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**Sampling Gold Ore by Diamond-Drilling  
in the Homestake Mine, Lead, S. Dak.**

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UNITED STATES DEPARTMENT OF THE INTERIOR

**Report of Investigations 7508**

**Sampling Gold Ore by Diamond-Drilling  
in the Homestake Mine, Lead, S. Dak.**

**By George S. Koch, Jr., and Richard F. Link**



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# SAMPLING GOLD ORE BY DIAMOND-DRILLING IN THE HOMESTAKE MINE, LEAD, S. DAK.

by

George S. Koch, Jr.,<sup>1</sup> and Richard F. Link<sup>2</sup>

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## ABSTRACT

Several methods of calculating ore grades by diamond-drill sampling in the Homestake mine, Lead, S. Dak., have been evaluated by statistical analyses of assay data. The natural distribution of gold particles, partly masked through sampling and assaying procedures, is probably lognormal. As a consequence of the gold particles being clustered rather than randomly distributed within the ore bodies, (1) more mine samples are needed to obtain a specified precision of mean grade than the number predicted by the standard-error-of-the-mean law; (2) the variance of gold values is not inversely proportional to sample volume, and, therefore, small-diameter drill core yields samples nearly as good as larger diameter core; and (3) sampling at 5-foot intervals provides nearly as good results as sampling at shorter intervals.

## INTRODUCTION

The Homestake mine, Lead, S. Dak., is the largest gold-producing mine in the United States and one of the larger mines in the world. Diamond drilling is the principal way of sampling in order to determine grade of ore and boundaries of ore shoots at the Homestake mine. This Bureau of Mines report presents the results of an investigation by statistical analysis of diamond-drill sampling at the Homestake mine to appraise this method of sampling and to suggest improvements in sampling procedures.

The most important purpose of this study is to determine in detail how gold is distributed in the ore body; this is the basis for devising a sound sampling program for any type of ore deposit. Once this distribution is sufficiently well understood, a reliable sampling plan can be devised to calculate average gold content to a specified accuracy. Gold distribution, as defined and used in this report, means the size distribution of the gold particles, the purity of the gold-bearing particles (whether native gold of a certain size and fineness or gold of submicroscopic particle size entrapped in another

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mineral, such as pyrite or arsenopyrite), and the distribution of these particles through the ore. While another gold ore body is unlikely to have a macrostructure similar to that of the Homestake deposit, its microstructure may be similar. Therefore, the microstructure can be useful in devising sampling procedures elsewhere for a similar ore body. Not all of these details of gold distribution are directly analyzed in this report, but they form a framework for a study of this type.

The second purpose of this report is to investigate some statistical methods that are applicable to the evaluation of assay data obtained for diamond-drill cores from the Homestake deposit. Just as the mining engineer chooses from various methods for mining an ore body, so the statistician chooses from various procedures for collecting and analyzing data. By illustrating the application of several statistical methods to the assay data in this report, we demonstrate which of these methods are likely to be suitable for analyzing assay data from similar ore deposits.

The third purpose of this report is to suggest changes in sampling methods that can be applied to sampling the type of ore found in the Homestake mine and types of ore found elsewhere. For instance, these procedures can be applicable to sampling other ore containing coarse gold, such as that found in South African mines.

This report presents the partial results of a larger Bureau of Mines study on sampling gold mines. The authors' previous work (4)<sup>3</sup> on a designed sampling experiment at the Homestake mine suggested the work in this report, while a report on sampling in a South African gold mine (3) suggested a mining strategy. Other relevant literature includes a report on the Getchell mine (5) which investigates sampling of fine-grained gold deposits and a discussion (6) of applying the lognormal frequency distribution to gold data.

The problem treated in this report developed from suggestions for further work made in our previous report<sup>4</sup> on gold distribution in the Homestake mine. For mining practice the two most significant conclusions from that investigation were:

"1. Most of the variability [in gold assays] is associated with 1-foot and wider [sample] intervals, rather than with narrower intervals.

2. Because high-grade material contains most of the gold, and is also the most variable, a good sampling plan must investigate a larger fraction of the high-grade material than would an ordinary random or systematic sample."

We further suggested that, "Because the basic variability is associated with 1-foot intervals, samples at narrower intervals are not necessary;

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<sup>3</sup>Underlined numbers in parentheses refer to items in the list of references preceding the appendix.

<sup>4</sup>Koch, George S., Jr., and Richard F. Link. Gold Distribution in Diamond-Drill Core From the Homestake Mine, Lead, S. Dak. BuMines Rept. of Inv. 6897, 1967, pp. 25-27.

because it is desirable to localize ore fairly closely, there is no apparent advantage, at least in potential ore areas, to take samples at intervals wider than 5 feet. Therefore, the sample interval should be between 1 and 5 feet." We proposed an experiment "...to test the consequences of taking samples at 1-foot intervals in contrast to the present practice of taking samples at 5-foot intervals, to determine whether the increased precision of estimate would be worth the additional expense of sampling and assaying. From this experiment, the effect of using intermediate sample intervals, 2 feet, for example, may also be derived."

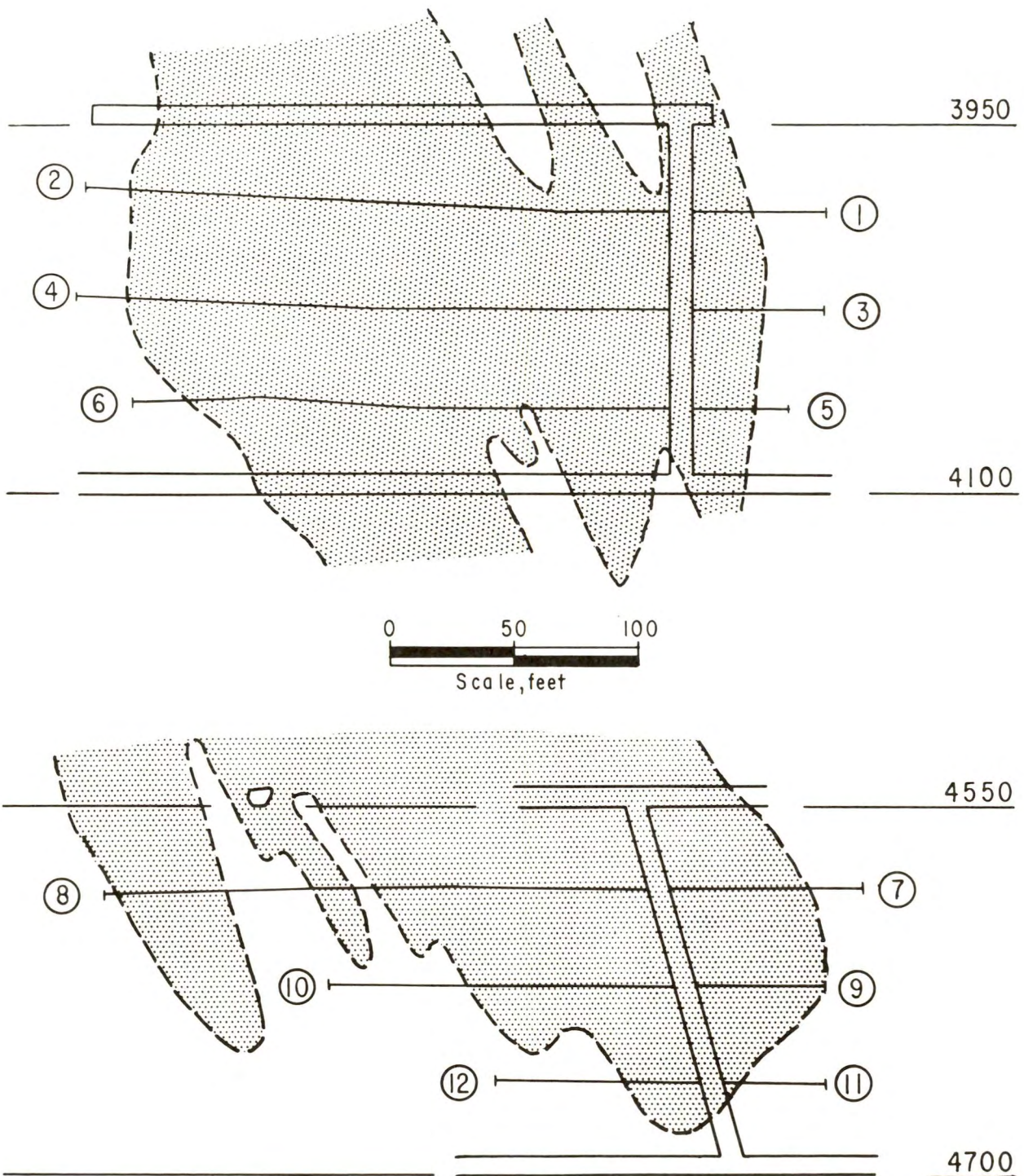
"Besides comparing the current 5-foot sample interval to a 1-foot interval, the proposed experiment would test a further modification suggested by the conclusion about the desirability of investigating a larger fraction of the high-grade material than would an ordinary systematic sample. Particularly, if a basic 5-foot sample interval were adopted, additional samples might be taken only where initial assays were high grade, and estimation made with appropriate statistical methods. Thus, the amount of work and expense would be increased less than the fivefold increase associated with a change from a 5-foot to a 1-foot sample interval." In the earlier report we described specific plans that could be used to sample diamond-drill core from the Homestake mine, gave the advantages and disadvantages of each, and suggested details to be specified for the particular experiment.

