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00108

Golder Associates
CONSULTING GEOTECHNICAL AND MINING ENGINEERS

TRANSMITTAL LETTER

RECEIVED
APR 13 1987
U.S. EPA, REGION V
WASTE MANAGEMENT DIVISION
HAZARDOUS WASTE ENFORCEMENT BRANCH

To U.S. Environmental Protection Agency
230 South Dearborn Street
Chicago, IL 60604

ATTN: Brad Bradley

Date 4-10-87
Project No. 863-2041

Sent by

- ☐ Mail
- XX Air Freight
- ☐ Hand Carried
- ☐ Under Separate Cover
- XX Enclosed

Quantity	Item	Description
1	UPFREEZ5Y Output a) 2 Feet Effective particle size	Manville Waukegan, Illinois, Upfreezing Cover Thickness Analysis
1	b) 0.1 Feet Effective particle size	
1	Graphical Analysis and Summary (2 sheets)	

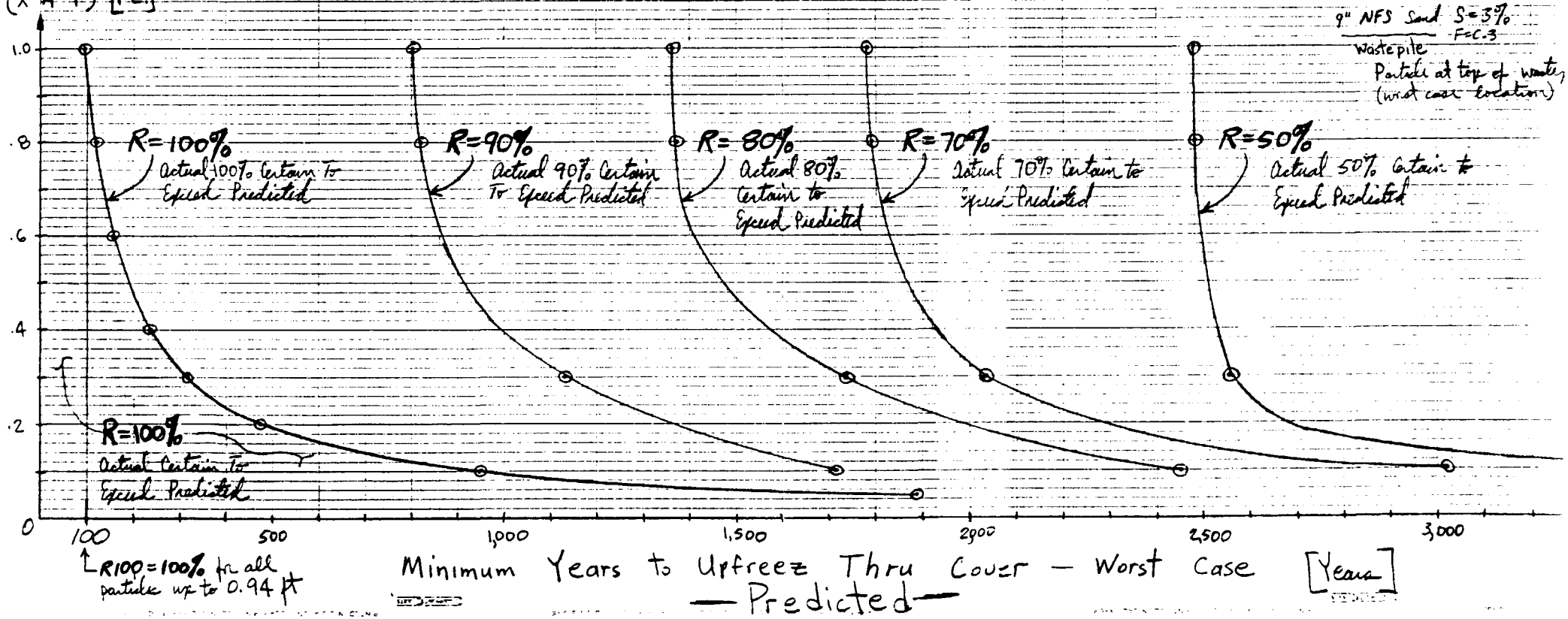
Remarks As discussed 4-8-87 during conference call.

Per C. Vita

CLV 4/9/87

21-inch, Two-Layer Cover: Performance Reliability (R) Vs. Particle Size

Reliability, R = Estimated Probability Predicted Minimum Years For Upfreezing Will Exceed Actual Minimum Years

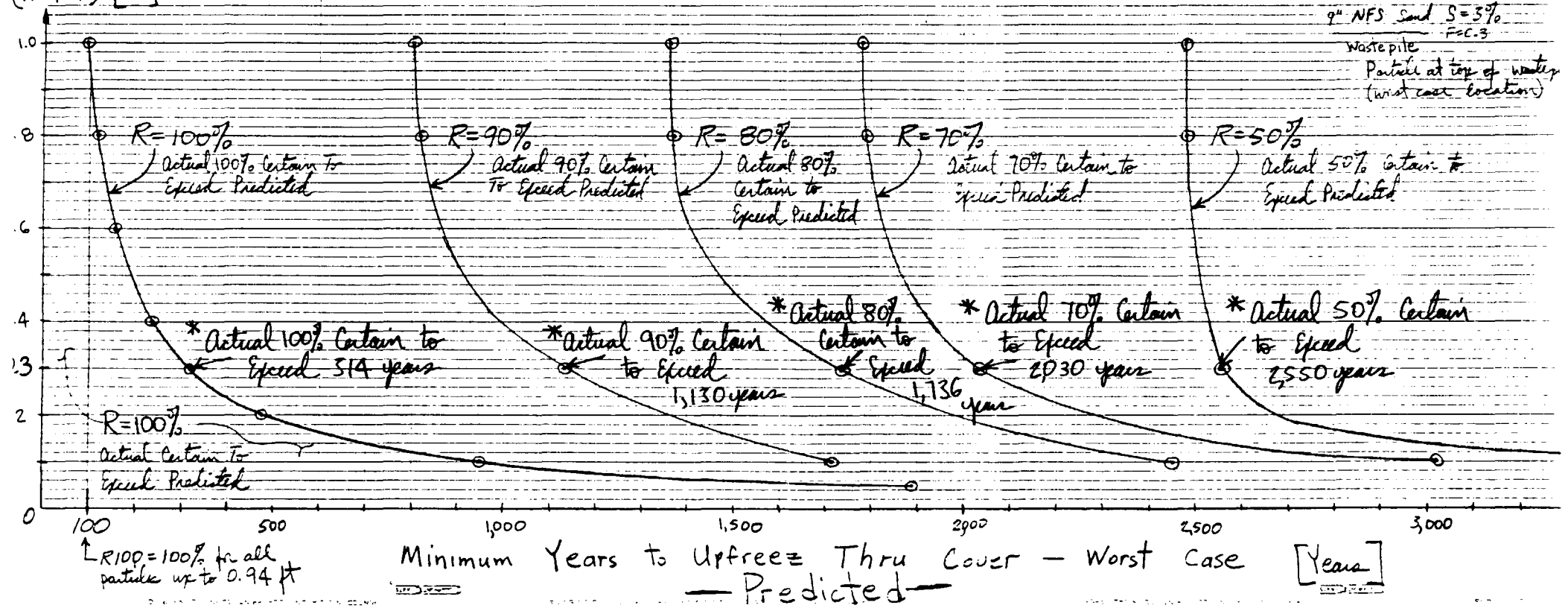


*Example For 0.3 ft. Effective Particle Size - so-called "critical particle size"

CLV 4/9/87

21-inch, Two-Layer Cover: Performance Reliability (R) Vs. Particle Size

Reliability, R = Estimated Probability Predicted Minimum Years For Upfreezing Will Exceed Actual Minimum Years



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**************************** PROGRAM UPFREEZ5Y ****************************
SAVED UNDER FILE NAME: UPF1-5Y                    DATE: 04-08-1987
                                                  TIME: 11:41:56

                PROBABILISTIC GEOTECHNICAL THERMAL ANALYSIS
                   1-LAYER FINE-GRAINED COVER SYSTEM

                MODIFIED BERGGREN EQUATION WITH KERSTEN K'S

                        PROPERTIES OF COVER

COVER LAYER DRY DENSITY=100 PCF,  WATER CONTENT =20.3% (80% SAT)    100% S=25.4%
AVERAGE HEAVE STRAIN = 10% TO 50%
FRACTION OF HEAVE NOT RECOVERED ON THAWING (R) = 0.10 TO 0.50
LAMBDA*SQR[N-FACTOR]: AVG=0.48;  SD=0.00
(COVER AND WASTE PILE USE THE SAME VALUES)


                       PROPERTIES OF WASTE PILE

FINE-GRAINED SOIL
UNFROZEN DRY DENSITY = 100. [PCF], WATER CONTENT = 20% (80% SAT)    100% S=25.4%
AVERAGE HEAVE STRAIN = 10% TO 50%
FRACTION OF HEAVE NOT RECOVERED ON THAWING (R) = 0.10 TO 0.50

                       THERMAL LOAD INFORMATION

FREEZE INDEX (FI) FOR WAUKEKGAN ASSUMED LOGNORMAL WITH MEAN & STANDARD DEVIATION
FROM HISTORICAL DATA 1949-50 TO 1984-85 EXCEPT 1982-83 (TOTAL = 35 YEARS)
LOGNORMAL FREEZE INDEX (THERMAL LOAD): MEAN=848, MEDIAN=800, SD=320, CV=0.378,
         SD[LN FI]=0.365, SKEWNESS=1.277                              HOWEVER:
CONSERVATIVE LOGNORMAL ENVELOPE USED FOR FREEZE INDEX: MEDIAN = 875, MEAN = 935
                                                       SD[LN FI] =0.365
ALL YEARS HAVE HISTORICAL FI FREQUENCY (= FORCASTED (PREDICTED) PROBABILITIES
 (1983-84 [FI=1200] LIES ON THE ENVELOPE ALL OTHER YEARS ARE BELOW)


OBJECT UPFREEZING INFORMATION--EQUATION:   U = (X - A - T) * S * R * C

UPFREEZING ASSUMPTIONS:
• EFFECTIVE PARTICLE SIZE (X - A) IS EPS.UF = 2.00 FT
AVERAGE HEAVE STRAIN (S) = 10 %  TO 50 %
FRACTION OF HEAVE NOT RECOVERED ON THAWING (R) = 0.10 TO 0.50
EFFECTIVE NUMBER OF COMPLETE FREEZE THAW CYCLES (C) = NUMBER OF FREEZE SEASONS
                                                      (YEARS) * P.H3

