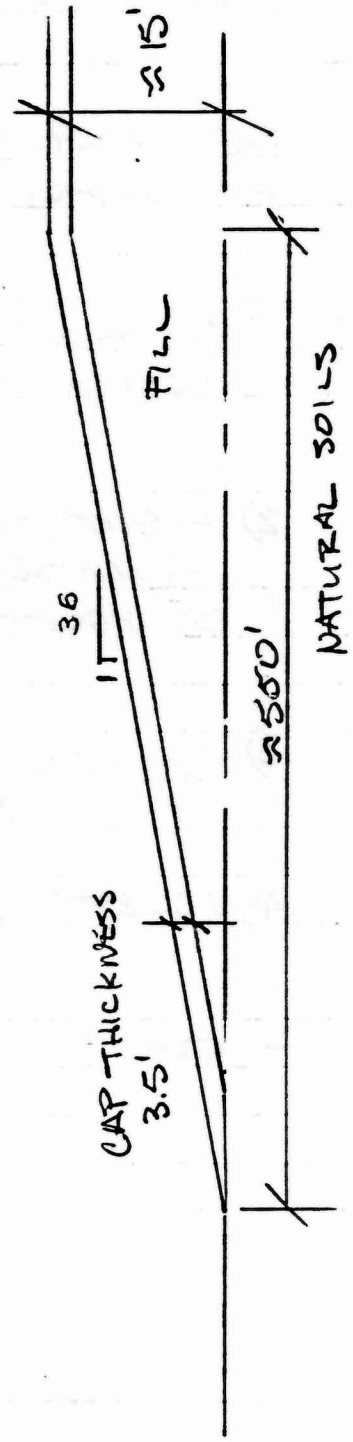
3) COMPUTE FACTOR OF SAFETY FOR WORST CASE (SEE ATTACHED PRINTOUT)

4) ACCEPT DESIGN IF FS ≈ 2 OR GREATER

RESULTS - OK.

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT NWS EARLE	JOB NUMBER 7602
SUBJECT STABILITY ANALYSES SITE 5	
BASED ON	DRAWING NUMBER
BY T Allen / CHECKED BY MEA	APPROVED BY / DATE 8/25/97



GENERAL SECTION
N.T.S.

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT NWS EARLE	JOB NUMBER 7602
SUBJECT STABILITY ANALYSES SITE 5	
BASED ON	DRAWING NUMBER
BY T Allen / CHECKED BY MEA	APPROVED BY / DATE 8/25/97

SOIL PARAMETERS

CAP - CLAYS

$\gamma^T = 110$ pcf
$\gamma^S = 115$ pcf
$c = 0$
$\phi = 25°$

FILL HETROGENEOUS - PRIMARILY SANDY

$\gamma^T = 110$ pcf
$\gamma^S = 115$ pcf
$c = 0$
$\phi = 20°$

NATURAL SOILS - MEDIUM DENSE SANDS

$\gamma^T = 110$ pcf
$\gamma^S = 115$ pcf
$c = 0$
$\phi = 30°$

** PCSTABL5M **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

√'d MEA
3/20/97

Run Date: 82297
Time of Run:
Run By: tja
Input Data Filename: earle5-1.in
Output Filename: earle5-1.out

PROBLEM DESCRIPTION general stability phi=20 waste, phi=25 c
ap, phi=30 base

BOUNDARY COORDINATES

3 Top Boundaries
7 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	100.00	100.00	100.00	3
2	100.00	100.00	650.00	115.00	1
3	650.00	115.00	700.00	115.00	1
4	100.00	100.00	112.00	100.00	3
5	112.00	100.00	650.00	111.50	2
6	650.00	111.50	700.00	111.50	2
7	112.00	100.00	700.00	100.00	3

1

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Total Saturated Cohesion Friction Pore Pressure Piez.

Type No.	Unit Wt. (pcf)	Unit Wt. (pcf)	Intercept (psf)	Angle (deg)	Pressure Param.	Constant (psf)	Surface No.
1	110.0	115.0	.0	25.0	.00	.0	1
2	110.0	115.0	.0	20.0	.00	.0	1
3	110.0	115.0	.0	30.0	.00	.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	.00	100.00
2	700.00	100.00

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

300 Trial Surfaces Have Been Generated.

30 Surfaces Initiate From Each Of 10 Points Equally Spaced Along The Ground Surface Between X = 50.00 ft.
and X = 100.00 ft.

Each Surface Terminates Between X = 300.00 ft.
and X = 700.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 25.00 ft.

10.00 ft. Line Segments Define Each Trial Failure Surface.

1

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 47 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	72.22	100.00
2	81.53	96.35
3	90.91	92.87
4	100.35	89.57
5	109.84	86.43
6	119.39	83.46
7	128.99	80.67
8	138.64	78.05
9	148.34	75.61
10	158.08	73.34
11	167.86	71.25
12	177.67	69.33
13	187.52	67.60
14	197.40	66.04
15	207.30	64.66
16	217.23	63.46
17	227.18	62.44
18	237.14	61.59
19	247.12	60.93
20	257.11	60.45
21	267.11	60.15
22	277.11	60.03
23	287.11	60.09
24	297.10	60.34
25	307.09	60.76
26	317.08	61.36
27	327.05	62.15
28	337.00	63.11
29	346.93	64.25
30	356.85	65.57
31	366.73	67.08
32	376.59	68.76
33	386.42	70.61
34	396.21	72.65
35	405.96	74.86
36	415.67	77.25
37	425.34	79.81

38	434.95	82.54
39	444.52	85.45
40	454.03	88.54
41	463.49	91.79
42	472.89	95.21
43	482.22	98.81
44	491.48	102.57
45	500.68	106.50
46	509.80	110.59
47	511.13	111.21

Circle Center At X = 278.7 ; Y = 613.4 and Radius, 553.4

*** 12.802 ***

Individual data on the 50 slices

Slice No.	Width Ft(m)	Weight Lbs(kg)	Water Force Top Lbs(kg)	Water Force Bot Lbs(kg)	Tie Force Norm Lbs(kg)	Tie Force Tan Lbs(kg)	Earthquake Force Hor Lbs(kg)	Earthquake Force Ver Lbs(kg)	Surcharge Load Lbs(kg)
1	9.3	1952.8	.0	1138.0	.0	.0	.0	.0	
2	9.4	5807.8	.0	3361.3	.0	.0	.0	.0	.
3	9.1	9115.8	.0	5241.5	.0	.0	.0	.0	.0
4	.3	413.1	.0	237.4	.0	.0	.0	.0	.0
5	9.5	13251.9	.0	7490.1	.0	.0	.0	.0	.0
6	2.2	3523.5	.0	1961.8	.0	.0	.0	.0	.0
7	7.4	13429.6	.0	7432.5	.0	.0	.0	.0	.0
8	9.6	20500.4	.0	11190.7	.0	.0	.0	.0	.0
9	9.7	23886.2	.0	12878.9	.0	.0	.0	.0	.0
10	9.7	27103.2	.0	14458.2	.0	.0	.0	.0	.0
11	9.7	30144.7	.0	15928.3	.0	.0	.0	.0	.0
12	9.8	33004.3	.0	17288.5	.0	.0	.0	.0	.0
13	9.8	35675.9	.0	18538.4	.0	.0	.0	.0	.0
14	9.8	38154.0	.0	19677.7	.0	.0	.0	.0	.0
15	9.9	40433.5	.0	20705.9	.0	.0	.0	.0	.0
16	9.9	42509.7	.0	21622.8	.0	.0	.0	.0	.0
17	9.9	44378.3	.0	22428.0	.0	.0	.0	.0	.0
18	9.9	46035.6	.0	23121.3	.0	.0	.0	.0	.0
19	10.0	47478.2	.0	23702.3	.0	.0	.0	.0	.0
20	10.0	48703.3	.0	24171.1	.0	.0	.0	.0	.0
21	10.0	49708.5	.0	24527.3	.0	.0	.0	.0	.0
22	10.0	50491.9	.0	24770.9	.0	.0	.0	.0	.0
23	10.0	51052.3	.0	24901.8	.0	.0	.0	.0	.0
24	10.0	51388.4	.0	24920.0	.0	.0	.0	.0	.0
25	10.0	51499.9	.0	24825.3	.0	.0	.0	.0	.0
26	10.0	51386.7	.0	24618.0	.0	.0	.0	.0	.0

27	10.0	51049.6	.0	24298.1	.0	.0	.0	.0	.0
28	10.0	50489.1	.0	23865.5	.0	.0	.0	.0	.0
29	10.0	49707.0	.0	23320.6	.0	.0	.0	.0	.0
30	9.9	48705.1	.0	22663.4	.0	.0	.0	.0	.0
31	9.9	47486.0	.0	21894.3	.0	.0	.0	.0	.0
32	9.9	46052.3	.0	21013.3	.0	.0	.0	.0	.0
33	9.9	44407.3	.0	20020.9	.0	.0	.0	.0	.0
34	9.8	42555.1	.0	18917.3	.0	.0	.0	.0	.0
35	9.8	40499.6	.0	17702.9	.0	.0	.0	.0	.0
36	9.8	38245.8	.0	16378.2	.0	.0	.0	.0	.0
37	9.7	35798.8	.0	14943.5	.0	.0	.0	.0	.0
38	9.7	33163.9	.0	13399.2	.0	.0	.0	.0	.0
39	9.6	30347.3	.0	11746.0	.0	.0	.0	.0	.0
40	9.6	27355.6	.0	9984.4	.0	.0	.0	.0	.0
41	9.5	24195.3	.0	8114.8	.0	.0	.0	.0	.0
42	9.5	20873.9	.0	6138.1	.0	.0	.0	.0	.0
43	9.4	17398.8	.0	4054.6	.0	.0	.0	.0	.0
44	9.3	13778.2	.0	1865.3	.0	.0	.0	.0	.0
45	2.9	3583.4	.0	118.0	.0	.0	.0	.0	.0
46	6.3	6477.5	.0	.0	.0	.0	.0	.0	.0
47	9.2	6342.3	.0	.0	.0	.0	.0	.0	.0
48	4.2	1649.9	.0	.0	.0	.0	.0	.0	.0
49	4.9	867.8	.0	.0	.0	.0	.0	.0	.0
50	1.3	42.6	.0	.0	.0	.0	.0	.0	.0

Failure Surface Specified By 57 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	77.78	100.00
2	87.06	96.28
3	96.40	92.70
4	105.79	89.26
5	115.22	85.95
6	124.71	82.79
7	134.24	79.77
8	143.82	76.89
9	153.44	74.16
10	163.10	71.57
11	172.79	69.12
12	182.53	66.81
13	192.29	64.66
14	202.08	62.64
15	211.91	60.77
16	221.76	59.05
17	231.63	57.48
18	241.53	56.05
19	251.45	54.77
20	261.39	53.64
21	271.34	52.65

22	281.30	51.82
23	291.28	51.13
24	301.26	50.59
25	311.26	50.20
26	321.25	49.96
27	331.25	49.86
28	341.25	49.92
29	351.25	50.12
30	361.24	50.47
31	371.23	50.97
32	381.21	51.62
33	391.18	52.42
34	401.13	53.37
35	411.07	54.46
36	421.00	55.70
37	430.90	57.09
38	440.78	58.63
39	450.64	60.31
40	460.47	62.14
41	470.27	64.11
42	480.05	66.23
43	489.79	68.50
44	499.49	70.91
45	509.16	73.47
46	518.79	76.16
47	528.38	79.00
48	537.92	81.99
49	547.42	85.11
50	556.87	88.38
51	566.27	91.78
52	575.62	95.33
53	584.92	99.01
54	594.16	102.83
55	603.35	106.79
56	612.47	110.89
57	619.49	114.17

Circle Center At X = 332.6 ; Y = 722.3 and Radius, 672.4

*** 12.805 ***

1

Failure Surface Specified By 62 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)

1	61.11	100.00
2	70.37	96.21
3	79.67	92.55
4	89.03	89.03
5	98.44	85.63
6	107.89	82.36
7	117.38	79.22
8	126.92	76.22
9	136.50	73.35
10	146.12	70.61
11	155.77	68.01
12	165.46	65.54
13	175.19	63.20
14	184.94	61.00
15	194.73	58.94
16	204.54	57.01
17	214.38	55.22
18	224.24	53.57
19	234.12	52.05
20	244.03	50.67
21	253.95	49.43
22	263.89	48.32
23	273.84	47.36
24	283.81	46.53
25	293.78	45.84
26	303.77	45.29
27	313.76	44.88
28	323.76	44.61
29	333.76	44.47
30	343.76	44.48
31	353.75	44.62
32	363.75	44.90
33	373.74	45.32
34	383.73	45.88
35	393.70	46.58
36	403.67	47.42
37	413.62	48.39
38	423.56	49.51
39	433.48	50.76
40	443.38	52.15
41	453.26	53.67
42	463.12	55.34
43	472.96	57.14
44	482.77	59.07
45	492.56	61.14
46	502.31	63.35
47	512.03	65.70
48	521.72	68.17
49	531.37	70.79
50	540.99	73.53
51	550.56	76.41
52	560.10	79.43

53	569.59	82.57
54	579.04	85.85
55	588.44	89.25
56	597.79	92.79
57	607.10	96.46
58	616.35	100.25
59	625.55	104.18
60	634.69	108.23
61	643.78	112.40
62	649.17	114.98

Circle Center At X = 338.4 ; Y = 764.4 and Radius, 720.0

*** 12.807 ***

Failure Surface Specified By 29 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	88.89	100.00
2	98.26	96.50
3	107.72	93.27
4	117.28	90.33
5	126.92	87.66
6	136.63	85.28
7	146.41	83.19
8	156.24	81.38
9	166.13	79.86
10	176.05	78.63
11	186.01	77.70
12	195.99	77.06
13	205.98	76.71
14	215.98	76.65
15	225.98	76.89
16	235.96	77.42
17	245.93	78.24
18	255.87	79.35
19	265.77	80.76
20	275.62	82.46
21	285.42	84.44
22	295.16	86.71
23	304.83	89.27
24	314.42	92.10
25	323.92	95.22
26	333.33	98.62
27	342.63	102.29

28	351.82	106.23
29	353.28	106.91

Circle Center At X = 212.9 ; Y = 417.5 and Radius, 340.8

*** 12.808 ***

1

Failure Surface Specified By 53 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	77.78	100.00
2	87.00	96.12
3	96.28	92.40
4	105.62	88.83
5	115.02	85.42
6	124.47	82.16
7	133.98	79.06
8	143.54	76.13
9	153.15	73.35
10	162.80	70.74
11	172.49	68.28
12	182.23	65.99
13	192.00	63.86
14	201.80	61.90
15	211.64	60.10
16	221.51	58.46
17	231.40	56.99
18	241.31	55.69
19	251.25	54.55
20	261.20	53.57
21	271.17	52.77
22	281.15	52.13
23	291.13	51.65
24	301.13	51.35
25	311.13	51.21
26	321.13	51.24
27	331.13	51.43
28	341.12	51.80
29	351.11	52.33
30	361.08	53.02
31	371.04	53.89
32	380.99	54.92
33	390.92	56.11
34	400.83	57.47

35	410.71	59.00
36	420.56	60.69
37	430.39	62.55
38	440.18	64.57
39	449.94	66.76
40	459.66	69.10
41	469.34	71.61
42	478.98	74.28
43	488.57	77.11
44	498.11	80.10
45	507.60	83.25
46	517.04	86.56
47	526.42	90.03
48	535.74	93.65
49	545.00	97.43
50	554.20	101.36
51	563.32	105.45
52	572.38	109.68
53	579.33	113.07

Circle Center At X = 314.4 ; Y = 649.4 and Radius, 598.2

*** 12.809 ***

Failure Surface Specified By 53 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	83.33	100.00
2	92.62	96.28
3	101.96	92.72
4	111.36	89.30
5	120.81	86.04
6	130.32	82.94
7	139.87	79.98
8	149.47	77.19
9	159.12	74.55
10	168.81	72.07
11	178.53	69.74
12	188.29	67.58
13	198.09	65.57
14	207.92	63.72
15	217.78	62.04
16	227.66	60.51
17	237.57	59.15
18	247.49	57.94

19	257.44	56.90
20	267.40	56.02
21	277.37	55.30
22	287.36	54.74
23	297.35	54.35
24	307.35	54.12
25	317.35	54.05
26	327.35	54.14
27	337.34	54.40
28	347.33	54.82
29	357.32	55.40
30	367.29	56.14
31	377.25	57.05
32	387.19	58.12
33	397.12	59.35
34	407.02	60.74
35	416.90	62.29
36	426.75	64.00
37	436.57	65.87
38	446.36	67.90
39	456.12	70.09
40	465.84	72.44
41	475.52	74.95
42	485.16	77.61
43	494.76	80.43
44	504.30	83.40
45	513.80	86.54
46	523.25	89.82
47	532.64	93.26
48	541.97	96.85
49	551.24	100.59
50	560.46	104.48
51	569.60	108.52
52	578.68	112.71
53	579.45	113.08

Circle Center At X = 316.6 ; Y = 669.0 and Radius, 614.9

*** 12.814 ***

1

Failure Surface Specified By 37 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	83.33	100.00

2	92.75	96.63
3	102.23	93.46
4	111.79	90.50
5	121.40	87.75
6	131.07	85.20
7	140.79	82.86
8	150.56	80.73
9	160.38	78.81
10	170.23	77.10
11	180.12	75.61
12	190.03	74.33
13	199.98	73.26
14	209.94	72.41
15	219.92	71.77
16	229.91	71.35
17	239.91	71.14
18	249.91	71.15
19	259.91	71.37
20	269.90	71.81
21	279.88	72.46
22	289.84	73.33
23	299.78	74.41
24	309.70	75.71
25	319.58	77.22
26	329.43	78.94
27	339.24	80.88
28	349.01	83.02
29	358.73	85.37
30	368.39	87.94
31	378.00	90.71
32	387.55	93.68
33	397.03	96.87
34	406.44	100.25
35	415.77	103.84
36	425.03	107.63
37	428.07	108.95

Circle Center At X = 244.5 ; Y = 535.5 and Radius, 464.4

*** 12.814 ***

Failure Surface Specified By 32 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	77.78	100.00

2	87.16	96.53
3	96.62	93.31
4	106.17	90.33
5	115.79	87.60
6	125.48	85.12
7	135.23	82.90
8	145.03	80.93
9	154.88	79.21
10	164.78	77.76
11	174.70	76.55
12	184.66	75.61
13	194.64	74.93
14	204.63	74.51
15	214.63	74.34
16	224.63	74.44
17	234.62	74.79
18	244.60	75.41
19	254.56	76.28
20	264.50	77.42
21	274.40	78.81
22	284.26	80.45
23	294.08	82.36
24	303.85	84.51
25	313.55	86.93
26	323.19	89.59
27	332.76	92.50
28	342.24	95.66
29	351.65	99.06
30	360.96	102.71
31	370.17	106.60
32	371.97	107.42

Circle Center At X = 215.9 ; Y = 459.0 and Radius, 384.6

*** 12.818 ***

1

Failure Surface Specified By 62 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	66.67	100.00
2	76.08	96.61
3	85.53	93.35
4	95.02	90.20
5	104.55	87.16

6	114.11	84.25
7	123.72	81.46
8	133.35	78.78
9	143.02	76.23
10	152.72	73.80
11	162.45	71.49
12	172.21	69.30
13	181.99	67.23
14	191.80	65.28
15	201.63	63.46
16	211.49	61.76
17	221.36	60.18
18	231.25	58.73
19	241.16	57.39
20	251.09	56.19
21	261.03	55.10
22	270.99	54.14
23	280.95	53.30
24	290.93	52.59
25	300.91	52.01
26	310.90	51.54
27	320.89	51.20
28	330.89	50.99
29	340.89	50.90
30	350.89	50.93
31	360.89	51.09
32	370.88	51.38
33	380.88	51.79
34	390.86	52.32
35	400.84	52.98
36	410.81	53.76
37	420.77	54.67
38	430.72	55.70
39	440.65	56.85
40	450.57	58.13
41	460.47	59.53
42	470.35	61.05
43	480.21	62.70
44	490.06	64.47
45	499.88	66.36
46	509.67	68.38
47	519.44	70.52
48	529.18	72.77
49	538.89	75.15
50	548.58	77.65
51	558.23	80.28
52	567.84	83.02
53	577.43	85.88
54	586.97	88.86
55	596.48	91.96
56	605.95	95.17
57	615.38	98.51

58	624.76	101.96
59	634.10	105.53
60	643.40	109.21
61	652.65	113.01
62	657.32	115.00

Circle Center At X = 343.1 ; Y = 853.3 and Radius, 802.4

*** 12.819 ***

Failure Surface Specified By 57 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	72.22	100.00
2	81.67	96.72
3	91.16	93.57
4	100.69	90.54
5	110.26	87.64
6	119.87	84.86
7	129.51	82.21
8	139.18	79.69
9	148.89	77.29
10	158.63	75.02
11	168.40	72.88
12	178.20	70.87
13	188.02	68.98
14	197.86	67.23
15	207.73	65.61
16	217.62	64.11
17	227.52	62.75
18	237.45	61.51
19	247.39	60.41
20	257.34	59.43
21	267.30	58.59
22	277.28	57.88
23	287.26	57.30
24	297.25	56.85
25	307.25	56.53
26	317.24	56.34
27	327.24	56.29
28	337.24	56.37
29	347.24	56.57
30	357.24	56.91
31	367.22	57.38
32	377.21	57.98

33	387.18	58.71
34	397.14	59.58
35	407.09	60.57
36	417.03	61.70
37	426.95	62.95
38	436.85	64.34
39	446.74	65.85
40	456.60	67.50
41	466.44	69.27
42	476.26	71.17
43	486.05	73.21
44	495.82	75.37
45	505.55	77.65
46	515.25	80.07
47	524.93	82.61
48	534.56	85.28
49	544.16	88.08
50	553.73	91.00
51	563.25	94.05
52	572.73	97.23
53	582.17	100.52
54	591.57	103.94
55	600.92	107.49
56	610.23	111.15
57	617.45	114.11

Circle Center At X = 326.5 ; Y = 817.5 and Radius, 761.2

*** 12.827 ***

1

```
            Y            A     X     I     S            F     T

             .00     87.50    175.00    262.50    350.00    437.50

X        .00 +---------+*--------+---------+---------+---------+
             -
             -
             -          .
             -         .3
             -        ..1
     87.50 +        ..31
             -      ..31*
             -     ...31*
             -    ...314.
             -   ....314.
             -   ...314..
```

```
A     175.00 +   ...314..
             -  ....214..
             -  ....114..
             -  ...3174..
             -  ...3174..
             -  ...2174..
X     262.50 +  ...2174..
             -  ..32174...
             -  ..321784..
             -  ..321.74..
             -  ..321.784.
             -  ..321.7.44
I     350.00 +  ..321.7.84
             -  ..3201.7.8
             -  ..3261.7.8
             -  ..3251..7.
             -  ..325.1.7.
             -  ...25.1..7
S     437.50 +  ...32611...
             -   ..325.1...
             -   ..325.11..
             -   ...326.1..
             -    ..325..1.
             -    ...205..1
      525.00 +    ...325...
             -     ..3205..
             -     ...3265.
             -      ..32255
             -      ...32.5
             -       ...32.
F     612.50 +       ...3.2
             -        ...3.
             -         ..33
             -          ..*
             -           ..
             -           ..
T     700.00 +          * *
```

CALCULATION WORKSHEET Order No. 19116 (01-91)

PAGE _____ OF _____

CLIENT NWS EARLE		JOB NUMBER 7602	
SUBJECT SETTLEMENT ANALYSES			
BASED ON		DRAWING NUMBER	
BY T Allen	CHECKED BY MEA 8/27/97	APPROVED BY	DATE 8/25/97

SETTLEMENT ANALYSIS

SITE 5

NWS EARLE

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT NWS EARLE		JOB NUMBER 7602	
SUBJECT SETTLEMENT ANALYSES			
BASED ON		DRAWING NUMBER	
BY T Allen	CHECKED BY MEA	APPROVED BY	DATE 8/25/97

PURPOSE: DETERMINE SETTLEMENT EFFECTS ON LANDFILL

APPROACH DETERMINE SETTLEMENT AT HIGH POINT OF FILL. ASSUMING NO SETTLEMENT AT EDGE, RECALCULATE SLOPE BASED ON FINAL ELEVATION

PROCEDURE OBTAIN LOADING FROM REGRADED SLOPE MAXIMUM DIFFERENTIAL = EL 120 - EL 110 OR 10 FT.