After the proposed experiment was devised, G. C. Mathisrud, former assistant chief geologist, Homestake Mining Company, brought up an additional point that had been raised within the company: the proposed substitution of XRT diamond-drill core of 0.75 inch diameter for the EX diamond-drill core of 0.9375 inch diameter currently obtained. Thus, this report considers specifically the following changes that could be made in diamond-drill sampling at the Homestake mine:

1. XRT core instead of EX core could be taken,
2. The sampling interval could be reduced from 5 feet to a narrower width, and/or
3. Sampling could be modified in order to take additional samples only where initial assays were high grade.

#### ACKNOWLEDGMENTS

We gratefully acknowledge the cooperation of the Homestake Mining Company, in particular for changing their usual sampling procedure in order to provide assay data from 1-foot intervals of diamond-drill core. G. C. Mathisrud, former assistant chief geologist, was especially helpful in discussing the investigation with us in detail.



Note: Ore shoots shown by a gray pattern.

FIGURE 1. - Longitudinal Sections to Show Locations of Diamond-Drill Holes Yielding 900 Assay Values for Experimental Sampling Study, Homestake Mine, Lead, S. Dak.

## DATA

Three sets of data are discussed in this report: 1-foot data, 5-foot data, and 1-inch data. The first set, for convenience designated the "1-foot data," comprises 900 assay values for gold obtained specially for this study by the Homestake Mining Company on 1-foot-long samples of EX diamond-drill core. The locations of the drill holes are plotted in figure 1, and the assays are listed in the appendix. Because of core losses, 363 intervals were less than the full 1 foot; however, the statistics in table 1 show no evidence that the gold content was different in the short core intervals than in the full core intervals (statistical tests indicate that the correlation coefficient of 0.049 is not different from 0 and that the correlation coefficient of 0.120 is not very different from 0).

TABLE 1. - Summary width data for 1-foot-long intervals of EX diamond-drill core from the Homestake mine, Lead, S. Dak.

Total number of width measurements.....	900
Number of width measurements of less than 1 inch.....	363
Mean width, feet.....	.95
Standard deviation.....	.080
Correlation coefficient between gold and width values.....	.049
Correlation coefficient between logarithm of gold and width values.	.120

The second set of data, designated the "5-foot data," comprises 297 assay values for gold obtained from holes drilled in the regular course of the Company's mining operation nearby the holes that provided the 1-foot data. The third set of data, designated the "1-inch data," comprises 219 assay values for gold obtained on 1-inch-long segments of EX core from holes drilled at the Homestake mine for the Bureau of Mines in a previous sampling study (4).

In table 2, summary statistics for the three sets of data are recorded. The methods of calculation are explained in an earlier report (6), and the significance of the various statistics are discussed later in this report. In table 2 and throughout this report, gold values are reported in grams per metric ton (parts per million), for the several reasons. Because the Company records assays in dollars at the rate of \$20.67 per troy ounce, a change to a unit that would be easily interpreted by other engineers seemed advisable. Because the grams-per-metric-ton unit is used nearly everywhere, except in some English-speaking countries, and is the most convenient unit for calculations, it was adopted instead of troy ounces per short ton. The values in grams per metric ton can be converted to dollars at \$20.67 per short ton by multiplying by 0.60287; to pennyweights per short ton by multiplying by 0.58333; and to ounces per short ton by multiplying by 0.029167.

TABLE 2. - Summary data calculated from two sets of gold assay data from the Homestake mine, Lead, S. Dak.

Item	Type of data			
	Gold, grams per metric ton		Gold, logarithms	
	Notation	Value	Notation	Value
900 OBSERVATIONS ON 1-FOOT-LONG EX CORES				
Mean.....	$\bar{w}$	7.59	$\bar{u}$	0.578
Variance.....	$s_w^2$	327	$s_u^2$	3.024
Standard deviation.....	$s_w$	18	$s_u$	1.739
Geometric mean.....	$e^{\bar{u}}$	1.783	-	-
Multiplying factor for geometric mean.....	$\Psi_n (\frac{1}{2}s_u^2)$	4.516	-	-
Estimate of mean from logarithms	m	8.1	-	-
297 OBSERVATIONS ON 5-FOOT-LONG EX CORES				
Mean.....	$\bar{w}$	4.04	$\bar{u}$	0.145
Variance.....	$s_w^2$	64	$s_u^2$	2.553
Standard deviation.....	$s_w$	8.0	$s_u$	1.598
Geometric mean.....	$e^{\bar{u}}$	1.156	-	-
Multiplying factor for geometric mean.....	$\Psi_n (\frac{1}{2}s_u^2)$	3.549	-	-
Estimate of mean from logarithms	m	4.1	-	-
219 OBSERVATIONS ON 1-INCH-LONG EX CORES				
Mean.....	$\bar{w}$	42.70	$\bar{u}$	1.036
Variance.....	$s_w^2$	28,609	$s_u^2$	5.6555
Standard deviation.....	$s_w$	169	$s_u$	2.378
Geometric mean.....	$e^{\bar{u}}$	2.817	-	-
Multiplying factor for geometric mean.....	$\Psi_n (\frac{1}{2}s_u^2)$	16.115	-	-
Estimate of mean from logarithms	m	45.4	-	-

#### FREQUENCY DISTRIBUTIONS

Frequency distributions of gold values are presented in table 3 for the 1-foot data and in table 4 for the 5-foot data. These tables and figure 3 in the previous report (4) display distributions that are extremely skewed to the right. (In table 4, the upper 1 percent of the distribution recorded in table 3 is missing; perhaps it is not naturally present, or the samples are of larger volume.) Distributions like these characterize assay data from many mines of coarse-grained gold ore.

TABLE 3. - Frequency distribution of 900 gold assays from 1-foot-long intervals of EX diamond-drill core from the Homestake mine, Lead, S. Dak.

Assay interval, grams per metric ton	Frequency	Cumulative frequency	Relative cumulative frequency, percent
0- 5	632	632	70.22
5- 10	91	723	80.33
10- 15	58	781	86.78
15- 20	31	812	90.22
20- 25	18	830	92.22
25- 30	17	847	94.11
30- 35	14	861	95.67
35- 40	3	864	96.00
40- 45	7	871	96.78
45- 50	3	874	97.11
50- 55	5	879	97.67
55- 60	2	881	97.89
60- 65	2	883	98.11
65- 70	6	889	98.78
70- 75	1	890	98.89
75- 80	1	891	99.00
80- 85	1	892	99.11
85- 90	0	892	99.11
90- 95	0	892	99.11
95-100	1	893	99.22
100-105	1	894	99.33
115-120	2	896	99.56
120-125	1	897	99.67
135-140	1	898	99.78
200-205	1	899	99.89
255-260	1	900	100.00

TABLE 4. - Frequency distribution of 297 gold assays from 5-foot-long intervals of EX diamond-drill core from the Homestake mine, Lead, S. Dak.

Assay interval, grams per metric ton	Frequency	Cumulative frequency	Relative cumulative frequency, percent
0- 5	231	231	77.78
5-10	28	259	87.21
10-15	19	278	93.60
15-20	7	285	95.96
20-25	6	291	97.98
25-30	2	293	98.65
30-35	0	293	98.65
35-40	1	294	98.99
40-45	1	295	99.33
45-50	0	295	99.33
50-55	0	295	99.33
55-60	1	296	99.66
60-65	0	296	99.66
65-70	0	296	99.66
70-75	1	297	100.00

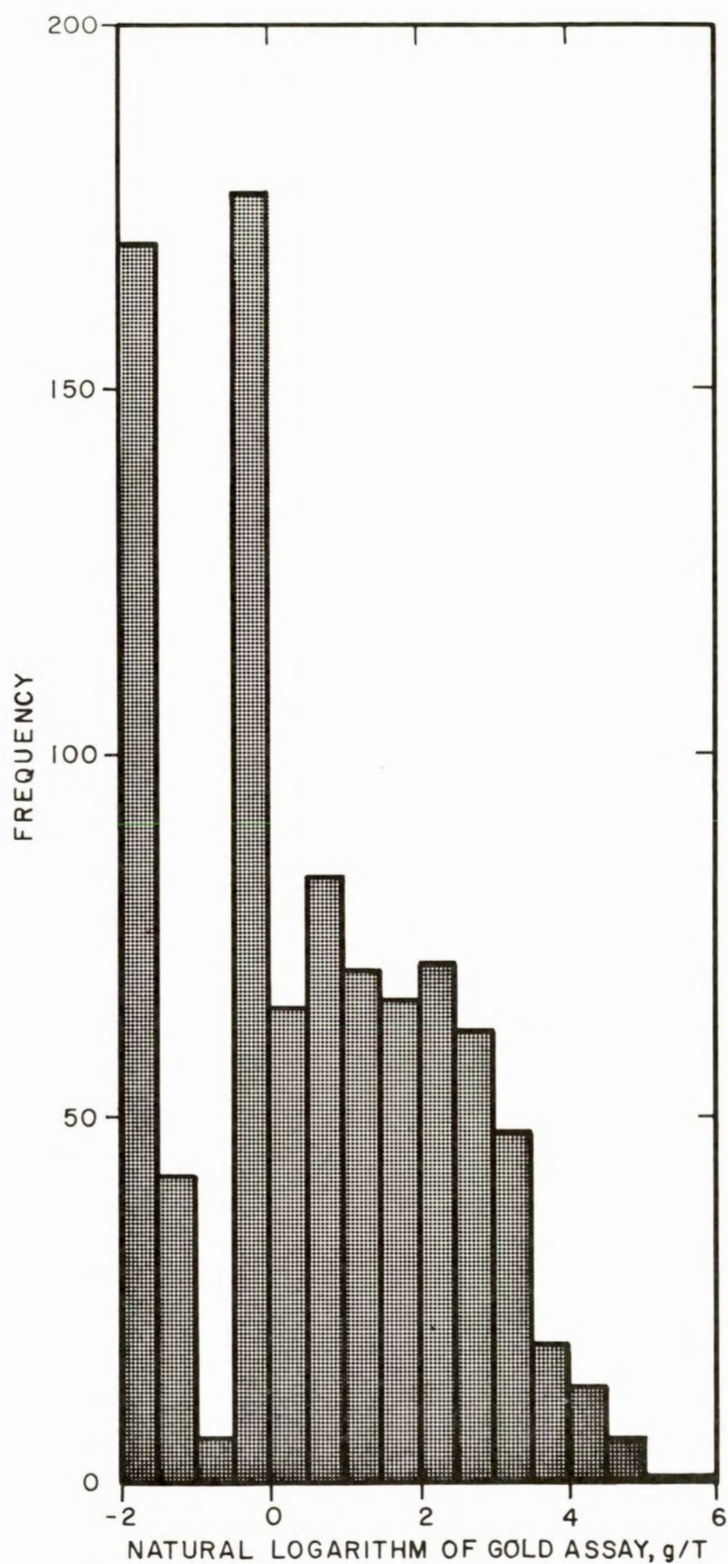


FIGURE 2. - Histogram of the Natural Logarithms of 900 Gold Values for the 1-Foot Data.

