C U R R A G H   R E S O U R C E S   I N C

INTER-OFFICE MEMORANDUM

FARO MINE SITE

DATE: July 10, 1991

TO: Wm. W. Dunn
Chief Engineer

FROM: Dave Tenney
Chief Geologist

SUBJECT: TO DATE SUMMARY OF MINE/MILL GRADE DISCREPANCY

The attached three memo's investigate the difference between geology predicted mill head grade based on stockpile grade estimates, and the reported mill head grade measured at the lead rougher feed. They form a part of an ongoing study into dilution and grade estimation errors. It has been noted that the mill head grade is higher than expected when ore from the medium grade stockpile is fed to the mill, but lower than expected when Faro (high grade) B stockpile, Faro underground, and Vangorda ore is fed. The biggest problem appears to be with overestimation of the grade of the underground stockpile.

The attached three memos analyze conditions during three separate periods of time. The aim is to discover what factors must be applied to the grades of various stockpiles, (by the use of multiple regression analysis) to calculate the reported mill head grade. These factors represent the effects of a combination of actual (as opposed to "apparent") dilution and grade estimation errors: underestimation in the case of the medium grade stockpile and overestimation in the case of all other stockpiles . In order to have some confidence in the results the three periods of time are chosen to cover different blend characteristics in the mill feed.

1) June 1st - July 31/90:

Feed is from Faro Pit (high grade "B" and medium grade stockpiles) and Faro underground. No ore from Vangorda was milled during this period.

2) September 1 - 30/90:

The feed comprised mainly Faro "B" (high grade) stockpile and Faro underground ore. For a large part of the month no medium grade ore was fed, and no Vangorda ore was treated at any time.

3) December 1st/90 - March 24/91:

Mill feed came from all available sources: Faro B, medium, underground stockpiles, and Vangorda.

Results - Medium Grade Stockpile:

Grade factors vary from 0.944 to 1.602 (see attached) and with one exception are all greater than 1.0. As there is no physical means by which our medium grade ore could increase in grade between the time it is mined and the time it reaches the mill, the problem must be one of grade under estimation. (This could be largely avoided if grades were "Kriged". To do this we would need to buy "Ore Control"). The very high factors for September 1st-30th/90 for both lead and zinc are not as valid as those for the other two periods studied, as for much of the month no medium grade ore was treated. Dagbert in his report and geostatistical evaluation of the Faro Pit (P.55) also notes that the grade of medium grade (and low grade) ore is underestimated using our present polygonal calculation method. Cumulative sum curves for September 1990 showing stockpile proportions in mill feed against grade loss support the contention that medium grade ore is undergraded: grade losses decrease when medium grade ore is being treated, and increase when higher grade stockpiles (particularly the U/G) are being treated.

Results - Faro High Grade (B) Stockpile:

Regression factors vary from 0.85 to 0.96, and are all less than 1.0, indicating some degree of grade loss or grade overestimation at all times. The extent to which grade factors (i.e. correlation coefficients) for lead and zinc differ may be an indication of actual physical dilution which is taking place.

Results - Faro Underground

Regression factors vary from 0.74 to 0.892. They are consistently smaller than those for any other ore source which indicates substantially greater grade overestimation of the Faro U/G stockpile. Physical dilution with waste as well as overgrading which traditionally accompanies polygonal calculation methods are at the root of the problem. Sampling bias may also be important.
Cumulative sum curves also indicate increasing grade discrepancies when Faro U/G ore is fed to the mill (see: July 19-31/90; September 26-30/90).

Results - Vangorda Stockpile:

The regression coefficients (i.e. grade factors) for the period studied, December 1/90 to March 24/91 were 0.91 for lead and 0.93 for zinc. These factors are higher (better) than those for the Faro high grade and U/G stockpiles. This tends to suggest that ore grades have been assigned more or less correctly but that there has been a small amount of physical dilution.

Conclusions:

It would be an assumption to use multiple correlation factors as strict indicators of grade estimation errors or of dilution. However, it is safe to conclude that the medium grade stockpile is being systematically undergraded, and all other ore sources, particularly the Faro U/G, overgraded to some degree. All errors result from a combination of effects derived from the calculation methods themselves and from actual physical dilution.

Recommendations:

1) The undervaluation of ores in the medium grade range indicates that physical dilution is not a significant problem. Ore grading errors which result from intrinsic problems with the (polygonal) calculation process may only be remedied by using Kriging. This can only reasonably be done in a production environment by the purchase and use of Gemcom´s "Ore Control" system. An AFE to purchase this system and the associated hardware is already in Toronto. It should be noted that Kriging will reduce the quantity of medium grade ore mistakenly undervalued and sent to the low grade stockpile.

2) The overvaluation of stockpile grades in the higher grade ranges will to some extent be alleviated by the use of Kriging, as noted above. In the case of Faro underground stockpile grades, the unconvential method of grade calculation needs verifying. The cheapest way of doing this would be with a muck sampling programme. At considerable expense a tower sampler could also be used.

D. Tenney.

Dave Tenney
Chief Geologist

DT:cc

cc: K. Ball
D. Basso
E. Beaumont
J. Hendry
J. Hogg
L. Hwozdyk
J. Vandenbroeck
G. Vos
G. Wilson
Geology Dept.