*NOTE:  BOTH C AND P.H3 ARE DEPTH DEPENDENT
```

Program will search for worst-case particle size up to EP.UF = 2.0 ft
Looking for effect of large "particles"

S=10% F=0.10

THERMAL AND UPFREEZING ANALYSIS ESTIMATES — PROGRAM UPFREEZSY — 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER — PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 2.00 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE—BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] — FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 90 PCF, WATER CONT.= 29.7% C/L=.0085 L=3658 KF=1.15
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL—HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 90 PCF WATER CONT.= 29.7% C/L=.0085 L=3658 KF=1.15

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 10%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.10,
LAMBDA*SQRT[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (1.10 FT ←
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

						COVER THERMAL PROPERTIES IN H3 (R1.3=1)						WST'PILE	
FT	DEG*DAYS		PROB.			——— YEARS ———				PROB.%	YEARS	FT	YEARS
H1	CAVG	CV%	FPAVG	CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	408	14	.976	1.9	1	201	0.3	200	50	100.00	44	.4	44
1.1	493	14	.931	4.9	1	253	1.0	250	55	100.00	59	.3	59
1.2	587	14	.851	9.9	1	323	2.4	315	60	100.00	81	.3	80
1.3	689	14	.737	16.7	1	422	5.2	401	65	100.00	119	.3	118
1.4	799	14	.601	24.6	2	571	9.4	518	70	100.00	179	.2	178
1.5	917	14	.463	32.9	2	802	15.2	680	75	100.00	282	.2	281
1.6	1044	14	.337	41.2	4	1180	22.6	914	80	100.00	474	.2	472
1.7	1178	14	.233	49.0	6	1836	31.0	1267	85	99.99	839	.2	834
1.8	1321	14	.154	56.1	9	3033	39.9	1822	90	99.98	1554	.2	1545
1.9	1472	14	.097	62.3	17	5307	48.6	2728	95	99.99	2995	.2	2977
2.0	1630	14	.059	67.8	31	9786	56.5	4253	100	100.00	5964	.2	5927
2.1	1798	14	.035	72.4	60	18732	63.4	6859	105	100.00	11927	.1	11909
2.2	1973	14	.020	76.4	119	36905	69.1	11385	110	100.00	24420	.1	24380
2.3	2156	14	.011	79.8	244	74700	74.0	19442	115	100.00	51171	.1	51088
2.4	2348	14	.006	82.6	512	154949	78.0	34115	120	100.00	109325	.1	109145
2.5	2548	14	.003	85.0	1093	328284	81.3	61372	125	100.00	237345	.1	236955

S=10% F=0.20

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FI	DEG*DAYS		PROB.		COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE		
					——— YEARS ———					PROB.%	YEARS	FT		YEARS
H1	TCAVG	CV%	FPAVG	CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M		DELTA
1.0	408	14	.976	1.9	1	100	0.3	100	25	95.20	22	.4		22
1.1	493	14	.931	4.9	1	126	1.0	125	28	100.00	29	.3		29
1.2	587	14	.851	9.9	1	161	2.4	157	30	100.00	40	.3		40
1.3	689	14	.737	16.7	1	211	5.2	200	33	100.00	60	.3		59
1.4	799	14	.601	24.6	2	286	9.4	259	35	100.00	89	.2		89
1.5	917	14	.463	32.9	2	401	15.2	340	38	100.00	141	.2		141
1.6	1044	14	.337	41.2	4	590	22.6	457	40	99.99	237	.2		236
1.7	1178	14	.233	49.0	6	918	31.0	633	43	99.90	419	.2		417
1.8	1321	14	.154	56.1	9	1516	39.9	911	45	99.79	777	.2		773
1.9	1472	14	.097	62.3	17	2654	48.6	1364	48	99.78	1497	.2		1488
2.0	1630	14	.059	67.8	31	4893	56.5	2127	50	99.84	2982	.2		2963
2.1	1798	14	.035	72.4	60	9366	63.4	3430	53	99.90	5964	.1		5954
2.2	1973	14	.020	76.4	119	18453	69.1	5693	55	99.95	12210	.1		12190
2.3	2156	14	.011	79.8	244	37350	74.0	9721	58	99.97	25586	.1		25544
2.4	2348	14	.006	82.6	512	77474	78.0	17058	60	99.99	54663	.1		54573
2.5	2548	14	.003	85.0	1093	164142	81.3	30686	62	99.99	118673	.1		118477

S=10% F=0.30

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FT	DEG*DAYS	PROB.			COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE		
					---------- YEARS					PROB.%		YEARS FT		YEARS
H1	TCAVG	&CV%	FPAVG	&CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100		DELTA	H3M	DELTA
1.0	408	14	.976	1.9	1	67	0.3	67	17	0.00		15	.4	15
1.1	493	14	.931	4.9	1	84	1.0	83	18	0.00		20	.3	20
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1.8	1321	14	.154	56.1	9	1011	39.9	607	30	99.55		518	.2	515
1.9	1472	14	.097	62.3	17	1769	48.6	909	32	99.54		998	.2	992
2.0	1630	14	.059	67.8	31	3262	56.5	1418	33	99.67		1988	.2	1976
2.1	1798	14	.035	72.4	60	6244	63.4	2286	35	99.79		3976	.1	3970
2.2	1973	14	.020	76.4	119	12302	69.1	3795	37	99.89		8140	.1	8127
2.3	2156	14	.011	79.8	244	24900	74.0	6481	38	99.94		17057	.1	17029
2.4	2348	14	.006	82.6	512	51650	78.0	11372	40	99.97		36442	.1	36382
2.5	2548	14	.003	85.0	1093	109428	81.3	20457	42	99.99		79115	.1	78985

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							COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE
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H1	TCAVG	CV%	FPAVG	CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100		DELTA	H3M	DELTA
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1.8	1321	14	.154	56.1	9	758	39.9	455	23	99.26		389	.2	386
1.9	1472	14	.097	62.3	17	1327	48.6	682	24	99.29		749	.2	744
2.0	1630	14	.059	67.8	31	2447	56.5	1063	25	99.49		1491	.2	1482
2.1	1798	14	.035	72.4	60	4683	63.4	1715	26	99.69		2982	.1	2977
2.2	1973	14	.020	76.4	119	9226	69.1	2846	28	99.83		6105	.1	6095
2.3	2156	14	.011	79.8	244	18675	74.0	4861	29	99.91		12793	.1	12772
2.4	2348	14	.006	82.6	512	38737	78.0	8529	30	99.95		27331	.1	27286
2.5	2548	14	.003	85.0	1093	82071	81.3	15343	31	99.98		59336	.1	59239

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UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 90 PCF WATER CONT.= 29.7% C/L=.0085 L=3658 KF=1.15

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 10%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.50,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (1.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

					COVER THERMAL PROPERTIES IN H3 (R1.3=1)						WST'PILE	
F	-DEG*DAYS		PROB.			YEARS				PROB.%	YEARS FT	YEARS
H1	TCAVG&CV%		FPAVG&CV%		FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA H3M	DELTA
1.0	408	14	.976	1.9	1	40	0.3	40	10	0.00	9 .4	9
1.1	493	14	.931	4.9	1	51	1.0	50	11	0.00	12 .3	12
1.2	587	14	.851	9.9	1	65	2.4	63	12	0.00	16 .3	16
1.3	689	14	.737	16.7	1	84	5.2	80	13	0.02	24 .3	24
1.4	799	14	.601	24.6	2	114	9.4	104	14	90.81	36 .2	36
1.5	917	14	.463	32.9	2	160	15.2	136	15	99.33	56 .2	56
1.6	1044	14	.337	41.2	4	236	22.6	183	16	99.47	95 .2	94
1.7	1178	14	.233	49.0	6	367	31.0	253	17	99.16	168 .2	167
1.8	1321	14	.154	56.1	9	607	39.9	364	18	98.92	311 .2	309
1.9	1472	14	.097	62.3	17	1061	48.6	546	19	99.03	599 .2	595
2.0	1630	14	.059	67.8	31	1957	56.5	851	20	99.31	1193 .2	1185
2.1	1798	14	.035	72.4	60	3746	63.4	1372	21	99.58	2385 .1	2382
2.2	1973	14	.020	76.4	119	7381	69.1	2277	22	99.76	4884 .1	4876
2.3	2156	14	.011	79.8	244	14940	74.0	3888	23	99.88	10234 .1	10218
2.4	2348	14	.006	82.6	512	30990	78.0	6823	24	99.94	21865 .1	21829
2.5	2548	14	.003	85.0	1093	65657	81.3	12274	25	99.97	47469 .1	47391

S=20% F=0.10

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 2.00 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 80 PCF, WATER CONT.= 37.7% C/L=.0076 L=4124 KF=1.18
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 80 PCF WATER CONT.= 37.7% C/L=.0076 L=4124 KF=1.18

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 20%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.10,
LAMBDA*SQRIN-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.90 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

						COVER THERMAL PROPERTIES IN H3 (R1.3=1)						WST'PILE	
FT	-DEG*DAYS		PROB.			------- YEARS				PROB.%	YEARS FT		YEARS
H1	TCAVG	CV%	FPAVG	CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	533	14	.901	6.8	1	140	1.5	138	25	100.00	39	.3	38
1.1	645	14	.789	13.6	1	189	3.9	181	28	100.00	58	.2	58
1.2	767	14	.640	22.3	2	262	8.1	241	30	100.00	90	.2	89
1.3	900	14	.482	31.8	2	383	14.5	328	33	100.00	152	.2	151
1.4	1044	14	.336	41.3	4	598	22.9	461	35	99.99	278	.2	277
1.5	1199	14	.220	50.1	6	1010	32.8	679	38	99.87	546	.2	542
1.6	1364	14	.135	58.0	11	1829	42.9	1045	40	99.75	1091	.1	1090
1.7	1540	14	.079	64.8	22	3505	52.3	1672	43	99.78	2262	.1	2258
1.8	1726	14	.044	70.5	45	7091	60.6	2793	45	99.86	4909	.1	4899
1.9	1923	14	.024	75.4	98	15081	67.6	4880	48	99.93	11070	.1	11046
2.0	2131	14	.012	79.4	221	33490	73.4	8903	50	99.96	25749	.1	25694
2.1	2350	14	.006	82.6	515	77077	78.1	16891	53	99.98	61427	.1	61295
2.2	2579	14	.003	85.4	1229	182570	81.8	33163	55	99.99	149558	.1	149237
2.3	2818	14	.001	87.6	2991	442405	84.8	67031	58	100.00	370111	.1	369323
2.4	3069	14	.001	89.5	7402	1091336	87.3	%138810	60	100.00	927752	.1	92579
6													
2.5	3330	14	.000	91.0	18555	2729636	89.3	%293263	62	100.00	2348848	.1	234398
0													

S=20% F=0.20

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 2.00 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 80 PCF, WATER CONT.= 37.7% C/L=.0076 L=4124 KF=1.18
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 80 PCF WATER CONT.= 37.7% C/L=.0076 L=4124 KF=1.18

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 20%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.20,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.90 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

F	-DEG*DAYS		PROB.		COVER THERMAL PROPERTIES IN H3 (R1.3=1)						WST'PILE		
						YEARS				PROB.%	YEARS	FT	YEARS
H1	TCAVG	CV%	FPAVG	CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	533	14	.901	6.8	1	70	1.5	69	13	0.00	19	.3	19
1.1	645	14	.789	13.6	1	94	3.9	91	14	6.13	29	.2	29
1.2	767	14	.640	22.3	2	131	8.1	120	15	99.83	45	.2	45
1.3	900	14	.482	31.8	2	191	14.5	164	16	99.95	76	.2	76
1.4	1044	14	.336	41.3	4	299	22.9	231	18	99.82	139	.2	138
1.5	1199	14	.220	50.1	6	505	32.8	340	19	99.44	273	.2	271
1.6	1364	14	.135	58.0	11	914	42.9	522	20	99.23	546	.1	545
1.7	1540	14	.079	64.8	22	1753	52.3	836	21	99.36	1131	.1	1129
1.8	1726	14	.044	70.5	45	3546	60.6	1397	23	99.59	2455	.1	2450
1.9	1923	14	.024	75.4	98	7540	67.6	2440	24	99.78	5535	.1	5523
2.0	2131	14	.012	79.4	221	16745	73.4	4451	25	99.89	12874	.1	12847
2.1	2350	14	.006	82.6	515	38539	78.1	8445	26	99.95	30713	.1	30647
2.2	2579	14	.003	85.4	1229	91285	81.8	16582	28	99.98	74779	.1	74619
2.3	2818	14	.001	87.6	2991	221202	84.8	33515	29	99.99	185056	.1	184661
2.4	3069	14	.001	89.5	7402	545668	87.3	69405	30	100.00	463876	.1	462898
2.5	3330	14	.000	91.0	18555	1364818	89.3	%146632	31	100.00	1174424	.1	117199

0

S=20% F=0.30

THERMAL AND UPFREEZING ANALYSIS ESTIMATES — PROGRAM UPFREEZSY — 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 2.00 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] — FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 80 PCF, WATER CONT.= 37.7% C/L=.0076 L=4124 KF=1.18
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL—HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
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BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 20%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.30,
LAMBDA*SQRIN-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
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CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.90 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

					COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE
F	-DEG*DAYS		PROB.		---------- YEARS				---------- PROB.%	YEARS FT		YEARS
H1	TCAVG	&CV%	FPAVG	&CV%	FPY	UP.YRS	CV%	LBOND	ABD R100	DELTA	H3M	DELTA
1.0	533	14	.901	6.8	1	47	1.5	46	8 0.00	13	.3	13
1.1	645	14	.789	13.6	1	63	3.9	60	9 0.00	19	.2	19
1.2	767	14	.640	22.3	2	87	8.1	80	10 3.82	30	.2	30
1.3	900	14	.482	31.8	2	128	14.5	109	11 93.29	51	.2	50
1.4	1044	14	.336	41.3	4	199	22.9	154	12 98.52	93	.2	92
1.5	1199	14	.220	50.1	6	337	32.8	226	13 98.56	182	.2	181
1.6	1364	14	.135	58.0	11	610	42.9	348	13 98.55	364	.1	363
1.7	1540	14	.079	64.8	22	1169	52.3	557	14 98.89	754	.1	753
1.8	1726	14	.044	70.5	45	2364	60.6	931	15 99.32	1636	.1	1633
1.9	1923	14	.024	75.4	98	5027	67.6	1627	16 99.63	3690	.1	3682
2.0	2131	14	.012	79.4	221	11163	73.4	2968	17 99.82	8583	.1	8565
2.1	2350	14	.006	82.6	515	25692	78.1	5630	18 99.92	20476	.1	20432
2.2	2579	14	.003	85.4	1229	60857	81.8	11054	18 99.97	49853	.1	49746
2.3	2818	14	.001	87.6	2991	147468	84.8	22344	19 99.99	123370	.1	123108
2.4	3069	14	.001	89.5	7402	363779	87.3	46270	20 99.99	309251	.1	308599
2.5	3330	14	.000	91.0	18555	909879	89.3	97754	21 100.00	782949	.1	781327

S=20% F=0.40

THERMAL AND UPFREEZING ANALYSIS ESTIMATES — PROGRAM UPFREEZSY — 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER — PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 2.00 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] — FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 80 PCF, WATER CONT.= 37.7% C/L=.0076 L=4124 KF=1.18
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL—HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
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BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 20%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.40,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) < 0.90 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

						COVER THERMAL PROPERTIES IN H3 (R1.3=1)						WST'PILE	
F	-DEG*DAYS		PROB.			YEARS				PROB.%	YEARS	FT	YEARS
H1	TCAVG	CV%	FPAVG	CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	533	14	.901	6.8	1	35	1.5	35	6	0.00	10	.3	10
1.1	645	14	.789	13.6	1	47	3.9	45	7	0.00	14	.2	14
1.2	767	14	.640	22.3	2	66	8.1	60	8	0.00	22	.2	22
1.3	900	14	.482	31.8	2	96	14.5	82	8	37.93	38	.2	38
1.4	1044	14	.336	41.3	4	150	22.9	115	9	92.60	70	.2	69
1.5	1199	14	.220	50.1	6	253	32.8	170	9	96.89	136	.2	135
1.6	1364	14	.135	58.0	11	457	42.9	261	10	97.68	273	.1	272
1.7	1540	14	.079	64.8	22	876	52.3	418	11	98.38	565	.1	564
1.8	1726	14	.044	70.5	45	1773	60.6	698	11	99.03	1227	.1	1225
1.9	1923	14	.024	75.4	98	3770	67.6	1220	12	99.49	2767	.1	2762
2.0	2131	14	.012	79.4	221	8372	73.4	2226	13	99.75	6437	.1	6423
2.1	2350	14	.006	82.6	515	19269	78.1	4223	13	99.89	15357	.1	15324
2.2	2579	14	.003	85.4	1229	45642	81.8	8291	14	99.95	37390	.1	37309
2.3	2818	14	.001	87.6	2991	110601	84.8	16758	14	99.98	92528	.1	92331
2.4	3069	14	.001	89.5	7402	272834	87.3	34702	15	99.99	231938	.1	231449
2.5	3330	14	.000	91.0	18555	682409	89.3	73316	16	100.00	587212	.1	585995

S=20% F=0.50

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 2.00 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
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FROZEN DRY DENS. = 80 PCF, WATER CONT.= 37.7% C/L=.0076 L=4124 KF=1.18
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
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BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 20%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.50,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.90 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

F	-DEG*DAYS		PROB.		COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE	
						YEARS				PROB.%	YEARS FT		YEARS
H1	TCAVG	CV%	FPAVG	CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	533	14	.901	6.8	1	28	1.5	28	5	0.00	8	.3	8
1.1	645	14	.789	13.6	1	38	3.9	36	6	0.00	12	.2	12
1.2	767	14	.640	22.3	2	52	8.1	48	6	0.00	18	.2	18
1.3	900	14	.482	31.8	2	77	14.5	66	7	1.74	30	.2	30
1.4	1044	14	.336	41.3	4	120	22.9	92	7	76.31	56	.2	55
1.5	1199	14	.220	50.1	6	202	32.8	136	8	93.99	109	.2	108
1.6	1364	14	.135	58.0	11	366	42.9	209	8	96.58	218	.1	218
1.7	1540	14	.079	64.8	22	701	52.3	334	9	97.82	452	.1	452
1.8	1726	14	.044	70.5	45	1418	60.6	559	9	98.74	982	.1	980
1.9	1923	14	.024	75.4	98	3016	67.6	976	10	99.34	2214	.1	2209
2.0	2131	14	.012	79.4	221	6698	73.4	1781	10	99.68	5150	.1	5139
2.1	2350	14	.006	82.6	515	15415	78.1	3378	11	99.85	12285	.1	12259
2.2	2579	14	.003	85.4	1229	36514	81.8	6633	11	99.94	29912	.1	29847
2.3	2818	14	.001	87.6	2991	88481	84.8	13406	12	99.97	74022	.1	73865
2.4	3069	14	.001	89.5	7402	218267	87.3	27762	12	99.99	185550	.1	185159
2.5	3330	14	.000	91.0	18555	545927	89.3	58653	12	100.00	469770	.1	468796

S=30% F=0.10

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 2.00 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 70 PCF, WATER CONT.= 47.9% C/L=.0068 L=4590 KF=1.23
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 70 PCF WATER CONT.= 47.9% C/L=.0068 L=4590 KF=1.23

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 30%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.10,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.80 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT	DEG*DAYS	PROB.			COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE		
					---------- YEARS ----------					PROB.%		YEARS	FT	YEARS
H1	TCAVG&CV%	FPAVG&CV%			FPY	UP.YRS	CV%	LBOND	ABD	R100		DELTA	H3M	DELTA
1.0	667	14	.763	15.2	1	134	4.6	128	17	100.00		46	.2	46
1.1	807	14	.591	25.2	2	197	10.0	177	18	100.00		79	.2	78
1.2	961	14	.417	35.9	3	311	18.2	255	20	99.99		150	.2	149
1.3	1128	14	.269	46.2	5	537	28.5	384	22	99.82		301	.1	300
1.4	1308	14	.160	55.5	9	1001	39.6	604	23	99.53		627	.1	625
1.5	1501	14	.089	63.4	19	2016	50.4	1001	25	99.52		1404	.1	1400
1.6	1708	14	.047	70.0	42	4386	59.9	1757	27	99.70		3335	.1	3327
1.7	1928	14	.023	75.5	100	10208	67.9	3276	28	99.85		8310	.1	8288
1.8	2162	14	.011	79.9	249	25116	74.3	6462	30	99.93		21506	.1	21448
1.9	2408	14	.005	83.4	645	64542	79.3	13384	32	99.97		57346	.1	57192
2.0	2669	14	.002	86.3	1720	171491	83.2	28886	33	99.99		156550	.1	156130
2.1	2942	14	.001	88.6	4696	467363	86.2	64473	35	100.00		435194	.1	434041
2.2	3229	14	.000	90.5	13056	1298255	88.6	%147855	37	100.00		1226591	.1	122339
6														
2.3	3529	14	.000	92.0	36798	3657817	90.5	%346506	38	100.00		3492534	.1	348365
1														
2.4	3843	14	.000	93.2	104776	10412310	92.1	%826217	40	100.00		%10016460	.1	9991
550														
2.5	4170	14	.000	94.2	300496	29852470	93.3	%1997166	42	100.00		%28863850	.1	%28
794100														

S=30% F=0.20

THERMAL AND UPFREEZING ANALYSIS/ESTIMATES -- PROGRAM UPFREEZSY -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 2.00 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 70 PCF, WATER CONT.= 47.9% C/L=.0068 L=4590 KF=1.23
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 70 PCF WATER CONT.= 47.9% C/L=.0068 L=4590 KF=1.23

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 30%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.20,
LAMBDA*SQRIN-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.80 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

					COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE	
FI	-DEG*DAYS		PROB.		------- YEARS					PROB.%	YEARS FT		YEARS
H1	TCAVG	&CV%	FPAVG	&CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	667	14	.763	15.2	1	67	4.6	64	8	0.00	23	.2	23
1.1	807	14	.591	25.2	2	98	10.0	89	9	43.29	39	.2	39
1.2	961	14	.417	35.9	3	156	18.2	127	10	97.55	75	.2	75
1.3	1128	14	.269	46.2	5	269	28.5	192	11	98.65	150	.1	150
1.4	1308	14	.160	55.5	9	500	39.6	302	12	98.50	313	.1	313
1.5	1501	14	.089	63.4	19	1008	50.4	500	13	98.78	702	.1	700
1.6	1708	14	.047	70.0	42	2193	59.9	879	13	99.26	1668	.1	1663
1.7	1928	14	.023	75.5	100	5104	67.9	1638	14	99.63	4155	.1	4144
1.8	2162	14	.011	79.9	249	12558	74.3	3231	15	99.84	10753	.1	10724
1.9	2408	14	.005	83.4	645	32271	79.3	6692	16	99.93	28673	.1	28596