For skewed data like these, it is customary to take logarithms (6) and study their distribution, which may be nearly normal. Figure 2 is a histogram of the distribution of logarithms for the 900 gold values whose frequency distribution is given in table 3. This distribution is not normal, because the assaying is not sensitive enough to differentiate the gold values smaller than 1 gram per ton ( $\ln 1 = 0$ ). If the assaying were more sensitive, the distribution of logarithms might be fairly close to the distribution in figure 3, which is a histogram for 900 fictitious gold values from a distribution with the same mean and variance as the empirical distribution.

#### GOLD CLUSTERING

Frequency distributions of gold assays do not indicate the geographical distribution of the gold within the ore bodies; the geographical distribution is more important than the frequency distribution for devising a sampling plan. Particles of gold (or any other constituent present in minute amounts) may be distributed in a rock body in several ways. When gold particles are randomly distributed, the chance of a gold particle being present at one place is the same as the chance of its being present elsewhere. Or the gold particles may be distributed in an orderly pattern; a farfetched illustration would be distribution in a three-dimensional grid at specified grid points. However, the gold in the Homestake mine is evidently distributed in a third way: in clumps or clusters

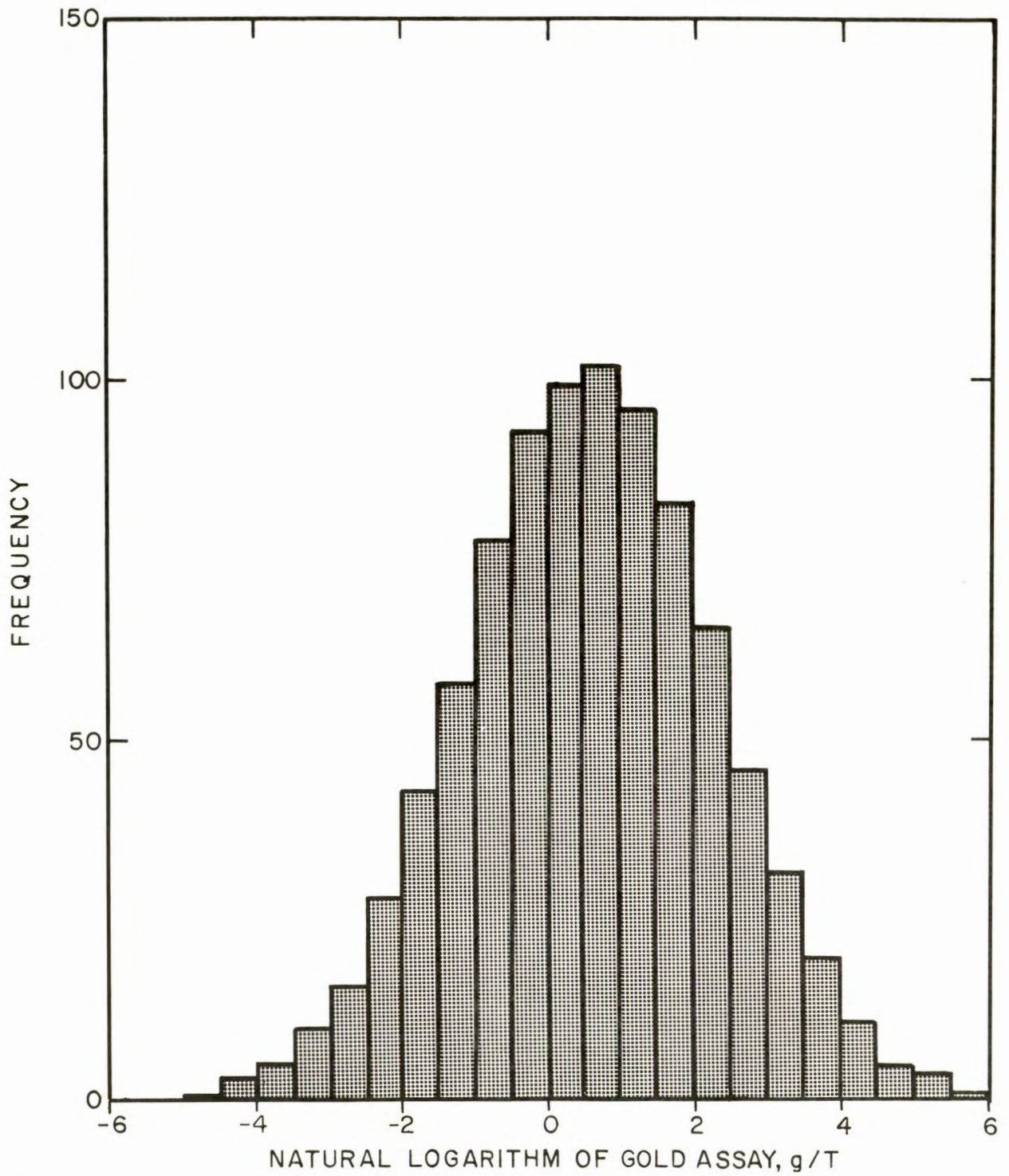


FIGURE 3. -Histogram of the Natural Logarithms of 900 Fictitious Gold Values With the Same Mean and Variance as the 1-Foot Data but Following a Lognormal Distribution.

rather than either in a random or an orderly pattern. Thus, at certain ill-defined places in the Homestake ore bodies, gold is much more concentrated than the average.

This clustering of gold is of great practical importance, because as a consequence, the standard-error-of-the-mean law does not apply. (This law states that  $s_{\bar{w}} = s/\sqrt{n}$ , where  $s_{\bar{w}}$  is the standard error of the mean,  $s$  is the standard deviation,  $n$  is the sample size, and the observations are assumed to be randomly distributed.) Therefore, for clustered gold more mine samples than the number predicted by this law are required in order to secure enough samples that contain gold for a reliable estimation of the gold content of the ore. Although their boundaries are ill-defined, most of the gold is in the clusters, and although in principle they can be related to mineralogy and to rock type, the association evidently is too subtle and detailed to be taken account of in mine sampling. Therefore, clustering is an awkward, but clearly present phenomenon, that must be accepted and provided for in sampling.

The clustering of the Homestake assay data is demonstrated by the list of 1-foot assay data in the appendix. The list for each hole shows distinct segments within the hole with much higher than average gold assays; each segment represents in one dimension the clustering present in three dimensions. For these particular data, the clustering is so strong that it is unmistakable. If it were less strong, clustering would be difficult to prove, because no generally accepted statistical test for recognizing clustering exists. However, one may test whether or not assays are randomly distributed throughout a hole, for if assays are not randomly distributed, they may, but need not be, clustered. The test is a serial correlation test explained by Hoel (2, p. 341).

Applied to the 1-foot data, the test yields the results in table 5. For correlations between gold values 1, 2, 3, 4, and 5 feet apart, the table shows by a "no" those cases for which (at the 5-percent significance level) the hypothesis that the values are drawn from a population with uncorrelated observations is rejected. Table 5 lists 15 rejections, although only three (5 percent of 60 tests) would have been expected if there were no serial correlation. These results confirm the fact that the gold values for intervals close together are indeed correlated and that the values cannot be randomly distributed geographically.

In table 6, some statistics calculated for the 1-foot data are compared to those calculated for other data, in order to investigate the consequences of clustering. The statistics in the first part of the table are for 1- to 5-foot intervals constructed by combining the original assays of the 1-foot-long cores. The first column of values lists the number of observations, which is the original 900 for the 1-foot intervals, and then one-half of 900, or 450, for the 2-foot intervals, in which the assays are combined in pairs, and so on. The second column gives the mean which is equal to 7.60 g/ton regardless of how the assays are combined, and the third column gives the variance. For the 1-foot intervals, the variance is 327.21 or about 320. If the standard-error-of-the-mean law applied to these data, the variance for the 2-foot intervals would be  $\sigma^2/n$ , which is  $320/2 = 160$ . However, the fact that the observed variance of 218.48 is larger than 160 shows that the observations

are not distributed independently and randomly. Rather assays of adjacent 1-foot cores especially in the clusters are correlated, with a high assay tending to be next to high assays on both sides. The 3- to 5-foot intervals display the same effect. For the 5-foot intervals, the observed variance of 124.91 is about twice that of 64, which is predicted by the standard-error-of-the-mean law.