GRADE FACTORS

(MULTIPLE REGRESSION COEFFICIENTS)

Stockpile	June 1-July 31/90		Sept. 1-30/90		Dec 1/90- Mar 24/90	
	Pb	Zn	Pb	Zn	Pb	Zn
Faro Medium	0.944	1.168	1.356	1.602	1.15	1.19
Faro High Grade	0.925	0.953	0.960	0.915	0.85	0.86
Faro U/G	0.892	0.837	0.824	0.890	0.78	0.74
Vangorda	-	-	-	-	0.91	0.93
Correlation Coefficent *	0.964	0.967	0.993	0.998	0.983	0.982

* These correlation coefficents are very high indicating a high degree of statistical confidence in the results.

C U R R A G H   R E S O U R C E S   I N C

INTER-OFFICE MEMORANDUM

FARO MINE SITE

DATE: June 18, 1991

TO: Wm. W. Dunn
Chief Engineer

FROM: Dave Tenney
Chief Geologist

SUBJECT: MINE-MILL GRADE DISCREPANCY - SEPTEMBER 1990

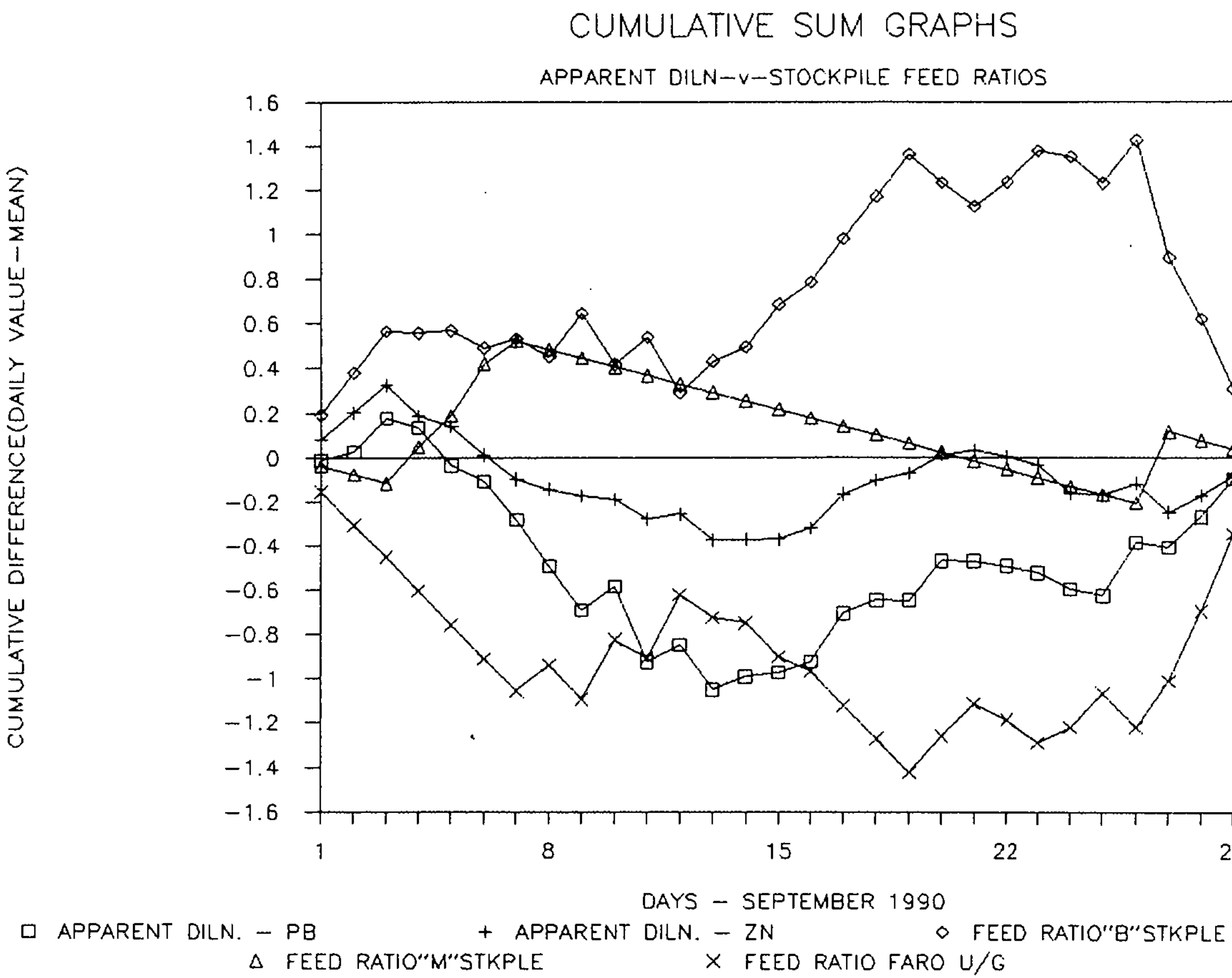
This study was done using the month of September 1990, when there was a significant amount of underground ore in the mill feed and relatively small amounts of medium grade ore. As usual most feed came from the Faro "B" high grade stockpile. Cumulative sum graphs and multiple linear regression are used to determine the relationship between stockpile blends and grades, and mill head grade (see attached).

Cumulative Sum Graphs:

September 1 -12: Trend of less than average grade loss (apparent dilution)with mainly a steady feed from the "B" high grade stockpile, and for a few days (3rd - 7th) an increased proportion of "M" medium grade stockpile in the mill feed.