2.0	2669	14	.002	86.3	1720	85745	83.2	14443	17	99.97	78275	.1	78065
2.1	2942	14	.001	88.6	4696	233681	86.2	32237	18	99.99	217597	.1	217020
2.2	3229	14	.000	90.5	13056	649127	88.6	73927	18	100.00	613295	.1	611698
2.3	3529	14	.000	92.0	36798	1828908	90.5	%173253	19	100.00	1746267	.1	174182
5													
2.4	3843	14	.000	93.2	104776	5206157	92.1	%413108	20	100.00	5008229	.1	499577
5													
2.5	4170	14	.000	94.2	300496	14926230	93.3	%998583	21	100.00	%14431930	.1	%143
97050													

S=30% F=0.30

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 2.00 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

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H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
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BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 30%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.30,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
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CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.80 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT	DEG*DAYS		PROB.		COVER THERMAL PROPERTIES IN H3 (R1.3=1)					PROB.%		WST'PILE		
					---------- YEARS ----------							YEARS	FT	YEARS
H1	TCAVG	&CV%	FPAVG	&CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100		DELTA	H3M	DELTA
1.0	667	14	.763	15.2	1	45	4.6	43	6	0.00		15	.2	15
1.1	807	14	.591	25.2	2	66	10.0	59	6	0.00		26	.2	26
1.2	961	14	.417	35.9	3	104	18.2	85	7	57.97		50	.2	50
1.3	1128	14	.269	46.2	5	179	28.5	128	7	93.96		100	.1	100
1.4	1308	14	.160	55.5	9	334	39.6	201	8	96.81		209	.1	208
1.5	1501	14	.089	63.4	19	672	50.4	334	8	97.89		468	.1	467
1.6	1708	14	.047	70.0	42	1462	59.9	586	9	98.80		1112	.1	1109
1.7	1928	14	.023	75.5	100	3403	67.9	1092	9	99.41		2770	.1	2763
1.8	2162	14	.011	79.9	249	8372	74.3	2154	10	99.74		7169	.1	7149
1.9	2408	14	.005	83.4	645	21514	79.3	4461	11	99.89		19115	.1	19064
2.0	2669	14	.002	86.3	1720	57164	83.2	9629	11	99.96		52183	.1	52043
2.1	2942	14	.001	88.6	4696	155788	86.2	21491	12	99.98		145065	.1	144680
2.2	3229	14	.000	90.5	13056	432752	88.6	49285	12	99.99		408864	.1	407799
2.3	3529	14	.000	92.0	36798	1219272	90.5	%115502	13	100.00		1164178	.1	116121
7														
2.4	3843	14	.000	93.2	104776	3470771	92.1	%275406	13	100.00		3338820	.1	333051
7														
2.5	4170	14	.000	94.2	300496	9950823	93.3	%665722	14	100.00		9621285	.1	959803
5														

S=30% F=0.40

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER — PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 2.00 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 70 PCF, WATER CONT.= 47.9% C/L=.0068 L=4590 KF=1.23
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
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BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 30%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.40,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.80 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT	DEG*DAYS	PROB.			COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE	
					---------- YEARS					PROB.%	YEARS FT		YEARS
H1	TCAVG&CV%	FPAVG&CV%			FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	667	14	.763	15.2	1	34	4.6	32	4	0.00	11	.2	11
1.1	807	14	.591	25.2	2	49	10.0	44	5	0.00	20	.2	20
1.2	961	14	.417	35.9	3	78	18.2	64	5	5.85	38	.2	37
1.3	1128	14	.269	46.2	5	134	28.5	96	5	81.50	75	.1	75
1.4	1308	14	.160	55.5	9	250	39.6	151	6	94.16	157	.1	156
1.5	1501	14	.089	63.4	19	504	50.4	250	6	96.84	351	.1	350
1.6	1708	14	.047	70.0	42	1096	59.9	439	7	98.31	834	.1	832
1.7	1928	14	.023	75.5	100	2552	67.9	819	7	99.19	2078	.1	2072
1.8	2162	14	.011	79.9	249	6279	74.3	1615	8	99.64	5376	.1	5362
1.9	2408	14	.005	83.4	645	16136	79.3	3346	8	99.85	14337	.1	14298
2.0	2669	14	.002	86.3	1720	42873	83.2	7221	8	99.94	39138	.1	39033
2.1	2942	14	.001	88.6	4696	116841	86.2	16118	9	99.98	108798	.1	108510
2.2	3229	14	.000	90.5	13056	324564	88.6	36964	9	99.99	306648	.1	305849
2.3	3529	14	.000	92.0	36798	914454	90.5	86627	10	100.00	873133	.1	870913
2.4	3843	14	.000	93.2	104776	2603079	92.1	%206554	10	100.00	2504115	.1	249788
8													
2.5	4170	14	.000	94.2	300496	7463118	93.3	%499291	10	100.00	7215964	.1	719852
6													

S=30% F=0.50

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZSY -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 2.00 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
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H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
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FROZEN DRY DENS. = 70 PCF, WATER CONT.= 47.9% C/L=.0068 L=4590 KF=1.23
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
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BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 30%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.50,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

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CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
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R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

						COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE
F	-DEG*DAYS		PROB.			---------- YEARS				PROB.%	YEARS	FT	YEARS
H1	TCAVG&CV%		FPAVG&CV%		FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	667	14	.763	15.2	1	27	4.6	26	3	0.00	9	.2	9
1.1	807	14	.591	25.2	2	39	10.0	35	4	0.00	16	.2	16
1.2	961	14	.417	35.9	3	62	18.2	51	4	0.04	30	.2	30
1.3	1128	14	.269	46.2	5	107	28.5	77	4	59.59	60	.1	60
1.4	1308	14	.160	55.5	9	200	39.6	121	5	90.30	125	.1	125
1.5	1501	14	.089	63.4	19	403	50.4	200	5	95.62	281	.1	280
1.6	1708	14	.047	70.0	42	877	59.9	351	5	97.79	667	.1	665
1.7	1928	14	.023	75.5	100	2042	67.9	655	6	98.96	1662	.1	1658
1.8	2162	14	.011	79.9	249	5023	74.3	1292	6	99.55	4301	.1	4290
1.9	2408	14	.005	83.4	645	12908	79.3	2677	6	99.81	11469	.1	11438
2.0	2669	14	.002	86.3	1720	34298	83.2	5777	7	99.93	31310	.1	31226
2.1	2942	14	.001	88.6	4696	93473	86.2	12895	7	99.97	87039	.1	86808
2.2	3229	14	.000	90.5	13056	259651	88.6	29571	7	99.99	245318	.1	244679
2.3	3529	14	.000	92.0	36798	731563	90.5	69301	8	100.00	698507	.1	696730
2.4	3843	14	.000	93.2	104776	2082463	92.1	%165243	8	100.00	2003292	.1	199831
0													
2.5	4170	14	.000	94.2	300496	5970494	93.3	%399433	8	100.00	5772771	.1	575882
1													

S=40% F=0.10

THERMAL AND UPFREEZING ANALYSIS ESTIMATES — PROGRAM UPFREEZ5Y — 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER — PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 2.00 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE—BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] — FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 60 PCF, WATER CONT.= 61.6% C/L=.0062 L=5057 KF=1.30
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL—HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 60 PCF WATER CONT.= 61.6% C/L=.0062 L=5057 KF=1.30

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 40%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.10,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (1.90 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

			COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE	
F-DEG*DAYS		PROB.	YEARS					PROB.%	YEARS FT		YEARS
H1	TCAVG&CV%	FPAVG&CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	803 14	.597 24.8	2	147	10.0	132	13	99.93	65	.2	65
1.1	971 14	.406 36.6	3	245	19.0	198	14	99.90	130	.1	130
1.2	1156 14	.248 47.8	5	445	30.4	310	15	99.54	271	.1	270
1.3	1356 14	.138 57.7	11	891	42.5	512	16	99.20	621	.1	619
1.4	1573 14	.071 65.9	25	1975	54.1	907	18	99.36	1546	.1	1542
1.5	1806 14	.034 72.6	62	4800	63.9	1733	19	99.66	4106	.1	4093
1.6	2055 14	.016 78.0	164	12587	71.7	3557	20	99.85	11467	.1	11430
1.7	2319 14	.007 82.2	459	34976	77.8	7777	21	99.94	33311	.1	33203
1.8	2600 14	.003 85.6	1332	101494	82.3	17920	23	99.98	99725	.1	99404
1.9	2897 14	.001 88.2	3989	304078	85.8	43058	24	99.99	305441	.1	304468
2.0	3210 14	.000 90.3	12218	932529	88.5	%106942	25	100.00	951462	.1	948484
2.1	3539 14	.000 92.0	38059	2908274	90.6	%272562	26	100.00	3000029	.1	2990874
2.2	3884 14	.000 93.4	120001	9177240	92.3	%708798	28	100.00	9537904	.1	9509607
2.3	4246 14	.000 94.4	381516	29186080	93.6	%1872115	29	100.00	%30479780	.1	%30391900
2.4	4623 14	.000 95.3	%1219190	65025610	94.3	%3682801	30	100.00	%41199280	.4	%13157890
2.5	5016 14	.000 96.0	%3906034	92204190	94.7	%4907494	31	100.00	%13157890	%1.9	%13157890

S=40% F=0.20

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 2.00 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

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H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
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BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 40%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.20,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
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R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT	DEG*DAYS	PROB.			COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE	
					---------- YEARS ----------					PROB.%	YEARS	FT	YEARS
H1	TCAVG	CV%	FPAVG	CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	803	14	.597	24.8	2	73	10.0	66	6	0.01	33	.2	32
1.1	971	14	.406	36.6	3	122	19.0	99	7	83.09	65	.1	65
1.2	1156	14	.248	47.8	5	223	30.4	155	8	96.59	135	.1	135
1.3	1356	14	.138	57.7	11	446	42.5	256	8	97.62	311	.1	310
1.4	1573	14	.071	65.9	25	987	54.1	454	9	98.46	773	.1	771
1.5	1806	14	.034	72.6	62	2400	63.9	866	9	99.22	2053	.1	2046
1.6	2055	14	.016	78.0	164	6293	71.7	1778	10	99.67	5734	.1	5715
1.7	2319	14	.007	82.2	459	17488	77.8	3888	11	99.87	16656	.1	16602
1.8	2600	14	.003	85.6	1332	50747	82.3	8960	11	99.95	49863	.1	49702
1.9	2897	14	.001	88.2	3989	152039	85.8	21529	12	99.98	152721	.1	152234
2.0	3210	14	.000	90.3	12218	466264	88.5	53471	13	99.99	475731	.1	474242
2.1	3539	14	.000	92.0	38059	1454137	90.6	%136281	13	100.00	1500014	.1	149543
7													
2.2	3884	14	.000	93.4	120001	4588620	92.3	%354399	14	100.00	4768952	.1	475480
4													
2.3	4246	14	.000	94.4	381516	14593040	93.6	%936057	14	100.00	%15239890	.1	%151
95950													
2.4	4623	14	.000	95.3	%1219190	32512810	94.3	%1841400	15	100.00	%20599640	.4	6
578946													
2.5	5016	14	.000	96.0	%3906034	46102100	94.7	%2453747	16	100.00	6578946	%1.9	6
578946													

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
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HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.30,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
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					COVER THERMAL PROPERTIES IN H3 (R1.3=1)						WST'PILE	
F	-DEG*DAYS		PROB.		---------- YEARS ----------					PROB.%	YEARS FT	YEARS
H1	TCAVG&CV%	FPAVG&CV%			FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA H3M	DELTA
1.0	803 14 .597	24.8			2	49	10.0	44	4	0.00	22 .2	22
1.1	971 14 .406	36.6			3	82	19.0	66	5	11.73	43 .1	43
1.2	1156 14 .248	47.8			5	148	30.4	103	5	85.93	90 .1	90
1.3	1356 14 .138	57.7			11	297	42.5	171	5	95.06	207 .1	206
1.4	1573 14 .071	65.9			25	658	54.1	302	6	97.42	515 .1	514
1.5	1806 14 .034	72.6			62	1600	63.9	578	6	98.76	1369 .1	1364
1.6	2055 14 .016	78.0			164	4196	71.7	1186	7	99.48	3822 .1	3810
1.7	2319 14 .007	82.2			459	11659	77.8	2592	7	99.80	11104 .1	11068
1.8	2600 14 .003	85.6			1332	33831	82.3	5973	8	99.93	33242 .1	33135
1.9	2897 14 .001	88.2			3983	101359	85.8	14353	8	99.98	101814 .1	101489
2.0	3210 14 .000	90.3			12218	310843	88.5	35647	8	99.99	317154 .1	316161
2.1	3539 14 .000	92.0			38059	969425	90.6	90854	9	100.00	1000010 .1	996958
2.2	3884 14 .000	93.4			120001	3059080	92.3	%236266	9	100.00	3179302 .1	316986
9												
2.3	4246 14 .000	94.4			381516	9728694	93.6	%624038	10	100.00	%10159930 .1	%101
30630												
2.4	4623 14 .000	95.3			%1219190	21675210	94.3	%1227600	10	100.00	%13733090 .4	4
385964												
2.5	5016 14 .000	96.0			%3906034	30734730	94.7	%1635831	10	100.00	4385964 %1.9	4
385964												

S=40% F=0.40

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
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H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
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BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 40%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.40,
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ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
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LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
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R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT	DEG*DAYS	PROB.			COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE		
					---------- YEARS ----------					PROB.%		YEARS	FT	YEARS
H1	TCAVG	&CV%	FPAVG	&CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100		DELTA	H3M	DELTA
1.0	803	14	.597	24.8	2	37	10.0	33	3	0.00		16	.2	16
1.1	971	14	.406	36.6	3	61	19.0	50	3	0.04		33	.1	33
1.2	1156	14	.248	47.8	5	111	30.4	78	4	63.14		68	.1	67
1.3	1356	14	.138	57.7	11	223	42.5	128	4	91.21		155	.1	155
1.4	1573	14	.071	65.9	25	494	54.1	227	4	96.20		387	.1	385
1.5	1806	14	.034	72.6	62	1200	63.9	433	5	98.28		1026	.1	1023
1.6	2055	14	.016	78.0	164	3147	71.7	889	5	99.29		2867	.1	2858
1.7	2319	14	.007	82.2	459	8744	77.8	1944	5	99.73		8328	.1	8301
1.8	2600	14	.003	85.6	1332	25374	82.3	4480	6	99.90		24931	.1	24851
1.9	2897	14	.001	88.2	3989	76019	85.8	10765	6	99.97		76360	.1	76117
2.0	3210	14	.000	90.3	12218	233132	88.5	26736	6	99.99		237865	.1	237121
2.1	3539	14	.000	92.0	38059	727063	90.6	68140	7	100.00		750007	.1	747719
2.2	3884	14	.000	93.4	120001	2294310	92.3	%177200	7	100.00		2384476	.1	237740
2														
2.3	4246	14	.000	94.4	381516	7296521	93.6	%468029	7	100.00		7619946	.1	759797
5														
2.4	4623	14	.000	95.3	%1219190	16256400	94.3	%920700	7	100.00		%10299820	.4	32
89473														
2.5	5016	14	.000	96.0	%3906034	23051050	94.7	%1226873	8	100.00		3289473	%1.9	3
289473														

S=40% F=0.50

THERMAL AND UPFREEZING ANALYSIS ESTIMATES — PROGRAM UPFREEZ5Y — 04-08-1987
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BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 40%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.50,
LAMBDA*SQRIN-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
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R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT	DEG*DAYS		PROB.		COVER THERMAL PROPERTIES IN H3 (R1.3=1) YEARS					PROB.%	YEARS	FT	WST'PILE YEARS
H1	TCAVG	CV%	FPAVG	CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	803	14	.597	24.8	2	29	10.0	26	3	0.00	13	.2	13
1.1	971	14	.406	36.6	3	49	19.0	40	3	0.00	26	.1	26
1.2	1156	14	.248	47.8	5	89	30.4	62	3	34.27	54	.1	54
1.3	1356	14	.138	57.7	11	178	42.5	102	3	85.80	124	.1	124
1.4	1573	14	.071	65.9	25	395	54.1	181	4	94.81	309	.1	308
1.5	1806	14	.034	72.6	62	960	63.9	347	4	97.77	821	.1	819
1.6	2055	14	.016	78.0	164	2517	71.7	711	4	99.09	2293	.1	2286
1.7	2319	14	.007	82.2	459	6995	77.8	1555	4	99.65	6662	.1	6641
1.8	2600	14	.003	85.6	1332	20299	82.3	3584	5	99.88	19945	.1	19881
1.9	2897	14	.001	88.2	3989	60816	85.8	8612	5	99.96	61088	.1	60894
2.0	3210	14	.000	90.3	12218	186506	88.5	21388	5	99.99	190292	.1	189697
2.1	3539	14	.000	92.0	38059	581655	90.6	54512	5	100.00	600006	.1	598175
2.2	3884	14	.000	93.4	120001	1835448	92.3	%141760	6	100.00	1907581	.1	190192
1													
2.3	4246	14	.000	94.4	381516	5837217	93.6	%374423	6	100.00	6095957	.1	607838
0													
2.4	4623	14	.000	95.3	%1219190	13005120	94.3	%736560	6	100.00	8239856	.4	2631
579													
2.5	5016	14	.000	96.0	%3906034	18440840	94.7	%981499	6	100.00	2631579	%1.9	26
31579													

S=50% F=0.10

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 2.00 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 50 PCF, WATER CONT.= 80.7% C/L=.0057 L=5523 KF=1.42
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 50 PCF WATER CONT.= 80.7% C/L=.0057 L=5523 KF=1.42

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 50%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.10,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (1.90 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

F	DEG*DAYS		PROB.		COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE		
						YEARS				PROB.%		YEARS	FT	YEARS
H1	TCAVG	CV%	FPAVG	CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100		DELTA	H3M	DELTA
1.0	925	14	.454	33.5	2	171	16.5	143	10	99.41		92	.1	92
1.1	1119	14	.275	45.7	5	316	28.1	227	11	99.28		198	.1	197
1.2	1332	14	.149	56.6	10	653	41.2	384	12	98.86		478	.1	476
1.3	1563	14	.073	65.6	24	1528	53.7	707	13	99.12		1271	.1	1267
1.4	1813	14	.033	72.8	64	3984	64.3	1421	14	99.56		3641	.1	3628
1.5	2081	14	.014	78.5	182	11324	72.6	3104	15	99.82		11039	.1	10998
1.6	2368	14	.006	82.9	552	34316	78.8	7283	16	99.94		34945	.1	34814
1.7	2673	14	.002	86.3	1747	108924	83.4	18093	17	99.98		114271	.1	113847
1.8	2997	14	.001	89.0	5714	357424	86.8	47010	18	99.99		382729	.1	381333
1.9	3339	14	.000	91.1	19136	1200831	89.5	%126432	19	100.00		1304086	.1	129944
0														
2.0	3699	14	.000	92.7	65205	4100963	91.5	%349143	20	100.00		4496179	.1	448060
1														
2.1	4079	14	.000	94.0	224809	14158130	93.1	%983758	21	100.00		%15618150	.1	%155
65750														
2.2	4476	14	.000	95.0	780906	38104060	94.1	%2259889	22	100.00		%32273710	.4	%32
684580														
2.3	4893	14	.000	95.8	%2723563	59504070	94.5	%3285273	23	100.00		%10526310	%1.9	
%10526310														
2.4	5327	14	.000	93.5	%5166669	70030380	94.5	%3844320	24	100.00		%10526310	%1.9	
%10526310														
2.5	5780	14	.000	82.1	%5491672	80556700	93.6	%5126309	25	100.00		%10526310	%1.9	
%10526310														

S=50% F=0.20

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 2.00 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 50 PCF, WATER CONT.= 80.7% C/L=.0057 L=5523 KF=1.42
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 50 PCF WATER CONT.= 80.7% C/L=.0057 L=5523 KF=1.42

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 50%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.20,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (1.90 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FI	DEG*DAYS		PROB.		COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE	
					---------- YEARS					PROB.%	YEARS FT		YEARS
H1	TCAVG	CV%	FPAVG	CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	925	14	.454	33.5	2	85	16.5	71	5	14.99	46	.1	46
1.1	1119	14	.275	45.7	5	158	28.1	113	6	90.40	99	.1	98
1.2	1332	14	.149	56.6	10	327	41.2	192	6	96.22	239	.1	238
1.3	1563	14	.073	65.6	24	764	53.7	353	7	97.89	636	.1	633
1.4	1813	14	.033	72.8	64	1992	64.3	710	7	99.02	1821	.1	1814
1.5	2081	14	.014	78.5	182	5662	72.6	1552	8	99.61	5519	.1	5499
1.6	2368	14	.006	82.9	552	17158	78.8	3641	8	99.86	17472	.1	17407
1.7	2673	14	.002	86.3	1747	54462	83.4	9046	9	99.96	57135	.1	56924
