AN INVESTIGATION OF THE GRAVITY RECOVERY OF GOLD

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A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Engineering

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ISBN 0-315-99978-0

ABSTRACT

A 7.6 cm laboratory Knelson Concentrator (LKC) was used to evaluate the performance of the gold gravity circuits at Lucien Béliveau (Val d'Or, Québec) and Dome Mines (South Porcupine, Ontario).

A detailed sampling program was conducted on the grinding and gravity circuits. To evaluate the size-by-size unit performance of Knelson Concentrators of 76 and 51 cm, an HG-7 Mineral Deposit spiral and four Denver Duplex mineral jigs (0.6 m X 0.9 m), total and gravity recoverable (determined by the LKC) gold content were measured in their feed, concentrate and tails. Sample dilution with silica was used as a tool to enhance Knelson recovery in samples with a high sulphide content.

At the Lucien Béliveau mill, gold was recovered consistently in all size fractions greater than 38 μm, averaging 45% in the 76 cm plant Knelson Concentrator. The spiral demonstrated an erratic behaviour although it still recovered significant coarse gold (+75 μm), yielding unit recoveries of 18% to 44%. The 51 cm plant Knelson unit recovery was only 17%, but this was largely due to the upstream spiral which recovered much of the coarse free gold, and the mineralogy of the flash flotation concentrate (the gravity circuit feed), which contained finer and less abundant free gold. Much of the gold in the ball mill recirculating load was found to be too coarse for significant recovery in the flash flotation cell and should be recovered by gravity from the cyclone underflow or ball mill discharge.

Unit jig recovery for the Dome mill was only 25% (of the total mill feed). Jig performance decreased with decreasing particle size. The jigs did not recover gold below 425 μm adequately. They also yielded very inconsistent

results with samples from the eight concentrate hutches having variable grades (9-367 oz/st), size distributions (26-86% -850 μm) and free gold content (61-93%). A 76 cm Knelson Concentrator has since replaced the jigs, and yields a higher gold recovery in a high concentrate grade.

RÉSUMÉ

Un concentrateur Knelson (CK) de 7.6 cm a été utilisé pour évaluer la performance des circuits de concentration gravimétrique de l'or aux concentrateurs Lucien Béliveau (Val d'Or, QC) et Dome Mines (South Porcupine, ON).

On a complété un programme d'échantillonnage des circuits de broyage et gravimétrie. Pour évaluer la performance de Knelson de 76 et 51 cm, d'une spirale Mineral Deposit HG-7 et des bacs oscillants Duplex, nous avons mesuré la quantité d'or libre et total dans chaque classe granulométrique de leur alimentation, rejet et concentré. La teneur en or libre a été déterminée par CK de laboratoire. Pour en maximiser l'efficacité, on a dilué certains échantillons très riches en sulfures avec de la silice.

Au concentrateur de Lucien Béliveau, le circuit gravimétrique traitait un concentré de cellule de flottation "flash". Le Knelson de 76 cm a récupéré 45% de l'or au-dessus de 38 μm. Le comportement de la spirale était beaucoup plus erratique, sa récupération d'or oscillant entre 18% et 44%, et se concentrant surtout au-dessus de 75 μm. Le Knelson de 51 cm n'a récupéré que 17% de l'or, mais la spirale, installée en amont, avait déjà récupéré l'or grossier, et l'alimentation du Knelson de 51 cm contenait beaucoup moins d'or grossier et libre que celle du 76 cm. La charge circulante du circuit de broyage contenait surtout de l'or trop grossier pour flotter dans la cellule "flash"; cet or devrait être récupéré par Knelson à partir de la sous-verse des cyclones ou la décharge du broyeur à boulets.

La récupération unitaire des quatre bacs oscillants de la mine Dome était de 25%. La récupération diminue dans les classes granulométriques fines,

particulièrement au-dessous de 425 μm. En conséquent, le Knelson de laboratoire a récupéré de 61% à 93% de l'or des rejets des bacs au-dessous de 850 μm. Les huit concentrés de bac étaient très variables en teneur d'or (9-367 oz/tc), granulométrie (26-86% -850 μm) et contenu d'or libre (61-93%). Un CK de 76 cm a depuis remplacé les quatre bacs, et récupère davantage d'or.

To my sister, whom I admire immensely and
who has been eminently successful in
challenging all the obstacles
life has offered her.

Acknowledgements

I would like to express my gratitude to Professor A.R. Laplante for his guidance, encouragement and boundless energy.

I am grateful to CANMET for the opportunity and support to pursue an advanced degree while remaining employed. I am indebted to all my colleagues at CANMET for their interest, patience and tolerance, especially Bob Campbell for his Harvard Graphics software abilities and acceptance of my sometimes less than courteous manner, Vaughan Reynolds for the endless discussions and his grammar skills, and Mickey Raicevic for his continual offering of assistance.

I wish to thank my colleagues at McGill. Although I was not on campus very often they all made me feel welcome when I was there. Thanks to the 'gravity group' for the many invaluable discussions, and a special thanks to Fred Woodcock for his refreshing perspective on life.

I am appreciative to Lucien Béliveau (Cambior) and Dome Mines (Placer Dome) for access to their plants and technical support. Support from the Natural Science and Engineering Research Council of Canada is also acknowledged.

Lastly, I would like to thank my parents for their encouragement throughout my life, my in-laws for continuously asking "Is it finished yet?" and my husband (who now claims proficiency in filtering samples) for his love, understanding and support...... most days.

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BMD	ball mill discharge
COF	cyclone overflow
CS	crusher slimes
CUF	cyclone underflow
DTT	deister table tailings
FLCC	flash flotation cell concentrate
JC1W1	jig concentrate one, west one
JC1E1	jig concentrate one, east one
JGC	jig concentrate
JTLS	jig tailings
KC	Knelson Concentrator
KNCON	Knelson concentrate
KF	Knelson feed
KNTLS	Knelson tailings
KT	Knelson tailings
LB	Lucien Béliveau
LKC	laboratory Knelson Concentrator
MLS	Mozley laboratory separator
OF	overflow
PCOF	primary cyclone overflow
PCUF	primary cyclone underflow
PKC	plant Knelson Concentrator
RCOF	regrind cyclone overflow
RCUF	regrind cyclone underflow
RMD	rod mill discharge
SAG	semi-autogenous grinding
SAGD	semi-autogenous grinding discharge
SAGF	semi-autogenous grinding feed
SBM	secondary ball mill
SBMD	secondary ball mill discharge
SBMF	secondary ball mill feed
SPC	spiral concentrate
SpC	spiral concentrate
SpF	spiral feed
SpT	spiral tailings
SPTLS	spiral tailings
THKOF	thickener overflow
THKUF	thickener underflow
UF	underflow
WTT	wilfley table tailings

CHAPTER 1

INTRODUCTION

1.1 Gravity Separation of Gold

Gravity concentration of gold is as old as the first glimmer of civilization and has been referred to, directly and indirectly, by a great majority of ancient writers, poets, historians, geographers and naturalists. The earliest indications of metallurgical work are among the Egyptians prior to 3800 B.C. (Hoover & Hoover, 1950). Due to the development of flotation and cyanidation at the turn of the century, the use of gravity concentration diminished. However, with the ever increasing emphasis on the environment, rising reagent and energy costs, more refractory ore bodies, and new separation units that are capable of treating larger amounts of material at finer size classes, gravity concentration is resurging (Terill & Villar, 1975).

Traditionally, gold processing facilities have had a strong gravity component, especially in the alluvial or placer deposits. Gravity separation of gold is very appealing due to the high specific gravity of gold compared to gangue minerals, although particle shape and the hydrophobicity of fine gold particles slightly detract from the benefit. Sluices were the first type of gravity concentrator utilized for alluvial gold deposits. Jigs were later introduced and had the advantage of allowing continuous processing and greater metallurgical efficiency (Richards & Bangerter, 1984). However, the few data available on jig performance indicate an inability to recover gold adequately below 200 μm, with performance falling off significantly below 75 μm (Fricker, 1984).

In Canadian hard-rock mines, gravity concentration is generally a process incorporated in the grinding circuit (usually on a mill discharge or cyclone underflow stream) to recover coarse gold. Gravity circuits are used to help maximize recovery in flotation or cyanide leaching processes. Jigs and tables are the most frequently used gravity units, while spirals and Reichert cones are used to a lesser extent (Wells & Patel, 1991). Recently, centrifugal concentrators such as the Knelson and Falcon (both Canadian inventions) have become more popular.

There are two opposing views regarding the use of gravity separation in conjunction with flotation or cyanidation. Its proponents claim that the earlier the gold can be extracted, the sooner it can be smelted, refined and sold (maximizing smelter return). Overall recoveries can be improved from cyanidation by reducing the head grade of the ore prior to leaching (which reduces the potential for solution gold losses) and from flotation by reducing flotation time to reach desired tailings grades. Recoveries may also be improved as gravity units recover coarse gold thereby excluding it from the leach circuit where it may have insufficient contact time for dissolution and the flotation circuit where it may be too coarse to float. It has been postulated that some gold particles may have coatings that will not leach or react with reagents adequately but can be readily recovered in a gravity circuit. Also, gold has a tendency to accumulate in the grinding circuit due to its density and malleability (Banisi, Laplante and Marois, 1991) which causes losses due to over-grinding.

The largest deterrent from gravity concentration is the increased security risk from the high grade concentrates generated[1]. Areas must be cordoned off when not attended, and require close supervision when concentrates are being handled. Additional problems include difficult sampling strategies and

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[1]But gold theft from sumps and launders might decrease because gravity circuits reduce the accumulation of coarse gold in such places.

inadequate accounting procedures. Another disadvantage is the complexity and cost of a gravity installation. As a single upgrading unit cannot upgrade from typical grades (in the grinding circuit) of 5 to 50 g/t to smeltable grades of 50 to 75% Au, many units must be used. Middlings recirculation, water addition, and/or regrinding may also be necessary to obtain a suitable concentrate grade (Stanley, 1987).

Overall, many factors must be weighed, such as ore mineralogy, cost, ease of operation, and applicability of possible alternatives, before gravity concentration is inserted into a milling circuit. Before any changes or improvements to a circuit can be made, one must also ask such questions as: Where is the gold predominantly located (which stream)?. Would that stream be a suitable candidate for gravity recovery? What size class of gold is liberated, and how much of it is gravity recoverable? What type of equipment would yield optimum recovery?

Gravity concentration circuits have historically been difficult to evaluate for a number of reasons. Large samples are required to make the assessment of gold content statistically sound, especially if coarse free gold is present. In addition, a laboratory concentration step is often needed to produce an appropriate sample mass for fire assaying. Duplicate and triplicate samples are also routinely assayed to reduce variability caused by "nugget" effects.

Traditional amalgamation techniques (Pryor, 1965) have been used to determine free gold[2] content or amenability of ore to gravity recovery techniques. However, due to health and workplace concerns and lack of facilities that perform mercury amalgamation testing, its use is declining. This

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[2]This thesis deals with the recovery of gold by gravity: this is generally possible when grinding liberates gold in particles of about 15 μm or more that can be recovered by efficient gravity units. This gold is generally referred to as 'free'. In this thesis the term 'free gold' will be used to mean gravity recoverable gold, as measured by a laboratory Knelson Concentrator operated under optimized conditions.

thesis will examine other options, with a focus on the 7.5 cm laboratory Knelson Concentrator (LKC). A schematic cross-section of the unit is shown in Figure 1.1 (Harris, 1984). This methodology, which was first proposed by Laplante and Shu (1992), will be demonstrated with two plant case studies.

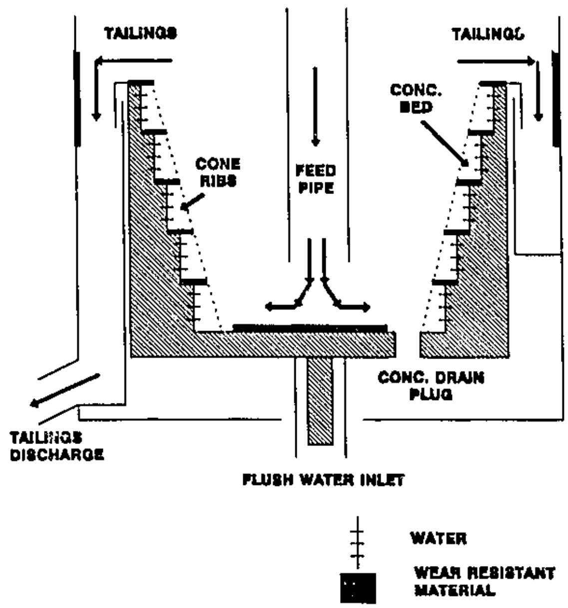

FIGURE 1.1: Cross-section of a Knelson Concentrator (modified Harris, 1984)

1.2 Objectives, Methodology, Expected Benefits

The overall purpose of this Masters Thesis is to refine and demonstrate the laboratory Knelson-based methodology.

The objectives of the study are as follows:

(a) refine the sample processing methodology to estimate free gold recovery

(b) sample jig, spiral and Knelson circuits to build a data base

(c) sample grinding circuits to add to the existing data base

(d) compare, at the Lucien Béliveau mill, the existing flash flotation/gravity approach to the more conventional gravity/flotation route.

The methodology used in this study includes the following steps:

(a) plant sampling of Dome and Lucien Béliveau (LB) mills, the latter with two different gravity configurations

(b) sample processing with a Laboratory Knelson Concentrator (LKC), with and without silica dilution; with a laboratory jig and a Mozley Laboratory Separator (MLS); and with amalgamation.

It is expected that the study will yield a better understanding of how the recovery units perform and should be used, and how the large samples extracted are best processed. The two industrial participants to the study should also benefit, in that these results should indicate how their gravity circuits may be improved.

1.3 Thesis Structure

Chapter two provides the background for the sampling campaigns. First, the statistical problem of free gold determination is 'revisited'. It is concluded that large samples (5-20 kg) must be collected and processed to concentrate free gold. The choices of processing methods are then discussed. Chapter two also presents the plant gravity units that will be studied: Knelson Concentrators, spirals and jigs.

Chapter three describes the two sampling campaigns at Cambior's Lucien Béliveau mill. After a description of the grinding and gravity circuits, the sampling scheme is explained. Sampling data are then used to estimate unit performance and gold's behaviour in the grinding circuit.

Chapter four describes one sampling campaign at Placer Dome's Dome Mine in a format identical to that of chapter three.

A discussion of the results from chapters two, three and four will be presented in chapter five.

Conclusions, recommendations and future work will be presented in chapter six.

CHAPTER 2

FREE GOLD: A BACKGROUND

2.1 Sampling Statistics for Free Gold

When sampling any process stream, great care must be taken to obtain a truly representative sample. For the evaluation of streams containing free gold particles, sampling precision (repeatability) and accuracy (lack of bias) are especially difficult to achieve due to the rare occurrence of gold particles (the nugget effect). Once a sample has been obtained, a subsample must be extracted for assaying, which introduces more errors. Traditional sampling often relies on a primary sample of inadequate size, from which a much smaller sub-sample is incorrectly extracted for assaying, resulting in a very large overall error. Errors can be minimized by alternating size and mass reduction (Springett, 1983), but size-specific information is then lost. Once gold is liberated, strong segregation phenomena occur due to the density of gold (Pitard, 1989). Every step of reduction of the fragment size and every division of a sample into subsamples introduce sampling errors. To obtain the variance of the complete process the variance from each individual step must be added together. Consequently, the average standard deviation of the process will be the square root of the total variance, or the square root of the sum of squares of the standard deviation of the individual steps (Vallée, 1992). Of these terms, the fundamental sampling variance is clearly the largest when sampling for liberated gold particles of gravity circuits.

Gy (1979) has developed a semi-empirical relationship to estimate the fundamental error of sampling $\sigma^2_{(FE)}$ (relative variance) or the minimum mass required for a certain sampling accuracy. When the element of interest is in low concentration and the sample mass is much smaller than the sampled mass, Gy's equation reduces to:

$$\sigma^2_{(FE)} = CLFG\frac{D^3}{M_s} \qquad (2.1)$$

Where

C : composition factor; the mass of ore per volume of the species sampled (g/cm^3)

L : liberation factor; can be approximated by $L = (D_l/D)^{0.5}$ where D_l is the maximum grain size of the species investigated

F : particle shape factor; usually adjusted to 0.5 although should be 1 for spherical shapes and less than 0.2 for flakes

G : size distribution factor; set to 1 for monosized material and 0.25 for unsized products

D : maximum particle size; D_{95} (cm)

Ms: sample mass (g)

Although Gy's theory is powerful, its application to gold ores has met with limited success due to the inadequacy of its sampling variance and minimum sample mass determination formulae. Application of these formulae often lead to unrealistically large minimum sample masses (Bongarçon, 1991). This stems largely from Gy's basic assumption that minimum mass should be estimated considering liberated mineral species, corrected with a liberation factor L. This factor, as defined in Equation (2.1), is usually too low, hence the high estimates of either $\sigma^2_{(FE)}$ or M_s. For studying gravity circuits, where the gold of interest is liberated, this problem is not so critical. Gy's equation nevertheless can overestimate required sample mass, if F, the particle shape factor, is overestimated. Banisi (1990) has weighed a large number of gold flakes in size classes where sampling problems are most likely to be acute. This makes it possible to short-circuit Gy's formula as the relative sampling variance for a given size class is simply equal to the inverse of the number of gold flakes in that size class in the sample. The overall sampling variance becomes a weighted average of the variance of each size class (Laplante & Shu, 1992).

The large masses required to estimate gold grade accurately in the coarsest size classes are best illustrated with an example. Consider the 840-1200 μm class, where gold flakes weigh on average 5 mg (Banisi, 1990). For a grade of 0.3 oz/st[3], the mass required to estimate grade with a relative standard deviation of 10% ($\pm$0.03 oz/st) is equal to 33 kg. If a stream contains 5% weight in the 840-1200 μm fraction, approximately 600 kg of unsized material must be extracted. In finer size classes the necessary sample mass decreases significantly. In the 300-420 μm (35/48 mesh) gold flakes average 0.5 mg (Banisi, 1990); to achieve the same 10% relative standard deviation a mass of 5 kg must be sampled. Below 210 μm, pure sampling errors become negligible and errors of screening, assaying, and stream fluctuations in grade become predominant (Laplante, Putz, & Huang, 1993).

Figure 2.1 offers useful guidelines for sample mass selection and realistic sample accuracy expectations. Generally, if the gold distribution is below 840 μm (0.5 mg gold particles) and the grade is above 0.1 oz/st, a sample size of 5-20 kg would be representative. This sample size would also yield good size-by-size information (relative error < 10%) when grades are at 0.6 oz/st (20 g/t) or higher. Clearly, in most cases it will be practically impossible to

[3]Although oz/st is not a metric unit, it is commonly used in industry.

generate acceptable information above 840 μm (5 mg gold particles) and alternatives to sampling, such as the use of tracers (Walsh and Rao, 1986), should be sought.

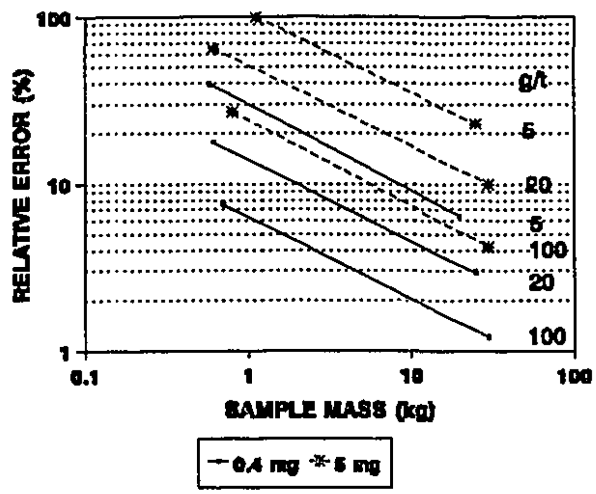

Figure 2.1: Relative Error (Standard Deviation) on Gold Content as a Function of the Sample Mass and Grade, and Flake Weight (Laplante, Putz & Huang, 1993)

The next problem is assaying all the free gold in large samples. Once a representative sample has been acquired in a plant, the sample must be prepared in the laboratory to produce a sub-sample that is both representative and of a suitable size for assay. Small sample size or large gold particle size will invalidate an assay of small samples (Bacon, Hawthorne & Poling, 1989). Table 2.1 shows the effect of gold particle size and the number of particles in a 4.5 kg sample and in other various assay sample sizes. Table 2.2 shows the nugget effect for one particle of gold of a given size on an assay of a sample of given weight. Clifton et al., (1969) state a sample must contain a minimum of 20 particles of gold to obtain a 95% probability that the true gold content will be within ± 50% of the gold content obtained by chemical or instrumental analysis of the sample. If fewer than five gold particles are present there is a high probability of certain samples mistakenly assaying zero gold content. Pre-concentration of samples may help eliminate this problem, as will be discussed in the next section. Large sample masses can then be completely assayed if free gold is concentrated in a smaller mass that will be fully analyzed.

Table 2.1: Gold particle content of the various sample sizes as a function of gold particle size for a 0.05 oz/st ore (McLean, 1982)

			Number of gold particles per assay sample					
Gold size (μm)	Mesh	No. of Au particles per 4535 g sample	1 AT*	2 AT	5 AT	1000 g (33 AT)	2000 g (66 AT)	10000 g (330 AT)
1650	10	0.17	0	0	0	0	0	0
833	20	0.71	0	0	0	0	0	1.6
589	28	2	0	0	0	0	1	
295	48	16	0	0	0.5	3	6	35
208	65	46	0.30	0.60	1.5	10	20	101
147	100	128	0.84	1.68	4.2	28	56	281
104	150	370	2.4	4.8	12.0	81	163	368
74	200	1000	6.6	13.2	33.0	220	440	2193
45	325	4588	30.4	60.8	91.2	1011	2022	
38	400	7959	52.6	105	263	1736	3472	
20		49920	330	660	1650	10890	21780	
5		3276000	21671	43342	108355			
2		50000000	330000	660000				

* AT = Assay Ton

2.2 Free Gold Recovery from a Large Sample

Traditionally amalgamation techniques have been used to determine the free gold content of ores (Pryor, 1965). Cyanidation is also used occasionally, especially on very large samples (Springett, 1983). Other methods such as flotation (Graham, 1989), Mozley separators (Liu, 1989), Superpanners (Agar, 1993) and laboratory Knelson Concentrators (Banisi, 1990) have been used as alternate choices for sample concentration. Laplante, Shu, and Marois (1993) demonstrated that for a cyclone underflow sample from Hemlo's Golden Giant

Mine, below a F_{80} of 400 μm and a density of 3.2 g/ml, the recovery of the KC is insensitive to feed density, size distribution, fluidizing water pressure (within 25 to 40 kPa), and is equal to 95% of amalgamation recovery. Banisi (1990) and Spiller (1982) obtained similar KC and amalgamation recoveries but on a limited number of samples. The KC recovers gold that is free, as its yield is normally 1 to 3% with a large feed mass, and therefore the probability of recovering significant locked gold is low. To verify this, Laplante, Putz and Huang (1993) showed that when feeds known to contain little gravity-recoverable gold are fed to the KC, gold recovery is particularly low, even if gold content is high. Urlich (1984) also showed that gold in KC concentrates was 96 to 99% amalgamable.

Table 2.2: "Nugget Effect" of gold particle size versus sample weight (McLean, 1982)

			Change in Au assay per particle of Au (oz/st)						
Gold Size (μm)	Mesh	Wt. of one Au particle (mg)	.5 AT*	1 AT	2 AT	5 AT	1000 g 32 AT	2000 g 64 AT	10000 g 320 AT
1650	10	88	176	88	44	17.6	1.75	1.38	0.27
833	20	11	22	11	5.5	2.2	0.34	0.17	0.03
589	28	4	8	4	2	0.80	0.215	0.062	0.021
295	48	0.50	1.0	0.50	0.25	0.10	0.016	0.008	0.002
208	65	0.17	0.34	0.17	0.18	0.03	0.005	0.002	0.001
147	100	0.061	0.12	0.06	0.03	0.01	0.002	0.001	0.001
104	150	0.021	0.04	0.02	0.01	0.004	0.001	0.001	0.001
74	200	0.0078	0.02	0.01	0.001	0.002	0.001	0.001	0.001
45	325	0.0017	0.004	0.002	0.001	0.001	0.001	0.001	0.001
38	400	0.0010	0.002	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
20		1.56E-4	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
5		2.41E-6	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
2		1.56E-7	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

* AT = Assay Ton

2.2.1 Amalgamation

Amalgamation is the process of separating gold and silver from their dissociated minerals by binding them into a mixture with mercury. Its use dates from Roman times. A phenomenon of moderately deep sorption involving a limited degree of interpenetration of solid gold and liquid mercury occurs when wetting gold into mercury. Gold is readily wetted by mercury because its surface tension is higher than that of mercury and it becomes absorbed into the mercury. Due to the density of gold (19.3) compared to mercury (13.5) gravitational forces act to drown the gold in the mercury and may be the most important forces at work. Two compounds are formed during amalgamation, $Au_{19}Hg_4$ and $Au_{19}Hg_3$. Once amalgamated, the bullion can be extracted by squeezing the amalgam through chamois leather or canvas in an amalgam press. The amalgam is then heated in a mercury retort furnace until all the mercury has been distilled off. Any remaining impurities can be removed by melting the bullion with a flux of silica, soda ash and borax. Although the amalgamation process is relatively simple, unsatisfactory results may be obtained by (Pryor, 1960):

- lack of suitable contact between gold and mercury
- too fine or flat gold particles which will not penetrate the mercury
- gold present as tellurides or locked in sulphides
- gold grains that have tarnished surfaces or surfaces containing contaminants such as oil, grease, talc or sulphur
- impure or floured mercury which cannot open its surface to gold

Due to health and workplace concerns and lack of facilities that perform mercury amalgamation, its use is declining. Current practice is limited and approached slightly differently. Once a sample has been amalgamated, the tailings and feed samples are assayed and the free gold content is determined by difference. Because amalgamated gold is not assayed, it does not address the problem of determining size-by-size free gold content. Although this approach is less informative regarding the free gold and total gold content of the sample it is less hazardous than the previous methods mentioned and was used in this study.

2.2.2 Flotation

Graham (1989) documented the gold recovery by size distribution through the Echo Bay Minerals Manhattan facility. The facility is a 590 t/d gravity and flotation gold circuit. Batch flotation in a 30 L Denver Sub A float cell was used to process a -600 μm (28 mesh) Wilfley table concentrate sample (a pyrite gold concentrate). Soda ash and sodium cyanide were used to depress pyrite. The gold was also depressed initially but after about 30 minutes of additional conditioning time it began to reactivate and float. The gold floated in stages where the finer gold particles floated first followed by the coarser gold particles and finally the very coarse particles (+210, +297, +420 μm) began to float. A recovery of 96% was achieved in 1.8% of the float feed. The batch flotation method of processing the table concentrates appears successful although it was reported to be very operator sensitive. Also, after the two-and-a-half-hour flotation test the feed size distribution appeared reduced. Size-by-size distribution of the gold particles floated indicates over 80% of the gold recovered was above 212 μm, 21% was above 425 μm, but only one percent was below 45 μm. Over 57% of the gold remaining in the tailings was below 45 μm. Assays of calculated feed, material balances and fire assay feed did not agree (802 g/t, 315 g/t, and 679 g/t, respectively). Graham concluded that there is no way to produce accurate metallurgical accountability, even in a carefully controlled batch flotation test, when coarse gold is present. Due to problems encountered during flotation of table concentrates, flotation was not used in this study as a method to document the size distribution of gold recovery.

2.2.3 Mozley Table and Superpanner

Flowing film concentration is the mechanism by which the Mozley

Laboratory Mineral Separator (MLS) and Superpanner sort material. The MLS unit consists essentially of a separating surface, or tray, sloping slightly in one direction, and oscillating in a simple harmonic motion by a crankshaft in the other direction (Burt, 1984). One advantage that the MLS has over other gravity devices (jigs, sluices, cones and spirals) is that it can efficiently recover particles below 100 μm. Mills and Burt (1979) report recoveries in excess of 50% for 5 μm cassiterite particles.

Liu (1989) used the MLS to estimate the free gold content of process streams from Les Mines Camchib. Two-to-three kilogram samples were wet and dry screened into various size classes. Portions of material from each fraction (75 to 150 g) were processed with the MLS, recovering four different products to generate grade-recovery curves. Although the MLS was an effective separator, the process was very time consuming, and often yielded noisy data. It was also very costly due to the large number of assays required to determine the grade-recovery curves (Laplante, Liu, Cauchon, 1990). An inherent limitation of the MLS is its lack of capacity. When processing coarse fractions, a 150 g mass is insufficient for good statistical reproducibility. Another problem encountered was the sensitivity of the MLS to the technique of the operator, which may have accounted for the noisy data.

Banisi (1990) compared size-by-size recoveries of a primary cyclone overflow (PCOF) and a secondary cyclone overflow (SCOF) sample from the Hemlo Mill using a 7.5 cm Knelson Concentrator and a MLS. The performance of the LKC decreased with increasing fineness from the PCOF and SCOF. As a result, the Mozley actually outperformed the LKC on the SCOF, by about 5% recovery at equivalent yield. Cyclone overflows, however, are the grinding circuit streams least effectively treated by a LKC; the comparison is therefore slightly unfair, and serves more to show that other streams should definitely be processed by a LKC. In this study the MLS was utilized to some extent when sample mass was too small for the LKC.

Agar (1993) reported use of a Superpanner as an ideal separator (complete separation of the valuable material from the gangue). Good grades (19 and 38% Au) were recorded. Two stages of superpanning separation were used with very low weight recoveries (50-60 mg) in the individual size fractions of the final concentrates. Since a superpanner is also a flowing film concentrator, similar problems to the MLS could be experienced. Superpanners are more difficult to operate than the MLS and process even smaller masses.

2.2.4 7.5 cm Laboratory Knelson Concentrator

The Knelson concentrator (KC) is a high-efficiency, low-maintenance centrifugal separator with an active fluidized bed that captures heavy minerals. Particles are acted upon by a centrifugal force about 60 times the force of gravity (60 G's) thereby trapping the denser particles in a series of rings located in the concentrator while gangue particles are flushed out. Operating at such high forces of gravity all surface chemistry effects such as surface tension on the air-water interface are eliminated (fine, flaky gold can be held by this surface tension or entrained in water flow and be lost to tails).

Hindered settling and centrifugal force are utilized by the KC (Knelson, 1988). Feed to the LKC is screened at 1680 μm (10 mesh) and fed through a central feed pipe as slurry at 20 to 40% solids. Once the slurried particles strike the base plate of the cone they are thrown to the sidewalls by the centrifugal force generated by the rotating cone. A constant-volume concentrate bed is formed between the cone rings.

Water is injected through holes in the inner bowl of the concentrator to prevent compaction of the concentrate bed. The fluidized concentrate bed allows even fine gold to penetrate the bed under high "G" forces. Clean water must be used to prevent hole blockage in the inner bowl. Excessive water pressures may hinder recovery of fine gold as it may not be capable of penetrating the bed. Higher fluidizing water flowrates are required to fluidize a bed of greater porosity for the recovery of coarse particles. Generally, optimum water back pressures increase as the specific gravity of the gangue increases (Ounpuu, 1992). The addition of the water prevents the material from attaining the same speed as the cone, thereby producing a shear (Bagnold effect) which dilates the flowing slurry and favours the recovery of fine dense particles (Banisi, 1990). This rotational shear is very similar to that used by Bagnold to demonstrate the existence of dispersion induced by shear (Bagnold, 1954).

The force generated in the KC bed is, according to the formula, (Harris, 1984)

$$F_c = 4\pi^2 m n^2 r \tag{2.2}$$

Where

F_c: centrifugal force (Newtons)

m: particle mass (Kg)

n: rotational speed (radians/sec)

r: bowl radius (m)

More effective separation is attained at 60 Gs than at gravitational acceleration because of the increase in specific gravity difference between gold and gangue (Harris, 1984). For example, gold has a specific gravity (rounded off and including impurities) of eighteen, 'black' sands (such as magnetite and illmenite) have a specific gravity of five, and 'grey' sands (silicates and carbonates) have a specific gravity of three. At zero gravity there will be no separation; at one force of gravity the specific gravities will be eighteen, five and three. When the force of gravity is increased to ten, the specific gravities increase by that factor to 180 for gold, 50 for black sands and 30 for grey sands. At 60 Gs the specific gravities are 1080 for gold, 300 for black sand and 180 for grey sand. The differences between specific gravities is now very large (780 between gold and black sands) allowing for separation in the Knelson Concentrator, with particle shape factors being virtually neglected (Knelson, 1985). A demonstration of enhanced operation due to greater G forces is seen in the comparison of two gravity separation devices operating at different G forces. A sluice box is one of the most basic gravity recovery devices. When material flows down a sluice box it picks up speed to a maximum of approximately 50 km/h and the G force pulling the material into the riffles or retainers is one. When material strikes the bottom of the Knelson Concentrator cone it gains speed, as it approaches the rim, to approximately 50 km/h also. Therefore, in the sluice box material travels at a forward speed of 50 km/h with one G and in the Knelson Concentrator material travels at a forward speed of 50 km/h with sixty Gs. If the G factor is reduced in both cases to 1 (all things relative) then the forward speed in the Knelson Concentrator would be reduced to 0.8 km/h which would allow gold to settle more readily in the Knelson due to the immense settling force in relation to the forward speed (Knelson, 1985)[4].

At the end of the feed cycle, the KC is stopped and the inner bowl containing the concentrate is washed out. One of the major drawbacks to the KC is that it is a batch operation, although in plant operations it can be automated, and Knelson is currently experimenting with a continuous unit.

Urlich (1984) states that testing on various deposits showed that the KC rejected black sands without losing significant amounts of gold and in laboratory tests 96% to 99% of the feed gold was recoverable from the concentrate by amalgamation. Given the right size distribution and gangue density, the KC can therefore be used as a nearly perfect separator. Unlike the superpanner or the MLS, the KC can treat up to 1 kg/min of unsized feed.

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[4]Of course, this discussion is overly simplified. For example, the retention time in the KC is much shorter than in a sluice. A sluice also creates its own centrifugal action in the vortices induced by the flow of slurry over the riffles. A more complete analysis would have to take into account micro fluid dynamics (e.g. terminal settling velocities and inter-particle collisions) and is beyond the scope of this work.

Laplante, Shu and Marois (1993) studied the effect (size-by-size) of varying feed rate, size distribution, gangue density and fluidizing water pressure on the ability of the KC unit to recover gold. The feed material used for the testwork was the primary cyclone underflow from the Golden Giant Mine of Hemlo Gold Mines Inc. (Marathon, Ontario). The effect of gangue density was insignificant between 2.8 and 3.2 g/cm^3, but recovery dropped from 89% Au to 83% at high feed rate and 78% to 66% at low feed rate when gangue density increased to 4.0 g/cm^3. It was found that the effect of fluidizing water pressure on gold recovery at feed densities of 2.8 and 4.0 g/mL was small but there was a maximum at 33 kPa (5psi). It appears the optimum pressure is a function of the material feed size distribution and is probably lower for finer feeds, but can span a significant range of 15 to 40 kPa. They concluded that the LKC could recover 95% of amalgamable gold for samples that have an F_{80} less than 400 μm and a density below 3.2 g/ml.

2.2.5 Comparison of Amalgamation and LKC

In this work, the performance of the LKC was compared to that of amalgamation, on primary and regrind cyclone overflows (PCOF and RCOF) from Dome Mines.

Processing Dome mine primary cyclone overflow (PCOF) by amalgamation produced similar feed grades, 0.07 oz/st compared with 0.08 oz/st calculated from the LKC results. Size-by-size feed grades were also very similar, as can be seen in Table 2.3; however, there appears to be a problem with the PCOF amalgamated tail assays. All the assays were extremely high and completely unreasonable for a COF, resulting in totally unrealistic free gold recoveries.

The Dome Mine regrind cyclone overflow (RCOF) sample was also processed by amalgamation. Table 2.4 compares amalgamation and LKC results for the RCOF. The head grades (0.15 oz/st for amalgamation and 0.14 oz/st for LKC) and size-by-size grades are in excellent agreement. The largest difference in assays appeared in the +38 μm class which assayed 0.13 oz/st for the amalgamation testing and 0.05 oz/st for the LKC testing, indicating that more free gold was recovered by the LKC in that class. It appears, from a size-by-size comparison of free gold recoveries that the LKC generally recovers more gold in the coarser fractions, while amalgamation recovers more gold below 38 μm (38% recovered by the LKC, and 41% recovered by amalgamation) resulting in an overall recovery of 56% for the LKC and 49% for amalgamation.

Table 2.3: Comparison of Amalgamation and LKC Testwork for a PCOF sample from Dome Mines

PCOF FEED						
SIZE µM	WT (%) AMALG.	WT (%) KNELS.	ASSAY AMALG.	ASSAY KNELS.	Au DIST AMALG.	Au DIST KNELS.
150	3.17	3.32	0.37	0.37	17.70	15.9
105	6.17	6.55	0.08	0.10	7.30	8.5
75	8.71	9.36	0.07	0.11	8.58	13.1
53	12.11	11.22	0.08	0.06	15.43	9.2
38	8.13	8.97	0.07	0.10	8.87	11.7
-38	61.71	60.58	0.05	0.05	42.12	41.7
TOTAL	100.00	100.00	0.07	0.08	100.00	100.0

PCOF TAIL						
SIZE µm	WT (%) AMALG.	WT (%) KNELS.	ASSAY AMALG.	ASSAY KNELS.	FREE AU RECOVERY AMALG.	FREE Au RECOVERY KNELS.
150	2.98	2.91	5.99	0.40	-1531	6.3
105	6.13	6.50	6.54	0.09	-8282	12.1
75	9.07	9.29	0.12	0.08	-83.08	27.1
53	10.56	11.14	0.15	0.03	-80.95	53.5
38	8.62	8.97	0.07	0.04	5.56	60.9
-38	62.64	61.20	0.96	0.05	-2028	6.0
TOTAL	100.00	100.00	1.21	0.06	-1737	20.1

Banisi (1990) found the opposite to be true, i.e. it appeared amalgamation recovered more free gold for a COF and CUF sample, although recoveries were very similar. Laplante, Shu and Marois (1993) also compared free gold recovery using amalgamation and the LKC. Overall recoveries were 89-90% for the LKC and 94-95% for amalgamation, indicating that the LKC recovered 95% of what was found recoverable by amalgamation, a figure also reported by Spiller (1982). Amalgamation and Knelson concentrator recoveries are similar although perhaps each recovers gold particles having slightly different characteristics.

Table 2.4: Comparison of Amalgamation and LKC Testwork for a RCOF Sample from Dome Mines

RCOF FEED						
SIZE µm	WT (%) AMALG.	WT (%) KNELS.	ASSAY AMALG.	ASSAY KNELS.	Au DIST AMALG.	Au DIST KNELS.
150	4.70	4.77	0.07	0.08	2.36	2.7
105	7.04	7.66	0.04	0.05	2.11	2.9
75	8.20	8.96	0.12	0.06	6.56	4.0
53	9.23	10.02	0.15	0.18	9.14	12.8
38	8.28	8.51	0.36	0.34	20.39	21.0
-38	62.56	60.08	0.14	0.13	59.44	56.7
TOTAL	100.00	100.00	0.15	0.14	100.00	100.0

RCOF TAILS						
SIZE µm	WT (%) AMALG.	WT (%) KNELS.	ASSAY AMALG.	ASSAY KNELS.	FREE Au RECOVERY AMALG.	FREE Au RECOVERY KNELS.
150	3.40	4.11	0.07	0.02	12.16	78.2
105	6.92	7.48	0.04	0.02	18.18	62.6
75	8.54	8.80	0.03	0.03	72.03	52.4
53	9.90	9.86	0.05	0.04	64.38	78.1
38	8.57	8.50	0.13	0.05	63.91	85.6
-38	62.68	61.25	0.08	0.08	41.43	38.4
TOTAL	100.00	100.00	0.08	0.06	48.91	55.7

2.3 Improving the LKC Performance: Dilution

When determining the size-by-size free gold content of a sample with the LKC there are two major factors that might minimize free gold recovery: excessive particle coarseness and density (Laplante, 1993).