10' x 110 pcf = 1100 psf

ASSIGN COMPRESSIBILITY TO FILL AND NATURAL SOILS

FILL ELASTIC COMPLETE DURING PLACEMENT

NATURAL SOILS ELASTIC - COMPLETE DURING FILL PLACEMENT

RESULTS NEGLIGIBLE LONG TERM SETTLEMENT. THEREFOR NO DETRAMENTAL EFFECTS TO SLOPES.

APPENDIX K

PAVEMENT DESIGN

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT NWS EARLE	JOB NUMBER 7602-0106
SUBJECT Asphalt Design	
BASED ON NAVFAC DM-5.4	DRAWING NUMBER
BY KMS / CHECKED BY DCW 8/28/97	APPROVED BY / DATE 8/18/97

OBJECTIVE: DETERMINE A SUITABLE ASPHALT DESIGN FOR A LANDFILL AREA BASED ON THE FOLLOWING CRITERIA:

- HAUL ROAD FOR LOADED PICKUP TRUCKS
- LANDFILL CAP LAYER FROST SUSCEPTIBILITY
- BITUMINOUS SECTION
- STATE OF NEW JERSEY SPECIFICATIONS
- END PRODUCT: OCCASIONAL PICKUP TRUCK USE

APPROACH: THE ASPHALT SECTION WILL BE DETERMINED USING THE METHODS DESCRIBED IN THE DESIGN MANUAL FOR PAVEMENTS BY THE DEPARTMENT OF THE NAVY NAVFAC DM-5.4 (OCTOBER 1979).

Relevant EQUATIONS:

$$C = a - p$$

where C is the zero frost penetration
a is the frost penetration depth
p is the thickness of the bituminous pavement

Source: AFM 88-7, June 1992.

ASSUMPTIONS:

- Subgrade CBR 18
- Subgrade compacted to ASTM 698 Standard Proctor
- Frost Susceptible Subgrade soil
- USE OF 'PASSENGER TRUCKS Predominant FOR OCCASIONAL SUSPENSE OF SHEET RANGE

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT NWS EARLE	JOB NUMBER 7602-0106
SUBJECT Asphalt Design	
BASED ON NAVFAC DM-5.4	DRAWING NUMBER
BY KMS / CHECKED BY DCW 8/28/97	APPROVED BY / DATE 8/18/97

CALCULATIONS:

1. TO DETERMINE THE DESIGN INDEX (DI) TO ACCOUNT FOR EFFECTS OF TRAFFIC INTENSITY AND WEIGHT

VEHICLE GROUP - CHOOSE 1 (TABLE A SHEET 8) PASSANGER CARS AND PANAL AND PICKUP TRUCKS

DESIGN INDEX (DI) CHOOSE #1 (TABLE 5 SHEET 8) PASSANGER VEHICLES AND LIGHT TRUCKS. NO TRUCKS IN GROUPS 2 or 3.

2. TO DETERMINE SUBGRADE STRENGTH FOR A FLEXIBLE PAVEMENT

ASSUME SUBGRADE SOIL TYPE TO BE A SILTY SAND.

CHOOSE CBR OF 18 (TABLE B SHEET 9)

(THIS IS A CONSERVATIVE VALUE BASED UPON THE FILL MATERIAL AND COMPACTION EFFORT TO BE DETERMINED).

3. TO DETERMINE TOTAL REQUIRED STRUCTURAL THICKNESS

CBR = 18
DI = 1

FROM FIGURE 7 - TOTAL THICKNESS ABOVE SUBGRADE IS Approx 5"
(SHEET 10, DM 5.4)

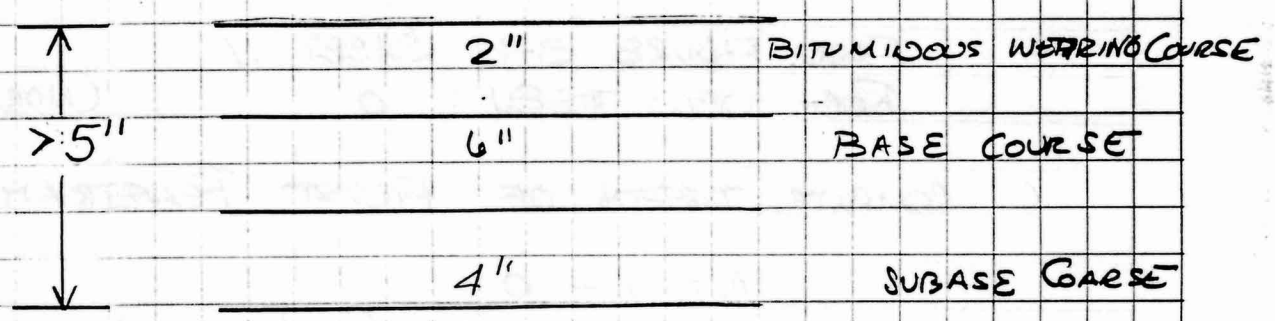
CLIENT NWS EARLE	JOB NUMBER 7602-0106
SUBJECT Asphalt Design	
BASED ON NAVFAC DM-5.4	DRAWING NUMBER
BY KMS / CHECKED BY DCW 8/28/97	APPROVED BY / DATE 8/18/97

4. TO DETERMINE THE STRUCTURAL THICKNESS OF EACH SECTION.

FROM PAGE 20 OF DM 5.4
MINIMUM SUBASE THICKNESS IS 4"
MINIMUM BASE THICKNESS IS 6" (PER II f pg 20)

FROM TABLE C SHEET 9, MINIMUM THICKNESS OF SURFACE IS 2". (SECONDARY ROADS)

∴ PROPOSED SECTION (STRUCTURAL THICKNESS)



THE MINIMUM PAVEMENT THICKNESSES EXCEED THE STRUCTURAL REQUIREMENTS, USE MINIMUM PAVEMENT THICKNESSES.

CLIENT NWS EARLE	JOB NUMBER 7602-0106
SUBJECT Asphalt Design	
BASED ON NAVFAC DM-5.4	DRAWING NUMBER
BY KMS / CHECKED BY DCW 8/28/97	APPROVED BY / DATE 8/18/97

5. FROST DESIGN AFM 88-7 Chapter 1, Sub Chapter 18

DETERMINE DEPTH OF FROST PENETRATION TO PROTECT GEOMEMBRANE FROM FROST USING AVERAGE FROST PENETRATION

a. ASSUME THE GEOMEMBRANE OF THE CAP CONFIGURATION IS THE FROST SUSCEPTABLE SOIL. CONCERNED WITH KEEPING THE GEOMEMBRANE BELOW THE FROST LINE.

b. DESIGN AIR FREEZING INDEX:

FROM FIGURE 3-1 SHEET 11
FOR NEW JESEY : 0 (NORMAL YEAR)

C. COMPUTE DEPTH OF FROST PENETRATION

$c = a - p$

where a = frost penetration depth
p = thickness of bituminous pavement
c = depth of base and subase material

FROM FIGURE 18-3 (SHEET 12, REFERENCE #2)

ASSUME SUBGRADE OF 7% MOISTURE
135 lb/ft^3

ENTER AIR FREEZING INDEX OF 0

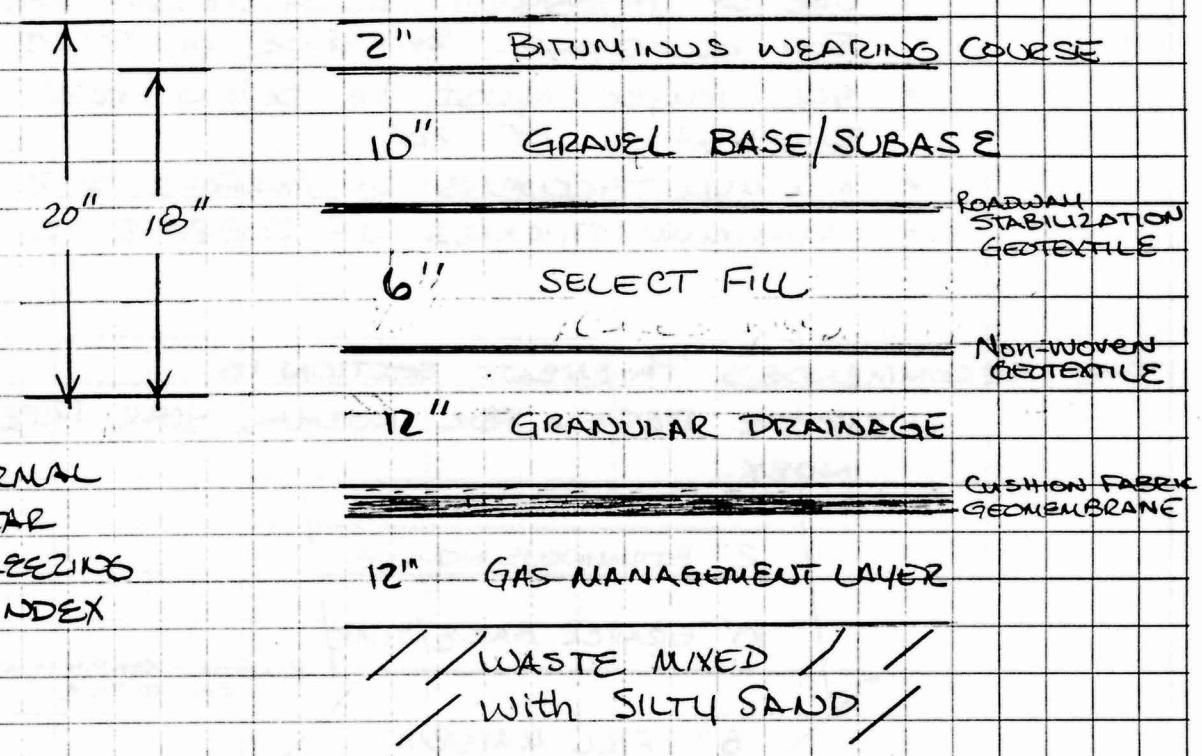
FROST PENETRATION = 20

CLIENT NWS EARLE	JOB NUMBER 7602-0106
SUBJECT Asphalt Design	
BASED ON NAVFAC DM-5.4	DRAWING NUMBER
BY KMS / CHECKED BY DCW 8/28/97	APPROVED BY / DATE 8/18/97

$C = 20 - 2 = \underline{18}$

∴ 18" OF NON-FROST SUSCEPTIBLE MATERIAL IS REQUIRED BELOW THE WEARING COURSE.

PROPOSED SECTION



NORMAL YEAR FREEZING INDEX

THEORETICALLY, THE GEOMEMBRANE IS NOT EFFECTED BY FROST SO THE EXTREME FROST PENETRATION EVENT WILL NOT BE USED TO DESIGN A PROPOSED SECTION.

THE THICKNESS USED FOR THE DRAINAGE LAYER AND SECTIONS OF THE COURSE MATERIALS WERE DETERMINED TO MAKE THE COVER SYSTEM COMPATABLE WITH THE FINAL COVERS OF THE GRAVEL ROADWAY AND VEGETATED AREAS.

CLIENT NWS EARLE	JOB NUMBER 7602-0106
SUBJECT Asphalt Design	
BASED ON NAVFAC DM-5.4	DRAWING NUMBER
BY KMS / CHECKED BY DCW 8/28/97	APPROVED BY / DATE 8/18/97

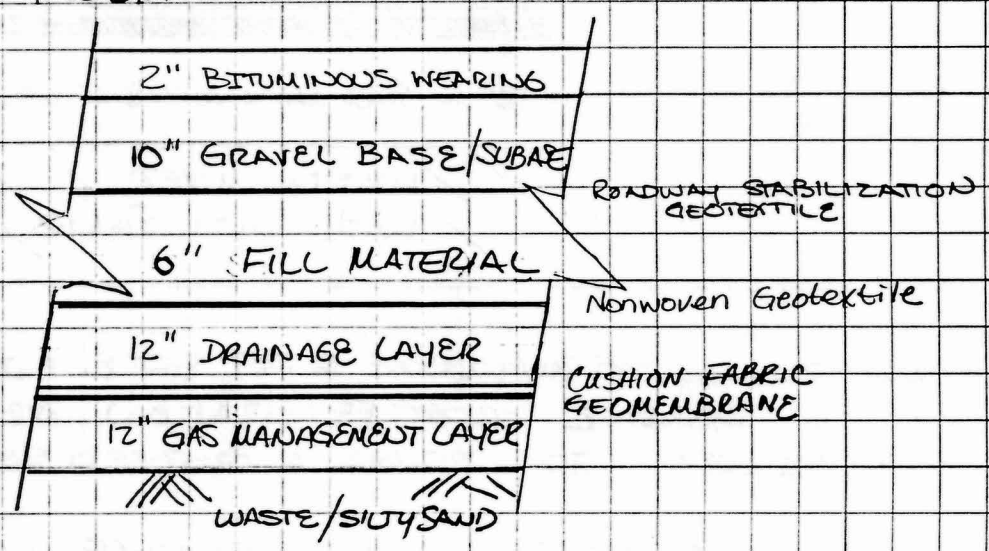
SUMMARY

WITH THE FOLLOWING CONDITIONS AND ASSUMPTIONS:

- SUBGRADE CBR 18
- SUBGRADE COMPACTED TO ASTM 698 Standard Proctor
- GCL OF CAP CONFIGURATION IS FROST SUSCEPTABLE.
- USE OF PASSANGER TRUCKS PREDOMINANT FOR OCCASIONAL SWEEPING OF STREET RANGE
- GCL layer MUST be below FROST Penetration of 20"
- MINIMUM THICKNESS OF SURFACE IS 2"
- MINIMUM THICKESS OF SUBBASE IS 6"

THE RECOMMENDED PAVEMENT SECTION IS:

- CHOOSE DESIGN FOR NORMAL YEAR FREEZING INDEX.



LOCATED IN APPENDIX A ARE THE SPECIFICATIONS REQUIRED BY NEW JERSEY FOR THE WEARING COURSE, BASE COURSE, AND SUBASE COURSE OF THIS SECTION.

CLIENT NWS EARLE	JOB NUMBER 7602-0106
SUBJECT Asphalt Design	
BASED ON NAVFAC DM-5.4	DRAWING NUMBER
BY KMS / CHECKED BY DW 8/28/97	APPROVED BY / DATE 8/18/97

References

1. Department of the Navy, Naval Facilities Engineering Command, October 1979, Civil Engineering Pavements NAVFAC DM-5.4.

2. Department of the Army and Air Force, January 1995, PAVEMENT Design for Seasonal Frost Conditions, AFM-88-6.

3. Department of the ARMY and the Air Force June 1992, Pavement Design for Roads, Streets, WALKS, AND OPEN STORAGE, AFM 88-7.

4. NEW JERSEY DEPARTMENT OF TRANSPORTATION, STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION, 1996

CLIENT NWS EARLE		JOB NUMBER 7602-0106	
SUBJECT Asphalt Design			
BASED ON NAVFAC DM-5.4		DRAWING NUMBER	
BY KMJ	CHECKED BY DCW 8/28/97	APPROVED BY	DATE 8/18/97

TABLE A

a. Vehicle Groups. Where detailed traffic survey and axle load data are not available, spot counts or estimates can be made to ascertain the general characteristics and volume of traffic. As an aid to determining a DI, vehicles should be grouped according to the following categories:

(1) Group 1: Passenger cars and panel and pickup trucks.
(2) Group 2: Two-axle trucks.
(3) Group 3: Trucks having three or more axles.

TABLE 5
Vehicular Traffic Design Index

DI	Traffic Characteristics	Approx. Daily EAL
1	Passenger Vehicles and Light Trucks. No trucks in Groups 2 or 3.	1-5
2	Medium-Light Traffic, less than 1000 VPD. 10% in Group 2 and none in Group 3.	6-20
3	Medium traffic up to 3000 VPD. Up to 10% Group 2 plus Group 3. 1% Group 3 vehicles.	21-75
4	Medium-heavy traffic up to 6000 VPD. Up to 15% Group 2 plus Group 3. 10% Group 3 vehicles.	76-250
5	Heavy traffic to 6000 VPD. Maximum 25% Group 2 plus Group 3 and 15% Group 3.	251-900
6	Very heavy traffic exceeding 6000 VPD. Over 25% Group 2 or Group 3.	901-3000

TAKEN FROM REFERENCE #1

CLIENT NWS EARLE		JOB NUMBER 7602-0106	
SUBJECT ASPHALT DESIGN			
BASED ON NAVFAC DM-5.4		DRAWING NUMBER	
BY KMS	CHECKED BY DCW 8/28/97	APPROVED BY	DATE 8/18/97

TABLE B

Subgrade Soil Type	Approx. CBR
Well and poorly graded gravels, well graded sands	>18
Silty and clayey sands	12-18
Low plastic clays, inorganic silts, very fine sands	6-12
Highly plastic and organic clays, micaceous silts	1-6

TABLE C
MINIMUM THICKNESS OF SURFACE

Type of Surface	Minimum Thickness (inches)
Primary Road	3
Secondary and Tertiary Roads	2
Parking Area	2
Driveway	1.5
Sidewalk	1
Surfacing Used by Tracked Vehicles	4

TAKEN FROM REFERENCE #1

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT NWS EARLE		JOB NUMBER 7602-0106	
SUBJECT ASPHALT DESIGN			
BASED ON NAVFAC DM-5.4		DRAWING NUMBER	
BY KMS	CHECKED BY DCW 8/28/97	APPROVED BY	DATE 8/18/97

