Geosyntec consultants

COMPUTATION COVER SHEET

Client: **Denison Mines** Project: **White Mesa Mill** Project/ Proposal No.: **SC0349-01** Task No. **04**

Title of Computations **ANALYSIS OF SLIMES DRAIN**

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Revisions (number and initial all revisions)

No.	Sheet	Date	By	Checked by	Approval

Written by:	M. Lithgow	Date:	05/11/07	Reviewed by:	G. Corcoran	Date:	05/12/07
Client:	Denison Mines	Project:	White Mesa Mill – Cell 4A	Project/ Proposal No.:	SC0349-01	Task No.:	04

PURPOSE AND METHOD OF ANALYSIS

The purpose of this calculation package is to demonstrate that the proposed "slimes drain system" will dewater the tailings at the site within a reasonable time.

Fluid flow rate in porous media will be evaluated using Darcy's law.

ASSUMPTIONS

- This project involves the construction of a 42 acre double lined tailings cell (Cell 4A) that is approximately 42 feet deep at its deepest point and 26 feet deep at the shallowest point with an average depth of 34 feet. The liquids level in the cell will be kept a minimum of 3 feet below the top of the berm (free-board). Therefore, the maximum depth of liquid in the cell will be 39 feet at the start of dewatering.
- The cell will be filled with -28 mesh (US No. 30 sieve) tailings, largely consisting of fine sands and silts, with some clay. Results of grinding test sieve analyses, which are reported based on Tyler Mesh sieve sizes, are presented in Table 1. The grinding test data report is presented in Attachment A. Sieve to Tyler Mesh conversions are presented in Attachment B.
- The tailings will be placed within the cell in a slurry form under the surface of the free liquid contained within the cell. This placement methodology is anticipated to result in a low density (no compaction) soil structure. Therefore, saturated hydraulic conductivity and total porosity are anticipated to be higher than similar soils that are compacted.
- Based on the grinding report (Attachment A), tailings are comprised of approximately 6% medium sand, 49% fine sand, and 45% silt and clay size particles (Table 1).
- Based on the gradation of the tailings (Table 1) from the grinding report (Attachment A), the tailings would be classified as silty sand (SM) by the unified soil classification system (USCS). According to the Hydrologic Evaluation of Landfill Performance (HELP) Model Engineering Documentation (Attachment C), **low density** SM soils would exhibit saturated hydraulic conductivities of

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between $1.7x10^{-3}$ cm/sec and $5.2x10^{-4}$ cm/sec and **low density** silt (ML) and sandy clay (SC) would exhibit saturated hydraulic conductivities of between $3.7x10^{-4}$ cm/sec and $1.2x10^{-4}$ cm/sec. The geomean of these two groups of soils, which are gradationally similar to the tailings, is $4.74x10^{-4}$ cm/sec (Table 2). According to Cedergren (Attachment D), under a normal stress of 2 tons per square foot (approximate normal stress on deeper tailings in the cell), medium sand, fine sand, silt, and silty clay would exhibit a saturated hydraulic conductivities of approximately $2x10^{-2}$ cm/sec, $1x10^{-2}$ cm/sec, $1x10^{-4}$ cm/sec $5x10^{-7}$ cm/sec, respectively. The geomean of these three soil types, where are gradationally similar to the tailings, is $3.31x10^{-4}$ cm/sec. The more conservative, lower hydraulic conductivity of $3.31x10^{-4}$ cm/sec, will be used in this analysis.

- Based on the gradation of the tailings from the grinding report, the tailings would be classified as silty sand (SM) by the unified soil classification system (USCS). According to the HELP Model Engineering Documentation (Attachment C), **low density** SM soils would exhibit drainable porosity of between 0.251 and 0.332 and **low density** silt (ML) and sandy clay (SC) would exhibit drainable porosity of between 0.154 and 0.231. The average of these two groups of soils, which are gradationally similar to the tailings, is 0.253 (Table 2). According to the HELP Model Engineering Documentation, medium sand, fine sand, silt, and silty clay would exhibit drainable porosity values of 0.35, 0.29, 0.14, and 0.11, respectively. The average of these three soil types, where are gradationally similar to the tailings, is 0.22. Since the average drainable porosity of 0.22 corresponds to the lower hydraulic conductivity (higher density, lower permeability, lower porosity) selected above, this value will be used in this analysis.
- The permeability of the tailings is isotropic.
- Darcy's law will be used to compute groundwater flow velocities.
- The proposed slimes drain system will consist of a series of strip drains (geotextile wrapped HDPE core, 1" thick, 12" wide, with a transmissivity of 29 (gal/min/ft), which connect to a perforated 4" diameter PVC header pipe that is bedded in drainage aggregate and wrapped in a woven geotextile. The PVC pipe will convey the liquid to the sump for removal.

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- The slimes drain spacing will be 50' and will be continuous across the base of the cell (Figure 1).

CALCULATIONS

The flow geometry for the average depth of liquid within the cell is illustrated on Figure 2 and used to compute the emptying time for the proposed slimes drain system.

Calculate the flow into a unit length of strip drain for the various hydraulic gradient conditions.

At the start of cell dewatering, the maximum depth of liquid will vary between 23 feet at the shallow end and 39 feet at the deep end, with an average depth of approximately 31 feet. As the water level drops within the cell, the length of the longest flow path and the associated hydraulic gradient will continually change with time.

The total volume to be drained by a unit length of strip, Q, can be calculated using Darcy's law as follows:

$$Q = kiA$$

where:

k = hydraulic conductivity of tailings = $3.31\text{x}10^{-4}$ cm/sec = $6.51\text{x}10^{-4}$ ft/min

i = gradient along flowpath = $\frac{dh}{dl} = \frac{31}{39.8} = 0.78$ (see Figure 2)

A = area of strip drain where flow will pass =1.17 ft^2/ft (see Figure 3)

$$Q = (6.51\times10^{-4}\,\frac{ft}{\min})(0.78)(1.17\ ft^2)$$

$$Q = 5.94x10^{-4}\,\frac{ft^3}{\min}\text{ x 7.48 gal/ft}^3 = 4.44\text{x}10^{-3}\text{ gpm}$$

For each one foot incremental drop in fluid elevation within the cell, the total volume to be drained by a unit length of strip drain is as follows:

V = 1 ft unit length x 1ft depth x 50 ft width x .022 (drainable porosity) = 11 CF of free liquid

Therefore, the time to drain the first one foot of liquid within the cell can be estimated as follows:

$t = V/Q = 11$ CF / $5.94\text{x}10^{-4}$ CF/min = 18,519 minutes = 12.86 days

Tables 3, 4, and 5 depict the calculations for the maximum (39 feet), average (31 feet), and minimum (23 feet) cell liquid depth, respectively. The results of the maximum depth calculations indicate that the proposed slimes drain system will allow the tailings contained in Cell 4A to drain within approximately 5.5 years.

Calculate the design flow rate of the strip drains.

For this calculation we will assume that the strip drains have a flow rate of 29 gallon per minute per foot (Attachment E, GDE Multi-Flow, 2006), a width of 12" and that flow is occurring under a gradient of 0.01.

Design Flow rate of strip drains:

$$q = \Theta i$$

where:

q = flowrate per unit width

$$i = \frac{dh}{dl} = 0.01$$

Θ = transmissivity = 29 gpm/ft

To account for detrimental effects on the geonet such as chemical clogging, biological clogging, installation defects, and creep, partial factors of safety were used to reduce the strip drain transmissivity. Using recommended partial factor of safety values from Koerner (1999) (Attachment F, 2/4), the reduced transmissivity is calculated as follows:

$$\Theta_{allow} = \Theta_{ult}\left[\frac{1}{FS_{IN} \times FS_{CR} \times FS_{CC} \times FS_{BC}}\right]$$

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where:

Θ_{allow} = allowable flow

$\Theta_{ultimate}$ = calculated value of flow

FS_{IN} = factor of safety for installation, 1.5 (CQA performed during installation)

FS_{CR} = factor of safety for creep, 2.0

FS_{CC} = factor of safety for chemical clogging, 2.0

FS_{BC} = factor of safety for biological clogging, 1.0 (low pH precludes biological activity)

The factors of safety are used to calculate the allowable transmissivity:

$$\Theta_{allow} = 29\,\frac{gpm}{ft}\left[\frac{1}{1.5 \times 2.0 \times 2.0 \times 1.0}\right] = 4.83\,\frac{gpm}{ft}$$

Using this transmissivity value, the average factor of safety for flow in the strip composite is estimated to be as follows:

$$FS = \frac{Q_D}{Q_R} = \frac{4.83\ gpm}{0.0044\ gpm} = 1{,}087 \quad \text{(Acceptable)}$$

The average allowable flow rate is much larger than the average maximum flow rate, even with the built-in partial factors of safety. Furthermore, as indicated on Tables 3, 4, and 5, the calculated flow rate within the strip drain decreases with time, which further increases the factor of safety.

Calculate the minimum required AOS and permittivity for filtration geotextile component of strip drain

The geotextile serves as a filter between the strip composite core and the tailings material. The geotextile minimizes fine particles of the tailings material from migrating into the strip composite, yet allows water to penetrate. Migration of fine particles would have the adverse effect of decreasing the transmissivity of the strip composite layer.

To be conservative in these calculations, the tailings material soil is assumed to consist of more than 20 percent clay.

The retention requirements for geotextiles can be evaluated using the chart entitled "Soil Retention Criteria for Steady-State Flow Conditions" developed by Luettich et al., (1991) (Attachment G, 1/3). This chart uses soil properties to evaluate the required apparent opening size (AOS or O_{95}) of the geotextile. Using the Soil Retention Chart, the AOS of the filter fabrics shall be:

$O_{95} < 0.21$ mm, which corresponds to sieve No. 70.

The permeability of the filter fabric must be evaluated to allow flow through the filter fabric. The following equation can be used to evaluate the minimum allowable geotextile permeability:

$k_g > i_s\, k_s$ (Luettich et al. (1991), Att. G, 2/3)

where: k_g = permeability of geotextile (cm/s)
i_s = hydraulic gradient (dimensionless)
k_s = permeability of the tailings material (cm/s)

Hydraulic Gradient, i: Attachment G, page 3/3 from Luettich et al. (1991) lists typical hydraulic gradients for various geotextile drainage applications. In this attachment, a hydraulic gradient of 10 for liquid impoundment applications is recommended.

Soil Permeability, k_s: A permeability of 3.31×10^{-4} cm/s was assumed for the tailings material, as previously defined.

Therefore,

$k_g >$ $i_s\, k_s = (10)(3.31\times10^{-4}$ cm/s)
$k_g >$ $3.31 \times 10^{-}$ cm/s

Koerner (1999) suggests applying partial factors of safety to the ultimate flow capacity of the geotextile to account for clogging of the geotextile. Using recommendations

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given in Table 2.12 on p. 150 of Koerner (1999) (Attachment F, 1/4), the following partial safety values were applied:

soil clogging and blinding:	10 (5 – 10)
creep reduction of voids:	2.0 (1.5 – 2.0)
intrusion into voids:	1.2 (1.0 – 1.2)
chemical clogging:	1.5 (1.2 – 1.5)
biological clogging (low pH precludes biological activity):	1.0 (2 – 10)

Therefore,

$k_g >$ $(3.31 \times 10^{-3})(10)(2)(1.2)(1.5)(1)$

$k_g >$ 0.12 cm/s

The thickness of a typical nonwoven needled punched 4 oz/yd^2 (135 g/m^2) geotextile is approximately 40 mils (0.10 cm), see Attachment H. Dividing the permeability by the thickness of the geotextile results in a required minimum permittivity of 1.2 sec^{-1}. The geotextile used in this project has a permittivity of 2.0 sec^{-1}, which is greater than the required permittivity.

Check Pipe Flow Rate

Based on calculations from previous sections, the maximum daily flow rate to the sump is estimated to be 132 gpm (0.29 cfs) (Table 3). The capacity of the pipe is calculated based on Manning's equation for gravity flow as follows:

$$Q = \frac{1.486}{n} R_h^{2/3} S^{1/2} A = 0.35\ cfs$$

Where

n = 0.010 (Koerner (1999), Attachment E, 4/4)

S = Slope of liner (ft/ft) = 1.0 %

R_h = hydraulic radius, ft

Q = flow rate, cubic feet per second, cfs

A = flow area, sf

Assuming 4-inch pipe:

$A = \pi D^2/4$ = 12.6 sq. inches = 0.088 sf

R_h = Area ($\pi D^2/4$)/Wetted Perimeter (πD)

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$= D/4 = 1 \text{ in} = 0.083 \text{ ft}$

$$Q = \frac{1.486}{0.010} 0.083^{2/3} 0.01^{1/2} 0.088\ sf = 0.28\ cfs = 112\ gpm$$

Since 112 gpm is less than the maximum required 132 gpm, this calculation shows that the 4-inch diameter slimes drain pipe is the limiting factor for dewatering the tailings in the early phase of dewatering (high flow rates). However, it does not mean that the pipe will be unable to handle this flow, but rather the pipe will require additional time to drain. The additional time needed is computed in the following section.

Effect of Maximum Pipe Capacity on Drainage Time

The maximum capacity of the pipe is 112 gpm, as computed above. Assuming the cell's total lateral length of strip drain is 27,550 feet, the flow rate, per foot of strip drain is calculated to be:

$$\text{Flow Rate} = \frac{112\ gallon}{\min} * \frac{60 \min}{1\ hr} * \frac{24\ hr}{1\ day} * \frac{1 ft^3}{7.48\ gallon} * \frac{1}{27{,}550\ feet} = 0.78 \frac{ft^3}{day}$$

The time needed to de-water first layer is:

$$Time = \frac{Volume}{Drain\ \ length\ \times flow\ rate} = \frac{(50x1x1x0.22)\ ft^3}{1\ ft \times 0.78 \frac{ft^3}{day}} = 14.1\ days$$

The difference between the maximum daily flow rate drainage time and the maximum daily flow the pipe is able to deliver for the first foot is:

14.1 day – 11.93 day (first row of Table 3) = 2.17 days.

Therefore, the first layer will require an additional 2.17 days to drain. The calculation is repeated until the pipe's allowable flow capacity of 112 gpm is equal to the maximum flow rate from the cell (Table 3). The additional drainage time needed for each layer is added to the original drainage time of 5.5 years. The results of this analysis are shown in Table 3.

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The total additional drainage time occurs over the first 9 layers and adds 11 days (0.03 years) to the computed drainage time. Including the effects of the maximum pipe capacity, the cell will take an estimated 5.5 years to drain.

Effect of Precipitation on Drainage Time

To account for the effect of precipitation added to the tailings cell, the HELP Model was used to estimate the average annual leakage through a 3 foot thick (tailings above the liquid) layer of silty sand material (Attachment I). HELP Model default parameters were used along with a maximum 16 inch evaporative zone (conservative for dry climate) and weather data from Grand Junction, Colorado. The model was performed for a 10 year period and included precipitation events ranging from 5.83 to 10.36 inches per year.

The results of this analysis suggest that a maximum average annual percolation through the 3 foot soil layer above the liquid will be approximately 12 ft^3 per acre or 504 ft^3 (3,770 gal.) for the entire Cell 4A area.

The average flow rate during Cell 4A dewatering, as calculated from Table 3 is equal to 71 gpm (102,240 gallon/day).

The time required to drain the additional volume of precipitation in the tailing is computed using the following equation:

$$Time = \frac{Volume}{FlowRate} = \frac{3{,}770\ gal}{102{,}240\,\frac{gal}{day}} = 0.04\ days$$

The additional time that the pond will require to empty due to precipitation is insignificant.

Therefore, the estimated time to dewater Cell 4A will be 5.5 years (baseline) + 0.03 years (pipe limitations) + 0 years (precipitation) = 5.5 years.