Coarse particles are generally found in the grinding circuit products, specifically SAG and rod mill discharges and to a lesser extent, cyclone underflows (generally finer due to the circulating load). Coarse feed is considered to have an F_{80} above 400 μm which can easily be screened out before processing on a LKC. If information is required on material above 400 μm, the material can be processed separately in a laboratory jig or LKC while the -400 μm material can be processed with a LKC.

Feed that is very dense can be diluted with silica to achieve the desired density for maximum free gold recovery (Laplante, Shu, and Marois, 1993). For massive sulphides (4.5 to 6.0 g/ml) a dilution of 4:1 (silica to feed material) is adequate to bring the density down to 3.2 g/cm^3. Less dilution may be acceptable for material with different blends of heavies and lights (Laplante, Putz, Huang, 1993). When diluting, it is extremely important to measure the size distribution of the original sample prior to dilution for purposes of mass balance calculations.

Gravity circuit samples from Cambior's Lucien Béliveau (LB) mine were diluted with silica prior to processing with the LKC. Details of the methodology are described in Chapter 3. Dilutions of 2:1 and 4:1 silica (70 mesh and 25 mesh from Indusmin) to sample were compared, along with different silica particle sizes (210 μm and 840 μm). Table 5 lists and describes the samples used. Undiluted plant KC tailings data are averages from four tests. Figure 2.2 shows the size-by-size total gold recoveries for the KC tail sample, as is, with a 2:1 silica dilution and a 4:1 silica dilution.

TABLE 2.5: Tests performed and samples used to examine the effects of free gold recovery by silica dilution (all samples are 95%+ pyrite).

TEST NO.	STREAM	SILICA DILUTION	*SILICA SIZE	SAMPLE DESCRIPTION
1	LB Plant KC Tails	as is	210 µm	Tails from a 76 cm KC operated at a very low feed rate, 1-2 t/h. Feed is a flash flotation conc.; gold is fine and flaky (least lib.)
2	LB Plant KC Tails	2:1	210 µm	
3	LB Plant KC Tails	4:1	210 µ	
4	LB Plant KC Feed	as is	210 µm	Feed is a flash flotation concentrate; gold is flaky (high liberation)
5	LB Plant KC Feed	4:1	210 µm	
6	LB Spiral Conc 1	4:1	210 µm	Feed to the spiral (HG 7) is a flash float conc; Au is flaky (very high liberation)
7	LB Spiral Conc 1	4:1	840 µm	
8	LB Spiral Tail	4:1	210 µm	Tails from the above spiral; gold is flaky (more liberated than 2 & 3, less liberated than 4 & 5, much less liberated than 6 & 7)
9	LB Spiral Tail	4:1	840 µm	

*(Full size distribution in Appendix A)

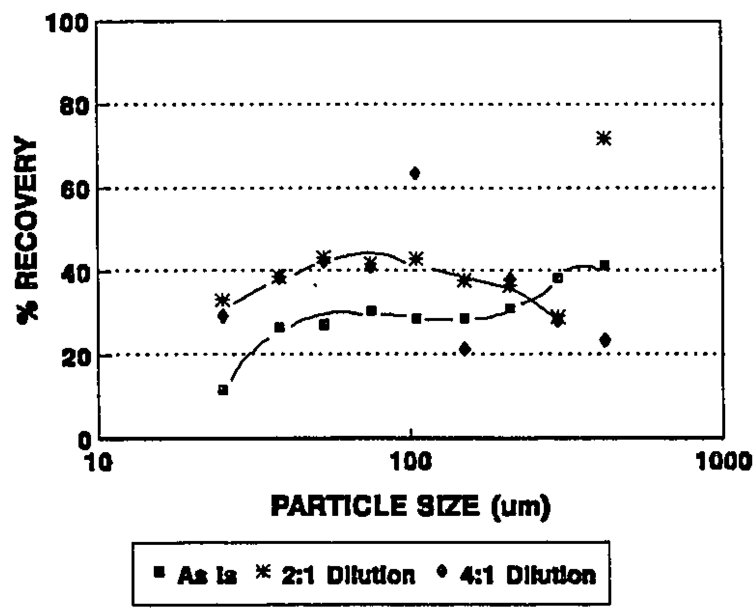

FIGURE 2.2: Effect of Silica Dilution on Size-by-Size Gold Recovery (Feed sample is a 76 cm PKC tails from LB)

Very little scatter is seen in the undiluted sample, but there is scatter above 100 μm in the diluted samples due to the lower mass of actual product processed. Despite the scatter, overall trends are clear: dilution produced higher free gold recoveries in all size classes below 300 μm. The improvement appears to increase with decreasing particle size. Below 37 μm (where the KC efficiency inherently begins to deteriorate) improvements are significant, as dilution increases recovery from 12% to 30-32%. The 2:1 and 4:1 dilutions appear to have the same effect on recoveries. Because sample density varies and silica is relatively inexpensive, a 4:1 dilution was chosen as a standard for this work.

Using the same dilution technique with a sample containing more gravity recoverable gold (the feed of the same unit) produces similar results (Figure 2.3). Here, size-by-size free gold recoveries improve, although to a lesser extent. Improvement appears undetectable above 150 μm. Again, the lower mass of product processed when diluted affects reproducibility above 150 μm.

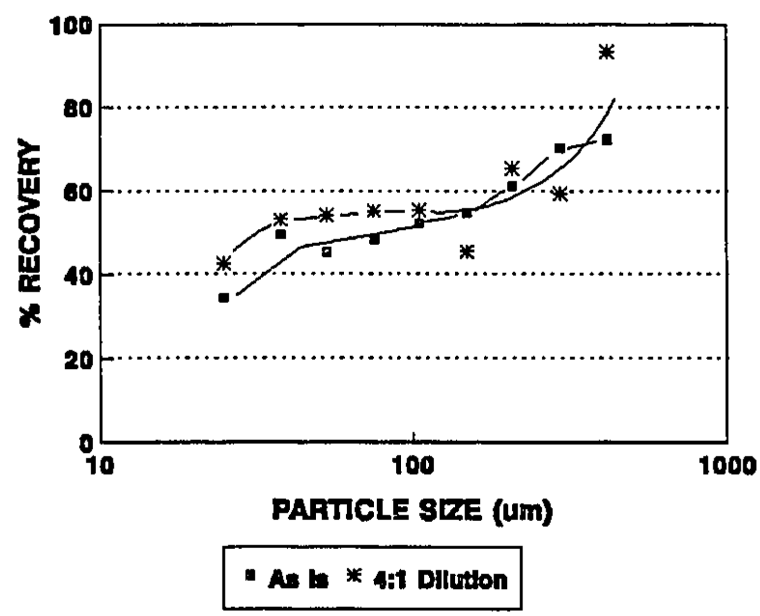

FIGURE 2.3: Effect of Silica Dilution on Size-by-Size Gold Recovery (Feed is LB PKC Feed)

Figure 2.4 shows the size-by-size LKC recovery results of Lucien Béliveau spiral concentrate and spiral tailings samples diluted with coarse (840 μm) and fine (210 μm) silica. Size-by-size recovery was virtually the same for the two, although recovery was lower below 25 μm and above 200 μm for the coarser dilution. Below 25 μm, the separation of very coarse silica from very fine gold is slightly more difficult to achieve, above 200 μm, it is likely that reduced trickling is the cause of the decrease in recovery. Coarser silica does yield a lower recovery; the difference is consistent with that observed for fine silica/no dilution (Figure 2.3), which suggests that using coarse silica might negate the advantages of dilution altogether, which is consistent with the fact that coarse silica would have a similar hindered settling velocity as the coarsest sulphides in the flash concentrate.

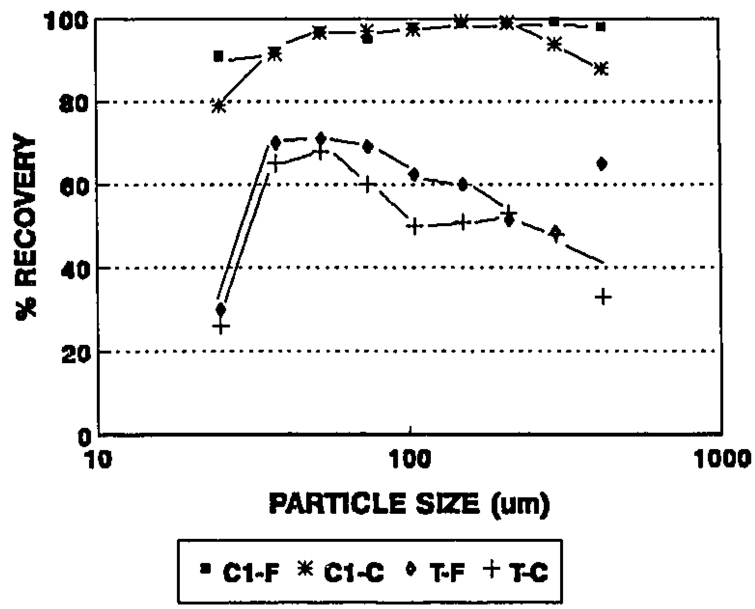

FIGURE 2.4: Effect of Silica Size Distribution on Size-by-Size Recovery of Spiral Concentrate (C1) & Spiral Tail (T) Samples as Diluted 4:1 with Fine (F) & Coarse (C) Silica

Similar results with dilution of samples using 210 μm silica prior to processing on a LKC were presented by Laplante, Putz, and Huang (1993). Lucien Béliveau table tails and Meston Resources (MR) table tails were processed with a LKC, both with and without 4:1 silica dilution. The Lucien Béliveau table tails results yielded a slightly higher gold recovery for the diluted sample below 100 μm, although above 150 μm, the undiluted recovery was slightly better. Because the Lucien Béliveau table tails originate from the same flotation concentrate as material used for this work, its dilution with 210 μm silica actually coarsens the sample. Dilution with finer silica may produce higher recoveries. The diluted Meston Resources table tails sample produced improved recoveries over the undiluted sample across the full size range. Overall recovery increased from 46% to 61%. In this case the recovery improvement was attributed to both the finer density and size distribution of the diluted sample.

Feed dilution increases fines recovery. It also illustrates the difficulty of recovering gold by gravity from high density gangues. When using the LKC as a measure of gravity recoverable gold, silica dilution becomes an important tool because it can minimize gangue density differences effected by the circuit that change the apparent density of response of gold to the LKC. It provides a more standard measure of the gravity recoverable gold content.

2.4 Plant Units for Free Gold Recovery

In this section, a background of the gravity units used at Lucien Béliveau and Dome Mines are presented; spirals and jigs. The KC is also used at Lucien Béliveau, but has been described above.

Plant data results from other operations utilizing spirals and jigs are also discussed.

2.4.1 Spirals

Spirals are film-type concentrators, where slurry flows down a helical conduit (spiral surface) and particles of different specific gravities stratify vertically and horizontally (Figure 2.5). The denser particles concentrate in a band along the inner side of the stream and are split off and discharged at different points. Washwater may or may not be added.

Vertical stratification of the flowing film down the spiral can be defined by different sorting processes consisting of hindered settling, interstitial trickling, attainment of minimum potential energy and Bagnold forces (Sivamohan & Forssberg, 1984).

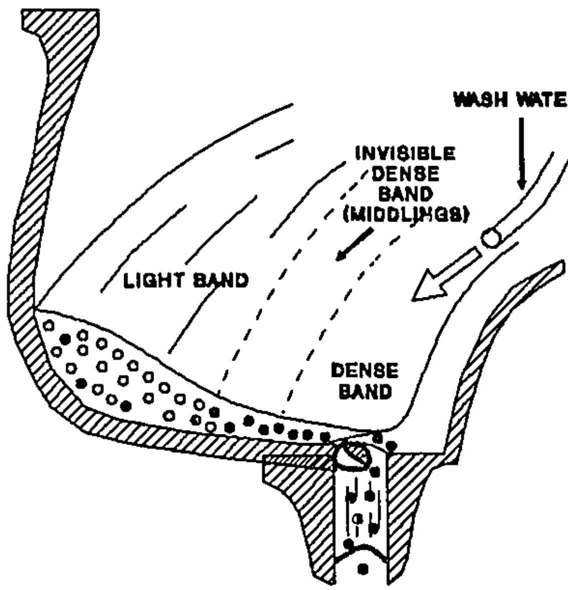

FIGURE 2.5: Segregation in a Spiral (Kelly & Spottiswood, 1982)

Hindered settling can be described as particles settling in a stationary fluid depending on their density, shape and size according to Newton and Stokes equations (Burt, 1984; Stokes, 1891; Taggart, 1954). Newton derived a relationship for the settling of coarse particles (greater than 2 mm) in a fluid as follows;

$$V_t = [\frac{4(\sigma_s - \sigma_f)dg}{3Q\sigma_f}]^{0.5} \tag{2.3}$$

where

V_t = terminal velocity of the particle, m/sec

Q = coefficient of resistance (for spherical particles Q = 0.4)

σ_s = specific gravity of the particle, kg m^{-3} X 10^{-3}

σ_f = density of the fluid, kg/L

d = particle diameter, m

g = gravitational acceleration m/sec^2

For fine particles (finer than 0.1 mm) settling in a fluid, Stokes' relationship applies:

$$V_t = (\sigma_s - \sigma_f) d^2 g / 18\mu \tag{2.4}$$

where

μ = fluid viscosity, mPa.s

The rate at which a particle settles is a function of its density relative to water (σ_s - 1), and particle diameter. The ratio of particle size (d_a and d_b) at which two minerals of different densities, a and b, will have equal terminal settling rates in hindered settling conditions is known as the hindered settling ratio R_h. When the solids content of the pulp increases, the effect of inter-particle interference becomes significant and the fluid acts as a heavy liquid with a density of the pulp rather than the fluid. The hindered settling ratio becomes

$$R_h = \frac{d_a}{d_b} = \left[\frac{\sigma_b - \sigma_f}{\sigma_a - \sigma_f}\right]^n \tag{2.5}$$

where

d_a = particle size of mineral 'a', m

d_b = particle size of mineral 'b', m

n = coefficient (ranging from 1 for particles settling in the Newtonian regime to 0.5 for particles settling in the Stokesian regime)

Interstitial trickling occurs when small particles in the system tend to trickle through any available interstices of the larger particles bridging together. Since the coarse particles remain in suspension for shorter periods than the finer particles, the coarse particles tend to bridge together when they come to rest. The maximum size of a particle that can trickle interstially is equal to:

$$d' - (2d^2)^{0.5} - d - 0.41d \tag{2.6}$$

where

d' = maximum size of particle that can pass between particles of size d, m

Attainment of potential energy occurs when there is stratification due to a reduction of energy in the system (Macer, 1984). Provided particle shape and size are favourable, the forward and lateral travel of the bed of particles (in a spiral) force the heavies downward to attain minimum potential energy (Sivamohan, Forssberg, 1985).

Bagnold forces favour the classification of material in vertical layers with the coarse lights on top, fine lights and coarse heavies following, and fine heavies on the bottom. Bagnold (1954) explains that when a suspension of particles are subjected to a continuous shear, such as a pulp flowing over an inclined surface, or movement of a surface underlying a pulp stream, a pressure will build across the plane of shear at right angles to the surface of shear. This dispersive pressure pries coarser particles apart and favours interstitial trickling. Bagnold forces on a particle are dependent on the square of its diameter and proportional to the rate of shear of the particles vertical to the plane of flow.

$$F_B = k_1 r^2 \tag{2.7}$$

where

F_B = Bagnold force (proportional to the rate of shear)

k_1 = constant of proportionality

r = particle diameter, m

Horizontal stratification is influenced by the different rising and falling currents near the inner radius and the outer radius of the spiral troughs. Due to the vertical stratification, particles are caught in different velocity layers while travelling in a curved path. Particles will tend to shift towards the outer edges by centrifugal forces, but the lower layer particles will not be able to migrate to the outer edge due to the inward slope of the conduit and the low centrifugal forces and radial velocity of the lower part of the stream. Therefore, bottom layers force the heavy particles towards the inner side of the spiral concentrator. Particle size also plays a role in separation of the bottom layer where the inwardly moving layers are acted on by large forward velocities so coarse heavy particles will move in a greater angle inward than the fine heavy particles. Currents on the inner radius tend to rise while currents on the outer radius fall, connecting the inward flow of the bottom layers and outward flow of the upper layers. A unique phenomenon is created by the rising currents where small particles are lifted upwards. The inner zone of the spiral controls the grade while the outer zone controls recovery (Holland-Batt, 1989).

Sivamohan (1984) reports three design variables, spiral pitch, profile, and radius, which can be adjusted to achieve desired separations.

The pitch (angle) of the spiral determines the velocity of the pulp. Generally high capacities and high grades but low recoveries are achieved with steep angles. Low-grade ores tend to perform well with a steep pitch. Shallow angles are used for operations involving small specific gravity differences and fine particle sizes, although steeper-pitch spirals also produce good recoveries of fine values (as feed densities can be higher, with a corresponding increase in particle-particle interactions and better trickling of fine dense particles, Burt, 1984). The original Humphreys spiral had a pitch of 34 cm, this has now increased to a 43-51 cm pitch allowing for higher densities and up to 45% solids, resulting in increased fines recovery.

There are many different profile patterns available (Ferree, 1993). Conventional spirals use a continuous curved profile for general applications such as mineral sands. For feeds containing a low percentage of heavy minerals a profile that has a less acute slope on the inner trough section than the outer should be suitable because it enables tailings and middlings to be treated on separate trough slopes. Flat bottomed profiles have a reduced pitch resulting in a low velocity and perform well with fine particles. The radius of the spiral appears arbitrary but the larger the diameter the finer the material a given spiral will treat. Spiral performance is also dependent on the feed rate, trough profile and pitch.

Spirals can have from 3 to 10 turns depending on the application. Generally the more difficult an operation is, the more turns are required (Sivamohan, 1984).

Feed variations such as grade, percent solids, flow rate and particles size distribution will affect spiral performance.

From testwork done by Dallaire et al. (1978) with a Humphreys spiral processing iron ore it can be seen that percent solids and feed rates have a marked effect on recovery and grade (Figures 2.6 and 2.7). Low flow rates and high percent solids yielded maximum recovery. Grade improved and recovery dropped due to the high centrifugal forces that kept the middlings and fines from the concentrate ports when feed rates were increased. Hindered settling improved when the percent solids were increased, resulting in improved grades, but a slight decrease in recovery.

Dallaire et al. (1978) also tested various coarse sizes, from 840 μm (20 mesh) to 1680 μm (10 mesh). The 840 μm feed gave the best recoveries. This was attributed to coarse, heavy particles preventing the fine, heavy particles from being carried upward by the rising currents in the inner regions of the spiral trough (Figure 2.7). As would be expected, concentrate grade improved as particle size decreased. The improved cleaning action of wash water progressively removed coarser, less liberated particles.

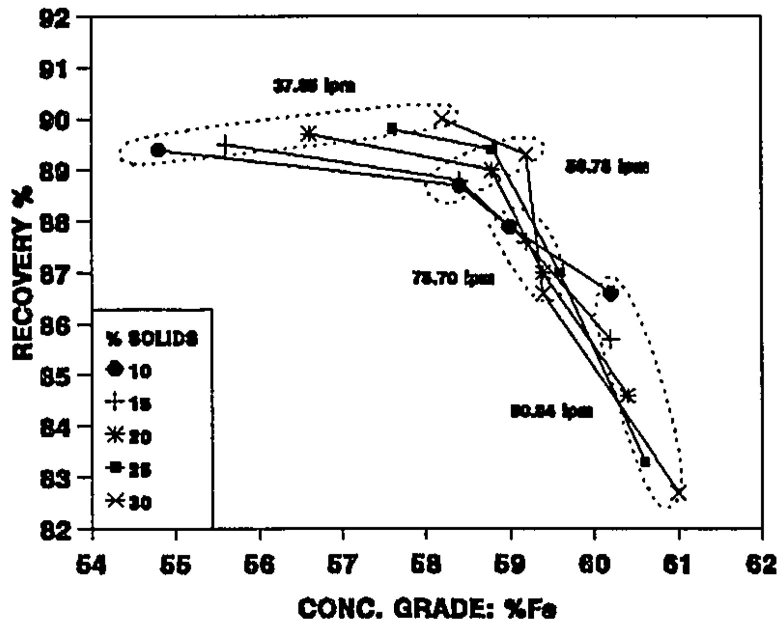

FIGURE 2.6: Performance at Different % Solids and Feed Rates (Dallaire et al., 1978)

Feed grade was found to be an important factor because surplus heavy minerals (middlings) could not find their way to ports, decreasing recovery and concentrate grades if the spiral were overloaded (Figure 2.8).

One limitation of this work is that the impact of feed size and grade was determined at specific operating conditions, without optimizing either feed density and flow rate, or splitter position. Attempting to mimic sudden and frequent feed changes which occur in plant operations would make these adjustments impossible. Results at optimized conditions may well be different.

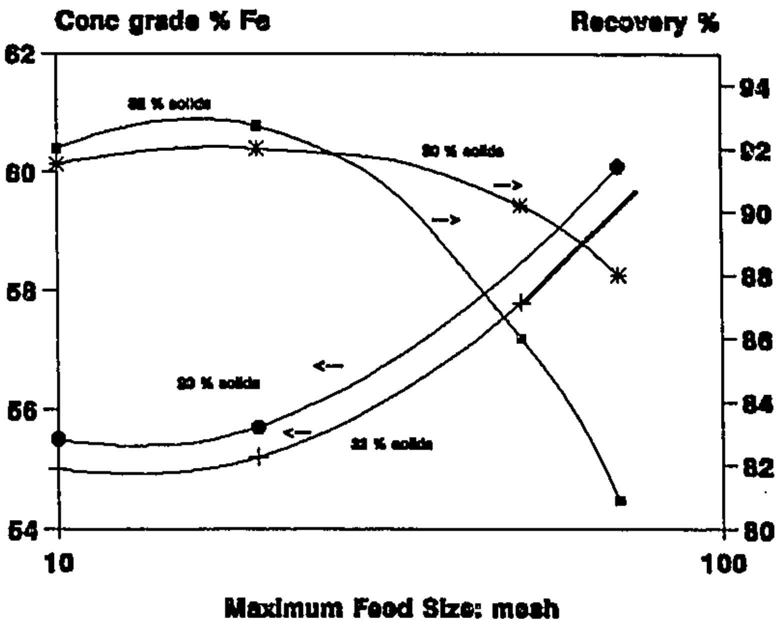

FIGURE 2.7: Grade and Recovery vs Particle Size at 76 l/min (Dallaire et al., 1978)

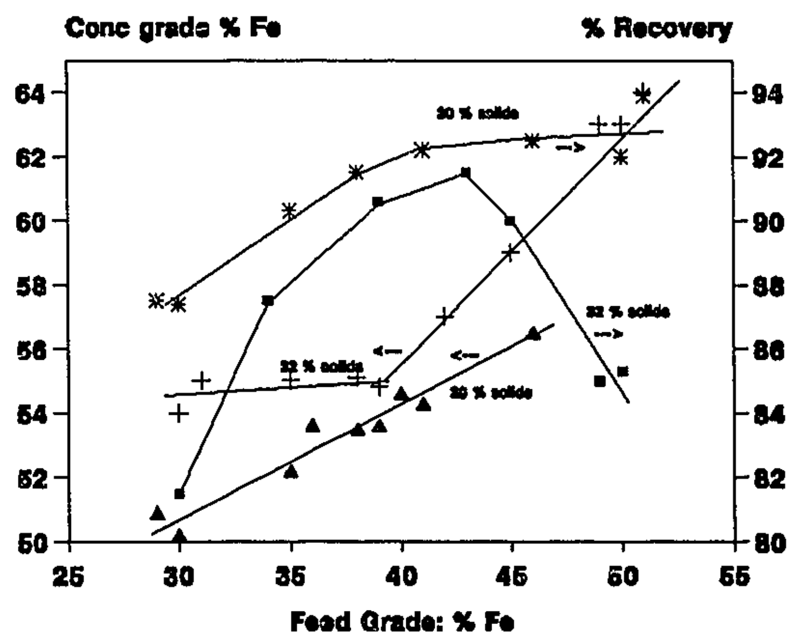

FIGURE 2.8: Grade and Recovery vs Feed Grade at 75.7 lpm (Dallaire et al., 1978)

2.4.2 Jigs

Jigging is one of the oldest methods of gravity concentration yet its principles are still not completely understood (Wills, 1988). It is used to concentrate a fairly wide range of material, from 200 mm to 0.1 mm (Figure 2.9).

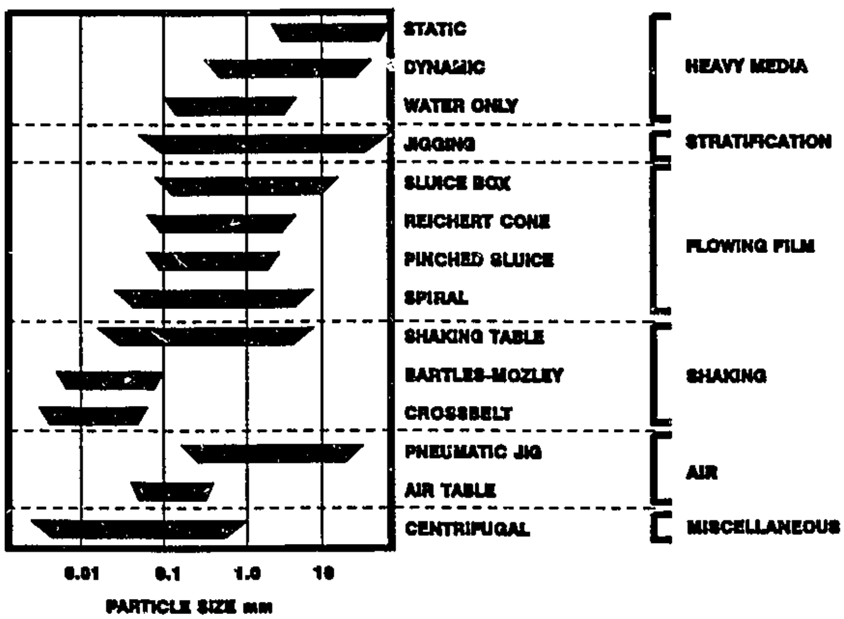

FIGURE 2.9: Operating Range of Gravity Concentrating Units (modified from Burt, 1984)

Separation of minerals of different specific gravity by jigging occurs in a fluidized bed by a pulsating current of water which produces stratification. The pulsation stroke allows the mineral bed to be lifted as a mass and then dilated as the velocity decreases, while the suction stroke slowly closes the bed. The purpose of jigging is to dilate the bed of minerals and control the dilation so that the heavier, smaller particles penetrate the interstices of the bed and the larger high specific gravity particles fall, and stratification occurs. Stratification is also affected by the length, frequency and cycle pattern of the jig stroke. The secondary function of the jig is to separate the stratified layers into two discrete products (Burt, 1984).

There are four mechanisms that control the mineral stratification in the jigging process: differential acceleration at the beginning of fall, hindered settling, attainment of minimum potential energy, and interstitial trickling (Burt, 1984), as shown in Figure 2.10.

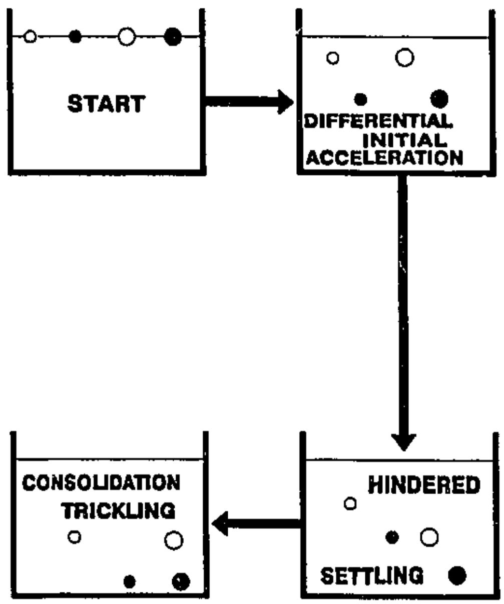

Figure 2.10: Jigging process (Wills, 1988)

The particle bed dilates and moves upwards until the velocity is reduced to zero during the upward stroke of the jig cycle. At that instant particles can be considered as starting to fall from rest with initial accelerations, and hence velocities, which are functions of particle densities and independent of particle size. Two particles of different specific gravity will initially have an acceleration ratio dependent on their densities and independent of their size. Thus their initial velocities would be different although their terminal velocities would be equal since the particles settle equally. If the repetition of fall is frequent enough and the duration short enough the distance travelled by dissimilar particles will depend upon their initial accelerations rather than their terminal velocities, resulting in stratification on the basis of specific gravity (Gaudin, 1939).

Hindered settling in a jig can only take place if the pulp has a high density. Therefore particle rearrangement is limited to the short period of time when the bed is dilated.

Attainment of minimum potential energy levels is a theory proposed by Mayer, 1964 and Van Koppen, 1966. According to their theory, a bed of particles in an undisturbed state possesses a certain potential energy. If the bed is loosened (energy supplied by the jig stroke), mineral particles of different specific gravities rearrange themselves to attain a minimum potential energy in the system, i.e. stratification occurs. Actual physical contact between the loosened bed of particles must exist for the theory to apply since rearrangement to lower potential energies could not take place otherwise.

Cycles are made up of a pulsion and a suction stroke producing harmonic motion. Different portions of the jig cycle are deemed important by different people. Two extremes are described: Bird (1960) believes that separation takes place on the suction stroke; Mayer (1964) believes the suction stroke is not important in the separation process.

Burt (1984) describes how the length and frequency of the stroke are inter-related. For close-sized coarse feeds with a high proportion of heavies, the amplitude required is large (with a longer cycle time), while for fines, with a wide size range and low heavy mineral content the amplitude needed is smaller and the cycle time shorter. Also, for clean concentrate production, a compact bed is required. This is achieved with a short rapid stroke, while high recovery is obtained with a mobile bed achieved by long slow strokes.

Jig capacity varies depending on the jig configuration (rectangular or circular), ore feed size, and adjustments of stroke length and speed. Generally, capacity is described as the optimum throughput that produces an acceptable recovery and is determined by the area of the screen bed. Coarser grains can usually be fed in larger volumes than fine grains in relation to the area of the jig bed. Higher-density minerals can be fed in larger volumes also. Flat-grained particles tend to slow the concentration rate (Richardson, 1984), which is an important consideration for gold since particles have the potential to flatten during the grinding process.

Jig feed rates need to be constant because too much feed will dampen the jigging process while under feeding will waste energy and diminish its efficiency. It is also important to have a constant pulp density of the feed, typically 30-50% solids, a relatively constant pulp density is more important than its absolute value (Burt, 1984).

Hutch water addition is another important factor in jigging. Jigs treating coarse material require more hutch water than those treating finer material (Burt, 1984).

Jigs are used in many applications, especially for treating coal, alluvial deposits and coarse free gold in North American grinding circuits.

2.4.3 Additional Gold Operations That Use Spirals and/or Jigs

Jolu Gold Mine

Jolu is located about 140 km north of LaRonge Saskatchewan. Operations commenced in October of 1988 with 3 years of ore reserves at a production rate of 400 tpd (Kazakoff, 1990). Mineralization there consists mainly of pyrite, pyrrhotite, native gold, minor chalcopyrite and minor arsenopyrite. The average head grade is 0.40 oz/st.

The Jolu mill flowsheet gravity circuit consists of a ball mill discharge reporting to a cyclopak. About 60% of the cyclone underflow is pumped to a 24" X 36" Minpro duplex jig while the remaining 30% of the cyclone underflow returns by gravity flow to the ball mill (9' X 13'). Jig concentrate is upgraded on a 4' X 9' Wilfley table with two passes to a 55% gold product at 65% recovery. Jig tails report back to the ball mill.

Average gravity circuit unit performance data as reported by Kazakoff (1990) are as follows:

mill feed grade	0.40 oz/st
leach feed grade	0.14 oz/st
cyclone U/F (jig feed grade)	1.25 oz/st
jig recovery as jig conc	30 %
jig conc (table feed grade)	20 oz/st
table recovery	70 %
table conc grade	55 %
combined gravity circuit recovery	65 %

Maximizing gold recovery at Jolu requires the Minpro duplex jig to be operated just short of sanding in the beds and therefore requires judicious operator attention. Recovery is dependent on many factors including: gold particle size, pulsation frequency, stroke, water volume, injection timing, discharge density, feed grade, feed rate, shot thickness, condition of natural bed, and frequency of hutch dumping.

Gold particles in the 75-600 μm range give the best recoveries. The lowest recoveries are reported for the -75 μm fraction at 12%. Due to the -75 μm circulating load in the ball mill, the -75 μm particles account for up to 40% of the jig concentrate.

Pulsation frequency was preset by the manufacturer at 300 pulsations per minute.

The stroke is a very important parameter and was set at 0.4 cm. At 0.3 cm the bed will sand and at 0.5 cm recovery for gold fines drops.

Water volume is also a critical parameter. Excessive water will flush out the fines and too little water will sand out the beds.

The injection of water into the hutch must take place with the upstroke of the diaphragm. The downstroke deslimes the hutch feed. Generally the first hutch recovers the coarser gold and the second hutch recovers finer gold fractions flushed out of the first hutch.

Through operator experience it was discovered that the best gold recovery occurs at a discharge density of 55 to 56% solids. If solids density reaches 57%, the beds will sand.

Because jig feed rate must be kept constant, only a fraction of the cyclone underflow is used. Dilution water is added to regulate densities since a feed which is too viscous will inhibit settling rates of finer sized gold particles.

Shot thickness varies from 2 to 4 cm. A 0.2-0.6 cm natural bed about 25 cm deep forms over the shot. A relief slot was found necessary because the bed has a tendency to become too deep causing sanding. A back flush once a day and a thorough cleaning once a week to remove tramp steel is also necessary in order to eliminate sanding.

Through plant experience it was found that a continuous pull of the jig hutches worked best rather than dumping only when full. Jig concentrate is pulled continuously from hutch number one, and every second hour from hutch number two.

<u>Homestake Gold Mine</u>

The Homestake Gold Mine Operation is located in Lead, South Dakota. Due to economic pressures, Homestake started a full scale gravity pilot test program in March 1986 until May 1986 to increase plant production (Hinds, Trautman, and Ommen, 1989). Good results prompted them to approve a complete gravity circuit which was increasing gold recovery and increasing mill availability for increased tonnage by July 1987.

Homestake installed a Hazen-Quinn duplex 61 cm X 91 cm jig and Hazen-Quinn belt strake to each of their four grinding areas. A portion of the circulating load in the ball mill circuit, 44 tonnes per hour, is pumped to the jig. The jig concentrate flows onto a belt strake (ribbed belts that move slowly in the opposite direction to the ore flow) while the jig tails return to the ball mill. The belt strake concentrate passes by gravity flow to a Deister table while the tails return to the ball mill circuit. Table concentrate is held in a holding tank before further cleaning and refining while table tails are again pumped back to the ball mill.

Because of the heavy sulphide concentrate, the jig hutches are pulled on a continuous but controlled basis to avoid sanding. Jig feed consists of about

50% solids, with water addition to maintain a 40% solids discharge density.

Problems and concerns encountered in bringing the gravity circuit on stream were: the amount of downtime required to redress the jig bed, all the wire, nails and cable collected in the jig basket, selection of bearings used on the arm that controls the diaphragm to the jig hutches, slippage in the eccentric stroke adjustments, excessive wear of brass bushings, feed box, pipeline, pumps and valves, and line plugging due to abrasives in the sulphides.

To alleviate these problems, the jigs now have a basket arrangement which can be lifted out allowing another basket to be installed within minutes; a Deister table is used to separate the ragging from the wire, nails and cable; the initial bearing manufacturer was changed; a locking bolt has been installed to the eccentric; and the lubrication schedule has been improved.

The results of the recovery distribution by the individual treatment plants before and after the gravity circuit was installed are shown in Table 2.6.

Table 2.6: Percent Recovery Distribution Chart (Hinds et al., 1989)

PLANT	BEFORE	AFTER
South Mill	28.5	56.0
Vat Leach	53.3	32.0
C.I.P.	12.9	7.3
TOTAL	94.7	95.3

The overall gold recovery of 95.3% was obtained with the addition of the gravity circuit. Although this was the same recovery as 1984 (95.3%) an additional 408,000 tonnes of ore were processed.

Johnny Mountain Gold Mine

Johnny Mountain Gold Mine, owned by Skyline Resources, is located in Northern British Columbia about 60 km east of Wrangell, Alaska. Operations started in August, 1988.

The initial flowsheet consisted of a gravity circuit, copper flotation to produce a gold-bearing copper concentrate, cyanidation of float tailings to recover any remaining gold, and Merrill Crowe for recovery of dissociated gold (Armstrong, Cron and Melis, 1990).

Due to many problems during early operations, detailed by Armstrong et al.(1990), testwork was done which indicated that 50% of the gold could be recovered by gravity and the remainding 40 to 45% recovered by flotation.

Implementing the changes to the flowsheet, omission of filtration and leaching, and addition of the gravity/flotation circuit allowed the plant to reach a capacity of over 181 tonnes/day compared to 118 tonnes/day under previous operation. The gravity flowsheet consisted of primary ball mill discharge reporting to a duplex jig. The jig concentrate was upgraded on a rougher table and a final concentrate table. The jig tails proceeded to the primary cyclone in open circuit with the primary ball mill.

Gold gravity recoveries were only 15 to 30%; because laboratory testwork had indicated that higher gravity recoveries were possible, additional tests were carried out to identify the optimum gravity recovery. These tests were performed using a Knelson Concentrator, Falcon Concentrator and a Reichert Mark VII spiral with solids of 60-65% -75 μm as the flotation feed (primary cyclone overflow). Table 2.7 shows gold recoveries and yield of the three gravity units. Although gold recovery in the spiral and KC were about the same (42% and 41%, respectively), the spiral was much cheaper, resulted in minimum dilution of pulp and required minimum floor space. It was therefore incorporated into the circuit. A rougher spiral bank consisting of 12 Reichert Mark VIIA spirals, feeding a single stage Reichert mark VIIB cleaner spiral was introduced to the circuit.

Table 2.7: Johnny Mountain Gold Mine Results of Gravity Recovery Tests on the Cyclone Overflow Stream (Armstrong, Cron, Melis, 1990)

		KNELSON	FALCON	SPIRAL
GRAVITY CON	Weight %	4.6	1.6	4.9
	Au oz/st	5.14	8.58	3.95
	Ag oz/st	5.57	6.64	-
	% Au Rec.	41.3	29.6	41.8
TAILS	Au oz/st	0.35	0.33	0.29
	Ag oz/st	1.39	1.31	-
	% Solids	14	11	35
FEED	Au oz/st	0.57	0.46	0.47
	Ag oz/st	1.57	1.40	-

Only 2 to 12 oz of gold per day was recovered in the spiral cleaner concentrate compared to the anticipated 10 to 20% recovery of gold in the feed. Because of these low recoveries, additional changes were made. A cleaner middlings fraction, which consisted of 40% of the cleaner feed, was recirculated, improving spiral performance. Feed to the cleaner spiral now totaled one tonne/hour which is the rated capacity of the cleaner spiral. Spirals should not be underfed (Walsh, 1992). Addition of the spirals increased overall recovery by 3% (to 85 to 88%) with a final tail grade of 0.07 to 0.09 oz/st.