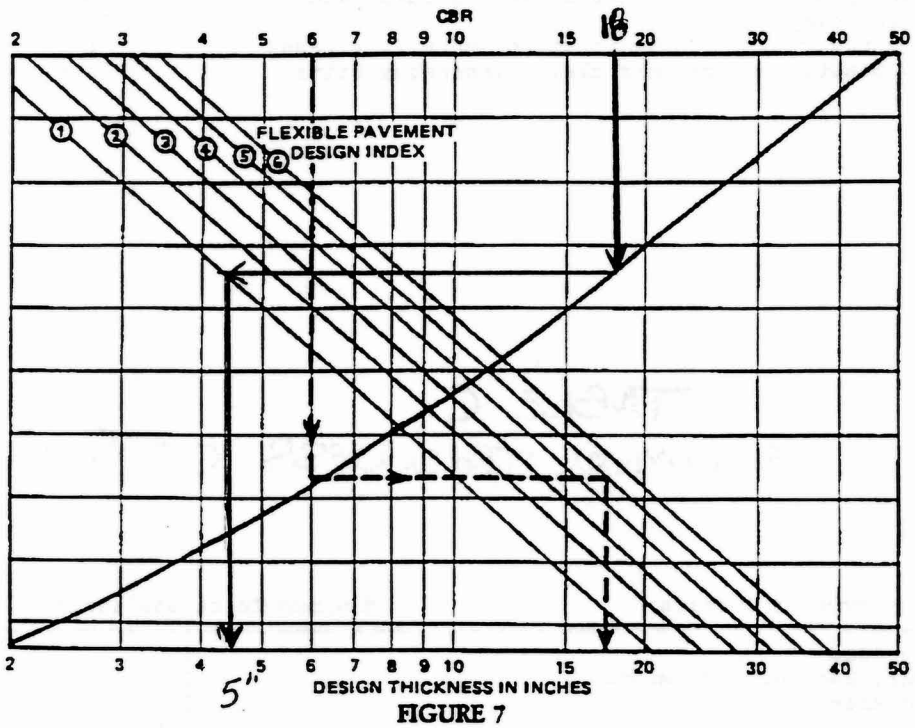


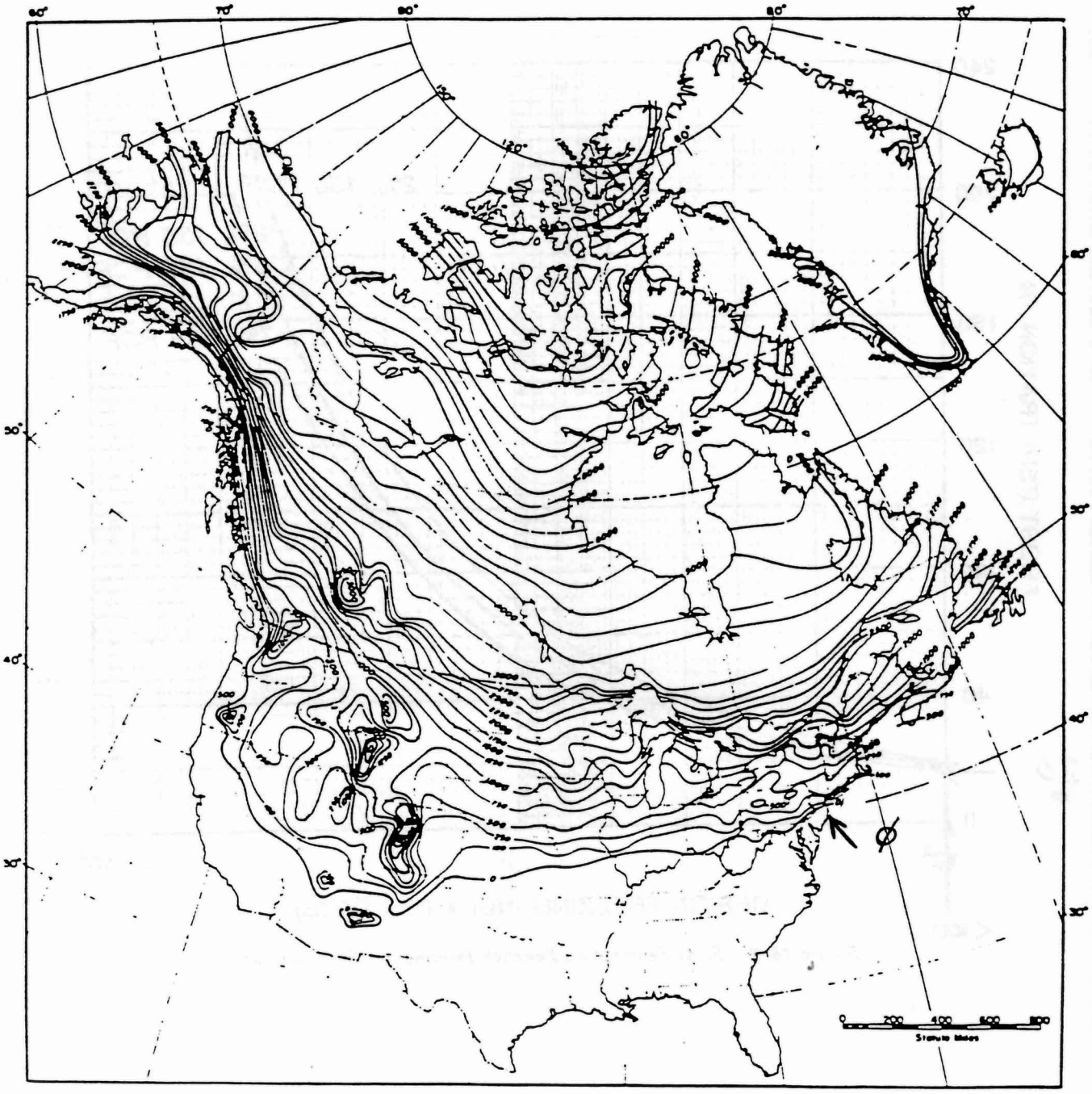
FIGURE 7
CBR Thickness Design Chart—Flexible Pavements

TAKEN FROM REFERENCE #1

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT NWS EARLE		JOB NUMBER 7602-0106	
SUBJECT Asphalt Design			
BASED ON NAVFAC DM-5.4		DRAWING NUMBER	
BY KMS	CHECKED BY DCW 8/28/97	APPROVED BY	DATE 8/18/97

TM 5-818-2/AFM 88-6, Chap. 4



U.S. Army Corps of Engineers

Figure 3-1. Distribution of mean air freezing indices in North America.
(NORMAL YEAR)

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT NWS EARLE		JOB NUMBER 7602-0106	
SUBJECT Asphalt Design			
BASED ON NAVFAC DM-5.4		DRAWING NUMBER	
BY KMS	CHECKED BY DCW 8/28/97	APPROVED BY	DATE 8/18/97

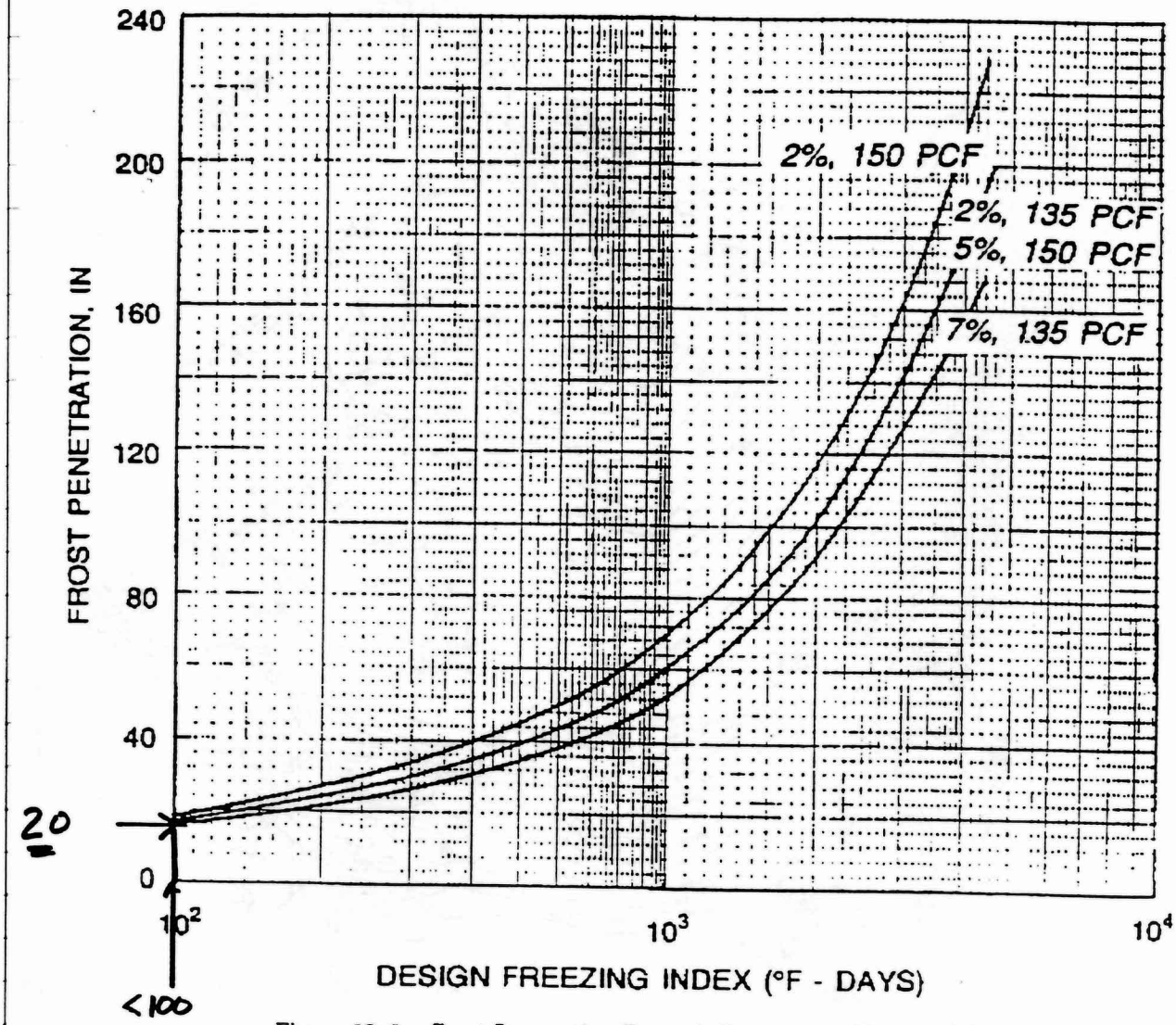


Figure 18-3. Frost Penetration Beneath Pavements. (Sheet 1 of 3)

TAKEN FROM REFERENCE # 2

CLIENT		JOB NUMBER	
SUBJECT			
BASED ON		DRAWING NUMBER	
BY	CHECKED BY DCW	APPROVED BY	DATE

Appendix A

FROM REFERENCE #4 SHEET 14, THE FOLLOWING SPECIFICATIONS ARE REQUIRED BY NEW JERSEY FOR THE 3 SECTIONS OF THE ASPHALT DESIGN:

WEARING COURSE (BITUMINUS):

USE I-5 MIX

BASE AND SUBASE COURSE

USE I-2 MIX

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT NWS EARLE		JOB NUMBER 7602-0106	
SUBJECT ASPHALT DESIGN			
BASED ON NAVFAC DM-5.4		DRAWING NUMBER	
BY KMS	CHECKED BY DCW 8/20/97	APPROVED BY	DATE 8/18/97

DIVISION 900 - MATERIALS

Table 903-1 Bituminous Concrete Mixtures
New Jersey Interagency Engineering Committee
Standard Bituminous Concrete Mixture Design Table

Mix Designation and Nominal Maximum Size of Aggregate

	Base Course			Surface Course		
Mix	**I-1**	**I-2**	**I-4 HD**	**I-4**	**I-5**	**I-5 HD**
Size, mm	25.0	37.5	19.0	19.0	9.5	12.5
Sieve Size	Grading of total aggregate (coarse plus fine, plus filler if required). Amounts finer than each laboratory sieve (square opening) weight percent.					
50 mm	--	100				
37.5 mm	100	90-100				
25.0 mm	90-100	80-100	100	100		
19.0 mm	60-80	65-95 (NA)	95-100	98-100		100
12.5 mm	--	50-85	75-95	88-98	100	72-98
9.5 mm	15-40	40-75 (NA)	65-85 (N/A)	65-88	80-100	60-82
4.75 mm	0-10	25-60	35-65	35-65	55-75	40-56
2.36 mm	--	20-45	25-36	25-46	30-56	28-37
1.18 mm	--	--	15-35	18-40	20-45	19-27
600 µm	--	--	10-30	12-30	15-35	13-19
300 µm	--	8-30	8-25	10-25	10-30	8-16
150 µm	--	--	--	--	--	5-10
75 µm	--	4-7.5	4-7.5	4-7.5	4-8	3-6
	Asphalt Cement, Percent by Weight of Total Mixture					
	2.5-3.1	4-6	4.8-7	5-7	5-7	5-6

Note 1: Material passing the 75-micrometer sieve may consist of fine particles of the aggregate mineral filler, or both. Material passing the 425-micrometer sieve shall be nonplastic when test in accordance with AASHTO T 90.

Note 2: Maximum aggregate size requirements - the maximum size of coarse aggregate for any given n on a project shall be no more than one-half of the proposed lift thickness on the Project. (I example: If the proposed lift thickness for an I-2 mix is 50 millimeters, the mix used must 100 percent passing the 25.0-millimeter sieve even though the overall specification allows 8 100 percent passing the 25.0-millimeter sieve.)

Note 3: Mix I-1 is not subject to the design requirements specified elsewhere.

Note 4: (NA) Denotes not applicable for NJDOT Mix.

Note 5: Mix Descriptions:

1. I-1 is a permeable base course which should be used in a minimum lift of 75 millimete
2. I-2 is a dense-graded base course which may be used in full depth construction or as bottom course in an overlay.
3. I-4 HD (heavy duty) is a 19.0-millimeter nominal maximum size surface course intended to be used on heavy traffic roadways.
4. I-4 is a 19.0-millimeter nominal maximum size surface course mix for medium to he traffic roadways.
5. I-5 is a 9.5-millimeter nominal maximum size surface course mix for low to medium tr roadways.
6. I-5 HD (heavy duty) is a 12.5-millimeter nominal maximum size surface course intended to be used for thin lifts (less than 37.5 millimeters) on heavy traffic roadway

TAKEN FROM REFERENCE #4

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT: NWS EARLE	JOB NUMBER: 7602 - 0106
SUBJECT: AGGREGATE ROAD DESIGN	
BASED ON:	DRAWING NUMBER:
BY: CSF / CHECKED BY: DCW	APPROVED BY: / DATE: 8/22/97

OBJECTIVE: Determine the aggregate thickness to be used for the unpaved utility roads at NWS Earle

BASIS OF DESIGN: Aggregate thickness will be determined using the AGGREGATE - SURFACED ROAD DESIGN CATALOG presented in Ref #1

ASSUMPTIONS: Assumptions used to determine the aggregate thickness for the utility roads using the aggregate - surfaced road design catalog include the following:

a) The allowable range of relative traffic for aggregate - surfaced roads design is between 10,000 and 100,000 18-kip equivalent single axle load (ESAL) applications.

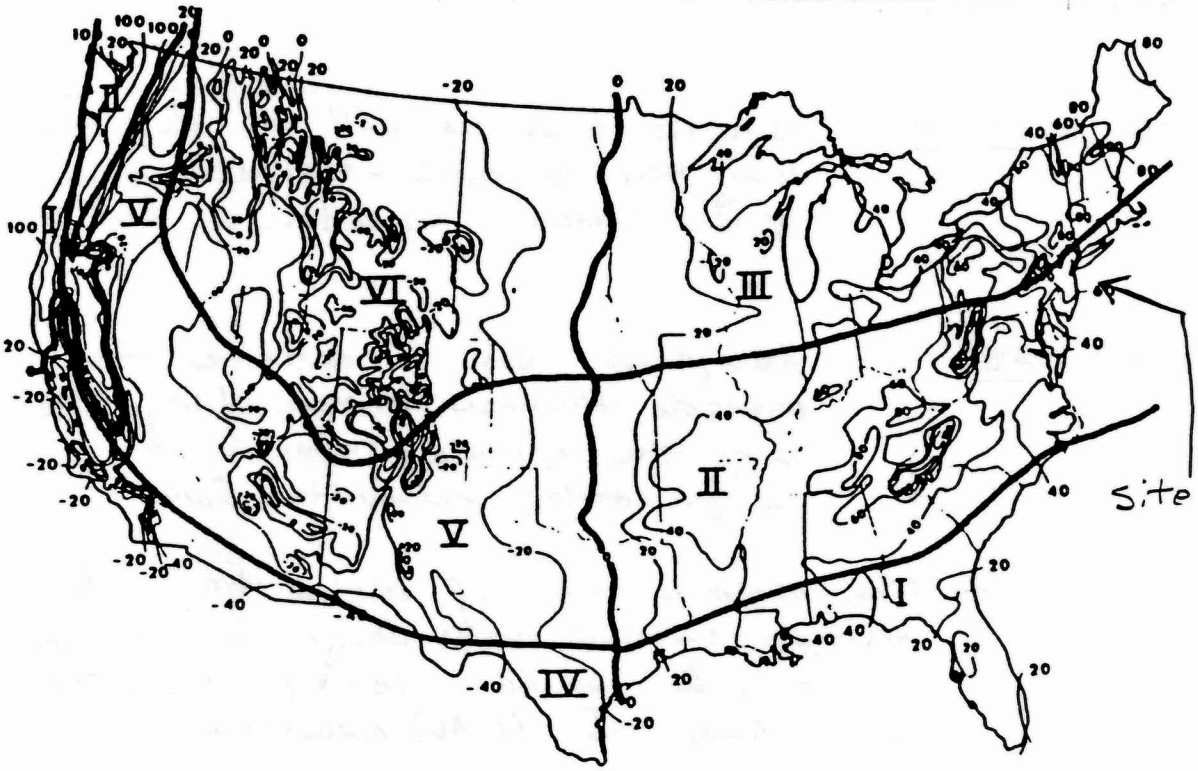
b) The presented design is based on a 50 - 75 percent level of reliability.

c) The effective resilient modulus of the aggregate base material is 30,000 psi regardless of the quality of the roadbed soil.

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT: NWS EARLE	JOB NUMBER: 7602 - 0106
SUBJECT: AGGREGATE ROAD DESIGN	
BASED ON:	DRAWING NUMBER:
BY: CSF / CHECKED BY: DCW	APPROVED BY: / DATE: 8/22/97

Select the appropriate climatic region for the site location:



REGION	CHARACTERISTICS
I	Wet, no freeze
II	Wet, freeze - thaw cycling
III	Wet, hard-freeze, spring thaw
IV	Dry, no freeze
V	Dry, freeze - thaw cycling
VI	Dry, hard freeze, spring thaw

* CLIMATIC REGION *

II

Figure 4.1. The Six Climatic Regions in the United States (*12*)

Reference: Ref (1) pp II-70.

CLIENT	JOB NUMBER
NWS EARLE	7602 - 0106

SUBJECT: AGGREGATE ROAD DESIGN

BASED ON	DRAWING NUMBER

BY	CHECKED BY	APPROVED BY	DATE
CSF	DCW		8/22/97

Traffic volume will be infrequent on the utility road. Select a low volume traffic pattern with a corresponding 18-kip ESAL range of 10,000 - 30,000

Traffic volume	18-kip ESAL range
High	60,000 to 100,000
Medium	30,000 to 60,000
Low	10,000 to 30,000

Source: Ref (1) pp II - 81

Table 4.10. Aggregate Surfaced Road Design Catalog: Recommended Aggregate Base Thickness (in Inches) for the Six U.S. Climatic Regions, Five Relative Qualities of Roadbed Soil and Three Levels of Traffic

Relative Quality of Roadbed Soil	Traffic Level	U.S. Climatic Region					
		I	II	III	IV	V	VI
Very good	High	8*	10	15	7	9	15
	Medium	6	8	11	5	7	11
	Low	4	4	6	4	4	6
Good	High	11	12	17	10	11	17
	Medium	8	9	12	7	9	12
	Low	4	5	7	4	5	7
Fair	High	13	14	17	12	13	17
	Medium	11	11	12	10	10	12
	Low	6	6	7	5	5	7
Poor	High	**	**	**	**	**	**
	Medium	**	**	**	15	15	**
	Low	9	10	9	8	8	9
Very poor	High	**	**	**	**	**	**
	Medium	**	**	**	**	**	**
	Low	11	11	10	8	8	9

*Thickness of aggregate base required (in inches).

**Higher type pavement design recommended.

Source: Ref (1) pp II - 86.

CLIENT NWS EARLE		JOB NUMBER 7602-0106	
SUBJECT AGGREGATE ROAD DESIGN			
BASED ON		DRAWING NUMBER	
BY CSF	CHECKED BY DCW	APPROVED BY	DATE 8/22/97

Given that the utility road is to be constructed on top of the graded and compacted landfill cap, select a GOOD relative quality for the roadbed soil.

⇒ From TABLE 4.10:

1. Good Roadbed Quality
2. Low Traffic Level
3. U.S. Climatic Region II

REQUIRED AGGREGATE THICKNESS FOR THE UTILITY ROAD:

5 INCHES MIN

⇒ USE 6 INCHES to conform with proposed surface layer thickness on the caps

Reference

1. AASHTO Guide for Design of Pavement Structures, American Association of State Highway and Transportation Officials, Washington, D.C. 1993.

APPENDIX L

CONCRETE SLAB CALCULATIONS

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT: NAVY (EARLE)	JOB NUMBER: 7602
SUBJECT: POTABLE WATER TANK SLAB AND SLAB CALCULATIONS – SPORTING CLAY BUILDING SLABS	
BASED ON:	DRAWING NUMBER:
BY: S. RUFFING / CHECKED BY: L Shipley 11/4/97	APPROVED BY: / DATE:

PROBLEM:

DESIGN SLAB TO SUPPORT SPORTING CLAY BUILDINGS (TYP FOR 4) AND A POTABLE WATER TANK. DETERMINE SLAB THICKNESS AND REINFORCING.

KNOWN:

- SLABS ARE ON GRADE W/ DRAINAGE LAYER CONSISTING OF GRANULAR MATERIAL UNDERNEATH.
- SPORTING CLAY SLABS ARE 10'X10'
- LOADING IS MINIMAL - ONLY BUILDING AND SKEET THROWING EQUIPMENT.
- POTABLE WATER TANK SLAB WILL BE 9'X15'
-

ASSUME:

- USE 3000 psi CONCRETE @ 150 pcf
- COEFFICIENT OF FRICTION BETWEEN SLAB AND SUBASE IS 1.5
- ALLOWABLE TENSILE STRENGTH OF CONCRETE IS 0.07 X 3000 = 210 psi ⇒ USE 200 psi
- MAXIMUM LOAD IS 2000 lb APPLIED OVER 4" DIAMETER
- POISSON'S RATIO (ν) FOR CONCRETE = 0.15
- STANDARD MODULUS OF SOIL REACTION (K) = 500 pci FOR SUBASE CLASSIFIED AS GW.
- LOADING FOR POTABLE WATER TANK SLAB AND SPORTING SLABS IS THE SAME.

  SPORTING CLAY SLAB LOAD = 2000 / ($2^2 \pi$) = 160 psi

  POTABLE WATER TANK LOAD = 750 gal X 8.3 lb/gal = 6225 lb

  6225 lb / 2 = 3110 lb/WHEEL APPLIED OVER ~ 6" DIA AREA

  3110 / ($3^2 \pi$) = 110 psi

  ∴ DESIGN FOR SPORTING CLAY LOADS FOR ALL SLABS.

USE:

- WESTERGAARD ANALYSIS
- ACI 318-89

CLIENT NAVY (EARLE)	JOB NUMBER 7602
SUBJECT SLAB CALCULATIONS - POTABLE WATER TANK SLAB AND SPORTING CLAY BUILDING SLABS	
BASED ON	DRAWING NUMBER
BY S. RUFFING / CHECKED BY LS 11/4/97	APPROVED BY / DATE

USING ACI 318-89, TABLE 9.5(a)
MINIMUM SLAB THICKNESS WITH BOTH ENDS CONTINUOUSLY SUPPORTED IS L/28 WHERE L IS THE LENGTH OF SLAB BETWEEN JOINTS IN INCHES.