1.8	2997	14	.001	89.0	5714	178712	86.8	23505	9	99.99	191365	.1	190666
1.9	3339	14	.000	91.1	19136	600416	89.5	63216	10	100.00	652043	.1	649720
2.0	3699	14	.000	92.7	65205	2050482	91.5	%174571	10	100.00	2248089	.1	224030
1													
2.1	4079	14	.000	94.0	224809	7079064	93.1	%491879	11	100.00	7809076	.1	778287
4													
2.2	4476	14	.000	95.0	780906	19052030	94.1	%1129944	11	100.00	%16136860	.4	%16
342290													
2.3	4893	14	.000	95.8	%2723563	29752040	94.5	%1642637	12	100.00	5263157	%1.9	5
263157													
2.4	5327	14	.000	93.5	%5166669	35015190	94.5	%1922160	12	100.00	5263157	%1.9	5
263157													
2.5	5780	14	.000	82.1	%5491672	40278350	93.6	%2563155	12	100.00	5263157	%1.9	5
263157													

S=50% F=0.30

THERMAL AND UPFREEZING ANALYSIS ESTIMATES — PROGRAM UPFREEZSY — 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER — PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 2.00 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 50 PCF, WATER CONT.= 80.7% C/L=.0057 L=5523 KF=1.42
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 50 PCF WATER CONT.= 80.7% C/L=.0057 L=5523 KF=1.42

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 50%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.30,
LAMBDA*SQRIN-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (1.90 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

F.	DEG*DAYS	PROB.			COVER THERMAL PROPERTIES IN H3 (R1.3=1)						WST'PILE	
					--------- YEARS			---------- PROB.%		YEARS FT		YEARS
H1	TCAVG&CV%	FPAVG&CV%			FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M DELTA
1.0	925 14	.454	33.5		2	57	16.5	48	3	0.00	31	.1 31
1.1	1119 14	.275	45.7		5	105	28.1	76	4	56.99	66	.1 66
1.2	1332 14	.149	56.6		10	218	41.2	128	4	91.33	159	.1 159
1.3	1563 14	.073	65.6		24	509	53.7	236	4	96.40	424	.1 422
1.4	1813 14	.033	72.8		64	1328	64.3	474	5	98.44	1214	.1 1209
1.5	2031 14	.014	78.5		182	3775	72.6	1035	5	99.40	3680	.1 3666
1.6	2368 14	.006	82.9		552	11439	78.8	2428	5	99.79	11648	.1 11605
1.7	2673 14	.002	86.3		1747	36308	83.4	6031	6	99.93	38090	.1 37949
1.8	2997 14	.001	89.0		5714	119141	86.8	15670	6	99.98	127576	.1 127111
1.9	3339 14	.000	91.1		19136	400277	89.5	42144	6	99.99	434695	.1 433147
2.0	3699 14	.000	92.7		65205	1366988	91.5	%116381	7	100.00	1498726	.1 149353
4												
2.1	4079 14	.000	94.0		224809	4719376	93.1	%327919	7	100.00	5206051	.1 518858
3												
2.2	4476 14	.000	95.0		780906	12701350	94.1	%753296	7	100.00	%10757900	.4 %108
94860												
2.3	4893 14	.000	95.8		%2723563	19834690	94.5	%1095091	8	100.00	3508772	%1.9 3
508772												
2.4	5327 14	.000	93.5		%5166669	23343470	94.5	%1281440	8	100.00	3508772	%1.9 3
508772												
2.5	5780 14	.000	82.1		%5491672	26852240	93.6	%1708770	8	100.00	3508772	%1.9 3
508772												

S=50% F=0.40

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 2.00 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 50 PCF, WATER CONT.= 80.7% C/L=.0057 L=5523 KF=1.42
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 50 PCF WATER CONT.= 80.7% C/L=.0057 L=5523 KF=1.42

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 50%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.40,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (1.90 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

F	-DEG*DAYS		PROB.		COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE	
						YEARS				PROB.%	YEARS FT		YEARS
H1	TCAVG	CV%	FPAVG	CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	925	14	.454	33.5	2	43	16.5	36	3	0.00	23	.1	23
1.1	1119	14	.275	45.7	5	79	28.1	57	3	17.07	49	.1	49
1.2	1332	14	.149	56.6	10	163	41.2	96	3	83.39	119	.1	119
1.3	1563	14	.073	65.6	24	382	53.7	177	3	94.60	318	.1	317
1.4	1813	14	.033	72.8	64	996	64.3	355	4	97.84	910	.1	907
1.5	2081	14	.014	78.5	182	2831	72.6	776	4	99.18	2760	.1	2750
1.6	2368	14	.006	82.9	552	8579	78.8	1821	4	99.72	8736	.1	8704
1.7	2673	14	.002	86.3	1747	27231	83.4	4523	4	99.91	28568	.1	28462
1.8	2997	14	.001	89.0	5714	89356	86.8	11752	5	99.97	95682	.1	95333
1.9	3339	14	.000	91.1	19136	300208	89.5	31608	5	99.99	326021	.1	324860
2.0	3699	14	.000	92.7	65205	1025241	91.5	87286	5	100.00	1124045	.1	1120150
2.1	4079	14	.000	94.0	224809	3539532	93.1	%245939	5	100.00	3904538	.1	389143
7													
2.2	4476	14	.000	95.0	780906	9526015	94.1	%564972	6	100.00	8068428	.4	817114
5													
2.3	4893	14	.000	95.8	%2723563	14876020	94.5	%821318	6	100.00	2631579	%1.9	26
31579													
2.4	5327	14	.000	93.5	%5166669	17507600	94.5	%961080	6	100.00	2631579	%1.9	26
31579													
2.5	5780	14	.000	82.1	%5491672	20139170	93.6	%1281577	6	100.00	2631579	%1.9	2
631579													

S=50% F=0.50

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 2.00 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 50 PCF, WATER CONT.= 80.7% C/L=.0057 L=5523 KF=1.42
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 50 PCF WATER CONT.= 80.7% C/L=.0057 L=5523 KF=1.42

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 50%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.50,
LAMBDA*SQRIN-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (1.90 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT	DEG*DAYS		PROB.		COVER THERMAL PROPERTIES IN H3 (R1.3=1)						WST'PILE		
					--------- YEARS			---------- PROB.%			YEARS FT		YEARS
H1	TCAVG	CV%	FPAVG	CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	925	14	.454	33.5	2	34	16.5	29	2	0.00	18	.1	18
1.1	1119	14	.275	45.7	5	63	28.1	45	2	1.88	40	.1	39
1.2	1332	14	.149	56.6	10	131	41.2	77	2	72.18	96	.1	95
1.3	1563	14	.073	65.6	24	306	53.7	141	3	92.48	254	.1	253
1.4	1813	14	.033	72.8	64	797	64.3	284	3	97.20	728	.1	726
1.5	2081	14	.014	78.5	182	2265	72.6	621	3	98.96	2208	.1	2200
1.6	2368	14	.006	82.9	552	6863	78.8	1457	3	99.64	6989	.1	6963
1.7	2673	14	.002	86.3	1747	21785	83.4	3619	3	99.88	22854	.1	22769
1.8	2997	14	.001	89.0	5714	71485	86.8	9402	4	99.96	76546	.1	76267
1.9	3339	14	.000	91.1	19136	240166	89.5	25286	4	99.99	260817	.1	259888
2.0	3699	14	.000	92.7	65205	820193	91.5	69829	4	100.00	899236	.1	896120
2.1	4079	14	.000	94.0	224809	2831626	93.1	%196752	4	100.00	3123631	.1	311315
0													
2.2	4476	14	.000	95.0	780906	7620812	94.1	%451978	4	100.00	6454743	.4	653691
6													
2.3	4893	14	.000	95.8	%2723563	11900820	94.5	%657055	5	100.00	2105263	%1.9	21
05263													
2.4	5327	14	.000	93.5	%5166669	14006080	94.5	%768864	5	100.00	2105263	%1.9	21
05263													
2.5	5780	14	.000	82.1	%5491672	16111340	93.6	%1025262	5	100.00	2105263	%1.9	2
105263													

UPFREEZ5 RUN COMPLETE

********** PROGRAM UPFREEZSY **********

SAVED UNDER FILE NAME: UPF1-5Y DATE: 04-08-1987

TIME: 12:30:42

PROBABILISTIC GEOTECHNICAL THERMAL ANALYSIS
1-LAYER FINE-GRAINED COVER SYSTEM

MODIFIED BERGGREN EQUATION WITH KERSTEN K'S

PROPERTIES OF COVER

COVER LAYER DRY DENSITY=100 PCF, WATER CONTENT =20.3% (80% SAT) 100% S=25.4%
AVERAGE HEAVE STRAIN = 10% TO 50%
FRACTION OF HEAVE NOT RECOVERED ON THAWING (R) = 0.30 TO 0.30
LAMBDA*SQRT(N-FACTOR): AVG=0.48; SD=0.00
(COVER AND WASTE PILE USE THE SAME VALUES)

PROPERTIES OF WASTE PILE

FINE-GRAINED SOIL
UNFROZEN DRY DENSITY = 100. [PCF], WATER CONTENT = 20% (80% SAT) 100% S=25.4%
AVERAGE HEAVE STRAIN = 10% TO 50%
FRACTION OF HEAVE NOT RECOVERED ON THAWING (R) = 0.30 TO 0.30

THERMAL LOAD INFORMATION

FREEZE INDEX (FI) FOR WAUKEKGAN ASSUMED LOGNORMAL WITH MEAN & STANDARD DEVIATION
FROM HISTORICAL DATA 1949-50 TO 1984-85 EXCEPT 1982-83 (TOTAL = 35 YEARS)
LOGNORMAL FREEZE INDEX (THERMAL LOAD): MEAN=848, MEDIAN=800, SD=320, CV=0.378,
SD(LN FI)=0.365, SKEWNESS=1.277 HOWEVER:
CONSERVATIVE LOGNORMAL ENVELOPE USED FOR FREEZE INDEX: MEDIAN = 875, MEAN = 935
SD(LN FI) =0.365
ALL YEARS HAVE HISTORICAL FI FREQUENCY (= FORCASTED (PREDICTED) PROBABILITIES
(1983-84 [FI=1200] LIES ON THE ENVELOPE ALL OTHER YEARS ARE BELOW)

OBJECT UPFREEZING INFORMATION--EQUATION: U = (X - A - T) * S * R * C

UPFREEZING ASSUMPTIONS:
EFFECTIVE PARTICLE SIZE (X - A) IS EPS.UF = 2.00 FT
AVERAGE HEAVE STRAIN (S) = 10 % TO 50 %
FRACTION OF HEAVE NOT RECOVERED ON THAWING (R) = 0.30 TO 0.30
EFFECTIVE NUMBER OF COMPLETE FREEZE THAW CYCLES (C) = NUMBER OF FREEZE SEASONS
(YEARS) * P.H3

*NOTE: BOTH C AND P.H3 ARE DEPTH DEPENDENT

Printing out from H_4=0.1 ft to 2.5 ft – check on results

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZSY -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 2.00 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 90 PCF, WATER CONT.= 29.7% C/L=.0085 L=3658 KF=1.15
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H2 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 90 PCF WATER CONT.= 29.7% C/L=.0085 L=3658 KF=1.15

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 10%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.30,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (1.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT H1	DEG*DAYS TCAVG	&CV%	PROB. FPAVG	&CV%	COVER THERMAL PROPERTIES IN H3 (R1.3=1) FPY	YEARS UP.YRS	CV%	LBOND	ABD	PROB.% R100	WST'PILE YEARS FT H3M	DELTA	YEARS DELTA
0.1	4	14	%1.000	0.0	1	4	0.0	4	2	0.00	4	%1.0	
4													
0.2	16	14	%1.000	0.0	1	7	0.0	7	3	0.00	4	%1.0	
4													
0.3	37	14	%1.000	0.0	1	12	0.0	12	5	0.00	4	.9	
4													
0.4	65	14	%1.000	0.0	1	16	0.0	16	7	0.00	5	.8	
5													
0.5	102	14	%1.000	0.0	1	22	0.0	22	8	0.00	6	.7	
6													
0.6	147	14	%1.000	0.0	1	28	0.0	28	10	0.00	7	.6	
7													
0.7	200	14	%1.000	0.0	1	35	0.0	35	12	0.00	8	.6	
8													
0.8	261	14	.999	0.1	1	43	0.0	43	13	0.00	9	.5	9
0.9	330	14	.994	0.5	1	54	0.1	54	15	0.00	12	.4	12
1.0	408	14	.976	1.9	1	67	0.3	67	17	0.00	15	.4	15
1.1	493	14	.931	4.9	1	84	1.0	83	18	0.00	20	.3	20
1.2	587	14	.851	9.9	1	108	2.4	105	20	99.78	27	.3	27
1.3	689	14	.737	16.7	1	141	5.2	134	22	100.00	40	.3	39
1.4	799	14	.601	24.6	2	190	9.4	173	23	100.00	60	.2	59
1.5	917	14	.463	32.9	2	267	15.2	227	25	100.00	94	.2	94
1.6	1044	14	.337	41.2	4	393	22.6	305	27	99.95	158	.2	157
1.7	1178	14	.233	49.0	6	612	31.0	422	28	99.76	280	.2	278
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

1.9	1472	14	.057	62.5	17	1765	48.6	909	32	99.54	990	.2	992
2.0	1630	14	.059	67.8	31	3262	56.5	1418	33	99.67	1988	.2	1976
2.1	1798	14	.035	72.4	60	6244	63.4	2286	35	99.79	3976	.1	3970
2.2	1973	14	.020	76.4	119	12302	69.1	3795	37	99.89	8140	.1	8127
2.3	2156	14	.011	79.8	244	24900	74.0	6481	38	99.94	17057	.1	17029
2.4	2348	14	.006	82.6	512	51650	78.0	11372	40	99.97	36442	.1	36382
2.5	2548	14	.003	85.0	1093	109428	81.3	20457	42	99.99	79115	.1	78985

S=20% F=0.30

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 2.00 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 80 PCF, WATER CONT.= 37.7% C/L=.0076 L=4124 KF=1.18
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 80 PCF WATER CONT.= 37.7% C/L=.0076 L=4124 KF=1.18

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 20%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.30,
LAMBDA*SQRIN-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) < 0.90 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

					COVER THERMAL PROPERTIES IN H3 (R1.3=1)						WST'PILE	
F	DEG*DAYS		PROB.		YEARS				PROB.%	YEARS FT		YEARS
H1	TCAVG&CV%	FPAVG&CV%			FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
0.1	5	14	%1.000	0.0	1	2	0.0	2	1	0.00	2	.9	
2													
0.2	21	14	%1.000	0.0	1	4	0.0	4	2	0.00	2	.8	
2													
0.3	48	14	%1.000	0.0	1	7	0.0	7	3	0.00	3	.7	
3													
0.4	85	14	%1.000	0.0	1	10	0.0	10	3	0.00	3	.7	
3													
0.5	133	14	%1.000	0.0	1	13	0.0	13	4	0.00	4	.6	
4													
0.6	192	14	%1.000	0.0	1	17	0.0	17	5	0.00	4	.5	
4													
0.7	261	14	.999	0.1	1	22	0.0	22	6	0.00	5	.4	5
0.8	341	14	.993	0.6	1	28	0.1	28	7	0.00	7	.4	7
0.9	432	14	.966	2.5	1	36	0.5	36	8	0.00	9	.3	9
1.0	533	14	.901	6.8	1	47	1.5	46	8	0.00	13	.3	13
1.1	645	14	.789	13.6	1	63	3.9	60	9	0.00	19	.2	19
1.2	767	14	.640	22.3	2	87	8.1	80	10	3.82	30	.2	30
1.3	900	14	.482	31.8	2	128	14.5	109	11	93.29	51	.2	50
1.4	1044	14	.336	41.3	4	199	22.9	154	12	98.52	93	.2	92
1.5	1199	14	.220	50.1	6	337	32.8	226	13	98.56	182	.2	181
1.6	1364	14	.135	58.0	11	610	42.9	348	13	98.55	364	.1	363
1.7	1540	14	.079	64.8	22	1168	52.3	557	14	98.89	754	.1	753
1.8	1726	14	.044	70.5	45	2364	60.6	931	15	99.32	1636	.1	1633

2.0	2151	14	.012	75.4	221	11163	75.4	2966	17	99.82	6383	.1	6383
2.1	2350	14	.006	82.6	515	25692	78.1	5630	18	99.92	20476	.1	20432
2.2	2579	14	.003	85.4	1229	60857	81.8	11054	18	99.97	49853	.1	49746
2.3	2818	14	.001	87.6	2991	147468	84.8	22344	19	99.99	123370	.1	123108
2.4	3069	14	.001	89.5	7402	363779	87.3	46270	20	99.99	309251	.1	308598
2.5	3330	14	.000	91.0	18555	909879	89.3	97754	21	100.00	782949	.1	781327

S=30% F=0.30

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 2.00 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 70 PCF, WATER CONT.= 47.9% C/L=.0068 L=4590 KF=1.23
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 70 PCF WATER CONT.= 47.9% C/L=.0068 L=4590 KF=1.23

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 30%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.30,
LAMEDA*SQRIN-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.80 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT	DEG*DAYS		PROB.		COVER THERMAL PROPERTIES IN H3 (R1.3=1)						WST'PILE	
					-------- YEARS					PROB.%	YEARS FT	YEARS
H1	TCAVG&CV%		FPAVG&CV%		FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA H3M	DELTA
0.1	7	14	%1.000	0.0	1	2	0.0	2	1	0.00	2 .8	
2												
0.2	27	14	%1.000	0.0	1	3	0.0	3	1	0.00	2 .7	
2												
0.3	60	14	%1.000	0.0	1	5	0.0	5	2	0.00	2 .6	
2												
0.4	107	14	%1.000	0.0	1	7	0.0	7	2	0.00	2 .6	
2												
0.5	167	14	%1.000	0.0	1	10	0.0	10	3	0.00	3 .5	
3												
0.6	240	14	%1.000	0.0	1	14	0.0	14	3	0.00	4 .4	
4												
0.7	327	14	.995	0.5	1	18	0.1	18	4	0.00	5 .3	5
0.8	427	14	.968	2.4	1	24	0.4	24	4	0.00	7 .3	7
0.9	540	14	.895	7.2	1	32	1.7	32	5	0.00	10 .2	10
1.0	667	14	.763	15.2	1	45	4.6	43	6	0.00	15 .2	15
1.1	807	14	.591	25.2	2	66	10.0	59	6	0.00	26 .2	26
1.2	961	14	.417	35.9	3	104	18.2	85	7	57.97	50 .2	50
1.3	1128	14	.269	46.2	5	179	28.5	128	7	93.96	100 .1	100
1.4	1308	14	.160	55.5	9	334	39.6	201	8	96.81	209 .1	208
1.5	1501	14	.089	63.4	19	672	50.4	334	8	97.89	468 .1	467
1.6	1708	14	.047	70.0	42	1462	59.9	586	9	98.80	1112 .1	1109
1.7	1928	14	.023	75.5	100	3403	67.9	1092	9	99.41	2770 .1	2763
1.8	2162	14	.011	79.9	249	8372	74.3	2154	10	99.74	7169 .1	7149

2.1	2942	14	.001	88.6	4696	155788	86.2	21491	12	99.98	145065	.1	144680
2.2	3229	14	.000	90.5	13056	432752	88.6	49285	12	99.99	408864	.1	407799
2.3	3529	14	.000	92.0	36798	1219272	90.5	%115502	13	100.00	1164178	.1	116121
7													
2.4	3843	14	.000	93.2	104776	3470771	92.1	%275406	13	100.00	3338820	.1	333051
7													
2.5	4170	14	.000	94.2	300496	9950823	93.3	%665722	14	100.00	9621284	.1	959803
4													

S=40% F=0.30

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 2.00 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 60 PCF, WATER CONT.= 61.6% C/L=.0062 L=5057 KF=1.30
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 60 PCF WATER CONT.= 61.6% C/L=.0062 L=5057 KF=1.30

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 40%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.30,
LAMBDA*SQRIN-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (1.90 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

					COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE	
FT	DEG*DAYS	PROB.			--------- YEARS					PROB.%	YEARS FT		YEARS
H1	TCAVG&CV%	FPAVG&CV%			FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
0.1	8 14	%1.000	0.0		1	1	0.0	1	0	0.00	1	.7	
1													
0.2	32 14	%1.000	0.0		1	3	0.0	3	1	0.00	2	.6	
2													
0.3	72 14	%1.000	0.0		1	4	0.0	4	1	0.00	2	.6	
2													
0.4	128 14	%1.000	0.0		1	6	0.0	6	2	0.00	2	.5	
2													
0.5	201 14	%1.000	0.0		1	9	0.0	9	2	0.00	3	.4	
3													
0.6	289 14	.998	0.2		1	12	0.0	12	3	0.00	4	.3	4
0.7	393 14	.981	1.5		1	16	0.3	16	3	0.00	5	.3	5
0.8	514 14	.917	5.8		1	22	1.3	22	3	0.00	7	.2	7
0.9	650 14	.782	14.0		1	32	4.2	31	4	0.00	12	.2	12
1.0	803 14	.597	24.8		2	49	10.0	44	4	0.00	22	.2	22
1.1	971 14	.406	36.6		3	82	19.0	66	5	11.73	43	.1	43
1.2	1156 14	.248	47.8		5	148	30.4	103	5	85.93	90	.1	90
1.3	1356 14	.138	57.7		11	297	42.5	171	5	95.06	207	.1	206
1.4	1573 14	.071	65.9		25	658	54.1	302	6	97.42	515	.1	514
1.5	1806 14	.034	72.6		62	1600	63.9	578	6	98.76	1369	.1	1364
1.6	2055 14	.016	78.0		164	4196	71.7	1186	7	99.48	3822	.1	3810
1.7	2319 14	.007	82.2		459	11659	77.8	2592	7	99.80	11104	.1	11068
1.8	2600 14	.003	85.6		1332	33831	82.3	5973	8	99.93	33242	.1	33135
1.9	2897 14	.001	88.2		3989	101359	85.8	14353	8	99.98	101814	.1	101489

2.1 3339 14 .000 92.0 38039 969423 90.8 90834 9 100.00 1000010 .1 996930
2.2 3884 14 .000 93.4 120001 3059080 92.3 %236266 9 100.00 3179301 .1 316986
9
2.3 4246 14 .000 94.4 381516 9728694 93.6 %624038 10 100.00 %10159930 .1 %101
30630
2.4 4623 14 .000 95.3 %1219190 21675210 94.3 %1227600 10 100.00 %13733090 .4 4
385964
2.5 5016 14 .000 96.0 %3906034 30734730 94.7 %1635831 10 100.00 4385964 %1.9 4
385964

S=50% F=0.30

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZSY -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 2.00 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 50 PCF, WATER CONT.= 80.7% C/L=.0057 L=5523 KF=1.42
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 50 PCF WATER CONT.= 80.7% C/L=.0057 L=5523 KF=1.42

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 50%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.30,
LAMBDA*SQRIN-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (1.90 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

					COVER THERMAL PROPERTIES IN H3 (R1.3=1)						WST'PILE	
F.	DEG*DAYS		PROB.		---------- YEARS					PROB.%	YEARS FT	YEARS
H1	TCAVG&CV%		FPAVG&CV%		FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA H3M	DELTA
0.1	9	14	%1.000	0.0	1	1	0.0	1	0	0.00	1 .7	
1												
0.2	37	14	%1.000	0.0	1	2	0.0	2	1	0.00	1 .6	
1												
0.3	83	14	%1.000	0.0	1	4	0.0	4	1	0.00	2 .5	
2												
0.4	148	14	%1.000	0.0	1	6	0.0	6	1	0.00	2 .4	
2												
0.5	231	14	%1.000	0.0	1	8	0.0	8	2	0.00	3 .4	
3												
0.6	333	14	.994	0.5	1	11	0.1	11	2	0.00	4 .3	3
0.7	453	14	.956	3.3	1	15	0.7	15	2	0.00	5 .2	5
0.8	592	14	.846	10.2	1	22	2.8	22	3	0.00	8 .2	8
0.9	749	14	.663	21.0	2	34	7.8	31	3	0.00	15 .2	15
1.0	925	14	.454	33.5	2	57	16.5	48	3	0.00	31 .1	31
1.1	1119	14	.275	45.7	5	105	28.1	76	4	56.99	66 .1	66
1.2	1332	14	.149	56.6	10	218	41.2	128	4	91.33	159 .1	159
1.3	1563	14	.073	65.6	24	509	53.7	236	4	96.40	424 .1	422
1.4	1813	14	.033	72.8	64	1328	64.3	474	5	98.44	1214 .1	1209
1.5	2081	14	.014	78.5	182	3775	72.6	1035	5	99.40	3680 .1	3666
1.6	2368	14	.006	82.9	552	11439	78.8	2428	5	99.79	11648 .1	11605
1.7	2673	14	.002	86.3	1747	36308	83.4	6031	6	99.93	38090 .1	37949
1.8	2997	14	.001	89.0	5714	119141	86.8	15670	6	99.98	127576 .1	127111
1.9	3339	14	.000	91.1	19136	400277	89.5	42144	6	99.99	434695 .1	433147
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7	100.00	1498726 .1	1493[illegible]