Through observation it was noted that the 200 μm gold particles reporting to the spiral concentrate were shaped much flatter than those reporting to the jig concentrate; it was concluded that flat particles of free gold are recovered by the spirals but not the jigs. The spirals recovered +75 μm free gold particles which may not float.

CHAPTER 3

TESTWORK AT THE LUCIEN BÉLIVEAU MILL

3.1 Description of the Lucien Béliveau (LB) Mill

The Lucien Béliveau mine and mill, solely owned and operated by Cambior Inc., are located 25 kilometres east of Val d'Or, Québec, Canada. Proven, probable and possible reserves totalled 1,352,000 t at 0.13 oz Au/st when milling was initiated in 1989 (Gignac et al, 1990). The deposit is characterized by quartz and tourmaline veins with inclusions of pyrite, arsenopyrite and native gold.

The mill processes approximately 1800 tpd, producing a gravity concentrate and a sulphide flotation concentrate. The 1800 tpd feed comes from two different sources: the Béliveau and the Chimo mines. The Béliveau mine provides 1,100 tpd of ore with free gold accounting for 90% of the total gold mineralization (70% +100 μm and 20% -100 μm). The remainder of the gold (10%) is associated with pyrite. Chimo ore provides 700 tpd where 85% of the gold is free milling (48% +100 μm; 37% -100 μm) and the balance (15%) is associated with arsenopyrite.

Underground ore is placed in a silo and is withdrawn by vibrating feeders discharging onto a conveyor belt. The conveyor belt feeds a 6 X 3 metre (20 X 11 ft) semi-autogenous grinding (SAG) mill in a continuous circuit with 52 centimetre (29 inch) primary cyclones. The cyclone underflow (CUF) feeds a ball mill. The ball mill discharge (BMD) is fed to a flash flotation cell for gold recovery. Concentrate from the flash cell, free of tramp iron (a beneficial side effect), is fed to a Knelson Concentrator (KC) operated on a four hour cycle for coarse gold removal. Concentrate from the KC proceeds to a Deister table where gold is further upgraded. Tailings from the KC continue to a cyclone for dewatering, while the CUF is further dewatered in a thickener prior to filtration. The cyclone and thickener overflows are recycled as process water. The primary cyclone overflow (COF), at 65% passing 75 μm, flows by gravity to a conditioning tank and continues to seven Denver 300 flotation cells. The rougher concentrate is further cleaned twice in seven Denver 24 cells. The pyrite concentrate is then directed to the same thickener as the KC tailings. Trucks haul the concentrate to the Yvan Vézina Mill, located 40 kilometres north of Rouyn-Noranda, to be eventually mixed with Yvan Vézina ore feed in cyclone feed pumps. The pyrite concentrate is then reground to 90% passing 75 μm and cyanided in six highly-agitated leach tanks for approximately 30 hours. A carbon-in-pulp circuit follows.

When the Lucien Béliveau concentrator was visited for the second time, changes had been made to the gravity circuit because of mechanical difficulties with the 76 cm plant Knelson Concentrator (PKC). The flash flotation cell concentrate fed a hydroclassifier for thickening and sizing. The hydroclassifier underflow (ThkUF) fed a spiral (Mineral Deposits, HG 7) for coarse gold removal. During some of the tests (T7, T8, T9) the flash flotation cell concentrate was directed to an open circuit secondary ball mill for regrind before continuing to the hydroclassifier. Spiral tailings (SpTls) and hydroclassifier overflow (ThkOF) fed a 56 cm PKC for residual gold removal. PKC concentrate and spiral concentrate (SpC1&2) proceeded to the Deister table where gold was further upgraded. Tailings from the PKC were treated as before.

3.2 Objectives

The objectives of this testwork were to:

- characterize the behaviour of free gold in the circuit
- assess the impact of a hydrosizer and spiral combination
- provide data to compare direct gravity recovery to flash flotation with gravity recovery.

3.3 Sampling Procedure

In both sampling campaigns samples were taken around the grinding and gravity circuit of the Lucien Béliveau mill every half hour for four hours in order to characterize a full cycle of the Knelson Concentrator.

3.3.1 Sampling Procedure 1

During the first sampling campaign the gravity circuit samples consisted of KC feed and tailings samples which were combined in one-hour composites. The KC tailing samples were taken at the underflow of a dewatering cyclone rather than directly at the KC discharge. At the end of the four-hour recovery cycle, the KC was stopped and the concentrate discharged, a process which takes approximately ten minutes. Forty to fifty cuts were taken and combined into a KC concentrate sample. The flowrate of the KC feed was measured twelve times throughout the four-hour cycle.

All other samples were four-hour composite samples from the SAG mill discharge (SMD), ball mill discharge (BMD), individual cyclone underflows (CUF1, CUF2), and a combined cyclone overflow (COF)[5].

All samples were weighed wet, filtered at Lucien Béliveau and

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[5]Individual cyclone overflows could not be sampled.

transported to CANMET (Ottawa) and McGill University (Montréal). The samples were then oven dried, weighed, and their percent solids calculated. A portion of all samples was wet screened at 38 μm, oven dried, and dry screened over size ranges of 600 μm to 38 μm for initial size distributions. Details are located in Appendix A.

A 7.5 cm laboratory Knelson Concentrator (LKC) was used to further upgrade all samples to assess their size-by-size total and free gold content. Samples were prescreened at 2 mm and processed in the LKC at a feed rate ranging from 36 to 308 g/min. For the KC feed and tails samples, the LKC was fed around 5% nominal capacity (40 g/min) to simulate plant conditions (where the KC was fed at 5% capacity). Pressure of the water jacket on the KC ranged from 21 to 28 kPa (3-4 psi), finer feed requiring less pressure. For each LKC test, four tailings samples were collected and weighed to determine if feed and water flow remained constant. The tailings samples were then combined for screen analysis. The concentrates were also collected, dried, weighed and screened.

KC tailings (KCTls) and concentrate (KCC) samples were wet screened at 38 μm and dry screened from 38 μm to 600 μm. All screen fractions were assayed to determine gold content (all of the KC concentrate mass and part of the tails mass).

When processing the KCC, all gold flakes plainly visible above 600 μm were weighed to determine the size of gold particles that report to the bowl of the KC.

3.3.2 Sampling Procedure 2

After an initial four-hour sampling campaign (T2), similar to the one described above, six additional tests were completed: three around the spiral (T3, T4, T5) and three around the 56 cm PKC (T7, T8, T9). Deister table tailings were also sampled (T6) and brought back to McGill for additional testwork.

During T2 the plant feed rate was 80 t/h and the SAG mill operated at 87 kW. Half of the feed was Chimo ore and the remainder was Béliveau. Grinding circuit samples, other than those described in the previous section, consisted of the spiral feed (SpF 1&2), tails (SpTls 1&2), and concentrate (SpC1, taken after 3 turns) which was sampled for eight minutes. Concentrate two (SpC2, taken at the bottom of the spiral) was sampled for 16 minutes. The spiral feed flowrate was repeatedly measured throughout the sampling period.

The hydroclassifier underflow (ThkUF) was adjusted for tests T3 to T5 to evaluate the spiral performance at varying feed rates and densities. Test 3 feed rate was set to the highest level, test 4 to the lowest level and test 5 was held in the original position. All spiral feed flow rates were also repeatedly measured. The spiral tailings and two concentrates were sampled for each test. Concentrate one was sampled eight times for one minute while spiral concentrate two was also sampled eight times, but for two minutes.

Knelson efficiency at different pressures was examined in tests T7 to T9. The pressure on the KC was kept at the normal operating pressure of 100 kPa (15 psi), 4.7 L/sec (75 USGPM, Signet ultras meter) for T7, reduced to 83 kPa (12 psi), 4.0 L/s (63 USGPM) for T8 and further reduced to 55 kPa (8 psi), 2.5 L/s (40 USGPM) for T9. A secondary grinding mill to regrind the flash flotation concentrate was in operation during the test period. Again, spiral flow feed rates were repeatedly taken for T7, T8, and T9. Thickener overflow rates were also measured for T7 and T8. Samples for T7 included secondary ball mill discharge (SBMD), TKOF, TKUF, SpTls, Knelson tailings (KTls), SpC1 and SpC2. Test T8 samples collected were SBMD, TKOF, TKUF, SpTls, and KTls. For T9, three SpTls and three KTls samples were taken. The spiral tails and hydrosizer overflow were sampled because these streams make up the Knelson feed, which could not be sampled directly.

All samples were treated as previously described in the first sampling campaign before processing with a LKC. A 7.5 cm LKC was used to further upgrade all samples to assess their size-by-size total and free gold recovery. Samples were prescreened at 2 mm. Grinding circuit samples were fed directly to the LKC, but gravity circuit samples were first diluted (4:1) with 210 μm silica (70 mesh silica from Indusmin). In some cases, 841 μm (20 mesh) silica was used. Feed rates to the LKC ranged from 200 to 500 g/min with an average rate of 327 g/min. Pressure of the water jacket ranged from 21 kPa (3 psi) to 35 kPa (5 psi). Four to five LKC tailings samples were taken during each LKC test to assess if feed and water flow remained constant. These samples were then oven dried, weighed, and combined for further processing. At the end of the test run LKC concentrates were collected from the Knelson bowl, oven dried, and weighed. Detailed test results are shown in Appendix B.

LKC tailings and concentrate samples were then wet screened at 25 μm and 38 μm. Once the oversize fraction was oven dried it was screened from 600 μm to 25 μm. Part of the tailings and all of the concentrate from the screen fractions were then fire assayed for gold.

3.4 Results and Discussion

The density of the samples in T1 was typical of normal grinding circuit operation excluding the two ball mill discharge samples whose density during the first two hours was 18%, and 32% solids during the last two hours. Sample densities are listed in Appendix A. Neither density is plausible; the anomalies may have been due to sampling errors, circuit instability, or excess water added in the trunnion (the normal practice at Lucien Béliveau is to add water in the trunnion to dilute to about 45% solids). The 18% solids sample was discarded because of its small mass. The two CUF samples were well matched at 73% solids and 71% solids respectively. The KC feed samples fluctuated from 7% solids to 17% solids but became more consistent during the second half of the sampling campaign. The KC tailings samples were very consistent, measuring 14% solids on average.

During the second sampling campaign, T2, two separate samples were extracted from the grinding circuit streams over the four-hour period, in order to clarify inconsistent results obtained during the first test period T1, in 1991. The first sample was collected over the first two hours of the KC loading cycle, and the second sample over the remaining two hours. T2 results show very consistent densities in the grinding circuit, suggesting stable operation. BMD1 and BMD2 samples were 30% and 31% solids, respectively, while SAGD1 and SAGD2 were both at 43% solids. CUF1, which returns to the SAG mill, had solids at 41%, as did CUF 2, which returns to the ball mill. Densities in the hydroclassifier underflow varied from a high of 19% solids for test T4 (hydrosizer valve closed one turn) to 13% solids for test T3 (hydrosizer valve opened one turn). Spiral tailings percent solids were all consistently lower than the feed solids due to wash water addition to the spiral. Knelson feed samples ranged from 6% solids in test T2 to a more consistent 10% solids in tests T7, T8, and T9. Because Knelson tailings samples are taken from a cyclone underflow stream they tend to have percent solids higher than or equivalent to that of the Knelson feed samples. If the Knelson tailings could be sampled directly from the Knelson Concentrator their percent solids would be very low due to water addition to the Knelson to create a fluidized bed.

3.4.1 Grinding Circuit

Sag Mill Discharge

SMD samples were processed in the LKC at a pressure of 28 kPa (4 psi) and a feedrate of 200 to 360 g/min.

The SMD grade (T1) was 0.34 oz/st, suspiciously high, and more than double that of the two samples from T2, which were 0.13 oz/st and 0.16 oz/st. During T2 the Lucien Béliveau orebody was near depletion, accounting for the lower grades. As for size-by-size assays, the largest difference was below 53 μm. Average gold recovery of T1 was low at 27% while T2 recoveries were much higher at 68% and 76%. Size-by-size recoveries for T1 were poor in all size classes, especially below 38 μm where recovery plummeted to 9%.

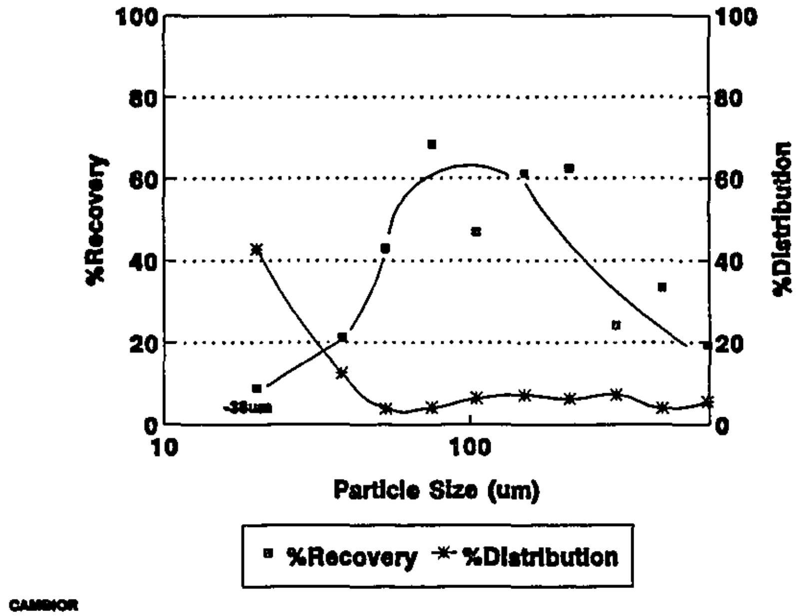

FIGURE 3.1: Test T1, Size-by-Size Recovery and Gold Distribution for the SAG Mill Discharge

Size-by-size recoveries in T2 were much better; all size classes above 38 μm had excellent recoveries as shown in Figures 3.2 and 3.3. Below 38 μm recovery dropped, but not as substantially as in T1. Recoveries below 25 μm (where the LKC reaches its mechanical limitations) dropped further to 18% and 27%. Non-liberated gold may also have been a factor contributing to the decreased recoveries. Since much of the gold in the SMD comes from the circulating load, it is also very plausible that much of the fine liberated gold was floated by the flash cell. The lower grade of the -25 μm strongly supports this.

Gold distribution was very different between the two tests. Test T1 had 43% of the gold below 38 μm while in T2, the majority of the gold was concentratred between 210 μm and 595 μm (55% and 64%, respectively). The size-by-size mass processed for all three samples was comparable.

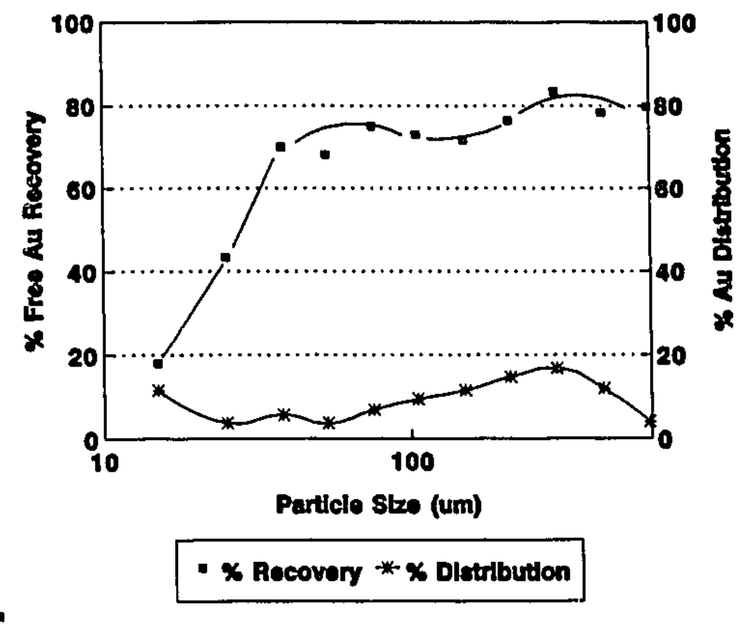

FIGURE 3.2: Test T2, Size-by-Size Recovery and Gold Distribution for the SAG Mill Discharge During the First Two Hours of Sampling

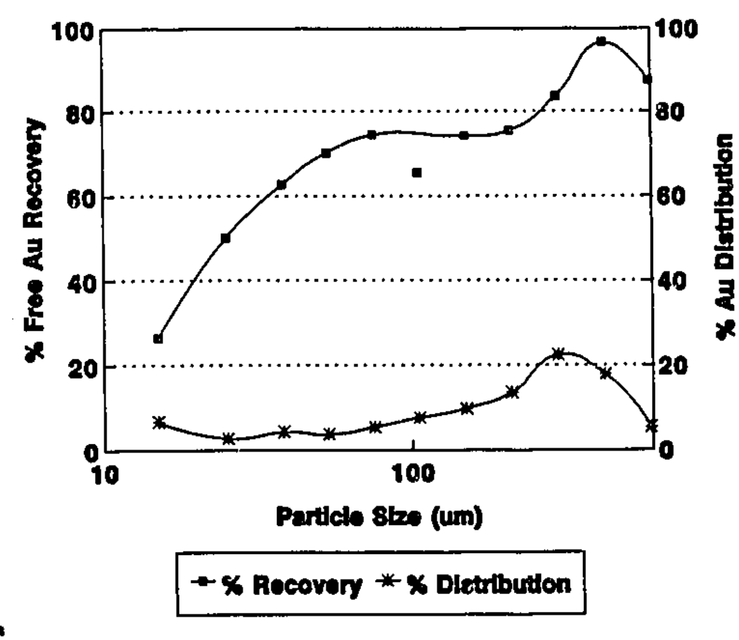

FIGURE 3.3: Test T2, Size-by-Size Recovery and Gold Distribution for the SAG Mill Discharge During the Last Two Hours of Sampling

It appears the high tailings grade in most size classes in T1 accounts for the low recovery and high feed grades. Test T2 results appear more plausible than test T1, especially since the redundant samples (hours 1&2 vs hours 3&4) are very similar. During the sampling period for test T1 the mill had only recently started, and that fact may explain the suspicious results.

Ball Mill Discharge

For test T1, the BMD sample had relatively little mass so the feedrate to the LKC was low (36 g/min) compared with test T2 where sufficient mass allowed for a feedrate averaging 326 g/min (two BMD samples were obtained, one for the first two hours, and another for the last two hours of the four-hour sampling cycle). Details of the LKC tests are located in Appendix B.

Due to the small mass processed, test T1 results are questionable: calculated grade was high (0.41 oz/st), free gold recovery was low (20%), and size distribution was atypical. Consequently, the focus of the BMD discussion will be on the two T2 tests.

Calculated grade for the first two hours of T2 was 0.29 oz/st and then it dropped off to 0.21 oz/st during the last two hours. Recovery, on the other hand, increased from 44% to 58% during the sampling period. A finer feed (45% vs 38% -53 μm) during the first two hours may account for the poorer recoveries during that time. Recoveries were above 90% in the +297 μm fractions and dropped off gradually down to 40 μm where a sharp decrease resulted in recoveries of only 10 and 16%. The drop in recovery was more pronounced during the first two hours of sampling. Figures 3.4 and 3.5 show a dip in recovery (in both cases) in the 105-297 μm fraction which is the range where the flash flotation cell is recovering its coarsest gold. The second dip in recovery occurs in the 38-105 μm fraction where the flash flotation cell appears to recover sulphides. This dip is more dramatic during the first two hours of sampling indicating that the flash flotation cell may have been recovering more sulphides at that time. Recovery below 25 μm was very poor at 2-4%.

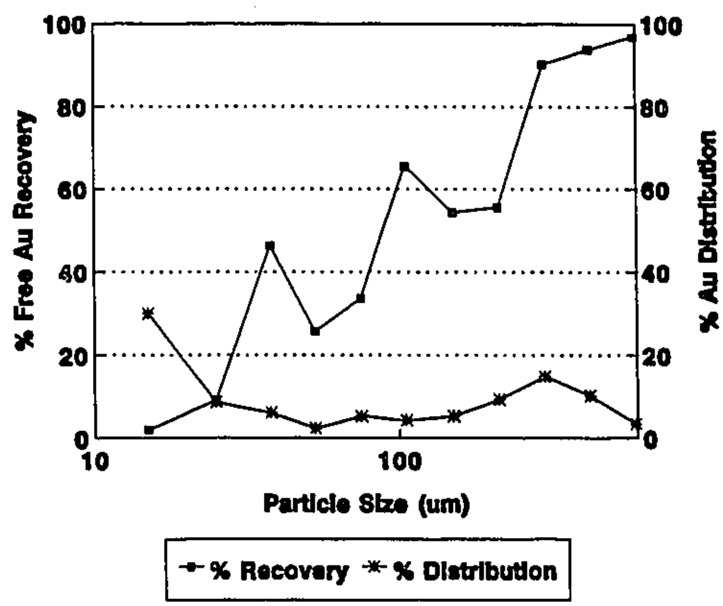

FIGURE 3.4: Ball Mill Discharge 1 (T2), Size-by-Size Recovery and Gold Distribution During the First Two Hours of Sampling

The -25 μm fraction contained the largest amount of gold at 30% and 27%, where (as previously mentioned) recovery was poorest. Most of the remainder of the gold appeared in the 105-590 μm range, 40% and 48% for the two samples, respectively. In both cases, low tail grades in the coarse fractions indicate good gold liberation, but the increase in tail grade in the fine size classes demonstrates that the gold may still be associated with pyrite below 38 μm. The coarse liberated gold is largely removed by the flash cell before it is ground to -38 μm.

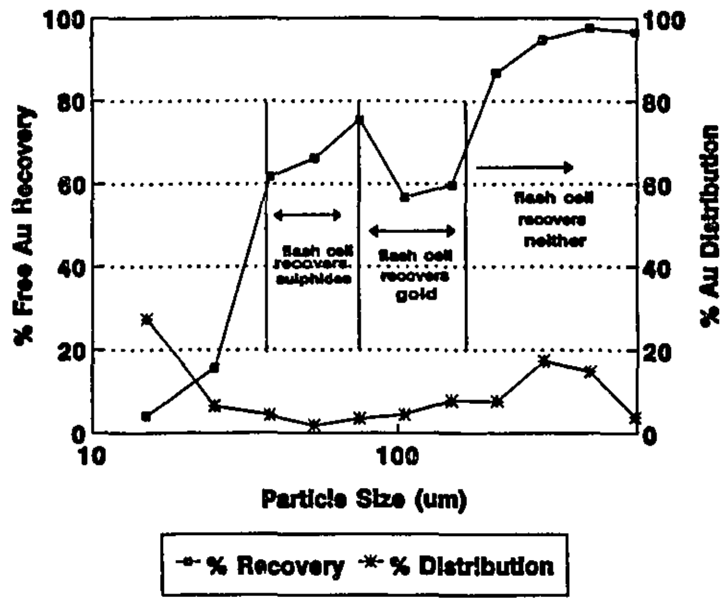

FIGURE 3.5: Ball Mill Discharge 2, (T2) Size-by-Size Recovery and Gold Distribution for the Last Two Hours of Sampling

Cyclone Underflow

Cyclone underflow 1 feeds the SAG mill while CUF 2 feeds the ball mill. Both underflows were sampled over the four-hour sampling cycle in tests T1 and T2. All samples were processed in the same fashion with the LKC. Details are found in Appendix B.

CUF2 (T1) had almost double the grade (0.30 oz/st) of the CUF1 (T1), (0.17 oz/st Au). This is a very significant difference, which may be due to asymmetrical piping of the cyclone feed, a known cause of severe differences in the feed of parallel cyclones (Mular and Bates, 1971). In test T2 the differences in calculated feed grade were also noticeable although in this case CUF1 was higher than CUF2, (0.30 and 0.24 oz/st respectively).

Calculated gold recoveries also show differences between the cyclone underflows. In test T1 recoveries are 54% for CUF1 and 71% for CUF2 while in test T2 recoveries are 62% for CUF1 and 73% for CUF2. These differences confirm the fact that the two cyclones were not working in the same way or were not fed exactly the same material.

Although the two cyclone underflows appear to be acting differently for both tests, their size distribution within their respective tests are identical, within experimental error. Comparing the size distribution of T1 and T2, it can be seen that T1 is coarser (66% above 105 μm for T1, and 58% above 105 μm for T2). This also holds true below 38 μm where 13% of the mass is located in T1 and 15% of the mass is located in T2. The difference in size distribution between the two tests is not large, but reveals a difference in feed material or operating conditions.

Size-by-size gold recoveries for the CUFs were markedly different within their respective tests. In T1, the largest difference in recovery occured below 53 μm where CUF1 recovery averages 40% while CUF2 recovery averaged 82%. A large difference in recovery also occured above 590 μm (65% and 22% respectively), but since there was little mass or gold distributed in

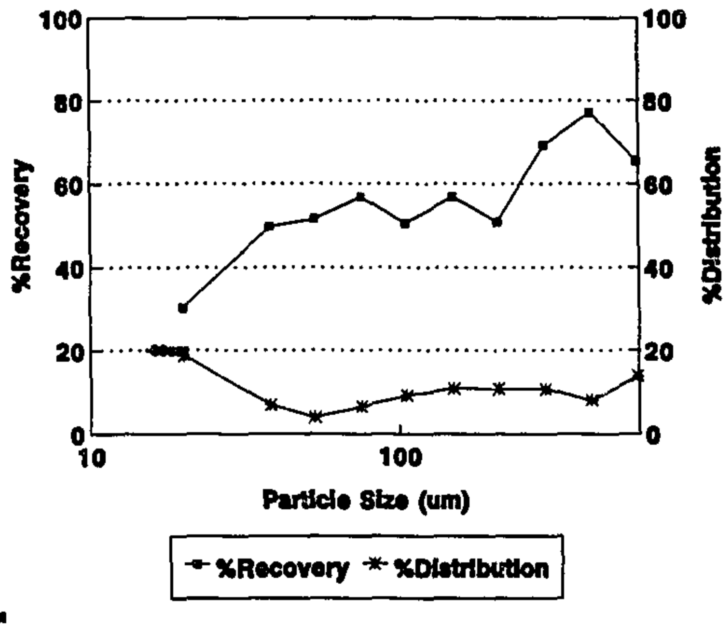

FIGURE 3.6: Cyclone Underflow 1 (T1), Size-by-Size Recovery and Gold Distribution

this class it is not so significant (Figures 3.6 and 3.7). In test T2 size-by-size recoveries were very constant between CUF1 and CUF2 above 38 µm (Figures 3.8 and 3.9). Below 38 µm, recoveries drop sharply with CUF2 having a slightly lower drop than CUF1 (CUF1 recovery dropped from 55% above 38 µm to 9% below 38 µm while CUF2 recovery dropped from 62% to 18% in the same size range).

Gold distribution was different in all four CUFs. In test T1, the -38 µm of both products contained a similar proportion of the gold (19% vs 20%), while CUF1 contained more coarse (+210 µm) gold. In test T2 gold distribution was very similar in both underflows in all the size classes excluding the finest fraction and the 420-590 µm fraction. The CUF2 had almost twice the gold distribution as that of CUF1 at 420-590 µm (22% vs. 13%) while CUF1 had over double the gold distribution below 25 µm (18% vs. 8%).

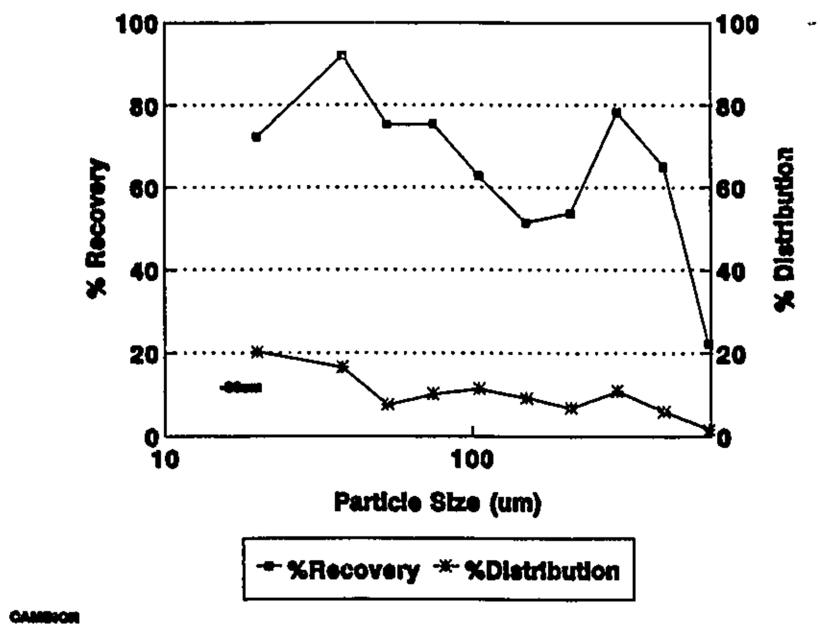

FIGURE 3.7: Cyclone Underflow 2 (T1) Size-by-Size Recovery and Gold Distribution

For test T1, the LKC tailings grades for the two CUFs were comparable at 0.08 and 0.09 oz/st, even though the feed grade in all size classes of CUF2 were higher. The most significant differences in feed grade occured in the finer fractions (-75 μm). These differences in feed grade account for the differences in recovery between the two CUFs. In test T2 the LKC tail grade of CUF1 was double that of CUF2 (0.12 vs 0.06 oz/st). The differences occur at 25-38 μm where the CUF1 grade (1.26 oz/st) was twice as high as the CUF2 grade (0.61 oz/st), and below 25 μm, where grades are 0.41 oz/st (CUF1) and 0.14 oz/st (CUF2).

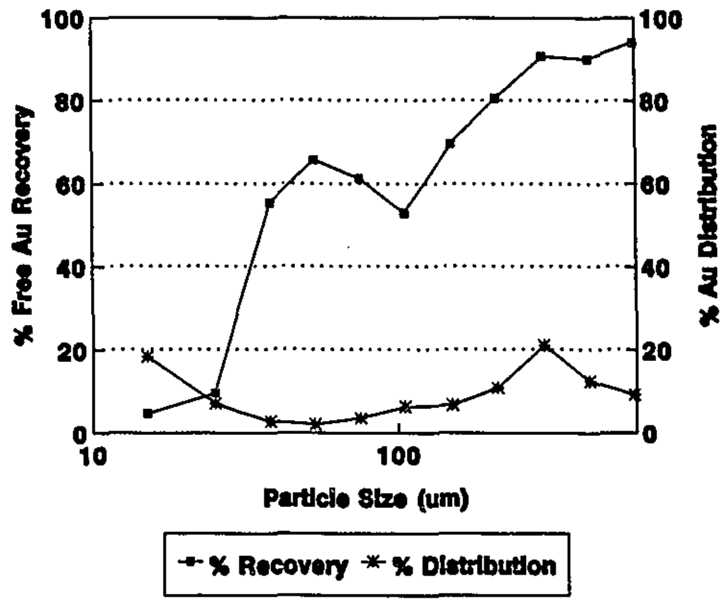

FIGURE 3.8: Cyclone Underflow 1 (T2) Size-by-Size Recovery and Gold Distribution

The results from tests T1 and T2 differ from those of Camchib, where two 38 cm cyclones are also operated in parallel, but gold distributions and LKC recoveries are very similar (Laplante & Shu, 1992).

Discharge streams from the ball mill and cyclone underflows have substantial coarse, liberated, gravity recoverable gold that is not recovered by the flash flotation cell and therefore would be ideal candidates for some form of gravity separation.

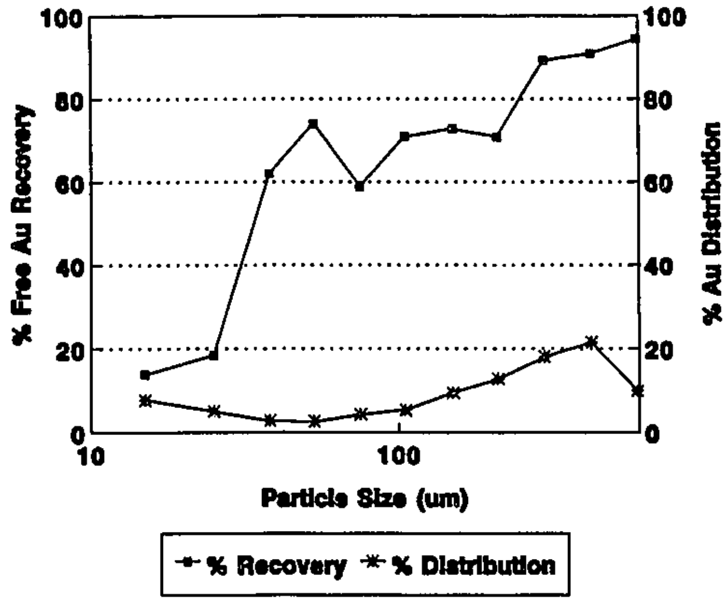

FIGURE 3.9: Cyclone Underflow 2 (T2) Size-by-Size Recovery and Gold Distribution

Cyclone Overflow

Feedrate to the LKC was lower for the COFs because of the finer size of particles. Results show that the calculated feed grade for T1 was abnormally high for the COF (0.32 oz/st). An expected grade would be in the range of 0.05 to 0.09 oz/st. In test T2 the grade was more typical at 0.05 oz/st.

Calculated gold recovery for tests T1 and T2 was very typical of cyclone overflow recovery when processed with a LKC; both were 20%. Liu (1989) obtained similar recoveries at Camchib.

Size distributions were very similar for both tests, showing 61% of the mass was located below 38 μm in T1, compared to 56% in T2.

Size-by-size gold recovery in T1 was high above 105 μm, at 81%, but then took an unusual drop below 75+38 μm to 7%, only to increase to 20% below 38 μm. Random errors cannot explain this dip, but fine gold may be present in pyrite and liberated only in the finer size class. This phenomenon did not occur in T2, but instead, recovery was good in the coarsest fraction (210 μm), at 85%, but then dropped to less than half that value (42%) in the 150 μm size. Below 75 μm recoveries were in the single digits, decreasing from 9% to 6% below 25 μm (Figures 3.10 and 3.11).

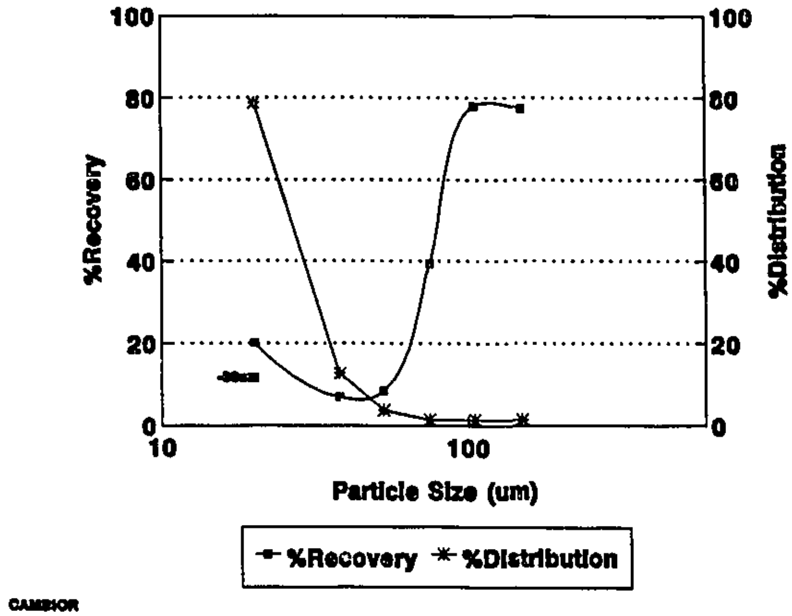

FIGURE 3.10: Cyclone Overflow (T1) Size-by-Size Recovery and Gold Distribution

The majority (79%) of the gold in T1 was distributed below 38 μm, which greatly influenced the overall recovery. Very little gold (3%) was distributed above 105 μm where recovery was high. Test T2 gold distribution was very different from that of T1 where only 52% of the gold was below 38 μm. T2 exhibited more gold (12%) above 210 μm, and below 53 μm (68%). Unfortunately recovery was low where most of the gold is distributed.

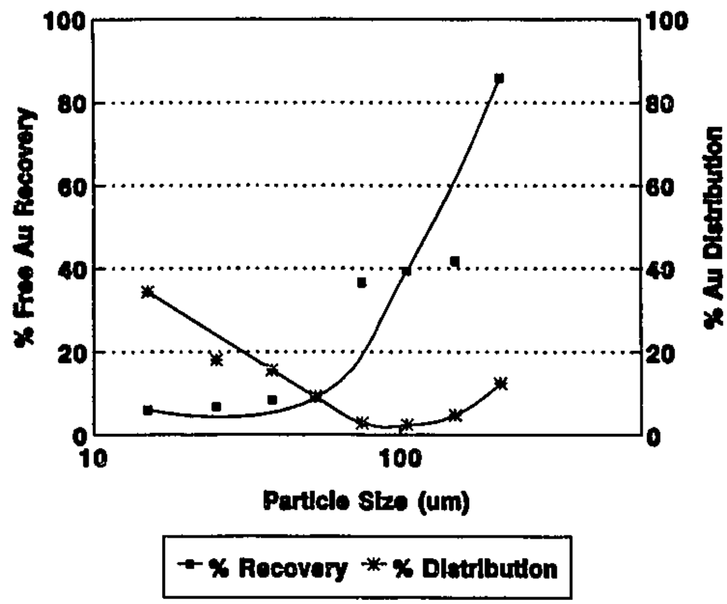

FIGURE 3.11: Cyclone Overflow (T2) Size-by-Size Recovery and Gold Distribution

Grinding Circuit Mass Balance

The NORBAL2 software (Spring, 1985) was used to balance the size distribution of gold, size by size, in the grinding circuit. NORBAL2 uses non-linear mass conservation equations to achieve a hierarchical decomposition that separates mass balance problems into smaller elements. Each component of the decomposition is described as a least squares problem under constraints and is solved by the Lagrange multipliers method. As an example, if a circuit contains four streams (primary mill discharge, PMD, secondary mill discharge, SMD, primary cyclone overflow, PCOF, and a primary cyclone underflow, PCUF) corresponding to one node, the twelve constraints for the mass conservation of twelve size classes (pan included) can be expressed by:

$$\sum_{i-1}^{11} W(1,i)C(1,i)+LW(2,i)C(2,i)-W(3,i)C(3,i)-LW(4,i)c(4,i)....-0$$

where

W(j,i) = percent retained on screen i (i=1 to 12) in stream j (j=1 to 4)

C(j,i) = gold content of the size class i of stream j

L = circulating load

In order to adjust the size-by-size assays, a Lagrangian formula is used (Smith & Ichiyen, 1973):

$$\underline{dc} = -VB'(BVB')^{-1}B\underline{c} \qquad (3.1)$$

where

$\underline{dc}$ = 48 X 1 column matrix of the grade adjustments

V = 48 X 48 diagonal matrix of the variances

B = 14 X 48 matrix expressing the mass balance constraints (from NORBAL2)

$\underline{c}$ = 48 X 1 column matrix of unadjusted grades

The balanced grades will be equal to:

$$\underline{C} = \underline{dc} + \underline{c} \qquad (3.2)$$

where

$\underline{C}$ = 48 X 1 column matrix of the adjusted grades

After obtaining the adjusted ore size distribution, size-by-size grades, and overall grade, the gold size distribution can be estimated by:

$$Gold(\%) = [Weight(\%) * Grade] / [Overall\ grade] \qquad (3.3)$$

For test T1 measured pulp mass flow rate values were utilized for SAG feed and FLCC samples, while other stream estimates were based on previous data with appropriately large standard deviations as shown in Appendix D. Assay data were supplied from KC laboratory testwork values. Some discrepancies occurred due to sampling errors, especially for the assay data. Circuit instability is also thought to have affected the mass balance results. Assay data required large adjustments because of the unexpected differences between the CUFs and the high COF assay. Fractional size distribution required little adjustment, suggesting that steady state for size distribution had been reached. A typical (according to the Lucien Béliveau staff) circulating load of 300% was calculated for the grinding circuit. Because of the larger gold circulating loads and possible fluctuations in head grade, it is quite possible that steady-state was reached for the ore but not for the gold.