$L = 10' \times 12\ \text{IN/FT} = 120$ INCHES

$h = \frac{120}{28} = 4.3'' \Rightarrow$ USE 5" ✓

VERIFY SLAB THICKNESS USING WESTERGAARD ANALYSIS
CASE 1 - CRITICAL LOAD @ SLAB CORNER

E_c = MODULUS OF ELASTICITY FOR CONCRETE
$= 57000\sqrt{f_c} = 57000\sqrt{3000} = 3{,}122{,}019$ psi ✓

DETERMINE RADIUS OF RELATIVE STIFFNESS (ℓ)

$$\ell = \sqrt[4]{\frac{E_c h^3}{12(1-\nu^2)k}}$$

$$= \sqrt[4]{\frac{3{,}122{,}019\,(5)^3}{12(1-0.15^2)500}} = \sqrt[4]{66539} = 16.06\ \text{in}$$ ✓

DETERMINE MINIMUM THICKNESS

$$h^2 = \frac{3P}{f_t}\left[1-\left(\frac{a\sqrt{2}}{\ell}\right)^{0.6}\right]$$

WHERE a = RADIUS OF LOAD CONTACT AREA
$a = 2''$
$f_t = 200$ psi (ALLOWABLE TENSILE STRESS)

$$h^2 = \frac{3(2000)}{200}\left[1-\left(\frac{2\sqrt{2}}{16.06}\right)^{0.6}\right]$$

$h^2 = 19.4\ \text{in}^2 \Rightarrow h = 4.4$ in ✓
$\therefore$ 5 INCH SLAB OK

CLIENT NAVY (EARLE)	JOB NUMBER 7602
SUBJECT SLAB CALCULATIONS - POTABLE WATER TANK SLAB, SPORTING CLAY BUILDING SLABS	
BASED ON	DRAWING NUMBER
BY S. RUFFING / CHECKED BY LS 11/4/97	APPROVED BY / DATE

CASE 2

VERIFY STRESS IN SLAB IS ACCEPTABLE IF LOAD APPLIED IN CENTER OF SLAB

$$f_b = 0.316\frac{P}{h^2}\left[\log h^3 - 4\log\left(\sqrt{1.6a^2+h^2} - 0.675h\right) - \log k + 6.48\right]$$

$$f_b = 0.316\frac{(2000)}{5^2}\left[\log 5^3 - 4\log\left(\sqrt{1.6(2)^2+5^2} - 0.675(5)\right) - \log 500 + 6.48\right]$$

$$f_b = 25.28\left[2.1 - 1.4 - 2.7 + 6.48\right] = 113.3 \text{ psi}$$

$$f_b = 113.3 \text{ psi} < 200 \text{ psi} \therefore \text{OK} \checkmark$$

CASE 3

VERIFY STRESS IN SLAB IF LOAD IS APPLIED ALONG EDGE

$$f_b = 0.572\frac{P}{h^2}\left[\log h^3 - 4\log\left(\sqrt{1.6a^2+h^2} - 0.675h\right) - \log k + 5.77\right]$$

$$f_b = 0.572\frac{(2000)}{5^2}\left[\log 5^3 - 4\log\left(\sqrt{1.6(2)^2+5^2} - 0.675(5)\right) - \log 500 + 5.77\right]$$

$$f_b = 45.76\left[2.1 - 1.4 - 2.7 + 5.77\right]$$

$$f_b = 172.5 \text{ psi}$$

$$172.5 \text{ psi} < 200 \text{ psi} \therefore \text{OK} \checkmark$$

CLIENT NAVY (EARLE)	JOB NUMBER 7602
SUBJECT POTABLE WATER TANK SLAB SLAB CALCULATIONS - SPORTING CLAY BUILDING SLABS	
BASED ON	DRAWING NUMBER
BY S. RUFFING / CHECKED BY LS 11/4/97	APPROVED BY / DATE

REINFORCING STEEL REQ'D:
ONLY NEED STEEL TO CONTROL TEMPERATURE/SHRINKAGE CRACKING.

TENSION DUE TO CONTRACTION (T) = $\frac{W_o \mu l}{2}$

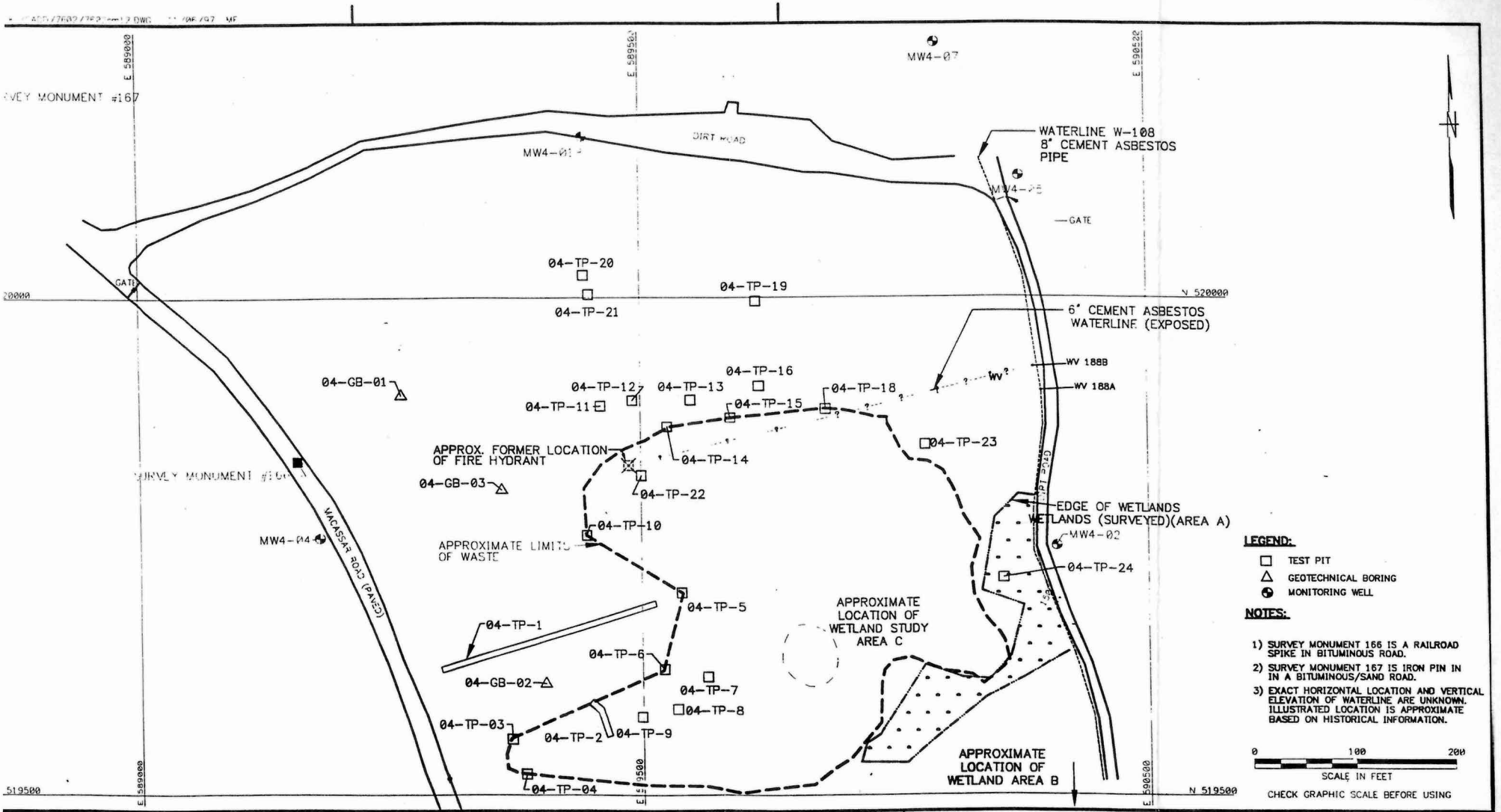
W_o = WEIGHT OF SLAB psf = 62.5 psf ✓
μ = COEFFICIENT OF FRICTION = 1.5
l = LENGTH BETWEEN CONTRACTION JOINTS = 10'
T = TENSILE FORCE, lb/FT WIDTH OF SLAB

$$T = \frac{62.5 \times 1.5 \times 10}{2} = 468.8 \text{ lb/FT OF WIDTH}$$ ✓

AREA OF STEEL (A_s) = $\frac{T}{f_s}$ WHERE f_s = ALLOWABLE STRESS IN STEEL ~ 1/2 YIELD STRESS = 30,000 psi FOR GRADE 60

$$A_s = \frac{468.8}{30{,}000} = 0.016 \text{ in}^2/\text{FT}$$ ✓

∴ USE WWF 6X6 – W2.9 x W2.9 WITH A_s = 0.06 in²/FT



DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

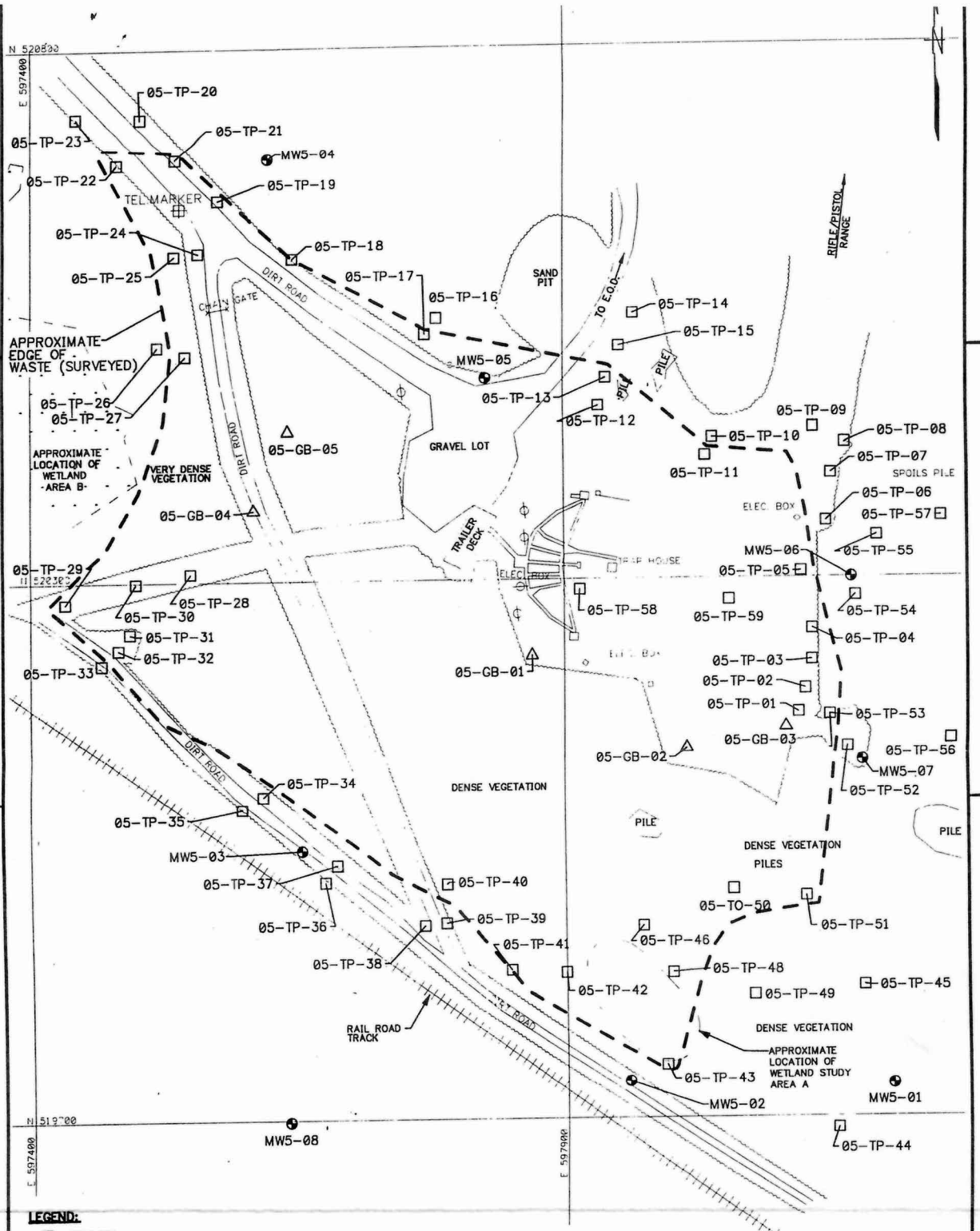
DRAWN BY TAD DATE 8/28/97
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

Brown & Root Environmental

SITE 4
PRE-DESIGN INVESTIGATION
EXISTING CONDITIONS PLAN
NAVAL WEAPONS STATION EARLE
COLTS NECK, NEW JERSEY

CONTRACT NO. 7602
OWNER NO.
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 1-2
REV. 0

RM CADD NO. SOUTH_BHLDGN - REV 0 - 02/11/97



LEGEND:

- □ TEST PIT
- △ GEOTECHNICAL BORING
- ⊕ MONITORING WELL

NOTES:

1) SITE 5 SURVEY MONUMENTS ARE LOCATED OUTSIDE THE BOUNDARIES PRESENTED ON THIS FIGURE.

0 100 200
SCALE IN FEET
CHECK GRAPHIC SCALE BEFORE USING

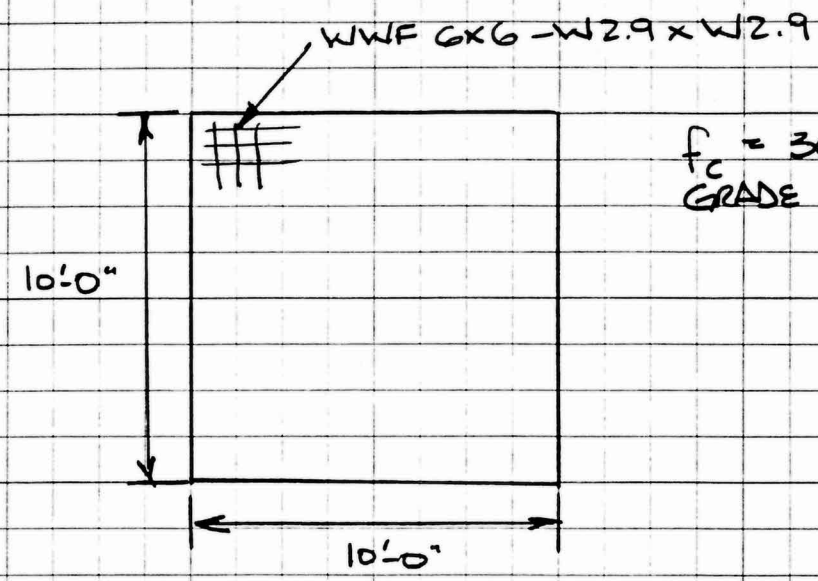
DRAWN BY TAD DATE 8/28/97	Brown & Root Environmental	CONTRACT NO. 7602	OWNER NO. 0289
CHECKED BY DATE	SITE 5 PRE-DESIGN EXISTING CONDITIONS PLAN NAVAL WEAPONS STATION EARLE COLTS NECK, NEW JERSEY	APPROVED BY DATE	
COST/SCHED-AREA		APPROVED BY DATE	
SCALE AS NOTED		DRAWING NO. FIGURE 1-3	REV. 0

FORM CADD NO. SOUTH_BV.DWG - REV 0 - 04/16/97

079716/P
1-7
CTO 0289
Rev. 1
November 1997

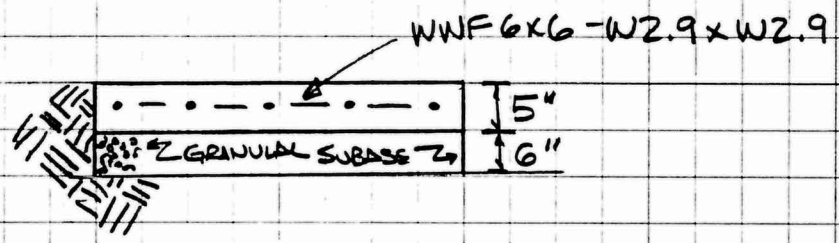
CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT NAVY (EARLE)	JOB NUMBER 7602
SUBJECT SLAB CALCULATIONS - POTABLE WATER TANK SLAB / SPORTING CLAY BUILDING SLABS	
BASED ON	DRAWING NUMBER
BY S. RUFFING	CHECKED BY LS 11/4/97
APPROVED BY	DATE



f_c = 3000 psi
GRADE 60 STEEL

PLAN



X-SECTION

NOTE: FOR POTABLE WATER TANK SLAB ADD CONTRACTION JOINT AT MIDPOINT ALONG 15' DIMENSION. NOTCH CONCRETE TO A DEPTH OF 1/4 OF THE SLAB THICKNESS.

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT NAVY (EARLE)	JOB NUMBER 7602
SUBJECT SLAB CALCULATIONS – HIGH AND LOW HOUSE BUILDING SLAB	
BASED ON	DRAWING NUMBER
BY S. RUFFING / CHECKED BY L. Shipley 11/4/97	APPROVED BY / DATE

PROBLEM:
DESIGN SLABS ON GRADE TO SUPPORT HIGH AND LOW HOUSE BUILDING AND THROWING EQUIPMENT. DETERMINE SLAB THICKNESS AND REINFORCING FOR EACH.

KNOWN:
- SLABS ARE ON GRADE W/ GRANULAR DRAINAGE LAYER UNDERNEATH.
- SLABS WILL BE 12'x22' (HIGH HOUSE) AND 12'x12' (LOW HOUSE)
- LOADING IS MINIMAL – ONLY BUILDING AND THROWING EQUIPMENT

ASSUME:
- USE 3000 psi CONCRETE @ 150 pcf
- COEFFICIENT OF FRICTION BETWEEN SLAB AND SUBBASE IS 1.5
- ALLOWABLE TENSILE STRENGTH OF CONCRETE IS 0.07 x 3000 = 210 psi ⇒ USE 200 psi
- MAXIMUM LOAD IS 2000 lb APPLIED OVER 4" DIAMETER SURFACE
- POISSON'S RATIO (ν) FOR CONCRETE IS = 0.15
- STANDARD MODULUS OF SOIL REACTION (k) = 500 pci FOR SUBBASE CLASSIFIED AS GW.

USE:
- ACI 318-89
- WESTERGAARD ANALYSIS

CLIENT	JOB NUMBER
NAVY (EARLE)	7602
SUBJECT: SLAB CALCS - HIGH AND LOW HOUSE	
BASED ON	DRAWING NUMBER

BY	CHECKED BY	APPROVED BY	DATE
S. RUFFING	LS 11/4/97		

USING ACI 318-89, TABLE 9.5(a)
THE MINIMUM SLAB THICKNESS WITH BOTH ENDS CONTINUOUSLY SUPPORTED IS L/28, WHERE L IS THE LENGTH OF SLAB BETWEEN JOINTS.

HIGH HOUSE $L = 12 \times 22 = 264$ IN ✓
LOW HOUSE $L = 12 \times 12 = 144$ IN ✓

HIGH HOUSE $h = 264/28 = 9.4$ in USE <u>10 in</u> ✓

LOW HOUSE $h = 144/28 = 5.1$ in USE <u>6 in</u> ✓

HIGH HOUSE:

VERIFY SLAB THICKNESS USING WESTERGAARD ANALYSIS
CASE 1 - CRITICAL LOAD @ SLAB CORNER

E_c = MOD. OF ELASTICITY FOR CONCRETE $= 57000\sqrt{f_c}$

$E_c = 57000\sqrt{3000} = 3{,}122{,}019$ psi ✓

RADIUS OF RELATIVE STIFFNESS $(\ell) = \sqrt[4]{\dfrac{E_c h^3}{12(1-\nu^2)k}}$

$$\ell = \sqrt[4]{\frac{3{,}122{,}019\,(10)^3}{12(1-0.15^2)500}} = 27 \text{ in} \checkmark$$

MINIMUM THICKNESS $(h) \Rightarrow h^2 = \dfrac{3P}{f_t}\left[1-\left(\dfrac{a\sqrt{2}}{\ell}\right)^{0.6}\right]$
WHERE $a = 2''$, $f_t = 200$ psi

$$h^2 = \frac{3(2000)}{200}\left[1-\left(\frac{2\sqrt{2}}{27}\right)^{0.6}\right] = 22.3 \text{ in}^2 \checkmark$$

$h = 4.7$ in ✓

∴ REDUCE SLAB TO 6 IN THICKNESS WITH CONTRACTION JOINT @ MIDPOINT

CLIENT NAVY (EARLE)	JOB NUMBER 7602
SUBJECT SLAB CALCS – HIGH AND LOW HOUSE	
BASED ON	DRAWING NUMBER
BY S. RUFFING / CHECKED BY LS 11/4/97	APPROVED BY / DATE

CASE 2

VERIFY STRESS IN SLAB IF LOAD APPLIED AT CENTER OF SLAB

$$f_b = 0.316 \frac{P}{h^2}\left[\log h^3 - 4\log\left(\sqrt{1.6a^2+h^2} - 0.675h\right) - \log k + 6.48\right]$$

$$= 0.316 \frac{(2000)}{6^2}\left[\log 6^3 - 4\log\left(\sqrt{1.6(2)^2+6^2} - 0.675(6)\right) - \log 500 + 6.48\right]$$

$$= 17.6\left[2.3 - 1.6 - 2.7 + 6.48\right] = 78.8 \text{ psi} \checkmark$$

$$f_b = 78.8 \text{ psi} < 200 \text{ psi} \therefore \underline{\text{OK}} \checkmark$$

CASE 3

VERIFY STRESS IN SLAB IF LOAD APPLIED AT EDGE

$$f_b = 0.572 \frac{P}{h^2}\left[\log h^3 - 4\log\left(\sqrt{1.6a^2+h^2} - 0.675h\right) - \log k + 5.77\right]$$

$$= 0.572 \frac{(2000)}{6^2}\left[\log 6^3 - 4\log\left(\sqrt{1.6(2)^2+6^2} - 0.675(6)\right) - \log 500 + 5.77\right]$$

$$= 31.8\left[2.3 - 1.6 - 2.7 + 5.77\right] = 119.9 \text{ psi} \checkmark$$

$$f_b = 119.9 \text{ psi} < 200 \text{ psi} \therefore \underline{\text{OK}} \checkmark$$