September 13-25: No medium grade stockpile in blend, mainly "B" stockpile with minor variable proportions of underground ore. There is higher than average lead grade apparent dilution. Zinc grade apparent dilution follows the lead curve very closely possibly indicating that actual physical dilution is responsible, rather than grade estimation errors.

September 26-30: During the last five days of the month substantial quantities of underground ore were blended with almost exclusively "B" stockpile. This produced a rapid increase in the lead grade loss (see steeper slope of Qsum curve for lead apparent dilution) indicating that grade losses increase more when a greater proportion of underground ore is fed to the mill than when the proportion of "B" high grade stockpile in the blend is increased. No medium grade ore was fed for the last four days of the month. Our current practice of blending medium


CUMULATIVE SUM GRAPHS
APPARENT DILN—v—STOCKPILE FEED RATIOS
CUMULATIVE DIFFERENCE(DAILY VALUE—MEAN)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
−1.2
−1.4
−1.6
1
8
15
22
29
DAYS — SEPTEMBER 1990
APPARENT DILN. — PB
APPARENT DILN. — ZN
FEED RATIO"B"STKPLE
FEED RATIO"M"STKPLE
FEED RATIO FARO U/G

and underground ore together will tend to cancel out the opposite effects noted when they are fed independently. When medium grade ore is fed to the mill there is a tendency for the grade loss to diminish, and when underground ore is fed there is a tendency for it to increase.

Multiple Linear Regression September 1-30:

The same base data used to derive the cumulative sum graphs discussed above was also used to derive multiple regression coefficients for the grades of the stockpiles. These grades were weighted by the ratio of the stockpile tonnage to total feed tonnage for the day. The resulting regression coefficients would thus represent a "grade factor" which in practice it may be possible to apply to stockpile grades to estimate mill head grade. From grade factors it is possible to calculate an apparent external dilution. The regression coefficients obtained for lead and zinc grades are as follows:

Stockpile	Lead Regression Coeff.	Zinc Regression Coeff.
Faro Underground	0.824	0.890
"B" Faro High Grade	0.960	0.915
"M" Faro Medium Grade	1.356	1.602
Multiple Corr. Coeff.	0.993	0.998

Although actual values differ from previous estimates, they are in the same relative order of magnitude. These data are considered good for the "B" stockpile and underground ore, but not so good for medium grade ore as much less than usual was blended into the mill feed during this month. This probably accounts for the relatively high medium stockpile regression coefficients for lead and zinc (1.356 and 1.602 respectively)

Conclusions:

This analysis tends to confirm earlier work indicating:

1. Medium grade ore is undergraded (regression coefficient > 1.0)
2. Underground ore leads to larger mine/mill grade discrepancies than the high grade "B" stockpile.

D. Tenney.

Dave Tenney
Chief Geologist

DT:cc

USGS STATPAC

WARNING:...WHEN THE EQUATION IS FORCED THRU THE ORIGIN
ALL STD DEVIATIONS AND CORRELATIONS ARE COMPUTED ABOUT
THE ORIGIN RATHER THAN THE MEAN

NUMBER OF SELECTED VARIABLES = 4

SELECTED VARIABLE INDICES

1	2	3	4

SELECTED VARIABLE IDENTIFIERS

MILL%PB	"B"RATIO	"M"RATIO	U/GRATIO

PROBABILITY LEVEL = 1.000

MEANS OF SELECTED VARIABLES
2.98733E+00 2.40200E+00 9.36667E-02 6.47000E-01
STANDARD DEVIATIONS OF SELECTED VARIABLES
3.00533E+00 2.49909E+00 2.41544E-01 1.01297E+00
CORRELATION MATRIX

ROW NUMBER 1	1.0000	.9542	.4152	.6415
ROW NUMBER 2	.9542	1.0000	.3257	.4329
ROW NUMBER 3	.4152	.3257	1.0000	.1664
ROW NUMBER 4	.6415	.4329	.1664	1.0000

VARIABLE 2 ("B"RATIO) ADDED. F = .305249E+03 DEG OF FR = 29 Q COMPUTED = .000000E+00

VARIABLE 4 (U/GRATIO) ADDED. F = .738082E+02 DEG OF FR = 28 Q COMPUTED = .000000E+00

VARIABLE 3 ("M"RATIO) ADDED. F = .202709E+02 DEG OF FR = 27 Q COMPUTED = .107944E-03

REGRESSION CONSTANT AND COEFFICIENTS IN THE ORDER OF VARIABLE NO.
0.00000E+00 9.60239E-01 1.35550E+00 8.24098E-01

MULTIPLE CORRELATION COEFFICIENT = .9926521 F VALUE FOR 3 AND 27 DEG OF FR = 605.678
THE PROBABILITY OF THIS F IS : .000

WTD SUM OF RESIDUALS SQUARED = .3967342E+01

PARTIAL CORRELATION COEFFICIENTS
.98496 .64803 .90030

REGRESSION WEIGHTS
7.98490E-01 1.08944E-01 2.77768E-01

STANDARD ERRORS OF REGRESSION WEIGHTS
2.69538E-02 2.46412E-02 2.58440E-02

STANDARD ERRORS OF REGRESSION CONSTANT AND REGRESSION COEFFICIENTS
0.00000E+00 3.24138E-02 3.06590E-01 7.66754E-02

STANDARD ERROR OF THE ESTIMATE OF THE DEPENDENT VARIABLE = 3.8333E-01

PERCENT OF TOTAL SUMS OF SQUARES OF DEPENDENT VARIABLE EXPLAINED = 98.536

REGRESSION ANALYSIS

USGS STATPAC

WARNING...WHEN THE EQUATION IS FORCED THRU THE ORIGIN
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THE ORIGIN RATHER THAN THE MEAN