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(Attachment D)

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(Attachment C)

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(Attachment F)

Luettich, S.M., Giroud, J.P., and Bachus, R.C., (1991), "Geotextile Filter Design Manual, report prepared for Nicolon Corporation, Norcross, GA.
(Attachment G)

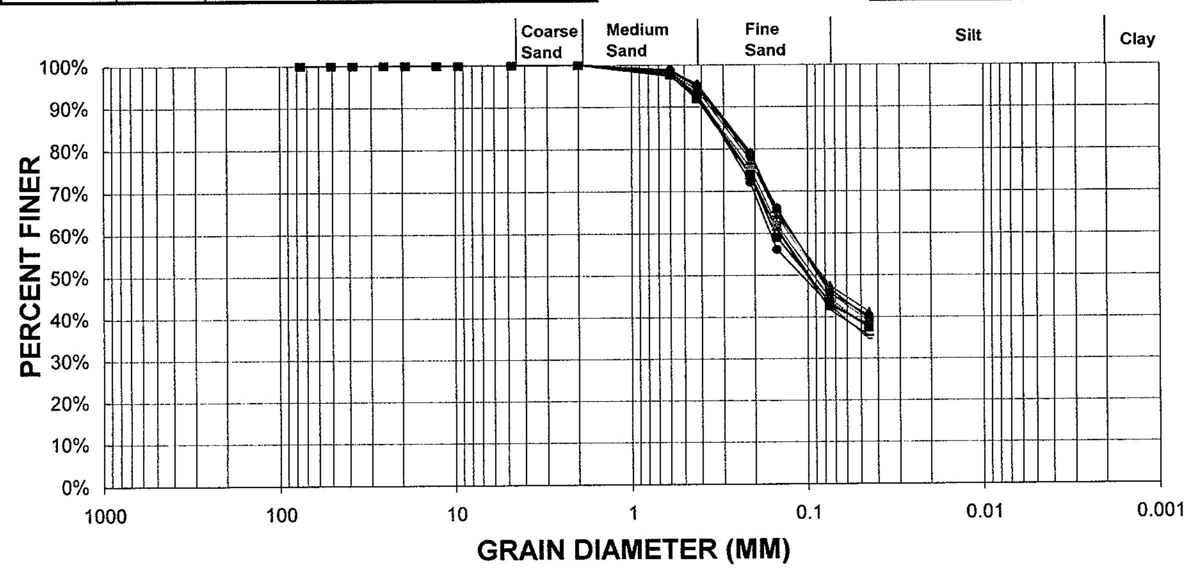
Amoco Fabrics and Fibers Company, (1991), "*Amoco Waste Related Geotextiles.*"
(Attachment H)

Table 1
DSM Screen Undersize Gradation

SIEVE ANALYSIS

Sieve No.	Diameter (mm)	Grinding Test 1 Wt. Retained (grams)	Grinding Test 1 % Retained	Grinding Test 1 % Finer	Grinding Test 2A Wt. Retained (grams)	Grinding Test 2A % Retained	Grinding Test 2A % Finer	Grinding Test 2B Wt. Retained (grams)	Grinding Test 2B % Retained	Grinding Test 2B % Finer	Grinding Test 3A Wt. Retained (grams)	Grinding Test 3A % Retained	Grinding Test 3A % Finer	Grinding Test 3B Wt. Retained (grams)	Grinding Test 3B % Retained	Grinding Test 3B % Finer
3 in.	76.2	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
2 in.	50.8	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
1 1/2 in.	38.1	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
1 in.	25.4	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
3/4 in.	19.1	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
1/2 in.	12.7	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
3/8 in.	9.530	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
No. 4	4.750	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
No. 10	2.000	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
No. 30	0.600	1.2	1.2%	98.8%	2.0	2.0%	98.0%	1.7	1.7%	98.3%	2.4	2.4%	97.6%	1.9	1.9%	98.1%
No. 40	0.425	4.6	4.6%	95.4%	7.3	7.3%	92.7%	6.0	6.0%	94.0%	8.1	8.1%	91.9%	6.9	6.9%	93.1%
No. 70	0.212	20.8	20.8%	79.2%	24.5	24.5%	75.5%	22.6	22.6%	77.4%	26.2	26.2%	73.8%	27.9	27.9%	72.1%
No. 100	0.150	34.8	34.8%	65.2%	38.1	38.1%	61.9%	35.5	35.5%	64.5%	41.0	41.0%	59.0%	43.9	43.9%	56.1%
No. 200	0.075	53.4	53.4%	46.6%	55.7	55.7%	44.3%	52.5	52.5%	47.5%	56.6	56.6%	43.4%	57.4	57.4%	42.6%
No. 325	0.045	60.5	60.5%	39.5%	62.7	62.7%	37.3%	58.8	58.8%	41.2%	62.5	62.5%	37.5%	61.9	61.9%	38.1%
Pan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Sieve No.	Diameter (mm)	Grinding Test 6A Wt. Retained (grams)	Grinding Test 6A % Retained	Grinding Test 6A % Finer	Grinding Test 6B Wt. Retained (grams)	Grinding Test 6B % Retained	Grinding Test 6B % Finer	Grinding Test 4A Wt. Retained (grams)	Grinding Test 4A % Retained	Grinding Test 4A % Finer	Grinding Test 4B Wt. Retained (grams)	Grinding Test 4B % Retained	Grinding Test 4B % Finer
3 in.	76.2	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
2 in.	50.8	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
1 1/2 in.	38.1	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
1 in.	25.4	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
3/4 in.	19.1	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
1/2 in.	12.7	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
3/8 in.	9.530	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
No. 4	4.750	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
No. 10	2.000	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%	0.0	0.0%	100.0%
No. 30	0.600	1.3	1.3%	98.7%	1.0	1.0%	99.0%	2.7	2.7%	97.3%	2.7	2.7%	97.3%
No. 40	0.425	5.2	5.2%	94.8%	4.7	4.7%	95.3%	7.6	7.6%	92.4%	7.3	7.3%	92.7%
No. 70	0.212	21.7	21.7%	78.3%	21.4	21.4%	78.6%	26.2	26.2%	73.8%	25.9	25.9%	74.1%
No. 100	0.150	34.1	34.1%	65.9%	35.9	35.9%	64.1%	38.7	38.7%	61.3%	39.2	39.2%	60.8%
No. 200	0.075	54.4	54.4%	45.6%	54.4	54.4%	45.6%	57.3	57.3%	42.7%	58.3	58.3%	41.7%
No. 325	0.045	59.7	59.7%	40.3%	61.1	61.1%	38.9%	65.4	65.4%	34.6%	64.6	64.6%	35.4%
Pan	-	-	-	-	-	-	-	-	-	-	-	-	-



Average	
Med Sand	6.4%
Fine Sand	49.1%
Silt	44.4%

%FINER = 100 - Σ%RETAINED

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Table 2
Tailings Parameters

Soil	Permeability[1] (cm/sec)	Drainable Porosity[2] (vol./vol.)
med sand	2.00E-02	0.35
fine sand	1.00E-02	0.29
silt	1.00E-04	0.14
silty clay	6.00E-07	0.11
average	7.53E-03	0.22
geomean	3.31E-04	0.20

Soil	Permeability[3] (cm/sec)	Drainable Porosity[3] (vol./vol.)
SM (LS)	1.70E-03	0.332
SM (LFS)	1.00E-03	0.326
SM (SL)	7.20E-04	0.263
SM (FSL)	5.20E-04	0.251
ML (L)	3.70E-04	0.231
ML (SiL)	1.90E-04	0.217
SC (SCL)	1.20E-04	0.154
average	6.60E-04	0.253
geomean	4.74E-04	0.246

Notes:

(1) Source - "Seepage, Drainage, and Flow Nets", Cedergren, H. R., 1989.

(2) Source - The Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3, EPA, 1994 - Figure 2 - Soil texture vs. Moisture Retention.

(3) Source - The Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3, EPA, 1994 - Table 1 - Low Density Soil Characteristics.

TABLE 3
White Mesa Mill
Cell 4A Slimes Drain
Maximum Liquid Depth

Permeability (cm/sec)	Permeability (ft/min)	Drainage Path Length (ft.)	Thickness (VF)	Q (cfm/ft)	Volume of Liquid (CF/ft)	Time to Dewater (min/VF/ft)	Time to Dewater (days/VF/ft)	Total Flow Rate (gpm)	Volume Removed (gal)	Pipe Limitation (days)
3.31E-04	6.51E-04	46.3	39	6.40E-04	11	17,185	11.93	131.92	2,266,966	2.17
3.31E-04	6.51E-04	45.8	38	6.31E-04	11	17,446	12.12	129.94	2,266,966	1.98
3.31E-04	6.51E-04	45.4	37	6.19E-04	11	17,761	12.33	127.63	2,266,966	1.77
3.31E-04	6.51E-04	45.0	36	6.08E-04	11	18,094	12.57	125.29	2,266,966	1.53
3.31E-04	6.51E-04	44.6	35	5.96E-04	11	18,446	12.81	122.90	2,266,966	1.29
3.31E-04	6.51E-04	44.2	34	5.85E-04	11	18,818	13.07	120.47	2,266,966	1.03
3.31E-04	6.51E-04	43.8	33	5.73E-04	11	19,213	13.34	117.99	2,266,966	0.76
3.31E-04	6.51E-04	43.5	32	5.59E-04	11	19,677	13.66	115.21	2,266,966	0.44
3.31E-04	6.51E-04	43.2	31	5.45E-04	11	20,172	14.01	112.38	2,266,966	0.09
3.31E-04	6.51E-04	43.0	30	5.30E-04	11	20,748	14.41	109.26	2,266,966	
3.31E-04	6.51E-04	42.8	29	5.15E-04	11	21,363	14.84	106.11	2,266,966	
3.31E-04	6.51E-04	42.6	28	4.99E-04	11	22,023	15.29	102.94	2,266,966	
3.31E-04	6.51E-04	42.4	27	4.84E-04	11	22,731	15.79	99.73	2,266,966	
3.31E-04	6.51E-04	42.3	26	4.67E-04	11	23,550	16.35	96.26	2,266,966	
3.31E-04	6.51E-04	42.2	25	4.50E-04	11	24,434	16.97	92.78	2,266,966	
3.31E-04	6.51E-04	42.1	24	4.33E-04	11	25,392	17.63	89.28	2,266,966	
3.31E-04	6.51E-04	42.1	23	4.15E-04	11	26,496	18.40	85.56	2,266,966	
3.31E-04	6.51E-04	42.1	22	3.97E-04	11	27,700	19.24	81.84	2,266,966	
3.31E-04	6.51E-04	42.1	21	3.79E-04	11	29,019	20.15	78.12	2,266,966	
3.31E-04	6.51E-04	42.2	20	3.60E-04	11	30,543	21.21	74.22	2,266,966	
3.31E-04	6.51E-04	42.3	19	3.41E-04	11	32,226	22.38	70.34	2,266,966	
3.31E-04	6.51E-04	42.5	18	3.22E-04	11	34,178	23.73	66.33	2,266,966	
3.31E-04	6.51E-04	42.6	17	3.03E-04	11	36,273	25.19	62.50	2,266,966	
3.31E-04	6.51E-04	42.8	16	2.84E-04	11	38,721	26.89	58.55	2,266,966	
3.31E-04	6.51E-04	43.1	15	2.64E-04	11	41,592	28.88	54.50	2,266,966	
3.31E-04	6.51E-04	43.3	14	2.46E-04	11	44,770	31.09	50.64	2,266,966	
3.31E-04	6.51E-04	43.6	13	2.27E-04	11	48,548	33.71	46.70	2,266,966	
3.31E-04	6.51E-04	44.0	12	2.07E-04	11	53,076	36.86	42.71	2,266,966	
3.31E-04	6.51E-04	44.3	11	1.89E-04	11	58,296	40.48	38.89	2,266,966	
3.31E-04	6.51E-04	44.7	10	1.70E-04	11	64,704	44.93	35.04	2,266,966	
3.31E-04	6.51E-04	45.1	9	1.52E-04	11	72,537	50.37	31.25	2,266,966	
3.31E-04	6.51E-04	45.6	8	1.33E-04	11	82,509	57.30	27.48	2,266,966	
3.31E-04	6.51E-04	46.0	7	1.16E-04	11	95,123	66.06	23.83	2,266,966	
3.31E-04	6.51E-04	46.5	6	9.81E-05	11	112,183	77.90	20.21	2,266,966	
3.31E-04	6.51E-04	47.1	5	8.07E-05	11	136,357	94.69	16.63	2,266,966	
3.31E-04	6.51E-04	47.6	4	6.39E-05	11	172,255	119.62	13.16	2,266,966	
3.31E-04	6.51E-04	48.2	3	4.73E-05	11	232,569	161.51	9.75	2,266,966	
3.31E-04	6.51E-04	48.8	2	3.11E-05	11	353,196	245.27	6.42	2,266,966	
3.31E-04	6.51E-04	49.4	1	1.54E-05	11	715,076	496.58	3.17	2,266,966	
						days	**1,989.58**		**88,411,655**	**11.06**
						years	**5.45**			

Average Soil Porosity	0.22	
Geomean Soil Permeability	3.31E-04	cm/sec
Distance Between Drains	50	ft
Thickness of Unit	1	ft
Maximum Depth	39	ft
Length of Strip Drain	27,550	ft

TABLE 4
White Mesa Mill
Cell 4A Slimes Drain
Average Liquid Depth

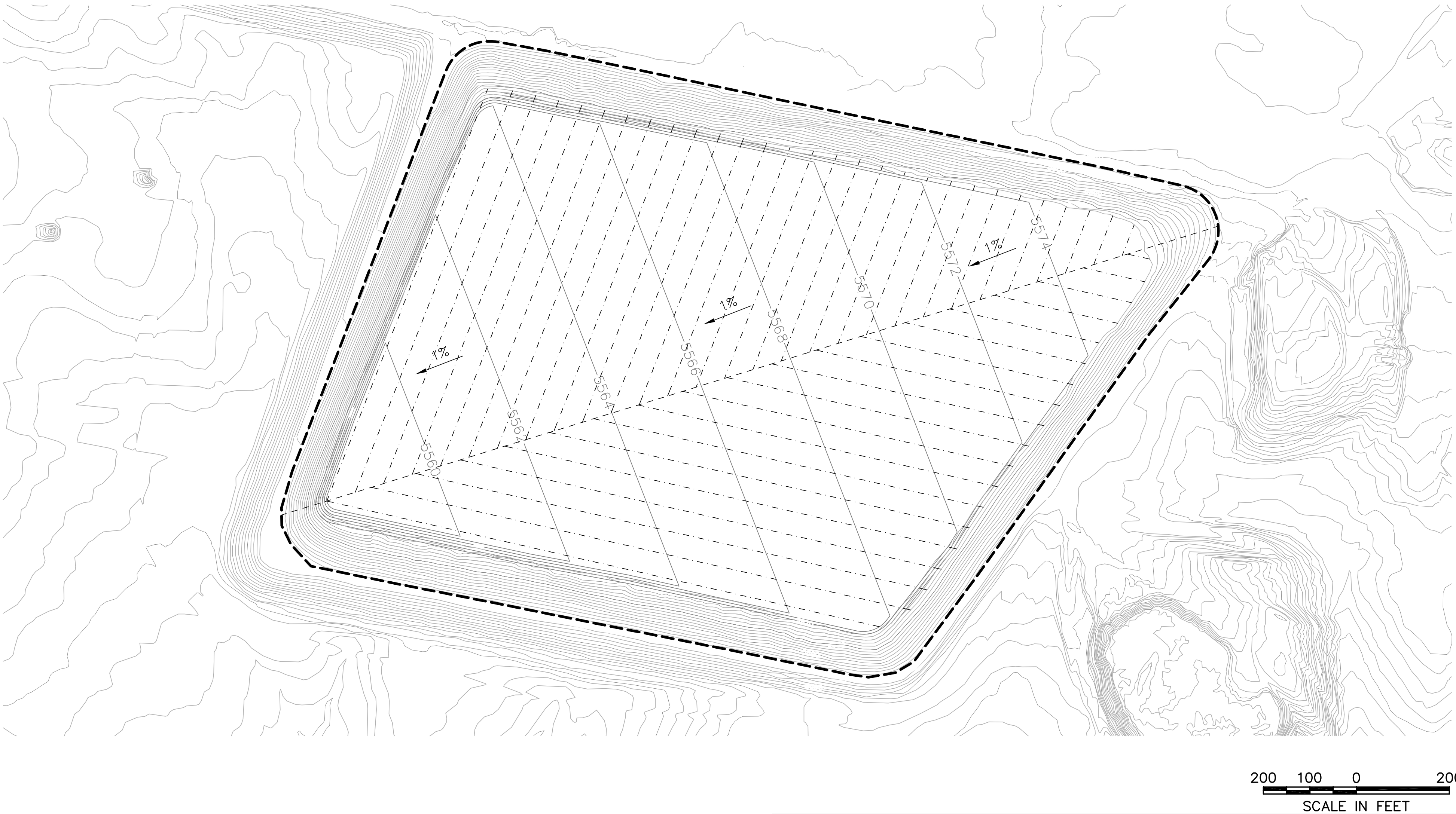
Permeability (cm/sec)	Permeability (ft/min)	Drainage Path Length (ft.)	Thickness (VF)	Q (cfm/ft)	Volume of Liquid (CF/ft)	Time to Dewater (min/VF/ft)	Time to Dewater (days/VF/ft)	Total Flow Rate (gpm)	Volume Removed (gal)
3.31E-04	6.51E-04	39.8	31	5.92E-04	11	18,584	12.91	121.98	2,266,966
3.31E-04	6.51E-04	39.6	30	5.76E-04	11	19,107	13.27	118.64	2,266,966
3.31E-04	6.51E-04	39.4	29	5.59E-04	11	19,666	13.66	115.27	2,266,966
3.31E-04	6.51E-04	39.2	28	5.43E-04	11	20,265	14.07	111.86	2,266,966
3.31E-04	6.51E-04	39.1	27	5.25E-04	11	20,962	14.56	108.14	2,266,966
3.31E-04	6.51E-04	39.0	26	5.07E-04	11	21,713	15.08	104.41	2,266,966
3.31E-04	6.51E-04	38.9	25	4.88E-04	11	22,523	15.64	100.65	2,266,966
3.31E-04	6.51E-04	38.9	24	4.69E-04	11	23,462	16.29	96.62	2,266,966
3.31E-04	6.51E-04	39.0	23	4.48E-04	11	24,545	17.05	92.36	2,266,966
3.31E-04	6.51E-04	39.0	22	4.29E-04	11	25,661	17.82	88.34	2,266,966
3.31E-04	6.51E-04	39.2	21	4.07E-04	11	27,020	18.76	83.90	2,266,966
3.31E-04	6.51E-04	39.3	20	3.87E-04	11	28,444	19.75	79.70	2,266,966
3.31E-04	6.51E-04	39.5	19	3.66E-04	11	30,093	20.90	75.33	2,266,966
3.31E-04	6.51E-04	39.8	18	3.44E-04	11	32,006	22.23	70.83	2,266,966
3.31E-04	6.51E-04	40.1	17	3.22E-04	11	34,145	23.71	66.39	2,266,966
3.31E-04	6.51E-04	40.4	16	3.01E-04	11	36,550	25.38	62.02	2,266,966
3.31E-04	6.51E-04	40.8	15	2.79E-04	11	39,373	27.34	57.58	2,266,966
3.31E-04	6.51E-04	41.2	14	2.58E-04	11	42,599	29.58	53.22	2,266,966
3.31E-04	6.51E-04	41.6	13	2.37E-04	11	46,321	32.17	48.94	2,266,966
3.31E-04	6.51E-04	42.1	12	2.17E-04	11	50,784	35.27	44.64	2,266,966
3.31E-04	6.51E-04	42.6	11	1.96E-04	11	56,059	38.93	40.44	2,266,966
3.31E-04	6.51E-04	43.1	10	1.76E-04	11	62,388	43.33	36.34	2,266,966
3.31E-04	6.51E-04	43.7	9	1.57E-04	11	70,285	48.81	32.25	2,266,966
3.31E-04	6.51E-04	44.3	8	1.37E-04	11	80,157	55.66	28.28	2,266,966
3.31E-04	6.51E-04	44.9	7	1.18E-04	11	92,848	64.48	24.42	2,266,966
3.31E-04	6.51E-04	45.6	6	1.00E-04	11	110,012	76.40	20.61	2,266,966
3.31E-04	6.51E-04	46.2	5	8.22E-05	11	133,751	92.88	16.95	2,266,966
3.31E-04	6.51E-04	46.9	4	6.48E-05	11	169,722	117.86	13.36	2,266,966
3.31E-04	6.51E-04	47.7	3	4.78E-05	11	230,156	159.83	9.85	2,266,966
3.31E-04	6.51E-04	48.4	2	3.14E-05	11	350,301	243.26	6.47	2,266,966
3.31E-04	6.51E-04	49.2	1	1.54E-05	11	712,181	494.57	3.18	2,266,966
						days	**1,841.45**		**70,275,931**
						years	**5.05**		