CLIENT NAVY (EARLE)	JOB NUMBER 7602
SUBJECT SLAB CALCS - HIGH AND LOW HOUSE	
BASED ON	DRAWING NUMBER
BY S. RUFFING / CHECKED BY LS 11/4/97	APPROVED BY / DATE

REINFORCING STEEL REQUIRED: (HIGH HOUSE)
ONLY NEED STEEL TO CONTROL CRACKING

TENSION DUE TO CONTRACTION (T) = $\frac{W_o \mu l}{2}$

W_o = WEIGHT OF SLAB psf = 75.0 psf ✓
μ = COEFFICIENT OF FRICTION = 1.5 ✓
l = LENGTH OF SLAB BETWEEN CONTRACTION JOINTS
T = TENSILE FORCE, lb/FT WIDTH OF SLAB

USE l = 11' (22' SLAB W/ CONTRACTION JOINT AT MIDPOINT)

$$T = \frac{75 \times 1.5 \times 11}{2} = 618.75 \text{ lb/FT OF WIDTH}$$ ✓

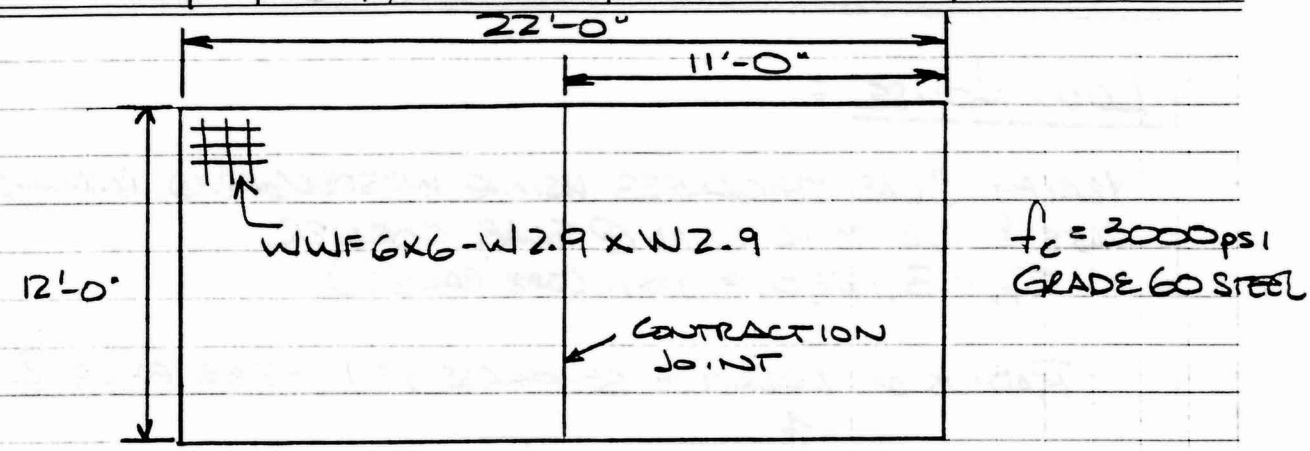
AREA OF STEEL (A_s) = $\frac{T}{f_s}$ WHERE f_s = ALLOWABLE STRESS IN STEEL ~ ½ YIELD STRESS = 30,000 psi FOR GRADE 60

$$A_s = \frac{618.75}{30{,}000} = 0.02 \text{ in}^2/\text{FT}$$ ✓

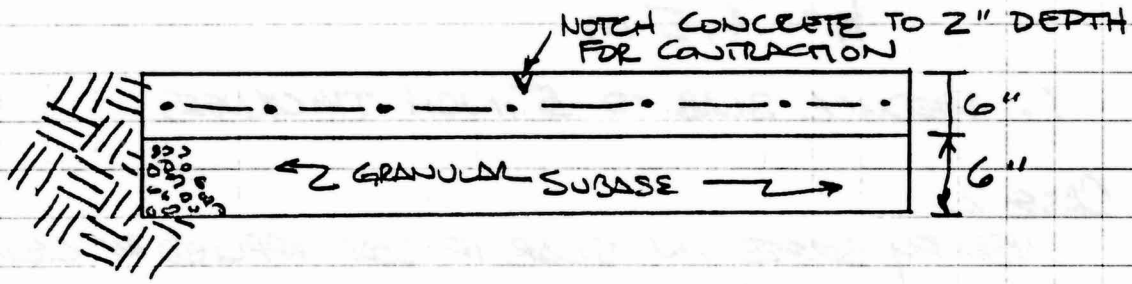
∴ USE WWF 6x6-W2.9 x W2.9 w/ A_s = 0.06 in²/FT

CLIENT NAVY (EARLE)	JOB NUMBER 7602
SUBJECT SLAB CALCS - HIGH AND LOW HOUSE	
BASED ON	DRAWING NUMBER

BY	CHECKED BY	APPROVED BY	DATE
S. RUFFING	LS 11/4/97		



HIGH HOUSE PLAN



X-SECTION

CLIENT	JOB NUMBER
NAVY (EARLE)	7602
SUBJECT: SLAB CALCS - HIGH AND LOW HOUSE	
BASED ON	DRAWING NUMBER

BY	CHECKED BY	APPROVED BY	DATE
S. RUFFING	LS 11/4/97		

LOW HOUSE:

VERIFY SLAB THICKNESS USING WESTERGAARD ANALYSIS
CASE 1 CRITICAL LOAD @ SLAB CORNER
$E_c = 3{,}122{,}019$ psi (SEE PAGE 2) ✓

RADIUS OF RELATIVE STIFFNESS (ℓ) - SEE PAGE 2

$$\ell = \sqrt[4]{\frac{3122019\,(6)^3}{12(1-0.15^2)500}} = 18.4 \text{ in} \quad ✓$$

MIN. THICKNESS (h)

$$h^2 = \frac{3(2000)}{200}\left[1-\left(\frac{2\sqrt{2}}{18A}\right)^{0.6}\right] = 20.2 \quad ✓$$

$$h = 4.5 \text{ in} \quad ✓$$

∴ REDUCE SLAB TO 5 INCH THICKNESS ✓

CASE 2
VERIFY STRESS IN SLAB IF LOAD APPLIED AT CENTER
(SEE PAGE 3)

$$f_b = 0.316\frac{(2000)}{5^2}\left[\log 5^3 - 4\log\left(\sqrt{1.6(2)^2+5^2} - 0.675(5)\right) - \log 500 + 6.48\right]$$

$$= 25.28\left[2.1 - 1.4 - 2.7 + 6.48\right]$$

$f_b = 113.3$ psi < 200 psi ∴ OK ✓

CLIENT NAVY (EARLE)	JOB NUMBER 7602
SUBJECT SLAB CALCULATIONS - HIGH AND LOW HOUSE	
BASED ON	DRAWING NUMBER
BY S. RUFFING / CHECKED BY LS 11/4/97	APPROVED BY / DATE

CASE 3

VERIFY STRESS IN SLAB IF LOAD APPLIED AT EDGE
(SEE PAGE 3)

$$f_b = 0.572\frac{(2000)}{5^2}\left[\log 5^3 - 4\log\left(\sqrt{1.6(2)^2+5^2} - 0.675(5)\right) - \log 500 + 5.77\right]$$

$$= 45.76\left[2.1 - 1.4 - 2.7 + 5.77\right]$$

$f_b = 172.5$ psi < 200 psi $\therefore$ OK ✓

REINFORCING STEEL REQ'D: (LOW HOUSE)
SEE PAGE 4

$T = \frac{W_o \mu l}{2}$ $\quad W_o = 62.5$ psf (FOR 5" SLAB) ✓

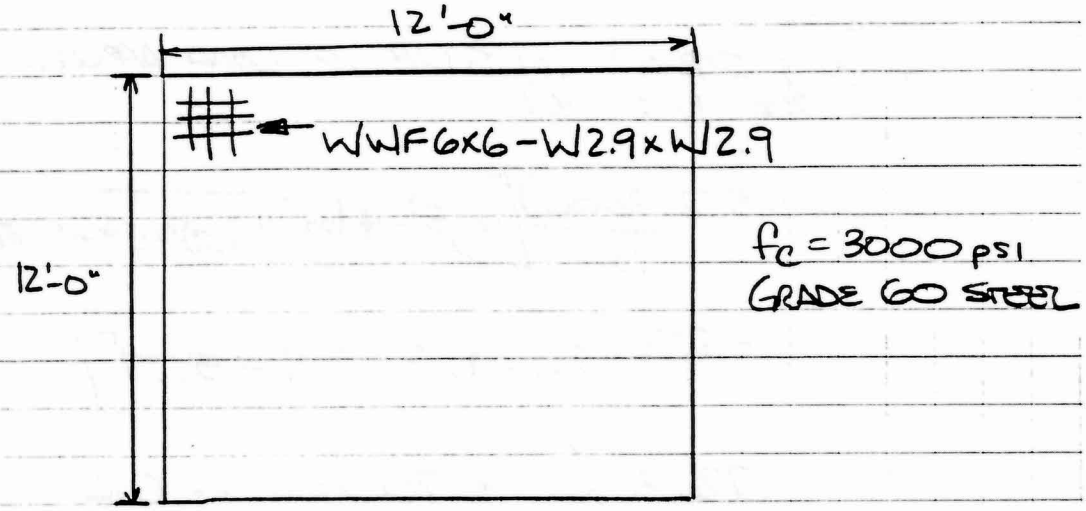
$T = \frac{62.5(1.5)12}{2} = 562.5$ lb/FT OF WIDTH ✓

$A_s = \frac{562.5}{30{,}000} = 0.019$ in²/FT

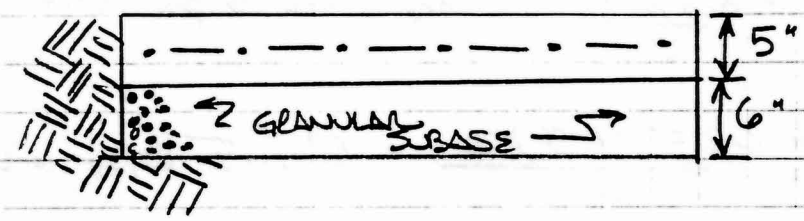
$\therefore$ USE WWF 6x6 - W2.9xW2.9 w/ $A_s = 0.06$ in²/FT

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT NAVY (EARLE)	JOB NUMBER 7602
SUBJECT SLAB CALCULATIONS - HIGH AND LOW HOUSE	
BASED ON	DRAWING NUMBER
BY S. RUFFING / CHECKED BY LS 11/4/97	APPROVED BY / DATE



LOW HOUSE PLAN



X-SECTION

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT: NAVY (EARLE)	JOB NUMBER: 7602
SUBJECT: SLAB CALCULATIONS - FUTURE CLUBHOUSE	
BASED ON	DRAWING NUMBER

BY	CHECKED BY	APPROVED BY	DATE
S. RUFFING	L. Shipley 11/4/97		

PROBLEM:

DESIGN SLAB TO SUPPORT CLUBHOUSE TRAILER. DETERMINE SLAB THICKNESS AND REINFORCING.

KNOWN:

- SLAB IS ON GRADE W/ DRAINAGE LAYER CONSISTING OF GRANULAR MATERIAL UNDERNEATH.
- SLAB WILL BE 15' x 70'
- LOADING WILL BE BASED ON ATTACHMENT 1 (DEAD LOAD) + 100 psf (LIVE LOAD)

ASSUME:

- USE 3000 psi CONCRETE @ 150 pcf
- USE COEFFICIENT OF FRICTION BETWEEN SLAB AND SUBASE = 1.5.
- ALLOWABLE TENSILE STRENGTH OF CONCRETE IS 0.07 x 3000 = 210 psi ⇒ USE 200 psi
- POISSON'S RATIO (ν) FOR CONCRETE = 0.15
- STANDARD MODULUS OF SOIL REACTION (K) = 500 pci FOR SUBASE MATERIAL CLASSIFIED AS GW.
- $E_C = 57000\sqrt{3000} = 3{,}122{,}019$ psi

USE:

WESTERGAARD ANALYSIS

CLIENT NAVY (EARLE)	JOB NUMBER 7602
SUBJECT SLAB CALCS. - FUTURE CLUBHOUSE	
BASED ON	DRAWING NUMBER
BY S. RUFFING / CHECKED BY LS 11/4/97	APPROVED BY / DATE

LOADING

AS PER ATTACHMENT 1 DEAD LOAD(DL) = 10 TONS
ASSUME LIVE LOAD = 100 psf
AREA OF TRAILER = 55' x 11'-9" = 646.25 sf ✓
⇒ LIVE LOAD (LL) = 64625 ✓

TOTAL LOAD = LL + DL = 84625 lb ✓

AS SHOWN IN ATTACHMENT 1 THE TRAILER WILL BE SUPPORTED BY BLOCKING AT 12 LOCATIONS

∴ LOAD / LOCATION = 84625 / 12 = 7052 lb/LOCATION
USE 7100 lb ✓

USING WESTERGAARD ANALYSIS ASSUME THE LOAD AT EACH LOCATION IS APPLIED OVER AN AREA OF 16" x 16" = 256 in² OR AN EQUIVALENT RADIUS OF

$\pi r^2 = 256 \text{ in}^2$

$r = 9 \text{ in}$ ✓

DETERMINE MINIMUM SLAB THICKNESS:

CASE 1: CRITICAL LOAD @ SLAB CORNER

$E_c = 3{,}122{,}019 \text{ psi}$

ASSUME $h = 8$ in

DETERMINE RADIUS OF RELATIVE STIFFNESS (l)

$$l = \sqrt[4]{\frac{E_c h^3}{12(1-\nu^2)k}} = \sqrt[4]{\frac{3122019\,(8)^3}{12\,(1-0.15^2)\,500}}$$

$l = 22.85$ in ✓

CLIENT NAVY (EARLE)	JOB NUMBER 7602
SUBJECT SLAB CALCS. – FUTURE CLUBHOUSE	
BASED ON	DRAWING NUMBER
BY S. RUFFING / CHECKED BY LS 11/4/97	APPROVED BY / DATE

MINIMUM THICKNESS:

$$h^2 = \frac{3P}{f_t}\left[1-\left(\frac{a\sqrt{2}}{l}\right)^{0.6}\right]$$

WHERE a = RADIUS OF LOAD CONTACT AREA = 9 in

$f_t = 200$ psi

$$h^2 = \frac{3(7100)}{200}\left[1-\left(\frac{9\sqrt{2}}{22.85}\right)^{0.6}\right]$$

$h^2 = 31.5 \text{ in}^2$ ✓

$h = 5.6$ in ✓

∴ USE 8" THICK SLAB TO ALLOW FOR TRAILER SETUP AND BLOCKING

CASE 2

VERIFY STRESS IN SLAB FOR LOAD APPLIED IN CENTER OF SLAB

$$f_b = 0.316\frac{P}{h^2}\left[\log h^3 - 4\log\left(\sqrt{1.6a^2+h^2} - 0.675h\right) - \log k + 6.48\right]$$

$$= 0.316\frac{(7100)}{8^2}\left[\log 8^3 - 4\log\left(\sqrt{1.6(9^2)+8^2} - 0.675(8)\right) - \log 500 + 6.48\right]$$

$$= 35\left[2.7 - 3.72 - 2.7 + 6.48\right]$$

$= 96.6$ psi < 200 psi ∴ OK ✓

CLIENT NAVY (EARLE)	JOB NUMBER 7602
SUBJECT SLAB CALCS - FUTURE CLUBHOUSE	
BASED ON	DRAWING NUMBER
BY S. RUFFING / CHECKED BY LS 11/4/97	APPROVED BY / DATE

CASE 3

VERIFY STRESS IN SLAB IF LOAD APPLIED ALONG EDGE

$$f_b = 0.572\frac{P}{h^2}\left[\log h^3 - 4\log\left(\sqrt{1.6(a^2)+h^2} - 0.675(h)\right) - \log k + 5.77\right]$$

$$= 0.572\frac{(7100)}{8^2}\left[\log 8^3 - 4\log\left(\sqrt{1.6(9^2)+8^2} - 0.675(8)\right) - \log 500 + 5.77\right]$$

$$= 63.5\left[2.7 - 3.7 - 2.7 + 5.77\right]$$

$f_b = 131.4\text{psi} < 200\text{ psi} \therefore$ OK ✓

REINFORCING STEEL REQ'D:

ONLY NEED STEEL FOR TEMP/SHRINK CONTROL

TENSION DUE TO CONTRACTION (T) $= \frac{W_o \mu l}{2}$

W_o = WT OF SLAB (PSF)
μ = COEFF. OF FRICTION
l = LENGTH BTWN CONTRACTION JOINT
T = TENSILE FORCE

$W_o = 150\text{pcf} \times (.67 \times 1 \times 1) = 100.5\text{ lb/sf}$ ✓
$\mu = 1.5$
$l = 12'$ MAX

$$T = \frac{100.5(1.5)(12)}{2} = 904.5\text{ lb/ft of width}$$ ✓

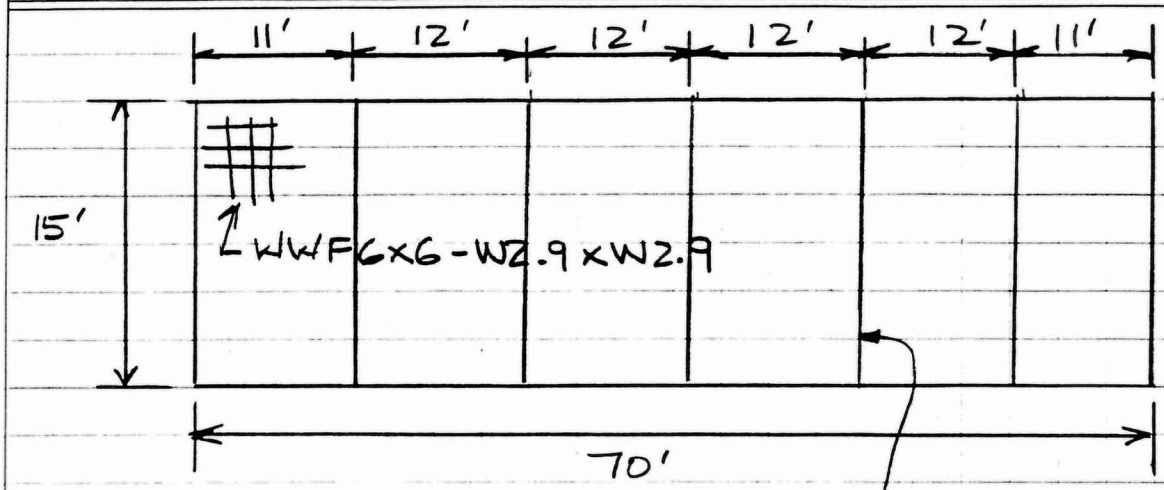
AREA OF STEEL $(A_s) = \frac{T}{f_s}$ WHERE $f_s = 30{,}000$ psi (ALLOWABLE STRESS ≈ ½ YIELD STRESS)

$$A_s = \frac{904.5}{30000} = 0.03\text{ in}^2/\text{ft of width}$$ ✓

$\therefore$ USE WWF 6x6-W2.9xW2.9 w/ $A_s = 0.06\text{ in}^2/\text{ft}$

CALCULATION WORKSHEET Order No. 19116 (01-91)

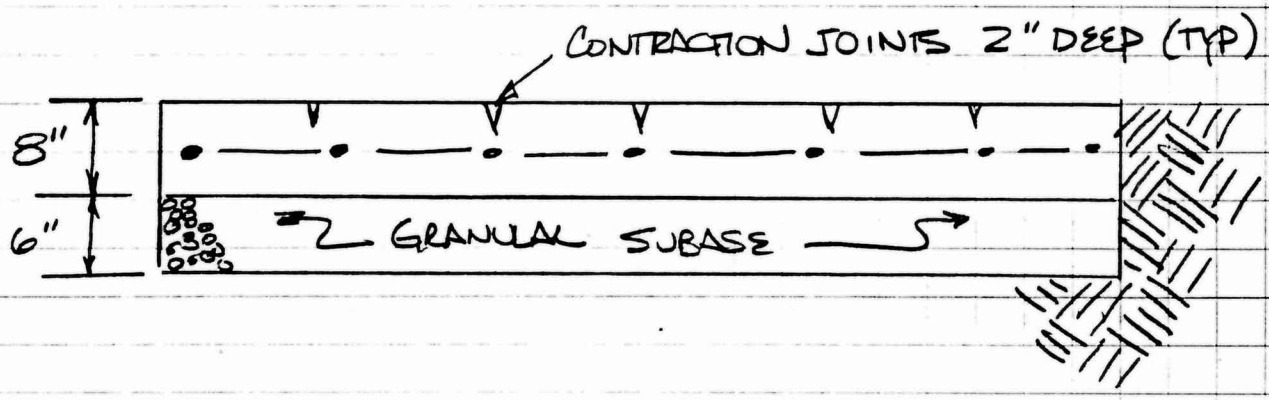
CLIENT NAVY (EARLE)	JOB NUMBER 7602
SUBJECT SLAB CALCS - FUTURE CLUBHOUSE	
BASED ON	DRAWING NUMBER
BY S. RUFFING / CHECKED BY LS 11/4/97	APPROVED BY / DATE



$f_c = 3000$ psi
GRADE 60 STEEL

PLAN

CONTRACTION JOINTS TYP. FOR 5



X-SECTION

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ATTACHMENT 1

To: Mike Weerman From: Michael O'Connell

Fax: 610-491-9645 Date: 10/28/97

Phone: Pages:

Re: CC:

• Urgent • For Review • Please Comment • Please Reply • Please Recycle

•Comments:

