

BP CHEMICALS, INC.  
MIXED WASTE POND CLOSURE PROJECT

FIELD CHANGE REQUEST FORM


Field Change Number: 003 Date: 9/27/96

Subject: Anchor Trench Design

Description: Revise Anchor Trench Design and Backfill Plan

Justification: Constructability problems of original design. Placement and compaction of 1 - foot thick clay layers between synthetic layer on vertical plane of Anchor Trench is not practical.

Attachments: Dames & Moore ECN# BUF-003 and Calc.# BUF-96-107

Requested by:  <sup>FDR</sup> New England Liner Systems, Inc. 9/20/96  
Signature Company Date

BPCI Project Approvals

Dames & Moore Robert R. Blukewich NOT Yes No 9/27/96  
Certifying Engineer Signature Approval Date

BPCI Radiation NOT APPLICABLE Yes No ✓  
Safety Officer Signature Approval Date

BPCI HSE NOT APPLICABLE Yes No ✓  
Manager Signature Approval Date

BPCI Project W. H. H. H. Yes No 11/1/96  
Manager Signature Approval Date

Regulatory Agency Concurrence

Ohio EPA Yes No  
Concurrence Signature Concur Date

NRC Yes No  
Concurrence Signature Concur Date

# Engineering Change Notice



**DAMES & MOORE**

A DAMES & MOORE GROUP COMPANY

3065 Southwestern Boulevard  
Suite 202  
Orchard Park, NY 14127  
716 675 7130 Tel  
716 675 7137 Fax

Job No: **22007-011-120** ECN No: **BUF-003** Date: **September 25, 1996**

	Drawing Number	Rev. No	Date	Detail
Affected Drawings:	DM-006-101-96 Sh 19	1	3/14/96	1

	Section	Date	Section	Date
Affected Specifications:				

**Description of changes (attach additional sheets, drawings and sketches as required):**

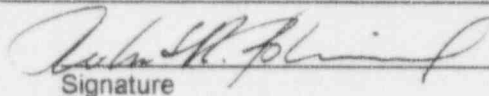
Change liner material to textured HDPE on slope portion of section. Revise anchor trench per attached sketch.

**Reason for change (attach additional sheets if required):**

Textured HDPE selected for all work in consideration of safety. Liner installer proposed alternate anchor trench from the one included in the original design to facilitate construction. As is shown on calculation BUF-96-107 (attached) a revised design can be used in consideration of increased friction coefficient of textured liner material.

**Estimated cost impact of change: none (Attach estimate details)**

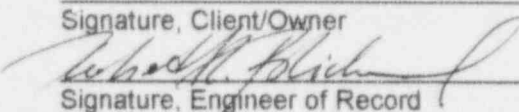
**Change initiated by:**

  
Signature

9/25/96  
Date

**Change approved by:**

Signature, Client/Owner

  
Signature, Engineer of Record

Date

9/25/96  
Date

**DRAFTING ROOM ACTION:**

Incorporate change: ☒ Immediately ☐ Next Drawing Revision ☐ As Built

**Documents Revised by:**

Signature, Drafter

Date

**Revisions approved by:**

Engineer of Record

Signature

Date

**Attachments:** Sketch of proposed new anchor trench design  
Calculation BUF-96-107

# Calculation



**DAMES & MOORE**

A DAMES & MOORE GROUP COMPANY

3065 Southwestern Boulevard  
Suite 202  
Orchard Park, NY 14127  
716 675 7130 Tel  
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Job No: **22007-011-120 / 6055**

Calculation No: **BUF-96-107**

Date: **September 25, 1996**

Subject: Revised Anchor Trench Design

Purpose: Check the strength of the proposed textured HDPE geomembrane and re-design anchor trench in consideration of improved friction characteristics and design configuration proposed by liner installer.

## Index:

<u>Topic</u>	<u>Sheet</u>
Liner Strength	2
Geonet & Geomembrane Anchorage	5
Geotextile Anchorage	8

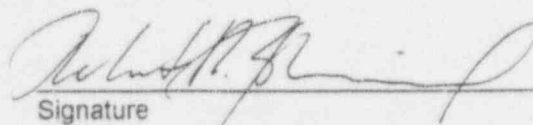
## References:

1. Koerner, R.M., 1990, *Designing with Geosynthetics*, Prentice Hall, Englewood Cliffs, New Jersey.
2. Richardson, G.M. and Koerner, R.M., 1987, "Geosynthetic Design Guidance for Hazardous Waste Landfill Cells and Surface Impoundments, U.S. Environmental Protection Agency, EPA/600/2-87/097.