For test T2, pulp mass flowrate was once again measured and used for SAG feed while other stream estimates were based on previous data with appropriately large standard deviations. Assay data were supplied from LKC testwork values. In this case, assay data, fractional size distribution data and assays of size fractions required little adjustment, suggesting that the circuit was in steady state during the sampling period. The ore circulating load was lower than in test T1, at 203%. Back calculating the feed grade (0.11 oz/st, which is reasonable, considering that the ore is from the Chimo deposit) results in a gold circulating load of 306%. The low gold circulating load suggests that the flash cell is recovering much of the gold.

3.4.2 76 cm Plant Knelson Concentrator

Plant KC Feed

Flash flotation concentrate, which serves as plant KC feed, was fed to the laboratory KC at a rate varying from 120 g/min to 200 g/min (details of the LKC tests are shown in Appendix B), well below the flowrate where recovery begins to drop (Shu, 1991). Slurrying water flowrate was low on the first sample (0.2 vs 0.7 L/min average), but because most of the water is added to fluidize the bed, tails flowrate was largely unaffected. Four individual feed samples were tested, corresponding to the four hours of testwork in the plant. All parameters were held constant when performing tests on the laboratory KC using similar samples.

Average recovery of the plant KC feed was 50%. Recovery of the plant KC feed dropped from 59% for the first hour to 44% for the fourth or last hour as shown in Figure 3.12. Particle size also dropped during the four hour cycle; feed grade to the KC increased slightly with values of 5.11 oz/st, 5.43 oz/st,

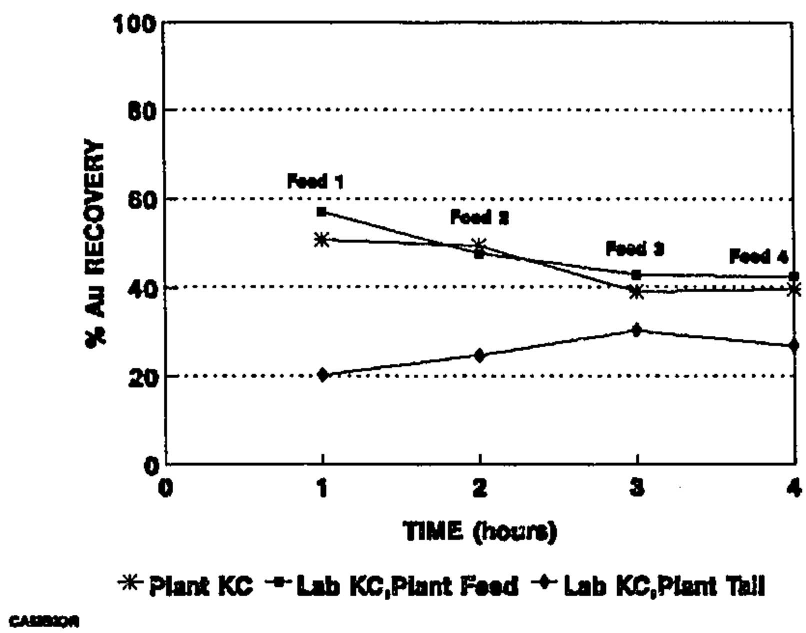

FIGURE 3.12: Gold Recovery for the Plant and Laboratory Knelson Concentrator. Feed Refractoriness Increases Over the Sampling Cycle.

5.18 oz/st, and 5.84 oz/st over the four hours (Figures 3.13 and 3.14). For each sample, recovery increased with increasing particle size, typically by 30% from the -38 μm to the 420-595 μm class. Throughout the cycle, moderate amounts of coarse gold caused the plant KC feed recovery to remain high until the amount of coarse gold feed decreased and gold became increasingly refractory to gravity recovery, resulting in a drop in recoveries. The Chimo ore is of a higher grade and has finer and less liberated gold than Lucien Béliveau. An increasing fraction of Chimo ore may have caused the increasing refractory gold content. Tailings grades for the four tests assayed 2.2 oz/st, 2.8 oz/st, 3.0 oz/st, and 3.4 oz/st, successively, with an average grade of 3.0 oz/st. These tailings grades match the plant KC tailings grades which average 2.8 oz/st as shown in Figure 3.15. Gold was distributed fairly evenly in the mid-size range of the mill feed with an increase in the -38 μm fraction, and a significant drop above 300 μm.

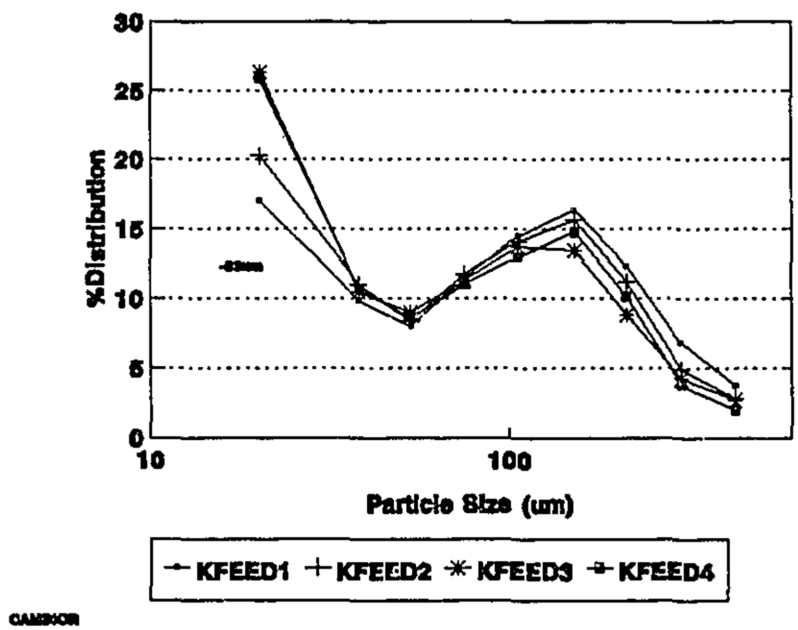

FIGURE 3.13: Gold Distribution of the Plant Knelson Feed Processed on a LKC Over the Four Hour Sampling Cycle

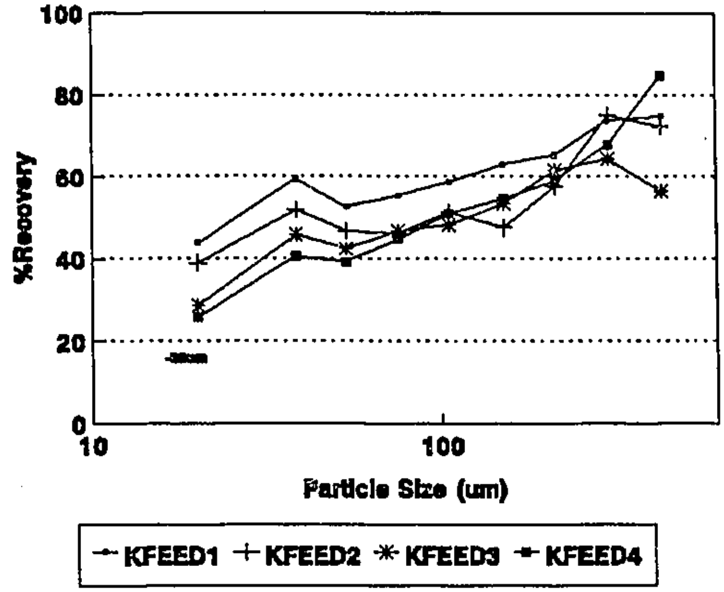

FIGURE 3.14: Size-by-Size Recovery of Plant Knelson Feed Processed on a LKC

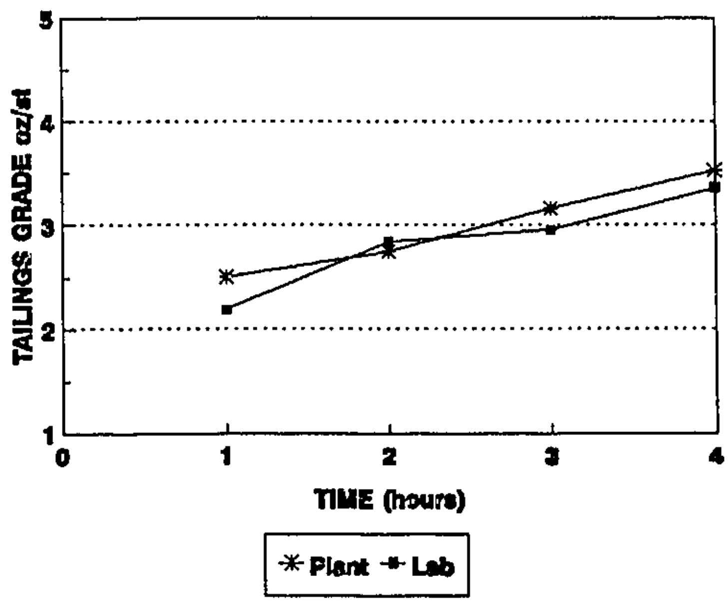

FIGURE 3.15: Plant and Lab Knelson Concentrator Tailings Grade Comparison for the Four Hour Sampling Cycle

Plant KC Tailings

Plant KC tailings samples were taken over the same four-hour period and processed in a laboratory KC. Feedrate of the tailings samples ranged from 160 g/min to 300 g/min under a pressure of 0.21 kg/cm^2 (3 psi).

Recoveries of the plant KC tailings increased with increasing particle size. Average overall recovery was 25%, which indicates potential for improvement in plant operations. This potential improvement was demonstrated at full scale in the plant by separate experimental work carried out by the Lucien Béliveau staff when a 54 cm (20") KC was run in series with the 76 cm unit.

Gold size distribution in the four plant tailings samples was relatively constant. Gold distribution in the +300 μm material was minimal (3%) as a result of efficient recovery by the plant KC. In all four tailings samples, 17% to 30% of the gold appeared in the -38 μm fraction as seen in Figures 3.16 and 3.17.

The plant KC tailing feed, tail and concentrate grades increased over the sampling cycle. Tailings grades increased only slightly from 2.06 to 2.66 oz/st, from the first to the fourth hour. As a similar increase in tailings grade is also observed in the lab work, it is concluded that it is due to a shift in the amount of gravity recoverable gold in the PKC feed (which becomes more refractory to gravity recovery from hour one to hour four), and not a decrease in PKC efficiency due to overloading. Previous attempts to study PKC load cycles (Laplante & Shu, 1992) has also failed to detect such an overload. However, Lucien Béliveau staff flushes the KC at four-hour intervals, more for mechanical than metallurgical reasons. It appears that uneven loading of the bowl causes excessive vibrations and frequent bearing failure. Shorter loading cycles alleviate this problem.

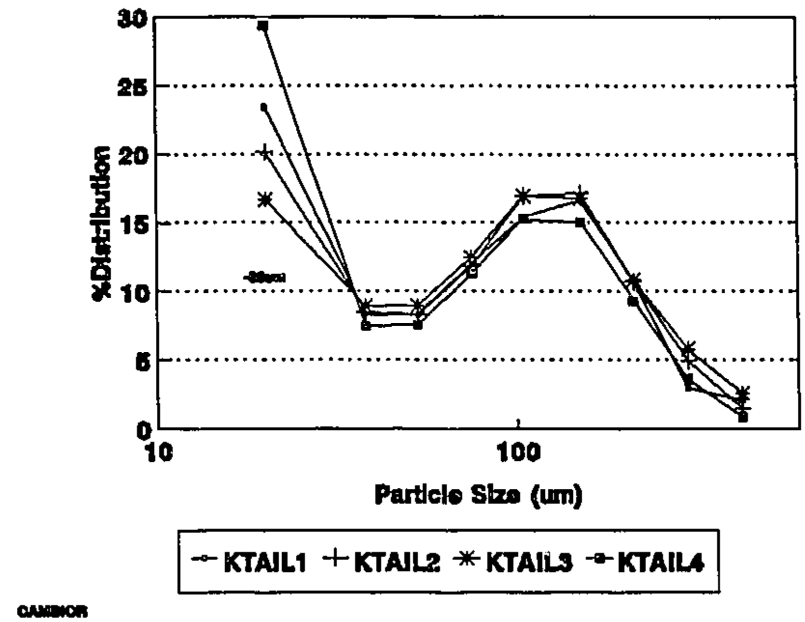

FIGURE 3.16: Size-by-Size Gold Distribution of Plant Knelson Tailings Over the Four Hour Sampling Cycle

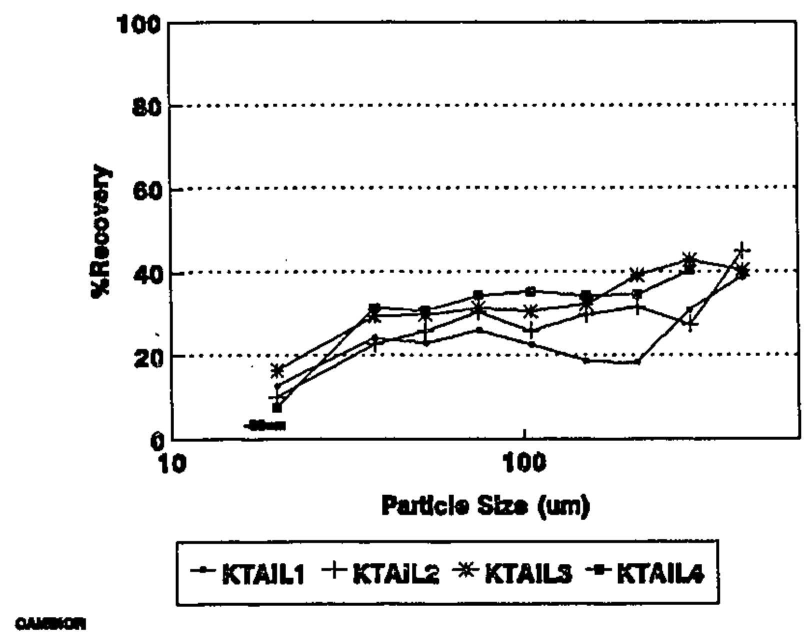

FIGURE 3.17: Size-by-Size Recovery of Plant Knelson Tailings Processed With a LKC Over the Four Hour Sampling Cycle

Knelson Concentrate

Processing the plant Knelson concentrate with the laboratory KC resulted in very high recoveries in all size classes, with an overall recovery of 96%. Material was fed to the laboratory KC at a rate of 200 g/min and a pressure of 0.28 kg/cm^2 (4 psi).

Concentrate grade exceeded 4000 oz/st (14% gold), a concentration factor of 16. Gold was distributed fairly evenly in the particle size range of 200 μm tc -38 μm while only 3% of the gold was distributed above 300 μm as shown in Figure 3.18. The coarser size classes had the lowest mass fraction, gold grade, and recoveries, in good agreement with a similar test performed with a KC concentrate at Les Mines Camchib (Liu, 1989). Liu verified that coarse gold in the KC tail was liberated, and postulated that the flaky nature of the coarse gold grains hinders concentration by trickling. Recovery increased from 83% to 98% in the 600 μm size down to the 75 μm size, and then decreased to 92% in the -38 μm class. Liu reported an increase in recovery from the coarse to the fine size with the highest recovery (98%) in the -38 μm. The difference may well stem from the density of the gangue, which was much lower for the Camchib plant KC concentrate.

Mass Balance of KC Samples

Mass Balancing of the plant KC feed, tail and concentrate yielded few adjustments to size distributions and overall assays (Appendix D, page 192). Assay data were based on the LKC test results. The laboratory KC average recovery of 50%, with the same feed, is in good agreement with the actual plant recovery, 45%. The low value for calculated concentrate mass (48 kg) raises some questions since historically the measured concentrate mass has been 70 kg consistently. However, concentrate mass in not a critical variable in the calculation of recovery, being equal to 1-(gT/gF) when yield is negligible, as is the case for the KC. The KC feed and tailings grades will ultimately determine the performance of the Knelson Concentrator.

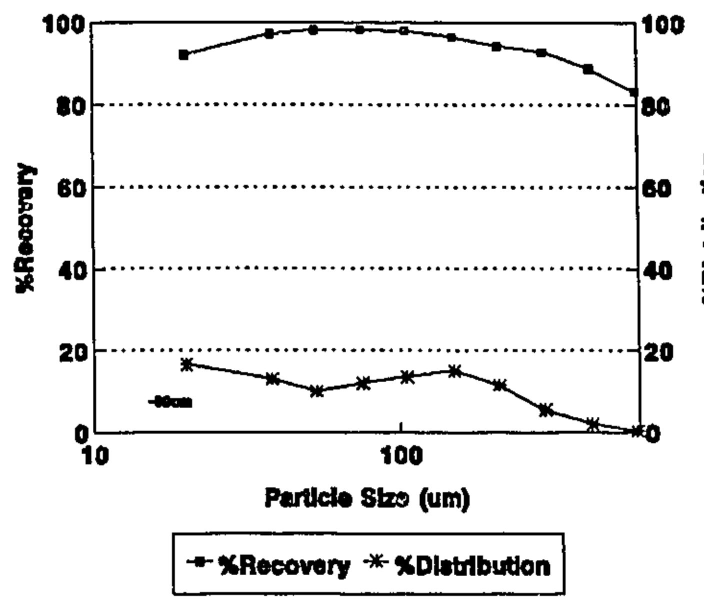

FIGURE 3.18: Size-by-Size Recovery and Gold Distribution of Plant Knelson Concentrate Processed With a LKC

Recovery comparison of PKC and LKC

A comparison of average recoveries during the four-hour sampling cycle, between the PKC and the LKC, as shown in Table 3.1, indicates the PKC performs best on +38 μm and +53 μm material while the LKC performs best on coarser material (larger than 75 μm), and on the finest size fraction, -38 μm. Although the same comparison for each sampling hour differs slightly, no distinct trend emerges except that in most cases the LKC performs better than the PKC below 38 μm. During the first hour, recovery below 38 μm was 44% for the LKC compared to 17% in the PKC, but there appeared to be a less significant gap during the second hour with recoveries of 39% and 25%, respectively.

Table 3.1: Average Comparisons of Plant and Laboratory Knelson Concentrators

Size (µm)	-38	38	53	75	105	150	210	297	420
PLANT KNELSON									
Feed:Au Dist'n	22.40	10.52	8.51	11.35	13.83	15.07	10.60	4.93	2.80
% Recovery	21.97	60.44	50.67	48.50	44.75	50.25	55.14	58.63	65.00
Tail:Au Dist'n	22.43	8.30	8.28	11.93	16.17	16.43	10.43	4.33	1.73
LKC ON PKF									
Feed:Au Dist'n	22.40	10.52	8.51	11.35	13.83	15.07	10.60	4.93	2.80
% Recovery	34.39	49.55	45.37	48.39	52.40	54.76	61.01	70.08	72.15
Tail:Au Dist'n	29.11	10.48	9.21	11.65	13.09	13.58	8.31	2.95	1.61
LKC ON PKT									
Feed:Au Dist'n	22.43	8.30	8.28	11.93	16.17	16.43	10.43	4.33	1.73
% Recovery	11.76	27.00	27.30	30.52	25.58	28.73	30.95	35.46	41.48
Tail:Au Dist'n	26.73	8.16	8.10	11.16	15.53	15.73	9.65	3.75	1.60

3.4.3 Sampling Campaign, Tests T2 to T7

T2 Plant Knelson Concentrate

The PKC concentrate was diluted with 12.4:1 silica, to a total mass of 4000 g and processed with a LKC. This unusually high dilution ratio was necessary to lower the yield of the LKC (to about 2-3%) in order to minimize the recovery of non gravity recoverable gold.

Overall recovery was 92%, with losses occurring in the finer sizes and the coarsest fraction, as seen in Figure 3.19. Concentrate grade was high, 994 oz/st, yielding a concentration factor of 35. Only 36% recovery was achieved in the +590 µm fraction due to the high tail grade of 155.31 oz/st. This result could be due to a nugget effect, since very little mass was sampled. The low recovery has little effect on overall performance since only 0.25% of the total gold reports to the 600-840 µm class. Recoveries were only 60% below 38

μm, but there was very little mass (2%) or gold distributed (8%) in the finer sizes.

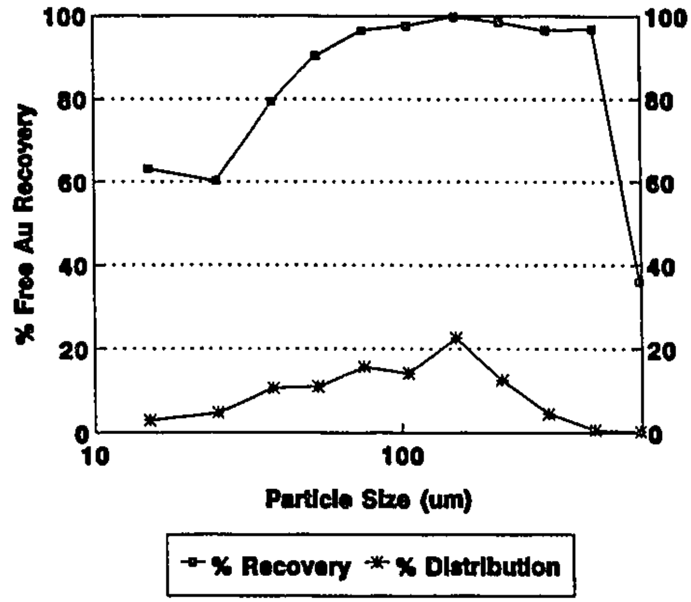

FIGURE 3.19: Plant Knelson Concentrate Size-by-Size Recovery and Gold Distribution

T2 Hydroclassifier Underflow

Hydroclassifier underflow (spiral feed) was processed with a LKC after being diluted 4:1 with 210 μm silica. Details are located in Appendix B.

The results indicate a spiral feed grade of 1.53 oz/st (7.65 oz/st without silica dilution) with a tail grade of 0.43 oz/st, yielding 72% gravity recoverable gold as shown in Figure 3.20. Although recovery was very poor in the coarsest and finest fractions there was little mass or gold distributed in those sizes. Most of the gold (84%) is coarser than 38 μm.

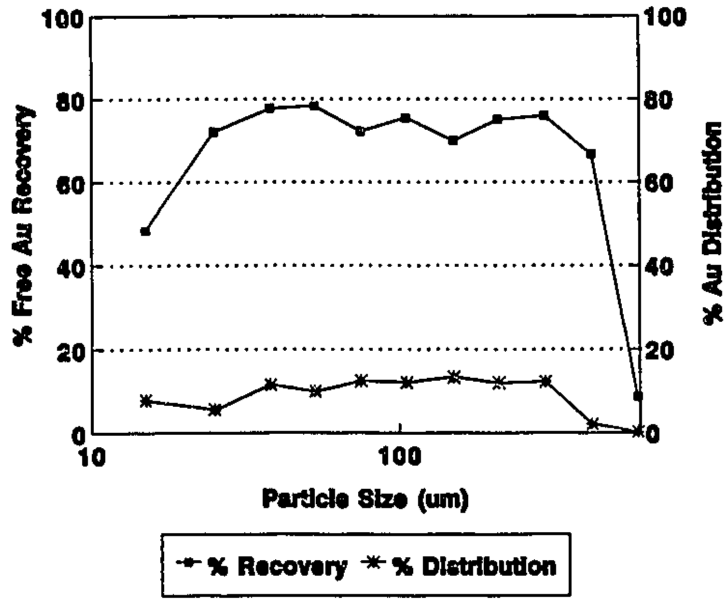

FIGURE 3.20: Spiral Feed Size-by-Size Recovery and Gold Distribution

Spiral Tails

Spiral tails were diluted 4:1 with 210 μm silica and processed on a LKC.

The calculated grade for the spiral tails was 0.79 oz/st, of which 61% was recovered by the LKC. Figure 3.21 shows that most of the gold recovered is between 25 and 105 μm. Most of the gold in the spiral tails (82%) is located below 210 μm; 42% of the gold is distributed below 53 μm, and is present in only 12% of the mass. There is substantial recoverable gold in this class. Most of the mass (76%) is in the 75-297 μm fraction. Most of the gravity recoverable gold reports to the 25-150 μm size range.

Plant Knelson Tails

Plant Knelson tails were fed to a LKC after being diluted 4:1 with 210 μm silica.

The calculated grade of the PKC tails was 0.98 oz/st. Overall recovery was 47%, indicating that the PKC did not recover all the gravity recoverable

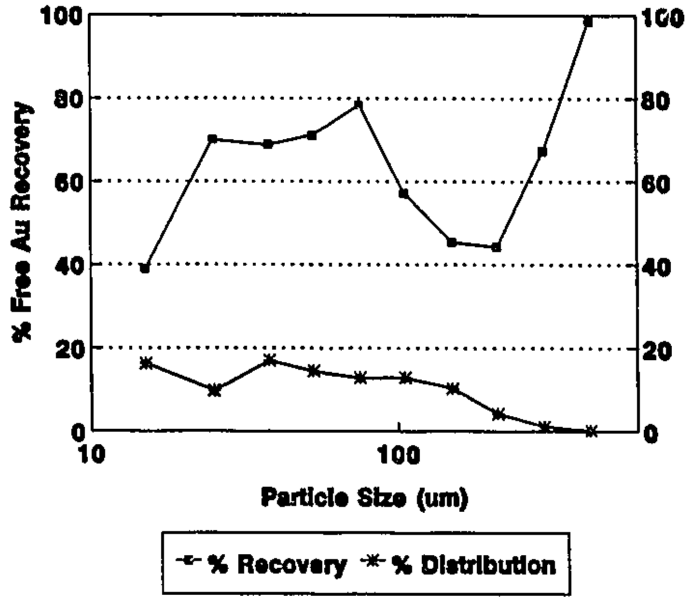

Figure 3.21: Spiral Tail Size-by-Size Recovery and Gold Distribution

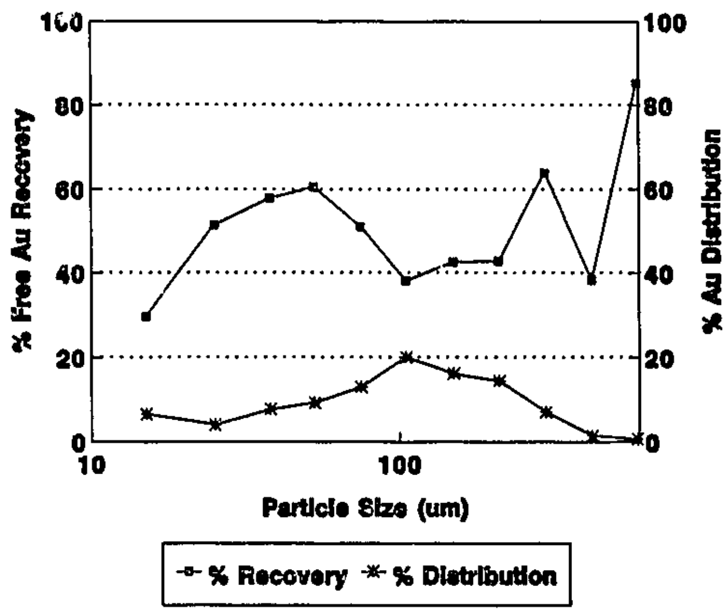

FIGURE 3.22: Plant Knelson Tail Size-by-Size Recovery and Gold Distribution

gold. Figure 3.22 shows that the 75-297 μm range contains 64% of the gold. About two thirds of the gold is in the middle size range, where free gold content is low, at 40%. Gold recovery increases somewhat in the 25-75 μm, to drop again below 25 μm. The recovery curve is a rough mirror image of gold distribution because size classes best recovered by the LKC and PKC are similar. Hence the LKC is most effective where the PKC has left the least gold to be recovered. A similar but less defined pattern was found in test T1 (without silica dilution), as shown in Figures 3.16 and 3.17.

Spiral Concentrate 1&2

Spiral concentrates 1&2 were both processed with a LKC after being diluted 4:1 with 210 μm silica. Details are shown in Appendix B.

The spiral concentrate 1 (SpC1) calculated grade was nearly double that of the spiral concentrate 2 (SpC2) (92 oz/st and 53 oz/st, respectively). Appendix C provides details of the LKC mass balances. Figure 3.23 shows most of the gold (70%) is located in the mid range (75-297 μm) for SpC1. Recoveries in all size classes excluding +590 μm and -25 μm were excellent for SpC1. Whereas the statistical reliability of the former is questionable (tail mass is extremely low), the latter is probably an indication that some fine, non-gravity recoverable gold is recovered by the spiral. Overall recovery (98.9%) is a strong indication that SpC1 contains largely liberated gold.

Processing SpC2 produced slightly different results: the gold distribution shifted one size class coarser, and overall recovery was slightly lower at 95%. Figure 3.24 shows that 76% of the gold is distributed between 105 and 420 μm. Recoveries in the coarse fraction (+420 μm) were lowest (81-85%) although very little mass (5%) makes up that fraction. Recovery of the -25 μm size was very good at 94%. It can be concluded that the second concentrate is still very largely made up of gravity recoverable gold.

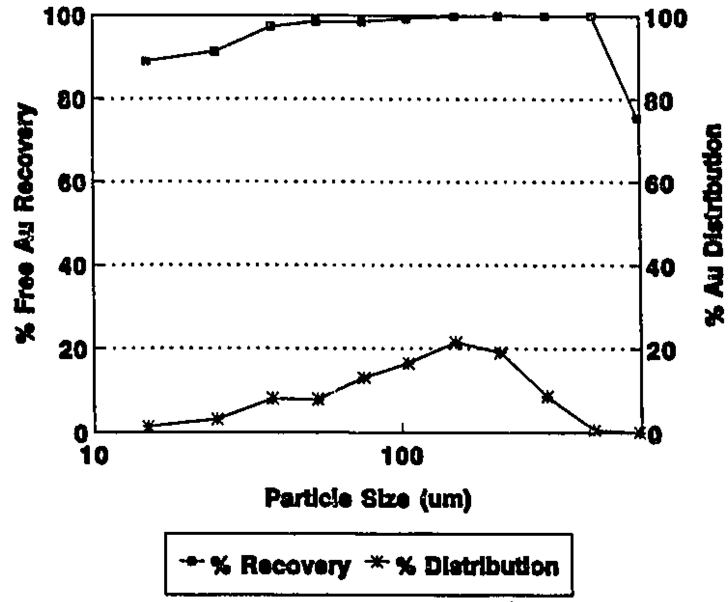

FIGURE 3.23: Spiral Concentrate 1 Size-by-Size Recovery and Gold Distribution

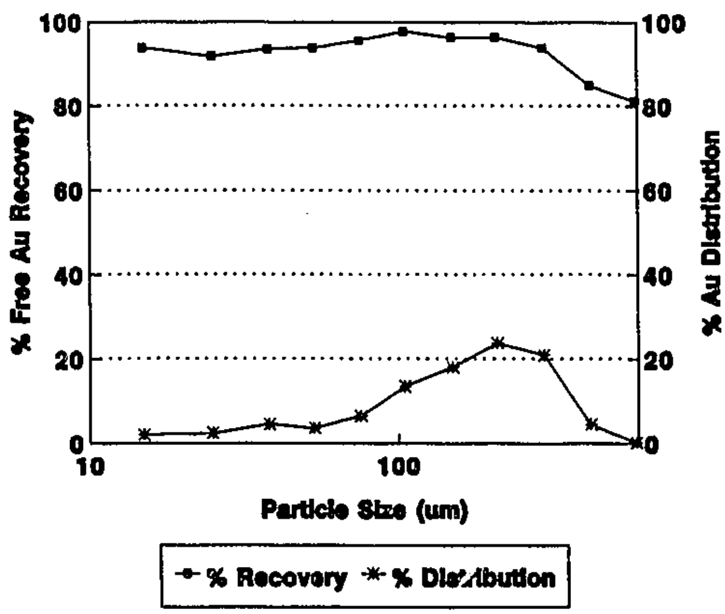

FIGURE 3.24: Spiral Concentrate 2 Size-by-Size Recovery and Gold Distribution

Spiral Mass Balance

Mass balancing of the spiral, hydroclassifier underflow, spiral tails, and spiral concentrate 1&2, provided very consistent results as shown in Appendix D (page 200). Assay data from LKC tests were used in the mass balance calculations. Flow rates, size distributions and assays of the size fractions were not radically adjusted. Some coarser size fraction assays required adjustment due to poor statistics related to their small mass. The spiral recovered 44% of the total gold; the LKC showed that 72% of the gold was gravity recoverable.

Effect of Spiral Feed Rate (T3, T4, T5)

All samples were diluted 4:1 with silica before being processed with a LKC. Details are located in Appendix B. Two samples from T4 and all T5 samples were diluted with coarse 840 μm (25 mesh) silica instead of the standard 210 μm (70 mesh) silica, thus slightly lowering the LKC performance and underestimating gravity recoverable gold content.

In T5 the valve position of the hydroclassifier underflow was in its original position (833 kg/hr); spiral feed density was 18%. In T3 the valve was opened 1.5 turns from the original position (903 kg/hr) and density decreased to 13% while T4 valve position was closed 3/4 of a turn (667 kg/hr) and density increased one percent to 19%. Two of the spiral feed grades were very similar (1.07 oz/st and 1.08 oz/st for T4 and T5, respectively), while the feed grade of T3 was slightly lower at 0.95 oz/st. Appendix C provides further details. Gold distribution in the feed was erratic as seen by comparing all three tests. In T3 61% of the gold reports to the 53-297 μm fraction, and 14% of the gold is distributed in the -25 μm fraction, as it is for T2. T4 exhibits a more erratic distribution and T5 exhibits a flatter distribution. The quantity of gravity recoverable gold is somewhat less in all three tests compared to T2 (59%, 55%, and 53% for T3, T4, T5 respectively).

All three tests were mass balanced around the spiral utilizing calculated assays and size distributions from LKC testwork as shown in Appendix C. Adjustments were minimal, an indication that the circuit was fairly stable during sampling, and were made mainly in the assays of the coarser size fractions.

Figure 3.25 shows that the size-by-size total gold recovery of the spiral is very erratic with no apparent correlation between feed rate and densities.

Significant coarse gold was recovered by the spiral, but recovery dropped sharply below 212 μm. Because of the nature of the feed, a flotation concentrate, the fine gold may be difficult to recover in this spiral. Overall recovery around the spiral for the three tests was 19%, 18%, and 12% for T3, T4, T5, respectively.

A comparison of the size-by-size gold distributions for T2, T3, T4, and T5 indicated that samples with a lower percentage of gold fines (-38 μm) in the spiral feed corresponded to the higher spiral recoveries as seen in Table 3.2. However, Figure 3.26 clearly shows that spiral recovery is better correlated with the free gold content in the spiral feed than the -38 μm gold distribution. Thus, spiral performance fluctuations are linked even more to mineralogical fluctuations than operational ones.

TABLE 3.2: Size-by-Size Gold Distributions of the Spiral Feed at Different Hydroclassifier Underflow Rates

PARTICLE SIZE	+ 420 μm	+ 38 - 420 μm	- 38 μm
TEST NO.	Au DISTRIBUTION (%)		
T2 44% RECOVERY	2.37	84.11	13.52
T3 19% RECOVERY	0.69	76.47	22.84
T4 18% RECOVERY	10.15	65.09	24.76
T5 12% RECOVERY	5.09	72.06	22.85

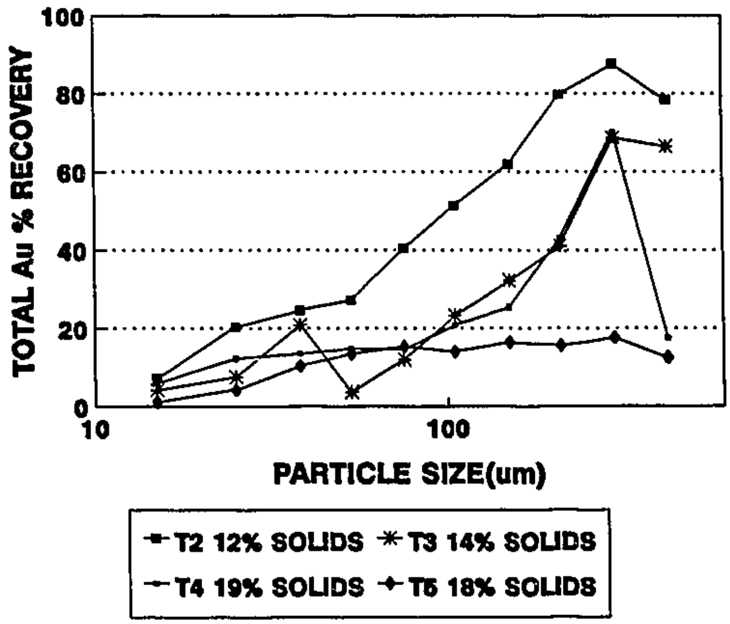

FIGURE 3.25: Size-by-Size Spiral Recovery at Various Spiral Feed Rates

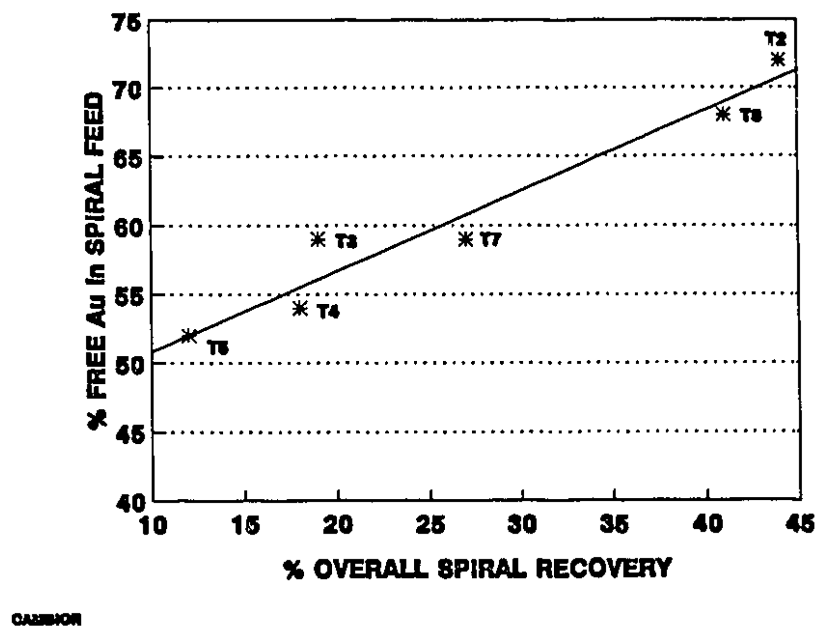

FIGURE 3.26: Correlation Between Spiral Recovery and Gravity Recoverable Gold Content in the Spiral Feed

<u>Effect of Fluidizing Water Pressure on Plant Knelson Performance (T7, T8, T9)</u>

For tests T7 to T9, mass balances were first completed around the spiral using assay data and size fractions from LKC tests[6] as shown in Appendices C and D. This information was then applied to mass balance the PKC in order to evaluate its performance. Feed grades were not adjusted significantly by NORBAL2. Figure 3.27 shows a poor overall PKC performance with total gold recoveries of 17%, 6% and 13% for T7, T8 and T9, respectively.