Mike

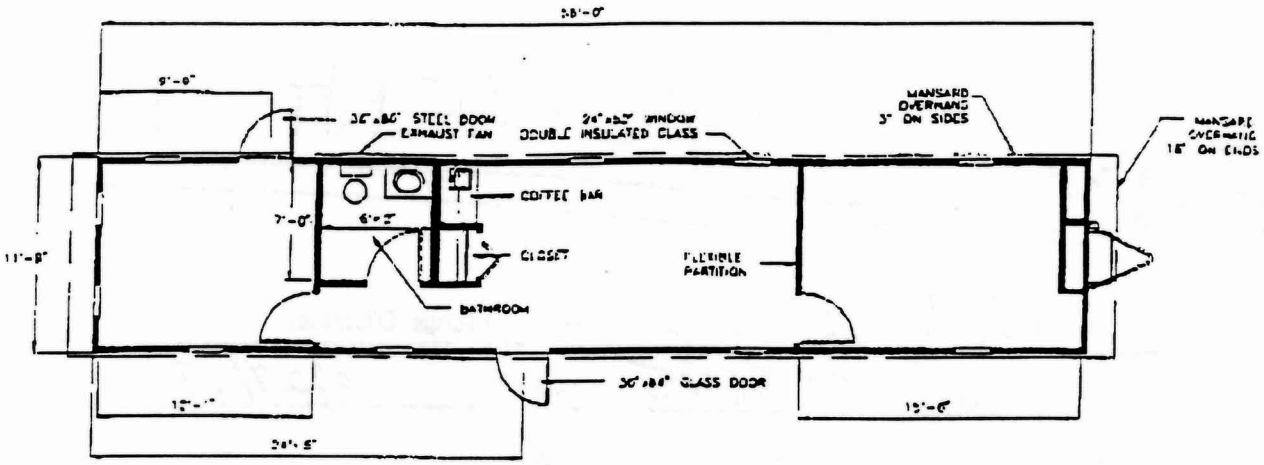
Call me if you have additional questions

Thank You

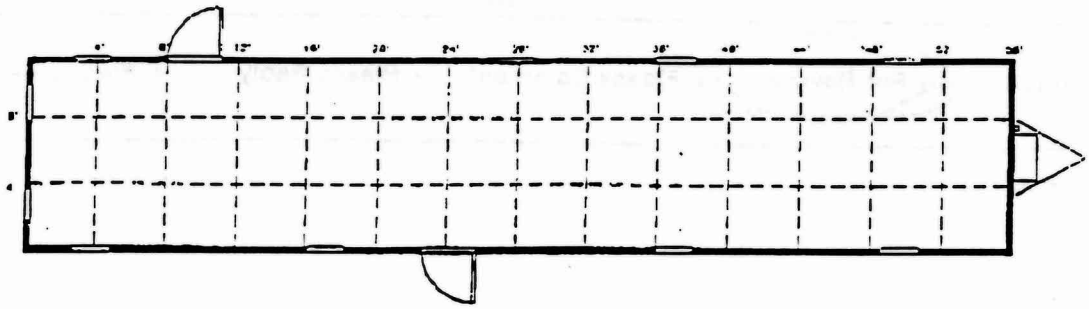
Michael O'Connell

Executive Line

EL6012



FLOOR PLAN



WORKING FLOOR PLAN

STANDARD FEATURES

3 Ton Central HVAC
1" Mini-blinds
Upgraded Insulation
Plywood Sub-floors
Simpson Board Siding
Flexible Front Partition

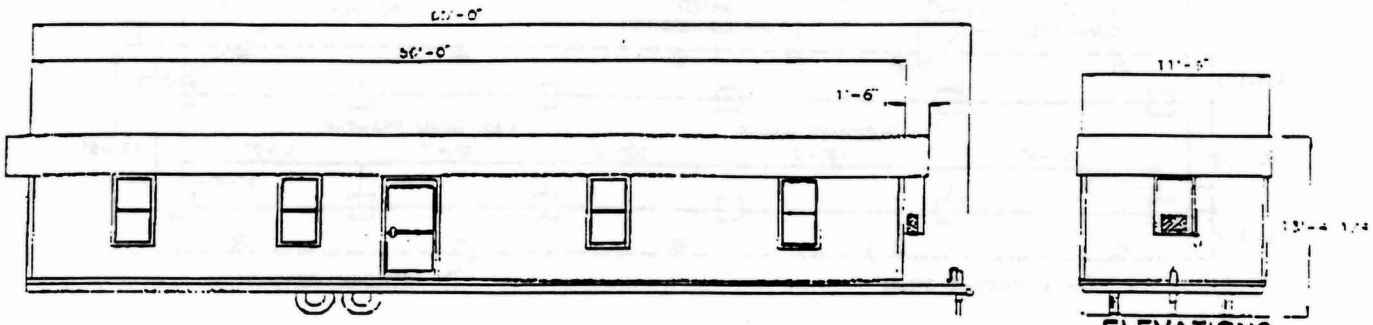
FRAME
12" I-Beam
Triple Axles
Electric Brakes
Asphalt Base Finish

WALLS
5/8" Simpson Board Siding
2x4 Ext. Wall Framing
1/2" Vinyl Covered Sheetrock
3 1/2" R-11 Insulation
Flexible Front Partition

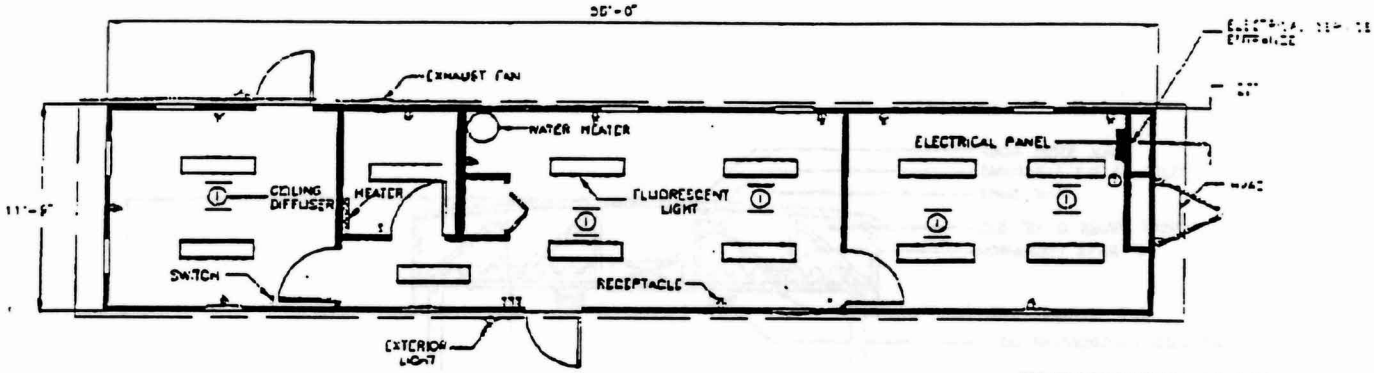
FLOOR
2x6 Joist
6" R-19 Insulation
5/8" Fir Plywood Decking (5 Ply)
Carpet Finish /Tile in
Bath & Entryway

ROOF
Galv. Steel Roofing
3/8" CD Plywood Sheathing
Wood Truss Rafters
6" R-19 Insulation
3/8" Gypsum Ceiling Finish
Mansard Roof Line w/Vent Soffit

EL6012



ELEVATIONS



ELECTRICAL PLAN

PLUMBING
Type L Copper Supply Lines
DWV Lines To Meet
Code Requirements
6 Gallon Electric Water Heater

ELECTRICAL/HVAC
100 Amp 120/240V 1 Phase Service
48" 2-Tube Diffused Fluorescent Lights
3 Ton A/C w/ 10 KW Heat

ENGINEERING DATA
Unit Weight - 10 Tons
Floor to Ceiling Height - 8'-0"
Square Footage- 672
Nominal

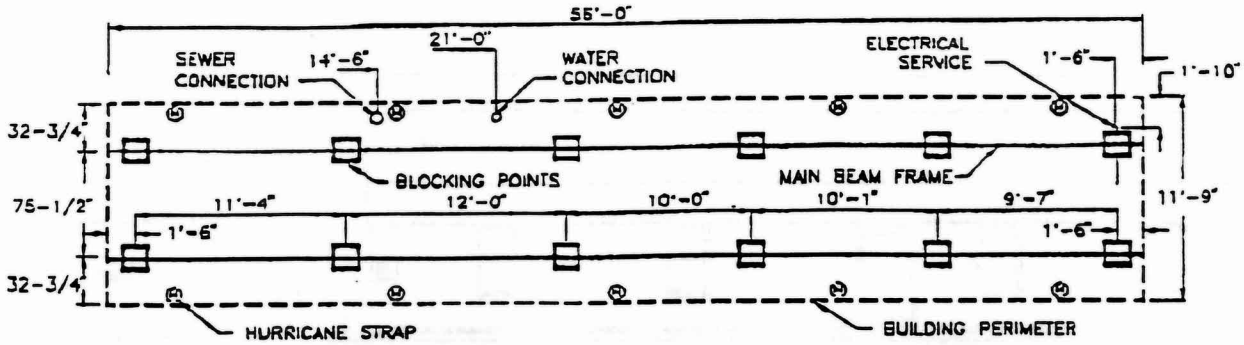
CODES

ANSI ..... ☐ UBC ..... ☐
BOCA ..... ☐ SBC ..... ☐
OTHER .....

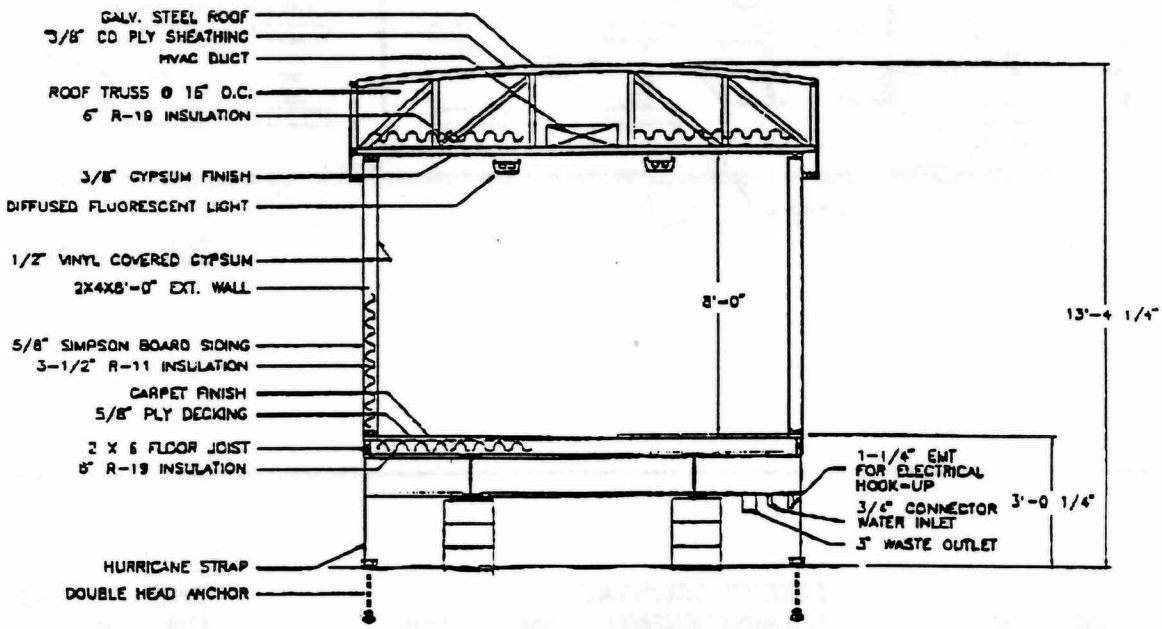
320S 0587- 8

Specifications subject to change without notice.

EL6012



BLOCKING DIAGRAM PLAN



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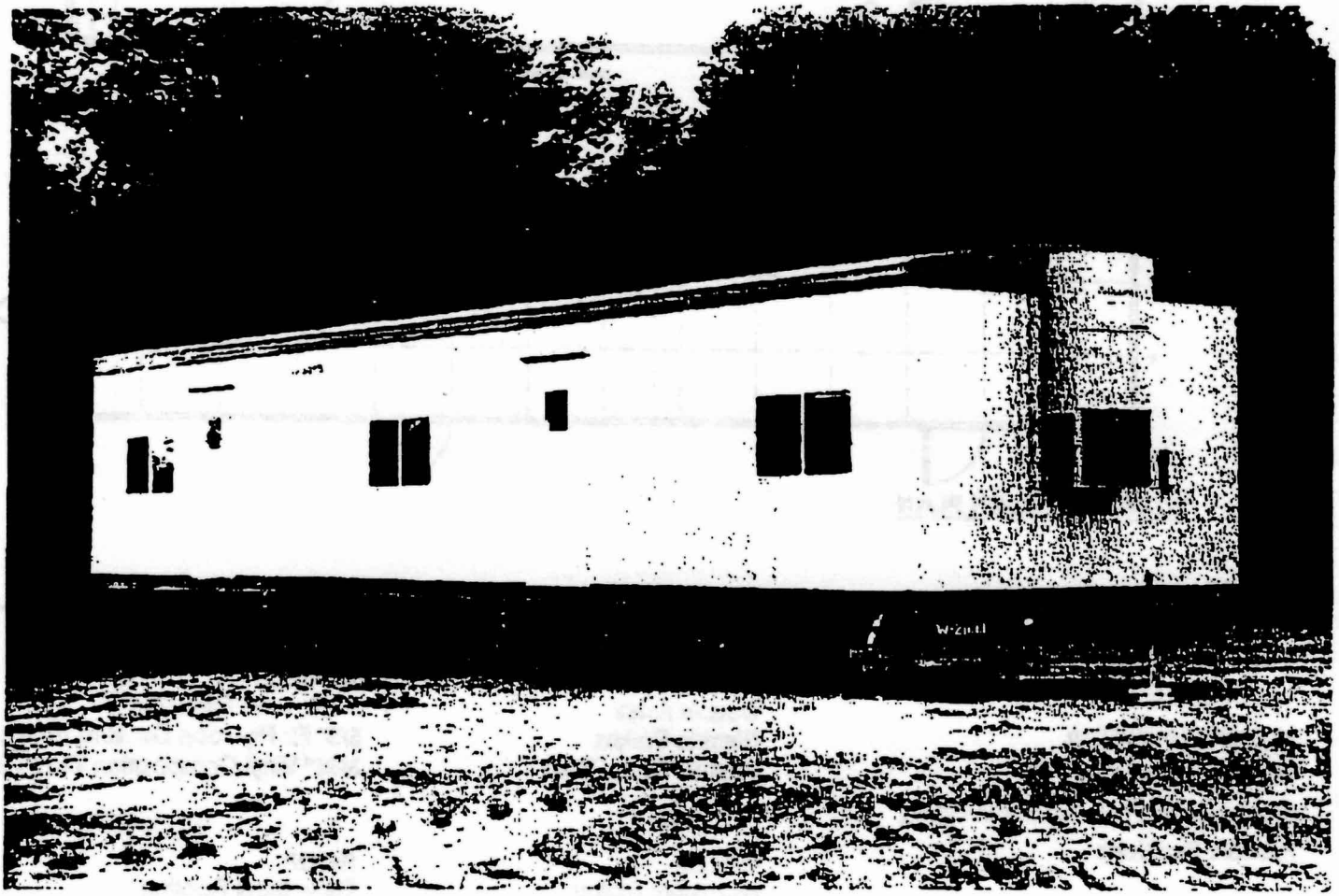

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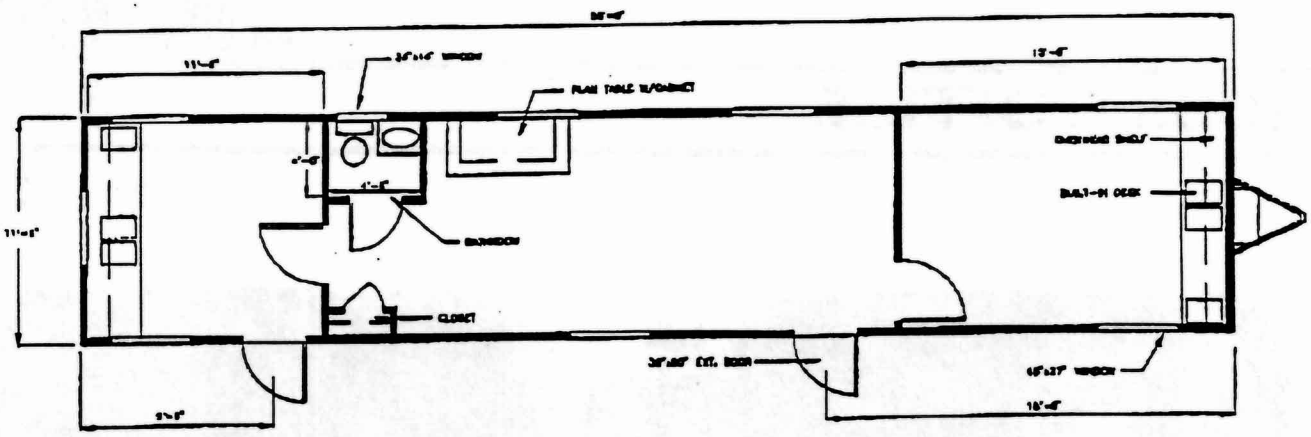
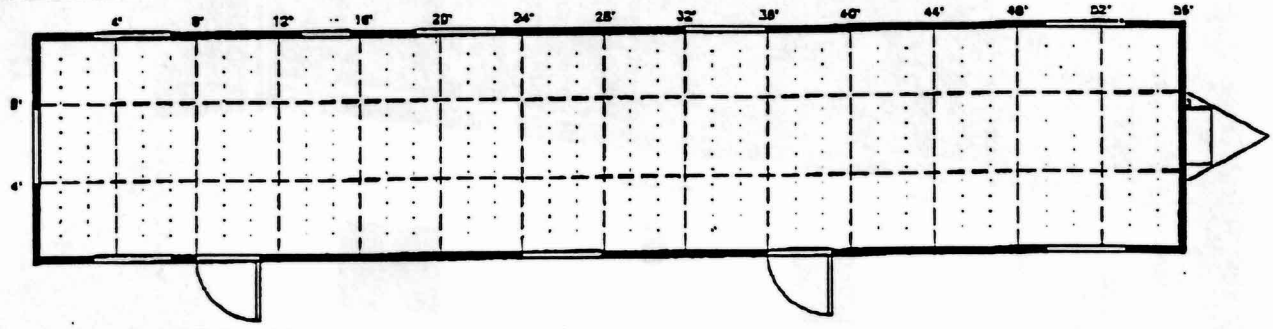


FLOOR PLAN



WORKING FLOOR PLAN

STANDARD FEATURES

3 Ton Central HVAC
1" Mini-blinds
Upgraded Insulation
Plywood Sub-floors
Maintenance Free Aluminum Siding
Flexible Partitions

FRAME
12" I-Beam
Double Axles
Electric Brakes
Asphalt Base Finish

FLOOR
2x6 Joist
3 1/2" R-11 Insulation
5/8" Fir Plywood Decking (5 Ply)
3/32" Vinyl Composition Tile Finish

WALLS
Aluminum Siding
*1/8" Thermo-Bar Sheathing
2x4 Ext. Wall Framing
1/4" Paneling
3 1/2" R-11 Insulation

ROOF
Galv. Steel Roofing
*3/8" CD Plywood Sheathing
Bow Truss Rafters
6" R-19 Insulation
3/8" Gypsum Ceiling Finish

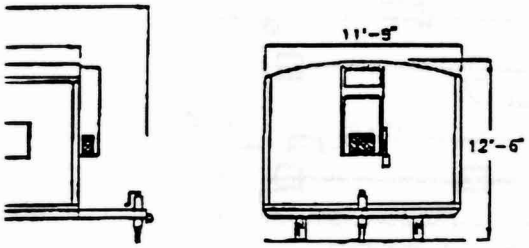
PLUMBING
Type L Copper Supply Lines
DWV Lines To Meet
Code Requirements
6 Gallon Electric Water Heater

ELECTRICAL/HVAC
100 Amp 120/240V 1 Phase Service
48" 2-Tube Fluorescent Lights
3 Ton A/C w/ 10 KW Heat

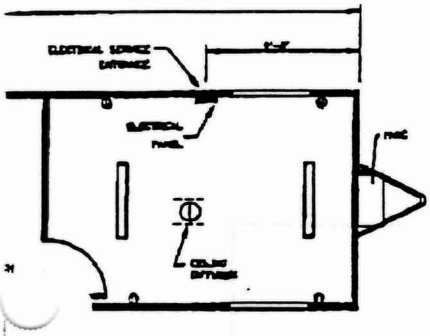
ENGINEERING DATA
Unit Weight - 7 Tons
Floor to Ceiling Height - 8'-0"
Square Footage - 672 Nominal

*Feature standard on BOCA, UBC, & SBC units only.