Average Soil Porosity	0.22	
Geomean Soil Permeability	3.31E-04	cm/sec
Distance Between Drains	50	ft
Thickness of Unit	1	ft
Maximum Depth	31	ft
Length of Strip Drain	27,550	ft

TABLE 5
White Mesa Mill
Cell 4A Slimes Drain
Minimum Liquid Depth

Permeability (cm/sec)	Permeability (ft/min)	Drainage Path Length (ft.)	Thickness (VF)	Q (cfm/ft)	Volume of Liquid (CF/ft)	Time to Dewater (min/VF/ft)	Time to Dewater (days/VF/ft)	Total Flow Rate (gpm)	Volume Removed (gal)
3.31E-04	6.51E-04	34.0	23	5.14E-04	11	21,398	14.86	105.94	2,266,966
3.31E-04	6.51E-04	34.1	22	4.90E-04	11	22,437	15.58	101.04	2,266,966
3.31E-04	6.51E-04	34.3	21	4.65E-04	11	23,643	16.42	95.88	2,266,966
3.31E-04	6.51E-04	34.6	20	4.39E-04	11	25,042	17.39	90.53	2,266,966
3.31E-04	6.51E-04	35.0	19	4.13E-04	11	26,665	18.52	85.02	2,266,966
3.31E-04	6.51E-04	35.4	18	3.86E-04	11	28,468	19.77	79.63	2,266,966
3.31E-04	6.51E-04	35.8	17	3.61E-04	11	30,483	21.17	74.37	2,266,966
3.31E-04	6.51E-04	36.3	16	3.35E-04	11	32,841	22.81	69.03	2,266,966
3.31E-04	6.51E-04	36.9	15	3.09E-04	11	35,609	24.73	63.66	2,266,966
3.31E-04	6.51E-04	37.5	14	2.84E-04	11	38,773	26.93	58.47	2,266,966
3.31E-04	6.51E-04	38.2	13	2.59E-04	11	42,535	29.54	53.30	2,266,966
3.31E-04	6.51E-04	38.9	12	2.34E-04	11	46,924	32.59	48.31	2,266,966
3.31E-04	6.51E-04	39.6	11	2.11E-04	11	52,111	36.19	43.50	2,266,966
3.31E-04	6.51E-04	40.4	10	1.88E-04	11	58,480	40.61	38.76	2,266,966
3.31E-04	6.51E-04	41.2	9	1.66E-04	11	66,264	46.02	34.21	2,266,966
3.31E-04	6.51E-04	42.1	8	1.44E-04	11	76,176	52.90	29.76	2,266,966
3.31E-04	6.51E-04	43.0	7	1.24E-04	11	88,919	61.75	25.49	2,266,966
3.31E-04	6.51E-04	43.9	6	1.04E-04	11	105,910	73.55	21.40	2,266,966
3.31E-04	6.51E-04	44.8	5	8.48E-05	11	129,698	90.07	17.48	2,266,966
3.31E-04	6.51E-04	45.8	4	6.64E-05	11	165,741	115.10	13.68	2,266,966
3.31E-04	6.51E-04	46.8	3	4.87E-05	11	225,814	156.81	10.04	2,266,966
3.31E-04	6.51E-04	47.9	2	3.17E-05	11	346,682	240.75	6.54	2,266,966
3.31E-04	6.51E-04	48.9	1	1.55E-05	11	707,839	491.55	3.20	2,266,966
						days	**1,665.59**		**52,140,207**
						years	**4.56**		

Average Soil Porosity	0.22	
Geomean Soil Permeability	3.31E-04	cm/sec
Distance Between Drains	50	ft
Thickness of Unit	1	ft
Maximum Depth	23	ft
Length of Strip Drain	27,550	ft



GEOSYNTEC CONSULTANTS

SLIMES DRAIN LAYOUT CELL 4A BLANDING, UTAH	FIGURE NO. 1 PROJECT NO. SC0349 DATE: MARCH 2007

P:\PRJ\SDCadd\CADD\SC0349\FIGURES\SC0349-01-04\SC0349_Figure 1_Slimes Drain Layout.dwg 7/10/2006 5:25 PM John Hall

Geosyntec consultants

Written by: G. Corcoran Date: 10/5/07 (DD MM YY) Reviewed by: ____ Date: __/__/__ (DD MM YY)

Client: Dawson Mines Project: Cell 4A Project/Proposal No. SC0349 Task No. 01/04

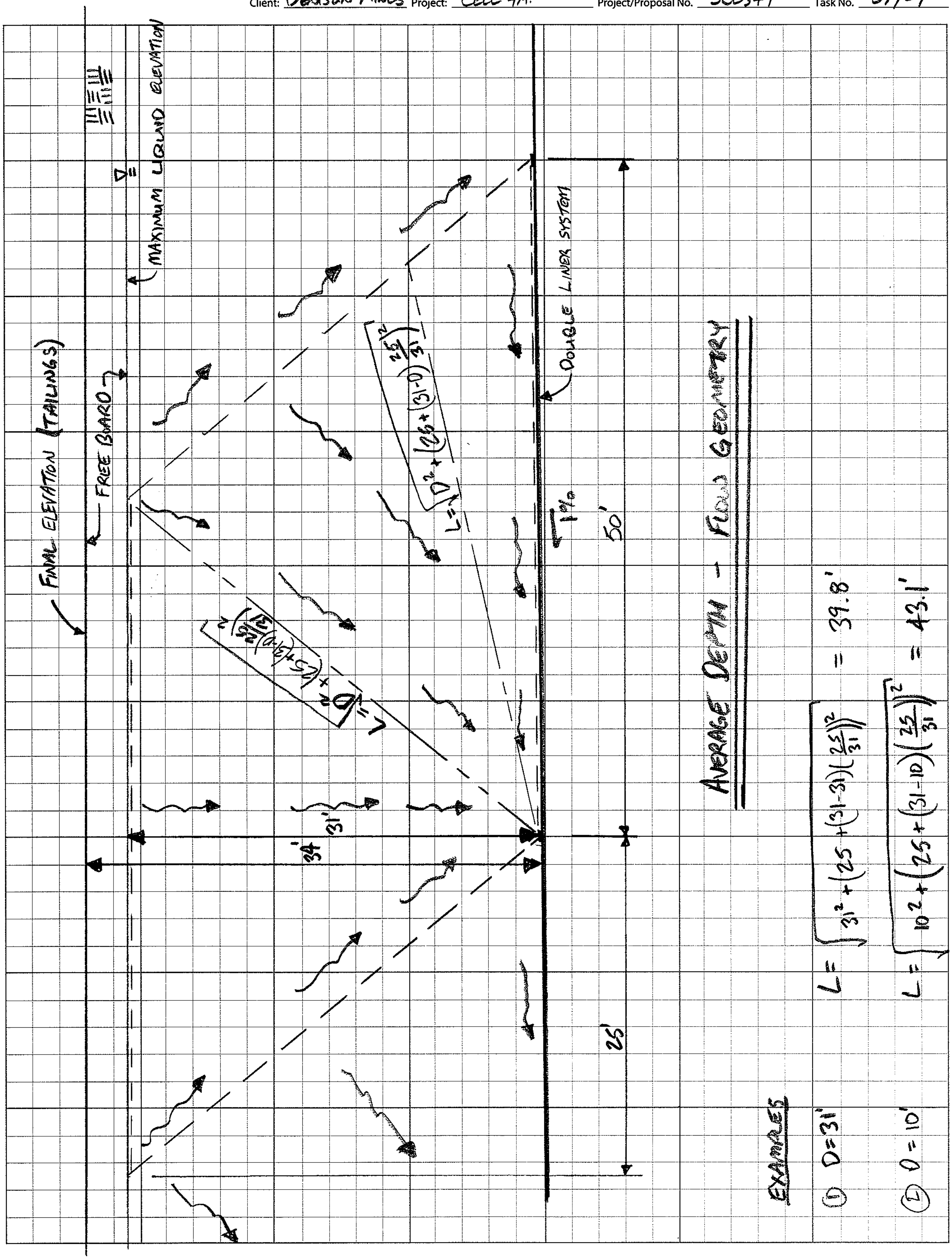
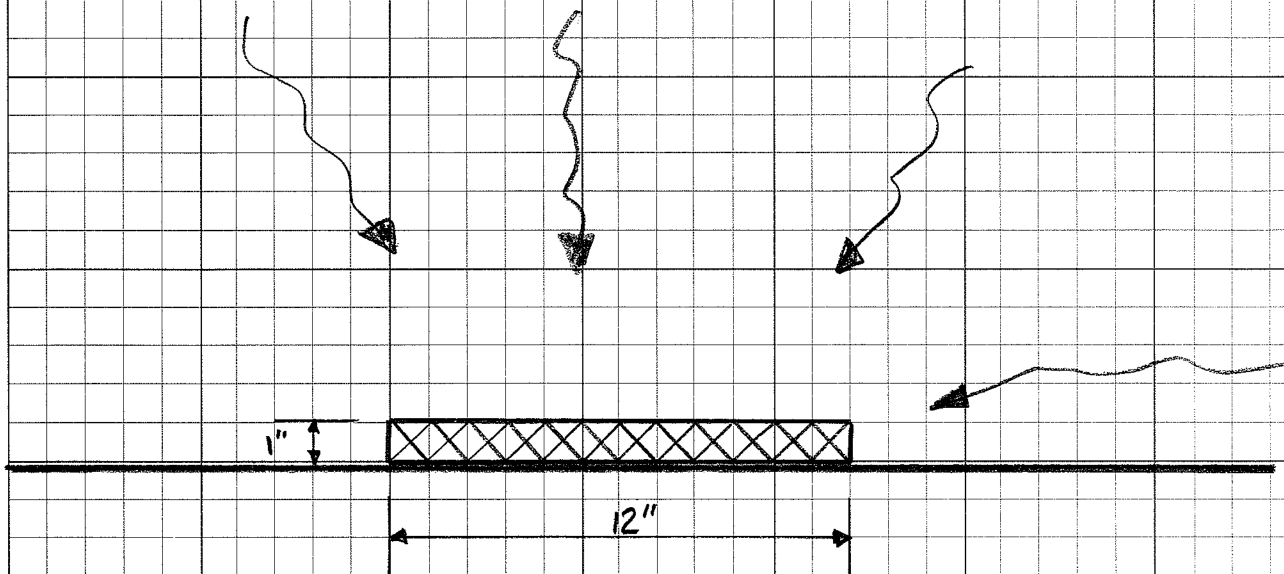


FIGURE 2

Geosyntec consultants

Written by: G. Corcoran Date: 10/5/07 (DD MM YY) Reviewed by: ____ Date: __/__/__ (DD MM YY)

Client: Denison Mines Project: Cell 4A Project/Proposal No. SC0349 Task No. 01/04



FLOW AREA - STRIP COMPOSITE

$$A = \frac{14''}{12''/ft} = 1.17\ ft^2/ft.$$

FIGURE 3

EXHIBIT 1

SAMPLE DESCRIPTION AND PREPARATION

CSMRI Sample 1

Sponsor's Designation of Sample:	Run-of-mine.
Date Received at Institute:	June 5, 1978.
Sample Weight:	100,520 lb.
Sample Container:	Two truckloads.
Sample Description:	Mine ore -- estimate 5% +10-in. material. Largest boulder -- 48 in. x 24 in. x 14 in. Only two or three rocks were greater than 36 in.
Method of Preparation:	All +10-in. material broken to -10 in. by sledgehammer and jackhammer. The sample was screened at 6 in. and 1-1/2 in. with the +6 in. fraction, put in barrels, and the -1/2 in. fraction piled. The -6 in. +1-1/2 in. material was screened at 4 in. and 1-1/2 in. with the -6 in. +4 in. and -4 in. +1-1/2 in. fractions barreled. The additional -1-1/2 in. fraction was piled with the previous -1-1/2 in. fraction. A screen size analysis of the entire quantity of mill feed material is presented in Exhibit 3. A summary screen size analysis of the ore is as follows:

Screen Product in.		Weight %
Head (calculated)		100.00
-10	+6	2.92
-6	+4	9.48
-4	+1-1/2	15.30
-1-1/2		72.30

ATTACHMENT A. 1/14

EXHIBIT 1

CSMRI Sample 2

Sponsor's Designation of Sample:	Crushed ore.
Date Received at Institute:	June 5, 1978.
Sample Weight:	47,380 lb.
Sample Container:	One truckload.
Sample Description:	Ore previously crushed to -3 in., maximum particles approximately 2-1/2 in.
Method of Preparation:	The ore was used as received.

EXHIBIT 2

GRINDING TESTS

Grinding Test 1, Autogenous

Date:	June 13, 1978
Feed Rate, stph:	2
Ore:	Run-of-mine
DSM Screen, in. width:	12
DSM Screen Opening, mm:	1.27
Measured Mill Power Tare (empty mill), kw:	2.06
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Meter Reading watt-hr	Mill-Bearing Oil Temp. °F	Ore Feed Rate (as received)(1) -1-1/2 in. lb/hr	-4 in. +1-1/2 in. lb/hr	-6 in. +4 in. lb/hr	-10 in. +6 in. lb/hr	Mill Discharge Solids %	Mill Discharge Solids lb/hr	Sweco Screen Oversize Solids %	Sweco Screen Oversize Solids lb/hr	DSM Screen Overflow Solids %	DSM Screen Overflow Solids lb/hr	DSM Screen Underflow Solids %	DSM Screen Underflow Solids lb/hr	Mill Water Meter %	Mill Water Rate lb/hr	Mill Load Volume %	Remarks
0910	0	--	--	104	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Start mill.
0915	5	12.2	12,964	--	3,150	612	380	116	63	8,335	--	--	--	--	--	--(2)	90	2,858	--	--
1005	55	8.7	--	--	2,880	612	380	116	62	--	90	506	60	3,348	57	2,616(2)	90	2,858	--	--
1030	80	6.8	--	105	2,835	612	380	116	69	--	90	304	70	3,591	58	710(2)	90	2,858	--	--
1100	110	6.5	12,977	106	2,993	612	380	116	66	--	--	--	69	4,223	58	679(2)	80	2,540	--	--
1135	145	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Mill down, elevator plugged.
1142	145	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Start mill.
1150	153	6.2	--	109	2,993	612	380	116	69	12,420	90	1,114	70	5,544	56	2,583	--	--	--	--
1230	193	6.0	12,988	111	2,903	612	380	116	64	10,829	90	405	69	6,955	60	4,388	75	2,382	--	--
1300	223	6.2	--	112	3,319	612	380	116	65	11,232	90	365	70	6,048	60	3,861	81	2,572	--	--
1345	238	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Pump plugged. DSM feed.
1400	253	6.4	--	112	3,128	612	380	116	65	11,700	90	122	69	3,229	60	3,996	80	2,540	--	Sample
1415	268	6.3	13,004	112	2,970	612	380	116	65	9,945	90	547	71	3,515	59	2,907	79	2,509	15	Sample.
Average					3,019	612	380	116	65	10,744	90	480	69	4,557	59	3,547	83	2,640		

(1) Moisture: -1-1/2 in., 2.8%; -4 in. +1-1/2 in., 1.0%; -6 in. +4 in., 0.8%; -10 in. +6 in., 0.7%. Average dry ore feed rate: -1-1/2 in., 2,934.5 lb/hr; -4 in. +1-1/2 in., 605.9 lb/hr; -6 in. +4 in., 376.8 lb/hr; -10 in. +6 in., 115.0 lb/hr; total, 4,032.2 lb/hr, 2.016 dry stph. Mill volume end of test: 15%.
(2) Excluded from average.

Feed Rate, stph dry:	2.016
Ball Charge:	None
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Instantaneous Gross Power (meter reading) kwhr	Instantaneous Corrected Power (from input-output curve) kwhr	Power Consumption Gross kwhr/st	Power Consumption Net kwhr/st	Circulating Load Weight % of Feed(1)	Mill Discharge Solids %	Remarks
0910	0	--	--	--	--	--	--	--	--
0915	5	12.2	4.25	2.64	1.31	1.01	--	63	--
1005	55	8.7	5.96	4.25	2.11	1.81	--	62	--
1030	80	6.8	7.62	5.80	2.88	2.58	--	69	--
1100	110	6.5	7.97	6.10	3.03	2.73	--	66	--
1135	145	--	--	--	--	--	--	--	Unplug bucket elevator.
1150	153	6.2	8.36	6.47	3.21	2.91(2)	162.0	69	--
1230	193	6.0	8.64	6.73	3.34	3.04(2)	183.0	64	--
1300	223	6.2	8.36	6.47	3.21	2.91(2)	145.0	65	--
1345	238	--	--	--	--	--	--	--	Unplug DSM feed pump.
1400(3)	253	6.4	8.10	6.23	2.09	2.79(2)	79.0	65	--
1415(3)	268	6.3	8.23	6.35	3.15	2.85(2)	100.0	65	--
Average						2.90	133.8		

(1) Calculated: Sum of Sweco oversize and DSM oversize as percentage of dry mill feed.
(2) Average for power (last five readings): 2.90 kwhr/st.
(3) Sample run.

EXHIBIT 2

Grinding Test 1 -- continued

Procedure: Sample was wet screened on a 325M screen, products dried, and the +325M material dry screened using a Ro-Tap for 30 min.