```
2.1  4079 14 .000 94.0 224809  4719376 93.1 %327919   7 100.00 5206050 .1 518858
2
2.2  4476 14 .000 95.0 780906 12701350 94.1 %753296   7 100.00 %10757900 .4 %108
94860
2.3  4893 14 .000 95.8 %2723563 19834690 94.5 %1095091   8 100.00 3508771 %1.9 3
508771
2.4  5327 14 .000 93.5 %5166669 23343460 94.5 %1281440   8 100.00 3508771 %1.9 3
508771
2.5  5780 14 .000 82.1 %5491672 26852230 93.6 %1708770   8 100.00 3508771 %1.9 3
508771

UPFREEZ5 RUN COMPLETE
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********** PROGRAM UPFREEZ5Y **********

SAVED UNDER FILE NAME: UPF1-5Y DATE: 04-08-1987

TIME: 12:11:41

PROBABILISTIC GEOTECHNICAL THERMAL ANALYSIS
1-LAYER FINE-GRAINED COVER SYSTEM

MODIFIED BERGGREN EQUATION WITH KERSTEN K'S

PROPERTIES OF COVER

COVER LAYER DRY DENSITY=100 PCF, WATER CONTENT =20.3% (80% SAT) 100% S=25.4%
AVERAGE HEAVE STRAIN = 10% TO 50%
FRACTION OF HEAVE NOT RECOVERED ON THAWING (R) = 0.10 TO 0.50
LAMBDA*SQR[N-FACTOR]: AVG=0.48; SD=0.00
(COVER AND WASTE PILE USE THE SAME VALUES)

PROPERTIES OF WASTE PILE

FINE-GRAINED SOIL
UNFROZEN DRY DENSITY = 100. [PCF], WATER CONTENT = 20% (80% SAT) 100% S=25.4%
AVERAGE HEAVE STRAIN = 10% TO 50%
FRACTION OF HEAVE NOT RECOVERED ON THAWING (R) = 0.10 TO 0.50

THERMAL LOAD INFORMATION

FREEZE INDEX (FI) FOR WAUKEKGAN ASSUMED LOGNORMAL WITH MEAN & STANDARD DEVIATION
FROM HISTORICAL DATA 1949-50 TO 1984-85 EXCEPT 1982-83 (TOTAL = 35 YEARS)
LOGNORMAL FREEZE INDEX (THERMAL LOAD): MEAN=848, MEDIAN=800, SD=320, CV=0.378,
SD[LN FI]=0.365, SKEWNESS=1.277 HOWEVER:
CONSERVATIVE LOGNORMAL ENVELOPE USED FOR FREEZE INDEX: MEDIAN = 875, MEAN = 935
SD[LN FI] =0.365
ALL YEARS HAVE HISTORICAL FI FREQUENCY (= FORCASTED (PREDICTED) PROBABILITIES
(1983-84 [FI=1200] LIES ON THE ENVELOPE ALL OTHER YEARS ARE BELOW)

OBJECT UPFREEZING INFORMATION--EQUATION: U = (X - A - T) * S * R * C

UPFREEZING ASSUMPTIONS:
EFFECTIVE PARTICLE SIZE (X - A) IS EPS.UF = 0.10 FT ← Looking for effect of small particles
AVERAGE HEAVE STRAIN (S) = 10 % TO 50 %
FRACTION OF HEAVE NOT RECOVERED ON THAWING (R) = 0.10 TO 0.50
EFFECTIVE NUMBER OF COMPLETE FREEZE THAW CYCLES (C) = NUMBER OF FREEZE SEASONS
(YEARS) * P.H3

*NOTE: BOTH C AND P.H3 ARE DEPTH DEPENDENT

S=10% F=0.10

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 90 PCF, WATER CONT.= 29.7% C/L=.0085 L=3658 KF=1.15
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 90 PCF WATER CONT.= 29.7% C/L=.0085 L=3658 KF=1.15

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 10%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.10,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FI	DEG*DAYS		PROB.		COVER THERMAL PROPERTIES IN H3 (R1.3=1)						WST'PILE		
					--------- YEARS			---------- PROB.%			YEARS FT		YEARS
H1	TCAVG	&CV%	FPAVG	&CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	408	14	.976	1.9	1	1007	0.2	1005	%1000	100.00	108	.1	10
8													
1.1	493	14	.931	4.9	1	1120	0.5	1115	%1100	100.00	119	.1	11
9													
1.2	587	14	.851	9.9	1	1249	1.2	1234	%1200	100.00	140	.1	14
0													
1.3	689	14	.737	16.7	1	1408	2.6	1371	%1300	100.00	177	.1	17
7													
1.4	799	14	.601	24.6	2	1617	5.0	1536	%1400	100.00	242	.1	24
2													
1.5	917	14	.463	32.9	2	1917	8.9	1747	%1500	100.00	357	.1	35
7													
1.6	1044	14	.337	41.2	4	2378	14.5	2033	%1600	100.00	564	.1	56
4													
1.7	1178	14	.233	49.0	6	3134	22.1	2440	%1700	100.00	948	.1	94
6													
1.8	1321	14	.154	56.1	9	4447	31.4	3050	%1800	100.00	1677	.1	167
5													
1.9	1472	14	.097	62.3	17	6840	41.5	4004	%1900	100.00	3109	.1	310
4													
2.0	1630	14	.059	67.8	31	11389	51.2	5556	%2000	100.00	5989	.1	598
0													
2.1	1798	14	.035	72.4	60	20347	59.9	8166	%2100	100.00	11927	.1	1190
9													

0

2.3 2156 14 .011 79.8 244 76316 72.8 20749 %2300 100.00 51171 .1 5108
8

2.4 2348 14 .006 82.6 512 156564 77.4 35422 %2400 100.00 109325 .1 10914
5

2.5 2548 14 .003 85.0 1093 329899 81.0 62679 %2500 100.00 237345 .1 23695
5

S=10% F=0.20

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 90 PCF, WATER CONT.= 29.7% C/L=.0085 L=3658 KF=1.15
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 90 PCF WATER CONT.= 29.7% C/L=.0085 L=3658 KF=1.15

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 10%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.20,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

					COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE	
FI	DEG*DAYS		PROB.			YEARS				PROB.%	YEARS FT		YEARS
H1	TCAVG	&CV%	FPAVG	&CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	408	14	.976	1.9	1	503	0.2	503	500	100.00	54	.1	54
1.1	493	14	.931	4.9	1	560	0.5	557	550	100.00	59	.1	59
1.2	587	14	.851	9.9	1	625	1.2	617	600	100.00	70	.1	70
1.3	689	14	.737	16.7	1	704	2.6	685	650	100.00	88	.1	88
1.4	799	14	.601	24.6	2	809	5.0	768	700	100.00	121	.1	121
1.5	917	14	.463	32.9	2	959	8.9	874	750	100.00	179	.1	179
1.6	1044	14	.337	41.2	4	1189	14.5	1016	800	100.00	282	.1	282
1.7	1178	14	.233	49.0	6	1567	22.1	1220	850	100.00	474	.1	473
1.8	1321	14	.154	56.1	9	2223	31.4	1525	900	100.00	839	.1	838
1.9	1472	14	.097	62.3	17	3420	41.5	2002	950	100.00	1554	.1	1552
2.0	1630	14	.059	67.8	31	5694	51.2	2778	%1000	100.00	2995	.1	299
0													
2.1	1798	14	.035	72.4	60	10173	59.9	4083	%1050	100.00	5964	.1	595
4													
2.2	1973	14	.020	76.4	119	19260	67.1	6346	%1100	100.00	12210	.1	1219
0													
2.3	2156	14	.011	79.8	244	38158	72.8	10374	%1150	100.00	25586	.1	2554
4													
2.4	2348	14	.006	82.6	512	78282	77.4	17711	%1200	100.00	54663	.1	5457
3													
2.5	2548	14	.003	85.0	1093	164950	81.0	31339	%1250	100.00	118673	.1	11847
7													

S=10% F=0.30

THERMAL AND UPFREEZING ANALYSIS ESTIMATES — PROGRAM UPFREEZ5Y — 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER — PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE—BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 90 PCF, WATER CONT.= 29.7% C/L=.0085 L=3658 KF=1.15
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL—HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 90 PCF WATER CONT.= 29.7% C/L=.0085 L=3658 KF=1.15