NUMBER OF SELECTED VARIABLES = 4

SELECTED VARIABLE INDICES

1	2	3	4

SELECTED VARIABLE IDENTIFIERS

MILL%ZN	"B"RATIO	"M"RATIO	U/GRATIO

PROBABILITY LEVEL = 1.000

MEANS OF SELECTED VARIABLES

5.16033E+00 4.43533E+00 1.44000E-01 9.69000E-01

STANDARD DEVIATIONS OF SELECTED VARIABLES

5.16713E+00 4.57776E+00 3.69522E-01 1.51403E+00

CORRELATION MATRIX

ROW NUMBER 1

1.0000	.9638	.4012	.6465

ROW NUMBER 2

.9638	1.0000	.3026	.4532

ROW NUMBER 3

.4012	.3026	1.0000	.1586

ROW NUMBER 4

.6465	.4532	.1586	1.0000

VARIABLE 2 ("B"RATIO) ADDED. F = .391652E+03 DEG OF FR = 29 Q COMPUTED = .596046E-07

VARIABLE 4 (U/GRATIO) ADDED. F = .101923E+03 DEG OF FR = 28 Q COMPUTED = -.119209E-06

VARIABLE 3 ("M"RATIO) ADDED. F = .865994E+02 DEG OF FR = 27 Q COMPUTED = .000000E+00

REGRESSION CONSTANT AND COEFFICIENTS IN THE ORDER OF VARIABLE NO.

0.00000E+00 9.15269E-01 1.60153E+00 8.90487E-01

MULTIPLE CORRELATION COEFFICIENT = .9980729 F VALUE FOR 3 AND 27 DEG OF FR = 2328.347
THE PROBABILITY OF THIS F IS : .000

WTD SUM OF RESIDUALS SQUARED = .3084177E+01

PARTIAL CORRELATION COEFFICIENTS

.99607	.86929	.96619

REGRESSION WEIGHTS

9.10874E-01 1.14532E-01 2.60923E-01

STANDARD ERRORS OF REGRESSION WEIGHTS

1.38620E-02 1.25333E-02 1.34009E-02

STANDARD ERRORS OF REGRESSION CONSTANT AND REGRESSION COEFFICIENTS

0.00000E+00 1.56692E-02 1.75256E-01 4.57349E-02

STANDARD ERROR OF THE ESTIMATE OF THE DEPENDENT VARIABLE = 3.3798E-01

PERCENT OF TOTAL SUMS OF SQUARES OF DEPENDENT VARIABLE EXPLAINED = 99.615

C U R R A G H   R E S O U R C E S   I N C

INTER-OFFICE MEMORANDUM

FARO MINE SITE

DATE: June 18, 1991

TO: Wm. W. Dunn
Chief Engineer

FROM: Dave Tenney
Chief Geologist

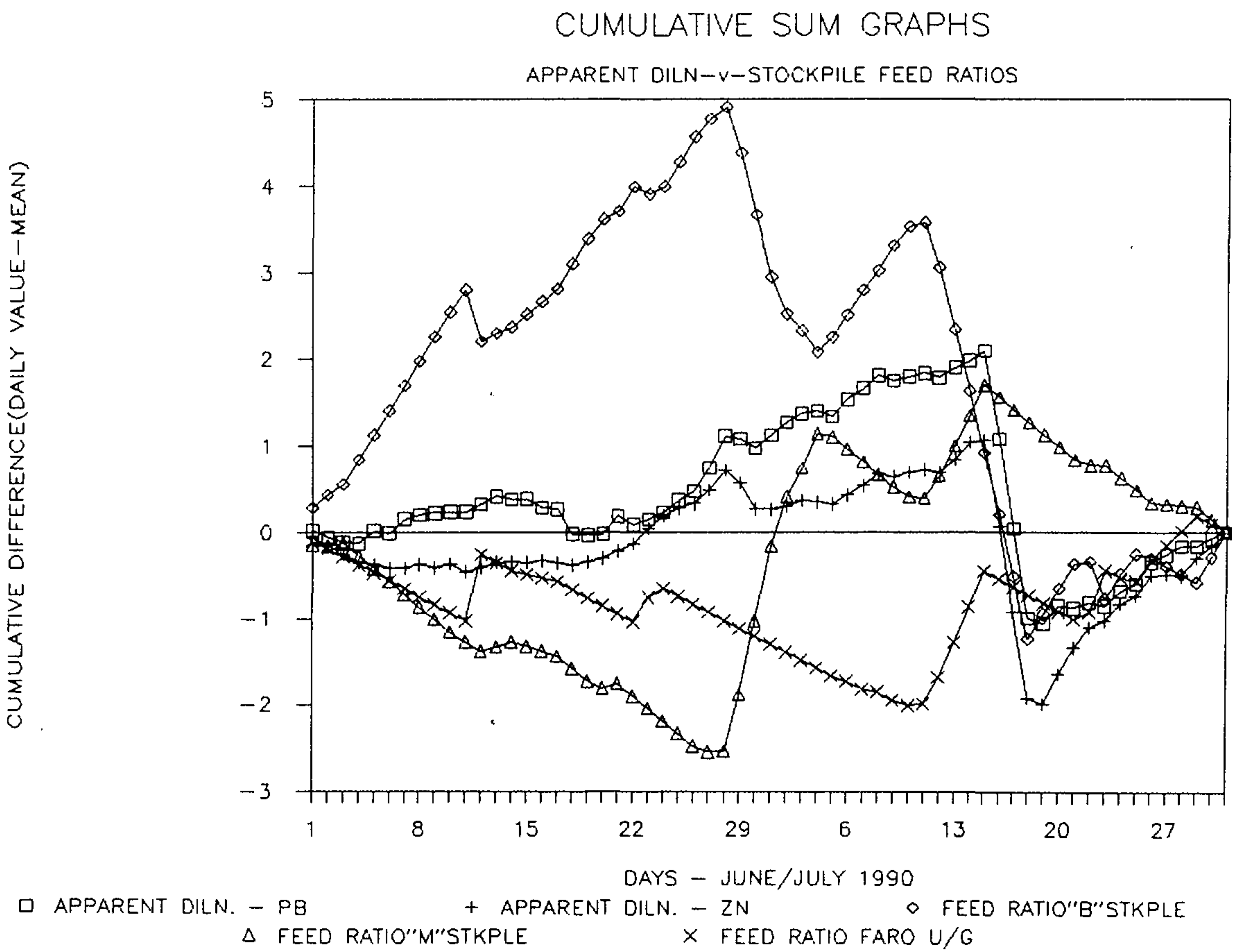
SUBJECT: NOTE ON MINE-MILL GRADE DIFFERENCES