Test Product	Screen Size Analysis DSM Screen Undersize
Sample Time:	1415
Sample Weight, g:	4,630.5
Screen Product (Tyler) Mesh	Weight %
Head (calculated)	100.0
+28	1.2
-28 +35	3.4
-35 +65	16.2
-65 +100	14.0
-100 +200	18.6
-200 +325	7.1
-325	39.5

US SIEVE

GTC
5/10/07

No. 30
No. 40
No. 70
No. 100
No. 200
No. 325

EXHIBIT 2

Grinding Test 2

Date:	June 14, 1978
Feed Rate, stph:	2.0
Ore:	Run-of-mine
Ball Charge:	Total: 301.8 lb; 2% mill volume
-1-1/2 in. +1 in. Balls, lb:	114.5
-2 in. +1-1/2 in. Balls, lb:	151.3
3 in. Balls, lb:	36.0
DSM Screen, in. width:	12
DSM Screen Openings, mm:	1.27
Measured Mill Power Tare (empty mill), kw:	2.06
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Meter Reading watt-hr	Mill-Bearing Oil Temp. °F	Ore Feed Rate (as received)(1) -1-1/2 in. lb/hr	-4 in. +1-1/2 in. lb/hr	-6 in. +4 in. lb/hr	-10 in. +6 in. lb/hr	Mill Discharge Solids %	Mill Discharge Solids lb/hr	Sweco Screen Oversize Solids %	Sweco Screen Oversize Solids lb/hr	DSM Screen Overflow Solids %	DSM Screen Overflow Solids lb/hr	DSM Screen Underflow Solids %	DSM Screen Underflow Solids lb/hr	Mill Water Meter %	Mill Water Rate lb/hr	Mill Load Volume %	Remarks
1040	0	8.7	13,004	102	--	612	380	116	--	--	--	--	--	--	--	--	95	3,017	-	Start mill.
1110	30	5.2	--	104	--	612	380	116	--	--	--	--	--	--	--	--	83	2,636	-	--
1130	50	5.3	--	106	3,060	612	380	116	62	8,147	50	248	74	1,565	54	2,989(2)	84	2,668	-	--
1200	80	5.0	--	108	2,846	612	380	116	63	6,577	67	653	71	1,150	--	--	82	2,604	-	--
1230	110	4.8	13,023	111	3,105	612	380	116	64	8,467	64	605	73	1,281	--	--	82	2,604	-	--
1300	140	4.8	--	112	3,139	612	380	116	63	6,917	62	391	73	2,102	57	3,694	81	2,572	-	--
1330	170	4.8	--	113	3,263	612	380	116	66	8,494	63	595	69	3,571	56	3,881	81	2,572	-	--
1400	200	4.9	--	113	2,981	612	380	116	66	9,029	64	624	71	2,939	58	3,680	81	2,572	-	--
1415	215	5.0	--	113	2,869	612	380	116	66	10,098	64	547	70	3,119	58	3,811	79	2,509	-	Sample.
1430	230	5.0	13,044	113	2,993	612	380	116	65	8,483	64	557	71	3,259	57	3,565	79	2,509	9	Sample. End of test.
Average					3,032	612	380	116	65	8,277	62	528	72	2,373	57	3,726	83	2,626		

(1) Moisture: -1-1/2 in., 2.8%; -4 in. +1-1/2 in., 1.0%; -6 in. +4 in., 0.8%; -10 in. +6 in., 0.7%. Average dry ore feed rate: -1-1/2 in., 2,947.0 lb/hr; -4 in. +1-1/2 in., 605.9 lb/hr; -6 in. +4 in., 376.8 lb/hr; -10 in. +6 in., 115.0 lb/hr; total: 4,044.7 lb/hr, 2.022 dry stph. Mill volume end of test: 9%.

(2) Excluded from average.

Feed Rate, stph dry:	2.022
Ball Charge:	301.8 lb, 2% mill volume
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Instantaneous Gross Power (meter reading) kwhr	Instantaneous Corrected Power (from input-output curve) kwhr	Power Consumption Gross kwh/st	Power Consumption Net kwh/st	Circulating Load Weight % of Feed(1)	Mill Discharge Solids %
1040	0	8.7	5.96	4.22	2.09	1.79	--	--
1110	30	5.2	9.97	7.93	3.92	3.63	--	--
1130	50	5.3	9.78	7.78	3.85	3.55	--	62
1200	80	5.0	10.36	8.25	4.08	3.78	--	63
1230	110	4.8	10.80	8.63	4.27	3.97	--	64
1300	140	4.8	10.80	8.63	4.27	3.97	59.0(4)	63
1330	170	4.8	10.80	8.63	4.27	3.97	95.0	66
1400	200	4.9	10.58	8.44	4.17	3.88	87.0	66
1415(3)	215	5.0	10.36	8.25	4.08	3.78(2)	92.0	66
1430(3)	230	5.0	10.36	8.25	4.08	3.78(2)	93.0	65
Average						3.78	91.8	

(1) Calculated: Sum of Sweco oversize and DSM oversize as a percentage of dry mill feed.
(2) Average for power (last two readings): 3.78 kwhr/st.
(3) Sample run.
(4) Omitted from average.

EXHIBIT 2

Grinding Test 2 -- continued

Procedure: Samples were wet screened on a 325M screen, products dried, and the +325M material dry screened using a Ro-Tap for 30 min.

Test Product	Screen Size Analysis: Mill Discharge		Sweco Screen Oversize		DSM Screen Oversize		DSM Screen Undersize		Circulating Load
Sample Time	1415	1430	1415	1430	1415	1430	1415	1430	
Sample Weight, g:	1,058.8	1,206.6	669.3	979.0	915.6	1,106.8	888.1	932.3	
Screen Product (Tyler) Mesh	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %
Head (calculated)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
+28	23.8	21.6	65.5	71.8	40.4	37.6	2.0	1.7	43.4
-28 +35	6.8	6.4	2.5	1.6	8.4	9.9	5.3	4.3	8.1
-35 +65	13.5	13.3	4.2	3.6	8.8	12.0	17.2	16.6	9.4
-65 +100	9.4	10.2	3.2	3.0	4.7	7.6	13.6	12.9	5.7
-100 +200	11.9	13.4	5.0	5.0	7.3	10.3	17.6	17.0	8.3
-200 +325	4.2	5.9	3.0	2.1	1.6	4.7	7.0	6.3	3.1
-325	30.4	29.2	16.6	12.9	28.8	17.9	37.3	41.2	22.0

EXHIBIT 2

Grinding Test 3

Date:	June 15, 1978
Feed Rate, stph:	3.0
Ore:	Run-of-mine
Ball Charge:	Total: 301.8 lb, 2% mill volume
-1-1/2 in. +1 in. Balls, lb:	114.5
-2 in. +1-1/2 in. Balls, lb:	151.3
3 in. Balls, lb:	36.0
DSM Screen, in. width:	12
DSM Screen Openings, mm:	1.27
Measured Mill Power Tare (empty mill), kw:	2.06
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Meter Reading watt-hr	Mill-Bearing Oil Temp. °F	Ore Feed Rate (as received)(1) -1-1/2 in. lb/hr	Ore Feed Rate -4 in. +1-1/2 in. lb/hr	Ore Feed Rate -6 in. +4 in. lb/hr	Ore Feed Rate -10 in. +6 in. lb/hr	Mill Discharge Solids %	Mill Discharge Solids lb/hr	Sweco Screen Oversize Solids %	Sweco Screen Oversize Solids lb/hr	DSM Screen Overflow Solids %	DSM Screen Overflow Solids lb/hr	DSM Screen Underflow Solids %	DSM Screen Underflow Solids lb/hr	Mill Water Meter %(2)	Mill Water Rate lb/hr	Mill Load Volume %	Remarks
1050	0	5.0	13,045	93	--	918	570	174	--	--	--	--	--	--	--	--	--	--	--	Start mill.
1135	45	4.5	--	--	--	918	570	174	--	--	--	--	--	--	--	--	--	--	--	--
1200	70	4.4	--	99	4,350	918	570	174	65	13,631	68	857	70	6,237	58	5,090	105	3,350	--	--
1207	77	--	--	--	--	918	570	174	--	--	--	--	--	--	--	--	--	--	--	Shutdown, rock jammed in feeder.
1230	77	--	--	--	--	918	570	174	--	--	--	--	--	--	--	--	--	--	--	Start mill.
1300	107	4.9	--	109	3,435	918	570	174	65	10,530	63	808	73	3,679	55	4,430	106	3,366	--	--
1330	137	4.8	--	108	4,815	918	570	174	66	11,642	64	878	72	5,508	61	5,408	104	3,303	--	--
1400	167	4.9	--	110	4,275	918	570	174	67	11,095	58	639	73	5,059	61	5,545	104	3,303	--	--
1430	197	4.7	--	111	4,590	918	570	174	67	11,156	65	761	72	5,573	61	4,804	103	3,271	--	Sample.
1445	212	4.8	13,085	112	5,040	918	570	174	67	15,135	67	1,010	71	6,646	62	5,692	104	3,303	--	Sample.
1500	242	--	--	--	--	918	570	174	--	--	--	--	--	--	--	--	--	--	25	Shut down.
Average					4,417	918	570	174	66	12,198	64	826	72	5,450	60	5,162	104	3,316		

(1) Moisture: -1-1/2 in., 2.8%; -4 in. +1-1/2 in., 1.0%; -6 in. +4 in., 0.8%, -10 in. +6 in., 0.7%. Average dry ore feed rate: -1-1/2 in., 4,293.8 lb/hr, -4 in. +1-1/2 in., 908.8 lb/hr; -6 in. +4 in., 565.4 lb/hr; -10 in. +6 in., 172.8 lb/hr; total, 5,940.8 lb/hr, 2.970 dry stph. Mill volume end of test: 25%.
(2) Auxilliary water line used -- measured twice, averaged, and added as percentage of regular water meter.

Feed Rate, stph dry:	2.970 stph dry
Ball Charge:	301.8 lb, 2% of mill volume
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Instantaneous Gross Power (meter reading) kwhr	Instantaneous Corrected Power (from input-output curve) kwhr	Power Consumption Gross kwhr/st	Power Consumption Net kwhr/st	Circulating Load Weight % of Feed(1)	Mill Discharge Solids %	Remarks
1050	0	5.0	10.36	8.26	2.78	2.58	--	--	--
1135	45	4.5	11.52	9.24	3.11	2.91	--	--	--
1200	70	4.4	11.78	9.45	3.18	2.98	118.0(4)	65	--
1207	77	--	--	--	--	--	--	--	Rock jammed in feeder.
1230	77	--	--	--	--	--	--	--	--
1300	107	4.9	10.58	8.43	2.84	2.64(2)	88.0	65	--
1330	137	4.8	10.80	8.62	2.90	2.70(2)	99.0	66	--
1400	167	4.9	10.58	8.43	2.84	2.64(2)	96.0	67	--
1430(3)	197	4.7	11.03	8.82	2.97	2.77(2)	101.0	67	--
1445(3)	212	4.8	10.80	8.62	2.90	2.70(2)	114.0	67	--
1500	242								
Average						2.70	99.6		

(1) Calculated: Sum of Sweco oversize and DSM oversize as a percentage of dry mill feed.
(2) Average for power (last four readings): 2.70 kwhr/st.
(3) Sample run.
(4) Omitted from average.

EXHIBIT 2

Grinding Test 3

Procedure: Samples were wet screened on a 325M screen, products dried, and the +325M material dry screened using a Ro-Tap for 30 min.

Test Product	Screen Size Analysis: Mill Discharge		Sweco Screen Oversize		DSM Screen Oversize		DSM Screen Undersize		Circulating Load
Sample Time	1430	1445	1430	1445	1430	1445	1430	1445	--
Sample Weight, g:	1,174.9	1,310.3	1,365.7	1,223.1	1,183.4	1,245.5	850.1	962.4	--
Screen Product (Tyler) Mesh	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %
Head (calculated)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
+28	27.8	25.1	65.0	67.5	47.4	33.3	2.4	1.9	43.7
-28 +35	6.5	7.1	1.8	2.0	9.1	7.9	5.7	5.0	7.6
-35 +65	12.8	14.6	3.7	4.0	12.4	13.2	18.1	21.0	11.7
-65 +100	9.2	9.0	3.1	3.4	6.5	8.5	14.8	16.0	7.0
-100 +200	11.4	13.5	5.4	5.5	8.9	9.9	15.6	13.5	8.9
-200 +325	4.8	3.4	3.4	3.3	1.6	3.3	5.9	4.5	2.5
-325	27.5	27.3	17.6	14.3	14.1	23.9	37.5	38.1	18.6

EXHIBIT 2

Grinding Test 4

Date:	June 16, 1978
Feed Rate, stph:	2.5
Ore:	Crushed
Ball Charge:	Total: 301.8 lb, 2% mill volume
-1-1/2 in. +1 in. Balls, lb:	114.5
-2 in. +1-1/2 in. Balls, lb:	151.3
3 in. Balls, lb:	36.0
DSM Screen, in. width:	12
DSM Screen Openings, mm:	1.27
Measured Mill Power Tare (empty mill), kw:	2.06
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Meter Reading watt-hr	Mill-Bearing Oil Temp. °F	Ore Feed Rate (as received)(1) -3 in. lb/hr	Mill Discharge Solids %	Mill Discharge Solids lb/hr	Sweco Screen Oversize Solids %	Sweco Screen Oversize Solids lb/hr	DSM Screen Overflow Solids %	DSM Screen Overflow Solids lb/hr	DSM Screen Underflow Solids %	DSM Screen Underflow Solids lb/hr	Mill Water Meter %(1)	Mill Water Rate lb/hr	Mill Load Volume %	Remarks
1010	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9	Start mill.
1030	20	6.6	13,094	96	--	--	--	--	--	--	--	--	--	90	2,858	--	--
1100	50	6.3	--	97	5,130	63	7,598	67	362	74	1,931	61	5,243	87	2,763	--	--
1130	80	5.9	--	99	5,350	62	8,091	64	418	72	2,398	60	4,482	82	2,604	--	--
1200	110	5.9	--	99	4,995	65	12,519	66	535	70	3,717	61	3,953	80	2,540	--	--
1215	125	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Feed off (feed belt jammed).
1218	125	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Start mill.
1230	137	6.0	--	100	4,770	62	5,692	62	288	71	2,077	58	3,628	80	2,540	--	--
1300	167	6.0	--	100	5,423	65	6,786	62	326	71	1,885	60	4,428	80	2,540	--	--
1320	187	--	--	--	--	--	--	--	--	--	--	60	4,316(3)	--	--	--	--
1330	197	5.8	--	102	4,826	65	6,728	65	449	69	2,298	59	4,806	79	2,509	--	--
1400	227	5.7	--	104	4,635	64	6,797	62	260	72	1,134	60	4,617	79	2,509	--	Sample.
1415	242	5.7	13,128	104	6,793	63	6,010	64	230	70	819	59	4,328	79	2,509	15	Sample.
1500	257	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
Average					5,240	64	7,528	64	359	71	2,032	60	4,422	82	2,597	--	

(1) Moisture: -3 in., 4.3%. Average dry ore feed rate: -3 in., 5,015 lb/hr, 2.508 dry stph. Mill volume end of test: 15%.
(2) Auxilliary water line used -- measured twice, averaged, and added as percentage of regular water meter.
(3) 55-gal drum timed sample.

Feed Rate, stph:	2.508
Ball Charge:	301.8 lb, 2% of mill volume
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Instantaneous Gross Power (meter reading) kwhr	Instantaneous Corrected Power (from input-output curve) kwhr	Power Consumption Gross kwhr/st	Power Consumption Net kwhr/st	Circulating Load Weight % of Feed(1)	Mill Discharge Solids %	Remarks
1010	0	--	--	--	--	--	--	--	--
1030	20	6.6	7.85	6.00	2.39	2.15	--	--	--
1100	50	6.3	8.23	6.35	2.53	2.29	--	63	--
1130	80	5.9	8.78	6.87	2.74	2.50	50.0(4)	62	--
1200	110	5.9	8.78	6.87	2.74	2.50	81.0(4)	65	--
1215	125	--	--	--	--	--	--	--	Feed belt jammed.
1230	137	6.0	8.64	6.73	2.68	2.44	48.0	62	--
1300	167	6.0	8.64	6.73	2.68	2.44	39.0	65	--
1320	187	--	--	--	--	--	--	--	--
1330	197	5.8	8.93	7.00	2.79	2.55(2)	54.0	65	--
1400(3)	227	5.7	9.09	7.13	2.84	2.60(2)	29.0	64	--
1415(3)	242	5.7	9.09	7.13	2.84	2.60(2)	14.0	63	--
Average						2.58	36.8		

(1) Calculated: Sum of Sweco oversize and DSM oversize as a percentage of dry mill feed.
(2) Average for power (last three readings): 2.58 kwhr/st.
(3) Sample run.
(4) Omitted from average.

EXHIBIT 2

Grinding Test 4 -- continued

Procedure: Samples were wet screened on a 325M screen, products dried, and the +325M material dry screened using a Ro-Tap for 30 min.