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 10%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.30,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT	DEG*DAYS		PROB.		COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE	
					--------- YEARS					PROB.%	YEARS FT		YEARS
H1	TCAVG	CV%	FPAVG	CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	408	14	.976	1.9	1	336	0.2	335	333	100.00	36	.1	36
1.1	493	14	.931	4.9	1	373	0.5	372	367	100.00	40	.1	40
1.2	587	14	.851	9.9	1	416	1.2	411	400	100.00	47	.1	47
1.3	689	14	.737	16.7	1	469	2.6	457	433	100.00	59	.1	59
1.4	799	14	.601	24.6	2	539	5.0	512	467	100.00	81	.1	81
1.5	917	14	.463	32.9	2	639	8.9	582	500	100.00	119	.1	119
1.6	1044	14	.337	41.2	4	793	14.5	678	533	100.00	188	.1	188
1.7	1178	14	.233	49.0	6	1045	22.1	813	567	100.00	316	.1	315
1.8	1321	14	.154	56.1	9	1482	31.4	1017	600	100.00	559	.1	558
1.9	1472	14	.097	62.3	17	2280	41.5	1335	633	100.00	1036	.1	1035
2.0	1630	14	.059	67.8	31	3796	51.2	1852	667	100.00	1996	.1	1993
2.1	1798	14	.035	72.4	60	6782	59.9	2722	700	100.00	3976	.1	3970
2.2	1973	14	.020	76.4	119	12840	67.1	4231	733	100.00	8140	.1	8127
2.3	2156	14	.011	79.8	244	25439	72.8	6916	767	100.00	17057	.1	17029
2.4	2348	14	.006	82.6	512	52188	77.4	11807	800	100.00	36442	.1	36382
2.5	2548	14	.003	85.0	1093	109966	81.0	20893	833	100.00	79115	.1	78985

THERMAL AND UPFREEZING ANALYSIS ESTIMATES — PROGRAM UPFREEZ5Y — 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER — PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE—BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] — FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 90 PCF, WATER CONT.= 29.7% C/L=.0085 L=3658 KF=1.15
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL—HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 90 PCF WATER CONT.= 29.7% C/L=.0085 L=3658 KF=1.15

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 10%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.40,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

					COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE	
FT	DEG*DAYS		PROB.		——— YEARS ———					PROB.%	YEARS FT		YEARS
H1	TCAVG	CV%	FPAVG	CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	408	14	.976	1.9	1	252	0.2	251	250	100.00	27	.1	27
1.1	493	14	.931	4.9	1	280	0.5	279	275	100.00	30	.1	30
1.2	587	14	.851	9.9	1	312	1.2	309	300	100.00	35	.1	35
1.3	689	14	.737	16.7	1	352	2.6	343	325	100.00	44	.1	44
1.4	799	14	.601	24.6	2	404	5.0	384	350	100.00	61	.1	61
1.5	917	14	.463	32.9	2	479	8.9	437	375	100.00	89	.1	89
1.6	1044	14	.337	41.2	4	595	14.5	508	400	100.00	141	.1	141
1.7	1178	14	.233	49.0	6	784	22.1	610	425	100.00	237	.1	237
1.8	1321	14	.154	56.1	9	1112	31.4	763	450	100.00	419	.1	419
1.9	1472	14	.097	62.3	17	1710	41.5	1001	475	100.00	777	.1	776
2.0	1630	14	.059	67.8	31	2847	51.2	1389	500	100.00	1497	.1	1495
2.1	1798	14	.035	72.4	60	5087	59.9	2042	525	100.00	2982	.1	2977
2.2	1973	14	.020	76.4	119	9630	67.1	3173	550	100.00	6105	.1	6095
2.3	2156	14	.011	79.8	244	19079	72.8	5187	575	100.00	12793	.1	12772
2.4	2348	14	.006	82.6	512	39141	77.4	8855	600	100.00	27331	.1	27286
2.5	2548	14	.003	85.0	1093	82475	81.0	15670	625	100.00	59336	.1	59239

S=10% F=0.50

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE—BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 90 PCF, WATER CONT.= 29.7% C/L=.0085 L=3658 KF=1.15
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL—HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 90 PCF WATER CONT.= 29.7% C/L=.0085 L=3658 KF=1.15

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 10%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.50,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT	DEG*DAYS	PROB.			COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE		
					---------- YEARS					PROB.%		YEARS	FT	YEARS
H1	TCAVG&CV%		FPAVG&CV%		FPY	UP.YRS	CV%	LBOND	ABD	R100		DELTA	H3M	DELTA
1.0	408	14	.976	1.9	1	201	0.2	201	200	100.00		22	.1	22
1.1	493	14	.931	4.9	1	224	0.5	223	220	100.00		24	.1	24
1.2	587	14	.851	9.9	1	250	1.2	247	240	100.00		28	.1	28
1.3	689	14	.737	16.7	1	282	2.6	274	260	100.00		35	.1	35
1.4	799	14	.601	24.6	2	323	5.0	307	280	100.00		48	.1	48
1.5	917	14	.463	32.9	2	383	8.9	349	300	100.00		71	.1	71
1.6	1044	14	.337	41.2	4	476	14.5	407	320	100.00		113	.1	113
1.7	1178	14	.233	49.0	6	627	22.1	488	340	100.00		190	.1	189
1.8	1321	14	.154	56.1	9	889	31.4	610	360	100.00		335	.1	335
1.9	1472	14	.097	62.3	17	1368	41.5	801	380	100.00		622	.1	621
2.0	1630	14	.059	67.8	31	2278	51.2	1111	400	100.00		1198	.1	1196
2.1	1798	14	.035	72.4	60	4069	59.9	1633	420	100.00		2385	.1	2382
2.2	1973	14	.020	76.4	119	7704	67.1	2538	440	100.00		4884	.1	4876
2.3	2156	14	.011	79.8	244	15263	72.8	4150	460	100.00		10234	.1	10218
2.4	2348	14	.006	82.6	512	31313	77.4	7084	480	100.00		21865	.1	21829
2.5	2548	14	.003	85.0	1093	65980	81.0	12536	500	100.00		47469	.1	47391

S=20% F=0.10

THERMAL AND UPFREEZING ANALYSIS ESTIMATES — PROGRAM UPFREEZSY — 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER — PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] — FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 80 PCF, WATER CONT.= 37.7% C/L=.0076 L=4124 KF=1.18
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 80 PCF WATER CONT.= 37.7% C/L=.0076 L=4124 KF=1.18

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 20%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.10,
LAMBDA*SQRIN-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

					COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE	
FT	DEG*DAYS		PROB.			YEARS				PROB.%	YEARS	FT	YEARS
H1	TCAVG&CV%		FPAVG&CV%		FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	533	14	.901	6.8	1	515	0.8	511	500	100.00	65	.1	65
1.1	645	14	.789	13.6	1	589	2.0	577	550	100.00	82	.1	82
1.2	767	14	.640	22.3	2	687	4.4	657	600	100.00	116	.1	115
1.3	900	14	.482	31.8	2	835	8.6	763	650	100.00	179	.1	179
1.4	1044	14	.336	41.3	4	1076	15.1	913	700	100.00	304	.1	303
1.5	1199	14	.220	50.1	6	1507	24.2	1142	750	100.00	557	.1	556
1.6	1364	14	.135	58.0	11	2331	35.2	1510	800	100.00	1091	.1	1090
1.7	1540	14	.079	64.8	22	4007	46.7	2137	850	100.00	2262	.1	2258
1.8	1726	14	.044	70.5	45	7593	57.1	3259	900	100.00	4909	.1	4899
1.9	1923	14	.024	75.4	98	15583	65.7	5346	950	100.00	11070	.1	11046
2.0	2131	14	.012	79.4	221	33992	72.4	9368	%1000	100.00	25749	.1	2569
4													
2.1	2350	14	.006	82.6	515	77579	77.6	17356	%1050	100.00	61427	.1	6129
5													
2.2	2579	14	.003	85.4	1229	183072	81.6	33628	%1100	100.00	149558	.1	14923
7													
2.3	2818	14	.001	87.6	2991	442906	84.8	67496	%1150	100.00	370111	.1	36932
3													
2.4	3069	14	.001	89.5	7402	1091838	87.2	%139275	%1200	100.00	927752	.1	925
796													
2.5	3330	14	.000	91.0	18555	2730138	89.2	%293729	%1250	100.00	2348848	.1	2343
980													

S=20% F=0.20

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZSY — 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] — FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 80 PCF, WATER CONT.= 37.7% C/L=.0076 L=4124 KF=1.18
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
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BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 20%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.20,
LAMBDA*SQRIN-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT	ÆG*DAYS		PROB.		COVER THERMAL PROPERTIES IN H3 (R1.3=1)					PROB.%	WST'PILE		
					YEARS						YEARS	FT	YEARS
H1	TCAVG	&CV%	FPAVG	&CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	533	14	.901	6.8	1	258	0.8	256	250	100.00	32	.1	32
1.1	645	14	.789	13.6	1	294	2.0	288	275	100.00	41	.1	41
1.2	767	14	.640	22.3	2	344	4.4	329	300	100.00	58	.1	58
1.3	900	14	.482	31.8	2	417	8.6	382	325	100.00	90	.1	89
1.4	1044	14	.336	41.3	4	538	15.1	457	350	100.00	152	.1	152
1.5	1199	14	.220	50.1	6	753	24.2	571	375	100.00	278	.1	278
1.6	1364	14	.135	58.0	11	1165	35.2	755	400	100.00	546	.1	545
1.7	1540	14	.079	64.8	22	2004	46.7	1069	425	100.00	1131	.1	1129
1.8	1726	14	.044	70.5	45	3797	57.1	1629	450	100.00	2455	.1	2450
1.9	1923	14	.024	75.4	98	7791	65.7	2673	475	100.00	5535	.1	5523
2.0	2131	14	.012	79.4	221	16996	72.4	4684	500	100.00	12874	.1	12847
2.1	2350	14	.006	82.6	515	38790	77.6	8678	525	100.00	30713	.1	30647
2.2	2579	14	.003	85.4	1229	91536	81.6	16814	550	100.00	74779	.1	74619
2.3	2818	14	.001	87.6	2991	221453	84.8	33748	575	100.00	185056	.1	184661
2.4	3069	14	.001	89.5	7402	545919	87.2	69638	600	100.00	463876	.1	462898
2.5	3330	14	.000	91.0	18555	1365069	89.2	%146864	625	100.00	1174424	.1	117199
0													

S=20% F=0.30

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

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H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
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FROZEN DRY DENS. = 80 PCF, WATER CONT.= 37.7% C/L=.0076 L=4124 KF=1.18
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
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BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 20%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.30,
LAMBDA*SQRIN-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT	DEG*DAYS		PROB.		COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE	
					---------- YEARS					PROB.%	YEARS	FT	YEARS
H1	TCAVG	&CV%	FPAVG	&CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	533	14	.901	6.8	1	172	0.8	170	167	100.00	22	.1	22
1.1	645	14	.789	13.6	1	196	2.0	192	183	100.00	27	.1	27
1.2	767	14	.640	22.3	2	229	4.4	219	200	100.00	39	.1	38
1.3	900	14	.482	31.8	2	278	8.6	254	217	100.00	60	.1	60
1.4	1044	14	.336	41.3	4	359	15.1	304	233	100.00	101	.1	101
1.5	1199	14	.220	50.1	6	502	24.2	381	250	100.00	186	.1	185
1.6	1364	14	.135	58.0	11	777	35.2	503	267	100.00	364	.1	363
1.7	1540	14	.079	64.8	22	1336	46.7	712	283	100.00	754	.1	753
1.8	1726	14	.044	70.5	45	2531	57.1	1086	300	100.00	1636	.1	1633
1.9	1923	14	.024	75.4	98	5194	65.7	1782	317	100.00	3690	.1	3682
2.0	2131	14	.012	79.4	221	11331	72.4	3123	333	100.00	8583	.1	8565
2.1	2350	14	.006	82.6	515	25860	77.6	5785	350	100.00	20476	.1	20432
2.2	2579	14	.003	85.4	1229	61024	81.6	11209	367	100.00	49853	.1	49746
2.3	2818	14	.001	87.6	2991	147635	84.8	22499	383	100.00	123370	.1	123108
2.4	3069	14	.001	89.5	7402	363946	87.2	46425	400	100.00	309251	.1	308599
2.5	3330	14	.000	91.0	18555	910046	89.2	97910	417	100.00	782949	.1	781327

S=20% F=0.40

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 80 PCF, WATER CONT.= 37.7% C/L=.0076 L=4124 KF=1.18
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 80 PCF WATER CONT.= 37.7% C/L=.0076 L=4124 KF=1.18

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 20%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.40,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT	DEG*DAYS		PROB.		COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE	
					---------- YEARS ----------					PROB.%	YEARS	FT	YEARS
H1	TCAVG	&CV%	FPAVG	&CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	533	14	.901	6.8	1	129	0.8	128	125	100.00	16	.1	16
1.1	645	14	.789	13.6	1	147	2.0	144	138	100.00	21	.1	21
1.2	767	14	.640	22.3	2	172	4.4	164	150	100.00	29	.1	29
1.3	900	14	.482	31.8	2	209	8.6	191	163	100.00	45	.1	45
1.4	1044	14	.336	41.3	4	269	15.1	228	175	100.00	76	.1	76
1.5	1199	14	.220	50.1	6	377	24.2	285	188	100.00	139	.1	139
1.6	1364	14	.135	58.0	11	583	35.2	377	200	100.00	273	.1	272
1.7	1540	14	.079	64.8	22	1002	46.7	534	213	100.00	565	.1	564
1.8	1726	14	.044	70.5	45	1898	57.1	815	225	100.00	1227	.1	1225
1.9	1923	14	.024	75.4	98	3896	65.7	1336	238	100.00	2767	.1	2762
2.0	2131	14	.012	79.4	221	8498	72.4	2342	250	100.00	6437	.1	6423
2.1	2350	14	.006	82.6	515	19395	77.6	4339	263	100.00	15357	.1	15324
2.2	2579	14	.003	85.4	1229	45768	81.6	8407	275	100.00	37390	.1	37309
2.3	2818	14	.001	87.6	2991	110727	84.8	16874	288	100.00	92528	.1	92331
2.4	3069	14	.001	89.5	7402	272960	87.2	34819	300	100.00	231938	.1	231449
2.5	3330	14	.000	91.0	18555	682535	89.2	73432	313	100.00	587212	.1	585995

S=20% F=0.50

THERMAL AND UPFREEZING ANALYSIS ESTIMATES — PROGRAM UPFREEZ5Y — 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER — PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE—BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] — FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 80 PCF, WATER CONT.= 37.7% C/L=.0076 L=4124 KF=1.18
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL—HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 80 PCF WATER CONT.= 37.7% C/L=.0076 L=4124 KF=1.18

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 20%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.50,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

					COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE	
FT	DEG*DAYS		PROB.		——— YEARS ———					PROB.%	YEARS FT		YEARS
H1	TCAVG	&CV%	FPAVG	&CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	533	14	.901	6.8	1	103	0.8	102	100	100.00	13	.1	13
1.1	645	14	.789	13.6	1	118	2.0	115	110	100.00	16	.1	16
1.2	767	14	.640	22.3	2	137	4.4	131	120	100.00	23	.1	23
1.3	900	14	.482	31.8	2	167	8.6	153	130	100.00	36	.1	36
1.4	1044	14	.336	41.3	4	215	15.1	183	140	100.00	61	.1	61
1.5	1199	14	.220	50.1	6	301	24.2	228	150	100.00	111	.1	111
1.6	1364	14	.135	58.0	11	466	35.2	302	160	100.00	218	.1	218
1.7	1540	14	.079	64.8	22	801	46.7	427	170	100.00	452	.1	452
1.8	1726	14	.044	70.5	45	1519	57.1	652	180	100.00	982	.1	980
1.9	1923	14	.024	75.4	98	3117	65.7	1069	190	100.00	2214	.1	2209
2.0	2131	14	.012	79.4	221	6798	72.4	1874	200	100.00	5150	.1	5139
2.1	2350	14	.006	82.6	515	15516	77.6	3471	210	100.00	12285	.1	12259
2.2	2579	14	.003	85.4	1229	36614	81.6	6726	220	100.00	29912	.1	29847
2.3	2818	14	.001	87.6	2991	88581	84.8	13499	230	100.00	74022	.1	73865
2.4	3069	14	.001	89.5	7402	218368	87.2	27855	240	100.00	185550	.1	185159
2.5	3330	14	.000	91.0	18555	546028	89.2	58746	250	100.00	469770	.1	468796

S=30% F=0.10

THERMAL AND UPFREEZING ANALYSIS ESTIMATES — PROGRAM UPFREEZSY — 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER — PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 70 PCF, WATER CONT.= 47.9% C/L=.0068 L=4590 KF=1.23
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 70 PCF WATER CONT.= 47.9% C/L=.0068 L=4590 KF=1.23