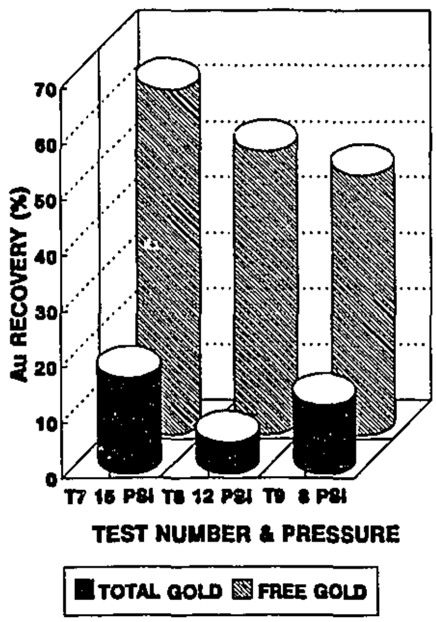

FIGURE 3.27: Plant Knelson Recovery at Different Operating Pressures

However, performance, when based on the amount of gravity recoverable gold in the KC tails (Figure 3.28), increases with decreasing fluidization pressure (from 49% gravity recoverable gold at 15 psi, test T7, to 39% at 8 psi, test T9). This trend is not apparent when considering total gold recovery alone.

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[6]Spiral tails and PKC tails samples were the only samples available for T9. Therefore, an average of T7 and T8 hydroclassifier underflow, hydroclassifier overflow, spiral tails, secondary ball mill discharge and spiral concentrate samples was used.

Figure 3.28 also shows that there is still some free gold in the PKC tails. The gravity recoverable gold content increases with decreasing particle size, and totals 49%, 43% and 39% for T7, T8, and T9, respectively. The highest LKC recoveries occurred in the finest size fractions indicating that PKC efficiency decreases with decreasing particle size.

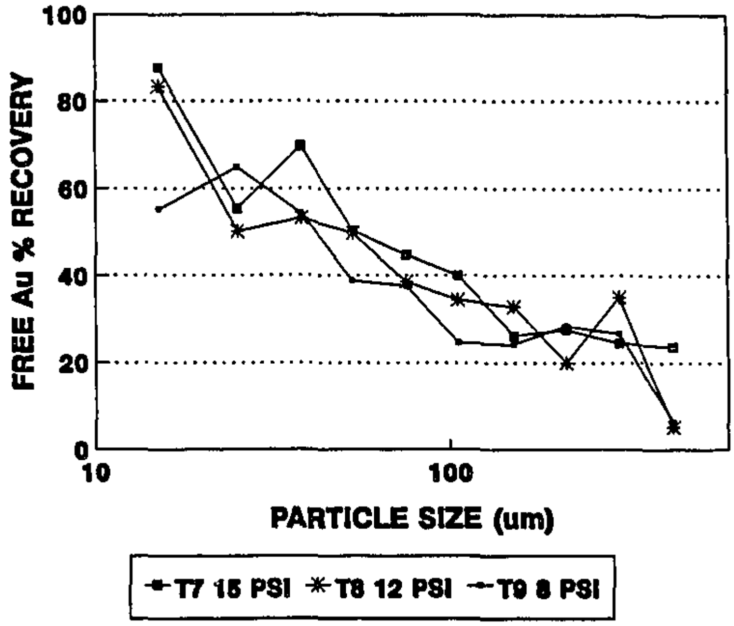

FIGURE 3.28: PKC Tailings Recovery to Determine Performance at Various Pressures

In the above discussion, some of the losses of gravity recoverable gold is clearly attributable to the high density of the gangue. Silica dilution, because it increases fines recovery of the LKC (hence the amount of fine gravity recoverable gold), makes these losses very apparent.

Table 3.3 displays an improved spiral recovery in T7, T8 and T9 compared with T3, T4 and T5. Spiral recovery was 27%, 41% and 36% respectively for T7, T8, and T9 for an overall grinding circuit recovery of 31%, 32% and 32%. Note that spiral feed grade for T7 and T8 were very different at 0.78 and 1.36 oz/st.

Overall recovery in the grinding circuit is consistent: Figure 3.29 shows that when the spiral is performing well, the PKC does not perform as efficiently and vice versa.

TABLE 3.3: Total Gold Recoveries for the Lucien Béliveau Gravity Circuit

TEST NO.	SPIRAL % RECOVERY	KNELSON % RECOVERY	TOTAL % RECOVERY
T2	44.1		
T3	19.3		
T4*	18.0		
T5**	11.8		
T7	26.9	17.4	31.4
T8	41.3	5.7	32.3
T9	35.7	12.5	31.9

* Two samples processed with coarse silica (840 μm), two with standard silica (210 μm)
** All samples processed with 840 μm silica

This result is also compatible with the working hypothesis that whatever the spiral recovers, the PKC will also recover. It appears that the PKC compensates for fluctuations in spiral performance, thereby yielding a very constant overall performance.

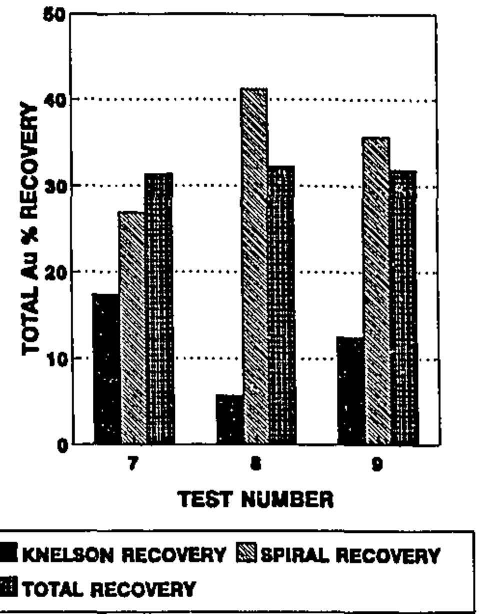

FIGURE 3.29: Spiral, Knelson, and Overall Gravity Circuit Recoveries

Hydroclassifier

The hydroclassifier serves mostly as a flow stabilizer for the spiral but it also thickens, yielding an overflow at 7-8% solids, and an underflow at 14-24% solids. Overflows and underflows processed with the LKC showed no trend in gravity recoverable gold content. Figure 3.30 shows, however, that gold in the underflow of test 8 was clearly coarser than the other underflow or the two overflows. Estimating the performance curve of the hydroseparator proved difficult, as severe assay adjustments were necessary for test T8. Figure 3.31 shows the hydroseparator's performance with respect to gold. Although there is uncertainty in the coarse range, there is virtually no evidence of classification.

It can be concluded that the hydroseparator acts as an overloaded thickener whose bed height exceeds the overflow lip.

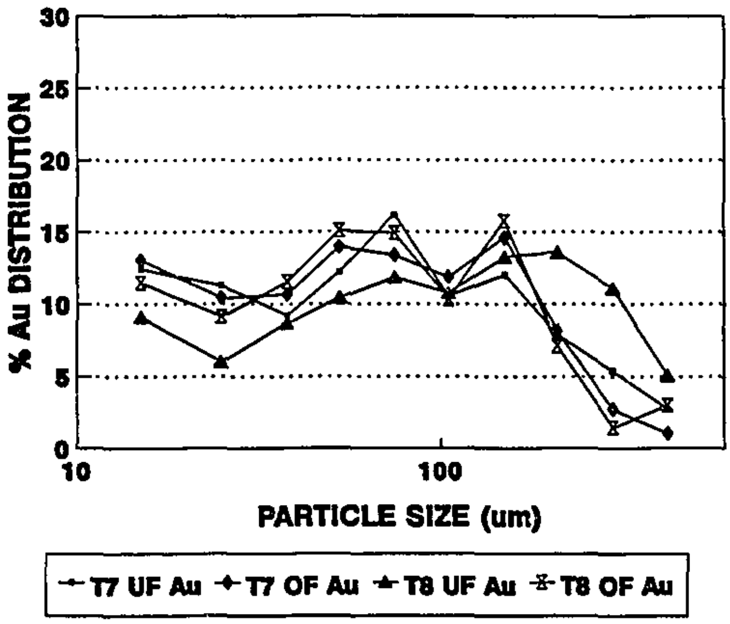

FIGURE 3.30: Comparison of Gold Distribution of Hydrosizer U/F and O/F For Tests T7 and T8

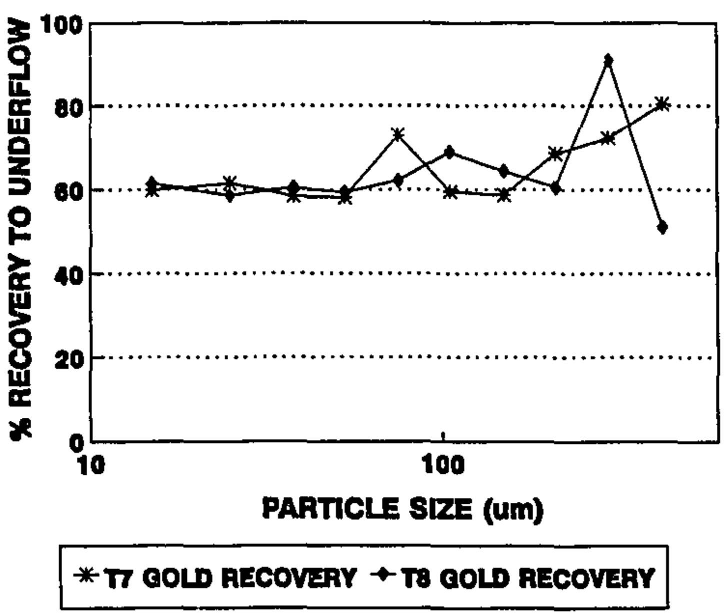

FIGURE 3.31: Hydroseparator Performance for Tests T7 and T8

CHAPTER 4

TESTWORK AT THE DOME MILL

4.1 Description of the Dome Mill

The Dome Mine, located near South Porcupine Ontario, is North America's oldest running mine, having begun production in 1910. Proven and probable mine reserves as of December 1, 1989 were 6.8 million tons grading 0.146 oz/st Au (Werniuk, 1990). Recent work has identified much larger tonnages at or near the surface, with about half that grade. Placer Dome Incorporated is the sole owner of the property.

Gold is found as coarse native metal in quartz and ankerite veins. The ore also contains 2-3% sulphides as pyrite and pyrrhotite. Several varieties of tellurides are present along with minor quantities of scheelite and sparsely disseminated arsenopyrite (Scales, 1989).

The mill throughput is approximately 3400 tonne/day with 1991 year-to-date (October 31) recovery at 96.4% (Harvey, 1992). Approximately 40-50% of the feed gold is removed in the gravity circuit as a gravity concentrate while the remainder of the ore passes through leaching, carbon-in-pulp, and electrowinning circuits. The Dome flowsheet can be seen in Appendix A.

Skips transport crushed ore from underground to surface where fines and slimes are removed by washing on a double-deck screen located in the crushing plant. Oversize products are reduced and classified by cone crushers in closed circuit with rod deck screens. Crushed ore is conveyed to two 3630 tonne ore bins. Variable speed slot feeders controlled by a weightometer feed the ore from the fine ore bins to the 3.2 m X 4.3 m (10.5' X 14') rod mill. Water is added to produce a pulp density of 75-80% solids. Rod mill discharge is combined with the 4.0 m X 6.1 m (13' X 20') ball mill discharge and crusher slimes and pumped to four Wemco 51 cm (20") primary cyclones. The cyclone underflow reports to the gravity circuit while the overflow is thickened to 50% solids before addition of lime and sodium cyanide for leaching in five agitated tanks.

The gravity circuit incorporates four 0.6 m X 0.9 m (24" X 36") Denver Duplex mineral jigs and two shaking tables. Cyclone underflow, at 75% solids, feeds the jigs with an additional 135 m^3/hr (600 USGPM) of hutch water. Jig concentrates are further upgraded by shaking tables and then directly smelted in a Wabi furnace. Gravity tails are classified in four 38 cm (15") Krebs cyclones, and reground.

The total residence time of the five mechanically agitated, air-sparged leach tanks is 24 hours. A carbon-in-pulp (CIP) circuit follows, consisting of 6 agitated tanks equipped with in-launder screens for counter-current contacting with activated carbon. Loaded carbon is then stripped by a caustic soda/cyanide solution and regenerated in an electrically heated rotary kiln. The resultant loaded solution is electrowon and refined. CIP tailings are pumped to backfill, densefill, or tailings.

4.2 Objectives

The objective of this testwork was to evaluate the Dome grinding and gravity circuit with a view to potential improvements. This was to be accomplished by determining the location of the largest amount of free gold in the grinding circuit (in the circulating load for example) and the amount available for recovery in the gravity circuit. Dome traditionally has had coarse gold that is amenable to gravity concentration; this work will focus more on finer gold (600 μm and less). This emphasis on the finer size classes is partly dictated by the maximum practical sample sizes (typically 10-20 kg) and their impact on sampling statistics as discussed in section 2.1.

4.3 Sampling Procedure and Sample Processing

Samples were taken around the grinding and gravity circuit of the Dome mill every half hour for six hours to characterize a full cycle of the duplex jigs.

The gravity circuit samples consisted of jig feed (primary cyclone underflow, PCUF) and jig tails (JTls) samples. Wilfley table tails (WTT) and Deister table tails (DTT) samples were taken by the refining room operator for security reasons. At the completion of the six-hour recovery cycle, the jig concentrate was discharged, a process which takes approximately 20 to 30 minutes. Samples were cut from the eight streams of jig concentrate discharge (JC1W1, JC1E1, JC2W1, JC2E1, JC3W1, JC3E1, JC4W1, JC4E1) every one to two minutes over the total discharge time.

All grinding circuit samples were six-hour composites which consisted of rod mill discharge (RMD), ball mill discharge (BMD), primary cyclone underflow and overflow (PCUF, PCOF), and regrind cyclone underflow and overflow (RCUF, RCOF).

The original weight of the jig concentrate samples was then halved, owing to its high gold content.

All samples were weighed wet and filtered at CANMET (Ottawa). Samples were processed at CANMET and McGill University (Montréal).

A portion of all samples was split to determine size distributions. Samples were wet screened at 37 μm, then oven dried and dry screened over size ranges of 600 μm to 37 μm. Size distributions are shown in Appendix A.

Very coarse samples (RMD, PCUF, RCUF, JTls, eight JC, DTT, WTT) were screened at 840 μm. The oversize product was processed in a 1M Denver Laboratory Mineral Jig. Jig bedding, consisting of +4 mm steel shot, ranged in mass from 100 to 300 g (depending on the sample mass to be treated). Any +4 mm material was removed from the samples prior to jigging. The laboratory jig was operated under standard test parameters at a stroke length of 1.3 cm (0.5"), a feed rate ranging from 100 to 300 g/min, and a water rate of 2.5 to 3.0 l/min. Details of laboratory jig testing parameters can be found in Appendix B. Some of the JC samples contained old ragging from the plant jigs which was removed prior to laboratory jigging. Samples were processed to obtain a concentrate of less than one assay ton (29.166 g) when separated into size classes, in order to eliminate the problem of nugget effects. Resultant tailings and concentrates were screened into five size fractions (2.4 mm, 2.0 mm, 1.2 mm, 841 μm, and 600 μm) and assayed.

The undersize fraction, where mass was sufficient (above 3 kg), was processed with a 7.5 cm laboratory Knelson Concentrator (LKC) to assess its size-by-size total and free gold content at a feed rate ranging from 150 to 400 g/min. These samples consisted of RMD, BMD, PCOF, PCUF, RCOF, RCUF, JTls, two JC, and DTT. Detailed results can be found in Appendix C. Water jacket pressure on the LKC was set at 21 kPa (3 psi) or 28 kPa (4 psi), finer feeds requiring less pressure than coarser ones. Details of the parameter settings for the LKC are found in Appendix B. In all tests, tailings samples were collected and weighed to determine if feed and water flow remained constant. The tailings samples were combined for screen analysis and assay. The concentrates were also collected, screened into nine size fractions ranging from +425 μm to -38 μm, and assayed. All of the concentrate and part of the tailings were assayed to determine gold content.

Where sample mass was insufficient to process with the 7.5 LKC (six JC's and the WTT) a Mozley Laboratory Mineral Separator (MLS) was used. All samples were wet screened at 38 μm, oven dried and dry screened at 600 μm to 38 μm. Each size fraction was processed separately on a MLS 'V' profile tray table to produce a concentrate of less than one assay ton and a tailings sample. The MLS was operated at a speed of 70 rpm, a stroke of 6.4 cm (2.5"), a water rate ranging from 0.5 to 1.5 l/min, and a slope ranging from 2.5 to 4.5 cm (measured from the 'upstream' end where zero slope is 0 cm), as recommended in the MLS brochure. Details of the experimental conditions are presented in Appendix B. All concentrate and tailings samples were assayed.

4.4 Results and Discussion

Generally the Dome operates with 50% of the ore coming from underground and 50% from open pit operations. During the sampling campaign, feed was solely from the open pit. After four hours the crushing plant stopped due to problems with the rod deck screen. Although feed to the plant was not interrupted, crusher fines were no longer fed to the primary pump box. Crusher fines normally consist of approximately 360 tonnes/day, and contain up to 40% solids.

Table 4.1 summarizes sample processing results; details are found in Appendix C.

4.4.1 Grinding Circuit

Rod Mill Discharge

The calculated assay for the RMD was high (0.11 oz/st) compared to the average open pit feed head of 0.075 oz/st. This may have been due to some residual underground ore in the fine ore bins.

Large samples of RMD were processed with the LKC (9.4 kg) and laboratory jig (8 kg) to ensure that a representative sample was attained for testwork. The + and -600 μm fractions from both tests were then mathematically combined. Much of the mass (45%) occurs in the coarser (+841 μm) and finer (-53 μm) fractions (35%).

Table 4.1: A Summary of Sample Processing Results

SAMPLE	LAB PROCESS	FEED GRADE oz/st	TAIL GRADE oz/st	CONC. GRADE oz/st	GRAVITY RECOVERABLE Au CONTENT %	DETAILS LOCATED ON PAGE
RMD	jig + kc	0.11	0.07	3.71	40.6	179
BMD	kc	0.53	0.23	13.86	58.0	179
PCUF	jig + kc	0.49	0.11	44.54	77.1	180
PCOF	kc	0.07	0.05	1.29	22.8	180
RCUF	jig + kc	0.57	0.14	41.84	76.5	181
RCOF	kc	0.14	0.06	3.16	55.7	181
JTLs	jig + kc	0.62	0.11	61.70	82.7	182
JC1W1	jig + kc	8.88	2.22	262.14	75.7	183
JC1E1	jig + mls	125.94	19.92	917.60	86.1	183
JC2W1	jig + mls	276.71	21.83	1937.77	93.2	184
JC2E1	jig + mls	274.58	132.31	884.66	60.9	184
JC3W1	jig + kc	20.84	6.44	490.50	70.0	185
JC3E1	jig + mls	52.03	12.47	384.95	78.6	185
JC4W1	jig + mls	367.02	53.96	1257.53	89.1	186
JC4E1	jig + kc	175.36	37.96	2341.89	79.7	186
WTT	jig + mls	40.67	15.21	255.25	66.6	187
DTT	jig + kc	7.36	2.97	223.96	60.4	187

Free gold content for the +600 μm fraction (processed on a laboratory jig) was high (58%) because much of the gold is coarse and already liberated. Free gold content for the -600 μm fraction (processed in a LKC) was much lower (37%) implying that the finer gold is less liberated. Overall, free gold content averaged 41%, which is high for a RMD (typical RMD gold recoveries are about 20-30%). Low gold recoveries occur in the +425 μm (23%) and the +600 μm (29%) size classes but the tail assays are suspiciously high, at 0.34

oz/st and 0.21 oz/st, respectively[7].

Most of the gold (78%) is distributed above 300 μm; the remainder is divided up fairly equally in all size classes below 300 μm. This coarse gold does not show up in any other streams except the jig concentrate and the PCUF (but in smaller quantities here due to dilution from the circulating load) suggesting that much of it is recovered in the jigs and what is not recovered is quickly ground in the ball mill, and thus disappears into finer size classes.

Ball Mill Discharge

Although there was coarse material in the BMD, the sample was not prescreened prior to processing with the LKC, as only 10% of the material was coarser than 600 μm.

The calculated BMD grade was 0.53 oz/st, which is approximately five times higher than that of the RMD. This is high for a grinding circuit with gravity (for example, at Meston Resources which employs a gravity circuit, the BMD (0.50 oz/st) is twice the grade of the RMD (0.22 oz/st) (Laplante, 1993). Overall, free gold content was 58%, which is reasonable for a system containing a gravity circuit (for example, Meston Resources' BMD free gold content was 50%).

Free gold content is fairly consistent throughout the +53 μm to -425 μm range at 69%. Most of the gold (75%) is located below 150 μm. Recovery is poor above 425 μm: very little coarse free gold is left as the +600 μm LKC concentrate contains virtually no gold (LKC concentrate assay is 0.38 oz/st). The +600 μm LKC tailings (0.37 oz/st) is a suspicious assay; this will lower the free gold content of this size class but does not affect the amount of coarse

[7]As explained in section 2.1, reliable information above 840 μm is nearly impossible to generate because of the 'nugget' effect. This problem is not serious below 210 μm, but often results in noisy data between 210 and 840 μm.

free gold, which remains low[8]. Coarse free gold may be absent from the BMD because the jigs recover it and what little is not recovered is ground in the ball mill. Recovery drops to 48% below 53 μm, primarily due to an increase in the amount of fine, unliberated gold and secondarily to a slight decrease in the LKC efficiency.

Size-by-size assays follow a common trend: the LKC concentrate and tailings assays increase with decreasing particle size, although the tailings assays do not increase to as large an extent as the concentrate assays.

Primary Cyclone Underflow

The +840 μm fraction of the PCUF was processed on a laboratory jig while the -840 μm was processed with the LKC. The material was not processed in the proportions of the initial size distribution (more oversize was processed to minimize the nugget effect). The results of the two tests were then combined in the correct proportion.

The PCUF calculated assay is slightly lower than the BMD at 0.49 oz/st. Overall free gold content was very high, at 77%, and it remained high in all size fractions excluding the coarser ones (above 600 μm) where gold may not be sufficiently liberated. An exceptionally high recovery (83%) appears in the +840-1180 μm class due to one to three coarse visible gold flakes in the jig concentrate (i.e. the nugget effect). By contrast, recovery above 1180 μm (20%) is probably grossly underestimated. Whilst both RMD and jig concentrate data clearly show that coarse gold must be present in the +1180 μm fraction of the PCUF, the observed lack of flakes can easily be explained statistically.

All other assays in the concentrate size classes appear reasonable. The tailings assays are fairly stable; the highest assay (0.35 oz/st) occurs below 75μm due to the corresponding high concentrate and feed grade in that class.

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[8]For an explanation of free gold content please see the footnote on page 3.

<u>Primary Cyclone Overflow</u>

The original calculated grade for the PCOF is slightly high at 0.077 oz/st. Generally COF grades are between 0.05 and 0.08 oz/st, but because lower-grade open pit ore was processed at the time of sampling, the PCOF grade should be in the lower end of this range. The high head grade may be due to a high tail assay (0.4 oz/st) in the +150 μm tail fraction. Therefore a cut of the sample was screened, re-assayed and used to verify the suspicious assay. The new assay was 0.087 oz/st, a more realistic number which decreased the head grade to 0.068 oz/st. Overall free gold content was very low, but typical of an overflow stream (23%) and strongly influenced by the -38 μm class where the majority of the gold (42%) exists. Only 3% of the PCOF mass is above 150 μm.

LKC recovery was poor in most size classes. The best recovery occurred in the +38 μm fraction (61%). Recovery below 38 μm was only 6%. The LKC appears to have limited efficiency in the recovery of fine flaky gold which characteristically occurs in cyclone overflows.

Gold distribution was typical for a cyclone overflow with most (47%) of the gold located below 38 μm and the least amount of gold (5%) located above 150 μm while the balance was distributed among the remaining fractions.

<u>Regrind Cyclone Underflow</u>

The calculated grade of the RCUF was 0.57 oz/st, while free gold content was very high at 77%. This is similar to the PCUF (77% recovery; 0.49 oz/st) which indicates the jigs are not recovering much gold. The largest mass (19%) occurred in the 150-212 μm range. About 27% of the mass is in the +600 μm fraction while only 8% is below 75 μm. Most of the mass (53%) is between 105 μm and 425 μm.

Gold recovery increases with decreasing particle size. Below 105 μm gold recovery is particularly high (greater than 80%); similar results were obtained at Snip Mines (Vincent, 1993). Most of the gold (48%) is distributed below 75 µm, with insignificant gold above 212 µm. Because the RCUF feed consists of jig tailings, it appears the jigs are not adequately recovering gold below 425 µm. They achieve better gold recoveries above 425 µm, thereby leaving behind only non gravity recoverable gold (hence the low recovery in the LKC above 425 µm). Size-by-size assays appear consistent.

<u>Regrind Cyclone Overflow</u>

The RCOF grade was calculated at 0.14 oz/st. The overall free gold content was high for a cyclone overflow at 56%. The regrind cyclone acts as a dewatering cyclone. Most of the mass (60%) is below 38 µm; only 12% is coarser than 105 µm. Recovery was good in most size classes (52-86%) except below 38 µm where recovery was only 38%. This could be due in part to the mechanical limitations of the LKC when processing fine material, but is much more likely to be the result of gold particle flakiness. A slight drop in recovery (from 70% to 53%) occurs below 105 µm, although very little of the gold (4%) is distributed in that class. Most of the gold (58%) is distributed below 38 µm while very little of the gold is located above 75 µm.

4.4.2 Plant Jigs

<u>Jig Tails</u>

The calculated grade for the JTls was 0.62 oz/st with a high overall free gold content of 83%. Most of the JTls mass (51%) is located between 105 µm and 425 µm.

Free gold content was low above 600 µm, where the plant jigs are most effective. An exception is the +840 µm class where recovery was 96%. This high recovery corresponds to 1 or 2 flakes of gold. Assuming the weight of one flake to be 5-10 mg, then in 20 g of sample the assay would be 8-16 oz/st (the actual concentrate assay was 10 oz/st). Below 600 µm, gold recovery was very good (even below 38 µm) increasing from 67% to 87%. Jig performance appears to decrease considerably with decreasing particle size.

Much of the gold (87%) is distributed below 212 μm. There is very little gold above 600 μm, where jig recovery is high. A single size class, -38 μm, has a large amount of gold (26%). Size-by-size assays are consistent, showing increasing concentrate, tailings and feed grade with decreasing particle size. The LKC is exceptionally efficient at recovering free gold in this stream. High recoveries (87%) occur below 38 μm for the jig tails as opposed to low recoveries (38%) for the RCOF in the same size class. Since the jig feed is cyclone underflow material, the gold would be less fine and flaky compared with the RCOF, allowing for better recovery in the LKC.

Jig Concentrates

In the Dome Mine gravity circuit there are four duplex jigs resulting in eight discharge concentrate streams. All the concentrate streams appear to be very different in grade, size distribution and free gold recovery, as can be seen in Table 4.2. Detail of Table 4.2 are found in Appendix C.

Table 4.2: Jig Concentrate Stream Comparisons

JIG CONC STREAM	GRADE oz/st	RECOVERY % FREE Au	%-75 μm Au DIST.	YIELD %	METHOD
1W	9	76	18	3	JIG + KC
1E	126	86	2	12	JIG + MLS
2W	277	93	1	13	JIG + MLS
2E	275	61	5	19	JIG + MLS
3W	21	70	12	3	JIG + KC
3E	52	79	5	11	JIG + MLS
4W	367	89	2	26	JIG + MLS
4E	175	80	10	6	JIG + MLS

Jig concentrate grades can vary from 9 oz/st to 367 oz/st, jig size distributions vary from 14% to 74% mass above 600 μm, and free gold contents vary from

61% to 93%. The range of free gold content observed may be somewhat dependent upon the method of free gold determination (laboratory jig for the +600 μm and MLS or KC for the -600 μm).

The lowest grade jig concentrate (8.9 oz/st) was produced from the jig concentrate one west discharge (JC1W1). The highest concentrate grade (367 oz/st) was issued from jig concentrate four, west discharge (JC4W1). The remainder of the concentrate streams fall between these two extremes with an average concentrate grade of 163 oz/st. During discharge, the physical difference between jig concentrates was very noticeable: size distributions were highly variable and the lower grade concentrates appeared to contain much less pyrite and jig shot. According to the Dome staff, the jig concentrates and hence the jig performances continually change from stream to stream and from jig to jig. Figure 4.1 illustrates the differences in the jig concentrate streams.

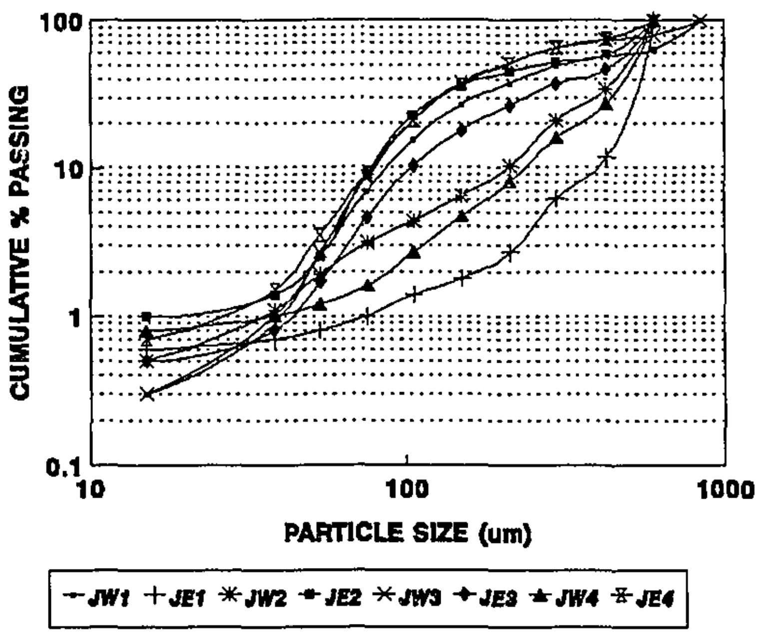

FIGURE 4.1: The Differences in Size Distribution of the Various Jig Concentrate Streams

All discharge streams are different in particle size distribution. Most of the mass in the jig concentrate streams is above 297 μm. The highest grade jig concentrate stream (JC4W1) has 92% of its mass above 297 μm, although there does not appear to be a correlation between grade and mass distribution. Low masses of 48% and 50% occur above 297 μm in streams JC4E1 and JC3W1 respectively. All streams have very little or no mass below 53 μm.

Gold distribution in the jig concentrates was also different in every stream; but gold distribution above 297 μm averages to 56%. The two extremes were JC1W1 and JC1E1 where 38% and 92%, respectively, of the gold was distributed above 297 μm.

Free gold content was high for all the jig concentrate streams, as expected, since free gold content for the jig tailings stream was 83%. Figure 4.1 demonstrates that free gold content increases with concentrate grade while fine gold content decreases, implying that fine gold is lost when jigs are operated more selectively. Unless concentrate grade is high, the jig gravity recoverable gold content is around that of feed and tails. Yields were very high for gravity recoverable gold recovery, which is unusual for the LKC. Yields for the lab tests are high because the jig concentrates are more difficult to separate. There is a direct correlation between yield and gravity recoverable gold content. The average free gold content of the eight concentrates was 79% (82% if JC2E1, which had the lowest recovery at 61%, is excluded). For JC1W1 the free gold contents were high below 425 μm and above 1180 μm. Recoveries suffered between these classes (where only 16% of the gold was distributed) and dropped to about 55%. Poor recovery (17%) was also encountered in the coarsest size fraction (+2380 μm) perhaps due to unliberated gold. The free gold content for jig stream JC1E1 was high at 86% with a concentrate grade of 918 oz/st. In the 212-297 μm class, gold recovery dropped sharply to only 11%. A gold flake may have gone to tails because concentrate grade in that size class was only 20 oz/st while tailings grade was 45 oz/st. Recovery also dropped below 75 μm from 91% to 44%, with little impact on overall recovery, as gold distribution below 75 μm is only 2%. The highest gold recovery (93%) was achieved from sample JC2W1. Recovery was excellent in most size classes excluding the coarser class above 1680 μm, where recovery was only 60% (but with very little gold, 0.1%, distributed there).

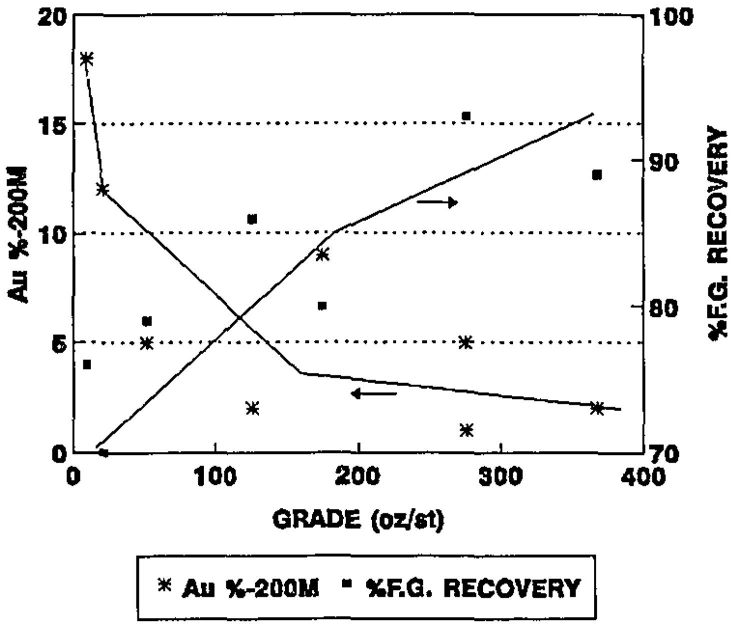

FIGURE 4.2: Free Gold Content Increases with Jig Concentrate Grade While the Fine Gold Content Decreases with Jig Concentrate Grade

The overall concentrate grade calculated from size class assays was 1938 oz/st, a concentration ratio of 7. Stream JC2E1 yielded the lowest free gold content (61%). Recovery suffered above 75 μm and below 212 μm (37% average); 33% of the mass and 34% of the gold is located in these range. Low recoveries may be due to large samples (in terms of sample mass) processed on the Mozley table resulting in overloading of the table and gold going to Mozley tails. The remainder of the streams, JC3W1, JC3E1, JC4W1, and JC4E1 all had fairly high recoveries with one or two of the size fractions producing lower recoveries which affected the overall recovery.

There does not appear to be a pattern in the jig concentrates to indicate that one size fraction is performing better than another. Poor recoveries seem very arbitrary and may be due to the mechanical parameters of the plant and/or laboratory jig such as the jig cycle, stroke length and frequency, depth of the jig bed, depth and size of the ragging, and the screen aperture.

Mass Balance

A mass balance using NORBAL2 was completed on the grinding circuit. Details of the mass balances are situated in Appendix D. Initially only size distributions were balanced. The RMD stream pulp mass flowrate value was set at 100 (arbitrary units) with a zero standard deviation. The RCOF and the RCUF flow rates were set at 25 and 350, respectively, with appropriately large standard deviations. Percent mass data were supplied from size distribution testwork performed on the initial streams. The results indicate a circulating load in the grinding circuit of about 360%. The fractional size distribution data did not require any large adjustments, suggesting that a fairly steady state of size distributions had been achieved in the circuit.

A second mass balance was performed utilizing the same data with the addition of overall gold assays. Once again the size distribution data did not adjust significantly. There were no exceptionally large adjustments on the overall assay data. The largest adjustment occurred for the JTls (0.62 oz/st to 0.52 oz/st) where the calculated assay was initially high. Results revealed a significant gold circulating load of 1800%. This may be typical for a grinding circuit that does not employ gravity concentration but is very high for one that does, suggesting the jigs are not reclaiming very much of the gold or that most of the gold is intermediate in size, or too small for efficient recovery by the jigs, yet too coarse to report to the PCOF. A different gravity device such as a plant Knelson concentrator could recover more of this intermediate gold thereby reducing the gold circulating load.

A third mass balance was carried out to determine what size class of gold was found in the recirculating load. Assays from the LKC, and laboratory jig testwork of the size distributions were utilized. Again, some of the assays were adjusted, with the largest changes to the fine fraction of the JTIs. From the results, the large gold circulating loads occur below 297μm and increase as particle size decreases, confirming the inefficiency of the jigs in recovering fine gold.

Cyclone Performance

From the mass balancing results the feed split to the PCUF and PCOF is 80%:20%. Table 4.3 and Figure 4.2 give the classification (Trump) curves for the ore and total and free gold.

The recovery curve of the ore shows a typical 'S' shaped curve without its complete 'toe'. Total gold and free gold are classified at a much finer size (<< 38 μm) than the ore, which cannot be determined without sub-sieve data. Both curves are closely matched, as most gold in the cyclone feed is free.

Table 4.3: Primary Cyclone Classification Efficiency Curves

Size (μm)	PCUF			
	Ore (%)	Gold (%)	'Free' Gold (%)	'corrected' Ore (%)
600	99.99	100.00	100.00	99.98
425	99.96	100.00	100.00	99.94
297	99.76	100.00	100.00	99.63
212	99.01	100.00	100.00	98.45
150	95.78	98.25	99.77	93.41
105	87.13	97.21	99.55	79.89
75	73.65	96.90	98.97	58.83
53	57.60	95.38	98.92	33.76
38	41.68	88.42	only -75 μm data available	8.89
-38	33.64	67.08		3.67

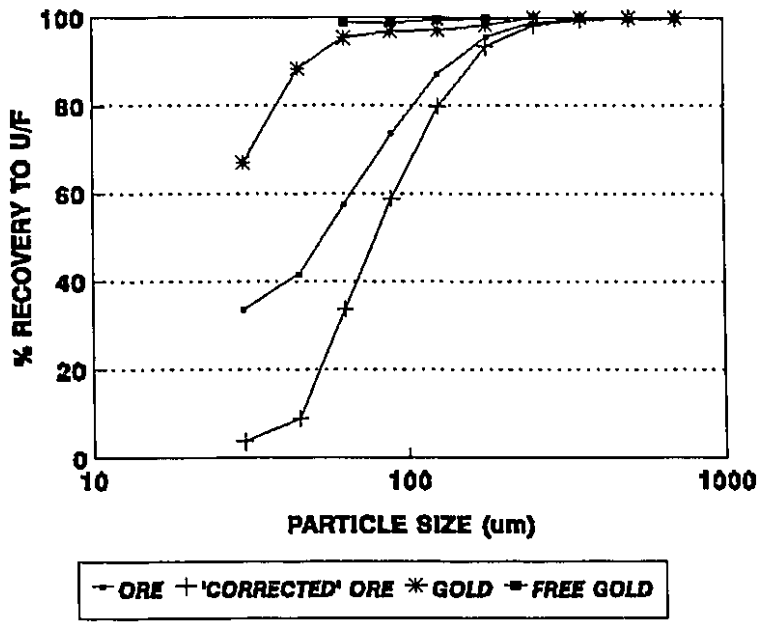

FIGURE 4.3: Primary Cyclone Classification Efficiency Curves

In reality, classification is never perfect, and some short circuiting occurs. In particular, part of the fines report to the cyclone underflow which is a proportion equal to water recovery, R_f. To model this phenomenon, a 'corrected' classification curve is calculated which takes the short circuiting into account. A 'corrected' d_{50c} (which will always be higher than the actual value because short circuiting is subtracted) can then be determined. The commonly used equation which represents a 'corrected' classification curve is (Plitt, 1976):

$$y_c = \frac{y-R_f}{1-R_f} = 1-\exp[-0.693(\frac{d}{d_{50c}})^m] \tag{4.1}$$

where

R_f: the fraction of the feed water which is recovered in the underflow and is determined from a water balance around the cyclone. In the case of the primary cyclone, R_f is equal to 35.99% which is in good agreement with the measured mass recovery in the -38 μm fraction (34%) which reports to the underflow

d_{50c}: the particle size for which the probability of reporting to the overflow or underflow products by true classification is equal

m: a representation of the classification sharpness

Equation 4.1 can be linearized (Plitt, 1971) to estimate d_{50c} and m. Alternately, the parameters can be estimated by non-linear least-square fit. The first method yielded estimates of 77 μm for d_{50c} and 2.3 for m; the second method yielded similar results: 70 μm for d_{50} and 1.7 for m.