	Screen Size Analysis								
Test Product	Mill Discharge		Sweco Screen Oversize		DSM Screen Oversize		DSM Screen Undersize		Circulating Load
Sample Time	1140	1415	1400	1415	1400	1415	1400	1415	--
Sample Weight, g:	1,139.4	886.7	715.4	726.2	1,152.9	1,020.0	763.8	769.4	--
Screen Product (Tyler) Mesh	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %
Head (calculated)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
+28	15.3	13.1	86.5	91.8	39.1	43.1	2.7	2.7	55.5
-28 +35	5.8	5.2	0.3	0.3	8.9	7.6	4.9	4.6	5.9
-35 +65	17.8	17.9	0.9	0.5	14.9	12.7	18.6	18.6	9.9
-65 +100	11.1	11.8	0.7	0.3	6.8	6.3	12.5	13.3	4.7
-100 +200	15.8	16.7	1.6	0.7	8.8	8.9	18.6	19.1	6.6
-200 +325	7.7	6.4	0.9	0.4	3.3	4.1	8.1	6.3	2.8
-325	26.5	28.9	9.1	6.0	18.2	17.3	34.6	35.4	14.6

EXHIBIT 2

Grinding Test 5

Date:	June 19, 1978
Feed Rate, stph:	2.0
Ore:	Crushed
Ball Charge:	Total 301.8 lb, 2% mill volume
-1-1/2 in. Balls, lb:	114.5
-2 in. +1-1/2 in. Balls, lb:	151.3
3 in. Balls, lb:	36.0
DSM Screen, in. width:	12
DSM Screen Openings, mm:	1.27
Measured Mill Power Tare (empty mill), kw:	2.06
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Meter Reading watt-hr	Mill-Bearing Oil Temp. °F	Ore Feed Rate (as received)(1) -3 in. lb/hr	Mill Discharge Solids %	Mill Discharge Solids lb/hr	Sweco Screen Oversize Solids %	Sweco Screen Oversize Solids lb/hr	DSM Screen Overflow Solids %	DSM Screen Overflow Solids lb/hr	DSM Screen Underflow Solids %	DSM Screen Underflow Solids lb/hr	Mill Water Meter %	Mill Water Rate lb/hr	Mill Load Volume %	Remarks
0840	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7	Start mill.
0910	30	6.7	13,136	90	3,623	--	--	--	--	--	--	--	--	75	2,382	--	--
0930	50	6.3	--	91	3,960	67	8,744	48	356	67	3,558	60	2,970	71	2,255	--	--
1000	80	6.2	--	92	3,803	66	6,663	45	324	70	2,079	60	4,077	68	2,159	--	--
1030	110	6.5	--	91	--	56	3,578	15	68	70	347	59	3,452	66	2,096	--	Shut down -- out of feed.
1035	115	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1040	115	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Start mill.
1100	135	6.5	--	94	4,230	66	4,990	38	182	75	346	62	4,241	68	2,159	--	--
1130	165	6.6	--	96	4,298	66	5,049	42	239	72	729	62	4,101	69	2,191	--	--
1155	190	--	--	--	--	--	--	--	--	--	--	--	--	--	--	13	--
1200	195	6.7	--	97	4,320	63	3,856	37	200	75	405	61	3,870	69	2,191	--	--
1230	225	6.7	--	100	3,533	62	3,894	27	101	73	394	58	3,445	64	2,032	--	--
1300	255	6.6	--	103	4,016	66	4,693	29	111	70	851	61	3,870	68	2,159	--	--
1330	285	6.3	--	104	4,005	68	9,058	34	173	68	3,672	64	3,744	61	1,937	--	--
1345	300	6.5	--	104	3,645	63	4,139	32	134	71	250	59	3,452	68	2,159	--	Sample.
1400	315	6.1	--	104	4,005	64	4,781	34	143	72	238	57	3,104	69	2,191	--	Sample.
1430	345	6.1	--	105	4,140	63	4,820	33	193	69	598	59	3,505	69	2,191	--	--
1445	360	6.0	--	106	3,713	62	4,018	38	182	71	423	56	2,696	69	2,191	--	Sample.
1500	375	5.7	13,184	107	4,028	63	4,139	36	151	70	1,323	56	2,696	69	2,191	--	Sample.
1510	380	--	--	--	--	--	--	--	--	--	--	--	--	--	--	15	Shut down.
1513	388	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Collecting mill discharge sample.
1522	397	--	--	--	3,690	--	--	--	--	--	--	--	--	--	--	--	Second barrel.
1529	404	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Third barrel.
1536	411	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Hopper went empty.
1537	412	--	--	--	--	--	--	--	--	--	--	--	--	--	--	15	Shut down mill.
Average	--	--	--	--	3,934	64	5,173	35	183	71	1,087	59	3,516	68	2,165	--	--

(1) Moisture: -3 in., 2.0%. Average dry ore feed rate: -3 in., 3,855 lb/hr, 1.928 dry stph. Mill volume end of test: 15%.

EXHIBIT 2

Grinding Test 5 -- continued

Feed Rate, stph (dry): 1.928
Ball Charge: 301.8 lb, 2% of mill charge
Corrected Mill Power Tare (empty mill), kw: 0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Instantaneous Gross Power (meter reading) kwhr	Instantaneous Corrected Power (from input-output curve) kwhr	Power Consumption Gross kwhr/st	Power Consumption Net kwhr/st	Circulating Load Weight % of Feed(1)	Mill Discharge Solids %	Remarks
0840	0	--	--	--	--	--	--	--	--
0910	30	6.7	7.73	5.89	3.05	2.74	--	--	--
0930	50	6.3	8.23	6.35	3.29	2.98	--	67	--
1000	80	6.2	8.36	6.47	3.36	3.04	--	66	--
1030	110	6.5	7.97	6.10	3.16	2.85	--	56	--
1035	115	--	--	--	--	--	--	--	Ran out of ore.
1100	135	6.5	7.97	6.10	3.16	2.85	12.0(4)	66	--
1130	165	6.6	7.85	6.00	3.11	2.80	23.0(4)	66	--
1155	190	--	--	--	--	--	--	--	Check mill volume.
1200	195	6.7	7.73	5.89	3.05	2.74	14.0	63	--
1230	225	6.7	7.73	5.89	3.05	2.74	14.0	62	--
1300	255	6.6	7.85	6.00	3.11	2.80	24.0	66	--
1330	285	6.3	8.23	6.35	3.29	2.98	96.0(4)	68	--
1345(3)	300	6.5	7.97	6.10	3.16	2.85	11.0	63	--
1400(3)	315	6.1	8.50	6.60	3.42	3.11(2)	10.0	64	--
1430	345	6.1	8.50	6.60	3.42	3.11(2)	19.0	63	--
1445(3)	360	6.0	8.64	6.73	3.49	3.18(2)	16.0	62	--
1500(3)	375	5.7	9.09	7.13	3.70	3.37	37.0	63	--
1510	385	--	--	--	--	--	--	--	Check mill load level.
1513	388	--	--	--	--	--	--	--	Start filling No. 1 mill discharge sample barrel.
1522	397	--	--	--	--	--	--	--	Start filling No. 2 mill discharge sample barrel.
1529	404	--	--	--	--	--	--	--	Start filling No. 3 mill discharge sample barrel.
1536	411	--	--	--	--	--	--	--	End filling No. 3 mill discharge sample barrel.
1537	412	--	--	--	--	--	--	--	End of test.
Average						3.13	18.0		

(1) Calculated: Sum of Sweco oversize and DSM oversize as a percentage of dry mill feed.
(2) Average for power (three readings, omitted reading at 1,500 from average): 3.13 kwhr/st.
(3) Sample run.
(4) Omitted from average.

Procedure: Samples were wet screened on a 325M screen, products dried, and the +325M material dry screened using a Ro-Tap for 30 min.

Screen Size Analysis

Test Product	Mill Discharge				Sweco Screen Oversize				DSM Screen Oversize				DSM Screen Underflow				Circulating Load
Sample Time	1345	1400	1445	1500	1345	1400	1445	1500	1345	1400	1445	1500	1345	1400	1445	1500	--
Sample Weight, g:	1,058.6	1,062.1	911.3	859.1	442.5	300.3	282.2	381.8	1,065.9	713.5	478.8	920.6	817.4	757.0	743.7	787.8	--
Screen Product (Tyler) Mesh	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %
Head (calculated)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
+28	12.0	11.5	10.2	10.8	78.4	82.9	81.4	87.5	67.0	54.5	51.9	32.0	1.8	2.0	1.9	1.6	58.1
-28 +35	3.7	3.7	2.7	2.9	1.5	0.8	1.0	0.4	5.0	4.6	4.5	3.9	3.1	3.1	2.8	2.3	3.7
-35 +65	15.3	16.3	12.9	13.4	4.1	1.9	3.0	1.1	6.2	7.4	6.9	10.9	16.8	16.3	15.8	14.2	6.7
-65 +100	12.3	13.4	12.8	12.7	2.4	1.2	1.9	0.8	3.4	5.2	5.2	9.1	14.7	14.6	14.2	14.5	4.8
-100 +200	19.1	18.5	21.3	20.6	4.1	2.7	3.7	1.6	5.3	8.2	9.3	14.2	20.5	20.5	21.7	21.8	8.0
-200 +325	8.0	6.6	9.0	8.6	1.1	1.0	1.1	1.2	1.6	2.8	4.0	5.3	8.1	8.4	7.4	7.4	2.9
-325	29.6	30.0	31.1	31.0	8.4	9.5	7.9	7.4	11.5	17.3	18.2	24.6	35.0	35.1	36.2	38.2	15.8

EXHIBIT 2

Grinding Test 6

Date:	June 20, 1978
Feed Rate, stph:	2.5
Ore:	Run-of-mine
Ball Charge:	Total: 301.8 lb, 2% mill volume
-1-1/2 in. +1 in. Balls, lb:	114.5
-2 in. +1-1/2 in. Balls, lb:	151.3
3 in. Balls, lb:	36.0
DSM Screen, in. width:	12
DSM Screen Openings, mm:	1.27
Measured Mill Power Tare (empty mill), kw:	2.06
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Meter Reading watt-hr	Mill-Bearing Oil Temp. °F	Ore Feed Rate (as received)(1) -1-1/2 in. lb/hr	-4 in. +1-1/2 in. lb/hr	-6 in. +4 in. lb/hr	-10 in. -6 in. lb/hr	Mill Discharge Solids %	Mill Discharge Solids lb/hr	Sweco Screen Oversize Solids %	Sweco Screen Oversize Solids lb/hr	DSM Screen Overflow Solids %	DSM Screen Overflow Solids lb/hr	DSM Screen Underflow Solids %	DSM Screen Underflow Solids lb/hr	Mill Water Meter %	Mill Water Rate lb/hr	Mill Load Volume %	Remarks
0820	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--(Grind out)--		Start mill.
0925	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Start feed.
0930	5	6.8	13,195	82	--	768	474	219	--	--	--	--	--	--	--	--	80	2,540	--	--
1000	35	5.9	--	80	--	768	474	219	66	11,286	60	662	71	4,090	61	5,737	85	2,699	--	--
1030	65	5.3	--	82	3,713	768	474	219	66	9,742	54	535	68	4,896	61	3,486	84	2,668	--	--
1100	95	5.2	--	83	3,825	768	474	219	67	10,492	60	608	68	4,651	61	4,255	85	2,699	--	--
1135	130	5.2	--	84	3,510	768	474	219	66	7,960	59	597	68	3,733	61	4,255	84	2,668	25	--
1200	155	5.2	--	87	3,758	768	474	219	68	10,588	57	487	68	4,651	60	3,699	85	2,699	--	--
1230	185	5.1	--	88	3,420	768	474	219	68	10,037	55	545	69	3,974	60	4,104	89	2,826	--	--
1245	200	5.1	--	88	3,420	768	474	219	67	9,950	52	714	68	4,223	59	4,275	89	2,826	--	Sample.
1300	215	5.0	--	89	3,600	768	474	219	67	11,759	62	781	68	6,487	62	3,627	85	2,699	--	Sample.
1330	245	5.0	12,236	92	--	768	474	219	67	8,924	60	1,337	68	4,039	60	3,780	88	2,795	--	--
1337	252	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	27	Shut down.
Average					3,607	768	474	219	67	10,082	58	696	68	4,527	61	4,135	85	2,712		

(1) Moisture: -1-1/2 in., 2.3%; -4 in. +1-1/2 in., 1.0%; -6 in. +4 in., 0.8%; -10 in. +6 in., 0.7%. Average dry ore feed rate: -1-1/2 in., 3,524 lb/hr; -4 in. +1-1/2 in., 760.3 lb/hr; -6 in. +4 in., 470.2 lb/hr; -10 in. +6 in., 217.5 lb/hr; Total: 4,972 lb/hr; 2.486 dry stph. Mill volume end of test: 27%.

Feed Rate, stph (dry):	2.486
Ball Charge:	301.8 lb, 2% of mill volume
Corrected Mill Power Tare (empty mill), kw:	0.6

Clock Time	Running Time min	Disc Revolutions sec/rev	Instantaneous Gross Power (meter reading) kwhr	Instantaneous Corrected Power (from input-output curve) kwhr	Power Consumption Gross kwhr/st	Power Consumption Net kwhr/st	Circulating Load Weight % of Feed(1)	Mill Discharge Solids %	Remarks
0820	--	--	--	--	--	--	--	--	Grind out.
0925	--	--	--	--	--	--	--	--	Start feed.
0930	5	6.8	7.62	5.80	2.33	2.09	--	--	--
1000	35	5.9	8.78	6.87	2.76	2.52	--	66	--
1030	65	5.3	9.78	7.78	3.13	2.92	105.0	66	--
1100	95	5.2	9.97	7.92	3.18	2.94	99.0	67	--
1135	130	5.2	9.97	7.92	3.18	2.94	87.0	66	--
1200	155	5.2	9.97	7.92	3.18	2.94	98.0	68	--
1230	185	5.1	10.16	8.09	3.25	3.01	93.0	68	--
1245(3)	200	5.1	10.16	8.09	3.25	3.01	101.0	67	--
1300(3)	215	5.0	10.36	8.26	3.32	3.08(2)	144.0	67	--
1330	245	4.0	10.36	8.26	3.32	3.08(2)	--	67	--
1337	252	--	--	--	--				End of test.
Average						3.08	103.9		

(1) Calculated: Sum of Sweco oversize and DSM oversize as a percentage of dry mill feed.
(2) Average for power (two readings): 3.08 kwhr/st.
(3) Sample run.

EXHIBIT 2

Grinding Test 6 -- continued

Procedure: Samples were wet screened on a 325M screen, products dried, and the +325M material dry screened using a Ro-Tap for 30 min.

	Screen Size Analysis								
Total Product	Mill Discharge		Sweco Screen Oversize		DSM Screen Oversize		DSM Screen Undersize		Circulating Load
Sample Time	1245	1300	1245	1300	1245	1300	1245	1300	
Sample Weight, g:	1,258.8	1,237.7	673.8	642.6	1,361.9	1,079.3	832.1	918.1	--
Screen Product (Tyler) Mesh	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %
Head (calculated)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
+28	21.0	18.4	64.8	70.7	32.9	23.1	1.3	1.0	32.9
-28 +35	6.4	6.5	1.9	1.2	9.4	8.5	3.9	3.7	8.1
-35 +65	13.9	15.1	3.8	2.7	12.8	14.3	16.5	16.7	12.2
-65 +100	10.5	11.4	3.2	2.2	8.8	8.6	12.4	14.5	8.0
-100 +200	13.3	14.2	5.4	5.0	11.8	14.2	20.3	18.5	12.0
-200 +325	5.5	5.6	3.1	2.2	4.8	3.7	5.3	6.7	4.1
-325	29.4	28.8	17.8	16.0	19.5	27.6	40.3	38.9	22.7

Sediment Description and Classification Background

U.S. Standard Sieves

Note that the same size mesh can be a differing sieve number depending on the Sieve manufacturer (Tyler vs. ASTM)

Mesh Size (microns)	**TYLER**	**ASTM-E11**	**BS-410**	**DIN-4188**
µm	Mesh	No.	Mesh	mm
5	2500		2500	0.005
10	1250		1250	0.010
15	800		800	0.015
20	625		625	0.020
22				0.022
25	500		500	0.025
28				0.028
32				0.032
36				0.036
38	400	400	400	
40				0.040
45	325	325	350	0.045
50				0.050
53	270	270	300	
56				0.056
63	250	230	240	0.063
71				0.071
75	200	200	200	
80				0.080
90	170	170	170	0.090
100				0.100
106	150	140	150	
112				0.112
125	115	120	120	0.125
140				0.140
150	100	100	100	

ATTACHMENT B, 1/10

160				0.160
180	80	80	85	0.180
200				0.200
212	65	70	72	
250	60	60	60	0.250
280				0.280
300	48	50	52	
315				0.315
355	42	45	44	0.355
400				0.400
425	35	40	36	
450				0.450
500	32	35	30	0.500
560				0.560
600	28	30	25	
630				0.630
710	24	25	22	0.710
800				0.800
850	20	20	18	
900				0.900
1000	16	18	16	1.0
1120				1.12
1180	14	16	14	
1250				1.25
1400	12	14	12	1.4
1600				1.6
1700	10	12	10	
1800				1.8
2000	9	10	8	2.0
2240				2.24
2360	8	8	7	
2500				2.5
2800	7	7	6	2.8
3150				3.15
3350	6	6	5	
3550				3.55
4000	5	5	4	4.0
4500				4.5

4750	4	4	3.5	
5000				5.0

Sediment Classification based on Grain Size:

Unified Soil Classification System (USCS)

Sediment Name	**Diameter (mm)**	**Sieve No.**
Cobble	greater than 75 mm	
Gravel	4.75 to 75 mm	4
Sand	0.075 to 4.75 mm	200
Fines (silt and clay)	less than 0.075 mm	

USCS Division of Sands

Sediment Name	Diameter Range (mm)	Passes through Sieve No.	Retained on Sieve No.
Coarse Sand	2.0 - 4.8	4	10
Medium Sand	0.43 - 2.0	10	40
Fine Sand	0.075 - 0.43	40	200

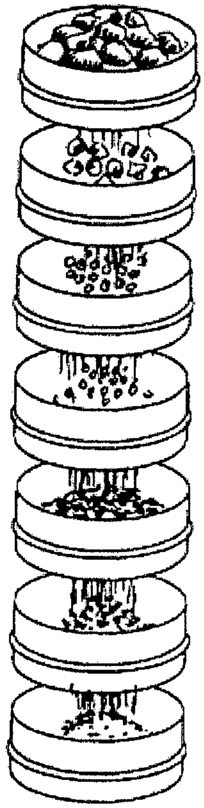


Figure 4-3. Dry sieve analysis.