## Approach:

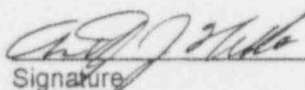
Use design methods outlined in reference 1 and 2 with data from Gundle's manufacturer's cut sheets and frictional properties cited in reference 1.

Prepared by:

  
Signature

9-25-96  
Date

Checked by:

  
Signature

9-26-96  
Date

Job No. 22007-011-120/6050 Job MIXED WASTE POND CLOSURE

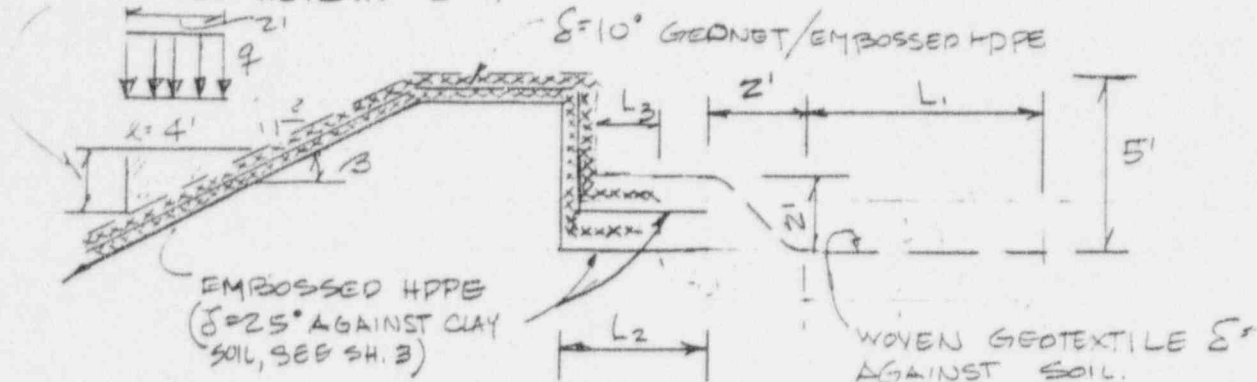
By TTB Date 9/25/96

Client BP CHEMICALS Subject REVISED ANCHOR TRENCH DESIGN

Chk'd. JIN Date 9/26/96

FILL WEIGHTS 120 LB/FT<sup>3</sup> (CONTAM. SOIL)

MAX FILL HEIGHT = 2' = h



$$\beta = \tan^{-1} 0.5 = 26.6^\circ$$

$q$  = WT OF CONSTR. EQ, ASSUME 2' WIDE TRACK w/ FAD PRESS = 1,000 PSF

$$F = \frac{1}{2}(2)(4)(120) + (2)(1000) = 2,480 \text{ LB.}$$

- ASSUME THAT UPPER GEONET AND GEOTEXTILE FUNCTION AS UNIT, BUT THAT LOAD IS CARRIED BY GEOTEXTILE (WOVEN), WHICH HAS HIGHER MODULUS. (ASSUMPTION BASED ON RIDGE FORMATION BY SOIL PRESSING INTO GEONET AND LOCKING ANY SLIPPAGE).
- ASSUME FRICTION OF GEONET TO EMBOSSSED HDPE IS  $\delta = 10^\circ$  (WOVEN SLIT FILM TO HDPE) AND FRICTION OF SAND TO GEOTEXTILE IS  $24^\circ$

$$T = (2480)(\cos 26.6^\circ)(\tan 24^\circ) - (2480)(\cos 26.6^\circ)(\tan 10^\circ) = 600 \text{ LB/FT} \checkmark$$

$$= 50 \text{ LB/IN.} \checkmark$$

STRENGTH OF GEOTEXTILE AT YIELD = 130 LB/IN (SH 4)

$$DR = \frac{130}{50} = 2.6 > 2.0 \text{ OK. ; DESIGN ANCHOR FOR FS = 2.0} \checkmark$$

# CALCULATION SHEET

JOB No: 22007-011-120/6050

CALC. No: BUF-96-107

REV: 0.00 DATE: 9/25/96

ORIG: Z. BLICKWEDEHL

CK: ASN DATE: 2/26/97

SHEET: 3 OF 8

**DAMES & MOORE**

Designing with Geomembranes Chap. 5

VALUES AND EFFICIENCIES (IN PARENTHESES) FOR VARIOUS  
IUS GEOMEMBRANES [9]