Gold's classification parameters are more difficult to estimate, as sub-sieve data are unavailable. Plitt (1976) suggests that the d_{50c} is inversely proportional to the square root of the difference between the density of the solids and that of the fluid. This would yield a d_{50c} for free gold of about 20 μm (with a density of 3.2 for the ore and 19 for gold). Figure 4.2 at least suggests that the d_{50c} of free gold is in this range.

The feed weight split to the RCUF and RCOF is 94% and 6%, respectively. Table 4.4 gives the classification functions for the ore and 'free' gold. The classification curves are shown in Figure 4.3. Once again, the curve for the ore shows the central section of a typical 'S' shaped curve. The cut size of the ore can be estimated at 37 μm. No sub-sieve data are available for the total and free gold, and therefore the d_{50} cannot be determined. Their curves are more closely matched than those of the PCOF since much of the gold is free. Data from the LKC testwork was not available below 75 μm due to the small mass available, and the necessity of minimizing assay costs.

Table 4.4: Regrind Cyclone Classification Efficiency Curves

Size (μm)	RCUF			
	Ore (%)	Gold (%)	'Free' Gold (%)	'corrected' Ore (%)
600	100.00	100.00	100.00	99.99
425	99.99	100.00	100.00	99.98
297	99.94	100.00	100.00	99.87
212	99.90	100.00	100.00	99.78
150	98.46	99.69	99.74	96.57
105	95.73	99.59	99.68	90.53
75	91.53	99.58	99.52	81.21
53	83.78	95.94	98.97	64.01
38	67.02	89.92	only -75 μm data available	26.81
-38	51.83	86.04		6.90

The 'corrected' cut size is slightly less (approximately one size class finer) than the PCUF at 40 μm. The separation sharpness is calculated at 2.4, similar to the results obtained with non-linear regression (a cut size of 50 μm and a separation sharpness of 2.0).

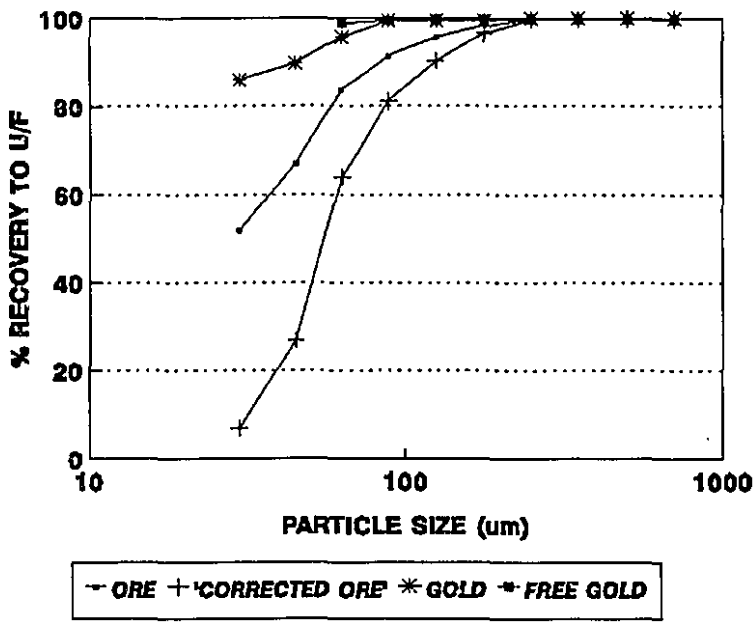

FIGURE 4.4: Regrind Cyclone Classification Efficiency Curves

Jig Performance

From the mass balance, recovery of the gravity circuit was only 25%, which is about half of the historical recovery (40-50%). A low RMD grade and a high COF grade contributed to the poor recovery (any small change in assay will affect recovery). Jig performance appears highly variable. Some of the jigs are performing well while others are so inefficient they should not be in the circuit. Unfortunately, performance changes from jig to jig on a daily basis, making it difficult to eliminate any particular unit. The jigs are also very selective with regard to particle size. They do not appear to recover particles effectively below 600 μm, where approximately 40% of the gold content resides. Figure 4.5 shows that there is substantial gold distributed below 600 in the jig tailings which could easily be recovered with the LKC and which was not recovered with the plant jigs. Introduction of a gravity unit that recovers a wider size distribution would be extremely beneficial.

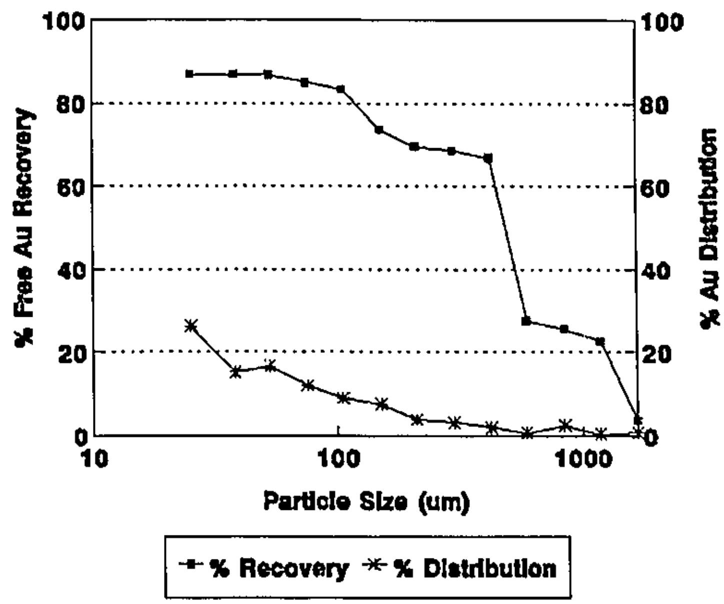

FIGURE 4.5: Size-by-Size Gold Distribution and Free Gold Content of the Jig Tailings

Table Tails

Processing the DTT with a Knelson concentrator produced a free gold content of 60% with a calculated DTT grade of 7.36 oz/st.

The majority of the mass for the DTT (73%) is in the 841-212 μm range.

Free gold recoveries are very poor above, but excellent below, 212 μm. This indicates that the Deister table is efficiently recovering particles above 212 μm, but that below 212 μm there is an abundance of free gold returning to the regrind pump box and hence to the ball mill, causing circulating loads of fine free gold. The effect on the overall circulating load however, is very small.

Most of the gold (77%) appears to be distributed in the 425-150 μm with only 1 to 5% distribution in the remaining individual fractions because coarse gold is recovered by the table, and fine gold is not recovered by the jigs. The DTT concentrate assayed 224 oz/st which is a substantial upgrade from the feed of 7.4 oz/st. The LKC concentrate assays increased with decreasing particle size, a result which is to be expected since feed grade also increased with decreasing particle size. Details of the testwork are found in Appendix C (pages 179-187).

Wilfley table tails (WTT) were processed with a lab jig and MLS. They have a calculated grade of 41 oz/st at a 67% recovery, slightly higher than the DTT (60% recovery). The weight distribution for the WTT is dominant in two size classes: 1168-2380 μm (30%), and 105-210 μm (25%); there is very little mass (3%) below 75 μm.

Unfortunately 35% of the gold is distributed above 1168 μm where free gold content drops to 47%. The free gold content is high below 38 μm (78%) and in the 105-1168 μm (average 76%) where most of the gold reports. It is quite normal that much of the gold should report in the size classes were gravity recoverable gold content is high. The result is that 67% of the gold in the WTT is gravity recoverable gold. The result would even be higher if a LKC was used to estimate the gravity recoverable gold content. Both tables lose significant gold, but in different size classes.

Size-by-size grades of the WTT feed vary from a low of 5.8 oz/st in the coarsest fraction (2380 μm) to 324 oz/st in the finest fraction (-38 μm), although they do not consistently increase as particle size decreases. Grade increases to 107 oz/st as size decrease to 297 μm, and then decreases to 28 oz/st at 75 μm only to increase again to 324 oz/st below 38 μm.

CHAPTER 5

DISCUSSION

5.1 Free Gold Content Measurement

The free (i.e. gravity recoverable) gold content of a stream can be readily measured using the laboratory Knelson Concentrator (LKC). Laplante, Shu and Marois (1993), Banisi (1990), Spiller (1982), and the results shown in chapter 2 indicate that the laboratory Knelson Concentrator can recover 95% of what was found recoverable by amalgamation, the traditional measure of gold liberation. However, estimating the free gold content with a LKC is subject to some limitations. For example, the LKC cannot recover 95% of amalgamable gold from streams that contain significant free gold but are unlikely to be processed by gravity, such as cyclone overflow or gravity tailings. In the Lucien Béliveau case, the KC does not recover 95% of amalgamable gold in the flash flotation concentrate for two fundamental reasons. First, the nature of the gold (very fine and flaky) dictates that gravity recovery will be difficult (to some extent cyclone overflows display the same behaviour). Second, as virtually no light gangue is recovered in the flash concentrate, the resulting 'gangue' has a specific gravity of about five, even higher than the vast majority of massive sulphide ores (that contain some silicates). Other streams with a similar, albeit lesser problem, include cyclone overflows or those with a high sulphide gangue. Streams such as cyclone underflows and mill discharges (ball mill and/or rod mill) are ideal for maximum free gold recovery, especially if sulphide content is low.

In the case of Lucien Béliveau, dilution of the LKC feed for the high sulphide content samples has been shown to be a successful tool to maximize the amount of gold recovered, provide a constant feed source to the KC, and allow the processing of small samples. Dilution of samples with silica reduces the gangue density and thereby maximizes free gold recovery. Laplante, Shu and Marois (1993) report maximum gold recoveries in samples that have an F_{80} below 400 μm and a density below 3.2 g/cm^3. For massive sulphides (4.5 to 6.0 g/cm^3) a dilution of 4:1 silica-to-feed material is adequate to bring its specific gravity down to 3.2. The size distribution of the silica used for dilution is an important factor to consider as silica that is coarser than the sample may actually reduce recovery. When the LKC is used as an analytical tool, maximizing free gold recovery with silica is beneficial. However, laboratory results may not reflect the true recovery in the plant, as the diluted recoveries will consistently improve by an unknown factor. For Lucien Béliveau, the observed increase in gold recovery by silica dilution provides a strong argument for locating the primary gravity unit before flotation. The cyclone underflow, whose density is much lower than that of the flotation concentrate (high sulphide gangue) currently fed to the gravity circuit, would provide an obvious feed for primary gravity recovery. For circuits with high density ores, processing diluted samples with the LKC may be less appropriate (as there is no equivalent stream in the grinding circuit), but will yield recoveries closer to that of amalgamation. Woodcock (1994) has shown that removing oversize (+210 μm) can also increase fine gold recovery; it may be an alternative to silica dilution to maximize recovery of the LKC, and is certainly feasible at plant scale, for much the same purpose.

One rationale for processing plant samples with a laboratory separator (i.e. an ideal separator) is the ability to achieve a 'mechanically perfect' separation, -i.e. a separation that will consistently be better than that of a plant unit (although some plant units, such as cyclones, may recover more gold because of a much higher yield). Plant performance can then be compared directly to lab performance, providing both a reproducible standard and a target to achieve or at least strive for. In that sense, the LKC can be considered an ideal separator, even when feed is not diluted with silica. Consider the first survey at Lucien Béliveau, where the PKC feed of each hour of a four-hour loading cycle was sampled and processed with the LKC. Tailings assays from the LKC and PKC were closely correlated: PKC tailings samples assayed 2.5, 2.8, 3.2 and 3.5 oz/st, averaging 3.0 oz/st; LKC tailings for the same feed samples were 2.2, 2.8, 3.0 and 3.4 oz/st, respectively, averaging 2.8 oz/st. Recovery of the PKC averaged 45%, whereas that of the LKC was slightly higher at 49%. Recovery progressively dropped throughout the PKC cycle because of changes in feed characteristics in both the plant and laboratory units. In this case the recovery of the plant unit (the PKC) approached that of the ideal separator (the LKC), because the PKC was operated at 1.7 t/h, which is only 5% of its rated capacity of 35 t/h. Recent testwork (Laplante et al., 1994) suggests that PKC operated near or even above their rated capacity achieve much lower recoveries of 20 to 70%. Plant recoveries much lower than those of the LKC were also measured when the LKC processed a diluted feed or when plant units less effective than Knelsons were studied (e.g. Fig. 3.26). The status of the LKC as the ideal separator in these circumstances is even more apparent.

Feed variability is an important factor when processing streams with a Knelson Concentrator. When testing the original circuit at Lucien Béliveau, PKC and LKC recoveries dropped over the four-hour sampling cycle. This decrease in the Knelson performance was ore-induced. During tests T3, T7, T8, and T9, Knelson performance was not as good as test T2 due to the change in the circuit: the addition of the hydroseparator and the spiral. In this case, the decrease in Knelson performance was partially circuit-induced. The Knelson then had to process flakier gold (from spiral tails) which it does poorly.

5.2 Lucien Béliveau

Two circuits were investigated at Lucien Béliveau. The circuit change was motivated by mechanical problems with the 76 cm plant Knelson Concentrator: bearings would wear due to uneven loading. From the results of Chapter 3 it appears that the initial circuit (flash flotation concentrate feeding a 76 cm plant Knelson Concentrator) produced better gravity recoveries (45%) than the second, more complex circuit (a hydroseparator, spiral and 51 cm plant Knelson Concentrator, at 32% recovery). Factors other than metallurgy also favour the 76 cm PKC circuit. Initially a spiral, with no moving parts, appeared to be a good choice as an alternative gravity unit. An important requirement for efficient spiral operation is a constant feed source. Therefore, a hydroseparator was added upstream. Spiral performance still proved erratic and required constant operator attention, both for adjustment of concentrate flow rate and for cleaning. A constant flow of material was also difficult to achieve (this was particularly obvious when performing test work). The 51 cm plant Knelson Concentrator served mostly as a back-up for the spiral, and recovered most gold when the spiral performed poorly. Its unit recovery was lower than the original 76 cm unit, but this was attributed largely to a more refractory flash flotation concentrate, from which the most easily gravity recoverable gold was skimmed off by the spiral. Therefore, although the bearings problem was solved, the revised circuit had its share of problems, to the extent that when the Lucien Béliveau deposit was mined out, and the mill moved to the Chimo mine site (fall 1993), the gravity circuit was not re-installed. A new circuit is planned, which would incorporate the major recommendation of this study, i.e. gold recovery from the cyclone underflow.

Testwork in the plant and laboratory has shown that processing the 76 cm plant Knelson Concentrator tailings with the 56 cm unit would yield a 25% gold recovery. It appears there is some short circuiting occurring in the Knelson Concentrator. However, the water balance in the mill cannot accommodate the two units in series. The additional recovery would also be minimal, as a significant fraction of the gold does not report to the flash cell concentrate in the first place.

There is still significant coarse liberated gold in the circulating load of the ball mill that may not be readily floated. These coarse particles then become smaller and flatter (flakier) when recirculated, decreasing their chance of being recovered by gravity. Testwork with the Chimo ore (Woodcock, 1994) indicates that there is more than 80% gravity recoverable gold, most of which could be reaped with a PKC. Recovering gold from the cyclone underflow (rather than the flash concentrates) achieves a purpose which the old circuit could not achieve: recovering, by gravity, part of the gold that did not float. Because this is the major rationale for using gravity ahead of flotation, this more traditional approach to gravity gold recovery has to prevail over the ingenious circuit used at Lucien Béliveau. Two additional advantages also favour the traditional approach of recovering from the circulating load: first, the high circulating load of gold can yield high circuit recoveries even when treating part of the bleed, and second, this is a more logical location for the water additions required by all gravity equipment.

5.3 Dome

Due to the very coarse gold in the Dome mill all data above 850 μm are questionable. As was discussed in chapter 2.1, large sample masses (33 to 600 kg) are required to estimate gold grade accurately in this size range. The task of processing such large samples becomes extremely difficult, and where size-by-size information is required it becomes almost impossible. Alternatives to sampling, such as tracers, would be necessary to generate acceptable data. The important point to note is that there is virtually no coarse gold in the jig tailings, yet it is quite prominent in the rod mill discharge and jig concentrate streams. This leads to the conclusion that the jigs must be recovering the coarse gold, although, of course, some of it is also ground to finer size fractions.

Three different laboratory units were used to process the Dome samples: a laboratory jig, a Mozley laboratory separator and a laboratory Knelson Concentrator. No sample was processed with more than one unit and therefore a direct comparison of results would be unfair. However, the Knelson Concentrator far outshone the other two units in ease and speed of operation. The laboratory jig was the most cumbersome unit and required constant attention. Changes in the amount of ragging, stroke length, and hutch water were necessary for each sample (as their size distributions were highly variable). The Mozley laboratory separator was very time consuming and operator sensitive; data were noisy, because of the small masses processed. Sample masses not exceeding 200 g are recommended. In cases where the Knelson Concentrator performance falls off (where gold is much finer than the ore) a Mozley laboratory separator may be beneficial as a single Tyler class is processed, thereby allowing gold particles to be separated from particles of comparable size, resulting in increased efficiency. It appears the Mozley laboratory separator is most effective when the mass is small (too small for the Knelson Concentrator), the grade is high (to get good statistics despite the low mass processed) and the particles are coarse.

The difficulties encountered with the laboratory jig appear to be amplified in the plant. As discussed in chapter 4, all four jigs produced varying grades, size distributions and recovery. Jig performance was very inconsistent and changed from jig to jig. Jig concentrate grades varied from 9 oz/st to 367 oz/st, jig size distribution varied from 14% to 74% mass above 600 μm, and free gold recoveries varied from 61% to 93%. It has been noted that there are many problems (mainly mechanical) associated with jig use. For example, jigs tend to sand frequently due to a variety of factors. At the Jolu Gold Mine, jigs were operated close to sanding in the beds for maximum recovery (Kazakoff, 1990). This required discerning operator attention to pulsation frequency, feed grade, feed rate, shot thickness, condition of natural bed and frequency of hutch dumping. All were factors in maximizing performance. At Homestake Gold Mine (Hinds, Trautman, and Ommen, 1989) it was reported that many problems were encountered during jig operation, such as selection of bearings, slippage in the eccentric stroke adjustments, excessive wear of brass bushings, feed box and pipeline problems, pump and valve wear, and line plugging due to abrasives in the sulphides. Although Johnny Mountain Gold Mine did not report mechanical problems with their jig, gold gravity recoveries were only 15 to 30% where laboratory testwork produced much higher recoveries (50%). Lac Minerals Est Malartic mill tested three different types of jigs (Hope, McMullen and Green, 1993). They found only one of the jigs was able to make the separation (with appropriate care) between the pyrite and the gold but the result was low unit recoveries of 15-20% and even lower overall recovery. The other two jigs tested sanded when too much pyrite reported to the hutch. If the jigs were pulled too hard in order to stop the sanding, upgrading suffered (upgrading ratio of 2). When a 76 cm Knelson Concentrator was installed to replace the jig, the result was a 40% gold recovery from the head and an upgrading ratio of 1000:1 in a single stage.

Since this work was initiated, the Dome mine has also replaced their four jigs with a single 76 cm Knelson Concentrator. The Knelson treats a bleed from the circulating load (13% of the flow) and recovers more gold than the jigs ever did. It is also a much simpler circuit. Gold at the Dome mine is so coarse that it is an ideal feed for jig operation. Yet a Knelson Concentrator is attaining better recoveries at higher upgrades. The implication is that jigs may almost never outperform Knelson Concentrators when recovering gold from circulating loads.

CHAPTER 6

CONCLUSIONS AND FUTURE WORK

6.1 Conclusions

The 7.5 cm laboratory Knelson Concentrator was an indispensable tool in evaluating the grinding and gravity circuits of Lucien Béliveau and Dome Mines. The laboratory Knelson Concentrator not only quantified the free gold content of streams but also predicted the performance of the plant Knelson Concentrator.

The addition of silica particles (210 μm) in a 4:1 silica to feed ratio enhanced the recovery of fine gold particles, provided a constant feed source to the Knelson Concentrator, and allowed the processing of small samples. It was found that silica around 210 μm reduced the recovery of gold particles of similar size slightly, but increased that of finer gold significantly. Much coarser silica (F_{80}: 840 μm) was also used, and clearly reduced gold recovery over the full size range.

There is significant coarse liberated gold in the circulating load of the ball mill at Lucien Béliveau that does not float in the flash cell but could easily be recovered from the cyclone underflow with a Knelson Concentrator.

The initial gravity circuit (76 cm PKC) for Lucien Béliveau produced gold recoveries of 45%. After changing the circuit (hydroseparator, spiral and 51 cm PKC) recovery dropped to 32%; this was partly attributed to the circuit change, but also to a more refractory feed.

Processing the 76 cm plant Knelson Concentrator tailings (initial gravity circuit) with a LKC produced 25% recovery. This was duplicated in the plant where the 76 cm unit was run in series with the 51 cm PKC. Due to water balance concerns it would not be feasible to run two Knelsons in series but it does show that, with some feeds, the Knelson may fail to recover recoverable particles in a single pass, despite very low feed rates. Processing the PKC concentrate with a LKC produced a recovery of 96% at a concentrate grade of 4000 oz/st (14% Au, i.e. approaching smelting grade); this indicates that the PKC recovered very largely free gold, and that the KC has potential as an upgrading device.

In the modified circuit, the hydroseparator served only as a flow stabilizer for the spiral since very little thickening or sizing was achieved (mass and gold distribution for the underflow and overflow were almost identical).

Spiral recovery was very erratic (12% to 44%) and dropped significantly below 150 μm. There appeared to be no correlation between recovery, spiral feed rate or % solids, spiral recovery, however, correlated with gravity recoverable gold in the spiral feed.

Inconsistent recoveries (6 to 17%) were also experienced with the 51 cm plant Knelson Concentrator. When the spiral was not performing well the 51 cm Knelson was performing well with the result that the overall recovery of the two units in series was very consistent (31-32% Au).

The gold circulating load at Dome Mines is very high (1800%) for a circuit employing gravity concentration, although it would be typical for a circuit that does not employ gravity concentration. This suggests that the jigs are not adequately recovering gold. Size-by-size studies showed that the recovery drop took place below 425 μm.

In the Dome gravity circuit, individual jig performance was very inconsistent: the eight hutches produced varying grades (9 oz/st to 367 oz/st), varying size distributions (14% to 74% mass above 600 μm) and varying free gold recovery (61% to 93%). Free gold content increased and fine gold content decreased with increasing jig concentrate grade.

6.2 Recommendations

There is significant gold in the Lucien Béliveau grinding circuit that is too coarse to float in the flash cell and which should be recovered by gravity (51 cm PKC) in the cyclone underflow or ball mill discharge streams. As an alternative, a 76 cm PKC located in the cyclone underflow stream may warrant discontinuing treatment of the flash flotation cell concentrate by gravity.

Medium and fine size gold is being recirculated in the grinding mill of the Dome Mine because the jigs are recovering only coarse gold (+425 μm). Replacement of the jigs by a Knelson Concentrator would recover a wider size distribution of gold (since the preliminary results of this study have been released, the jigs have indeed been replaced by a 76 cm Knelson, with excellent results). Because there is so much coarse gold in the rod mill discharge, a jig could still be useful in the grinding circuit, provided that the primary mill discharge be screened at around 1 mm to return oversize to the mill feed. The oversize, which would constitute a low mass, could still be processed with a jig for very coarse gold removal. This would be as much for security as metallurgical reasons (as this recycle stream would constitute a serious security risk for gold theft).

Using a smaller Knelson for secondary upgrading, either as a first cleaner or a scavenger, would recover much of the fine free gold that is returning to the grinding circuit from the Deister table tails. The table middlings and tails from the Wilfley table could then be recycled to the Knelson Concentrator for scavenging rather than returning to the grinding circuit. This would allow a shorter processing time, easier bin feeding and less operator attention.

6.3 Future Work

(1) A follow-up at the plants previously tested if the recommended changes are made. This could confirm that the conclusions reached in this study were correct, and would indirectly confirm the usefulness of the laboratory Knelson Concentrator for the evaluation of grinding and gravity circuits.

(2) Further work should be done on dilution as to why recovery falls off in the coarser sizes when the sample is diluted. Also, an alternative to dilution such as removal of oversize should investigated, although this cannot be done readily on some material (the flash flotation products at Lucien Béliveau being a very good example).

(3) Even though the Knelson Concentrator manufacturer is testing a continuous discharge unit, further work should be done on the time required to actually overload the plant unit. It appears that operators at most mills containing Knelson Concentrators do not know the maximum loading cycle before recovery suffers due to overloading. Ultimately, the Knelson could even be used to produce smeltable grade concentrate, thus replacing or supplementing shaking tables normally used for this purpose.

(4) The recovery of sub-sieve gold particles with the laboratory Knelson Concentrator should also be investigated as little data are currently available on this topic.

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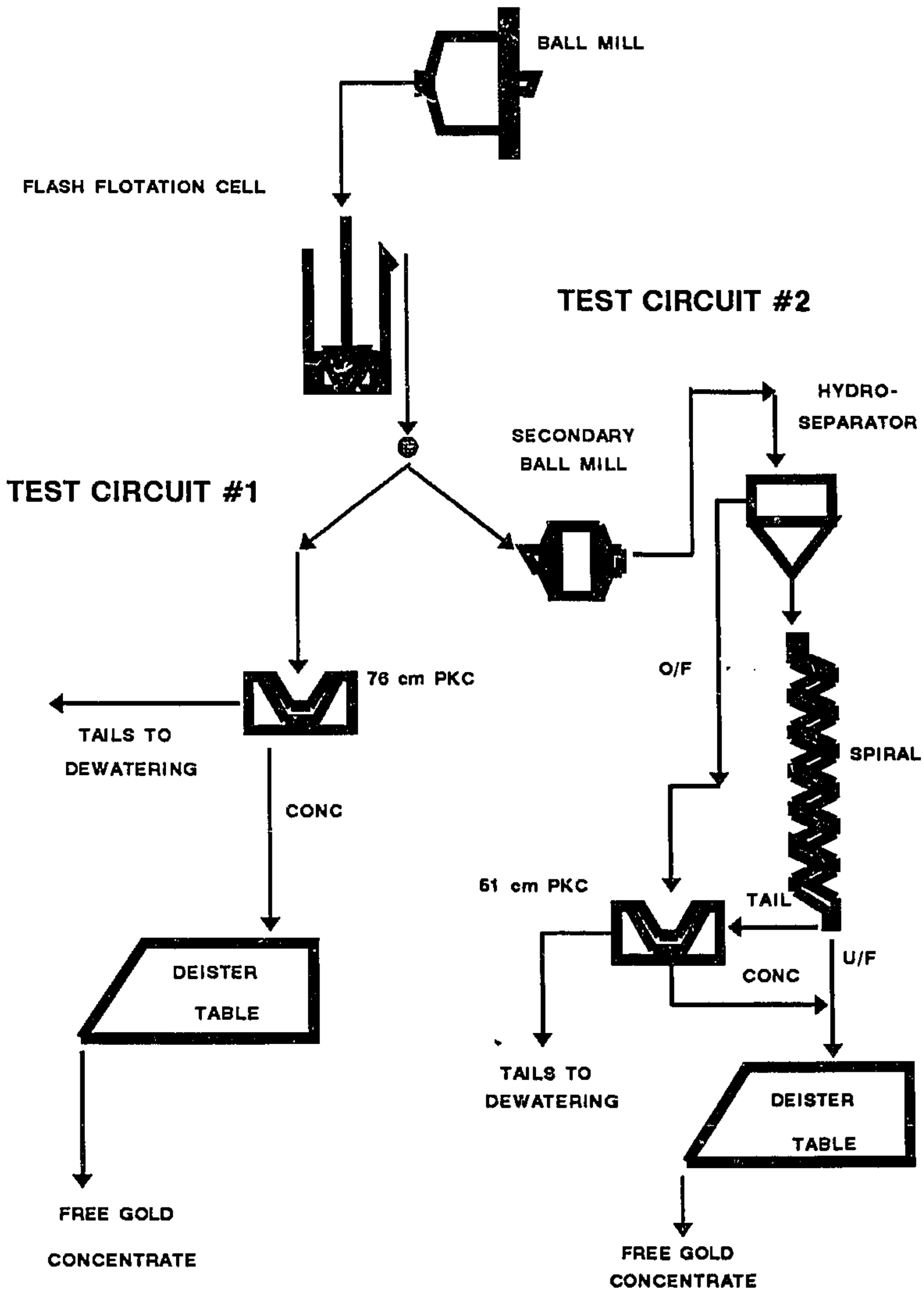
APPENDIX A

Appendix A.1: Flowsheet of the Lucien Béliveau and Dome Mills

Appendix A.2: Percent solids of the Lucien Béliveau and Dome Mine sampling campaigns

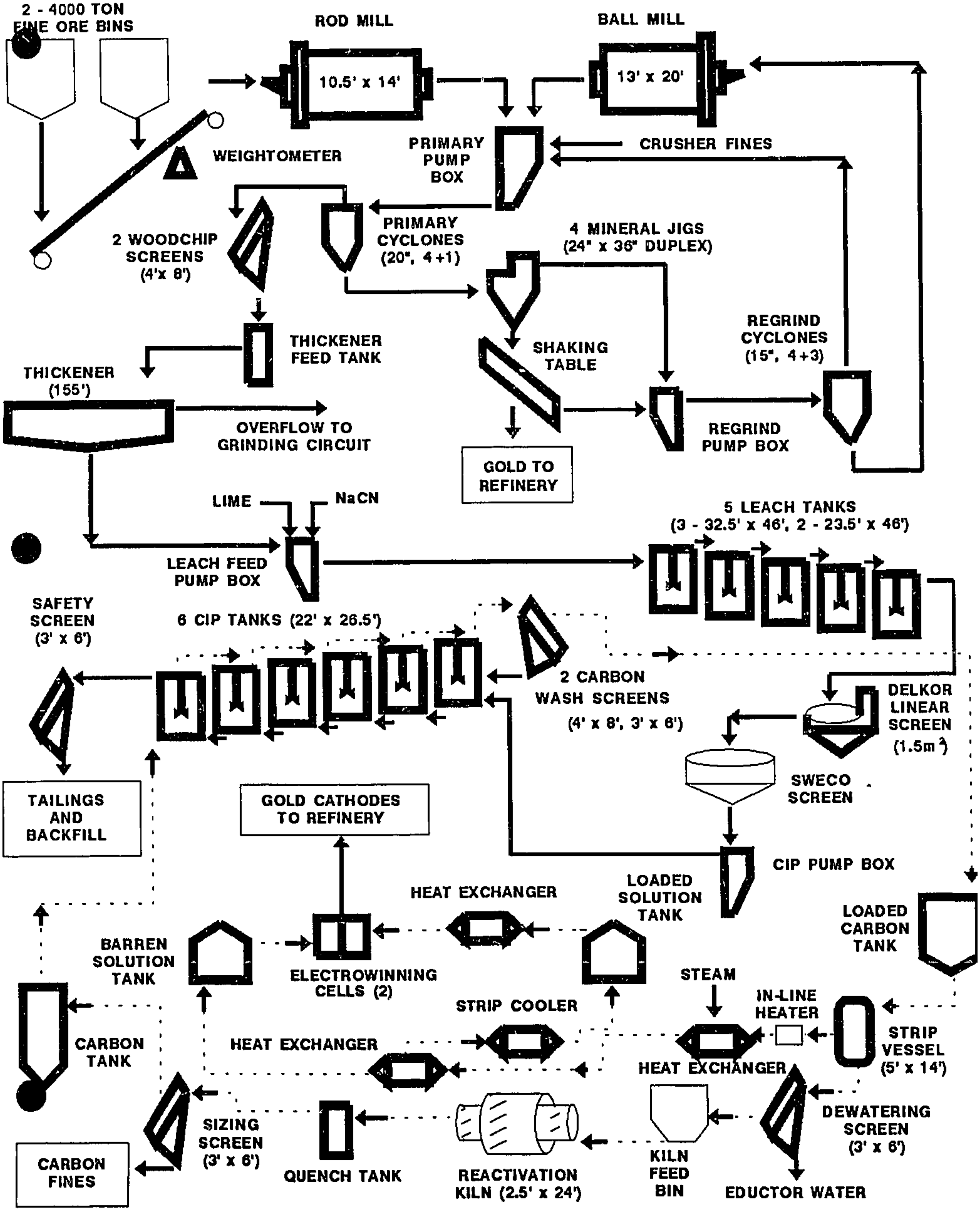
Appendix A.3: Size distributions of the Lucien Béliveau and Dome Mine samples before processing

A.1: Flowsheet of the Lucien Béliveau and Dome Mills



Lucien Beliveau Test Circuits

PLACER DOME INC.
DOME MINE - MILL FLOWSHEET



A.2: Percent Solids of the Lucien Béliveau and Dome Mine Sampling Campaigns

LUCIEN BELIVEAU TEST T1
SAMPLE % SOLIDS

SAMPLE	WET WT (kg)	DRY WT (kg)	SOLIDS (%)
SAGD-1,2	8.19	6.33	77.29
BMD-1	7.05	1.23	17.45
BMD-2	6.51	2.08	31.95
CYC U/F1	8.75	6.34	72.46
CYC U/F2	9.89	6.98	70.58
CYC O/F	9.43	3.83	40.62
KF1-1A	8.54	0.81	9.48
KF1-1B	9.18	1.54	16.78
KF1-2A	9.70	0.68	7.01
KF1-2B	11.77	1.63	13.85
KF2-1A	8.58	0.67	7.81
KF2-1B	10.75	1.17	10.88
KF2-2A	10.80	1.07	9.91
KF2-2B		1.04	
KF3-1A	9.14	1.24	13.57
KF3-1B	9.33	1.13	12.11
KF3-2A	10.02	1.24	12.38
KF3-2B	9.11	1.14	12.51
KF4-1A	9.72	1.19	12.24
KF4-1B	10.55	0.99	9.38
KF4-2A	10.38	1.19	11.46
KF4-2B	10.55	1.01	9.57
KT1-1A	7.26	0.94	12.95
KT1-1B	8.50	1.25	14.71
KT1-2A	8.98	1.22	13.59
KT1-2B	9.06	1.42	15.67
KT2-1A	10.95	1.41	12.88
KT2-1B	9.38	1.09	11.62
KT2-2A	10.30	1.54	14.95
KT2-2B	10.56	1.56	14.77
KT3-1A	9.46	1.42	15.01
KT3-1B	9.46	1.21	12.79
KT3-2A	9.64	1.55	16.08
KT3-2B	9.85	1.44	14.62
KT4-1A	9.97	1.60	16.05
KT4-1B	10.15	1.40	13.79
KT4-2A	10.11	1.37	13.55
KT4-2B	9.88	1.29	13.06

LUCIEN BELIVEAU TESTS T2-T9
SAMPLE % SOLIDS

SAMPLE	WET WT (kg)	DRY WT (kg)	SOLIDS (%)
BMD1-T2	12.85	5.69	44.28
SMD1-T2	15.26	11.61	76.08
COF1-T2	10.66	4.26	39.96
CUF1-T2	18.24	12.57	68.91
SpF1-T2	9.74	1.40	14.37
KnF1-T2	7.20	0.51	7.08
KnT1-T2	8.68	0.70	8.06
BMD2-T2	12.04	5.24	43.52
SMD2-T2	13.79	10.49	76.07
COF2-T2	11.93	4.80	40.23
CUF2-T2	17.54	12.26	69.90
SpF2-T2	8.97	1.05	11.71
KnF2-T2	11.25	0.82	7.29
KnT2-T2	9.63	0.87	9.03
SpC1-T2g	1342.40	512.80	38.20
SpC2-T2g	1664.70	588.60	35.36
KnC1-T2g		298.8	
SpF1-T3	9.89	1.54	15.57
SpT1-T3	9.91	1.21	12.21
SpC1-T3g	908.20	406.20	44.73
SpC2-T3g	1419.10	662.40	46.68
SpF1-T4	11.90	2.84	23.87
SpT1-T4	10.98	1.27	11.57
SpC1-T4g	1191.40	574.60	48.23
SpC2-T4g	1343.70	588.20	43.77
SpF1-T5	11.61	2.59	22.31
SpT1-T5	11.21	1.60	14.27
SpC1-T5g	1178.30	594.30	50.44
SpC2-T5g	1444.90	640.30	44.31
SBMD-T7	11.18	1.62	14.49
ThOF-T7	15.01	1.10	7.33
ThUF-T7	11.49	2.25	19.58
KnF1-T7	10.60	1.16	10.94
KnT1-T7	10.77	1.06	9.84
KnT2-T7	10.06	0.96	9.54
SpC1-T7g	386.14	154.90	40.11
SpC2-T7g	668.40	221.70	33.17
SBMD-T8	11.73	1.65	14.07
ThOF-T8	9.95	0.67	6.73
ThUF-T8	11.68	2.49	21.32
KnF1-T8	11.26	1.25	11.10
KnF2-T8	10.93	1.23	11.25
KnT1-T8	10.79	1.05	9.73
KnT2-T8	10.96	1.03	9.40
KnF1-T9	11.89	1.39	11.69
KnF2-T9	11.36	1.32	11.62
KnF3-T9	11.80	1.35	11.44
KnT1-T9	10.29	1.01	9.82
KnT2-T9	10.93	1.02	9.33
KnT3-T9	10.91	1.14	10.45

DOME
SAMPLE % SOLIDS

SAMPLE	WEIGHT (g)	BUCKET WT (g)	WET WT (g)	DRY WT (g)	SOLIDS %
RMD1	16154	530	15624	11473	73.4
BMD1	16481	530	15951	11447	71.8
PCO/F1	9926	530	9396	2660	28.3
PCU/F1	15010	530	14480	10622	73.4
RCO/F1	10666	530	10136	2226	22.0
RCU/F1	18877	530	18347	14251	77.7
CS1	8728	822	7906	311	3.9
JTLS1	11887	530	11357	7798	68.7
RMD2	14761	530	14231	10379	72.9
BMD2	17023	530	16493	11831	71.7
PCO/F2	8099	482	7617	2215	29.1
PCU/F2	16505	531	15974	11810	73.9
RCO/F2	10471	530	9941	2169	21.8
RCU/F2	19061	531	18530	14293	77.1
CS2	4206	822	3384	73	2.2
JTLS2	14592	530	14062	9588	68.2
PCO/F3	9412	531	8881	2446	27.5
PCU/F3	14306	531	13775	10213	74.1
JTLS3	15267	530	14737	10006	67.9