Previous work has suggested that the mine mill grade difference (apparent dilution) drops when the medium grade stockpile is used as mill feed, and increases when Faro "B" high grade stockpile is fed. Preliminary conclusions for Vangorda mill feed and Faro underground feed is that both can at times increase the grade differential (i.e. the apparent dilution).

The attached cumulative sum graph is for the months of June and July 1990 when only Faro ore was being fed to the crusher. It shows mill feed ratios, based on tonnage, for the Faro high grade, medium and underground stockpiles. These curves should be compared with the apparent dilution (grade lóss) curves for lead and zinc, which as expected mimic each other.

June 1 - July 11:
Trend is for generally above average content of "B" (high grade) stockpile in the mill feed, accompanied by higher than average apparent dilution (grade loss) for both lead and zinc. Mill head grades did not react favourably to the increasing content of medium "M" stockpile in the mill feed from June 28 to July 4 (except possibly zinc).

July 11 - July 18:
This is a critical period when the proportion of "B" high grade Faro stockpile ore in the mill feed is below average. It coincides with a marked drop in grade difference (apparent dilution) for both lead and zinc.


CUMULATIVE SUM GRAPHS
APPARENT DILN—v—STOCKPILE FEED RATIOS
CUMULATIVE DIFFERENCE(DAILY VALUE—MEAN)
5
4
3
2
1
0
−1
−2
−3
1
8
15
22
29
6
13
20
27
DAYS — JUNE/JULY 1990
APPARENT DILN. — PB
APPARENT DILN. — ZN
FEED RATIO"B"STKPLE
FEED RATIO"M"STKPLE
FEED RATIO FARO U/G

July 19 - July 31:

Grade difference between mine and mill is increasing with increasing content of Faro "B" high grade stockpile and Faro underground ore in the mill feed. The content of Faro "M" medium grade stockpile in the feed is below average.

Multiple Linear Regression - (June 1 - July 31)

Multiple linear regression of mill head lead and zinc grades against stockpile lead and zinc grades (weighted by tonnage) gave results in agreement with earlier studies, and confirmed that the higher the predicted mine grade the larger would be the differential (loss) at the mill head. The multiple regression coefficients in the following table are an indication of the size of the loss (or gain, if the regression coefficient is greater than 1). They are also an unreliable measure of the apparent dilution.

Stockpile	Multiple Regression Coefficients	
	Pb	Zn
Faro Underground	0.892	0.837
Faro "B" (High Grade)	0.925	0.953
Faro "M" (Medium Grade)	0.944	1.168
Multiple Corr. Coeff.	0.964	0.967

The regression coefficient for lead in the medium grade stockpile is less than one. Otherwise the data is in good agreement with earlier results. The relative magnitude of the regression coefficients is always in the same increasing order shown above. Higher regression coefficients indicate lower mine/mill grade differentials and lower apparent dilution. Dilution cannot explain a coefficient greater than one, as this would be equivalent to negative dilution, or a gain in grade at the mill head. If geological grade estimates were not understated (or mill heads overstated) this situation would be impossible.

Conclusions:

This work confirms earlier studies which indicated that the mill never reaches the higher grade levels predicted when high grade ore is fed. By contrast when lower than average grade ore, the medium grade stockpile for instance, is fed to the mill, mill head grade does not drop to the expected level. This is a reflection of two factors:

1. In geology grade calculations higher grades are overestimated, and lower grades are underestimated (Dagbert report p.55)
2. There is always some mixing of ore in the crushing/grinding circuit so that changes in stockpile blend are never immediately reflected in the mill head grades. The mill smooths out grade changes in the mill feed.