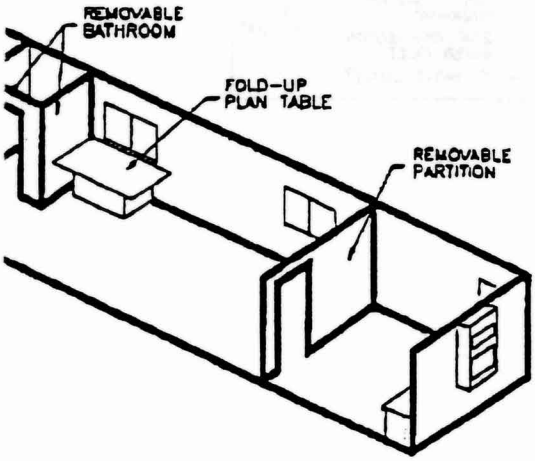
MO6012



ELEVATIONS



ELECTRICAL PLAN



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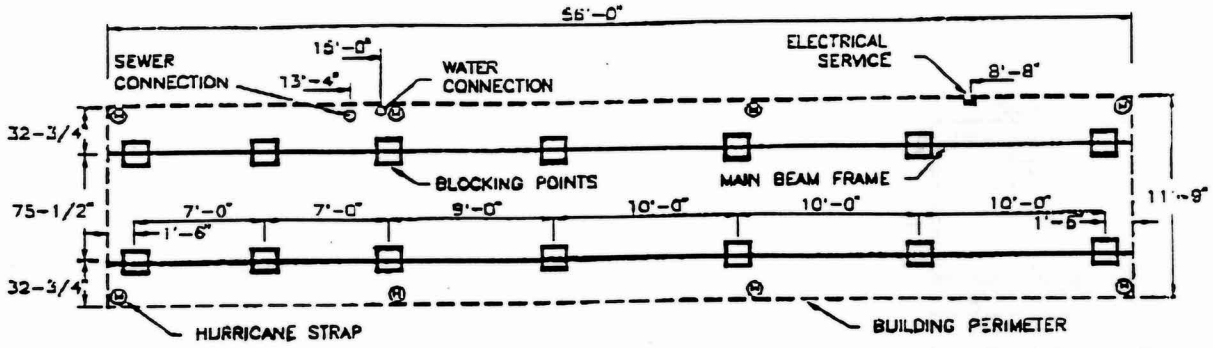
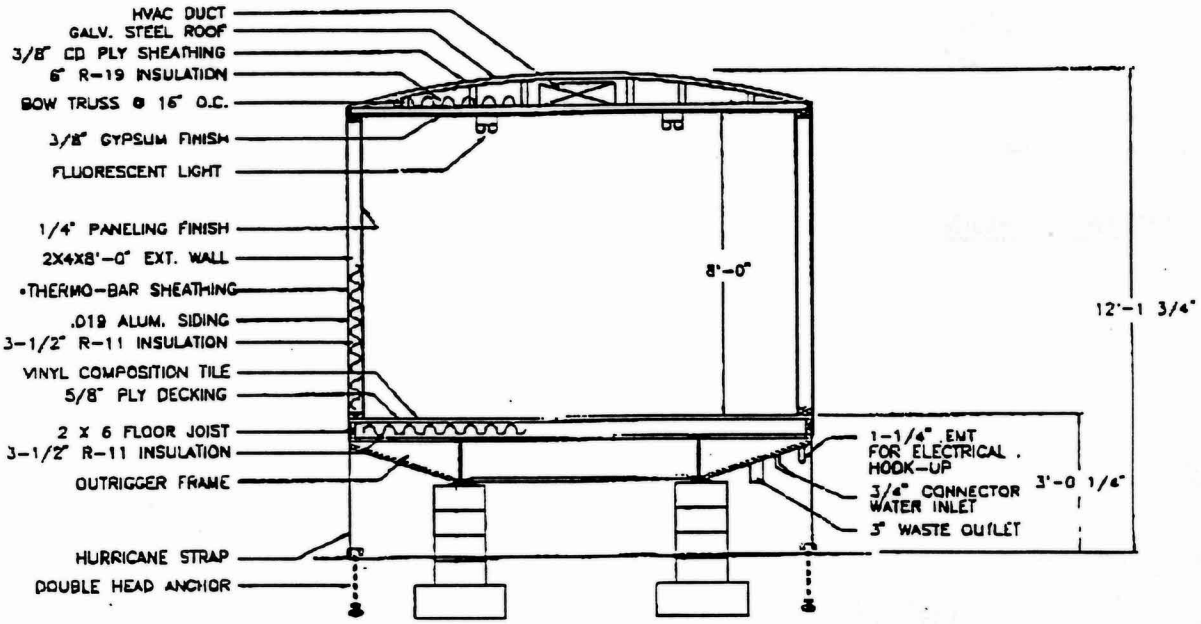


BLOCKING DIAGRAM PLAN



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Environmental Permits Report and Consolidated Compliance Assessment Report

for

Final Design Submission Remedial Action at Operable Unit 1 (Sites 4 and 5)

Naval Weapons Station Earle

Colts Neck, New Jersey

Northern Division

Naval Facilities Engineering Command

Contract Number N62472-90-D-1298

Contract Task Order 0289

November 1997

079716/P

ENVIRONMENTAL PERMITS REPORT AND CONSOLIDATED COMPLIANCE ASSESSMENT REPORT FOR REMEDIAL ACTION AT OPERABLE UNIT 1 (SITES 4 AND 5)

NAVAL WEAPONS STATION EARLE
COLTS NECK, NEW JERSEY

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Northern Division
Environmental Branch Code 18
Naval Facilities Engineering Command
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1.0 INTRODUCTION

This Environmental Permits Report/Consolidated Compliance Assessment Report was prepared under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract No. N62472-90-D-1298, Contract Task Order (CTO) No. 289. Under CTO No. 289, Brown & Root (B&R) Environmental is performing engineering, design, and post-construction award services for remedial action at Operable Unit 1 (OU-1) at Naval Weapons Station (NWS) Earle in Colts Neck, New Jersey.

OU-1 includes Site 4 (the Landfill West of "D" Group) and Site 5 (the Landfill West of Army Barricades). The OU-1 sites were grouped together based on similarities of waste volumes, types of contaminants, and the potential for contaminants to migrate to human and/or environmental receptors. Figure 1-1 provides the location of Sites 4 and 5 at NSW Earle.

1.1 BACKGROUND INFORMATION

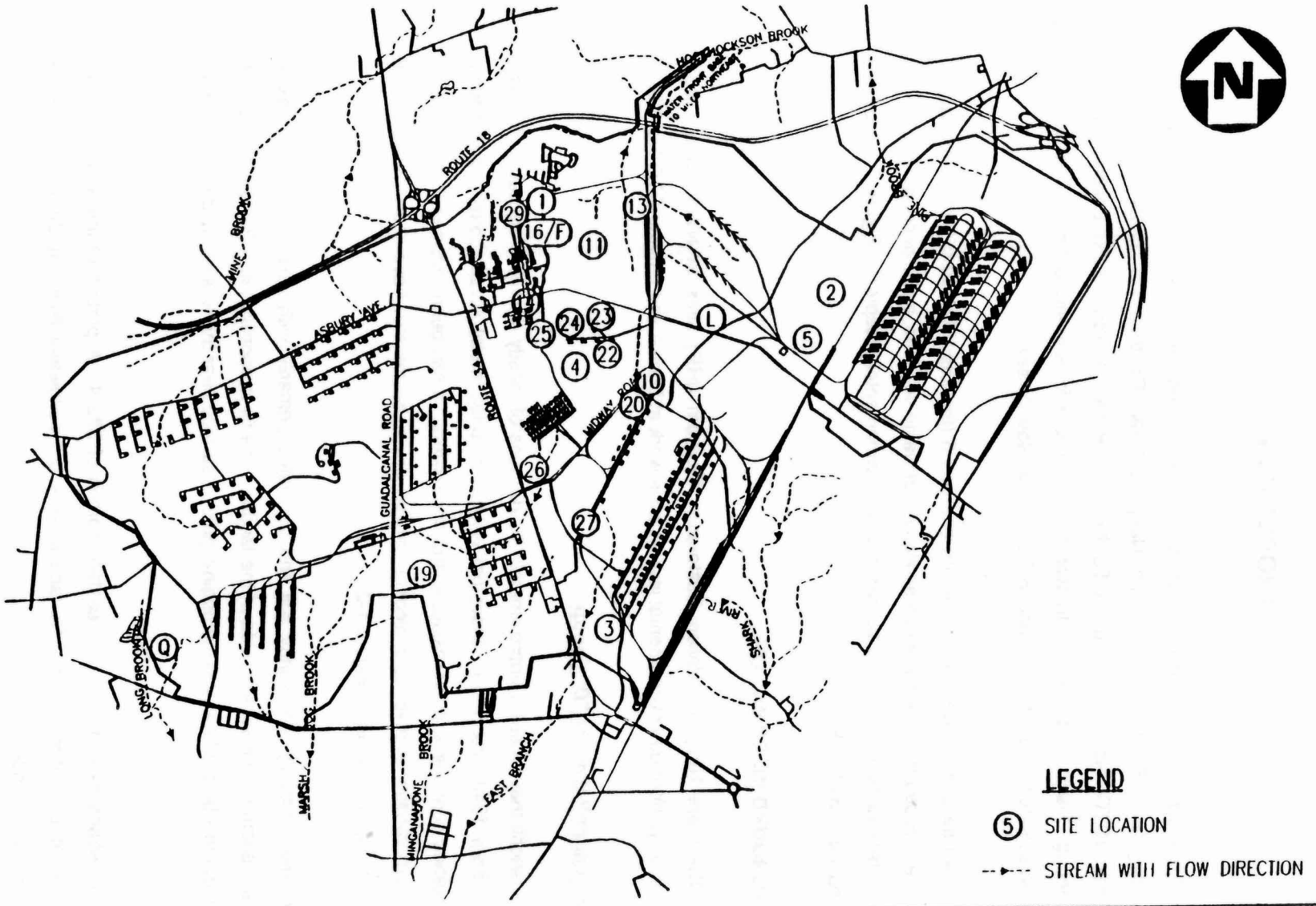
Sites 4 and 5 (OU-1) are Navy Installation Restoration Program (IRP) sites at NWS Earle. B&R Environmental recently performed environmental investigative work at Sites 4 and 5 under CTO No. 231.

1.1.1 Site 4 - Landfill West of "D" Group

Site 4 is a 5-acre landfill that received approximately 10,200 tons of mostly domestic wastes, with some industrial wastes, from 1943 until 1960. Industrial wastes included metal scrap, construction debris, pesticide and herbicide containers, paint residues, and rinsewaters. It has been reported that containers of paint, paint thinner, varnish, shellac, acid, alcohol, caustic, and asbestos may have been disposed of at Site 4. A site layout map is provided in Figure 1-2.

The landfill is covered primarily with sandy soil and vegetated primarily with white pine and grasses. Exposed debris is present on the eastern side of the landfill. The fill is approximately 25 feet high on the southeastern part of the site, but tapers to the original ground surface near the western and northern limits of the landfill.

A broad, low-lying wetland extends from the eastern portion of Site 4. A portion of this wetland exists immediately to the southeast of the landfill. Surface water and groundwater flow is to the east and east-southeast toward these wetlands.



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SCALE IN FEET

DRAWN BY MRM	DATE 1/7/97	Brown & Root Environmental	CONTRACT NO. / OWNER NO.
CHECKED BY RET	DATE 1/7/97	MAINSIDE SITE LOCATIONS NAVAL WEAPONS STATION EARLE COLTS NECK, NEW JERSEY	APPROVED BY / DATE
COST/SCHED.-AREA			APPROVED BY / DATE
SCALE 1"=5000'			DRAWING NO. FIGURE 1-1 / REV

1.2 PURPOSE

This report identifies applicable permits, filing procedures, and filing costs required to complete the remedial actions outlined in Section 2.0. The Comprehensive Environmental Response Compensation and Liability Act (CERCLA) Section 121(e) exempts any response action conducted entirely on site from having to obtain a federal, state, or local permit. Onsite actions need comply only with the substantive aspects of environmental regulations, not with the corresponding administrative requirements, such as permits, reporting, and recordkeeping. For onsite actions, the substantive aspects of permits regulations are also identified. According to 40 CFR 300.400(e), the term "onsite" means the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action. Permits, if required, shall be obtained for all response activities conducted offsite.

2.0 PROPOSED REMEDIAL ACTION

2.1 REMEDIAL ACTION OBJECTIVE

Analytical results for groundwater samples collected during the remedial investigations at Sites 4 and 5 indicated that there were contaminant concentrations that exceeded the established Preliminary Remediation Goals (PRGs). The remedial investigations also concluded that buried wastes in the landfill at each site represent future risks to human and ecological receptors. No impacts to surface water or sediment were identified as a result of waste disposal at each site. The scope of this report is limited to landfilled wastes and groundwater at the site that have been affected by hazardous chemical constituents.

The objective of the proposed remedial action for OU-1 is to contain buried waste beneath low-permeability caps. Potential exposure to groundwater will be mitigated through institutional controls.

2.2 REMEDIAL ACTION DESCRIPTION

The remedial action for OU-1 will consist of general site preparation work, capping the landfills, and restoration of the sites. Institutional controls will be imposed, and the sites will be monitored.

General Site Preparation: The areas in which construction activities will be performed will be cleared and grubbed. In addition, appropriate erosion and sediment control measures will be implemented. Because of the existing topography and drainage patterns at Site 4, a sedimentation basin will need to be constructed near the adjacent wetlands. The site surfaces will be graded to construct a suitable base for the cover systems and allow for proper drainage after the caps have been installed. The skeet shooting range at Site 5 will be removed, and the existing on-lot septic system will be abandoned. The skeet shooting range will be rebuilt once the site is capped, and a wastewater holding tank will be installed to replace the existing on-lot septic system.

Cap Landfills: A low-permeability cap, designed in accordance with New Jersey closure requirements for sanitary landfills, will be installed over the landfills at each site. The purpose of capping is to prevent potential human and animal contact with contaminants in the landfill materials, limit contaminant leaching to groundwater, and minimize contaminant migration via surface runoff and erosion. Some waste may be consolidated at each site or between sites to facilitate cap construction. Portions of the skeet shooting range (concrete rubble and other non-degradable waste) will be disposed of under the cap.

During cap installation at Site 5, existing wells within the work area will be affected. Several wells within the cap boundaries will need to be modified from "stick ups" to "flush mount." One monitoring well (MW5-04) will need to be abandoned to allow installation of a sedimentation basin.

Institutional Controls: Institutional controls will consist of maintaining records of the contamination at Sites 4 and 5 in the NWS Earle Master Plan and Navy real estate records, limiting future uses of the sites that may result in disturbance of the soil cover or direct contact with contaminated media, and prohibiting use of untreated contaminated groundwater. Long-term periodic monitoring of groundwater, surface water, and wetland sediment will be conducted to assess the migration of contaminants and to determine the need for future actions. Because site groundwater does not meet New Jersey groundwater quality standards, a classification exception area (CEA) will be established to provide notice that the constituent standards will not be met for a specified duration and to ensure that use of groundwater in the affected areas is suspended until standards are achieved.

Offsite Disposal: Portions of the skeet shooting range at Site 5 will be removed and transported offsite to a nonhazardous waste landfill.

3.0 REQUIRED PERMITS

Table 3-1 presents a project permit checklist to assess what (if any) permits may be required for specific projects to assure regulatory compliance. This table lists the type of permit, license, or certification that may be required by government agencies for specific types of projects. Based on a review of the permit checklist in Table 3-1, transporters of solid waste to an offsite landfill must have an approved registration statement. No other permits are required by government agencies for remedial actions at OU-1, since onsite remedial actions at CERCLA sites are exempt from obtaining permits or compliance with administrative requirements of federal, state, or local environmental laws and regulations. However, onsite remedial actions must comply with the substantive requirements. The substantive requirements are summarized below and described in Section 4.0.

3.1 FEDERAL PERMITS AND REQUIREMENTS

No U.S. Environmental Protection Agency (EPA) requirements apply to this project.

No Army Corps of Engineers (COE) permits or requirements apply to this project. Army COE regulations relating to construction activities that affect wetlands and open waters have been assumed by the State of New Jersey.

3.2 STATE PERMITS AND REQUIREMENTS

A limited amount of solid waste from the skeet shooting range (demolition debris) at Site 5 will be transported offsite. The transporter must have an approved registration statement from the New Jersey Department of Environmental Protection (NJDEP). There are no other NJDEP permits required for this project. Onsite remedial actions at CERCLA sites are exempt from permits and other administrative requirements; however, substantive requirements must be met. Requirements for stormwater discharges associated with construction activities, construction of a sedimentation basin near wetlands adjacent to Site 4, closure of the solid waste landfills, abandonment of the Site 5 on-lot septic system, modification or abandonment of existing monitoring wells, and construction of the wastewater holding tank to replace the on-lot septic system at Site 5 must be met. In addition, classification exemption areas must be established where groundwater contaminant concentrations exceed state standards. Requirements for earth moving operations (i.e., erosion and sediment control) have been delegated to the Freehold Soil Conservation District.

TABLE 3-1

PROJECT PERMIT CHECKLIST
OPERABLE UNIT 1 (SITES 4 AND 5), NWS EARLE
COLTS NECK, NEW JERSEY
PAGE 1 OF 3

Type of Project	Type of Permit, License, Certification	Issuing Agency	Applicability	Reason
Stationary Air Emission Source	Permit-to-Construct/Modify Source Permit-to-Operate	State	Not Applicable	Discharge of air emissions will not occur.
Construction in Floodplain, Waterway, or Wetlands	Dredge/Fill Permit Freshwater Wetland Permit Stream Encroachment Permit	COE State State	Applicable	Sedimentation basin at Site 4 will be constructed near adjacent wetlands. Permit not required; substantive requirements discussed in Section 4.1.
Wastewater Discharge to "Waters of the U.S."	Permit-to-Discharge (NJPDES)	State	Not Applicable	No discharge of wastewater will occur.
Wastewater Discharge to Sewer	Sewer-Use-Permit (if to municipal POTW)	State or Local	Not Applicable	No discharge of wastewater will occur.
Wastewater Facility	Treatment Works Approval	State	Applicable	Wastewater holding tank will be installed at Site 5. Permit not required; substantive requirements discussed in Section 4.2.
Septic Tank System	Permit to Construct/Alter/ Repair	State and Local	Applicable	On-lot septic system at Site 5 will be abandoned. Permit not required; substantive requirements discussed in Section 4.2.
Potable Water Treatment	Permit-to-Operate	State	Not Applicable	Water is not being treated for potable use.
Underground Injection for Waste Disposal	Discharge to Groundwater	State	Not Applicable	Underground injection will not be performed.
Ocean Dumping	Permit-to-Dump	EPA	Not Applicable	Ocean dumping will not be performed.
Dredging	Dredge/Fill Permit Ocean Disposal Permit State Water Quality Cert.	COE COE State	Not Applicable	Dredging will not be performed.

TABLE 3-1

PROJECT PERMIT CHECKLIST
OPERABLE UNIT 1 (SITES 4 AND 5), NWS EARLE
COLTS NECK, NEW JERSEY
PAGE 2 OF 3

Type of Project	Type of Permit, License, Certification	Issuing Agency	Applicability	Reason
Structure in Navigable Water	Section 10 Permit	COE	Not Applicable	Structures will not be built in navigable water.
Stormwater Discharge to "Waters of the U.S."	Permit-to-Construct/Modify Source Permit-to-Discharge	State	Applicable	Stormwater runoff during construction activities will be controlled and discharged. Permit not required; substantive requirements discussed in Section 4.3.
Earth Moving Operations	Permit-to-Construct Erosion and Sediment Control Plan	State or Local	Applicable	Earth moving will occur during cap construction. Permit or Erosion and Sediment Control Plan not required; substantive requirements discussed in Section 4.4.
Fill Wetlands	Dredge/Fill Permit Freshwater Wetlands Permit	COE State	Applicable	Sedimentation basin at Site 4 will be constructed near adjacent wetlands. Permit not required; substantive requirements discussed in Section 4.1.
Solid Waste Landfills/Dumps	Permit-to-Operate	State	Applicable	Solid waste landfills will be closed. No permit required; closure requirements discussed in Section 4.5.
Solid Waste Transporting	Approved Registration Statement	State	Applicable	Offsite shipment of solid waste will occur (see Section 4.6).

TABLE 3-1

PROJECT PERMIT CHECKLIST
OPERABLE UNIT 1 (SITES 4 AND 5), NWS EARLE
COLTS NECK, NEW JERSEY
PAGE 3 OF 3

Type of Project	Type of Permit, License, Certification	Issuing Agency	Applicability	Reason
Hazardous Waste Generation	EPA Identification Number	State	Not Applicable	Hazardous wastes will not be generated.
Hazardous Waste Transporting	State Waste Hauler License/Permit	State	Not Applicable	Hazardous waste will not be hauled off site.
Hazardous Waste Treatment, Storage, Disposal	Permit-to-Construct Permit-to-Operate (Part B Permit)	State	Not Applicable	Hazardous waste will not be treated, stored, or disposed.
Underground Storage Tanks	Permit-to-Construct Permit-to-Operate Registration	State or EPA	Not Applicable	No underground storage tanks exist within this project.
Pesticide Application	Applicator Certification	DOD	Not Applicable	Pesticides will not be used.
Groundwater Remediation (Active or Passive)	Classification Exception Area	State	Applicable	Groundwater contaminant concentrations exceed state standards (see Section 4.7).
Modification at Monitoring Wells	New Jersey Well Drilling Certification	State	Applicable	All modifications to an existing well must be performed by a New Jersey Certified well driller.
Abandonment of Monitoring Wells	Well Abandonment Form Completed by a New Jersey Certified Driller	State	Applicable	One well will be abandoned.

3.3 LOCAL PERMITS AND REQUIREMENTS

The Freehold Soil Conservation District is responsible for the implementation of New Jersey erosion and sedimentation control requirements. An Erosion and Sedimentation Plan will not be required because onsite remedial actions at CERCLA sites are exempt from permits and other administrative requirements. However, the substantive aspects of these requirements must be met. Because preparation of an Erosion and Sediment Control Plan is included in the Scope of Work for this CTO, the plan will be prepared according to the Standards for Soil Erosion and Sediment Control in New Jersey.

Although not shown on Table 3-1, NWS Earle has construction contractor requirements that must be followed. Many of these requirements are contained in an information package supplied by NWS Earle (see Section 4.8).

4.0 PERMIT APPLICATIONS AND COMPLIANCE

No permits are required for OU-1 remedial activities. Onsite remedial actions at CERCLA sites are exempt from obtaining permits and other administrative requirements. However, compliance with substantive requirements is needed. An Erosion and Sedimentation Control Plan is part of the scope of work for this project. Compliance with substantive requirements and certification of the Erosion and Sedimentation Control Plan as well as other aspects of the proposed remedial activities are discussed in the following sections.

4.1 CONSTRUCTION IN FLOODPLAIN, WATERWAY, OR WETLAND; FILL WETLANDS

4.1.1 Freshwater Wetlands

A storm water retention basin of approximately 0.4 acres is proposed to be constructed adjacent to the freshwater wetland area south of Site 4. The installed landfill cap is likely to encroach on these wetlands. Waste materials in one area adjacent to these wetlands will be excavated and removed, providing additional area for wetlands restoration. In addition, stormwater may be discharged to wetlands from both sites. Under Section 404 of the Clean Water Act, EPA and the Army Corps of Engineers have authority to control the discharge of fill into lakes, ponds, rivers, and streams and their associated wetlands. The EPA has formally turned administration of the federal wetlands program over to the NJDEP.