A.3: Size Distributions of the Lucien Béliveau and Dome Mine Samples Before Processing

LUCIEN BELIVEAU TEST T1 SIZE DISTRIBUTIONS

BMD1

TYLER SCREEN	WT:(g)	CUM WT:(g)	WT:%	CUM WT% RETAINED	CUM WT% PASSING
+28	6.2	6.2	2.2	2.2	100.0
+35	7.0	13.2	2.5	4.7	97.8
+48	14.0	27.2	5.0	9.7	95.3
+65	29.1	56.3	10.4	20.1	90.3
+100	40.0	96.3	14.3	34.4	79.9
+150	26.2	122.5	9.3	43.7	65.6
+200	20.6	143.1	7.3	51.1	56.3
+270	11.5	154.6	4.1	55.2	48.9
+325	9.9	164.5	3.5	58.7	44.8
+400	6.4	170.9	2.3	61.0	41.3
-400	109.4	280.3	39.0	100.0	39.0

BMD2

TYLER SCREEN	WT:(g)	CUM WT:(g)	WT:%	CUM WT% RETAINED	CUM WT% PASSING
+28	6.9	6.9	2.8	2.8	100.0
+35	10.6	17.5	4.4	7.2	97.2
+48	18.5	36.0	7.6	14.8	92.8
+65	36.1	72.1	14.9	29.7	85.2
+100	46.4	118.5	19.1	48.8	70.3
+150	27.4	145.9	11.3	60.0	51.2
+200	18.2	164.1	7.5	67.5	40.0
+270	10.7	174.8	4.4	71.9	32.5
+325	6.8	181.6	2.8	74.7	28.1
+400	3.2	184.8	1.3	76.0	25.3
-400	58.2	243.0	24.0	100.0	24.0

CYC O/F

TYLER SCREEN	WT:(g)	CUM WT:(g)	WT:%	CUM WT% RETAINED	CUM WT% PASSING
+28	0.0	0.0	0.0	0.0	100.0
+35	0.1	0.1	0.0	0.0	100.0
+48	0.2	0.3	0.1	0.1	100.0
+65	1.5	1.8	0.6	0.8	99.9
+100	12.7	14.5	5.5	6.2	99.2
+150	21.6	36.1	9.3	15.5	93.8
+200	21.6	57.7	9.3	24.8	84.5
+270	16.7	74.4	7.2	32.0	75.2
+325	11.9	86.3	5.1	37.1	68.0
+400	8.5	94.8	3.7	40.7	62.9
-400	138.0	232.8	59.3	100.0	59.3

SAGD1&2

TYLER SCREEN	WT:(g)	CUM WT:(g)	WT:%	CUM WT% RETAINED	CUM WT% PASSING
+28	32.1	32.1	12.8	12.8	100.0
+35	14.5	46.6	5.8	18.5	87.2
+48	16.4	63.0	6.5	25.1	81.5
+65	26.9	89.9	10.7	35.8	74.9
+100	31.7	121.6	12.6	48.4	64.2
+150	20.5	142.1	8.2	56.5	51.6
+200	15.0	157.1	6.0	62.5	43.5
+270	10.2	167.3	4.1	66.6	37.5
+325	6.4	173.7	2.5	69.1	33.4
+400	4.1	177.8	1.6	70.8	30.9
-400	73.5	251.3	29.2	100.0	29.2

CUF 1

TYLER SCREEN	WT:(g)	CUM WT:(g)	WT:%	CUM WT% RETAINED	CUM WT% PASSING
+28	32.6	32.6	16.3	16.3	100.0
+35	13.0	45.6	6.5	22.8	83.7
+48	18.2	63.8	9.1	31.9	77.2
+65	33.6	97.4	16.8	48.7	68.1
+100	37.5	134.9	18.8	67.5	51.3
+150	17.6	152.5	8.8	76.3	32.6
+200	10.2	162.7	5.1	81.4	23.8
+270	5.5	168.2	2.8	84.1	18.7
+325	2.8	171.0	1.4	85.5	15.9
+400	1.4	172.4	0.7	86.2	14.5
-400	27.6	200.0	13.8	100.0	13.8

CUF 2

TYLER SCREEN	WT:(g)	CUM WT:(g)	WT:%	CUM WT% RETAINED	CUM WT% PASSING
+28	34.6	34.6	14.8	14.8	100.0
+35	18.4	53.0	7.9	22.7	85.2
+48	24.1	77.1	10.3	33.0	77.3
+65	41.7	118.8	17.8	50.8	67.0
+100	44.6	163.4	19.1	69.9	49.2
+150	20.3	183.7	8.7	78.6	30.1
+200	11.1	194.8	4.7	83.4	21.4
+270	6.3	201.1	2.7	86.1	16.6
+325	1.9	203.0	0.8	86.9	13.9
+400	0.2	203.2	0.1	86.9	13.1
-400	30.5	233.7	13.1	100.0	13.1

KF-3

TYLER SCREEN	WT:(g)	CUM WT:(g)	WT:%	CUM WT% RETAINED	CUM WT% PASSING
+28	0.2	0.2	0.1	0.1	100.0
+35	1.7	1.9	0.8	0.9	99.9
+48	5.3	7.2	2.4	3.2	99.1
+65	15.1	22.3	6.8	10.0	96.8
+100	26.7	49.0	12.0	22.0	90.0
+150	27.1	76.1	12.1	34.1	78.0
+200	28.9	105.0	13.0	47.1	65.9
+270	24.1	129.1	10.8	57.9	52.9
+325	15.9	145.0	7.1	65.0	42.1
+400	11.1	156.1	5.0	70.0	35.0
-400	67.0	223.1	30.0	100.0	30.0

KT-3

TYLER SCREEN	WT:(g)	CUM WT:(g)	WT:%	CUM WT% RETAINED	CUM WT% PASSING
+28	.0.3	0.3	0.1	0.1	100.0
+35	2.3	2.6	0.8	0.9	99.9
+48	7.4	10.0	2.6	3.5	99.1
+65	21.7	31.7	7.6	11.1	96.5
+100	41.0	72.7	14.4	25.5	88.9
+150	42.8	115.5	15.0	40.5	74.5
+200	46.0	161.5	16.1	56.6	59.5
+270	38.7	200.2	13.6	70.1	43.4
+325	17.8	218.0	6.2	76.4	29.9
+400	13.4	231.4	4.7	81.1	23.6
-400	54.1	285.5	18.9	100.0	18.9

LUCIEN BELIVEAU TEST T1 SIZE DISTRIBUTIONS cont.

TYLER SCREEN	KCONC WT:(g)	CUM WT:(g)	WT:%	CUM WT% RETAINED	CUM WT% PASSING
+28	1.6	1.6	0.8	0.8	100.0
+35	5.6	7.2	2.9	3.7	99.2
+48	11.7	18.9	6.0	9.6	96.3
+65	27.7	46.6	14.1	23.8	90.4
+100	42.3	88.9	21.6	45.3	76.2
+150	33.4	122.3	17.0	62.4	54.7
+200	29.8	152.1	15.2	77.6	37.6
+270	18.6	170.7	9.5	87.0	22.4
+325	9.1	179.8	4.6	91.7	13.0
+400	5.8	185.6	3.0	94.6	8.3
-400	10.5	196.1	5.4	100.0	5.4

DOME MINE SIZE DISTRIBUTIONS

BMD

TYLER SCREEN	WT:(g)	CUM WT:(g)	WT:%	CUM WT% RETAINED	CUM WT% PASSING
+28	45.7	45.7	9.9	9.9	100.0
+35	22.4	68.1	4.8	14.7	90.1
+48	46.3	114.4	10.0	24.7	85.3
+65	57.9	172.3	12.5	37.2	75.3
+100	87.3	259.6	18.8	56.0	62.8
+150	57.4	317.0	12.4	68.4	44.0
+200	38.2	355.2	8.2	76.7	31.6
+270	26.1	381.3	5.6	82.3	23.3
+400	12.9	394.2	2.8	85.1	17.7
-400	69.0	463.2	14.9	100.0	14.9

RMD

WT:(g)	CUM WT:(g)	WT:%	CUM WT% RETAINED	CUM WT% PASSING
116.5	116.5	44.9	44.9	100.0
15.8	132.3	6.1	51.0	55.1
18.0	150.3	6.9	58.0	49.0
12.3	162.6	4.7	62.7	42.0
11.4	174.0	4.4	67.1	37.3
8.0	182.0	3.1	70.2	32.9
6.9	188.9	2.7	72.9	29.8
6.9	195.8	2.7	75.5	27.1
5.5	201.3	2.1	77.7	24.5
57.9	259.2	22.3	100.0	22.3

PCUF

TYLER SCREEN	WT:(g)	CUM WT:(g)	WT:%	CUM WT% RETAINED	CUM WT% PASSING
+28	67.3	67.3	20.7	20.7	100.0
+35	20.2	87.5	6.2	27.0	79.3
+48	34.2	121.7	10.5	37.5	73.0
+65	41.1	162.8	12.7	50.2	62.5
+100	57.6	220.4	17.8	67.9	49.8
+150	37.2	257.6	11.5	79.4	32.1
+200	21.9	279.5	6.7	86.1	20.6
+270	12.8	292.3	3.9	90.1	13.9
+400	5.5	297.8	1.7	91.8	9.9
-400	26.7	324.5	8.2	100.0	8.2

RCUF

WT:(g)	CUM WT:(g)	WT:%	CUM WT% RETAINED	CUM WT% PASSING
71.9	71.9	22.8	22.8	100.0
21.4	93.3	6.8	29.6	77.2
35.2	128.5	11.2	40.7	70.4
42.9	171.4	13.6	54.3	59.3
57.9	229.3	18.3	72.7	45.7
36.7	266.0	11.6	84.3	27.3
20.5	286.5	6.5	90.8	15.7
11.3	297.8	3.6	94.4	9.2
4.0	301.8	1.3	95.6	5.6
13.8	315.6	4.4	100.0	4.4

DTT

TYLER SCREEN	WT:(g)	CUM WT:(g)	WT:%	CUM WT% RETAINED	CUM WT% PASSING
+20	4542.0	4542.0	31.3	31.3	100.0
+28	1790.0	6332.0	12.3	43.6	68.7
+35	1676.1	8008.1	11.5	55.2	56.4
+48	1896.9	9905.0	13.1	68.2	44.8
+65	1712.1	11617.1	11.8	80.0	31.8
+100	1539.7	13156.8	10.6	90.7	20.0
+150	890.5	14047.3	6.1	96.8	9.3
+200	342.4	14389.7	2.4	99.1	3.2
+270	74.9	14464.6	0.5	99.7	0.9
+400	17.1	14481.7	0.1	99.8	0.3
-400	31.5	14513.2	0.2	100.0	0.2

WTT

WT:(g)	CUM WT:(g)	WT:%	CUM WT% RETAINED	CUM WT% PASSING
919.9	919.9	47.6	47.6	100.0
70.3	990.2	3.6	51.3	52.4
106.3	1096.5	5.5	56.8	48.7
124.2	1220.7	6.4	63.2	43.2
214.6	1435.3	11.1	74.3	36.8
262.8	1698.1	13.6	87.9	25.7
168.6	1866.7	8.7	96.7	12.1
50.0	1916.7	2.6	99.3	3.3
12.8	1929.5	0.7	99.9	0.7
1.5	1931.0	0.1	100.0	0.1

JTls

TYLER SCREEN	WT:(g)	CUM WT:(g)	WT:%	CUM WT% RETAINED	CUM WT% PASSING
+28	68.1	68.1	20.7	20.7	100.0
+35	21.3	89.4	6.5	27.2	79.3
+48	34.8	124.2	10.6	37.8	72.8
+65	42.7	166.9	13.0	50.9	62.2
+100	59.5	226.4	18.1	69.0	49.1
+150	37.5	263.9	11.4	80.4	31.0
+200	22.5	286.4	6.9	87.3	19.6
+270	12.7	299.1	3.9	91.1	12.7
+400	5.2	304.3	1.6	92.7	8.9
-400	23.9	328.2	7.3	100.0	7.3

DOME MINE SIZE DISTRIBUTIONS

JC1W1

TYLER SCREEN	WT:(g)	CUM WT:(g)	WT:%	CUM WT% RETAINED	CUM WT% PASSING
+20	1461.7	1461.7	35.8	35.8	100.0
+28	3910.8	5372.5	7.0	42.8	64.2
+35	1026.9	6399.4	8.2	51.0	57.2
+48	1400.4	7799.8	11.2	62.2	49.0
+65	1373.2	9173.0	10.9	73.1	37.8
+100	1426.7	10599.7	11.4	84.5	26.9
+150	1074.8	11674.5	8.6	93.0	15.5
+200	549.0	12223.5	4.4	97.4	6.9
+270	198.8	12422.3	1.6	99.0	2.5
+400	84.0	12506.3	0.7	99.7	1.0
-400	36.2	12542.5	0.3	100.0	0.3

JC1E1

WT:(g)	CUM WT:(g)	WT:%	CUM WT% RETAINED	CUM WT% PASSING
1135.2	1135.2	88.2	88.2	100.0
71.6	1206.8	5.6	93.8	11.8
44.7	1251.5	3.5	97.3	6.2
12.3	1263.8	1.0	98.2	2.7
5.4	1269.2	0.4	98.6	1.8
4.3	1273.5	0.3	99.0	1.4
2.9	1276.4	0.2	99.2	1.0
1.3	1277.7	0.1	99.3	0.8
1.6	1279.3	0.1	99.4	0.7
7.4	1286.7	0.6	100.0	0.6

JC2W1

TYLER SCREEN	WT:(g)	CUM WT:(g)	WT:%	CUM WT% RETAINED	CUM WT% PASSING
+28	1128.9	1128.9	65.5	65.5	100.0
+35	232.9	1361.8	13.5	79.0	34.5
+48	184.7	1546.5	10.7	89.7	21.0
+65	64.1	1610.6	3.7	93.5	10.3
+100	36.4	1647.0	2.1	95.6	6.5
+150	22.7	1669.7	1.3	96.9	4.4
+200	20.1	1689.8	1.2	98.1	3.1
+270	14.1	1703.9	0.8	98.9	1.9
+400	10.5	1714.4	0.6	99.5	1.1
-400	8.9	1723.3	0.5	100.0	0.5

JC2E1

WT:(g)	CUM WT:(g)	WT:%	CUM WT% RETAINED	CUM WT% PASSING
812.7	812.7	41.2	41.2	100.0
122.7	935.4	6.2	47.5	58.8
150.2	1085.6	7.6	55.1	52.5
171.3	1256.9	8.7	63.8	44.9
265.4	1522.3	13.5	77.3	36.2
267.6	1789.9	13.6	90.8	22.7
130.1	1920.0	6.6	97.5	9.2
22.1	1942.1	1.1	98.6	2.5
8.3	1950.4	0.4	99.0	1.4
19.8	1970.2	1.0	100.0	1.0

JC3W1

TYLER SCREEN	WT:(g)	CUM WT:(g)	WT:%	CUM WT% RETAINED	CUM WT% PASSING
+20	1947.2	1947.2	20.0	20.0	100.0
+28	578.6	2525.8	6.0	26.0	80.0
+35	876.8	3402.6	9.0	35.0	74.0
+48	1283.5	4686.1	13.2	48.2	65.0
+65	1355.4	6041.5	13.9	62.2	51.8
+100	1621.4	7662.9	16.7	78.9	37.8
+150	1219.0	8881.9	12.5	91.4	21.1
+200	571.3	9453.2	5.9	97.3	8.6
+270	174.7	9627.9	1.8	99.1	2.7
+400	56.8	9684.7	0.6	99.7	0.9
-400	32.9	9717.6	0.3	100.0	0.3

JC3E1

WT:(g)	CUM WT:(g)	WT:%	CUM WT% RETAINED	CUM WT% PASSING
1213.2	1213.2	53.4	53.4	100.0
210.1	1423.3	9.3	62.7	46.6
244.2	1667.5	10.8	73.4	37.3
194.3	1861.8	8.6	82.0	26.6
175.8	2037.6	7.7	89.7	18.0
128.2	2165.8	5.6	95.4	10.3
66.6	2232.4	2.9	98.3	4.6
19.0	2251.4	0.8	99.2	1.7
8.9	2260.3	0.4	99.5	0.8
10.4	2270.7	0.5	100.0	0.5

JC4W1

TYLER SCREEN	WT:(g)	CUM WT:(g)	WT:%	CUM WT% RETAINED	CUM WT% PASSING
+28	420.1	420.1	72.7	72.7	100.0
+35	64.9	485.0	11.2	84.0	27.3
+48	46.1	531.1	8.0	91.9	16.0
+65	19.4	550.5	3.4	95.3	8.1
+100	11.5	562.0	2.0	97.3	4.7
+150	6.4	568.4	1.1	98.4	2.7
+200	2.5	570.9	0.4	98.8	1.6
+270	1.0	571.9	0.2	99.0	1.2
+400	1.0	572.9	0.2	99.2	1.0
-400	4.7	577.6	0.8	100.0	0.8

JC4E1

WT:(g)	CUM WT:(g)	WT:%	CUM WT% RETAINED	CUM WT% PASSING
785.2	785.2	24.9	24.9	100.0
303.9	1089.1	9.6	34.5	75.1
453.7	1542.8	14.4	48.9	65.5
455.0	1997.8	14.4	63.3	51.1
494.0	2491.8	15.7	79.0	36.7
370.9	2862.7	11.8	90.8	21.0
181.1	3043.8	5.7	96.5	9.2
62.6	3106.4	2.0	98.5	3.5
24.8	3131.2	0.8	99.3	1.5
22.9	3154.1	0.7	100.0	0.7

APPENDIX B

Appendix B.1: Laboratory Knelson Concentrator parameter settings

Appendix B.2: Laboratory jig parameter settings

Appendix B.3: Laboratory Mozley separator parameter settings

B.1: Laboratory Knelson Concentrator Parameter Settings

LABORATORY KNELSON CONCENTRATOR PARAMETERS
LUCIEN BELIVEAU TEST T1

SAMPLE	WT gm	TIME min	FEEDRATE g/min	PRESSURE kPa	WATERRATE kg/min	WASHWATER RATE g/min	SAMPLE INTERVAL	TAILINGS kg/min
T1BMD1	736	20.4	36	28	5.3	746	2 min	6.0
					(avg)	(avg)	4 min	5.9
							6 min	6.0
							8 min	5.9
T1CUF1	4462	21.4	208	28	5.4	805	3 min	7.0
					(avg)	(avg)	7 min	7.1
							11 min	6.9
							15 min	6.9
T1CUF2	4631	16.6	280	28	5.8	1096	3 min	7.1
					(avg)	(avg)	7 min	7.1
							11 min	7.1
							15 min	7.2
T1SAGD	4960	24.8	200	28	5.7	1077	3 min	7.0
					(avg)	(avg)	7 min	6.9
							11 min	6.9
							15 min	7.0
T1COF	1904	25.7	74	21	4.4	792	3 min	5.0
					(avg)	(avg)	7 min	5.1
							11 min	4.9
							15 min	5.0
T1KCONC	2857	14.2	202	28	5.4	980	2 min	6.3
					(avg)	(avg)	4 min	6.3
							6 min	6.0
							8 min	6.5
T1KFEED1	3910	31.1	126	21	4.8	175	2 min	5.2
					(avg)	(avg)	6 min	5.1
							10 min	5.3
							14 min	5.3
							18 min	5.4
T1KFEED2	3132	17.3	181	21	4.5	762	5 min	5.3
					(avg)	(avg)	10 min	5.3
							12 min	5.4
							15 min	5.3
T1KFEED3	3752	18.2	206	21	5.0	662	2 min	5.7
					(avg)	(avg)	7 min	5.8
							12 min	5.8
							16 min	5.8
T1KFEED4	3696	18.4	201	21	5.0	676	2 min	5.8
					(avg)	(avg)	6 min	5.6
							10 min	5.4
							14 min	5.4

LABORATORY KNELSON CONCENTRATOR PARAMETERS cont.
LUCIEN BELIVEAU TEST T1

SAMPLE	WT gm	TIME min	FEEDRATE g/min	PRESSURE kPa	WATERRATE kg/min	WASHWATER RATE g/min	SAMPLE INTERVAL	TAILINGS kg/min
T1KTAIL1	3998	13.0	308	21	4.8	665	3 min	5.8
					(avg)	(avg)	6 min	5.6
							9 min	5.4
							12 min	5.4
T1KTAIL2	4685	29.1	161	21	5.1	624	2 min	5.8
					(avg)	(avg)	6 min	5.7
							10 min	5.6
							14 min	5.8
T1KTAIL3	4216	20.0	211	21	5.1	724	2 min	6.0
					(avg)	(avg)	6 min	5.8
							10 min	5.8
							14 min	5.7
T1KTAIL4	4705	29.6	159	21	5.2	542	2 min	5.7
					(avg)	(avg)	7 min	5.6
							12 min	5.6
							17 min	5.7

LABORATORY KNELSON CONCENTRATOR PARAMETERS
LUCIEN BELIVEAU TEST T2-T9

SAMPLE	WT gm	TIME min	FEEDRATE g/min	PRESSURE kPa	WATERRATE kg/min	WASHWATER RATE g/min	SAMPLE INTERVAL	TAILINGS kg/min
T2 SAGD 1	6000	15.0	400	28	7.8	included	2 min	6.1
					(avg)	in waterrate	5 min	7.0
							8 min	7.1
							10 min	7.1
							14 min	6.5
T2 SAGD 2	6000	18.7	321	28	7.5	included	2 min	6.5
					(avg)	in waterrate	5 min	6.4
							9 min	6.4
							11 min	6.5
							15 min	6.9
T2 BMD 1	5620	17.3	324	32	7.8	included	2 min	6.8
					(avg)	in waterrate	5 min	6.6
							8 min	6.7
							11 min	6.9
							14 min	7.0
T2 BMD 2	5190	15.8	328	35	8.2	included	2 min	6.5
					(avg)	in waterrate	5 min	7.2
							8 min	7.1
							11 min	7.2
							14 min	7.5
T2 CUF 1	11158	34.4	324	28	5.7	included	3 min	4.7
					(avg)	in waterrate	8 min	5.1
							14 min	5.2
							20 min	5.3
							26 min	5.6
T2 CUF 2	10990	35.7	308	35	8.1	included	3 min	6.6
					(avg)	in waterrate	8 min	7.0
							14 min	6.9
							20 min	6.9
							26 min	7.3
T2 COF	6000	28.1	214	28	7.1	included	3 min	5.7
					(avg)	in waterrate	8 min	5.9
							14 min	6.5
							20 min	6.4
							26 min	6.0
T2 Thk UF*	11182	29.9	374	28			3 min	4.1
							10 min	4.0
							16 min	4.1
							22 min	4.3
							28 min	3.4
T2 SpTls*	5556	15.6	356	28			2 min	4.2
							5 min	4.0
							8 min	3.8
							11 min	3.9
							15 min	3.8

* feed weight + Si dilution

LABORATORY KNELSON CONCENTRATOR PARAMETERS cont.
LUCIEN BELIVEAU TEST T2-T9

SAMPLE	WT + Si gm	TIME min	FEEDRATE g/min	PRESSURE kPa	WATERRATE kg/min	WASHWATER RATE g/min	SAMPLE INTERVAL	TAILINGS kg/min
T2 KnTls	6863	23.7	290	28			2 min	3.6
							6 min	3.7
							10 min	3.6
							14 min	3.8
							18 min	3.8
T2 KCONC	4000	14.1	284	28	6.6	included	1 min	6.3
					(avg)	in waterrate	3 min	5.7
							5 min	5.5
							8 min	5.7
							10 min	5.6
T2 SpC 1	2566	7.5	342	28	8.0	included	1 min	4.5
					(avg)	in waterrate	2 min	4.9
							4 min	4.8
							5 min	4.9
							7 min	4.6
T2 SpC 2	2945	9.2	320	28	5.6	included	1 min	4.1
					(avg)	in waterrate	2 min	3.4
							4 min	3.3
							5 min	3.5
							7 min	3.3
T3 Thk UF	7716	17.9	432	28			2 min	6.9
							5 min	7.3
							8 min	7.3
							10 min	7.0
							14 min	7.2
T3 SpTls	6067	17.1	355	28			2 min	7.7
							5 min	7.8
							9 min	7.8
							11 min	7.7
							15 min	6.1
T3 SpC 1	2035	7.3	279	28			.5 min	8.9
							1 min	7.7
							2 min	6.7
							3 min	4.0
							4 min	6.8
							5 min	6.2
T3 SpC 2	3312	10.1	328	28			1 min	7.0
							2 min	6.3
							4 min	6.3
							6 min	6.6
							8 min	6.4
T4 Thk UF	7537	16.5	458	21	5.1	675	3 min	5.8
					(avg)	(avg)	7 min	5.9
							11 min	6.1
							15 min	6.0

LABORATORY KNELSON CONCENTRATOR PARAMETERS cont..
LUCIEN BELIVEAU TEST T2-T9

SAMPLE	WT+Si gm	TIME min	FEEDRATE g/min	PRESSURE kPa	WATERRATE kg/min	WASHWATER RATE g/min	SAMPLE INTERVAL	TAILINGS kg/min
T4 SpTls	6334	12.5	507	21	5.0	977	3 min	6.3
					(avg)	(avg)	7 min	6.5
							11 min	6.6
							12 min	5.1
T4 SpC 1	2941	16.2	181	28			1 min	7.6
							3 min	7.6
							5 min	7.8
							7 min	7.4
							9 min	7.5
T4 SpC 2	2873	7.9	366	28			1 min	7.3
							2 min	7.1
							3 min	7.2
							5 min	7.1
							6 min	8.0
T5 Thk UF	7691	21.0	366	21	5.0	676	3 min	5.7
					(avg)	(avg)	7 min	5.9
							11 min	6.0
							15 min	5.9
							19 min	5.9
T5 SpTls	7984	20.6	387	21	4.6	933	3 min	5.5
					(avg)	(avg)	7 min	5.6
							11 min	5.9
							15 min	5.9
							18 min	5.6
T5 SpC 1	2972	14.7	203	21	5.0	812	2 min	5.6
					(avg)	(avg)	5 min	5.8
							8 min	5.8
							12 min	5.8
T5 SpC 2	3202	12.1	266	21	5.3	765	2 min	6.3
					(avg)	(avg)	5 min	6.4
							8 min	6.4
							11 min	6.5
T7 SBMD	8080	23.3	347	21	6.0	831	3 min	6.2
					(avg)	(avg)	9 min	6.2
							15 min	6.2
							21 min	6.3
T7 Thk UF	11248	40.9	275	28	7.6	included	3 min	7.5
					(avg)	in waterrate	12 min	7.5
							21 min	7.4
							30 min	7.3
							38 min	7.2
T7 Thk OF	5504	23.2	238	21	6.0	included	3 min	5.9
					(avg)	in waterrate	7 min	5.9
							11 min	5.8
							15 min	5.8
							19 min	5.8

LABORATORY KNELSON CONCENTRATOR PARAMETERS cont...
LUCIEN BELIVEAU TEST T2-T9

SAMPLE	WT+Si gm	TIME min	FEEDRATE g/min	PRESSURE kPa	WATERRATE kg/min	WASHWATER RATE g/min	SAMPLE INTERVAL	TAILINGS kg/min
T7 SpTls	5040	22.3	226	21	5.9	included	3 min	5.9
					(avg)	in waterrate	7 min	5.8
							11 min	5.5
							15 min	5.8
							19 min	5.9
T7 KnTls	9419	32.9	287	28	8.0	included	3 min	8.0
					(avg)	in waterrate	10 min	8.0
							17 min	8.1
							24 min	7.9
							29 min	8.0
T7 SpC 1	775	3.8	206	21	5.7	included	1 min	5.7
					(avg)	in waterrate	2 min	6.1
T7 SpC 2	1110	4.5	246	21	6.0	included	1 min	5.9
					(avg)	in waterrate	3 min	6.0
							4 min	5.9
T8 SBMD	6992	18.3	383	21	5.7	742	3 min	5.8
					(avg)	(avg)	8 min	5.9
							13 min	5.7
							15 min	6.0
T8 Thk UF	7520	22.6	332	28	7.9	included	3 min	7.8
					(avg)	in waterrate	9 min	7.7
							14 min	7.7
							19 min	7.7
							22 min	7.7
T8 Thk OF	3340	11.2	299	21	5.8	818	2 min	6.0
					(avg)	(avg)	5 min	6.1
							8 min	6.2
							10 min	6.3
T8 SpTls	7475	27.1	276	21	5.4	686	3 min	5.9
					(avg)	(avg)	8 min	6.2
							13 min	6.2
							18 min	6.1
							23 min	6.4
T8 KnTls	7253	19.0	382	21	6.1	697	3 min	6.4
					(avg)	(avg)	8 min	6.4
							13 min	6.3
							17 min	6.3
T9 SpTls	10500	22.0	477	21	6.6	788	3 min	6.8
					(avg)	(avg)	8 min	7.0
							13 min	7.1
							18 min	7.0
T9 KnTls	10115	21.1	480	21	6.5	781	3 min	6.5
					(avg)	(avg)	8 min	6.8
							13 min	6.8
							18 min	6.8

LABORATORY KNELSON CONCENTRATOR PARAMETERS
DOME MINE

SAMPLE	WT gm	TIME min	FEEDRATE g/min	PRESSURE kPa	WATERRATE kg/min	WASHWATER RATE g/min	SAMPLE INTERVAL	TAILINGS kg/min
BMD	9743	35.8	272	28	7.8	576	4 min	5.5
					(avg)	(avg)	13 min	5.5
							16 min	5.6
							20 min	5.5
							25 min	5.4
RMD	9365	32.5	288	28	6.7	981	3 min	5.7
					(avg)	(avg)	8 min	5.8
							13 min	5.8
							20 min	5.8
							25 min	5.8
PCUF	9996	39.0	256	28	7.3	884	3 min	5.6
					(avg)	(avg)	9 min	5.6
							18 min	5.5
							27 min	5.5
							33 min	5.7
RCUF	9114	34.1	267	28	7.4	852	3 min	4.4
					(avg)	(avg)	9 min	4.9
							15 min	5.0
							21 min	5.0
							25 min	4.9
PCOF	4996	32.3	155	21	6.8	1413	3 min	5.0
					(avg)	(avg)	8 min	5.6
							14 min	5.8
							20 min	6.0
							24 min	5.9
RCOF	2278	17.0	134	21	7.1	980	2 min	4.8
					(avg)	(avg)	5 min	4.8
							7 min	4.8
							10 min	4.7
							15 min	4.6
JTls	11593	42.7	271	28	8.0	888	5 min	5.5
					(avg)	(avg)	12 min	5.5
							20 min	5.4
							28 min	5.5
							35 min	5.6
DTT	4849	13.0	373	28	7.6	888	3 min	5.3
					(avg)	(avg)	6 min	5.2
							9 min	5.3
							11 min	5.2
JC1W1	5577	15.3	365	28	7.6	898	3 min	5.2
					(avg)	(avg)	6 min	5.2
							9 min	5.3
							12 min	5.2
JC3W1	5804	12.8	453	28	6.9	891	3 min	5.1
					(avg)	(avg)	5 min	5.2
							8 min	5.3
							10 min	5.2

B.2: Laboratory Jig Parameter Settings

LABORATORY JIGGING +28M PARAMETERS
DOME MINE

SAMPLE	TAIL WT (g)	CONC WT (g)	BED+ RAGGING WT (g)	INITIAL SHOT WT(g)	FINAL SHOT WT(g)	STROKE (inch)	MATERIAL REMOVED (g)	FEED RATE (g/min)	WATER RATE (l/min)	TIME (min)		+4mm REMOVED BEFORE JIG
RMD	7935	135.0	94	208	258	0.5		128	3.0	64 67	FT* TT**	177.3
PCUF	4680	57.2	92	258	258	0.5		201	3.0	24 27		81.6
RCUF	4069	200.3	115	168	168	0.5		107	3.0	41 43		131.7
JTls	3629	46.7	117	258	159	0.5		115	3.0	33 36		50.0
DTT (1st run)	2997	1343.5	183	251	74	0.5			2.5			11.0
DTT (conc rerun)	1012	147.8	184	251	251	0.5			2.5			
WTT	651	124.8	144	263	330	0.5		115	3.0	8 10		
JC1W1	886	102.8	428	255	87	0.5		129	2.5	11 15		42.4
JC1E1*	601	60.9	202	227	227	0.5	267.6	108	3.0	8 11		
JC2W1	880	31.4	217	168	168	0.5		141	2.5	8 13		
JC2E1*	244	41.9	137	327	327	0.5	396.3	70	3.0	6 9		
JC3W1	1390	346.8	208	122	122	0.5		177	2.5	11 13		
JC3E1	869	144.9	197	168	168	0.5		303	2.5	4 5		
JC4W1	171	34.5	215	182	182	0.5		140	3.0	3 5		
JC4E1	442	17.7	186	178	123	0.5	141.4	129	3.0	5 7		

* all old ragging taken out prior to jigging
** FT = feed time, TT = total time

B.3: Laboratory Mozley Separator Parameter Settings

LABORATORY MOZLEY TABLE PARAMETERS
DOME MINE

SAMPLE	MESH SIZE	TABLE TYPE	SPEED (rpm)	STROKE (inch)	WATERRATE (l/min)	TIME (min)	SLOPE* (cm)	CONC WT(g)	TAIL WT(g)
WTT	+35	V-NOTCH	70	2.5	1.0	5.1	4.0	23.5	51.6
WTT	+48	V-NOTCH	70	2.5	1.0	9.9	4.5	13.9	92.1
WTT	+65	V-NOTCH	70	2.5	1.5	18.5	4.5	21.5	101.6
WTT	+100	V-NOTCH	70	2.5	1.5	23.8	4.5	10.4	204.2
WTT	+150	V-NOTCH	70	2.5	1.5	36.4	4.5	23.0	239.2
WTT	+200	V-NOTCH	70	2.5	1.5	36.1	4.5	12.7	155.5
WTT	+270	V-NOTCH	70	2.5	1.5	8.0	4.5	4.2	45.4
WTT	+400	V-NOTCH	70	2.5	0.5	11.0	2.5	1.3	11.1
WTT	-400	V-NOTCH	70	2.5	0.5	3.4	2.5	0.6	0.7
JC1E1	+35	V-NOTCH	70	2.5	1.0	5.6	3.5	23.3	55.6
JC1E1	+48	V-NOTCH	70	2.5	1.0	5.1	4.0	11.7	32.9
JC1E1	+65	V-NOTCH	70	2.5	1.0	4.1	4.5	2.7	9.4
JC1E1	+100	V-NOTCH	70	2.5	1.5	4.7	4.5	0.3	5.0
JC1E1	+150	V-NOTCH	70	2.5	1.5	2.1	4.5	0.6	3.7
JC1E1	+200	V-NOTCH	70	2.5	1.5	2.1	4.5	0.3	2.6
JC1E1	+270	V-NOTCH	70	2.5	1.5	1.1	4.5	0.4	1.0
JC1E1	+400	V-NOTCH	70	2.5	0.5	1.0	2.5	0.2	1.4
JC1E1	-400	V-NOTCH	70	2.5	0.5	2.3	2.5	0.5	4.3
JC2W1	+35	V-NOTCH	70	2.5	1.0	15.0	4.0	31.2	226.7
JC2W1	+48	V-NOTCH	70	2.5	1.0	15.1	4.0	38.5	145.6
JC2W1	+65	V-NOTCH	70	2.5	1.0	7.5	4.5	31.3	32.5
JC2W1	+100	V-NOTCH	70	2.5	1.5	10.8	4.5	15.9	20.3
JC2W1	+150	V-NOTCH	70	2.5	1.5	3.5	4.5	6.2	16.0
JC2W1	+200	V-NOTCH	70	2.5	1.5	4.4	4.5	1.1	18.7
JC2W1	+270	V-NOTCH	70	2.5	1.5	4.7	4.5	1.5	12.5
JC2W1	+400	V-NOTCH	70	2.5	0.5	10.1	2.5	0.7	9.2
JC2W1	-400	V-NOTCH	70	2.5	0.5	3.7	2.5	0.9	6.7
JC2E1	+35	V-NOTCH	70	2.5	1.0	6.4	4.0	36.5	98.5
JC2E1	+48	V-NOTCH	70	2.5	1.0	10.8	4.5	37.8	111.8
JC2E1	+65	V-NOTCH	70	2.5	1.5	32.4	4.5	24.8	145.6
JC2E1	+100	V-NOTCH	70	2.5	1.5	22.2	4.5	39.3	222.7
JC2E1	+150	V-NOTCH	70	2.5	1.5	41.7	4.5	14.6	252.5
JC2E1	+200	V-NOTCH	70	2.5	1.5	15.1	4.5	7.4	122.3
JC2E1	+270	V-NOTCH	70	2.5	1.5	5.5	4.5	4.6	17.3
JC2E1	+400	V-NOTCH	70	2.5	0.5	7.2	2.5	1.3	6.2
JC2E1	-400	V-NOTCH	70	2.5	0.5	2.0	2.5	1.2	17.0
JC3E1	+35	V-NOTCH	70	2.5	1.0	6.4	4.0	29.7	207.1
JC3E1	+48	V-NOTCH	70	2.5	1.0	19.6	4.5	48.4	192.5
JC3E1	+65	V-NOTCH	70	2.5	1.5	28.7	4.5	27.4	165.4
JC3E1	+100	V-NOTCH	70	2.5	1.5	39.1	4.5	32.5	141.6
JC3E1	+150	V-NOTCH	70	2.5	1.5	28.2	4.5	12.3	115.7
JC3E1	+200	V-NOTCH	70	2.5	1.5	7.2	4.5	2.1	63.5
JC3E1	+270	V-NOTCH	70	2.5	1.5	5.1	4.5	1.3	17.5
JC3E1	+400	V-NOTCH	70	2.5	0.5	7.5	2.5	0.7	7.8
JC3E1	-400	V-NOTCH	70	2.5	0.5	2.9	2.5	0.6	8.5

* measured in centimetres, where zero slope is zero centimetres (flat table)