We shall continue to monitor the difference between blasthole predicted mill head grade and the assayed lead rougher feed (mill head) grade as a means of determining whether or not the steps we have taken to reduce external dilution have been effective. I note that during March the mine/mill grade differential dropped to 0.47% Pb + Zn, down from over 1.0% in January and February, which seems to indicate that the steps taken in late February have indeed been effective.

D. Tenney

Dave Tenney
Chief Geologist

DT:cc

REGRESSION ANALYSIS

USGS STATPAC

WARNING...WHEN THE EQUATION IS FORCED THRU THE ORIGIN
ALL STD DEVIATIONS AND CORRELATIONS ARE COMPUTED ABOUT
THE ORIGIN RATHER THAN THE MEAN

NUMBER OF SELECTED VARIABLES = 4

SELECTED VARIABLE INDICES

1	2	3	4

SELECTED VARIABLE IDENTIFIERS

MILL%PB	"B"RATIO	"M"RATIO	U/GRATIO

PROBABILITY LEVEL = 1.000

MEANS OF SELECTED VARIABLES
3.01312E+00 2.33803E+00 3.47541E-01 3.84754E-01
STANDARD DEVIATIONS OF SELECTED VARIABLES
3.02654E+00 2.61799E+00 7.03742E-01 8.37581E-01
CORRELATION MATRIX

ROW NUMBER 1	1.0000	.8919	.4527	.4726
ROW NUMBER 2	.8919	1.0000	.1960	.1974
ROW NUMBER 3	.4527	.1960	1.0000	.3093
ROW NUMBER 4	.4726	.1974	.3093	1.0000

VARIABLE 2 ("B"RATIO) ADDED. F = .237337E+03 DEG OF FR = 60 Q COMPUTED = .000000E+00

VARIABLE 4 (U/GRATIO) ADDED. F = .485890E+02 DEG OF FR = 59 Q COMPUTED = .596046E-07

VARIABLE 3 ("M"RATIO) ADDED. F = .357920E+02 DEG OF FR = 58 Q COMPUTED = .596046E-07

REGRESSION CONSTANT AND COEFFICIENTS IN THE ORDER OF VARIABLE NO.
0.00000E+00 9.25075E-01 9.44003E-01 8.91538E-01

MULTIPLE CORRELATION COEFFICIENT = .9642000 F VALUE FOR 3 AND 58 DEG OF FR = 255.607
THE PROBABILITY OF THIS F IS : .000

WTD SUM OF RESIDUALS SQUARED = .3929087E+02

PARTIAL CORRELATION COEFFICIENTS
.94630 .61448 .65860

REGRESSION WEIGHTS
8.00199E-01 2.19503E-01 2.46729E-01

STANDARD ERRORS OF REGRESSION WEIGHTS
3.58962E-02 3.70049E-02 3.70155E-02

STANDARD ERRORS OF REGRESSION CONSTANT AND REGRESSION COEFFICIENTS
0.00000E+00 4.14981E-02 1.59145E-01 1.33753E-01

STANDARD ERROR OF THE ESTIMATE OF THE DEPENDENT VARIABLE = 8.2306E-01

PERCENT OF TOTAL SUMS OF SQUARES OF DEPENDENT VARIABLE EXPLAINED = 92.968

REGRESSION ANALYSIS

USGS STATPAC

WARNING...WHEN THE EQUATION IS FORCED THRU THE ORIGIN
ALL STD DEVIATIONS AND CORRELATIONS ARE COMPUTED ABOUT
THE ORIGIN RATHER THAN THE MEAN

NUMBER OF SELECTED VARIABLES = 4

SELECTED VARIABLE INDICES

1 2 3 4

SELECTED VARIABLE IDENTIFIERS

MILLYR ZN 'B'%ZN#f 'M'%ZN#f U/6%ZN#f

PROBABILITY LEVEL = 1.000

MEANS OF SELECTED VARIABLES

5.12869E+00 3.95443E+00 5.00820E-01 5.81639E-01

STANDARD DEVIATIONS OF SELECTED VARIABLES

5.15132E+00 4.42276E+00 9.96827E-01 1.27662E+00

CORRELATION MATRIX

ROW NUMBER 1

1.0000 .9035 .4633 .4433

ROW NUMBER 2

.9035 1.0000 .2014 .1919

ROW NUMBER 3

.4633 .2014 1.0000 .3492

ROW NUMBER 4

.4433 .1919 .3492 1.0000

VARIABLE 2 ('B'%ZN#f) ADDED. F = .271166E+03 DEG OF FR = 60 Q COMPUTED = .000000E+00

VARIABLE 3 ('M'%ZN#f) ADDED. F = .489137E+02 DEG OF FR = 59 Q COMPUTED = .238419E-06

VARIABLE 4 (U/6%ZN#f) ADDED. F = .341582E+02 DEG OF FR = 58 Q COMPUTED = .596046E-07

REGRESSION CONSTANT AND COEFFICIENTS IN THE ORDER OF VARIABLE NO.