TABLE 5. - Results of tests of the hypothesis that assays are randomly distributed at various spacings in 12 diamond-drill holes

Hole	Distance between intervals, feet				
	1	2	3	4	5
1.....	Yes <sup>1</sup>	Yes	Yes	Yes	Yes
2.....	Yes	Yes	Yes	Yes	Yes
3.....	Yes	Yes	Yes	Yes	Yes
4.....	No	No	No	No	Yes
5.....	Yes	Yes	Yes	Yes	Yes
6.....	No	Yes	Yes	Yes	Yes
7.....	Yes	Yes	No	Yes	Yes
8.....	No	No	No	No	Yes
9.....	No	Yes	Yes	Yes	Yes
10.....	Yes	No	No	Yes	Yes
11.....	Yes	Yes	Yes	Yes	Yes
12.....	No	Yes	Yes	Yes	No

<sup>1</sup>"Yes" indicates hypothesis is accepted at the 5-percent significance level. "No" indicates hypothesis is rejected at the 5-percent significance level.

TABLE 6. - Estimates of means and variances from different sources

Source of estimate	Number of observations	Gold, g/ton		
		Mean	Variance	Variance based on $\sigma^2/n$ law
Experimental data:				
1-foot intervals....	900	7.60	327.21	320
2-foot intervals....	450	7.60	218.48	160
3-foot intervals....	300	7.60	165.77	107
4-foot intervals....	225	7.60	141.44	80
5-foot intervals....	180	7.60	124.91	64
Standard mine data, nearby drill holes:				
Group 1.....	297	4.01	63.83	-
Group 2.....	30	7.90	141.91	-

The last two rows of table 6 present calculations for the 5-foot data. Group 1 is for 297 5-foot intervals; group 2 is a subgroup of group 1, chosen to have a mean about equal to that of the 1-foot data. The variances for these 5-foot cores are about 15 times the means, as is the variance for the simulated 4-foot intervals constructed by combining the 1-foot data; for

group 2, the variance is nearly identical with that of the simulated 4-foot intervals. These facts suggest that mixing of the crushed and pulverized 5-foot cores during sample preparation was fairly good.

Clustering within holes is evident from the previous data. However, if within the individual clusters the gold was distributed more or less randomly, stratified random sampling would be feasible. But table 7 shows that even within the clusters the gold distribution evidently is nonrandom. Table 7 is constructed like table 6 for the 5-foot data, except that the data are the higher grade grouped data. As in table 6, the variance does not decrease to the levels predicted by the standard-error-of-the-mean law which demonstrates that gold is not distributed randomly within the clusters.

TABLE 7. - Estimates of means and variances from higher grade grouped data

Source of estimate for experimental data	Number of intervals	Gold, g/ton		
		Mean	Variance	Variance based on $\sigma^2/n$ law
1-foot intervals.....	463	13.29	422.74	420
2-foot intervals.....	231	13.29	264.34	210
3-foot intervals.....	154	13.29	202.00	140
4-foot intervals.....	115	13.29	163.18	105
5-foot intervals.....	92	13.29	141.47	84

Another consequence of the clustering of gold in the Homestake ore bodies is that the variance of observations is not inversely proportional to sample volume as predicted by the theory of sample-volume variance (1). In table 8, the gold assays for the 1-foot intervals are combined to simulate the assays that would have been obtained, assuming perfect sample preparation and assaying, from 2-, 3-, 4-, and 5-foot intervals. The observed variances are not inversely proportional to the sample volumes, although there is a tendency for a small decline. Therefore, using the current procedures of sample preparation and assaying, XRT drill core of smaller diameter than EX drill core probably yields nearly, if not exactly, as good a sample.

TABLE 8. - Sample-volume variance in the 1-foot data

Item	Volumes and variance ratios				
	1	2	3	4	5
Interval length (ft).....	1	2	3	4	5
Volume (cc).....	129	258	387	516	645
Observed variances (g/ton)...	327	218	166	141	125
Theoretical variances (g/ton)	320	160	107	80	64

#### AUGMENTING HIGH VALUES

As the extremely skewed frequency distributions demonstrate, a few of the Homestake mine samples contain most of the gold, and the gold content of the high-grade ore shoots within the ore bodies also is highly variable and difficult to estimate. This phenomenon usually occurs in most gold ore bodies, and it would be desirable to develop a sampling plan to sample more of the high-grade and less of the low-grade ore than would ordinarily occur in a random or

systematic statistical sample. In practice, the rock to be sampled more intensively might be identified in one of several ways: for instance, by scanning the core or other rock sample with some quick-measurement device, such as X-ray or neutron activation, or by making additional assays when an initial assay identifies high-grade ore.

One sampling method which we have named "augmenting" obtains more samples of the high-grade ore by making one or more additional assays of a sample that initially yielded a high-grade assay. For instance, the central 1-foot section of each 5-foot length of core might be assayed and then additional assays made only if this first assay were higher than a specified grade. In this subsection, the consequences of applying this procedure to the Homestake data are discussed. Although the procedure was unsuccessful for these data, it may be useful for other deposits' data.

For the 1-foot data we investigated the properties of statistics obtained by augmenting high assays by two additional assays from the 1-foot cores on either side of the high assay samples, or, alternatively, by four additional assays, two on each side. In this way, the original assays were augmented if they were higher than one of the specified values or cutoff grades listed in table 9. The specified values were chosen so that the percent of high-grade cores ranged from 81 to 6. The table lists the percent of augmented assays at various specified grades. The five replications were obtained by defining 5-foot-long intervals starting from the first, second, third, fourth, and fifth foot, with the data lists from the several boreholes arranged sequentially in a single list. The spotty distribution of the gold is demonstrated once again by the small differences among replications.

TABLE 9. - Percent of augmented assays at various specified grades

Replication number	Specified assay, g/ton				
	0.25	1.00	5.80	16.60	29.90
1.....	82	59	27	13	6
2.....	82	62	29	11	5
3.....	80	60	28	10	4
4.....	81	57	26	14	9
5.....	81	63	29	11	5
Average.....	81	60	28	12	6

NOTE.--The specified assays are not integers, because they were originally defined in dollars at \$20.67.

As the specified assay increases, the percent of augmented values decreases (table 9). All five replication numbers as well as the average demonstrate the fluctuation in the estimated percentages depending on which assay is picked as the starting point. If the frequency distribution (table 3) applied to the entire mine or to a clearly defined part of it, a particular assay could be specified, and the fraction of high assays could be calculated from theory rather than being empirically estimated.

The principal drawback to augmenting is that the resulting means are biased. Table 10 shows the percentage biases that are introduced on the average; the entries are the percentages of the unweighted means corresponding to the augmented means. For instance, if assays greater than 16.60 g/ton were augmented by 4, the estimated grade would be divided by 0.68 to remove the bias. If these estimated biases held for the entire Homestake mine, they could readily be eliminated, but unfortunately the biases may vary with the grade of ore, its distribution in the mine, and other unforeseen factors. Therefore, these results cannot be used for the mine as a whole.

TABLE 10. - Estimated percentage biases of augmented means

Augmentation basis	Specified assay, g/ton				
	0.25	1.00	5.80	16.60	29.90
2.....	0.98	0.96	0.86	0.81	0.83
4.....	.78	.77	.68	.68	.74

Because augmenting may be useful in sampling deposits other than Homestake, it is of theoretical interest to estimate which cutoff and augmentation schemes provide estimates with minimum variance. If the fraction of high assays (above a specified value) and low assays were known, an estimate of the grade would be given by the formula,

$$\text{Grade estimate} = f_L \bar{x}_L + f_H \bar{x}_H,$$

where  $f$  is the fraction,  $\bar{x}$  the mean grade, and the subscripts L and H stand for low and high, respectively. An estimation of the variance of estimate would be given by the formula,

$$\text{Variance} = f_L^2 \frac{\sigma_L^2}{n_L} + f_H^2 \frac{\sigma_H^2}{n_H},$$

where  $\sigma^2$  is the population variance and  $n$  is the sample size. An estimation of the variance of the unbiased estimate would be given by the formula,

$$\text{Variance of unbiased estimate} = \text{variance}/\text{bias}^2.$$

Table 11 gives the variances of unbiased estimates for each of the cutoffs and each of the augmenting schemes. The table shows that an augmentation by four observations at a specified assay of 16.60 g/ton leads to a minimum estimated variance. The results are insensitive to the cutoff grade but are rather sensitive to the number of assays used to augment.

TABLE 11. - Estimated variances of unbiased estimates from augmented means

Augmentation basis	Specified assay, g/ton				
	0.25	1.00	5.80	16.60	29.90
2.....	0.85	0.80	0.63	0.55	0.52
4.....	.72	.66	.50	.44	.50

## CONCLUSIONS

From this investigation, we draw the following conclusions:

1. The frequency distribution of the 900 1-foot gold values is skewed to the right but is not lognormal, probably because the assaying is not sensitive enough to differentiate among gold values smaller than about 1 g/ton.

2. As gold particles are clustered throughout the ore shoots, more mine samples are needed to obtain a specified precision of estimated grade than that precision predicted by the standard-error-of-the-mean law of statistics.

3. As a second consequence of the clustering, the variance of gold values is not inversely proportional to sample volume as predicted by the theory of sample-volume variance. Therefore, XRT drill core should yield nearly as precise results as the more expensive EX drill core yields following present sample preparation and assaying procedures. If present methods of sample preparation were modified to obtain better mixing, XRT drill core should yield more precise results than present EX core yields.