USCS Classification System

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS				GROUP SYMBOLS	DESCRIPTIONS
COARSE GRAINED SOILS More Than Half Retained on 200 Sieve	GRAVELS	More Than Half Coarse Fraction Retained on No. 4 Sieve	Clean Gravels (Little or no Fines)	GW	Well Graded Gravels, Gravel - Sand Mixtures, Little or no Fines
				GP	Poorly Graded Gravels, Gravel - Sand Mixtures, Little or no Fines
			Gravels With Fines (Appreciable Fines)	GM	Silty Gravels, Gravel-Sand-Silt Mixtures
				GC	Clayey Gravels, Gravel-Sand-Clay Mixtures
	SANDS	More Than Half Coarse Fraction Passes a No. 4 Sieve	Clean Sands (Little or no Fines)	SW	Well Graded Sands, Gravelly Sands, Little or no Fines
				SP	Poorly Graded Sands, Gravelly Sands, Little or no Fines
			Sands With Fines (Appreciable Fines)	SM	Silty Sands, Sand - Silt Mixtures
				SC	Clayey Sands, Sand - Clay Mixtures
FINE GRAINED SOILS More Than Half Passes 200 Sieve	SILTS and CLAYS	Liquid Limit Less Than 50		ML	Inorganic Silts & Very Fine Sands, Silty or Clayey Fine Sands, Clayey Silts
				CL	Inorganic Clays of Low to Medium Plasticity, Lean Clays
				OL	Organic Silts & Organic Silty Clays of Low Plasticity
	SILTS and CLAYS	Liquid Limit Greater Than 50		MH	Inorganic Silts, Fine Sand or Silty Soils, Elastic Silts
				CH	Inorganic Clays of High Plasticity, Fat Clays
				OH	Organic Clays of Medium to High Plasticity, Organic Silts
Highly Organic Soils				PT	Peat and Other Highly Organic Soils

Visual logging of sediments entails estimating percentages of gravels, sands and fines (silt and clays). Practice and the use of the Geotechnical Gage will increase your confidence and ability in visually logging sediments.

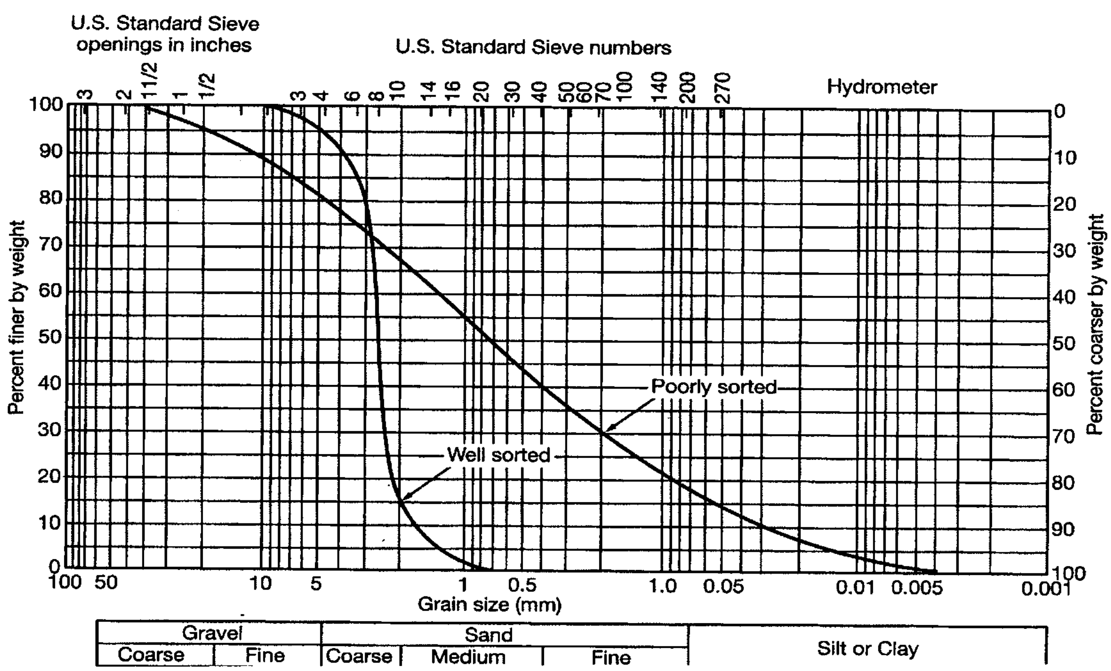
Read: Visual Exam Test

Read: Field Identification Guidelines

Ultimately, sediment samples may undergo grain size analysis through sieves. Graphing the cumulative weight percent retained/passing by sieve no. or grain size will result in the sediment grain-size distribution curve. The grain-size distribution curve is used to quantitatively classify the sediment type (your visual identification is a qualitative classification).

Read: Grain Size Distribution Measurement

Grain Size Distribution Curve



The grain-size distribution curve is used with the USCS classification chart to classify the sediment type. Other measures used to describe the sediment are the sorting or gradation of the sediment. As can be seen in the above chart, a well-sorted sediment has a small range of sediment grain sizes while a poorly sorted sediment has a large range of sediment grain sizes. In the USCS classification scheme, the gradation of the sediment is used instead of the sorting. A well-graded sediment has a large range of grain sizes while a poorly or uniformly graded sediment has a small range of grain sizes.

Figure 4-6. Well-graded soil.

POORLY SORTED SEDIMENT = WELL GRADED SEDIMENT

Figure 4-7. Uniformly graded soil.

WELL-SORTED SEDIMENT = POORLY OR UNIFORMLY GRADED SEDIMENT

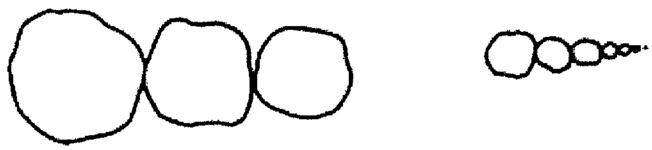


Figure 4-8. Gap-graded soil.

After sieve analysis, the data are tabulated showing the weight of sediment retained on each sieve. The cumulative weight retained is calculated starting from the largest sieve size and adding subsequent sediment weights from the smaller size sieves (see table below). The percent retained is calculated from the weight retained and the total weight of the sample. [Don't get confused by the graph - it is individual percent retained in Column 16 and cumulative percent passing in Column 17]. The cumulative percent passing in Column 17 of the table below is calculated by sequentially subtracting percent retained from 100 %. In table below, cumulative percent passing 1/4 inch sieve = 100 - 16 = 84; cumulative percent passing #4 sieve = 84-5.2 = 78.8; etc.

SIEVE ANALYSIS DATA					1. DATE STARTED 22 FEB 91	
2 PROJECT BRAVO AIRFIELD			3. EXCAVATION 1+00		4. DATE COMPLETED 28 FEB 91	
5. SAMPLE DESCRIPTION LIGHT BROWN SANDY SOIL					6. SAMPLE NUMBER 1A	
					7. PREWASHED (✓ one) XX YES	NO
8 ORIGINAL SAMPLE WEIGHT 2459			9. + #200 SAMPLE WEIGHT 2359		10 − #200 SAMPLE WEIGHT 100	
11. SIEVE SIZE	12. WEIGHT OF SIEVE	13. WEIGHT OF SIEVE + SAMPLE	14 WEIGHT RETAINED	15 CUMULATIVE WEIGHT RETAINED	16 PERCENT RETAINED	17 PERCENT PASSING
1½	202					
1	231					
½	210	210	0	0	0	100.0
¼	230	624	394	394	16.0	84.0
#4	205	332	127	521	5.2	78.8
#8	225	691	466	987	19.0	59.8
#20	215	612	397	1384	16.2	43.6
#60	235	581	346	1730	14.1	29.5
#100	250	612	362	2092	14.7	14.8
#200	260	515	255	2347	10.4	4.4
18. TOTAL WEIGHT RETAINED IN SIEVES (Sum Column 14)				2347	19 ERROR (8 - 23) 2459-2457 = 2	
20 WEIGHT SIEVED THROUGH #200 (weight in pan) 270-260				10		
21. WASHING LOSS (8 - (9 + 10)) 2459-(2359+100)				0		
22 TOTAL WEIGHT PASSING #200 (20 + 10) 10+100				110		
23. TOTAL WEIGHT OF FRACTIONS (18 + 22)				2457		
24. REMARKS USCS SP PERCENT - G 21.2 PERCENT - S 74.4 PERCENT - F 4.4					25 ERROR (Percent) ERROR (19) / ORIGINAL WT (8) x 100 = 2/2459 x 100 = .08	
26 TECHNICIAN Joe Blob PVZ			27 COMPUTED BY (Signature) Joe Blob PVZ		28 CHECKED BY (Signature) Fred Jones SSG	

DD Form 1206, DEC 86 *Previous editions are obsolete*

Figure 4-4. Data sheet, example of dry sieve analysis.

The cumulative percent passing is plotted on the grain-size distribution graph. The percentage passing the No. 4 and 200 sieves is used to classify the sediments as gravels (G), sands (S) or fines (must use plasiticity index to differentiate between silts and clays).

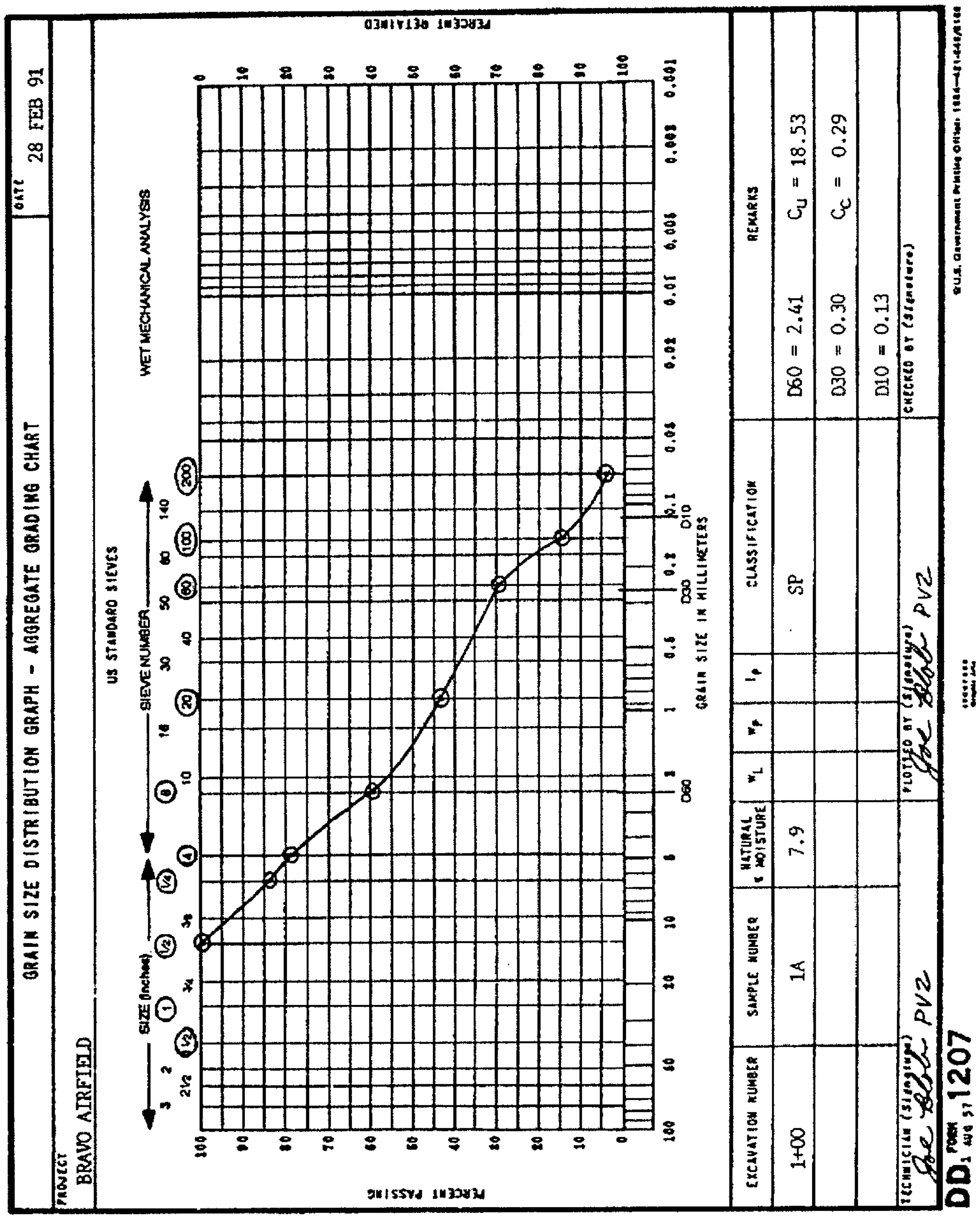


Figure 4-5. Grain-size distribution curve from sieve analysis.

The grain-size distribution graph is used to read off the grain size at which 10% of the sample passed (D_{10}), 30% of the sample passed (D_{30}) and 60% of the sample passed (D_{60}). These numbers are used to calculate several coefficients:

Hazen's effective size, D_{10}, which will be used to estimate permeability

Uniformity Coefficient, $C_u = D_{60}/D_{10}$

In the above graph,

$$D_{60} = 2.4 \text{ mm and } D_{10} = 0.13 \text{ mm}$$

$$\text{then} \quad C_u = 2.4/0.13 = 18.5$$

The uniformity coefficient is used to judge gradation.

Coefficient of Curvature, C_c

$$C_c = \frac{(D_{30})^2}{(D_{60} \times D_{10})}$$

In the above graph,

$$D_{30} = 0.3 \text{ mm}$$

$$\text{and } C_c = \frac{(0.3)^2}{(2.4)(0.13)} = .29$$

In the graph below, well-graded soils (GW and SW) are long curves spanning a wide range of sizes with a constant or gently varying slope. Uniformly graded soils (SP) are steeply sloping curves spanning a narrow range of sizes. For a gap-graded soil (GP), the curve flattens out in the area of the grain-size deficiency or gap.

The USCS criteria for well-graded gravels (GW) and sands (SW) are:

1. Less than 5% finer than No. 200 sieve
2. Uniformity coefficient greater than 4
3. Coefficient of curvature between 1 and 3

If Criterion 1 is met, but not Criteria 2 and 3, the gravels are gap-graded or uniform gravels (GP) or sands (SP)

If you are interested in more information: Gradation and Bearing Capacity

United States
Environmental Protection
Agency

Office of Research and
Development
Washington DC 20460

EPA/600/R-94/168b
September 1994

EPA

The Hydrologic Evaluation of Landfill Performance (HELP) Model

Engineering Documentation for Version 3

ATTACHMENT C, 1/3

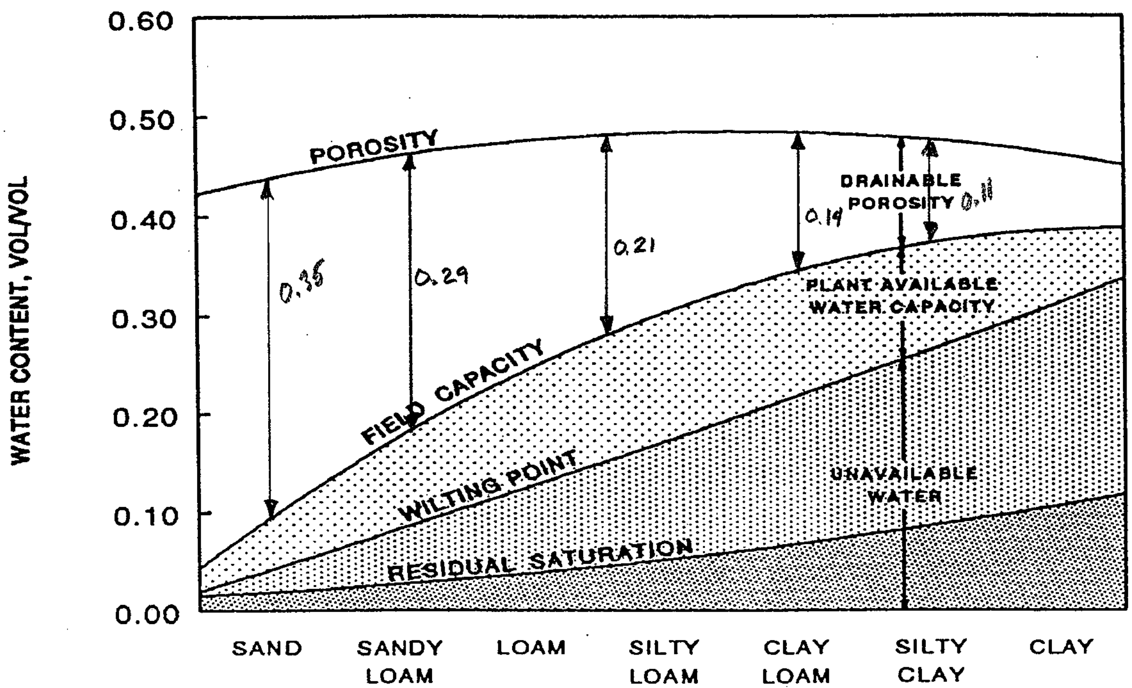


Figure 2. Relation Among Moisture Retention Parameters and Soil Texture Class

are not specified, the program assumes values near the steady-state values (allowing no long-term change in moisture storage) and runs a year of simulation to initialize the moisture contents closer to steady state. The soil water contents at the end of this year are substituted as the initial values for the simulation period. The program then runs the complete simulation, starting again from the beginning of the first year of data. The results of the volumetric water content initialization period are not reported in the output.

3.3.2 Unsaturated Hydraulic Conductivity

Darcy's constant of proportionality governing flow through porous media is known quantitatively as hydraulic conductivity or coefficient of permeability and qualitatively as permeability. Hydraulic conductivity is a function of media properties, such as particle size, void ratio, composition, fabric, degree of saturation, and the kinematic viscosity of the fluid moving through the media. The HELP program uses the saturated and unsaturated hydraulic conductivities of soil and waste layers to compute vertical drainage, lateral drainage and soil liner percolation. The vapor diffusivity for geomembranes is specified as a saturated hydraulic conductivity to compute leakage through geomembranes by vapor diffusion.