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 30%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.10,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT	DEG*DAYS	PROB.			COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE	
					---------- YEARS			---------- PROB.%			YEARS	FT	YEARS
H1	TCAVG	&CV%	FPAVG	&CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	667	14	.763	15.2	1	364	2.4	355	333	100.00	60	.1	60
1.1	807	14	.591	25.2	2	440	5.7	415	367	100.00	92	.1	92
1.2	961	14	.417	35.9	3	564	11.5	500	400	100.00	158	.1	158
1.3	1128	14	.269	46.2	5	794	20.5	631	433	100.00	301	.1	300
1.4	1308	14	.160	55.5	9	1258	32.3	852	467	100.00	627	.1	625
1.5	1501	14	.089	63.4	19	2273	45.1	1248	500	100.00	1404	.1	1400
1.6	1708	14	.047	70.0	42	4642	56.8	2004	533	100.00	3335	.1	3327
1.7	1928	14	.023	75.5	100	10465	66.3	3524	567	100.00	8310	.1	8288
1.8	2162	14	.011	79.9	249	25373	73.6	6709	600	100.00	21506	.1	21448
1.9	2408	14	.005	83.4	645	64799	79.0	13631	633	100.00	57346	.1	57192
2.0	2669	14	.002	86.3	1720	171747	83.0	29133	667	100.00	156550	.1	156130
2.1	2942	14	.001	88.6	4696	467619	86.2	64720	700	100.00	435194	.1	434041
2.2	3229	14	.000	90.5	13056	1298512	88.6	%148102	733	100.00	1226591	.1	122339
6													
2.3	3529	14	.000	92.0	36798	3658074	90.5	%346754	767	100.00	3492534	.1	348365
1													
2.4	3843	14	.000	93.2	104776	10412570	92.1	%826464	800	100.00	%10016460	.1	9991
550													
2.5	4170	14	.000	94.2	300496	29852730	93.3	%1997413	833	100.00	%28863850	.1	%28
794100													

S=30% F=0.20

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER — PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
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THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] — FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 70 PCF, WATER CONT.= 47.9% C/L=.0068 L=4590 KF=1.23
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
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BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 30%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.20,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
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R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT	DEG*DAYS		PROB.		COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE		
					YEARS					PROB.%		YEARS	FT	YEARS
H1	AVG&CV%		FPAVG&CV%		FPY	UP.YRS	CV%	LBOND	ABD	R100		DELTA	H3M	DELTA
1.0	667	14	.763	15.2	1	182	2.4	177	167	100.00		30	.1	30
1.1	807	14	.591	25.2	2	220	5.7	207	183	100.00		46	.1	46
1.2	961	14	.417	35.9	3	282	11.5	250	200	100.00		79	.1	79
1.3	1128	14	.269	46.2	5	397	20.5	316	217	100.00		150	.1	150
1.4	1308	14	.160	55.5	9	629	32.3	426	233	100.00		313	.1	313
1.5	1501	14	.089	63.4	19	1136	45.1	624	250	100.00		702	.1	700
1.6	1708	14	.047	70.0	42	2321	56.8	1002	267	100.00		1668	.1	1663
1.7	1928	14	.023	75.5	100	5233	66.3	1762	283	100.00		4155	.1	4144
1.8	2162	14	.011	79.9	249	12687	73.6	3354	300	100.00		10753	.1	10724
1.9	2408	14	.005	83.4	645	32400	79.0	6816	317	100.00		28673	.1	28596
2.0	2669	14	.002	86.3	1720	85874	83.0	14566	333	100.00		78275	.1	78065
2.1	2942	14	.001	88.6	4696	233810	86.2	32360	350	100.00		217597	.1	217020
2.2	3229	14	.000	90.5	13056	649256	88.6	74051	367	100.00		613295	.1	611698
2.3	3529	14	.000	92.0	36798	1829037	90.5	%173377	383	100.00		1746267	.1	174182
5														
2.4	3843	14	.000	93.2	104776	5206285	92.1	%413232	400	100.00		5008229	.1	499577
5														
2.5	4170	14	.000	94.2	300436	14926360	93.3	%998706	417	100.00		%14431930	.1	%143
97050														

S=30% F=0.30

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZSY -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
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BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 30%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.30,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
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CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
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R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT	DEG*DAYS		PROB.		COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE	
					---------- YEARS ----------					PROB.%	YEARS FT		YEARS
H1	TCAVG	CV%	FPAVG	CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	667	14	.763	15.2	1	121	2.4	118	111	100.00	20	.1	20
1.1	807	14	.591	25.2	2	147	5.7	138	122	100.00	31	.1	31
1.2	961	14	.417	35.9	3	188	11.5	167	133	100.00	53	.1	53
1.3	1128	14	.269	46.2	5	265	20.5	210	144	100.00	100	.1	100
1.4	1308	14	.160	55.5	9	419	32.3	284	156	100.00	209	.1	208
1.5	1501	14	.089	63.4	19	758	45.1	416	167	100.00	468	.1	467
1.6	1708	14	.047	70.0	42	1547	56.8	668	178	100.00	1112	.1	1109
1.7	1928	14	.023	75.5	100	3488	66.3	1175	189	100.00	2770	.1	2763
1.8	2162	14	.011	79.9	249	8458	73.6	2236	200	100.00	7169	.1	7149
1.9	2408	14	.005	83.4	645	21600	79.0	4544	211	100.00	19115	.1	19064
2.0	2669	14	.002	86.3	1720	57249	83.0	9711	222	100.00	52183	.1	52043
2.1	2942	14	.001	88.6	4696	155873	86.2	21573	233	100.00	145065	.1	144680
2.2	3229	14	.000	90.5	13056	432837	88.6	49367	244	100.00	408864	.1	407799
2.3	3529	14	.000	92.0	36798	1219358	90.5	%115585	256	100.00	1164178	.1	116121
7													
2.4	3843	14	.000	93.2	104776	3470857	92.1	%275488	267	100.00	3338820	.1	333051
7													
2.5	4170	14	.000	94.2	300496	9950909	93.3	%665804	278	100.00	9621285	.1	959803
5													

S=30% F=0.40

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 70 PCF, WATER CONT.= 47.9% C/L=.0068 L=4590 KF=1.23
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 70 PCF WATER CONT.= 47.9% C/L=.0068 L=4590 KF=1.23

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 30%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.40,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

							COVER THERMAL PROPERTIES IN H3 (R1.3=1)						WST'PILE	
FT	DEG*DAYS		PROB.				---------- YEARS ----------				PROB.%	YEARS	FT	YEARS
H1	CAVG	&CV%	FPAVG	&CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100		DELTA	H3M	DELTA
1.0	667	14	.763	15.2	1	91	2.4	89	83	0.00		15	.1	15
1.1	807	14	.591	25.2	2	110	5.7	104	92	94.54		23	.1	23
1.2	961	14	.417	35.9	3	141	11.5	125	100	100.00		39	.1	39
1.3	1128	14	.269	46.2	5	198	20.5	158	108	100.00		75	.1	75
1.4	1308	14	.160	55.5	9	314	32.3	213	117	100.00		157	.1	156
1.5	1501	14	.089	63.4	19	568	45.1	312	125	100.00		351	.1	350
1.6	1708	14	.047	70.0	42	1161	56.8	501	133	100.00		834	.1	832
1.7	1928	14	.023	75.5	100	2616	66.3	881	142	100.00		2078	.1	2072
1.8	2162	14	.011	79.9	249	6343	73.6	1677	150	100.00		5376	.1	5362
1.9	2408	14	.005	83.4	645	16200	79.0	3408	158	100.00		14337	.1	14298
2.0	2669	14	.002	86.3	1720	42937	83.0	7283	167	100.00		39138	.1	39033
2.1	2942	14	.001	88.6	4696	116905	86.2	16180	175	100.00		108798	.1	108510
2.2	3229	14	.000	90.5	13056	324628	88.6	37026	183	100.00		306648	.1	305849
2.3	3529	14	.000	92.0	36798	914519	90.5	86688	192	100.00		873133	.1	870913
2.4	3843	14	.000	93.2	104776	2603143	92.1	%206616	200	100.00		2504115	.1	249788
8														
2.5	4170	14	.000	94.2	300496	7463182	93.3	%499353	208	100.00		7215964	.1	719852
6														

S=30% F=0.50

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y — 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 70 PCF, WATER CONT.= 47.9% C/L=.0068 L=4590 KF=1.23
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 70 PCF WATER CONT.= 47.9% C/L=.0068 L=4590 KF=1.23

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 30%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.50,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

						COVER THERMAL PROPERTIES IN H3 (R1.3=1)						WST'PILE	
FT	EG*DAYS	PROB.				--------- YEARS				---------- PROB.%	YEARS	FT	YEARS
H1	TCAVG&CV%	FPAVG&CV%			FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	667	14 .763	15.2		1	73	2.4	71	67	0.00	12	.1	12
1.1	807	14 .591	25.2		2	88	5.7	83	73	0.79	18	.1	18
1.2	961	14 .417	35.9		3	113	11.5	100	80	84.46	32	.1	32
1.3	1128	14 .269	46.2		5	159	20.5	126	87	97.76	60	.1	60
1.4	1308	14 .160	55.5		9	252	32.3	170	93	99.45	125	.1	125
1.5	1501	14 .089	63.4		19	455	45.1	250	100	100.00	281	.1	280
1.6	1708	14 .047	70.0		42	928	56.8	401	107	100.00	667	.1	665
1.7	1928	14 .023	75.5		100	2093	66.3	705	113	100.00	1662	.1	1658
1.8	2162	14 .011	79.9		249	5075	73.6	1342	120	100.00	4301	.1	4290
1.9	2408	14 .005	83.4		645	12960	79.0	2726	127	100.00	11469	.1	11438
2.0	2669	14 .002	86.3		1720	34349	83.0	5827	133	100.00	31310	.1	31226
2.1	2942	14 .001	88.6		4696	93524	86.2	12944	140	100.00	87039	.1	86808
2.2	3229	14 .000	90.5		13056	259702	88.6	29620	147	100.00	245318	.1	244679
2.3	3529	14 .000	92.0		36798	731615	90.5	69351	153	100.00	698507	.1	696730
2.4	3843	14 .000	93.2		104776	2082514	92.1	%165293	160	100.00	2003292	.1	199831
0													
2.5	4170	14 .000	94.2		300496	5970546	93.3	%399483	167	100.00	5772771	.1	575882
1													

S=40% F=0.10

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZSY -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 60 PCF, WATER CONT.= 61.6% C/L=.0062 L=5057 KF=1.30
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 60 PCF WATER CONT.= 61.6% C/L=.0062 L=5057 KF=1.30

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 40%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.10,
LAMBDA*SQRIN-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT	DEG*DAYS	PROB.			COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE		
					---------- YEARS					PROB.%		YEARS FT		YEARS
H1	CAVG	&CV%	FPAVG	&CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100		DELTA	H3M	DELTA
1.0	803	14	.597	24.8	2	303	5.7	286	250	100.00		71	.1	71
1.1	971	14	.406	36.6	3	404	12.4	354	275	100.00		130	.1	130
1.2	1156	14	.248	47.8	5	605	22.9	466	300	100.00		271	.1	270
1.3	1356	14	.138	57.7	11	1050	36.4	668	325	100.00		621	.1	619
1.4	1573	14	.071	65.9	25	2134	50.2	1063	350	100.00		1546	.1	1542
1.5	1806	14	.034	72.6	62	4960	61.9	1888	375	100.00		4106	.1	4093
1.6	2055	14	.016	78.0	164	12746	70.9	3712	400	100.00		11467	.1	11430
1.7	2319	14	.007	82.2	459	35135	77.4	7933	425	100.00		33311	.1	33203
1.8	2600	14	.003	85.6	1332	101654	82.2	18075	450	100.00		99725	.1	99404
1.9	2897	14	.001	88.2	3989	304237	85.8	43214	475	100.00		305441	.1	304468
2.0	3210	14	.000	90.3	12218	932688	88.5	%107098	500	100.00		951462	.1	94848
4														
2.1	3539	14	.000	92.0	38059	2908433	90.6	%272718	525	100.00		3000029	.1	299087
4														
2.2	3884	14	.000	93.4	120001	9177400	92.3	%708954	550	100.00		9537904	.1	950960
7														
2.3	4246	14	.000	94.4	381516	29186240	93.6	%1872271	575	100.00		%30479780	.1	%30
391900														
2.4	4623	14	.000	95.3	%1219190	93251800	94.6	%5003732	600	100.00		%97651340	.1	%
97379000														
2.5	5016	14	.000	96.0	%3906034	%207219500	95.2	%9870539	625	100.00		%130284000	.	
1 %130301100														

S=40% F=0.20

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZSY -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 60 PCF, WATER CONT.= 61.6% C/L=.0052 L=5057 KF=1.30
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 60 PCF WATER CONT.= 61.6% C/L=.0062 L=5057 KF=1.30

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 40%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.20,
LAMBDA*SQRIN-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT	EG*DAYS	PROB.			COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE		
					---------- YEARS					PROB.%		YEARS	FT	YEARS
H1	TCAVG&CV%		FPAVG&CV%		FPY	UP.YRS	CV%	LBOND	ABD	R100		DELTA	H3M	DELTA
1.0	803	14	.597	24.8	2	152	5.7	143	125	100.00		36	.1	35
1.1	971	14	.406	36.6	3	202	12.4	177	138	100.00		65	.1	65
1.2	1156	14	.248	47.8	5	302	22.9	233	150	100.00		135	.1	135
1.3	1356	14	.138	57.7	11	525	36.4	334	163	100.00		311	.1	310
1.4	1573	14	.071	65.9	25	1067	50.2	532	175	100.00		773	.1	771
1.5	1806	14	.034	72.6	62	2480	61.9	944	188	100.00		2053	.1	2046
1.6	2055	14	.016	78.0	164	6373	70.9	1856	200	100.00		5734	.1	5715
1.7	2319	14	.007	82.2	459	17568	77.4	3966	213	100.00		16656	.1	16602
1.8	2600	14	.003	85.6	1332	50827	82.2	9038	225	100.00		49863	.1	49702
1.9	2897	14	.001	88.2	3989	152118	85.8	21607	238	100.00		152721	.1	152234
2.0	3210	14	.000	90.3	12218	466344	88.5	53549	250	100.00		475731	.1	474242
2.1	3539	14	.000	92.0	38059	1454217	90.6	%136359	263	100.00		1500014	.1	149543
7														
2.2	3884	14	.000	93.4	120001	4588700	92.3	%354477	275	100.00		4768952	.1	475480
4														
2.3	4246	14	.000	94.4	381516	14593120	93.6	%936135	288	100.00		%15239890	.1	%151
95950														
2.4	4623	14	.000	95.3	%1219190	46625900	94.6	%2501866	300	100.00		%48825670	.1	%
48689500														
2.5	5016	14	.000	96.0	%3906034	%103609700	95.2	%4935270	313	100.00		%65142010	.1	
%65150540														

S=40% F=0.30

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 60 PCF, WATER CONT.= 61.6% C/L=.0062 L=5057 KF=1.30
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 60 PCF WATER CONT.= 61.6% C/L=.0062 L=5057 KF=1.30

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 40%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.30,
LAMBDA*SQRIN-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT	DEG*DAYS	PROB.			COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE		
					---------- YEARS					PROB.%		YEARS	FT	YEARS
H1	TCAVG	&CV%	FPAVG	&CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100		DELTA	H3M	DELTA
1.0	803	14	.597	24.8	2	101	5.7	95	83	57.34		24	.1	24
1.1	971	14	.406	36.6	3	135	12.4	118	92	98.60		43	.1	43
1.2	1156	14	.248	47.8	5	202	22.9	155	100	100.00		90	.1	90
1.3	1356	14	.138	57.7	11	350	36.4	223	108	100.00		207	.1	206
1.4	1573	14	.071	65.9	25	711	50.2	354	117	100.00		515	.1	514
1.5	1806	14	.034	72.6	62	1653	61.9	629	125	100.00		1369	.1	1364
1.6	2055	14	.016	78.0	164	4249	70.9	1237	133	100.00		3822	.1	3810
1.7	2319	14	.007	82.2	459	11712	77.4	2644	142	100.00		11104	.1	11068
1.8	2600	14	.003	85.6	1332	33885	82.2	6025	150	100.00		33242	.1	33135
1.9	2897	14	.001	88.2	3989	101412	85.8	14405	158	100.00		101814	.1	101489
2.0	3210	14	.000	90.3	12218	310896	88.5	35699	167	100.00		317154	.1	316161
2.1	3539	14	.000	92.0	38059	969478	90.6	90906	175	100.00		1000010	.1	996958
2.2	3884	14	.000	93.4	120001	3059133	92.3	%236318	183	100.00		3179302	.1	316986
9														
2.3	4246	14	.000	94.4	381516	9728747	93.6	%624090	192	100.00		%10159930	.1	%101
30630														
2.4	4623	14	.000	95.3	%1219190	31082930	94.6	%1667911	200	100.00		%32550450	.1	%
32459670														
2.5	5016	14	.000	96.0	%3906034	69073160	95.2	%3290180	208	100.00		%43428010	.1	%
43433690														

S=40% F=0.40

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 60 PCF, WATER CONT.= 61.6% C/L=.0062 L=5057 KF=1.30
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 60 PCF WATER CONT.= 61.6% C/L=.0062 L=5057 KF=1.30