4. As a third consequence of the clustering, sampling at 5-foot intervals yields nearly as precise results as sampling at 1-foot intervals. Significant correlations are found among assays as far apart as 6 feet. Therefore, with the attendant increase in cost, there is little or no advantage to sampling at a narrower interval than 5 feet.

5. Augmenting high values, by making one or more additional assays of samples that initially yielded a high-grade assay, is an unsatisfactory method for the Homestake ore bodies, because the resulting biased estimates cannot be adjusted reliably. However, this method may have application in the sampling of other ore bodies.

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## APPENDIX.--LIST OF 1-FOOT DATA

Serial number	From	To	Width, feet	Gold, g/ton
DRILL HOLE NO. 1				
1.....	0	1	1.00	5.97
2.....	1	2	1.00	1.99
3.....	2	3	0.75	1.99
4.....	3	4	1.00	11.94
5.....	4	5	1.00	2.32
6.....	5	6	1.00	0.66
7.....	6	7	1.00	18.25
8.....	7	8	0.83	2.65
9.....	8	9	1.00	0.66
10.....	9	10	1.00	11.94
11.....	10	11	1.00	12.27
12.....	11	12	1.00	1.33
13.....	12	13	1.00	1.99
14.....	13	14	1.00	10.28
15.....	14	15	0.83	1.99
16.....	15	16	1.00	3.32
17.....	16	17	1.00	33.34
18.....	17	18	1.00	104.17
19.....	18	19	1.00	5.14
20.....	19	20	1.00	1.99
21.....	20	21	0.92	1.00
22.....	21	22	0.83	2.32
23.....	22	23	0.79	0.66
24.....	23	24	0.79	1.66
25.....	24	25	1.00	0.66
26.....	25	26	1.00	0.66
27.....	26	27	1.00	0.17
28.....	27	28	1.00	0.66
29.....	28	29	1.00	0.33
DRILL HOLE NO. 2				
30.....	0	1	1.00	1.33
31.....	1	2	0.92	0.50
32.....	2	3	0.92	1.33
33.....	3	4	0.92	20.90
34.....	4	5	0.92	0.33
35.....	5	6	1.00	9.29
36.....	6	7	1.00	0.33
37.....	7	8	0.92	0.66
38.....	8	9	0.92	0.33
39.....	9	10	0.92	6.63
40.....	10	11	1.00	139.33
41.....	11	12	1.00	32.51
42.....	12	13	1.00	5.31
43.....	13	14	1.00	17.91
44.....	14	15	0.92	21.56
45.....	15	16	0.92	27.87
46.....	16	17	1.00	21.23
47.....	17	18	1.00	1.99

Serial number	From	To	Width, feet	Gold, g/ton
DRILL HOLE NO. 2--Continued				
48.....	18	19	1.00	3.15
49.....	19	20	1.00	23.89
50.....	20	21	1.00	27.53
51.....	21	22	1.00	4.64
52.....	22	23	0.92	11.61
53.....	23	24	0.92	0.66
54.....	24	25	1.00	0.66
55.....	25	26	1.00	40.80
56.....	26	27	1.00	14.18
57.....	27	28	1.00	12.61
58.....	28	29	1.00	11.61
59.....	29	30	0.92	12.61
60.....	30	31	0.92	15.92
61.....	31	32	0.92	17.08
62.....	32	33	1.00	10.95
63.....	33	34	1.00	1.99
64.....	34	35	1.00	7.30
65.....	35	36	1.00	12.27
66.....	36	37	0.92	11.61
67.....	37	38	0.92	21.90
68.....	38	39	1.00	14.60
69.....	39	40	1.00	17.67
70.....	40	41	1.00	67.01
71.....	41	42	1.00	21.31
72.....	42	43	1.00	13.27
73.....	43	44	0.92	25.79
74.....	44	45	1.00	1.99
75.....	183	184	1.00	22.56
76.....	184	185	0.92	40.97
77.....	185	186	0.92	26.54
78.....	186	187	1.00	8.04
79.....	187	188	1.00	15.09
80.....	188	189	1.00	18.08
81.....	189	190	0.92	28.61
82.....	190	191	0.92	16.01
83.....	191	192	1.00	5.97
84.....	192	193	1.00	54.32
85.....	193	194	1.00	50.59
86.....	194	195	1.00	55.57
87.....	195	196	1.00	9.45
88.....	196	197	1.00	25.05
89.....	197	198	1.00	29.11
90.....	198	199	1.00	4.15
91.....	199	200	0.92	32.10
92.....	200	201	0.92	25.38
93.....	201	202	1.00	8.96
94.....	202	203	1.00	20.57
95.....	203	204	0.92	13.10
96.....	204	205	0.92	31.18
97.....	205	206	1.00	19.24

Serial number	From	To	Width, feet	Gold, g/ton
DRILL HOLE NO. 3				
98.....	0	1	0.92	1.99
99.....	1	2	0.92	1.66
100.....	2	3	1.00	14.60
101.....	3	4	1.00	9.79
102.....	4	5	1.00	3.32
103.....	5	6	1.00	3.65
104.....	6	7	0.92	6.30
105.....	7	8	0.92	3.98
106.....	8	9	1.00	7.96
107.....	9	10	1.00	7.63
108.....	10	11	1.00	18.58
DRILL HOLE NO. 4				
109.....	0	1	1.00	1.00
110.....	1	2	1.00	2.32
111.....	2	3	1.00	0.66
112.....	3	4	0.92	6.63
113.....	4	5	0.92	0.66
114.....	5	6	1.00	4.64
115.....	6	7	1.00	0.66
116.....	7	8	1.00	0.17
117.....	8	9	0.92	1.33
118.....	9	10	0.92	0.66
119.....	10	11	1.00	6.30
120.....	11	12	1.00	0.66
121.....	12	13	1.00	23.97
122.....	13	14	1.00	32.51
123.....	14	15	1.00	12.94
124.....	15	16	0.92	4.98
125.....	16	17	0.92	4.31
126.....	17	18	1.00	1.99
127.....	18	19	1.00	13.44
128.....	19	20	1.00	1.00
129.....	20	21	1.00	0.66
130.....	21	22	1.00	0.66
131.....	22	23	0.92	0.17
132.....	23	24	0.92	0.17
133.....	24	25	1.00	0.17
134.....	25	26	1.00	0.17
135.....	26	27	1.00	0.17
136.....	27	28	1.00	0.17
137.....	28	29	1.00	0.66
138.....	29	30	0.50	0.17
139.....	30	31	0.50	0.66
140.....	31	32	0.50	1.33
141.....	32	33	1.00	1.33
142.....	33	34	1.00	2.65
143.....	34	35	1.00	31.27
144.....	35	36	0.83	47.44
145.....	36	37	0.83	5.97

Serial number	From	To	Width, feet	Gold, g/ton
DRILL HOLE NO. 4--Continued				
146.....	37	38	0.83	2.99
147.....	38	39	0.92	12.94
148.....	39	40	0.92	3.98
149.....	40	41	1.00	7.96
150.....	41	42	1.00	11.61
151.....	42	43	1.00	6.30
152.....	43	44	1.00	8.96
153.....	44	45	1.00	16.92
154.....	45	46	1.00	10.95
155.....	46	47	1.00	2.65
156.....	47	48	1.00	10.95
157.....	48	49	1.00	5.64
158.....	49	50	1.00	2.99
159.....	50	51	1.00	0.66
160.....	51	52	1.00	1.33
161.....	52	53	0.92	0.66
162.....	53	54	0.92	1.00
163.....	54	55	1.00	1.33
164.....	55	56	1.00	3.65
165.....	56	57	1.00	1.66
166.....	57	58	1.00	1.99
167.....	58	59	0.92	3.65
168.....	59	60	1.00	8.96
169.....	60	61	1.00	1.99
170.....	61	62	1.00	2.32
171.....	62	63	0.92	0.66
172.....	63	64	0.92	1.66
173.....	64	65	1.00	0.66
174.....	65	66	1.00	15.43
175.....	66	67	1.00	8.29
176.....	67	68	0.92	31.60
177.....	68	69	0.92	1.66
178.....	69	70	1.00	5.31
179.....	70	71	1.00	31.35
180.....	71	72	1.00	18.41
181.....	72	73	1.00	98.11
182.....	73	74	1.00	62.04
183.....	74	75	0.92	1.33
184.....	75	76	0.92	26.04
185.....	76	77	1.00	6.97
186.....	77	78	1.00	4.64
187.....	78	79	1.00	6.63
188.....	79	80	1.00	66.51
189.....	80	81	0.92	13.93
190.....	81	82	0.92	12.94
191.....	82	83	1.00	4.98
192.....	83	84	1.00	20.32
193.....	84	85	1.00	9.62
194.....	85	86	1.00	2.99