0.00000E+00 9.52975E-01 1.16828E+00 8.36750E-01

MULTIPLE CORRELATION COEFFICIENT = .9674333 F VALUE FOR 3 AND 58 DEG OF FR = 282.406
THE PROBABILITY OF THIS F IS : .000

WTD SUM OF RESIDUALS SQUARED = .1037150E+03

PARTIAL CORRELATION COEFFICIENTS

.95280 .63772 .60553

REGRESSION WEIGHTS

8.18195E-01 2.26073E-01 2.07366E-01

STANDARD ERRORS OF REGRESSION WEIGHTS

3.42342E-02 3.58553E-02 3.57852E-02

STANDARD ERRORS OF REGRESSION CONSTANT AND REGRESSION COEFFICIENTS

0.00000E+00 3.98735E-02 1.85290E-01 1.44398E-01

STANDARD ERROR OF THE ESTIMATE OF THE DEPENDENT VARIABLE = 1.3372E+00

PERCENT OF TOTAL SUMS OF SQUARES OF DEPENDENT VARIABLE EXPLAINED = 93.593

C U R R A G H   R E S O U R C E S   I N C

INTER-OFFICE MEMORANDUM

DATE: June 18, 1991

TO: Wm. W. Dunn
Chief Engineer

FROM: Dave Tenney
Chief Geologist

SUBJECT: APPARENT DILUTION IN CRUSHER STOCKPILES

An estimate of the factors required to correct stockpile grades to mill head grade can be obtained by regressing daily mill head grade against estimated stockpile feed grades weighted by proportion of that stockpile in the feed. If stockpile grade estimates were perfect:

Mill Head Grade = $\sum$ stockpile grade * stockpile proportion in feed.
= $\sum G*P$

However, in practice, grade estimates contain no allowance for dilution, and because of the polygonal calculation used, are overstated for high grade stockpiles and understated for medium and low grade stockpiles. A correction factor "F" to allow for dilution and grade estimation errors (i.e. apparent dilution) is required. If:

F = grade correction factor
G = grade
b = high grade stockpile
m = medium grade stockpile
v = Vangorda stockpile
u = Underground stockpile
P = stockpile proportion in millfeed for day

then millhead grade = $F_b*P_b*G_b + F_m*P_m*G_m + F_v*P_v*G_v + F_u*P_u*G_u$

The estimated grades of the stockpiles and their proportional contribution to the millhead grade are known from daily production statistics, as is the millhead grade itself. "F" can be statistically derived from multiple regression. This was done for the period December 1/90 to March 24/91 using both lead and zinc grades. Results were, for the most part in startling conformity with our own expectations and also relevant parts of the report on grade estimation by Dr. Dagbert. (p.55). The correction factors for stockpile lead and zinc grades are shown below, along with the equivalent apparent dilution: (see appendices I and II)

	Zn Factors	* App Dil. %	Pb Factors	* App. Dil. %
"B" (High Grade) Stockpile - F_b	0.86	(16%)	0.85	(18%)
"M" (Med Grade) Stockpile - F_m	1.19	(-ve)	1.15	(-ve)
"V" (Plateau) Vangorda Stockpile - F_v	0.93	(8%)	0.91	(10%)
"U" Faro U/G Stockpile - F_u	0.74	(33%)	0.78	(28%)

* calculation assumes dilution with zero grade

Conclusions:

1) The grade of the medium grade stockpile is understated.
2) High grade stockpile grades are overstated, the largest overstatement being in the highest grade of the high grade stockpiles (i.e. the underground stockpile).

Comments:

Owing to the way stockpiles are blended some mixing must occur in the crushing/grinding circuit. When higher grade is added to the crusher mixing with (lower grade) material already in the mill circuit will prevent head grades from reaching the expected levels unless the new high grade blend is continued for an extended period of time. In other words the assayed mill head grade does not immediately reflect the contribution of the new higher grade material fed to the crusher. In this situation the multiple regression factor "F" which will be calculated for the highest grade stockpile (i.e. Faro U/G) will <u>overstate</u> the expected grade loss (i.e. the factor will be too small because the millhead grade is smoothed around a mean value.) A similar argument can be made in reverse to conclude that any stockpile with a grade below the average mill head grade will have a grade correction factor which <u>understates</u> the expected grade loss (or overstates the expected grade gain.)

The further a stockpile grade is from the average mill head grade the greater the distortion there is likely to be in grade factors derived from multiple regression. This is a direct result of the mixing which occurs in the grinding/crushing circuit, which tends to smooth out variations in head grade.

Caution:

These results are statistically valid for conditions during the period tested only - their applicability to future stockpile grade estimates will be examined in the coming weeks. They do, however, indicate "orders of magnitude", and for that reason a check to verify the grade of the underground ore should be made.

D. Tenney.

Dave Tenney
Chief Geologist

DT:cc
cc: I. Bilquist L. Hwozdyk B. Pisony

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 WARNING...WHEN THE EQUATION IS FORCED THRU THE ORIGIN
ALL STD DEVIATIONS AND CORRELATIONS ARE COMPUTED ABOUT
THE ORIGIN RATHER THAN THE MEAN



NUMBER OF SELECTED VARIABLES   =    5

SELECTED VARIABLE INDICES
     1           2           3           4           5
SELECTED VARIABLE IDENTIFIERS
 MIL%PB      'B'%PB*T    'M'%PB*T    VAN*PB*T    U/6%PB*T