	Soil no. 1 ML-CL				Soil no. 2 CL-ML			
	c	E <sub>v</sub> (%)	φ	E <sub>s</sub> (%)	c	E <sub>v</sub> (%)	φ	E <sub>s</sub> (%)
	9.0	100	38	100	12.0	100	34	100
	c <sub>s</sub>	E <sub>v</sub> (%)	δ	E <sub>s</sub> (%)	c <sub>s</sub>	E <sub>v</sub> (%)	δ	E <sub>s</sub> (%)
Geomembrane-to-soil								
PVC	8.5	94	39	100	3.7	31	23	69
CPE	8.0	89	40	100	3.2	27	24	71
EPDM	5.0	55	33	87	5.0	42	23	67
HDPE	5.0	88	26	68	2.0	17	23	67
Embossed HDPE	9.0	100	35	92	11.0	92	29	58

Description	Soil no. 3 CL				Soil no. 4 SP-CH			
	c	E <sub>v</sub> (%)	φ	E <sub>s</sub> (%)	c	E <sub>v</sub> (%)	φ	E <sub>s</sub> (%)
Soil-to-soil	20	100	30	100	25	100	24	100
	c <sub>s</sub>	E <sub>v</sub> (%)	δ	E <sub>s</sub> (%)	c <sub>s</sub>	E <sub>v</sub> (%)	δ	E <sub>s</sub> (%)
Geomembrane-to-soil								
PVC	14.0	70	16	53	7.0	28	24	100
CPE	13.0	65	17	57	8.0	32	23	96
EPDM	8.0	40	23	77	7.5	30	20	83
HDPE	14.0	70	15	50	3.0	12	21	88
Embossed HDPE	18.0	90	27	90	15.0	60	26	100

Description	Soil no. 5 CL-SP			
	c	E <sub>v</sub> (%)	φ	E <sub>s</sub> (%)
Soil-to-soil	28	100	22	100
	c <sub>s</sub>	E <sub>v</sub> (%)	δ	E <sub>s</sub> (%)
Geomembrane-to-soil				
PVC	12.0	43	17	77
CPE	10.0	36	19	86
EPDM	9.0	32	18	82
HDPE	14.0	50	15	68
Embossed HDPE	16.0	57	25	100

Note: c and c<sub>s</sub> are in units of kN/m<sup>2</sup>, φ and δ are in degrees.

SOURCE: REF #



# GSE Lining Technology, Inc.

## MINIMUM PROPERTIES FOR STANDARD TEXTURED HDPE GEOMEMBRANES: GSE<sup>TM</sup> FRICTIONFLEX<sup>®</sup>, TEXTURED HYPERFLEX<sup>®</sup> AND GSE<sup>TM</sup> HDT

Property	<sup>1</sup> Test Method	<sup>4</sup> 30	40	60	80	100
minimum thickness [mil]	ASTM D 751,	27	36	54	72	90
average thickness [mil]	D 1593 or D 5199	30	40	60	80	100
Density [g/cc]	ASTM D 792 (B) or D 1505	0.940	0.940	0.940	0.940	0.940
carbon black content [%]	ASTM D 1603	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0
carbon black dispersion	ASTM D 3015	A1, A2, B2	A1, A2, B2	A1, A2, B2	A1, A2, B2	A1, A2, B2
<i>Tensile Properties:</i>						
tensile strength @ yield [ppi]	ASTM D 638 Type IV, 2 ipm NSF 54 modified	65	86	130	173	216
<sup>1</sup> tensile strength @ break [ppi]		(38)	162 (50)	243 (75)	324 (100)	405 (125)
elongation @ yield [%]	(1.3" gauge length)	13	<sup>1</sup> 13	13	13	13
<sup>1</sup> elongation @ break [%]	(2.5" gauge length)	(120)	560 (120)	560 (120)	560 (120)	560 (120)
tear resistance [lb.]	ASTM D 1004	22	30	45	60	75
puncture resistance [lb.]	FTMS 101 Method 2065	39	52	80		
ESCR [hours]	ASTM D 1693, B	1500	1500	1500		
dimensional stability [% change]	ASTM D 1204 (1 hr. @ 100 °C)	± 2	± 2	± 2		

### CALCULATION SHEET

JOB No: 22007-011-120/0050

CALC. No: BUF-96-107

REV: 0.00 DATE: 9/25/96

ORIG: R. BLICKWEDELL

CK: ASN DATE: 7/2/96

SHEET: 4 OF 8

**DAMES & MOORE**

<sup>1</sup> GSE utilizes test equipment and procedures which enable effective and economical confirmation that the product will conform to specifications based on the noted price change without prior notification.