Serial number	From	To	Width, feet	Gold, g/ton
DRILL HOLE NO. 4--Continued				
195.....	86	87	1.00	3.98
196.....	87	88	0.96	0.66
197.....	88	89	0.88	0.17
198.....	89	90	0.92	0.66
199.....	90	91	0.92	0.17
200.....	91	92	1.04	0.66
201.....	92	93	1.00	0.17
202.....	93	94	1.00	0.50
203.....	94	95	0.92	0.66
204.....	95	96	1.00	0.17
205.....	96	97	0.92	0.33
206.....	97	98	1.00	0.33
207.....	98	99	0.96	0.66
208.....	99	100	0.92	0.17
209.....	100	101	0.92	0.17
210.....	101	102	1.00	0.17
211.....	102	103	1.00	0.17
212.....	103	104	1.00	0.17
213.....	104	105	0.92	0.17
214.....	105	106	0.92	0.17
215.....	106	107	1.00	0.17
216.....	107	108	0.92	0.17
217.....	108	109	0.92	0.17
218.....	109	110	0.92	0.66
219.....	110	111	0.92	0.66
220.....	111	112	1.00	0.33
221.....	112	113	0.92	0.66
222.....	113	114	0.92	0.17
223.....	114	115	0.50	0.17
224.....	115	116	0.67	0.17
225.....	116	117	0.67	0.17
226.....	117	118	0.50	0.17
227.....	118	119	0.58	0.17
228.....	119	120	0.83	0.17
229.....	120	121	1.00	0.66
230.....	121	122	0.92	0.66
231.....	122	123	0.92	0.17
232.....	123	124	1.00	0.17
233.....	124	125	1.00	0.17
234.....	125	126	0.92	0.17
235.....	126	127	1.00	0.17
236.....	127	128	1.00	0.17
237.....	128	129	1.00	0.33
238.....	129	130	0.92	0.17
239.....	130	131	1.00	0.17
240.....	131	132	1.00	0.17
241.....	132	133	0.92	0.33
242.....	133	134	0.96	0.17
243.....	134	135	1.00	0.17

Serial number	From	To	Width, feet	Gold, g/ton
DRILL HOLE NO. 4--Continued				
244.....	135	136	1.00	1.33
245.....	136	137	1.00	1.33
246.....	137	138	1.00	0.66
247.....	138	139	1.00	0.17
248.....	139	140	1.00	2.32
249.....	140	141	1.00	1.00
250.....	141	142	1.00	1.00
251.....	142	143	0.96	0.33
252.....	143	144	0.92	0.33
253.....	144	145	1.00	0.66
254.....	145	146	1.00	0.66
255.....	146	147	0.83	0.66
256.....	147	148	1.00	0.33
257.....	148	149	0.96	0.17
258.....	149	150	1.00	0.66
259.....	150	151	1.00	1.33
260.....	151	152	1.00	1.33
261.....	152	153	0.87	0.66
262.....	153	154	0.92	15.92
263.....	154	155	1.00	1.00
264.....	155	156	1.00	1.00
265.....	156	157	1.00	0.66
266.....	157	158	0.92	0.66
267.....	158	159	1.00	0.66
268.....	159	160	1.00	29.69
269.....	160	161	0.92	2.32
270.....	161	162	0.87	1.99
271.....	162	163	0.83	2.32
272.....	163	164	1.00	1.99
273.....	164	165	0.92	4.64
274.....	165	166	0.92	4.64
275.....	166	167	0.92	4.31
276.....	167	168	1.00	21.65
277.....	168	169	0.83	6.30
278.....	169	170	0.92	6.63
279.....	170	171	1.00	9.62
280.....	171	172	1.00	10.95
281.....	172	173	1.00	12.94
282.....	173	174	1.00	1.00
283.....	174	175	1.00	13.27
284.....	175	176	0.92	8.63
285.....	176	177	0.92	4.64
286.....	177	178	1.00	1.99
287.....	178	179	0.92	4.31
288.....	179	180	1.00	0.66
289.....	180	181	0.92	4.64
290.....	181	182	0.92	5.31
291.....	182	183	0.92	2.32
292.....	183	184	1.00	1.99

Serial number	From	To	Width, feet	Gold, g/ton
DRILL HOLE NO. 4--Continued				
293.....	184	185	0.50	2.32
294.....	185	186	0.50	1.33
295.....	186	187	1.00	5.14
296.....	187	188	1.00	6.97
297.....	188	189	0.92	1.33
298.....	189	190	1.00	0.17
299.....	190	191	1.00	0.17
300.....	191	192	0.92	0.66
301.....	192	193	0.92	0.33
302.....	193	194	1.00	0.33
303.....	194	195	1.00	0.66
304.....	195	196	1.00	0.17
305.....	196	197	1.00	0.17
306.....	197	198	1.00	0.17
307.....	198	199	1.00	0.17
308.....	199	200	1.00	0.66
309.....	200	201	1.00	0.17
310.....	201	202	1.00	0.17
311.....	202	203	0.92	1.33
312.....	203	204	0.92	65.85
313.....	204	205	0.83	1.33
314.....	205	206	0.92	0.17
315.....	206	207	0.83	1.99
316.....	207	208	0.92	200.71
317.....	208	209	0.92	18.74
318.....	209	210	0.92	29.19
319.....	210	211	1.00	71.99
320.....	211	212	1.00	47.77
321.....	212	213	1.00	31.85
322.....	213	214	1.08	41.80
323.....	214	215	1.08	8.63
DRILL HOLE NO. 5				
324.....	0	1	1.00	12.61
325.....	1	2	1.00	6.47
326.....	2	3	1.00	4.98
327.....	3	4	1.00	2.32
328.....	4	5	0.92	14.26
329.....	5	6	1.00	2.65
330.....	6	7	1.00	1.00
331.....	7	8	1.00	3.65
332.....	8	9	0.83	4.64
333.....	9	10	0.92	5.31
334.....	10	11	1.00	28.53
335.....	11	12	0.92	5.31
336.....	12	13	1.00	2.65
337.....	13	14	1.00	2.99
338.....	14	15	0.92	0.17
339.....	15	16	0.92	9.62
340.....	16	17	0.92	4.31

Serial number	From	To	Width, feet	Gold, g/ton
DRILL HOLE NO. 5--Continued				
341.....	17	18	0.92	3.65
342.....	18	19	0.83	3.32
343.....	19	20	0.92	0.66
344.....	20	21	0.96	0.50
345.....	21	22	0.92	1.00
346.....	22	23	0.96	0.66
347.....	23	24	0.92	0.17
348.....	24	25	1.00	0.66
349.....	25	26	1.00	1.99
DRILL HOLE NO. 6				
350.....	0	1	0.92	0.17
351.....	1	2	0.92	0.17
352.....	2	3	1.00	0.17
353.....	3	4	0.92	21.81
354.....	4	5	1.00	4.31
355.....	5	6	1.00	0.17
356.....	6	7	0.92	3.98
357.....	7	8	0.92	1.99
358.....	8	9	1.00	3.32
359.....	9	10	1.00	4.31
360.....	10	11	0.92	6.30
361.....	11	12	1.00	8.96
362.....	12	13	1.00	7.30
363.....	13	14	0.83	1.99
364.....	14	15	0.92	0.17
365.....	15	16	0.83	0.17
366.....	16	17	0.83	0.66
367.....	17	18	0.92	0.17
368.....	18	19	0.79	3.32
369.....	19	20	0.83	0.66
370.....	20	21	0.83	0.66
371.....	21	22	0.83	1.33
372.....	22	23	0.92	3.98
373.....	23	24	0.83	3.65
374.....	24	25	0.79	1.33
375.....	25	26	0.83	0.66
376.....	26	27	0.83	0.66
377.....	27	28	0.83	1.33
378.....	28	29	0.83	0.66
379.....	29	30	0.88	2.32
380.....	30	31	0.83	0.66
381.....	31	32	0.83	0.66
382.....	32	33	0.83	1.66
383.....	33	34	0.83	1.33
384.....	34	35	0.92	1.33
385.....	35	36	0.92	1.66
386.....	36	37	1.00	0.66
387.....	37	38	1.00	0.17
388.....	38	39	1.00	1.00

Serial number	From	To	Width, feet	Gold, g/ton
DRILL HOLE NO. 6--Continued				
389.....	39	40	1.00	0.66
390.....	40	41	1.00	0.66
391.....	41	42	1.00	0.17
392.....	42	43	1.00	2.99
393.....	43	44	1.00	6.80
394.....	44	45	1.00	29.03
395.....	45	46	1.00	11.28
396.....	46	47	1.00	118.76
397.....	47	48	1.00	124.74
398.....	48	49	1.00	40.72
399.....	49	50	1.00	13.27
400.....	50	51	1.00	9.29
401.....	51	52	1.00	1.99
402.....	52	53	1.00	4.98
403.....	53	54	1.00	16.59
404.....	54	55	0.92	0.66
405.....	55	56	1.00	1.33
406.....	56	57	0.92	0.17
407.....	57	58	1.00	0.66
408.....	58	59	1.00	0.66
409.....	59	60	1.00	5.64
410.....	60	61	1.00	14.26
411.....	61	62	1.00	2.99
412.....	62	63	1.00	2.32
413.....	63	64	0.92	3.65
414.....	64	65	1.00	0.66
415.....	65	66	1.00	51.25
416.....	66	67	1.00	1.33
417.....	67	68	1.00	2.32
418.....	68	69	0.92	1.66
419.....	69	70	0.92	0.66
420.....	70	71	0.96	0.33
421.....	71	72	1.00	0.17
422.....	72	73	0.92	0.66
423.....	73	74	1.00	1.33
424.....	74	75	1.00	0.17
425.....	75	76	1.00	0.33
426.....	76	77	1.00	0.17
427.....	77	78	1.00	0.66
428.....	78	79	1.00	2.65
429.....	79	80	1.00	1.00
430.....	80	81	1.00	6.14
431.....	81	82	1.00	0.66
432.....	82	83	1.00	5.31
433.....	83	84	1.00	51.50
434.....	84	85	1.00	67.10
435.....	85	86	1.00	4.64
436.....	86	87	1.00	2.65
437.....	87	88	1.00	1.00