PROBABILITY LEVEL =   1.000


MEANS OF SELECTED VARIABLES
 3.05965E+00  1.28254E+00  4.60614E-01  1.09982E+00  4.71754E-01
STANDARD DEVIATIONS OF SELECTED VARIABLES
 3.08790E+00  1.74478E+00  7.23335E-01  1.50510E+00  8.39469E-01
CORRELATION MATRIX
ROW NUMBER   1
     1.0000       .6980       .6061       .7773       .5890
ROW NUMBER   2
      .6980      1.0000       .1944       .3113       .1295
ROW NUMBER   3
      .6061       .1944      1.0000       .3399       .4408
ROW NUMBER   4
      .7773       .3113       .3399      1.0000       .4420
ROW NUMBER   5
      .5890       .1295       .4408       .4420      1.0000

VARIABLE  4 (VAN*PB*T) ADDED.    F =    .174047E+03 DEG OF FR =   113  Q COMPUTED =     .000000E+00

VARIABLE  2 ('B'%PB*T) ADDED.    F =    .157210E+03 DEG OF FR =   112  Q COMPUTED =     .119209E-06

VARIABLE  3 ('M'%PB*T) ADDED.    F =    .174614E+03 DEG OF FR =   111  Q COMPUTED =     .596046E-07

VARIABLE  5 (U/6%PB*T) ADDED.    F =    .109039E+03 DEG OF FR =   110  Q COMPUTED =     .000000E+00

REGRESSION CONSTANT AND COEFFICIENTS IN THE ORDER OF VARIABLE NO.
 0.00000E+00  8.50449E-01  1.14627E+00  9.05201E-01  7.82838E-01

MULTIPLE CORRELATION COEFFICIENT =    .9835517   F VALUE FOR    4 AND   110 DEG OF FR =     815.387
THE PROBABILITY OF THIS F IS :    .000

WTD SUM OF RESIDUALS SQUARED =   .3546460E+02

PARTIAL CORRELATION COEFFICIENTS
      .92914      .79368      .90154      .70395

REGRESSION WEIGHTS
 4.80534E-01  2.68512E-01  4.42385E-01  2.12820E-01

STANDARD ERRORS OF REGRESSION WEIGHTS
 1.32322E-02  1.96228E-02  2.02446E-02  2.04733E-02

STANDARD ERRORS OF REGRESSION CONSTANT AND REGRESSION COEFFICIENTS
 0.00000E+00  3.22673E-02  8.37691E-02  4.14242E-02  7.53091E-02

STANDARD ERROR OF THE ESTIMATE OF THE DEPENDENT VARIABLE =   5.6781E-01
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WARNING...WHEN THE EQUATION IS FORCED THRU THE ORIGIN
ALL STD DEVIATIONS AND CORRELATIONS ARE COMPUTED ABOUT
THE ORIGIN RATHER THAN THE MEAN

NUMBER OF SELECTED VARIABLES = 5

SELECTED VARIABLE INDICES

1	2	3	4	5

SELECTED VARIABLE IDENTIFIERS

MILL%ZN	'B'%ZN*T	'M'%ZN*T	VAN%ZN*T	U/6%ZN*T

PROBABILITY LEVEL = 1.000

MEANS OF SELECTED VARIABLES

4.65342E+00 2.21658E+00 7.79298E-01 1.24368E+00 7.06842E-01

STANDARD DEVIATIONS OF SELECTED VARIABLES

4.67517E+00 3.00295E+00 1.21990E+00 1.72894E+00 1.26001E+00

CORRELATION MATRIX

ROW NUMBER 1	1.0000	.7450	.6265	.7082	.5631
ROW NUMBER 2	.7450	1.0000	.1966	.3106	.1289
ROW NUMBER 3	.6265	.1966	1.0000	.3367	.4503
ROW NUMBER 4	.7082	.3106	.3367	1.0000	.4319
ROW NUMBER 5	.5631	.1289	.4503	.4319	1.0000

VARIABLE 2 ('B'%ZN*T) ADDED. F = .142228E+03 DEG OF FR = 113 Q COMPUTED = .000000E+00

VARIABLE 4 (VAN%ZN*T) ADDED. F = .147152E+03 DEG OF FR = 112 Q COMPUTED = .000000E+00

VARIABLE 3 ('M'%ZN*T) ADDED. F = .217612E+03 DEG OF FR = 111 Q COMPUTED = .000000E+00

VARIABLE 5 (U/6%ZN*T) ADDED. F = .891920E+02 DEG OF FR = 110 Q COMPUTED = .000000E+00

REGRESSION CONSTANT AND COEFFICIENTS IN THE ORDER OF VARIABLE NO.

0.00000E+00 8.57353E-01 1.19006E+00 [illegible].32432E-01 7.54744E-01

MULTIPLE CORRELATION COEFFICIENT = .9816262 F VALUE FOR 4 AND 110 DEG OF FR = 727.786
THE PROBABILITY OF THIS F IS : .000

WTD SUM OF RESIDUALS SQUARED = .9072388E+02

PARTIAL CORRELATION COEFFICIENTS

.93892 .81782 .83983 .66748

REGRESSION WEIGHTS

5.50695E-01 3.10526E-01 3.44824E-01 2.03412E-01

STANDARD ERRORS OF REGRESSION WEIGHTS

1.92625E-02 2.08341E-02 2.12515E-02 2.16361E-02

STANDARD ERRORS OF REGRESSION CONSTANT AND REGRESSION COEFFICIENTS

0.00000E+00 2.99889E-02 7.98450E-02 5.74657E-02 8.02790E-02

STANDARD ERROR OF THE ESTIMATE OF THE DEPENDENT VARIABLE = 9.0816E-01