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 40%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.40,
LAMBDA*SQRIN-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT	DEG*DAYS	PROB.			COVER THERMAL PROPERTIES IN H3 (R1.3=1)					PROB.%	YEARS FT	WST'PILE YEARS
H1	TCAVG	&CV%	FPAVG	&CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA H3M	DELTA
1.0	803	14	.597	24.8	2	76	5.7	71	63	0.00	18 .1	18
1.1	971	14	.406	36.6	3	101	12.4	88	69	53.44	33 .1	33
1.2	1156	14	.248	47.8	5	151	22.9	116	75	94.32	68 .1	67
1.3	1356	14	.138	57.7	11	263	36.4	167	81	98.40	155 .1	155
1.4	1573	14	.071	65.9	25	533	50.2	266	88	99.49	387 .1	385
1.5	1806	14	.034	72.6	62	1240	61.9	472	94	99.88	1026 .1	1023
1.6	2055	14	.016	78.0	164	3187	70.9	928	100	100.00	2867 .1	2858
1.7	2319	14	.007	82.2	459	8784	77.4	1983	106	100.00	8328 .1	8301
1.8	2600	14	.003	85.6	1332	25413	82.2	4519	113	100.00	24931 .1	24851
1.9	2897	14	.001	88.2	3989	76059	85.8	10804	119	100.00	76360 .1	76117
2.0	3210	14	.000	90.3	12218	233172	88.5	26774	125	100.00	237865 .1	237121
2.1	3539	14	.000	92.0	38059	727108	90.6	68179	131	100.00	750007 .1	747719
2.2	3884	14	.000	93.4	120001	2294350	92.3	%177239	138	100.00	2384476 .1	237740
2												
2.3	4246	14	.000	94.4	381516	7296561	93.6	%468068	144	100.00	7619946 .1	759797
5												
2.4	4623	14	.000	95.3	%1219190	23312950	94.6	%1250933	150	100.00	%24412840 .1	%
24344750												
2.5	5016	14	.000	96.0	%3906034	51804870	95.2	%2467635	156	100.00	%32571010 .1	%
32575270												

S=40% F=0.50

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZSY -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 60 PCF, WATER CONT.= 61.6% C/L=.0062 L=5057 KF=1.30
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 60 PCF WATER CONT.= 61.6% C/L=.0062 L=5057 KF=1.30

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 40%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.50,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT	EG*DAYS	PROB.			COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE	
					YEARS					PROB.%	YEARS	FT	YEARS
H1	TCAVG	&CV%	FPAVG	&CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	803	14	.597	24.8	2	61	5.7	57	50	0.00	14	.1	14
1.1	971	14	.406	36.6	3	81	12.4	71	55	2.79	26	.1	26
1.2	1156	14	.248	47.8	5	121	22.9	93	60	78.56	54	.1	54
1.3	1356	14	.138	57.7	11	210	36.4	134	65	95.25	124	.1	124
1.4	1573	14	.071	65.9	25	427	50.2	213	70	98.36	309	.1	308
1.5	1806	14	.034	72.6	62	992	61.9	378	75	99.41	821	.1	819
1.6	2055	14	.016	78.0	164	2549	70.9	742	80	99.81	2293	.1	2286
1.7	2319	14	.007	82.2	459	7027	77.4	1587	85	99.95	6662	.1	6641
1.8	2600	14	.003	85.6	1332	20331	82.2	3615	90	99.99	19945	.1	19881
1.9	2897	14	.001	88.2	3989	60847	85.8	8643	95	100.00	61088	.1	60894
2.0	3210	14	.000	90.3	12218	186538	88.5	21420	100	100.00	190292	.1	189697
2.1	3539	14	.000	92.0	38059	581687	90.6	54544	105	100.00	600006	.1	598175
2.2	3884	14	.000	93.4	120001	1835480	92.3	%141791	110	100.00	1907581	.1	190192
1													
2.3	4246	14	.000	94.4	381516	5837249	93.6	%374454	115	100.00	6095957	.1	607838
0													
2.4	4623	14	.000	95.3	%1219190	18650360	94.6	%1000746	120	100.00	%19530270	.1	%
19475800													
2.5	5016	14	.000	96.0	%3906034	41443900	95.2	%1974108	125	100.00	%26056810	.1	%
26060220													

S=50% F=0.10

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 50 PCF, WATER CONT.= 80.7% C/L=.0057 L=5523 KF=1.42
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 50 PCF WATER CONT.= 80.7% C/L=.0057 L=5523 KF=1.42

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 50%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.10,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT	DEG*DAYS	PROB.			COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE	
					---------- YEARS ----------					PROB.%	YEARS FT		YEARS
H1	TCAVG	&CV%	FPAVG	&CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	925	14	.454	33.5	2	282	10.6	252	200	100.00	92	.1	92
1.1	1119	14	.275	45.7	5	427	21.2	336	220	100.00	198	.1	197
1.2	1332	14	.149	56.6	10	765	35.4	494	240	100.00	478	.1	476
1.3	1563	14	.073	65.6	24	1639	50.2	816	260	100.00	1271	.1	1267
1.4	1813	14	.033	72.8	64	4095	62.6	1530	280	100.00	3641	.1	3628
1.5	2081	14	.014	78.5	182	11435	71.9	3214	300	100.00	11039	.1	10998
1.6	2368	14	.006	82.9	552	34427	78.5	7392	320	100.00	34945	.1	34814
1.7	2673	14	.002	86.3	1747	109035	83.3	18203	340	100.00	114271	.1	113847
1.8	2997	14	.001	89.0	5714	357535	86.8	47119	360	100.00	382729	.1	381333
1.9	3339	14	.000	91.1	19136	1200942	89.5	%126542	380	100.00	1304086	.1	129944
0													
2.0	3699	14	.000	92.7	65205	4101074	91.5	%349252	400	100.00	4496179	.1	448060
1													
2.1	4079	14	.000	94.0	224809	14158240	93.1	%983867	420	100.00	%15618150	.1	%155
65750													
2.2	4476	14	.000	95.0	780906	49202810	94.3	%2814283	440	100.00	%54470990	.1	%54
294070													
2.3	4893	14	.000	95.8	%2723563	%128105000	95.1	%6329062	460	100.00	%103333400	.	
1 %103345900													
2.4	5327	14	.000	93.5	%5166669	%234688400	94.9	%12026730	480	100.00	%109833500		
.1 %109868900													
2.5	5780	14	.000	82.1	%5491672	%354152600	92.3	%27127720	500	100.00	%129094900		
.1 %129196300													

S=50% F=0.20

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZ5Y -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 50 PCF, WATER CONT.= 80.7% C/L=.0057 L=5523 KF=1.42
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 50 PCF WATER CONT.= 80.7% C/L=.0057 L=5523 KF=1.42

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 50%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.20,
LAMBDA*SQRIN-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT H1	DEG*DAYS AVG	CV%	PROB. FPAVG	CV%	COVER THERMAL PROPERTIES IN H3 (R1.3=1) YEARS FPY	UP.YRS	CV%	LBOND	ABD	PROB.% R100	WST'PILE YEARS FT DELTA	H3M	YEARS DELTA
1.0	925	14	.454	33.5	2	141	10.6	126	100	100.00	46	.1	46
1.1	1119	14	.275	45.7	5	213	21.2	168	110	100.00	99	.1	98
1.2	1332	14	.149	56.6	10	382	35.4	247	120	100.00	239	.1	238
1.3	1563	14	.073	65.6	24	820	50.2	408	130	100.00	636	.1	633
1.4	1813	14	.033	72.8	64	2048	62.6	765	140	100.00	1821	.1	1814
1.5	2081	14	.014	78.5	182	5718	71.9	1607	150	100.00	5519	.1	5499
1.6	2368	14	.006	82.9	552	17214	78.5	3696	160	100.00	17472	.1	17407
1.7	2673	14	.002	86.3	1747	54517	83.3	9101	170	100.00	57135	.1	56924
1.8	2997	14	.001	89.0	5714	178767	86.8	23560	180	100.00	191365	.1	190666
1.9	3339	14	.000	91.1	19136	600471	89.5	63271	190	100.00	652043	.1	649720
2.0	3699	14	.000	92.7	65205	2050537	91.5	%174626	200	100.00	2248083	.1	224030
1													
2.1	4079	14	.000	94.0	224809	7079120	93.1	%491934	210	100.00	7809076	.1	778287
4													
2.2	4476	14	.000	95.0	780906	24601410	94.3	%1407141	220	100.00	%27235500	.1	%27
147040													
2.3	4893	14	.000	95.8	%2723563	64052500	95.1	%3164531	230	100.00	%51666690	.1	%
51672950													
2.4	5327	14	.000	93.5	%5166669	%117344200	94.9	%6013365	240	100.00	%54916730	.1	
%54934460													
2.5	5780	14	.000	82.1	%5491672	%177076300	92.3	%13563860	250	100.00	%64547460	.	
1 %64598150													

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZSY -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] -- FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 50 PCF, WATER CONT.= 80.7% C/L=.0057 L=5523 KF=1.42
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 50 PCF WATER CONT.= 80.7% C/L=.0057 L=5523 KF=1.42

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 50%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.30,
LAMBDA*SQRIN-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT	DEG*DAYS	PROB.			COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE	
						YEARS				PROB.%	YEARS	FT	YEARS
H1	TCAVG	&CV%	FPAVG	&CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	925	14	.454	33.5	2	94	10.6	84	67	27.54	31	.1	31
1.1	1119	14	.275	45.7	5	142	21.2	112	73	92.99	66	.1	66
1.2	1332	14	.149	56.6	10	255	35.4	165	80	98.28	159	.1	159
1.3	1563	14	.073	65.6	24	546	50.2	272	87	99.48	424	.1	422
1.4	1813	14	.033	72.8	64	1365	62.6	510	93	99.89	1214	.1	1209
1.5	2081	14	.014	78.5	182	3812	71.9	1071	100	100.00	3680	.1	3666
1.6	2368	14	.006	82.9	552	11476	78.5	2464	107	100.00	11648	.1	11605
1.7	2673	14	.002	86.3	1747	36345	83.3	6068	113	100.00	38090	.1	37949
1.8	2997	14	.001	89.0	5714	119178	86.8	15706	120	100.00	127576	.1	127111
1.9	3339	14	.000	91.1	19136	400314	89.5	42181	127	100.00	434695	.1	433147
2.0	3699	14	.000	92.7	65205	1367025	91.5	%116417	133	100.00	1498726	.1	149353
4													
2.1	4079	14	.000	94.0	224809	4719414	93.1	%327956	140	100.00	5206051	.1	518858
3													
2.2	4476	14	.000	95.0	780906	16400940	94.3	%938094	147	100.00	%18157000	.1	%180
98020													
2.3	4893	14	.000	95.8	%2723563	42701670	95.1	%2109688	153	100.00	%34444460	.1	%
34448630													
2.4	5327	14	.000	93.5	%5166669	78229480	94.9	%4008910	160	100.00	%36611150	.1	%
36622970													
2.5	5780	14	.000	82.1	%5491672	%118050900	92.3	%9042571	167	100.00	%43031640	.1	
%43065430													

S=50% F=0.40

THERMAL AND UPFREEZING ANALYSIS ESTIMATES — PROGRAM UPFREEZ5Y — 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER — PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

H1 = DEPTH OF COVER ABOVE OBJECT, STARTING AT H1=TCT [FT] — FINE-GRAINED SOIL
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 50 PCF, WATER CONT.= 80.7% C/L=.0057 L=5523 KF=1.42
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 50 PCF WATER CONT.= 80.7% C/L=.0057 L=5523 KF=1.42

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 50%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.40,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FPY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) (0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

FT	DEG*DAYS	PROB.			COVER THERMAL PROPERTIES IN H3 (R1.3=1)							WST'PILE	
					——— YEARS			——— PROB.%			YEARS FT		YEARS
H1	TCAVG	&CV%	FPAVG	&CV%	FPY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	925	14	.454	33.5	2	71	10.6	63	50	0.00	23	.1	23
1.1	1119	14	.275	45.7	5	107	21.2	84	55	62.36	49	.1	49
1.2	1332	14	.149	56.6	10	191	35.4	123	60	93.56	119	.1	119*
1.3	1563	14	.073	65.6	24	410	50.2	204	65	97.99	318	.1	317
1.4	1813	14	.033	72.8	64	1024	62.6	383	70	99.31	910	.1	907
1.5	2081	14	.014	78.5	182	2859	71.9	803	75	99.79	2760	.1	2750
1.6	2368	14	.006	82.9	552	8607	78.5	1848	80	99.94	8736	.1	8704
1.7	2673	14	.002	86.3	1747	27259	83.3	4551	85	99.99	28568	.1	28462
1.8	2997	14	.001	89.0	5714	89384	86.8	11780	90	100.00	95682	.1	95333
1.9	3339	14	.000	91.1	19136	300236	89.5	31635	95	100.00	326021	.1	324860
2.0	3699	14	.000	92.7	65205	1025269	91.5	87313	100	100.00	1124045	.1	1120150
2.1	4079	14	.000	94.0	224809	3539560	93.1	%245967	105	100.00	3904538	.1	3891437
2.2	4476	14	.000	95.0	780906	12300700	94.3	%703571	110	100.00	%13617750	.1	%13573520
2.3	4893	14	.000	95.8	%2723563	32026250	95.1	%1582266	115	100.00	%25833350	.1	%25836480
2.4	5327	14	.000	93.5	%5166669	58672110	94.9	%3006683	120	100.00	%27458370	.1	%27467230
2.5	5780	14	.000	82.1	%5491672	88538150	92.3	%6781929	125	100.00	%32273730	.1	%32299080

S=50% F=0.50

THERMAL AND UPFREEZING ANALYSIS ESTIMATES -- PROGRAM UPFREEZSY -- 04-08-1987
MANVILLE WAUKEGAN, ILL PLANT WASTE PILE
****** YEARS TO UPFREEZE OBJECTS THRU COVER -- PRELIMINARY RESULTS ******

OBJECTS HAVE (X - A) = 0.10 FT (EFFECTIVE PARTICLE SIZE, EPS.UF) STARTING AT
TOP OF WASTE PILE--BOTTOM OF COVER OF TOTAL THICKNESS = TCT

THERMAL LOAD FREEZE INDEX (FI): LOGNORMAL W/ MEDIAN = 875 MEAN = 935 SD.LN=.365

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UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 50 PCF, WATER CONT.= 80.7% C/L=.0057 L=5522 KF=1.42
H3M = OBJECT LENGTH FOR MAX UPFREEZE, STARTING IN:
H3 = WASTE PILE OF SOIL--HAVING:
UNFROZEN DRY DENS.=100 PCF, WATER CONT.= 20.3% (80% SAT) KU=0.81
FROZEN DRY DENS. = 50 PCF WATER CONT.= 80.7% C/L=.0057 L=5523 KF=1.42

BOTH COVER AND WASTE PILE USE HEAVE STRAIN, S = 50%, 95% OF MAX L
HEAVE FRACTION NOT RECOVERED ON THAWING, F = 0.50,
LAMBDA*SQR[N-FACTOR] = .48 (AVG) .00 (SD)
ESTIMATES USE MOD. BERGGREN EQU. W/ KERSTEN KF'S AND + 0% - 25% ERROR IN KF'S
CORRELATION COEFFICIENT BETWEEN K1.F AND K3.F, R1.3=0.00

FRY = AVG YEARS TO FIRST FROST PENETRATION TO DEPTH H1 AND RETURN PERIOD
UP.YRS = ESTIMATED YEARS FOR OBJECT UPFREEZING FROM H1 (FOR H1 PROPS IN H3) BUT
CORRECT UP.YRS FOR DIFFERENCE IN DELTA'S WHEN OBJECT IN H3.
CONSERATIVE FOR ALL OBJECTS HAVING (X-A) < 0.10 FT
FOR H1=TCT: UP.YRS IS AN ESTIMATE (+ OR - CV%) OF YEARS TO UPFREEZE THRU COVER
LBOND = 1 STANDARD DEVIATION LOWER BOUND (LB),
ABD = ABOND = ABSOLUTE LB FOR HEAVE STRAIN, UNRECOVER FACTOR AND EPS.UF
R100 = EST'ED RELIABILITY (PROBABILITY) UP.YRS EXCEEDS 100 YEARS

					COVER THERMAL PROPERTIES IN H3 (R1.3=1)						WST'PILE	
FT	EG*DAYS	PROB.			---------- YEARS ----------				PROB.%	YEARS	FT	YEARS
H1	TCAVG&CV%	FPAVG&CV%			FRY	UP.YRS	CV%	LBOND	ABD	R100	DELTA	H3M	DELTA
1.0	925	14	.454	33.5	2	56	10.6	50	40	0.00	18	.1	18
1.1	1119	14	.275	45.7	5	85	21.2	67	44	21.17	40	.1	39
1.2	1332	14	.149	56.6	10	153	35.4	99	48	85.83	96	.1	95
1.3	1563	14	.073	65.6	24	328	50.2	163	52	96.20	254	.1	253
1.4	1813	14	.033	72.8	64	819	62.6	306	56	98.71	728	.1	726
1.5	2081	14	.014	78.5	182	2287	71.9	643	60	99.57	2208	.1	2200
1.6	2368	14	.006	82.9	552	6885	78.5	1478	64	99.87	6989	.1	6963
1.7	2673	14	.002	86.3	1747	21807	83.3	3641	68	99.96	22854	.1	22769
1.8	2997	14	.001	89.0	5714	71507	86.8	9424	72	99.99	76546	.1	76267
1.9	3339	14	.000	91.1	19136	240188	89.5	25308	76	100.00	260817	.1	259888
2.0	3699	14	.000	92.7	65205	820215	91.5	69850	80	100.00	899236	.1	896120
2.1	4079	14	.000	94.0	224809	2831648	93.1	%196773	84	100.00	3123631	.1	311315
0													
2.2	4476	14	.000	95.0	780906	9840562	94.3	%562857	88	100.00	%10894200	.1	%108
58810													
2.3	4893	14	.000	95.8	%2723563	25621000	95.1	%1265813	92	100.00	%20666680	.1	%
20669180													
2.4	5327	14	.000	93.5	%5166669	46937690	94.9	%2405346	96	100.00	%21966690	.1	%
21973790													
2.5	5780	14	.000	82.1	%5491672	70830520	92.3	%5425543	100	100.00	%25818990	.1	%
25839260													

UPFREEZ5 RUN COMPLETE