Serial number	From	To	Width, feet	Gold, g/ton
DRILL HOLE NO. 6--Continued				
438.....	88	89	1.00	1.33
439.....	89	90	1.00	0.66
440.....	90	91	1.00	0.66
441.....	91	92	1.00	1.00
442.....	92	93	1.00	0.17
443.....	93	94	1.00	0.17
444.....	94	95	0.92	1.00
445.....	95	96	1.00	0.17
446.....	96	97	1.00	2.99
447.....	97	98	1.00	1.00
448.....	98	99	1.00	2.82
449.....	99	100	0.92	1.16
450.....	100	101	1.00	1.00
451.....	101	102	1.00	1.33
452.....	102	103	1.00	2.32
453.....	103	104	1.00	1.33
454.....	104	105	1.00	1.33
455.....	105	106	0.92	0.33
456.....	106	107	0.92	0.66
457.....	107	108	1.00	0.33
458.....	108	109	1.00	0.33
459.....	109	110	1.00	0.66
460.....	110	111	1.00	0.17
461.....	111	112	0.92	0.17
462.....	112	113	0.92	0.66
463.....	113	114	0.96	3.32
464.....	114	115	1.00	2.99
465.....	115	116	1.00	0.33
466.....	116	117	1.00	0.66
467.....	117	118	0.92	1.00
468.....	118	119	0.96	0.17
469.....	119	120	0.92	0.66
470.....	120	121	1.00	0.66
471.....	121	122	1.00	0.66
472.....	122	123	1.00	0.66
473.....	123	124	0.92	0.33
474.....	124	125	1.00	0.66
475.....	125	126	1.00	0.17
476.....	126	127	1.00	0.17
477.....	127	128	1.00	1.33
478.....	128	129	1.00	0.66
479.....	129	130	0.88	0.17
480.....	130	131	0.92	1.33
481.....	131	132	0.92	1.33
482.....	132	133	1.00	0.66
483.....	133	134	1.00	0.33
484.....	134	135	1.00	0.17
485.....	135	136	0.92	0.17
486.....	136	137	0.83	0.33

Serial number	From	To	Width, feet	Gold, g/ton
DRILL HOLE NO. 6--Continued				
487.....	137	138	0.88	0.66
488.....	138	139	0.92	1.33
489.....	139	140	0.83	0.17
490.....	140	141	0.96	0.17
491.....	141	142	0.83	0.17
492.....	142	143	0.83	0.17
493.....	143	144	1.00	0.66
494.....	144	145	1.00	0.17
495.....	145	146	1.00	0.17
496.....	146	147	1.00	0.17
497.....	147	148	1.00	0.17
498.....	148	149	1.00	0.17
499.....	149	150	0.92	0.17
500.....	150	151	0.92	0.17
501.....	151	152	0.92	0.17
502.....	152	153	0.92	0.66
503.....	153	154	0.92	0.33
504.....	154	155	1.00	7.30
505.....	155	156	0.92	23.80
506.....	156	157	0.83	32.93
507.....	157	158	0.92	2.99
508.....	158	159	0.92	0.66
509.....	159	160	0.92	3.65
510.....	160	161	0.83	2.99
511.....	161	162	0.83	3.32
512.....	162	163	0.92	2.99
513.....	163	164	0.92	1.33
514.....	164	165	0.83	0.66
515.....	165	166	0.92	0.66
516.....	166	167	0.92	0.17
517.....	167	168	0.92	0.66
518.....	168	169	0.83	1.00
519.....	169	170	0.96	0.17
520.....	170	171	1.00	0.17
521.....	171	172	1.00	1.33
522.....	172	173	1.00	0.66
523.....	173	174	0.92	0.66
524.....	174	175	1.00	1.33
525.....	175	176	0.83	0.66
526.....	176	177	0.95	1.00
527.....	177	178	0.50	0.17
528.....	178	179	0.50	0.66
529.....	179	180	0.50	1.00
530.....	180	181	0.50	0.17
531.....	181	182	0.50	0.33
532.....	182	183	0.50	0.17
533.....	183	184	0.92	258.10
534.....	184	185	0.92	35.33
535.....	185	186	1.00	2.99

Serial number	From	To	Width, feet	Gold, g/ton
DRILL HOLE NO. 6--Continued				
536.....	186	187	0.92	3.32
537.....	187	188	0.92	1.33
538.....	188	189	1.00	0.17
539.....	189	190	0.92	0.33
540.....	190	191	1.00	0.66
541.....	191	192	0.96	0.33
542.....	192	193	1.00	0.66
543.....	193	194	1.00	0.33
544.....	194	195	0.92	1.00
545.....	195	196	0.92	0.66
546.....	196	197	1.00	0.33
DRILL HOLE NO. 7				
547.....	0	1	0.92	8.63
548.....	1	2	1.00	9.29
549.....	2	3	0.92	9.29
550.....	3	4	1.00	8.96
551.....	4	5	1.00	8.29
552.....	5	6	0.83	14.60
553.....	6	7	0.83	13.93
554.....	7	8	0.83	4.98
555.....	8	9	1.00	4.64
556.....	9	10	1.00	3.32
557.....	10	11	1.00	3.32
558.....	11	12	0.83	2.32
559.....	12	13	1.00	2.32
560.....	13	14	1.00	18.91
561.....	14	15	1.00	9.79
562.....	15	16	0.92	27.37
563.....	16	17	1.00	15.92
564.....	17	18	1.00	15.43
565.....	18	19	0.92	23.06
566.....	19	20	1.00	65.02
567.....	20	21	1.00	16.42
568.....	21	22	1.00	8.04
569.....	22	23	1.00	43.79
570.....	23	24	1.00	6.30
571.....	24	25	1.00	3.32
572.....	25	26	1.00	1.00
573.....	26	27	1.00	1.33
574.....	27	28	1.00	0.17
575.....	28	29	1.00	4.31
576.....	29	30	1.00	1.99
577.....	30	31	1.00	6.97
578.....	31	32	0.92	10.62
579.....	32	33	1.00	2.99
580.....	33	34	1.00	2.16
581.....	34	35	1.00	7.63
582.....	35	36	1.00	1.33
583.....	36	37	1.00	1.33

Serial number	From	To	Width, feet	Gold, g/ton
DRILL HOLE NO. 7--Continued				
584.....	37	38	0.92	2.32
585.....	38	39	0.92	0.33
586.....	39	40	0.92	2.99
587.....	40	41	0.92	1.33
588.....	41	42	1.00	32.01
589.....	42	43	1.00	10.28
590.....	43	44	1.00	30.02
591.....	44	45	1.00	4.31
592.....	45	46	1.00	2.65
593.....	46	47	1.00	6.97
594.....	47	48	1.00	8.29
595.....	48	49	1.00	2.65
DRILL HOLE NO. 8				
596.....	0	1	1.00	32.35
597.....	1	2	0.92	41.97
598.....	2	3	1.00	12.11
599.....	3	4	0.92	13.44
600.....	4	5	1.00	18.41
601.....	5	6	1.00	48.93
602.....	6	7	0.92	29.03
603.....	7	8	0.92	40.31
604.....	8	9	1.00	3.98
605.....	9	10	0.92	2.32
606.....	10	11	1.00	3.65
607.....	11	12	0.92	8.63
608.....	12	13	0.92	1.33
609.....	13	14	0.96	1.66
610.....	14	15	0.96	3.98
611.....	15	16	1.00	17.42
612.....	16	17	1.00	8.96
613.....	17	18	1.00	10.62
614.....	18	19	1.00	9.62
615.....	19	20	1.00	18.41
616.....	20	21	0.92	8.96
617.....	21	22	1.00	13.77
618.....	22	23	1.00	5.31
619.....	23	24	1.00	6.63
620.....	24	25	1.00	11.94
621.....	25	26	1.00	1.99
622.....	26	27	0.92	17.08
623.....	27	28	0.92	3.98
624.....	28	29	0.92	7.63
625.....	29	30	1.00	5.64
626.....	30	31	1.00	1.99
627.....	31	32	1.00	1.33
628.....	32	33	0.96	0.17
629.....	33	34	1.00	0.50
630.....	34	35	1.00	0.66
631.....	35	36	1.00	0.66

Serial number	From	To	Width, feet	Gold, g/ton
DRILL HOLE NO. 8--Continued				
632.....	36	37	1.00	0.66
633.....	37	38	1.00	0.17
634.....	38	39	1.00	1.00
635.....	39	40	1.00	2.32
636.....	40	41	1.00	7.63
637.....	41	42	1.00	5.97
638.....	42	43	1.00	20.40
639.....	43	44	1.00	14.43
640.....	44	45	0.75	2.99
641.....	45	46	0.75	76.47
642.....	46	47	0.75	11.53
643.....	47	48	0.75	50.43
644.....	48	49	0.75	57.72
645.....	49	50	0.75	9.95
646.....	50	51	0.75	5.97
647.....	51	52	1.00	3.32
648.....	52	53	1.00	1.33
649.....	53	54	1.00	0.17
650.....	54	55	1.00	0.66
651.....	55	56	1.00	0.33
652.....	56	57	1.00	0.33
653.....	57	58	1.00	0.66
654.....	58	59	0.92	1.33
655.....	59	60	0.96	1.33
656.....	60	61	1.00	0.66
657.....	61	62	1.00	1.33
658.....	62	63	1.00	2.32
659.....	63	64	0.92	1.99
660.....	64	65	0.92	3.65
661.....	65	66	0.92	1.99
662.....	66	67	1.00	5.97
663.....	67	68	0.92	20.73
664.....	68	69	1.00	10.70
665.....	69	70	1.00	15.26
666.....	70	71	0.92	65.85
667.....	71	72	1.00	16.09
668.....	72	73	1.00	7.63
669.....	73	74	0.92	0.50
670.....	74	75	0.92	1.00
671.....	75	76	0.92	8.29
672.....	76	77	1.00	11.61
673.....	77	78	1.00	119.59
674.....	78	79	1.00	38.65
675.....	79	80	1.00	39.48
676.....	80	81	1.00	11.94
677.....	81	82	1.00	80.45
678.....	82	83	1.00	13.35
679.....	83	84	1.00	4.64
680.....	84	85	1.00	8.29