Attachment C, 2/3

TABLE 1. DEFAULT LOW DENSITY SOIL CHARACTERISTICS

Soil Texture Class			A Total Porosity vol/vol	B Field Capacity vol/vol	Wilting Point vol/vol	Saturated Hydraulic Conductivity cm/sec	A-B Drainable Porosity vol/vol
HELP	USDA	USCS					
1	CoS	SP	0.417	0.045	0.018	1.0×10^{-2}	
2	S	SW	0.437	0.062	0.024	5.8×10^{-3}	
3	FS	SW	0.457	0.083	0.033	3.1×10^{-3}	
4	LS	SM	0.437	0.105	0.047	1.7×10^{-3}	0.332
5	LFS	SM	0.457	0.131	0.058	1.0×10^{-3}	0.326
6	SL	SM	0.453	0.190	0.085	7.2×10^{-4}	0.263
7	FSL	SM	0.473	0.222	0.104	5.2×10^{-4}	0.251
8	L	ML	0.463	0.232	0.116	3.7×10^{-4}	0.231
9	SiL	ML	0.501	0.284	0.135	1.9×10^{-4}	0.217
10	SCL	SC	0.398	0.244	0.136	1.2×10^{-4}	0.154
11	CL	CL	0.464	0.310	0.187	6.4×10^{-5}	
12	SiCL	CL	0.471	0.342	0.210	4.2×10^{-5}	
13	SC	SC	0.430	0.321	0.221	3.3×10^{-5}	
14	SiC	CH	0.479	0.371	0.251	2.5×10^{-5}	
15	C	CH	0.475	0.378	0.251	2.5×10^{-5}	
21	G	GP	0.397	0.032	0.013	3.0×10^{-1}	

a = constant representing the effects of various fluid constants and gravity, 21 cm^3/sec

ϕ = total porosity, vol/vol

θ_r = residual volumetric water content, vol/vol

ψ_b = bubbling pressure, cm

λ = pore-size distribution index, dimensionless

A more detailed explanation of Equation 11 can be found in Appendix A of the HELP program Version 3 User's Guide and the cited references.

ATTACHMENT C, 3/3

ered that when well-graded mixtures of sand and gravel contained as little as 5% of fines (sizes smaller than a No. 200 sieve) high compactive efforts reduced the effective porosities nearly to zero and the permeabilities to less than 0.01% of those at moderate densities. These tests explain one of the reasons that blends of sand and gravel often used for drains are virtually useless as drainage aggregates if they contain more than insignificant amounts of fines.

In the preceding paragraphs variations in the permeability of remolded materials caused by variable compaction were discussed. Any factor that densifies soils reduces permeability. Studies of the rate of consolidation of clay and peat foundations are sometimes made by using initial coefficients of permeability of compressible formations. While the consolidation process is going on in foundations their permeabilities are becoming less. Generally, decreases in the permeabilities of clay foundations are rather moderate, but they can be large in highly compressible organic silts and clays and in peats. Modified calculation methods utilizing the changing permeability are needed in the analysis of highly compressible foundations. Some typical variations in permeability caused by consolidation are given in Fig. 2.10, a plot of consolidation pressure versus permeability.

$\sigma_n \approx 31' \times 130$ pcf.
≈ 4000 psf
≈ 2 Tsf

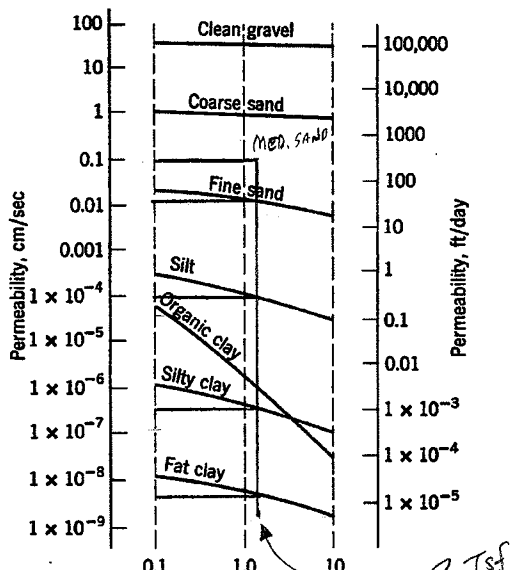


FIG. 2.10 Permeability versus consolidation pressure.

Attachment D

1/2

"Seepage, Drainage, and Flow Nets"
3rd Edition, Cedergren, H.R. 1989

$$k = \frac{Q}{iAt} \tag{2.2}$$

Darcy's *discharge velocity* multiplied by the entire cross-sectional area, including voids e and solids 1, gives the seepage quantity Q under a given hydraulic gradient $i = \Delta h/\Delta l$ or h/L. It is an imaginary velocity that does not exist anywhere. The average *seepage velocity* v_s of a mass of water progressing through the pore spaces of a soil is equal to the discharge velocity $(v_d = ki)$ multiplied by $(1 + e)/e$ or the discharge velocity divided by the effective porosity n_e; hence permeability is related to seepage velocity by the expression

$$k = \frac{v_s n_e}{i} \tag{2.3}$$

For any seepage condition in the laboratory or in the field in which the *seepage quantity,* the area perpendicular to the direction of flow, and the hydraulic gradient are known the coefficient of permeability can be calculated. Likewise, for any situation where the *seepage velocity* is known at a point at which the hydraulic gradient and soil porosity also are known, permeability can be calculated.

Experimentally determined coefficients of permeability can be combined with prescribed hydraulic gradients and discharge areas in solving practical problems involving seepage quantities and velocities. When a coefficient of permeability has been properly determined, it furnishes a very important factor in the analysis of seepage and in the design of drainage features for engineering works.

The coefficient of permeability as used in this book and in soil mechanics in general should be distinguished from the physicists' coefficient of permeability K, which is a more general term than the engineers' coefficient and has units of centimeters squared rather than a velocity; it varies with the porosity of the soil but is independent of the viscosity and density of the fluid. The transmissibility factor T represents the capability of an aquifer to discharge water and is the product of permeability k and aquifer thickness t.

The engineers' coefficient, which is used in practical problems of seepage through masses of earth and other porous media, applies only to the flow of water and is a simplification introduced purely from the standpoint of convenience. It has units of a velocity and is expressed in centimeters per second, feet per minute, feet per day, or feet per year, depending on the habits and personal preferences of individuals using the coefficient. In standard soil mechanics terminology k is expressed in centimeters per second.

Although coefficient of permeability is often considered to be a constant for a given soil or rock, it can vary widely for a given material, depending on a number of factors. Its absolute values depend, first of all, on the properties of water, of which viscosity is the most important. For individual materials

Attachment D, 2/2

Cedergren, "Seepage, Drainage, and Flow Nets", 3rd Ed. 1989

GDE Control Products, Inc.

Multi-FLO

Technical Properties

Drainage Core

Property	Test Method	Value
Thickness, inches	ASTM D-1777	1.0
Flow Rate, gpm/ft*	ASTM D-4716	29 *
~~Compressive Strength~~	~~ASTM D-1621~~	~~6000~~

Geotextile Filter

Property	Test Method	Value
Weight, oz/sq yd2	ASTM D-3776	4.0
Tensile Strength, lb.	ASTM D-4632	100
Elongation, %	ASTM D-4632	50
Puncture, lb.	ASTM D-4833	50
Mullen Burst, psi	ASTM D-3786	200
Trapezoidal Tear, lb.	ASTM D-4533	42
Coeffecient of Perm,cm/sec	ASTM D-4491	0.1
Flow Rate, gpm/ft2	ASTM D-4491	100
Permittivity, 1/sec	ASTM D-4491	1.8
A.O.S Max US Std Sieve	ASTM D 4751	70
UV Stability, 500 hrs., %	ASTM D-4355	70
Seam Strength, lb./ft	ASTM D-4595	100
Fungus	ASTM G-21	No Growth

* Horizontal Installation , gradient = 0.01, compressive force = 10 psi for 1(

All values given represent minimum average roll values

GDE Control Products, Inc. Laguna Hills, CA. 949-305-7117

GDE, Multi-Flow
<http: www.gdecontrol.com/Multi-Flow5.html> Attachment E 1/1

TABLE 2.12 RECOMMENDED REDUCTION FACTOR VALUES FOR USE IN EQ. (2.25a)

	Range of Reduction Factors				
Application	Soil Clogging and Blinding*	Creep Reduction of Voids	Intrusion into Voids	Chemical Clogging†	Biological Clogging
Retaining wall filters	2.0 to 4.0	1.5 to 2.0	1.0 to 1.2	1.0 to 1.2	1.0 to 1.3
Underdrain filters	5.0 to 10	1.0 to 1.5	1.0 to 1.2	1.2 to 1.5	2.0 to 4.0
Erosion-control filters	2.0 to 10	1.0 to 1.5	1.0 to 1.2	1.0 to 1.2	2.0 to 4.0
Landfill filters	5.0 to 10	1.5 to 2.0	1.0 to 1.2	1.2 to 1.5	5 to 10‡
Gravity drainage	2.0 to 4.0	2.0 to 3.0	1.0 to 1.2	1.2 to 1.5	1.2 to 1.5
Pressure drainage	2.0 to 3.0	2.0 to 3.0	1.0 to 1.2	1.1 to 1.3	1.1 to 1.3

*If stone riprap or concrete blocks cover the surface of the geotextile, use either the upper values or include an additional reduction factor.

†Values can be higher particularly for high alkalinity groundwater.

‡Values can be higher for turbidity and/or for microorganism contents greater than 5000 mg/l.

$$q_{\text{allow}} = q_{\text{ult}}\left(\frac{1}{\Pi \text{RF}}\right) \tag{2.25b}$$

where

q_{allow} = allowable flow rate,
q_{ult} = ultimate flow rate,
RF_{SCB} = reduction factor for soil clogging and blinding,
RF_{CR} = reduction factor for creep reduction of void space,
RF_{IN} = reduction factor for adjacent materials intruding into geotextile's void space,
RF_{CC} = reduction factor for chemical clogging,
RF_{BC} = reduction factor for biological clogging, and
ΠRF = value of cumulative reduction factors.

As with Eqs. (2.24) for strength reduction, this flow-reduction equation could also have included additional site-specific terms, such as blocking of a portion of the geotextile's surface by riprap or concrete blocks.

2.5 DESIGNING FOR SEPARATION

Application areas for geotextiles used for the separation function were given in Section 1.3.3. There are many specific applications, and it could be said, in a general sense, that geotextiles always serve a separation function. If they do not also serve this function, any other function, including the primary one, will not be served properly. This should not give the impression that the geotextile function of separation always plays a secondary role. Many situations call for separation only, and in such cases the geotextiles serve a significant and worthwhile function.

ATTACHMENT F 1/4

4.1.6 Allowable Flow Rate

As described previously, the very essence of the design-by-function concept is the establishment of an adequate factor of safety. For geonets, where flow rate is the primary function, this takes the following form.

$$FS = \frac{q_{allow}}{q_{reqd}} \tag{4.3}$$

where

FS = factor of safety (to handle unknown loading conditions or uncertainties in the design method, etc.),

q_{allow} = allowable flow rate as obtained from laboratory testing, and

q_{reqd} = required flow rate as obtained from design of the actual system.

Alternatively, we could work from transmissivity to obtain the equivalent relationship.

$$FS = \frac{\theta_{allow}}{\theta_{reqd}} \tag{4.4}$$

where θ is the transmissivity, under definitions as above. As discussed previously, however, it is preferable to design with flow rate rather than with transmissivity because of nonlaminar flow conditions in geonets.

Concerning the allowable flow rate or transmissivity value, which comes from hydraulic testing of the type described in Section 4.1.3, we must assess the realism of the test setup in contrast to the actual field system. If the test setup does not model site-specific conditions adequately, then adjustments to the laboratory value must be made. This is usually the case. Thus the laboratory-generated value is an ultimate value that must be reduced before use in design; that is,

$$q_{allow} < q_{ult}$$

One way of doing this is to ascribe reduction factors on each of the items not adequately assessed in the laboratory test. For example,

$$q_{allow} = q_{ult}\left[\frac{1}{RF_{IN} \times RF_{CR} \times RF_{CC} \times RF_{BC}}\right] \tag{4.5}$$

or if all of the reduction factors are considered together.

$$q_{allow} = q_{ult}\left[\frac{1}{\Pi RF}\right] \tag{4.6}$$

where

q_{ult} = flow rate determined using ASTM D4716 or ISO/DIS 12958 for short-term tests between solid platens using water as the transported liquid under laboratory test temperatures,

ATTACHMENT F, 2/6

ıction concept is the es-
: flow rate is the primary

(4.3)

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$\overline{\text{RF}_{BC}}\Big]$ (4.5)

(4.6)

ISO/DIS 12958
as the transp

q_{allow} = allowable flow rate to be used in Eq. (4.3) for final design purposes,
RF_{IN} = reduction factor for elastic deformation, or intrusion, of the adjacent geosynthetics into the geonet's core space,
RF_{CR} = reduction factor for creep deformation of the geonet and/or adjacent geosynthetics into the geonet's core space,
RF_{CC} = reduction factor for chemical clogging and/or precipitation of chemicals in the geonet's core space,
RF_{BC} = reduction factor for biological clogging in the geonet's core space, and
ΠRF = product of all reduction factors for the site-specific conditions.

Some guidelines for the various reduction factors to be used in different situations are given in Table 4.2. Please note that some of these values are based on relatively sparse information. Other reduction factors, such as installation damage, temperature effects, and liquid turbidity, could also be included. If needed, they can be included on a site-specific basis. On the other hand, if the actual laboratory test procedure has included the particular item, it would appear in the above formulation as a value of unity. Examples 4.2 and 4.3 illustrate the use of geonets and serve to point out that high reduction factors are warranted in critical situations.

Example 4.2

What is the allowable geonet flow rate to be used in the design of a capillary break beneath a roadway to prevent frost heave? Assume that laboratory testing was done at the proper design load and hydraulic gradient and that this testing yielded a short-term between-rigid-plates value of 2.5×10^{-4} m²/s.

Solution: Since better information is not known, average values from Table 4.2 are used in Eq. (4.5).

TABLE 4.2 RECOMMENDED PRELIMINARY REDUCTION FACTOR VALUES FOR EQ. (4.5) FOR DETERMINING ALLOWABLE FLOW RATE OR TRANSMISSIVITY OF GEONETS

Application Area	RF_{IN}	RF_{CR}*	RF_{CC}	RF_{BC}
Sport fields	1.0 to 1.2	1.0 to 1.5	1.0 to 1.2	1.1 to 1.3
Capillary breaks	1.1 to 1.3	1.0 to 1.2	1.1 to 1.5	1.1 to 1.3
Roof and plaza decks	1.2 to 1.4	1.0 to 1.2	1.0 to 1.2	1.1 to 1.3
Retaining walls, seeping rock, and soil slopes	1.3 to 1.5	1.2 to 1.4	1.1 to 1.5	1.0 to 1.5
Drainage blankets	1.3 to 1.5	1.2 to 1.4	1.0 to 1.2	1.0 to 1.2
Surface water drains for landfill covers	1.3 to 1.5	1.1 to 1.4	1.0 to 1.2	1.2 to 1.5
Secondary leachate collection (landfills)	1.5 to 2.0	1.4 to 2.0	1.5 to 2.0	1.5 to 2.0
Primary leachate collection (landfills)	1.5 to 2.0	1.4 to 2.0	1.5 to 2.0	1.5 to 2.0

*These values are sensitive to the density of the resin used in the geonet's manufacture. The higher the density, the lower the reduction factor. Creep of the covering geotextile(s) is a product-specific issue.

ATTACHMENT F, 3/4

The above formula can be readily converted to flow rate, Q, by multiplying the velocity by the cross-sectional area A of the pipe.

For pipelines that are either flowing full or flowing partially full, the *Manning equation* is generally used.

$$V = \frac{1}{n} R_H^{0.66} S^{0.5} \tag{7.10}$$

where

V = velocity of flow (m/s),
R_H = hydraulic radius (m),
S = slope or gradient of pipeline (m/m), and
n = coefficient of roughness (see Table 7.7) (dimensionless).

Note that plastic pipe of the type discussed in this chapter, with a *smooth interior,* has a Manning coefficient from 0.009 to 0.010. Plastic pipe with a *profiled or corrugated interior* has a Manning coefficient ranging from 0.018 to 0.025.

Eqs. (7.9) and (7.10) are generally used in the form of charts or nomographs to determine pipe sizes, flow velocity or discharge flow rates (see Figures 7.6 and 7.7). For each chart we include an example from Hwang [7], illustrated on the respective nomographs by heavy lines. Note that both nomographs are for pipes flowing full.

Example 7.1

A 100 m long pipe with D = 200 mm and C = 120 carries a discharge of 30 l/s. Determine the head loss in the pipe. (See the Hazen-Williams chart in Figure 7.6.)