<sup>2</sup> The flat cast line can achieve, when necessary, ± 5% of nominal thickness except for < 60 mil; co-extruded lines can achieve a range of -10% to +15% of nominal thickness.

<sup>3</sup> Values in parenthesis correspond to the MARV (minimum average roll value) for co-extruded textured material.

<sup>4</sup> 30 mil FrictionFlex<sup>®</sup>, textured HyperFlex<sup>®</sup> is a nonstandard product

*For environmental lining solutions...the world comes to GSE<sup>TM</sup>  
A Gundler/SLT Environmental, Inc. Company*

Prepared By:  
Melody A. Adams

Job No. 22007-011-120/6050 Job MIXED WASTE POND CLOSURE

Client BP CHEMICALS Subject REVISED ANCHOR TRENCH DESIGN

DESIGN ANCHOR TRENCH FOR GEONET TO ONLY CARRY WEIGHT OF GEONET. (300' x 14' ROLL WEIGHS 840 LB PER SH 6.)

UNIT WT OF GEONET =  $840 / (300)(14) = 0.20 \text{ LB/FT}^2$   
 SLOPE HT = 30'. ASSUME A PERSON STANDS ON GEONET

$$W = ((30) / \sin 26.6^\circ)(0.2) + 200 = 214 \text{ LB}$$

ASSUME  $\delta = 10^\circ$  - WOVEN SLIT FILM TO HDPE (SH 7)

$$F = 214 \cdot \cos 26.6^\circ \cdot \tan 10^\circ = 33 \text{ LB}$$

$$T = 214 \sin 26.6^\circ - 33 = 63 \text{ LB/FT}$$

DESIGN FOR FS OF 2.0, ASSUME  $\delta = 25^\circ$ , SAME AS TEXTURED HDPE

$$L_3 = \frac{(63)(2.0)}{(3.5)(120) \tan 25^\circ} = 0.64 \quad \underline{\underline{\text{USE } 2'}} \quad \checkmark$$

### GEOMEMBRANE

LOAD PICKED UP BY GEOMEMBRANE IS

$$(2480)(\cos 26.6^\circ)(\tan 10^\circ) = 391 \text{ LB/FT} = 35 \text{ LB/IN.} \quad \checkmark$$

MIN TENSILE BREAK LOAD = 70 LB/IN

$$\text{DES. RATIO} = \frac{70}{35} = 2.0 \quad \text{OK.}$$

ANCHOR TRENCH RUNOUT, FOR FS = 2.0 &  $\delta_{\text{HDPE TEXT}} = 25^\circ$

$$L_2 = \frac{(391)(2)}{(4)(120)(\tan 25^\circ)} = 3.5' \quad \text{SAY } 4' \quad \checkmark$$

# SPECIFICATIONS FOR GUNDNET® XL-14

Gundnet is a high quality formulation of High Density Polyethylene containing approximately 97.5% polymer and 2.5% of carbon black, anti-oxidants and heat stabilizers. The product was designed specifically for exposed conditions. It contains no additives or fillers which can leach out and cause embrittlement over time.

TYPICAL PROPERTIES*	TEST METHOD	GUNDNET XL-14
Roll Length (typical)		225 ft.
Roll Width (typical)		14 ft.
Roll Weight (typical)		840 lbs.
Specific Gravity (g/cm <sup>3</sup> minimum)	ASTM D1505	.94
Melt Flow Index (g/10 minutes) (maximum)	ASTM D1238 Condition E	0.3
Thickness (minimum)	ASTM D374 at Strand Intersection	5.0-6.5 mm 200 mil-265 mil
Percent Carbon Black (minimum)	ASTM D1603	2%
Transmissivity (minimum)	ASTM D4716 10,000 psf compressive load between two layers of Gundline HD; 0.25 Gradient	10 g/min./ft. or $2 \times 10^{-2} \text{ m}^2/\text{sec.}$

\*Note: All values are typical test results, unless stated otherwise.