NJDEP Freshwater Wetlands Regulations (NJAC 7:7A) are applicable to the "dumping, discharging, or filling with any materials" in a freshwater wetland. The wetlands adjacent to Sites 4 and 5 meet the classification of a freshwater wetland of intermediate resource value. NJDEP has a general permit program (NJAC 7:7A-9) that authorizes activities on a statewide basis. The following Statewide General Permits and related substantive requirements are relevant to this project.

Statewide General Permit 4 authorizes regulated activities, including work, discharges, and the construction or placement of structures, which are undertaken, authorized, or otherwise expressly approved in writing by NJDEP for the investigation, cleanup, or removal of hazardous substances. Mitigation shall be performed according to the procedures for mitigation at NJAC 7:7A-14 for all disturbance or destruction of freshwater wetlands caused by cleanup. Mitigation must be performed prior to or concurrently with activities that will permanently disturb wetlands and immediately after activities that will temporarily disturb wetlands. Mitigation may include restoration, creation, enhancement, or donation of money and/or land to the Mitigation Bank, or to other public or private non-profit conservation organizations. These mitigation measures are described below:

- Restoration refers to actions performed in the site of a regulated activity, within six months of the regulated activity, in order to reverse or remedy the effects of the activity on the wetland and to restore the site to pre-activity condition. Restoration is required at a ratio of one acre restored to one acre lost, modified, or disturbed. If more than six months has elapsed, creation will be required.

- Creation refers to actions performed to establish freshwater wetland characteristics, habitat, and functions on upland areas. Creation is required at a ratio of two acres created to one acre lost or disturbed.

- Enhancement refers to actions performed to improve the characteristics, habitat, and functions of an existing, degraded wetland such that the enhanced wetland will have resource values and functions similar to an undisturbed wetland.

- Contribution refers to the donation of money or land to the Mitigation Bank or to other public or private non-profit conservation organizations as approved by the Mitigation Council and the NJDEP in consultation with USEPA. Donations shall only be considered if other forms of mitigation are not feasible on site or off site in the same watershed.

Statewide General Permit 6 covers regulated activities (work, discharges, construction or placement of structures, placement of fill) in freshwater wetlands, provided the activity would not result in the loss or substantial modification of more than one acre of wetland.

Statewide General Permit 11 covers construction of stormwater outfall structures and associated stormwater conveyance structures such as pipes, headwalls, rip-rap, and other energy dissipation structures. The following conditions must be met:

- The structures must be designed to minimize the area of freshwater wetlands disturbed. The limit of disturbance or modification cannot exceed 20 feet in width.

- The total area of freshwater wetlands disturbed or modified cannot exceed 0.25 acre.

- The facility must be designed in accordance with the Standards for Soil Erosion and Sediment Control in New Jersey.

- All stormwater that is discharged into a freshwater wetland from an outfall constructed under this general permit must first be filtered or otherwise treated outside of the wetland to minimize sediment, pollutants, and any other detrimental effects. Detention basins, contour terraces, and grasses swales are examples of pre-discharge treatment techniques. This Statewide General Permit does not authorize placement of detention facilities in freshwater wetlands.

- The total amount of rip-rap or other material used for energy dissipation at the end of a headwall placed in the wetland cannot exceed 10 cubic yards.

- Excavated areas for the placement of conveyance pipes shall be returned to the pre-existing elevation using the original topsoil to backfill from a depth of 18 inches to the original grade and revegetated with indigenous wetland species.

- Pipes used for stormwater conveyance through the wetlands shall be properly sealed with anti-seep collars at a spacing sufficient to prevent drainage of the surrounding wetlands and designed not to exceed the pre-existing elevation.

- If a detention basin is proposed as the method of pretreatment of water quality, routing calculations shall show that the basin has been designed for the one-year storm event according to the Stormwater Management Regulations (NJAC 7:8).

- If a swale is proposed to convey stormwater through the wetlands, profiles from the outlet to the receiving water body, cross sections, and design support information shall show that the proposed swale will not result in drainage of wetlands. Swales can only be used if onsite conditions prohibit the construction of a buried pipe to convey stormwater to the outfall.

Standards and Conditions for all Statewide General Permit Authorizations (NJAC 7:7A-9.3) list other substantive requirements. The following requirements would apply to this project:

- Any discharge of dredged or fill material shall consist of suitable materials free from toxic pollutants (Section 307 of the Clean Water Act) in toxic amounts.

- Any structure or fill shall be maintained as specified in the construction plans.

- During construction activities, all excavation must be monitored to check for the presence of acid-producing deposits pursuant to NJAC 7:13-5.10 of the New Jersey Flood Hazard Area Control Rules.

If any such deposits are encountered, the mitigation and disposal standards described in NJAC 7:13-5.10 must be implemented.

- Best management practices shall be followed whenever applicable.

The activity shall not result in any direct or indirect adverse impacts to Swamp Pink (Helonias bullata) or its documented habitat, as contained in NJAC 7:7A-9.5(a)(2)(iii). The municipality of Colts Neck Township in Monmouth County has a documented record of Helonias bullata.

4.1.2 Transition Areas

There are also requirements for transition areas (NJAC 7:7A-6 and 7:7-A7), which are defined as an ecological transition zone from uplands to freshwater wetlands. The standard width of a transition area adjacent to a freshwater wetland area of intermediate resource value is 50 feet. The following activities are prohibited in transition areas:

- Removal, excavation, or disturbance of the soil.
- Dumping or filling or any material.
- Erection of structures.
- Placement of pavements.
- Destruction of plant life that would alter the existing pattern of vegetation.

The following activities may be conducted (i.e., are not prohibited) in transition areas, provided that the activities are performed in a manner that minimizes adverse effects to the transition area and adjacent freshwater wetlands:

- Normal property maintenance.

- Minor and temporary disturbance of the transition area resulting from, and necessary for, normal construction activities on land adjacent to the transition area.

- The erection of temporary structures (i.e., sheds or fences which do not have a foundation, or other structures that remain in the transition area for less than six months) covering a combined total of 150 square feet of less.

Authorization of activities under a Statewide General Permit, individual freshwater wetland permit, or mitigation plan automatically include a transition area waiver. The transition area waiver will allow encroachment only in that portion of the transition area bordering on that portion of the wetland in which the authorized activity is to take place. Any additional prohibited activities in the transition area not directly required for the authorized activity would require a separate waiver.

4.2 WASTEWATER FACILITIES; SEPTIC TANK SYSTEMS

During this project, the existing on-lot septic system at Site 5 will be replaced with a wastewater holding tank. Technical requirements for wastewater collection, conveyance, treatment, and discharge of wastewater are contained in the NJPDES regulations. These regulations contain the substantive requirements for wastewater facilities, including holding tanks and sewers (NJAC 7:14A-23). Requirements for septic tank systems are contained in the state standards for individual subsurface sewage disposal systems (NJAC 7:9A).

The following requirements apply to permanent holding tanks (NJAC 7:14A-23.5):

- A high water alarm is required to alert the responsible person that the tank has reached 75 percent of its capacity and to allow sufficient time to take appropriate measures to prevent overflows.

- The tank must have provisions for aeration at a rate of 2 cfm per 1,000 gallons to prevent septic conditions and solids settling.

- Measures shall be taken to protect the tank from vandalism and to safeguard public health and safety.

- Tanks shall be sized to provide a minimum of two days storage.

The following requirements apply to gravity sewers (NJAC 7:14A-23.6):

- Gravity sewers shall be designed to carry at least twice the estimated average projected flow when flowing half full.

- The minimum diameter for sewer extensions is 8 inches; however, smaller diameter sewers can be used for laterals. Sewer lines that are larger than necessary only for the purpose of achieving minimum slope requirements are not permitted. Minimum slope requirements are specified in NJAC 7:14A-23.6. Slopes producing a velocity of greater than 10 feet per second are not recommended.

- Sewer lines shall be constructed at least 3 feet below grade, as measured from the top of the pipe.

- Sewers containing sanitary flow shall be separated from water mains by a distance of at least 10 feet horizontally. If this is not possible, the pipes shall be installed in separate trenches with the sewer at least 18 inches below the bottom of the water main.

- The maximum infiltration/exfiltration rate shall not exceed 100 gallons per inch diameter per mile per day.

The following are the requirements for abandonment of a septic tank system (NJAC 7:9A-12.8):

- When it is necessary to abandon a system for any reason other than connection to a sanitary sewer line, all wastes must be removed and the septic tank must be removed or filled completely with gravel, stones, or soil.

- When components or residuals are removed from the ground, they shall be properly managed in accordance with state solid waste regulations (NJAC 7:26).

4.3 STORMWATER DISCHARGE TO "WATERS OF THE U.S."

Many stormwater discharges are covered by New Jersey Pollutant Discharge Elimination System (NJPDES) discharge to surface water (DSW) general permit regulations. Regulations applicable to this project include NJAC 7:14-3.9 (General permits) and the requirements contained in statewide general permit NJ0088323, which are contained in the NJPDES regulations (NJAC 7:14).

General Permit NJ0088323 applies to stormwater discharges from construction activities, including clearing, grading, and excavation activities, that disturb 5 or more acres. There are no specific effluent limitations or monitoring requirements; however, no discharges of hazardous substances, as defined in NJAC 7.1E-1.7, are permitted. Land disturbances shall be executed only in accordance with requirements for soil erosion and sediment control.

Stormwater discharge permits would not be required after completion of the construction provided that the landfills are closed in accordance with sanitary landfill regulations (see Section 4.5).

4.4 EARTH MOVING OPERATIONS

Although onsite actions would be exempt from permit and other administrative requirements, the scope of work for this project includes preparation of a Soil Erosion and Sediment Control Plan. Substantive requirements are contained in Standards for Soil Erosion and Sediment Control in New Jersey and include vegetative standards and structural standards. The purpose of these standards is to help those responsible for construction to control soil movement.

Vegetative standards are available for temporary and permanent soil stabilization, topsoil, maintaining vegetation, selection of vegetation, and tree protection.

Structural standards are available for grading, diversion, grassed waterways, sedimentation basins, slope protection structures, channel stabilization, detention basins, subsurface drainage, traffic control, dust control, lined waterways, riprap, sediment barriers, conduit outlet protection, stabilized construction entrances, storm sewer inlet protection, and grade stabilization structures.

Appendices contained in the standards include guidance, specifications, and examples.

4.5 SANITARY LANDFILL CLOSURE REQUIREMENTS

The landfills at Sites 4 and 5 were used for disposal of domestic waste, small amounts of industrial waste, construction debris, and demolition debris. Sanitary landfill engineering design standards and construction requirements (NJAC 7:26-2A.7) are in the New Jersey solid waste regulations. These regulations contain substantive requirements for surface drainage systems and final cover systems.

Surface drainage systems act to hydraulically isolate the landfill from surface water drainage in a controlled manner. The surface drainage system shall be designed and constructed to protect the sanitary landfill from run-on and control run-off, from, at a minimum, the peak discharge of a 24-hour, 25-year storm. Run-on/run-off structures shall be designed utilizing the U.S. Department of Agriculture, Soil Conservation Service, methods and in accordance with the Standards for Soil Erosion and Sedimentation Control (NJAC 2:90).

The final cover system shall be designed and constructed in accordance with the following:

- The permeability of the final cover shall be less than or equal to that of natural subsoils present or 1E-5 cm/sec, whichever is less. The depth of the final cover shall be a minimum of 18 inches with a minimum 6-inch erosion layer.

- The minimum thickness for a clay cap shall be 12 inches. The minimum thickness for a geomembrane cap shall be 30 mils (60 mils for HDPE).

- Geomembranes used as a cap shall be designed and constructed to withstand the calculated tensile forces acting on the geosynthetic materials. The design shall consider the maximum friction angle of the geomembrane with regard to any interface and shall ensure that the overall slope stability and erosion control of the final cover system are maintained.

- The geomembrane shall be protected from below and above by a minimum thickness of six inches of bedding and cover that is no coarser that a poorly graded sand (SP) and that is free of rocks, fractured stones, debris, cobbles, and solid waste. An equivalent geotextile may be utilized.

- The impermeable cap shall be located wholly below the average depth of frost penetration in the area. The average frost depth at the Earle facility is approximately 15 inches.

A drainage layer shall be designed and constructed according to the following:

- The material used in the drainage layer shall be an open graded material of clean aggregate. The material shall be in accordance with the following criteria of the cumulative grain-size distribution curves:

  $D_{85} > 4D_{15}$ and $D_2 > 0.1$ inch.

- The drainage layer shall be designed and constructed so that the discharge flows freely in the lateral direction to minimize the hydrostatic head on the cap, flows through the drainage layer, and provides a path for infiltrated liquids to exit the capping system.

- The drainage layer shall have a thickness and hydraulic conductivity capable of transmitting the estimated percolation, based on modeling of the system. The latest version of the HELP model shall be used to facilitate rapid estimations of surface run-off, subsurface drainage, and leachate generation quantities.

- When located above a clay cap, the drainage shall be a minimum of six inches thick. When located above a geomembrane cap, the drainage layer shall be a minimum of 12 inches thick.

- Drainage pipes and/or geonets, where necessary to control the hydrostatic head on the cap, should be located within the drainage layers. The drainage pipe should be installed at a distance sufficient to ensure that the hydrostatic head on the cap does not exceed the thickness of the drainage layer during a 25-year, 24-hour storm. A coarse gravel envelope, within a geotextile fabric, shall be installed around the drainage pipe to minimize the movement of soil particles in the drainage pipe.

- A soil filter or geotextile should be designed and constructed above the open aggregate in order to minimize the intrusion of fines into the drainage layer.

The vegetative layer shall be designed and constructed in accordance with the following:

- The vegetative layer shall be thick enough to contain the effective root depth or irrigation depth for the type of vegetation planted.

- Fertilizer, mulch, and seeding applications shall be performed in accordance with Standards for Soil Erosion and Sedimentation Control for permanent vegetative cover for soil stabilization.

- The minimum thickness of uncompacted topsoil in the upper layer of the vegetative layer shall be five inches. The topsoil shall meet the Topsoil Standard specified in Section 909.10 of the New Jersey Department of Transportation Standard Specifications for Road and Bridge Construction.

- The application of sludge or of Sludge Derived Product (SDP) to the final grades of the vegetative layer shall be performed in accordance with NJAC 7:14A.

The grades of the final slope shall be constructed in accordance with the following:

- The top slope final grades, after allowing for settlement and subsidence, shall be, at a minimum, three percent.

- The side slopes of the final grades shall be no steeper than three horizontal to one vertical (3:1)

A gas venting layer shall be designed and constructed in accordance with the following:

- The gas venting layer shall be located directly below the impermeable barrier.

- Passive gas venting systems may be designed and constructed initially as a preventive measure against sanitary landfill gas migration. Situations where gas migration is detected in amounts greater that 25 percent of the lower explosive limit of combustible landfill gas at the perimeter of the sanitary landfill property shall trigger the construction of an induced draft or active venting system.

In addition to the cover system standards listed above, the sanitary landfill regulations also contain requirements for design testing of materials and quality control testing.

4.6 SOLID WASTE TRANSPORT REQUIREMENTS

During this project, some components of the skeet shooting range at Site 5 will be removed and disposed of off site as a nonhazardous waste. Transportation requirements are contained in the New Jersey solid waste management regulations (NJAC 7:26-3). No person shall engage in the transportation of solid wastes without first obtaining an approved registration statement from NJDEP. Although NWS Earle will not transport the waste, it should insure that the waste transporter(s) meet all applicable requirements.

4.7 REQUIREMENTS FOR CLASSIFICATION EXCEPTION AREAS

Chemical concentrations in groundwater at Sites 4 and 5 exceed state groundwater quality standards. Whenever NJDEP approves a groundwater pollution remedy at a contaminated site under an applicable regulatory program (e.g., CERCLA), a CEA must be established if groundwater standards are not or will not be met during implementation of an approved remedy (active or passive). Requirements for a CEA are contained in the state regulations for groundwater quality (NJAC 7:9-6.6). Formal designation of the CEA is pursuant to the authority of an appropriate oversight document. Although the NJDEP Case Manager, with assistance from support staff, upon request by the lead program, will formally designate an area of non-compliance as a CEA, the information needed to develop the CEA should be provided by the responsible party.

A CEA consists of the following:

- Written and mapped description of the area in which constituent standards are not or will not be met. This includes the latitude and longitude of the affected property. Roads, streams, natural and manmade borders, and the plume extent should be shown on a USGS 7.5 minute quadrangle map.

- Identification of the contaminants for which the CEA has been established. The CEA only applies to contaminants that exceed groundwater standards and the formations (or aquifers) in which they are exceeded.

- Estimate of the longevity of the CEA. CEAs are related to the estimated time for completion of a remediation. If natural attenuation is proposed, the responsible party must provide an estimate of the time to achieve the groundwater standards. CEAs will remain in effect for the projected term of the cleanup.

- Additional information such as present and projected future property and surrounding land use and the presence or absence of receptors.

NJDEP is obligated to restrict or require the restriction of potable groundwater uses within any CEA when there is or will be an exceedance of Primary Drinking Water Standards (NJAC 7:10). When contaminant levels exceed MCLs and the designated aquifer classification includes potable use, NJDEP will identify the CEA as a Well Restriction Area (WRA). The WRA functions as the institutional control by which potable use restriction can be effected.

The state Remedial Lead will provide internal NJDEP notification of CEA designations. NJDEP requires the person responsible for conducting the remediation to notify the external agencies and affected parties of these designations. The degree of public notice required will depend upon current and projected groundwater use in a given area.

4.8 WELL INSTALLATION/MODIFICATION/ABANDONMENT

Several existing monitoring wells, which are located within the boundaries of the landfill cap at Site 5, will need to be modified. Existing monitoring wells located within the cap will be changed from the existing "stickup" configuration to a "flush mount" configuration. The length of the outer and inner casings will need changed to conform to the new grade elevations. Existing monitoring well MW5-04, located outside the cap boundary, will need to be abandoned to allow for installation of a sedimentation pond.

The State of New Jersey requires that installation, modification, and abandonment of monitoring wells be performed by a New Jersey licensed well driller. If a well is to be abandoned, a well abandonment form must be filed with the State of New Jersey.

4.9 NWS EARLE CONSTRUCTION CONTRACTOR REQUIREMENTS

NWS Earle has a information package containing multiple handouts obtained through the Officer in Charge, NAVFAC Contracts. The handouts cover the following topics:

- Agenda for Preconstruction Conference
- Security Department Agenda
- Contractor Passes and Vehicle Passes
- Fire Prevention Regulations and Safety Requirements for Contractors
- Sample Accident Prevention Plan Format
- Hard Hat and Protective Clothing Policy
- Clothing Requirements
- Contractor Weekly Safety Meeting Form
- Schedule of Prices Form
- Contractor Drawing and Information Submittal Form
- After Hours Request Form
- Statement of Acknowledgment Form
- Statement of Compliance Form
- Contractor Quality Control Requirements
- Quality Control Report Form
- Contractor Invoice Form with Certification
- Contractor Performance Statement Form
- Contractor Release Forms
- Equal Opportunity and Notice to All Employees Posters

5.0 COMPLIANCE SUMMARY

5.1 CONSTRUCTION IN FLOODPLAIN, WATERWAY, OR WETLAND; FILL WETLANDS

Any wetland areas that are disturbed by the remedial actions at Sites 4 and 5 will be mitigated by restoration and/or creation in accordance with the substantive requirements of Statewide General Permit 4 for freshwater wetlands. Stormwater outfall structures and associated stormwater conveyance structures that may disturb wetlands have been designed in accordance with the substantive requirements of Statewide General Permit 11. The design also complies with Standards and Conditions for all General Permit Authorizations (NJAC 7:7A-9.3).

5.2 WASTEWATER FACILITIES; SEPTIC TANK SYSTEMS

The gravity sewer system and holding tank that will replace the existing on-lot septic system at Site 5 have been designed in accordance with the requirements for gravity sewers (NJAC 7:14A-23.6) and permanent holding tanks (NJAC 7:14A-23.5), respectively. The existing on-lot septic system will be abandoned in accordance with the requirements of NJAC 7:9A-12.8).

5.3 STORMWATER DISCHARGES TO "WATERS OF THE U.S."

Stormwater discharges from the construction activities at Sites 4 and 5 will be in compliance with NJPDES General Permit NJ0088323. Land disturbance will be conducted in accordance with the requirements for soil erosion and sediment control, as required by this general permit (see Section 5.4).

5.4 EARTH MOVING OPERATIONS

Earth moving operations at Sites 4 and 5 will be conducted in accordance with a Soil Erosion and Sediment Control Plan. The design of the erosion and sediment control structures and vegetation requirements is in accordance with Standards for Soil Erosion and Sediment Control in New Jersey.

5.5 SANITARY LANDFILL CLOSURE REQUIREMENTS

The cap systems for the landfills at Sites 4 and 5 have been designed in accordance with sanitary landfill engineering design standards and construction requirements (NJAC 7:26-2A.7). This includes standards and requirements for surface drainage systems, final cover systems, drainage layers, vegetation layers, slopes of final grades, and gas venting layers.

5.6 SOLID WASTE TRANSPORT REQUIREMENTS

Solid waste transport requirements are not specifically addressed in the Remedial Design. However, the subcontractor that transports solid waste from Site 5 to the offsite landfill will be required to comply with New Jersey solid waste transportation requirements (NJAC 7:26-3), including registration requirements. This will be specified in subcontractor procurement documents.

5.7 REQUIREMENTS FOR CLASSIFICATION EXCEPTION AREAS

Requirements for classification exception areas (CEAs) are not specifically addressed in the Remedial Design. However, the following information needed to develop CEAs at Sites 4 and 5 will be supplied to NJDEP: written and mapped description of areas, contaminants of concern, estimate of time to achieve groundwater standards, and present and projected future property and land use.

5.8 REQUIREMENTS FOR WELL INSTALLATION /MODIFICATION/ABANDONMENT

Modification and abandonment of existing monitoring wells will be performed by a New Jersey licensed well driller. A well abandonment form will be filed with the State of New Jersey after monitoring well MW5-04 is abandoned.

5.8 NWS EARLE CONSTRUCTION CONTRACTOR REQUIREMENTS

Specific requirements for construction contractors are not addressed in the Remedial Design. However, remedial action subcontractors must comply with all NWS Earle requirements for construction contractors. This will be specified in subcontractor procurement documents.