Serial number	From	To	Width, feet	Gold, g/ton
DRILL HOLE NO. 8--Continued				
681.....	85	86	1.00	17.83
682.....	86	87	1.00	15.92
683.....	87	88	1.00	16.26
684.....	88	89	1.00	13.85
685.....	89	90	1.00	10.45
686.....	90	91	1.00	24.22
687.....	91	92	0.92	27.04
688.....	92	93	0.92	60.38
689.....	93	94	0.92	8.63
690.....	94	95	0.92	6.30
691.....	95	96	0.92	2.32
692.....	96	97	0.92	0.66
693.....	97	98	0.96	0.66
694.....	98	99	1.00	0.17
695.....	99	100	0.92	0.17
696.....	100	101	0.92	0.17
697.....	101	102	0.92	0.17
698.....	102	103	1.00	0.66
699.....	103	104	1.00	0.66
700.....	104	105	1.00	1.99
701.....	105	106	1.00	1.33
702.....	106	107	0.92	0.66
703.....	107	108	1.00	0.66
704.....	108	109	1.00	0.66
705.....	109	110	1.00	1.33
706.....	110	111	1.00	3.65
707.....	111	112	1.00	0.17
708.....	112	113	0.92	0.17
709.....	113	114	1.00	0.66
710.....	114	115	1.00	0.17
711.....	115	116	0.92	0.66
712.....	116	117	0.92	0.17
713.....	117	118	0.92	1.00
714.....	118	119	1.00	0.66
715.....	119	120	1.00	0.17
716.....	120	121	1.00	0.66
717.....	121	122	0.96	0.17
718.....	122	123	0.92	0.17
719.....	123	124	0.92	0.17
720.....	124	125	1.00	0.17
721.....	125	126	1.00	0.17
722.....	126	127	1.00	2.32
723.....	127	128	0.92	4.64
724.....	128	129	0.92	2.65
725.....	129	130	0.88	8.96
726.....	130	131	0.83	1.33

Serial number	From	To	Width, feet	Gold, g/ton
DRILL HOLE NO. 9				
727.....	0	1	0.92	1.00
728.....	1	2	0.96	0.17
729.....	2	3	0.92	0.17
730.....	3	4	0.92	0.17
731.....	4	5	0.92	1.33
732.....	5	6	0.92	3.32
733.....	6	7	0.92	13.93
734.....	7	8	0.92	5.31
735.....	8	9	0.92	6.30
736.....	9	10	0.92	9.62
737.....	10	11	1.00	8.29
738.....	11	12	1.00	3.32
739.....	12	13	1.00	23.06
740.....	13	14	1.00	16.42
741.....	14	15	1.00	5.31
742.....	15	16	0.96	1.00
743.....	16	17	0.96	0.66
744.....	17	18	1.00	4.98
745.....	18	19	1.00	11.61
746.....	19	20	1.00	5.31
747.....	20	21	1.00	7.96
748.....	21	22	1.00	2.32
749.....	22	23	1.00	1.33
750.....	23	24	1.00	1.33
751.....	24	25	1.00	1.33
752.....	25	26	0.92	1.00
753.....	26	27	0.92	1.33
754.....	27	28	1.00	0.66
755.....	28	29	1.00	2.99
756.....	29	30	1.00	2.32
757.....	30	31	1.00	1.99
758.....	31	32	1.00	1.00
759.....	32	33	0.96	1.99
760.....	33	34	0.96	0.66
761.....	34	35	1.00	0.66
762.....	35	36	1.00	3.65
763.....	36	37	1.00	7.63
764.....	37	38	1.00	12.77
765.....	38	39	1.00	15.09
766.....	39	40	1.00	10.62
767.....	40	41	1.00	1.66
768.....	41	42	1.00	1.33
769.....	42	43	1.00	0.66
770.....	43	44	1.00	1.33
771.....	44	45	1.00	0.66
772.....	45	46	1.00	1.99
773.....	46	47	1.00	1.99
774.....	47	48	1.00	1.33

Serial number	From	To	Width, feet	Gold, g/ton
DRILL HOLE NO. 10				
775.....	0	1	0.92	6.97
776.....	1	2	0.92	4.31
777.....	2	3	0.96	10.62
778.....	3	4	1.00	0.66
779.....	4	5	1.00	26.54
780.....	5	6	1.00	0.66
781.....	6	7	0.92	1.99
782.....	7	8	0.92	0.66
783.....	8	9	1.00	0.66
784.....	9	10	1.00	0.17
785.....	10	11	0.96	0.17
786.....	11	12	1.00	0.66
787.....	12	13	1.00	0.66
788.....	13	14	0.92	0.17
789.....	14	15	1.00	0.66
790.....	15	16	0.92	0.17
791.....	16	17	1.00	0.17
792.....	17	18	1.00	0.17
793.....	18	19	1.00	0.17
794.....	19	20	1.00	0.17
795.....	20	21	0.92	0.66
796.....	21	22	0.92	0.33
797.....	22	23	1.00	0.17
798.....	23	24	1.00	0.17
799.....	24	25	1.00	0.66
800.....	25	26	1.00	0.17
801.....	26	27	1.00	0.17
802.....	27	28	0.92	0.17
803.....	28	29	0.92	0.17
804.....	29	30	1.00	0.17
805.....	30	31	1.00	0.17
806.....	31	32	1.00	0.17
807.....	32	33	1.00	0.17
808.....	33	34	0.92	0.17
809.....	34	35	1.00	0.17
810.....	35	36	1.00	0.17
811.....	36	37	1.00	0.17
812.....	37	38	1.00	0.17
813.....	38	39	0.92	0.17
814.....	39	40	0.92	0.17
815.....	40	41	1.00	0.66
816.....	41	42	1.00	0.17
817.....	42	43	1.00	0.17
818.....	43	44	0.92	0.17
819.....	44	45	0.92	0.17
820.....	45	46	0.92	0.17
821.....	46	47	0.92	0.17
822.....	47	48	0.92	0.17
823.....	48	49	0.96	0.17

Serial number	From	To	Width, feet	Gold, g/ton
DRILL HOLE NO. 10--Continued				
824.....	49	50	1.00	7.96
825.....	50	51	1.00	1.33
826.....	51	52	1.00	0.66
827.....	52	53	1.00	1.00
828.....	53	54	1.00	2.99
829.....	54	55	1.00	14.76
830.....	55	56	1.00	5.31
831.....	56	57	0.92	2.82
832.....	57	58	1.00	30.11
833.....	58	59	1.00	5.47
834.....	59	60	0.92	3.98
835.....	60	61	1.00	1.00
836.....	61	62	1.00	0.17
837.....	62	63	1.00	2.32
838.....	63	64	0.92	0.66
839.....	64	65	0.92	3.32
840.....	65	66	1.00	0.50
841.....	66	67	1.00	2.32
842.....	67	68	1.00	0.66
843.....	68	69	1.00	1.33
844.....	69	70	1.00	12.27
845.....	70	71	0.92	10.62
846.....	71	72	0.83	4.31
847.....	72	73	0.92	10.62
848.....	73	74	0.92	4.64
849.....	74	75	1.00	0.66
850.....	75	76	1.00	0.17
851.....	76	77	1.00	0.66
852.....	77	78	1.00	0.17
853.....	78	79	1.00	0.17
854.....	79	80	1.00	0.66
855.....	80	81	1.00	0.66
856.....	81	82	1.00	0.17
857.....	82	83	1.00	0.17
858.....	83	84	1.00	0.66
DRILL HOLE NO. 11				
859.....	0	1	0.83	0.66
860.....	1	2	0.83	0.66
861.....	2	3	0.83	0.17
862.....	3	4	0.83	1.00
863.....	4	5	1.00	0.17
864.....	5	6	1.00	0.66
865.....	6	7	1.00	0.17
866.....	7	8	1.00	0.17
867.....	8	9	0.96	0.17
868.....	9	10	1.00	0.17

Serial number	From	To	Width, feet	Gold, g/ton
DRILL HOLE NO. 12				
869.....	0	1	1.00	2.99
870.....	1	2	0.92	2.32
871.....	2	3	1.00	1.33
872.....	3	4	1.00	2.32
873.....	4	5	1.00	1.00
874.....	5	6	1.00	3.32
875.....	6	7	0.83	3.98
876.....	7	8	0.83	0.33
877.....	8	9	1.00	0.33
878.....	9	10	1.00	0.66
879.....	10	11	1.00	2.32
880.....	11	12	1.00	1.99
881.....	12	13	1.00	1.00
882.....	13	14	1.00	0.33
883.....	14	15	1.00	1.00
884.....	15	16	1.00	1.33
885.....	16	17	0.92	0.33
886.....	17	18	0.92	1.33
887.....	18	19	0.92	0.33
888.....	19	20	0.83	0.17
889.....	20	21	0.83	0.17
890.....	21	22	0.83	0.17
891.....	22	23	0.83	0.33
892.....	23	24	0.83	0.33
893.....	24	25	0.83	0.17
894.....	25	26	1.00	1.33
895.....	26	27	1.00	0.17
896.....	27	28	1.00	0.17
897.....	28	29	1.00	0.33
898.....	29	30	1.00	0.33
899.....	30	31	1.00	1.00
900.....	31	32	1.00	0.17