## ROLL PROPERTIES FOR FABRI-NET®

Roll Length (typical)		100 ft.
Roll Width (typical)		6.5 ft. <sup>1</sup>
Roll Weight (typical)		194 lbs. <sup>2</sup>
Specific Gravity of Net (g/cm <sup>3</sup> ) (minimum)	ASTM D1505	.94
Melt Flow Index of Net (g/10 minutes) (maximum)	ASTM D1238 Condition E	0.3
Thickness of Net (minimum)	ASTM D374 at Strand Intersection	5.0-6.5 mm 200 mil-265 mil
Percent Carbon Black of Net (minimum)	ASTM D1603	
Permeability of Geotextile (cm/second) (typical)	ASTM D4491	
Pty Adhesion (pounds/inch)	ASTM F904 2" x 8" @ 2 ipm	

\*Note: All values are typical test results, unless stated otherwise.

1) Width with geotextile overlap is 7 ft.

2) This is the weight for Fabri-Net double-sided with 6 ounce geotextile only. Bonding geotextile weight value.

Gundnet and Fabri-Net are rolled on 6" I.D. hollow cores. Each Gundnet roll is provided with a sling to aid handling on site. Fabri-Net is wrapped in a protective plastic bag. Dimensions and weights are approximate. Custom lengths available on request.

Gundle Lining Systems Inc



19103 Gundle Road  
Houston, Texas 77073 U.S.A.  
Phone: (713) 443-8564  
Toll Free: (800) 435-2008  
Telex: 166657 GundleHou  
Fax: (713) 875-6010

### CALCULATION SHEET

JOB No: 27007-011-120/6050

CALC. No: BUF-96-107

REV: 0.00 DATE: 9/25/96

ORIG: B. BLICKWEDEHL

CK: ASN DATE: 9/26/96

SHEET: 6 OF 8

**DAMES & MOORE**



# CALCULATION SHEET

JOB No: 22007-011-120/0030

CALC. No: BUF-96-107

REV: 0.00 DATE: 9/25/96

ORIG: R. SLICKWIEDEHL

CK: ASN DATE: 9/21/96

SHEET: 7 OF 8

**DAMES & MOORE**

Designing with Geomembranes Chap. 5

VALUES AND EFFICIENCIES (IN PARENTHESES) FOR (a)  
(b) GEOMEMBRANE-TO-GEOTEXTILE, AND  
COMBINATIONS\*

friction angles

	Soil types		
	Concrete sand ( $\phi = 30^\circ$ )	Ottawa sand ( $\phi = 28^\circ$ )	Mica schist sand ( $\phi = 26^\circ$ )
rough	24° (0.77)	20° (0.68)	24° (0.91)
smooth	27° (0.88)	—	25° (0.96)
CSPE	25° (0.81)	21° (0.72)	21° (0.79)
HDPE	18° (0.56)	18° (0.61)	23° (0.87)

(b) Geomembrane-to-geotextile friction angle

	Geomembrane				
	PVC			CSPE	HDPE
Geotextile	EPDM	Rough	Smooth		
nonwoven, needle-punched	23°	23°	21°	15°	8°
nonwoven, melt-bonded	18°	20°	18°	21°	11°
woven, monofilament	17°	11°	10°	9°	8°
woven, slit film	21°	28°	24°	13°	10°

(c) Soil-to-geotextile friction angle

	Soil types		
Geotextile	Concrete sand ( $\phi = 30^\circ$ )	Ottawa sand ( $\phi = 28^\circ$ )	Mica schist sand ( $\phi = 26^\circ$ )
nonwoven, needle-punched	30° (1.00)	28° (0.92)	25° (0.96)
nonwoven, melt-bonded	26° (0.84)	—	—
woven, monofilament	26° (0.84)	—	—
woven, slit film	24° (0.77)	24° (0.84)	23° (0.87)

Source: After Martin, et al. [8]

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

on smooth geotextiles giving the lowest friction values. For reference purposes, Part c of Table 5.5 gives the soil-to-geotextile friction values that are necessary for slope design of lined slopes with geotextiles under or over the liner.