Solution: Applying the conditions given to the solution chart in Figure 7.6, the energy gradient is obtained.

$$S = 0.0058 \text{ m/m}$$

TABLE 7.7 VALUES OF MANNING ROUGHNESS COEFFICIENT, N, FOR REPRESENTATIVE SURFACES

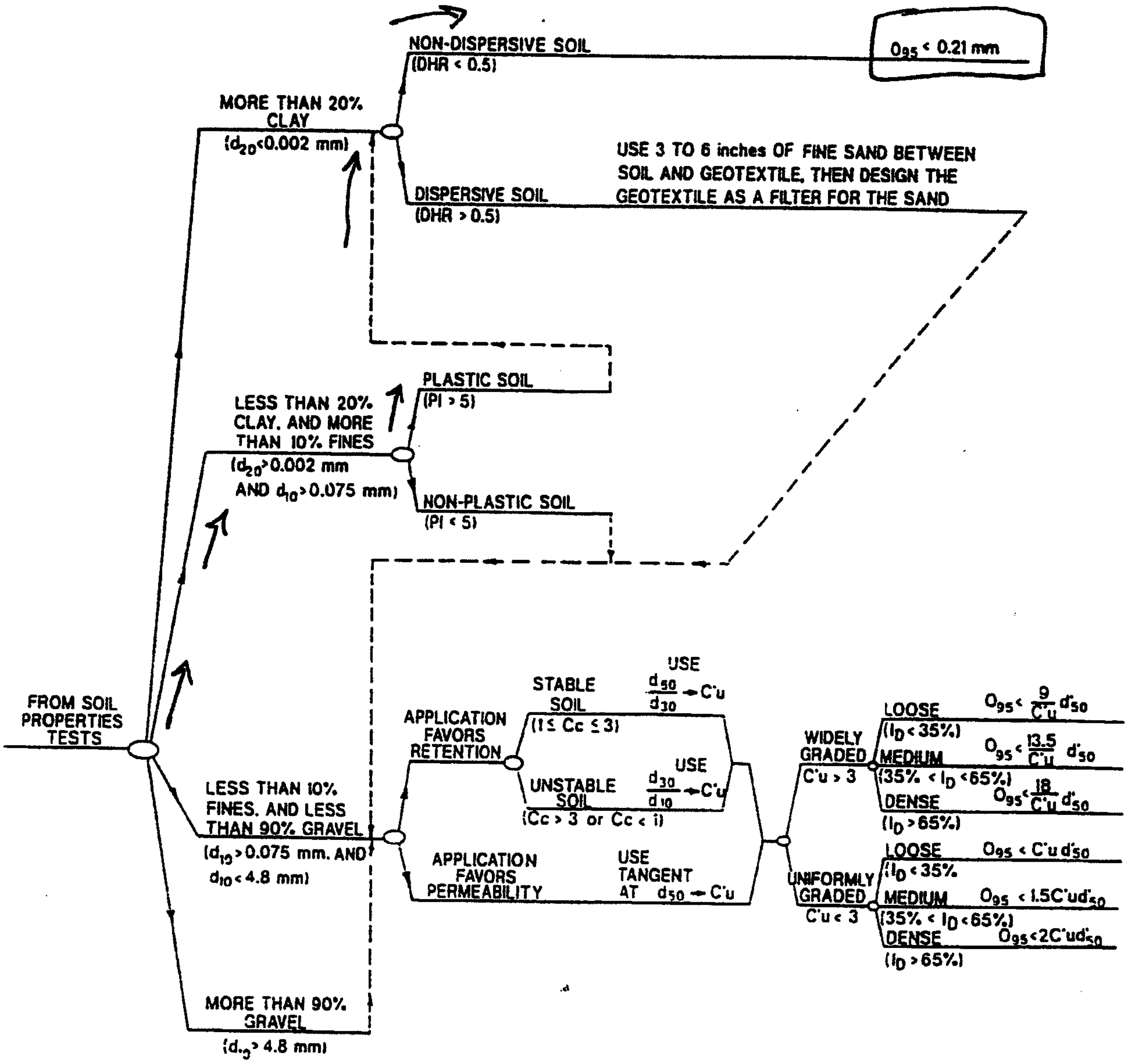
Type of Pipe Surface	Representative n value
Lucite, glass, or plastic*	0.010
Wood or finished concrete	[illegible]
Unfinished concrete, well-laid brickwork, concrete or cast iron pipe	0.015
Riveted or spiral steel pipe	[illegible]
Smooth, uniform earth channel	[illegible]
Corrugated flumes, typical canals, river free from large stones and heavy weeds	[illegible]
Canals and rivers with many stones and weeds	[illegible]

*The table does not distinguish between different types of plastic, or between smooth wall [illegible] pipes with perforations.

Source: After Fox and McDonald [9].

Koerner, R.M., "Designing with Geosynthetics," 4th Ed., 1999.
Attachment F 1/4

CHART 1
SOIL RETENTION CRITERIA
FOR STEADY-STATE FLOW CONDITIONS



NOTES:

d_x is the particle size of which x percent is smaller

$C'u = \sqrt{\frac{d'_{100}}{d'_0}}$ where: d'_{100} and d'_0 are the extremities of a straight line drawn through the particle-size distribution, as directed above; and d'_{50} is the midpoint of this line.

$Cc = \frac{(d_{30})^2}{d_{60} \times d_{10}}$

I_D is the relative denisty of the soil

PI is the plasticity index of the soil

DHR is the double-hydrometer ratio of the soil

Portions of this flow chart modified from Giroud (1988)

Source: Luettich, S.M., Giroud, J.P., and Bachus, R.C. (1991). "Geotextile Filter Design Manual". Report prepared for Nicolon Corporation, Norcross, Georgia.

Attachment G 1/3

4.2 Define the Hydraulic Gradient for the Application (i_s)

The hydraulic gradient will vary depending on the application of the filter. Anticipated hydraulic gradients for various applications may be estimated using Figure 3.

4.3 Determine the Minimum Allowable Geotextile Permeability (k_g)

After determining the soil hydraulic conductivity and the hydraulic gradient, the following equation can be used to determine the minimum allowable geotextile permeability [Giroud, 1988]:

$$k_g > i_s \, k_s$$

The hydraulic conductivity (permeability) of the geotextile can be calculated from the permittivity test method ASTM D 4491; this value can often be obtained from the manufacturer's literature as well. The geotextile permeability is defined as the product of the permittivity, ψ, and the geotextile thickness, t_g:

$$k_g > \varphi \, t_g$$

STEP 5. DETERMINE ANTI-CLOGGING REQUIREMENTS

To minimize the risk of clogging, the following criteria should be met:

- Use the largest opening size (O_{95}) that satisfies the retention criteria.
- For nonwoven geotextiles, use the largest porosity available, but not less than 30 percent.
- For woven geotextiles, use the largest percent open area available, but not less than 4 percent.

Source: Luettich, S.M., Giroud, J.P., and Bachus, R.C. (1991). "Geotextile Filter Design Manual". Report prepared for Nicolon Corporation, Norcross, Georgia.

Attachment G 2/3

Table 4-5

Typical Hydraulic Gradients[a]

DRAINAGE APPLICATION	TYPICAL HYDRAULIC GRADIENT
Standard Dewatering Trench	1.0
Vertical Wall Drain	1.5
Pavement Edge Drain	1[b]
Landfill LCDRS	1.5
Landfill LCRS	1.5
Landfill SWCRS	1.5
Inland Channel Protection	1[b]
Shoreline Protection	10[b]
Dams	10[b]
Liquid Impoundments	10[b]

NOTES: [a] Table developed after Giroud [1988].

[b] Critical applications may require designing with higher gradients than those given.

Attachment G
3/3

AMOCO WASTE RELATED GEOTEXTILES

MINIMUM PHYSICAL PROPERTIES
(Minimum Average Roll Values)

Property	Test Method	Units	4504	4506	4508	4510	4512	4516
Unit Weight	ASTM D-3776	Oz./yd.²	4.0 *	6.0	8.0	10.0	12.0	16.0
Grab Tensile	ASTM D-4632	lbs.	95	150	200	235	275	350
Grab Elongation	ASTM D-4632	%	50	50	50	50	50	50
Mullen Burst	ASTM D-3787	psi	225	350	450	550	650	750
Puncture	ASTM D-4833	lbs.	55	90	130	165	185	220
Trapezoid Tear	ASTM D-4533	lbs.	35	65	80	95	115	130
Apparent Opening Size	ASTM D-4751	US Sieve Number	70	70	100	100	100	100
Permittivity	ASTM D-4491	gal/min/ft² sec^{-1}	100 2.0	90 1.7	80 1.5	70 1.1	60 0.9	50 0.7
Permeability	ASTM D-4491	cm/sec	.2	.2	.2	.2	.2	.2
Thickness	ASTM D-1777	mils	40 *	65	90	110	130	175
U.V. Resistance	ASTM D-4355[1]	%[2]	70	70	70	70	70	70

1. Fabric conditioned per ASTM D-4355 2. Percent of minimum grab tensile after conditioning.

TYPICAL PHYSICAL PROPERTIES

Property	Test Method	Units	4504	4506	4508	4510	4512	4516
Grab Tensile	ASTM D-4632	lbs.	130/115	225/200	275/270	315/310	410/370	510/470
Grab Elongation	ASTM D-4632	%	75	65	65	65	65	65
Mullen Burst	ASTM D-3786	psi	285	410	575	650	825	920
Puncture	ASTM D-4833	lbs.	75	120	170	190	210	270
Trapezoid Tear	ASTM D-4533	lbs.	60/50	100/80	140/120	160/140	185/155	220/180
Apparent Opening Size	ASTM D-4751	US Sieve Number	70/120	70/140	100/200	100+	100+	100+
Permittivity	ASTM D-4491	gal/min/ft² sec^{-1}	150 3.1	110 2.0	100 1.8	80 1.5	70 1.3	60 1.0
Permeability	ASTM D-4491	cm/sec	.35	.31	.27	.26	.25	.23
Thickness	ASTM D-1777	mils	50	75	115	130	150	195

PACKAGING

Dimensions		4504	4506	4508	4510	4512	4516
Roll Width	ft.	15	15	15	15	15	15
Roll Length	ft.	1200	900	600	600	450	300
Gross Weight	lbs.	500	550	500	600	550	500
Area	sq. yds.	2000	1500	1000	1000	750	500

The information contained herein is furnished without charge or obligation and the recip... conditions of use and handling may vary and are beyond our control we make no represent... accuracy or reliability of said information or the performance of any product. Any specif... provided as information only and in no way modify, amend, enlarge or create any warra... permission or as a recommendation to infringe any patent.

Amoco Fabrics and Fibers Company 900 Circle 75 Parkway, Suite 300 Atlanta, Georgia

"Amoco Fabrics & Fibers Company, 1991. "Amoco Waste Related Geotextiles" H 1/1

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**                                                                          **
**                                                                          **
**             HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                   USAE WATERWAYS EXPERIMENT STATION                      **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\HLP3\IUC\IUC30.D4
TEMPERATURE DATA FILE:       C:\HLP3\IUC\IUC30.D7
SOLAR RADIATION DATA FILE:   C:\HLP3\IUC\IUC30.D13
EVAPOTRANSPIRATION DATA:     C:\HLP3\IUC\IUC30.D11
SOIL AND DESIGN DATA FILE:   C:\HLP3\IUC\SOIL-8.D10
OUTPUT DATA FILE:            C:\HLP3\IUC\3ft-sm2.OUT


TIME:  11:34     DATE:   5/ 4/2007


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     TITLE:  IUC 40 feet, 10 year slime drain simulation

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


                                  LAYER  1
                                  --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER   0
           THICKNESS                  =     36.00   INCHES
           POROSITY                   =      0.4730 VOL/VOL
           FIELD CAPACITY             =      0.2220 VOL/VOL
           WILTING POINT              =      0.1040 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.2000 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.520000001000E-03 CM/SEC


                                  LAYER  2
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                          TYPE 2 - LATERAL DRAINAGE LAYER
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ATTACHMENT I, 1/9

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	6.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2220	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC
SLOPE	=	1.00	PERCENT
DRAINAGE LENGTH	=	75.0	FEET

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 75. FEET.

SCS RUNOFF CURVE NUMBER	=	88.80	
FRACTION OF AREA ALLOWING RUNOFF	=	0.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	16.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.762	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.568	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.664	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	8.532	INCHES
TOTAL INITIAL WATER	=	8.532	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM GRAND JUNCTION COLORADO

STATION LATITUDE	=	39.07	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.00	
START OF GROWING SEASON (JULIAN DATE)	=	109	
END OF GROWING SEASON (JULIAN DATE)	=	293	
EVAPORATIVE ZONE DEPTH	=	16.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	60.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	36.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	36.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	57.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR GRAND JUNCTION COLORADO

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC

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0.64	0.54	0.75	0.71	0.76	0.44
0.47	0.91	0.70	0.87	0.63	0.58

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GRAND JUNCTION COLORADO

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
25.50	33.50	41.90	51.70	62.10	72.30
78.90	75.90	67.10	54.90	39.60	28.30

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GRAND JUNCTION COLORADO
AND STATION LATITUDE = 39.07 DEGREES

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	7.42	26934.602	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	6.873	24947.395	92.62
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	0.547	1987.206	7.38
SOIL WATER AT START OF YEAR	8.532	30971.395	
SOIL WATER AT END OF YEAR	9.080	32958.598	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.002	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.91	35973.301	100.00

RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	11.228	40758.055	113.30
PERC./LEAKAGE THROUGH LAYER 2	0.012633	45.857	0.13
CHANGE IN WATER STORAGE	-1.331	-4830.604	-13.43
SOIL WATER AT START OF YEAR	9.080	32958.598	
SOIL WATER AT END OF YEAR	7.619	27656.164	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.130	471.831	1.31
ANNUAL WATER BUDGET BALANCE	0.0000	-0.008	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.74	31726.203	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.431	30605.041	96.47
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	0.309	1121.151	3.53
SOIL WATER AT START OF YEAR	7.619	27656.164	
SOIL WATER AT END OF YEAR	8.058	29249.146	
SNOW WATER AT START OF YEAR	0.130	471.831	1.49
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.010	0.00

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.57	31109.109	100.00
RUNOFF	0.000	0.000	0.00

EVAPOTRANSPIRATION	8.223	29850.770	95.96
PERC./LEAKAGE THROUGH LAYER 2	0.003014	10.940	0.04
CHANGE IN WATER STORAGE	0.344	1247.404	4.01
SOIL WATER AT START OF YEAR	8.058	29249.146	
SOIL WATER AT END OF YEAR	8.401	30496.551	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.004	0.00

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	10.36	37606.805	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.137	36797.102	97.85
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	0.223	809.710	2.15
SOIL WATER AT START OF YEAR	8.401	30496.551	
SOIL WATER AT END OF YEAR	8.624	31306.262	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.007	0.00

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ANNUAL TOTALS FOR YEAR 6

	INCHES	CU. FEET	PERCENT
PRECIPITATION	7.78	28241.400	100.00
RUNOFF	0.000	0.000	0.00

EVAPOTRANSPIRATION	8.167	29645.734	104.97
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	-0.387	-1404.339	-4.97
SOIL WATER AT START OF YEAR	8.624	31306.262	
SOIL WATER AT END OF YEAR	8.237	29901.922	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.005	0.00

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ANNUAL TOTALS FOR YEAR 7

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.20	29766.002	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.154	25970.750	87.25
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	1.046	3795.249	12.75
SOIL WATER AT START OF YEAR	8.237	29901.922	
SOIL WATER AT END OF YEAR	9.023	32752.676	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.260	944.495	3.17
ANNUAL WATER BUDGET BALANCE	0.0000	0.004	0.00

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ANNUAL TOTALS FOR YEAR 8

	INCHES	CU. FEET	PERCENT
PRECIPITATION	7.46	27079.803	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.640	31362.828	115.82

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PERC./LEAKAGE THROUGH LAYER 2	0.017125	62.163	0.23
CHANGE IN WATER STORAGE	-1.197	-4345.196	-16.05
SOIL WATER AT START OF YEAR	9.023	32752.676	
SOIL WATER AT END OF YEAR	7.452	27050.932	
SNOW WATER AT START OF YEAR	0.260	944.495	3.49
SNOW WATER AT END OF YEAR	0.634	2301.042	8.50
ANNUAL WATER BUDGET BALANCE	0.0000	0.009	0.00

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ANNUAL TOTALS FOR YEAR 9

	INCHES	CU. FEET	PERCENT
PRECIPITATION	5.83	21162.902	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	6.171	22400.824	105.85
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	-0.341	-1237.930	-5.85
SOIL WATER AT START OF YEAR	7.452	27050.932	
SOIL WATER AT END OF YEAR	7.582	27522.836	
SNOW WATER AT START OF YEAR	0.634	2301.042	10.87
SNOW WATER AT END OF YEAR	0.163	591.209	2.79
ANNUAL WATER BUDGET BALANCE	0.0000	0.008	0.00

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ANNUAL TOTALS FOR YEAR 10

	INCHES	CU. FEET	PERCENT
PRECIPITATION	7.35	26680.502	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	6.669	24209.432	90.74

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PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	0.681	2471.069	9.26
SOIL WATER AT START OF YEAR	7.582	27522.836	
SOIL WATER AT END OF YEAR	8.309	30162.926	
SNOW WATER AT START OF YEAR	0.163	591.209	2.22
SNOW WATER AT END OF YEAR	0.116	422.187	1.58
ANNUAL WATER BUDGET BALANCE	0.0000	0.001	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 10

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.44	0.44	0.65	0.81	0.75	0.52
	0.39	1.08	0.58	1.00	0.94	0.54
STD. DEVIATIONS	0.23	0.30	0.31	0.44	0.53	0.63
	0.30	0.48	0.44	0.63	0.52	0.31
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.440	0.536	0.624	0.720	0.941	1.161
	0.512	0.979	0.483	0.735	0.587	0.451
STD. DEVIATIONS	0.214	0.265	0.279	0.353	0.546	0.558
	0.398	0.510	0.397	0.632	0.250	0.226
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.0000	0.0000	0.0001	0.0010	0.0009	0.0008
	0.0000	0.0000	0.0000	0.0000	0.0005	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0004	0.0024	0.0020	0.0017
	0.0000	0.0000	0.0000	0.0000	0.0014	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 10

	INCHES		CU. FEET	PERCENT
PRECIPITATION	8.16	(1.320)	29628.1	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	8.169	(1.5803)	29654.79	100.090
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.00328	(0.00628)	11.896	0.04015
CHANGE IN WATER STORAGE	-0.011	(0.7880)	-38.63	-0.130

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 10

	(INCHES)	(CU. FT.)
PRECIPITATION	0.86	3121.800
RUNOFF	0.000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.002888	10.48416
SNOW WATER	0.72	2615.3926
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2313	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1040	

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FINAL WATER STORAGE AT END OF YEAR 10

LAYER	(INCHES)	(VOL/VOL)
1	6.9773	0.1938
2	1.3320	0.2220
SNOW WATER	0.116	

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