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

SOURCE: REF 7

Job No. 22007-011-120/6050 Job MIXED WASTE POND CLOSUREClient BP CHEMICALS Subject REVISED ANCHOR TRENCH DESIGNANCHOR TRENCH FOR GEOTEKSTILE

T = 600 LB/FT, DESIGN FOR FS = 2.0

ASSUME FRICTION ANGLE FOR HDPE TO CL SOIL, WHICH  
WILL BE CONSERVATIVE BECAUSE IT NEGLECTS TEXTURE  
OF GEOMEMBRANE.  $\delta = 15^\circ$

$$L = \frac{(600)(2.0) - (3)(120)(4)(\tan 15^\circ)}{(5)(120)(\tan(15))} = 5.1' \quad \underline{\text{SAY } 5'-6} \quad \checkmark$$

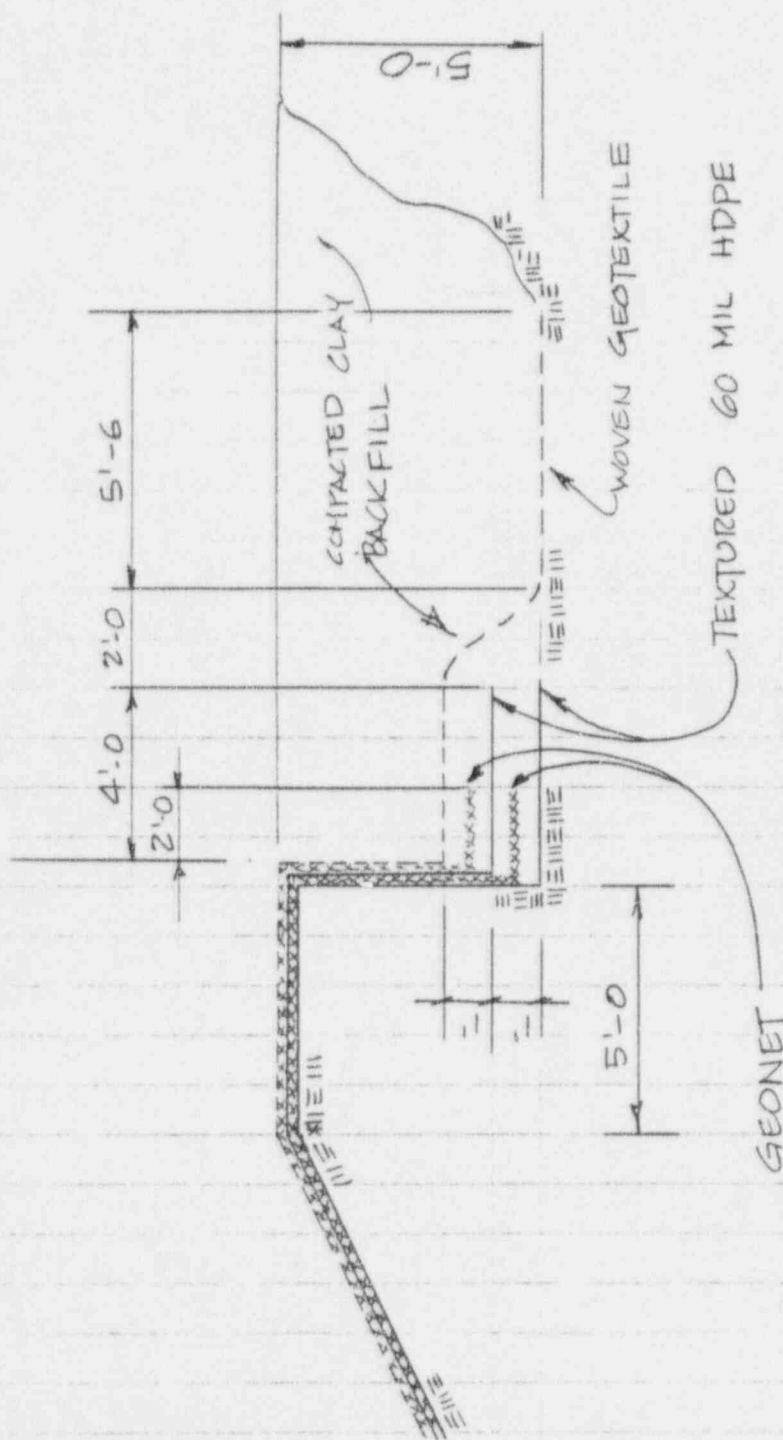


Chk'd.	Date
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Job

Client

Subject



REVISED ANCHOR TRENCH