LABORATORY MOZLEY TABLE PARAMETERS cont.
DOME MINE

SAMPLE	MESH SIZE	TABLE TYPE	SPEED (rpm)	STROKE (inch)	WATERRATE (l/min)	TIME (min)	SLOPE* (cm)	CONC WT(g)	TAIL WT(g)
JC4W1	+35	V-NOTCH	70	2.5	1.0	5.2	4.0	22.5	48.8
JC4W1	+48	V-NOTCH	70	2.5	1.0	4.9	4.5	12.0	33.8
JC4W1	+65	V-NOTCH	70	2.5	1.5	4.5	4.5	5.5	13.7
JC4W1	+100	V-NOTCH	70	2.5	1.5	5.3	4.5	3.8	7.4
JC4W1	+150	V-NOTCH	70	2.5	1.5	3.8	4.5	1.0	5.5
JC4W1	+200	V-NOTCH	70	2.5	1.5	1.8	4.5	0.5	2.1
JC4W1	+270	V-NOTCH	70	2.5	1.5	1.0	4.5	0.4	0.6
JC4W1	+400	V-NOTCH	70	2.5	0.5	2.5	2.5	0.2	0.7
JC4W1	-400	V-NOTCH	70	2.5	0.5	1.9	2.5	1.2	3.0
JC4E1	+35	V-NOTCH	70	2.5	1.0	20.3	4.0	30.2	315.1
JC4E1	+48	V-NOTCH	70	2.5	1.0	39.1	4.5	24.7	427.2
JC4E1	+65	V-NOTCH	70	2.5	1.0	56.3	4.5	31.9	421.0
JC4E1	+100	V-NOTCH	70	2.5	1.5	43.3	4.5	14.2	479.1
JC4E1	+150	V-NOTCH	70	2.5	1.5	53.6	4.5	19.7	350.3
JC4E1	+200	V-NOTCH	70	2.5	1.5	36.6	4.5	12.9	167.8
JC4E1	+270	V-NOTCH	70	2.5	1.5	8.7	4.5	5.4	56.4
JC4E1	+400	V-NOTCH	70	2.5	0.5	9.5	2.5	2.1	21.6
JC4E1	-400	V-NOTCH	70	2.5	0.5	5.0	2.5	1.6	20.6

HIGH WEIGHT LABORATORY JIG CONCENTRATES

SAMPLE	MESH SIZE	TABLE TYPE	SPEED (rpm)	STROKE (inch)	WATERRATE (l/min)	TIME (min)	SLOPE* (cm)	CONC WT(g)	TAIL WT(g)
RMD	+14	V-NOTCH	70	2.5	1	1.4	3	11.0	31.1
RMD	+20	V-NOTCH	70	2.5	1	2.5	3	23.8	57.9
PCUF	+20	V-NOTCH	70	2.5	1	1.2	3	15.4	20.0
RCUF	+14	V-NOTCH	70	2.5	1	1.8	3	21.2	45.6
RCUF	+20	V-NOTCH	70	2.5	1	3.8	3	16.6	98.6
DTT	+10	V-NOTCH	70	2.5	1	1.5	3	18.4	15.6
DTT	+14	V-NOTCH	70	2.5	1	3.4	3	23.7	38.7
DTT	+20	V-NOTCH	70	2.5	1	4.8	3	24.6	92.5
WTT	+14	V-NOTCH	70	2.5	1	2.9	3	22.8	33.8
WTT	+20	V-NOTCH	70	2.5	1	2.7	3	25.3	21.5
JC1W1	+8	V-NOTCH	70	2.5	1	4.5	3	22.4	54.1
JC1W1	+10	V-NOTCH	70	2.5	1	7.1	3	27.9	82.4
JC1E1	+10	V-NOTCH	70	2.5	1	2.1	3	23.1	18.6
JC1E1	+14	V-NOTCH	70	2.5	1	2.1	3	23.8	23.3
JC1E1	+20	V-NOTCH	70	2.5	1	1.8	3	5.8	26.6
JC2E2	+10	V-NOTCH	70	2.5	1	2.1	3	23.8	14.0
JC3W1	+10	V-NOTCH	70	2.5	1	2.9	3	29.3	39.4
JC3W1	+14	V-NOTCH	70	2.5	1	9.2	3	22.6	129.7
JC3W1	+20	V-NOTCH	70	2.5	1	6.0	3	22.9	115.4
JC3E1	+20	V-NOTCH	70	2.5	1	3.2	3	13.2	52.2
JC3E1	+28	V-NOTCH	70	2.5	1	4.5	3	12.8	52.5
JC4W1	+20	V-NOTCH	70	2.5	1	1.3	3	19.6	11.3

* measured in centimetres, where zero slope is zero centimetres (flat table)

APPENDIX C

Appendix C.1: Recovery, grade and gold distribution of the various streams after processing with a LKC

C.1: Recovery, Grade and Gold Distribution of the Various Streams After Processing With a Laboratory Knelson Concentrator

Lucien Beliveau Test T1

	SAG DISCHARGE		Mass Processed			4960									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590	15.8	17.36	1.14	18.0	19.36	38.9	8.56	416.7	0.18	75	432.5	8.72	93	0.22	5.51
420	8.9	9.78	2.55	22.7	33.53	28.0	6.16	300.0	0.15	45	308.9	6.23	68	0.22	4.01
297	9.8	10.77	3.04	29.8	24.26	31.0	6.82	332.1	0.28	93	341.9	6.89	123	0.36	7.27
210	14.7	16.15	4.50	66.2	62.51	52.9	11.64	566.7	0.07	40	581.4	11.72	106	0.18	6.26
150	15.7	17.25	4.76	74.7	61.31	62.9	13.84	673.8	0.07	47	689.5	13.90	122	0.18	7.21
105	9.9	10.88	5.11	50.6	46.92	41.1	9.04	440.3	0.13	57	450.2	9.08	108	0.24	6.38
75	5.8	6.37	8.14	47.2	68.39	29.1	6.40	311.7	0.07	22	317.5	6.40	69	0.22	4.09
53	3.1	3.41	9.14	28.3	42.97	19.5	4.29	208.9	0.18	38	212.0	4.27	66	0.31	3.90
38	3.3	3.63	13.70	45.2	21.32	22.9	5.04	245.3	0.68	167	248.6	5.01	212	0.85	12.55
-38	4.0	4.40	16.07	64.3	8.88	128.2	28.21	1373.4	0.48	659	1377.4	27.77	724	0.53	42.82
TOTAL	91.0	100.00	4.91	447.0	26.46	454.5	100.00	4869	0.26	1243	4960.0	100.00	1690	0.34	100.00

	BM DISCHARGE		Mass Processed			735.9									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590	3.8	5.05	0.21	0.8	5.30	5.8	1.93	12.7	1.12	14	16.5	2.25	15	0.91	4.98
420	3.9	5.18	0.25	1.0	26.32	11.3	3.76	24.8	0.11	3	28.7	3.90	4	0.13	1.23
297	7.0	9.30	0.25	1.8	2.81	21.4	7.11	47.0	1.29	61	54.0	7.34	62	1.16	20.63
210	13.1	17.40	0.32	4.2	20.41	53.2	17.68	116.8	0.14	16	129.9	17.65	21	0.16	6.80
150	15.1	20.05	0.42	6.3	33.71	71.0	23.60	155.9	0.08	12	171.0	23.23	19	0.11	6.22
105	10.2	13.55	0.76	7.8	49.19	45.6	15.15	100.1	0.08	8	110.3	14.99	16	0.14	5.21
75	6.4	8.50	1.19	7.6	38.85	27.3	9.07	59.9	0.20	12	66.3	9.01	20	0.30	6.48
53	3.9	5.18	1.02	4.0	10.17	16.0	5.32	35.1	1.00	35	39.0	5.30	39	1.00	12.94
38	4.6	6.11	1.50	6.9	14.64	15.8	5.25	34.7	1.16	40	39.3	5.34	47	1.20	15.59
-38	7.3	9.69	2.91	21.2	35.27	33.5	11.13	73.5	0.53	39	80.8	10.99	60	0.74	19.92
TOTAL	75.3	100.00	0.82	61.5	20.36	300.9	100.00	660.6	0.36	241	735.9	100.00	302	0.41	100.00

Lucien Beliveau Test T1

CYCL U/F 1 Mass Processed 4462

Size um	Knelson Conc Mass	Mass %	Grade oz/t	Units	Recovery	Knelson Tails Mass	Mass %	Total Mass	Grade oz/t	Units	Feed Total Mass	Mass %	Units	Grade oz/t	Dist.
590	15.7	16.90	4.41	69.2	65.48	43.3	9.28	405.6	0.09	37	421.3	9.44	106	0.25	13.85
420	8.0	8.61	5.96	47.7	77.24	37.5	8.04	351.3	0.04	14	359.3	8.05	62	0.17	8.08
297	11.6	12.49	4.91	57.0	69.30	44.9	9.63	420.6	0.06	25	432.2	9.69	82	0.19	10.76
210	18.5	19.91	2.27	42.0	50.95	86.3	18.50	808.4	0.05	40	826.9	18.53	82	0.10	10.79
150	19.3	20.78	2.45	47.3	57.00	95.2	20.41	891.8	0.04	36	911.1	20.42	83	0.09	10.86
105	9.7	10.44	3.68	35.7	50.65	46.4	9.95	434.7	0.08	35	444.4	9.96	70	0.16	9.23
75	4.4	4.74	6.50	28.6	56.93	23.1	4.95	216.4	0.10	22	220.8	4.95	50	0.23	6.58
53	2.0	2.15	8.00	16.0	51.69	13.3	2.85	124.6	0.12	15	126.6	2.84	31	0.24	4.05
38	2.0	2.15	13.27	26.5	49.80	13.6	2.92	127.4	0.21	27	129.4	2.90	53	0.41	6.98
-38	1.7	1.83	25.68	43.7	30.39	62.8	13.46	588.3	0.17	100	590.0	13.22	144	0.24	18.81
TOTAL	92.9	100.00	4.45	413.6	54.17	466.4	100.00	4369.1	0.08	350	4462.0	100.00	764	0.17	100.00

CYCL U/F 2 Mass Processed 4631

Size um	Knelson Conc Mass	Mass %	Grade oz/t	Units	Recovery	Knelson Tails Mass	Mass %	Total Mass	Grade oz/t	Units	Feed Total Mass	Mass %	Units	Grade oz/t	Dist.
590	13.0	14.49	0.37	4.8	22.18	52.1	9.29	421.9	0.04	17	434.9	9.39	22	0.05	1.58
420	9.0	10.03	5.92	53.3	65.10	50.4	8.99	408.1	0.07	29	417.1	9.01	82	0.20	5.95
297	11.6	12.93	9.97	115.7	78.34	56.4	10.06	456.7	0.07	32	468.3	10.11	148	0.32	10.74
210	18.4	20.51	2.74	50.4	53.71	107.3	19.13	868.9	0.05	43	887.3	19.16	94	0.11	6.83
150	19.4	21.63	3.33	64.6	51.37	107.9	19.24	873.8	0.07	61	893.2	19.29	126	0.14	9.15
105	9.4	10.48	10.44	98.1	62.74	51.4	9.17	416.2	0.14	58	425.6	9.19	156	0.37	11.37
75	4.2	4.68	24.98	104.9	75.48	26.3	4.69	213.0	0.16	34	217.2	4.69	139	0.64	10.11
53	1.7	1.90	46.18	78.5	75.35	15.1	2.69	122.3	0.21	26	124.0	2.68	104	0.84	7.58
38	1.8	2.01	115.72	208.3	92.06	14.8	2.64	119.8	0.15	18	121.6	2.63	226	1.86	16.46
-38	1.2	1.34	167.98	201.6	72.39	79.1	14.10	640.5	0.12	77	641.7	13.86	278	0.43	20.25
TOTAL	89.7	100.00	10.93	980.2	71.28	560.8	100.00	4541.3	0.09	395	4631.0	100.00	1375	0.30	100.00

Lucien Beliveau Test T1

	CYCL O/F Mass Processed					1904									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420															
297															
210															
150	15.3	26.75	0.62	9.5	83.61	7.2	5.03	93.0	0.02	2	108.3	5.69	11	0.10	1.89
105	11.3	19.76	0.55	6.2	78.09	13.5	9.44	174.3	0.01	2	185.6	9.75	8	0.04	1.33
75	7.7	13.46	0.39	3.0	39.44	11.9	8.32	153.7	0.03	5	161.4	8.48	8	0.05	1.27
53	5.6	9.79	0.34	1.9	8.45	9.4	6.57	121.4	0.17	21	127.0	6.67	23	0.18	3.76
38	6.9	12.06	0.75	5.2	6.80	12.2	8.53	157.6	0.45	71	164.5	8.64	76	0.46	12.69
-38	10.4	18.18	9.17	95.4	20.13	88.8	62.10	1146.8	0.33	378	1157.2	60.78	474	0.41	79.05
TOTAL	57.2	100.0	2.12	121.2	20.21	143.0	100.00	1846.8	0.26	478	1904.0	100.00	599	0.31	100.00

	KNEL CONC Mass Processed					2857									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590	2.6	1.54	692.06	1799	83.11	2.9	0.84	22.6	16.21	366	25.2	0.88	2165	86.07	0.30
420	5.0	2.97	2681.51	13408	88.74	10.2	2.95	79.3	21.45	1701	84.3	2.95	15109	179.18	2.09
297	11.0	6.52	3406.26	37469	92.99	23.6	6.83	183.5	15.38	2823	194.5	6.81	40292	207.12	5.57
210	23.9	14.18	3303.36	78950	94.33	59.3	17.15	461.2	10.29	4745	485.1	16.98	83696	172.55	11.56
150	35.1	20.82	3013.33	105768	96.52	82.5	23.86	641.6	5.95	3817	676.7	23.68	109585	161.95	15.14
105	29.3	17.38	3294.15	96519	98.04	63.2	18.28	491.5	3.92	1927	520.8	18.23	98445	189.03	13.60
75	22.1	13.11	3882.92	85813	98.37	42.7	12.35	332.1	4.27	1418	354.2	12.40	87230	246.30	12.05
53	14.4	8.54	4962.39	71458	98.20	25.6	7.41	199.1	6.57	1308	213.5	7.47	72766	340.85	10.05
38	14.8	8.78	6210.19	91911	97.34	22.1	6.39	171.9	14.61	2511	186.7	6.53	94422	505.84	13.04
-38	10.4	6.17	10650.66	110767	92.12	13.6	3.93	105.8	89.55	9471	116.2	4.07	120238	1035.08	16.61
TOTAL	168.6	100.0	4115.43	693861	95.84	345.7	100.00	2688.4	11.19	30087	2857.0	100.00	723948	253.39	100.00

Lucien Beliveau Test T1

	KNELS 1	FEED	Mass Processed					3910							
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	5.9	4.34	93.92	554.1	74.86	4.3	0.92	34.9	5.34	186	40.8	1.04	740	18.16	3.71
297	8.2	6.03	121.52	996.5	73.00	11.9	2.56	96.5	3.82	368	104.7	2.68	1365	13.04	6.84
210	17.6	12.95	91.42	1609.0	65.36	34.6	7.43	280.5	3.04	853	298.1	7.62	2462	8.26	12.33
150	26.7	19.65	77.28	2063.4	63.21	64.7	13.90	524.5	2.29	1201	551.2	14.10	3264	5.92	16.35
105	23.4	17.22	72.68	1700.7	58.85	70.2	15.08	569.0	2.09	1189	592.4	15.15	2890	4.88	14.48
75	18.0	13.25	70.04	1260.7	55.40	62.6	13.45	507.4	2.00	1015	525.4	13.44	2276	4.33	11.40
53	11.8	8.68	71.52	843.9	52.75	52.4	11.25	424.7	1.78	756	436.5	11.16	1600	3.67	8.01
38	12.6	9.27	93.01	1171.9	59.62	53.8	11.55	436.1	1.82	794	448.7	11.48	1966	4.38	9.85
-38	11.7	8.61	127.58	1492.7	43.88	111.1	23.86	900.6	2.12	1909	912.3	23.33	3402	3.73	17.04
TOTAL	135.9	100.00	86.04	11692.9	58.57	465.6	100.00	3774.1	2.19	8271	3910.0	100.00	19964	5.11	100.00

	KNELS 2	FEED	Mass Processed					3132							
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	3.6	2.79	96.89	348.8	72.43	3.1	0.76	22.9	5.79	133	26.5	0.85	482	18.15	2.83
297	6.2	4.81	100.55	623.4	75.04	9.1	2.24	67.3	3.08	207	73.5	2.35	831	11.30	4.89
210	14.3	11.09	76.54	1094.5	57.81	27.4	6.75	202.7	3.94	799	217.0	6.93	1893	8.72	11.14
150	22.6	17.52	56.22	1270.6	47.66	52.1	12.84	385.5	3.62	1395	408.1	13.03	2666	6.53	15.68
105	21.8	16.90	56.51	1231.9	51.41	56.0	13.80	414.3	2.81	1164	436.1	13.92	2396	5.49	14.10
75	17.7	13.72	52.21	924.1	46.39	51.0	12.56	377.3	2.83	1068	395.0	12.61	1992	5.04	11.72
53	12.6	9.77	52.84	665.8	46.83	43.3	10.67	320.3	2.36	756	332.9	10.63	1422	4.27	8.36
38	14.1	10.93	69.02	973.2	51.98	48.6	11.97	359.6	2.50	899	373.7	11.93	1872	5.01	11.01
-38	16.1	12.48	83.60	1346.0	39.08	115.3	28.41	853.0	2.46	2098	869.1	27.75	3444	3.96	20.26
TOTAL	129.0	100.00	65.72	8478.3	49.88	405.9	100.00	3003	2.84	8520	3132.0	100.00	16998	5.43	100.00

Lucien Beliveau Test T1

	KNELS FEED 3		Mass Processed			3752									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	4.8	3.65	60.86	292.1	56.45	2.1	0.54	19.6	11.49	225	24.4	0.65	518	21.20	2.66
297	7.3	5.55	72.22	527.2	64.37	7.3	1.88	68.2	4.28	292	75.5	2.01	819	10.85	4.21
210	15.6	11.85	67.50	1053.0	61.62	23.1	5.96	215.8	3.04	656	231.4	6.17	1709	7.39	8.79
150	24.5	18.62	57.17	1400.7	53.46	47.3	12.20	441.8	2.76	1219	466.3	12.43	2620	5.62	13.48
105	22.3	16.95	57.87	1290.5	48.35	53.1	13.70	496.0	2.78	1379	518.3	13.81	2669	5.15	13.73
75	17.1	12.99	59.97	1025.5	46.82	50.7	13.08	473.6	2.46	1165	490.7	13.08	2190	4.46	11.27
53	11.5	8.74	64.66	743.6	42.47	41.8	10.78	390.4	2.58	1007	401.9	10.71	1751	4.36	9.01
38	12.8	9.73	73.17	936.6	45.91	46.7	12.05	436.2	2.53	1104	449.0	11.97	2040	4.54	10.49
-38	15.7	11.93	93.41	1466.5	28.62	115.5	29.80	1078.8	3.39	3657	1094.5	29.17	5124	4.68	26.36
TOTAL	131.6	100.00	66.38	8735.7	44.94	387.6	100.00	3620.4	2.96	10705	3752.0	100.00	19440	5.18	100.00

	KNELS FEED 4		Mass Processed			3696									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	5.0	3.81	72.42	362.1	84.85	3.4	0.63	22.4	2.89	65	27.4	0.74	427	15.59	1.98
297	8.0	6.10	69.40	555.2	67.89	11.3	2.09	74.4	3.53	263	82.4	2.23	818	9.93	3.79
210	16.9	12.88	76.64	1295.2	59.24	34.9	6.44	229.7	3.88	891	246.6	6.67	2186	8.87	10.13
150	24.8	18.90	70.34	1744.4	54.70	68.8	12.70	452.8	3.19	1445	477.6	12.92	3189	6.68	14.78
105	20.9	15.93	68.37	1428.9	50.99	72.2	13.33	475.2	2.89	1373	496.1	13.42	2802	5.65	12.99
75	16.1	12.27	66.25	1066.6	44.93	66.2	12.22	435.7	3.00	1307	451.8	12.22	2374	5.25	11.00
53	11.2	8.54	65.69	735.7	39.41	55.8	10.30	367.3	3.08	1131	378.5	10.24	1867	4.93	8.65
38	12.7	9.68	74.26	943.1	40.69	60.2	11.12	396.2	3.47	1375	408.9	11.06	2318	5.67	10.74
-38	15.6	11.89	93.13	1452.8	25.96	168.8	31.17	1111.0	3.73	4144	1126.6	30.48	5597	4.97	25.94
TOTAL	131.2	100.00	73.05	9584.2	44.42	541.6	100.00	3564.8	3.36	11994	3696.0	100.00	21578	5.84	100.00

Lucien Beliveau Test T1

	KNELS 1	TAIL	Mass Processed					3998							
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	4.5	3.39	17.82	80.2	38.91	5.1	0.74	28.7	4.38	126	33.2	0.83	206	6.20	2.06
297	7.4	5.58	12.31	91.1	30.88	16.9	2.46	95.3	2.14	204	102.7	2.57	295	2.87	2.95
210	16.1	12.13	12.36	199.0	18.40	55.5	8.09	312.9	2.82	882	329.0	8.23	1081	3.29	10.80
150	24.0	18.09	12.92	310.1	18.59	103.4	15.08	582.9	2.33	1358	606.9	15.18	1668	2.75	16.66
105	21.4	16.13	16.29	348.6	22.59	108.1	15.76	609.4	1.96	1194	630.8	15.78	1543	2.45	15.41
75	17.5	13.19	17.90	313.3	25.95	97.9	14.28	551.9	1.62	894	569.4	14.24	1207	2.12	12.05
53	12.5	9.42	15.36	192.0	23.09	79.9	11.65	450.4	1.42	640	462.9	11.58	832	1.80	8.30
38	14.0	10.55	14.40	201.6	24.16	87.7	12.79	494.4	1.28	633	508.4	12.72	834	1.64	8.33
-38	15.3	11.53	19.60	299.9	12.77	131.2	19.13	739.6	2.77	2049	754.9	18.88	2349	3.11	23.45
TOTAL	132.7	100.00	15.34	2035.7	20.33	685.7	100.00	3865.3	2.06	7979	3998.0	100.00	10015	2.51	100.00

	KNELS 2	TAIL	Mass Processed					4685							
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	5.6	4.19	14.85	83.2	45.10	2.7	0.72	32.8	3.09	101	38.4	0.82	184	4.81	1.43
297	8.4	6.28	20.84	175.1	27.50	9.1	2.43	110.4	4.18	462	118.8	2.54	637	5.36	4.94
210	17.9	13.39	24.40	436.8	31.57	29.9	7.97	362.8	2.61	947	380.7	8.13	1384	3.63	10.74
150	26.6	19.90	24.85	661.0	29.91	59.1	15.76	717.1	2.16	1549	743.7	15.87	2210	2.97	17.16
105	22.1	16.53	25.66	567.1	25.93	61.8	16.48	749.9	2.16	1620	772.0	16.48	2187	2.83	16.98
75	16.4	12.27	28.33	464.6	30.44	52.4	13.97	635.8	1.67	1062	652.2	13.92	1526	2.34	11.85
53	11.0	8.23	24.98	274.8	25.81	42.0	11.20	509.6	1.55	790	520.6	11.11	1065	2.05	8.27
38	12.8	9.57	19.51	249.7	22.91	47.1	12.56	571.5	1.47	840	584.3	12.47	1090	1.87	8.46
-38	12.9	9.65	20.44	263.7	10.15	71.0	18.93	861.5	2.71	2335	874.4	18.66	2598	2.97	20.17
TOTAL	133.7	100.00	23.75	3175.9	24.66	375.1	100.00	4551.3	2.13	9705	4685.0	100.00	12881	2.75	100.00

Lucien Beliveau Test T1

	KNELS 3	TAIL	Mass Processed			4216									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	5.5	4.06	24.75	136.1	40.43	3.70	0.71	29.0	6.92	201	34.5	0.82	337	9.76	2.53
297	8.1	5.97	40.99	332.0	43.03	12.90	2.48	101.1	4.35	440	109.2	2.59	772	7.07	5.79
210	17.2	12.68	32.94	566.6	39.19	41.40	7.95	324.4	2.71	879	341.6	8.10	1446	4.23	10.86
150	25.2	18.58	28.55	719.5	32.16	79.70	15.30	624.4	2.43	1517	649.6	15.41	2237	3.44	16.80
105	21.5	15.86	32.11	690.4	30.57	84.80	16.28	664.4	2.36	1568	685.9	16.27	2258	3.29	16.96
75	16.9	12.46	30.88	521.9	31.40	76.60	14.71	600.2	1.90	1140	617.1	14.64	1662	2.69	12.48
53	11.9	8.78	29.8	354.6	29.70	63.40	12.17	496.7	1.69	839	508.6	12.06	1194	2.35	8.97
38	13.9	10.25	25.25	351.0	29.53	68.10	13.08	533.6	1.57	838	547.5	12.99	1189	2.17	8.93
-38	15.4	11.36	23.66	364.4	16.39	90.20	17.32	706.7	2.63	1859	722.1	17.13	2223	3.08	16.69
TOTAL	135.6	100.00	29.77	4036.4	30.31	520.80	100.00	4080.4	2.27	9281	4216.0	100.00	13317	3.16	100.00

	KNELS 4	TAIL	Mass Processed			4705									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420															
297	14.1	10.23	27.60	389.2	52.07	9.4	3.13	142.7	2.51	358	156.8	3.33	747	4.77	4.50
210	18.6	13.50	28.82	536.1	34.63	23.3	7.75	353.8	2.86	1012	372.4	7.91	1548	4.16	9.31
150	27.0	19.59	31.81	858.9	34.25	46.8	15.56	710.6	2.32	1649	737.6	15.68	2507	3.40	15.08
105	22.8	16.55	39.32	896.5	35.23	49.8	16.56	756.1	2.18	1648	778.9	16.56	2545	3.27	15.31
75	17.1	12.41	37.81	646.6	34.28	43.9	14.59	666.6	1.86	1240	683.7	14.53	1886	2.76	11.35
53	11.7	8.49	32.95	385.5	30.59	34.7	11.54	526.9	1.66	875	538.6	11.45	1260	2.34	7.58
38	13.0	9.43	29.96	389.5	31.38	37.9	12.60	575.5	1.48	852	588.5	12.51	1241	2.11	7.47
-38	13.5	9.80	28.04	378.5	7.74	55.0	18.28	835.1	5.40	4510	848.6	18.04	4888	5.76	29.40
TOTAL	137.8	100.00	32.52	4480.7	26.95	300.8	100.00	4567.2	2.66	12143	4705.0	100.00	16623	3.53	100.00

Lucien Beliveau Test T2-T9

	SAG DISCHARGE 1		Mass Processed			6000									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590	5.8	7.34	4.24	24.4	79.76	10.3	3.48	206.2	0.03	6	211.9	3.53	31	0.14	3.97
420	6.8	8.71	10.56	72.1	78.37	14.2	4.80	284.4	0.07	20	291.2	4.85	92	0.32	11.95
297	11.9	15.12	9.09	107.7	83.32	26.9	9.10	538.9	0.04	22	550.8	9.18	129	0.23	16.79
210	12.8	16.38	6.73	86.4	76.37	33.3	11.29	668.5	0.04	27	681.3	11.36	113	0.17	14.70
150	14.3	18.30	4.46	64.0	71.79	41.8	14.15	837.8	0.03	25	852.1	14.20	89	0.10	11.57
105	10.1	12.85	5.25	52.9	73.07	32.4	10.97	649.6	0.03	19	659.7	10.99	72	0.11	9.40
75	6.2	7.94	6.43	40.0	75.05	22.1	7.49	443.2	0.03	13	449.5	7.49	53	0.12	6.92
53	2.6	3.32	7.43	19.3	68.14	15.0	5.08	301.0	0.03	9	303.6	5.06	28	0.09	3.68
38	4.3	5.47	7.19	30.8	70.04	16.5	5.57	329.9	0.04	13	334.2	5.57	44	0.13	5.72
25	1.4	1.82	8.79	12.6	43.32	10.3	3.47	205.6	0.08	16	207.0	3.45	29	0.14	3.77
-25	2.2	2.76	7.40	16.0	18.00	72.6	24.60	1456.5	0.05	73	1458.6	24.31	89	0.06	11.53
TOTAL	78.4	100.00	6.71	526.2	68.34	295.3	100.00	5921.6	0.04	244	6000.0	100.00	770	0.13	100.00

* note: actual assay appeared suspicious at 0.27 oz/st and was therefore changed to 0.04 oz/t

	SAG DISCHARGE 2		Mass Processed			6000									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590	5.9	7.82	7.53	44.3	87.47	10.6	3.57	211.5	0.03	6	217.4	3.62	51	0.23	5.38
420	6.8	8.99	24.12	163.1	96.66	14.1	4.76	282.0	0.02	6	288.8	4.81	169	0.58	17.94
297	10.9	14.53	16.18	176.7	83.64	24.7	8.33	493.7	0.07	35	504.6	8.41	211	0.42	22.46
210	11.8	15.71	8.20	96.8	75.51	31.5	10.61	628.3	0.05	31	640.1	10.67	128	0.20	13.64
150	13.3	17.70	5.17	68.8	74.26	39.8	13.42	794.9	0.03	24	808.2	13.47	93	0.11	9.85
105	9.6	12.73	4.96	47.5	65.49	31.3	10.55	625.3	0.04	25	634.9	10.58	72	0.11	7.71
75	6.1	8.15	6.26	38.4	74.41	22.0	7.43	440.0	0.03	13	446.1	7.44	52	0.12	5.48
53	3.3	4.34	7.65	24.9	70.19	13.3	4.47	264.8	0.04	11	268.1	4.47	36	0.13	3.78
38	3.7	4.89	6.91	25.4	62.81	18.9	6.35	376.5	0.04	15	380.2	6.34	40	0.11	4.30
25	1.5	1.96	8.77	12.9	50.10	12.9	4.34	256.8	0.05	13	258.3	4.31	26	0.10	2.74
-25	2.4	3.18	7.01	16.8	26.48	77.7	26.18	1550.9	0.03	47	1553.2	25.89	63	0.04	6.73
TOTAL	75.2	100.00	9.52	715.5	76.07	296.7	100.00	5924.8	0.04	225	6000.0	100.00	941	0.16	100.00

Lucien Beliveau Test T2-T9

	BM		Mass Processed			5620									
	DISCHARGE 1														
	Knelson Conc							Knelson Tails				Feed			
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590	3.2	4.71	16.35	52.8	96.80	2.3	0.79	43.6	0.04	2	46.8	0.83	55	1.16	3.40
420	4.9	7.13	31.75	155.3	93.84	6.1	2.04	113.3	0.09	10	118.2	2.10	165	1.40	10.30
297	10.2	14.79	21.26	215.8	90.17	21.0	7.06	392.0	0.06	24	402.2	7.16	239	0.60	14.90
210	12.8	18.62	6.55	83.7	55.59	35.9	12.04	668.6	0.10	67	681.4	12.12	151	0.22	9.37
150	15.3	22.28	3.05	46.6	54.40	52.4	17.60	977.1	0.04	39	992.4	17.66	86	0.09	5.34
105	10.5	15.35	4.31	45.4	65.53	42.7	14.33	795.7	0.03	24	806.3	14.35	69	0.09	4.31
75	5.8	8.39	4.97	28.6	33.67	27.5	9.23	512.6	0.11	56	518.4	9.22	85	0.16	5.29
53	1.3	1.94	7.18	9.5	25.74	14.8	4.96	275.5	0.10	28	276.8	4.93	37	0.13	2.31
38	3.8	5.46	12.10	45.4	46.34	18.8	6.31	350.2	0.15	53	354.0	6.30	98	0.28	6.09
25	0.6	0.89	20.91	12.8	9.16	9.6	3.21	178.2	0.71	127	178.8	3.18	139	0.78	8.67
-25	0.3	0.44	31.72	9.5	1.97	66.8	22.42	1244.4	0.38	473	1244.7	22.15	482	0.39	30.03
TOTAL	68.6	100.00	10.28	705.4	43.91	297.8	100.00	5551.4	0.16	901	5620.0	100.00	1607	0.29	100.00

	BM		Mass Processed			5190									
	DISCHARGE 2														
	Knelson Conc							Knelson Tails				Feed			
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590	2.9	4.03	14.78	42.1	96.68	2.1	0.71	36.1	0.04	1	39.0	0.75	44	1.12	3.92
420	4.8	6.76	33.82	161.7	97.69	5.6	1.87	95.6	0.04	4	100.3	1.93	165	1.65	14.91
297	10.4	14.73	17.51	182.5	94.71	19.8	6.63	339.6	0.03	10	350.0	6.74	193	0.55	17.35
210	12.6	17.82	5.92	74.7	86.82	33.1	11.07	566.5	0.02	11	579.2	11.16	86	0.15	7.74
150	15.8	22.33	3.30	52.1	59.83	51.1	17.10	875.3	0.04	35	891.1	17.17	87	0.10	7.85
105	11.8	16.68	2.41	28.4	56.73	42.2	14.12	722.9	0.03	22	734.7	14.16	50	0.07	4.51
75	6.9	9.81	4.21	29.2	75.41	27.8	9.30	476.3	0.02	10	483.2	9.31	39	0.08	3.49
53	2.1	2.98	6.51	13.7	66.22	13.6	4.56	233.6	0.03	7	235.7	4.54	21	0.09	1.87
38	2.9	4.07	10.44	30.1	61.78	21.7	7.27	372.0	0.05	19	374.9	7.22	49	0.13	4.38
25	0.3	0.48	33.60	11.4	15.77	10.8	3.61	185.0	0.33	61	185.3	3.57	72	0.39	6.53
-25	0.2	0.31	57.85	12.7	4.18	71.0	23.76	1216.3	0.24	292	1216.5	23.44	305	0.25	27.44
TOTAL	70.8	100.00	9.03	638.6	57.52	298.9	100.00	5119.3	0.09	472	5190.0	100.00	1110	0.21	100.00

Lucien Beliveau Test T2-T9

	CUF1		Mass Processed			11158									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590	8.3	9.81	34.76	289.2	94.06	12.2	4.13	457.0	0.04	18	465.3	4.17	307	0.66	9.12
420	8.2	9.70	45.94	378.1	90.08	18.5	6.27	694.1	0.06	42	702.3	6.29	420	0.60	12.45
297	13.3	15.71	48.20	642.5	90.78	34.8	11.79	1305.1	0.05	65	1318.4	11.82	708	0.54	21.00
210	16.3	19.21	18.09	294.9	80.59	47.4	16.03	1775.5	0.04	71	1791.8	16.06	366	0.20	10.86
150	17.3	20.43	9.09	157.5	69.60	61.2	20.71	2293.2	0.03	69	2310.6	20.71	226	0.10	6.71
105	10.3	12.09	10.91	111.9	52.95	37.9	12.83	1421.2	0.07	99	1431.4	12.83	211	0.15	6.27
75	5.1	5.96	14.26	72.2	61.28	17.4	5.88	651.4	0.07	46	656.5	5.88	118	0.18	3.49
53	2.3	2.70	19.38	44.4	65.69	8.8	2.99	331.1	0.07	23	333.4	2.99	68	0.20	2.00
38	2.4	2.83	20.68	49.6	55.36	11.9	4.02	444.6	0.09	40	447.0	4.01	90	0.20	2.66
25	0.7	0.80	33.82	23.0	9.62	5.1	1.71	189.5	1.14	216	190.2	1.70	239	1.26	7.09
-25	0.6	0.74	45.88	28.9	4.68	40.3	13.64	1510.3	0.39	589	1511.0	13.54	618	0.41	18.33
TOTAL	84.8	100.00	24.66	2092.2	62.07	295.6	100.00	11073.2	0.12	1278	11158.0	100.00	3371	0.30	100.00

	CUF2		Mass Processed			10990									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590	7.2	8.72	34.04	244.7	94.42	13.2	4.42	482.6	0.03	14	489.8	4.46	259	0.53	9.91
420	8.7	10.51	59.35	514.0	90.93	17.6	5.88	641.1	0.08	51	649.8	5.91	565	0.87	21.62
297	13.9	16.85	30.34	421.4	89.27	34.7	11.61	1266.5	0.04	51	1280.4	11.65	472	0.37	18.06
210	15.2	18.45	15.70	238.8	70.96	44.6	14.93	1628.6	0.06	98	1643.8	14.96	337	0.20	12.87
150	17.2	20.91	10.49	180.7	72.87	61.4	20.56	2242.7	0.03	67	2259.9	20.56	248	0.11	9.49
105	10.2	12.36	9.88	100.7	71.01	37.5	12.56	1369.9	0.03	41	1380.1	12.56	142	0.10	5.42
75	4.7	5.75	14.18	67.2	58.93	21.4	7.16	780.7	0.06	47	785.4	7.15	114	0.15	4.36
53	2.4	2.91	21.03	50.5	74.08	9.7	3.24	353.3	0.05	18	355.7	3.24	68	0.19	2.61
38	1.7	2.04	26.95	45.3	62.00	12.7	4.24	462.5	0.06	28	464.2	4.22	73	0.16	2.79
25	0.6	0.69	42.93	24.5	18.48	5.9	1.98	215.9	0.50	108	216.5	1.97	132	0.61	5.06
-25	0.7	0.80	43.02	28.4	13.91	40.1	13.42	1463.8	0.12	176	1464.5	13.33	204	0.14	7.80
TOTAL	82.4	100.00	23.25	1916.2	73.29	298.6	100.00	10907.6	0.06	698	10990.0	100.00	2615	0.24	100.00

Lucien Beliveau Test T2-T9

	CYCL OVERFLOW		Mass Processed			6000									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420															
297															
210	5.3	9.93	7.15	37.9	85.97	0.5	0.28	16.7	0.37	6	22.0	0.37	44	2.00	12.48
150	8.3	15.55	0.85	7.1	41.71	5.9	3.32	197.2	0.05	10	205.5	3.43	17	0.08	4.79
105	9.9	18.55	0.33	3.3	39.29	15.1	8.49	504.7	0.01	5	514.6	8.58	8	0.02	2.35
75	10.3	19.30	0.37	3.8	36.66	19.7	11.07	658.5	0.01	7	668.8	11.15	10	0.02	2.94
53	5.7	10.68	0.52	3.0	9.08	14.8	8.32	494.7	0.06	30	500.4	8.34	33	0.07	9.24
38	8.8	16.49	0.53	4.7	8.41	21.7	12.20	725.4	0.07	51	734.2	12.24	55	0.08	15.69
25	2.5	4.68	1.72	4.3	6.71	14.9	8.38	498.1	0.12	60	500.6	8.34	64	0.13	18.14
-25	2.6	4.83	2.84	7.3	6.04	85.3	47.95	2851.3	0.04	114	2853.9	47.56	121	0.04	34.36
TOTAL	53.4	100.00	1.34	71.3	20.18	177.9	100.00	5946.6	0.05	282	6000.0	100.00	353	0.06	100.00

Lucien Beliveau Test T2-T9 (T2)
4:1 Si

	SPIRL FEED	Mass Processed		11182											
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590	1.4	1.39	3.02	4.3	8.74	0.1	0.06	6.1	7.29	45	7.6	0.07	49	6.49	0.29
420	2.3	2.26	102.45	236.7	66.73	0.8	0.41	45.2	2.61	118	47.5	0.42	355	7.46	2.08
297	7.9	7.68	203.89	1600.5	76.06	7.2	3.64	402.9	1.25	504	410.8	3.67	2104	5.12	12.32
210	18.3	17.94	84.42	1548.3	75.05	32.9	16.59	1838.4	0.28	515	1856.7	16.60	2063	1.11	12.08
150	27.9	27.27	57.73	1608.9	69.96	58.9	29.69	3289.4	0.21	691	3317.3	29.67	2300	0.69	13.46
105	18.8	18.43	83.28	1569.0	75.46	35.2	17.71	1962.2	0.26	510	1981.1	17.72	2079	1.05	12.17
75	13.2	12.90	117.42	1547.6	72.31	26.6	13.37	1481.7	0.40	593	1494.9	13.37	2140	1.43	12.53
53	6.6	6.47	202.52	1338.7	78.34	13.8	6.96	771.3	0.48	370	777.9	6.96	1709	2.20	10.01
38	4.0	3.93	381.54	1533.8	77.78	9.5	4.77	528.0	0.83	438	532.0	4.76	1972	3.71	11.55
25	0.9	0.91	750.43	697.9	72.18	3.1	1.57	173.6	1.55	269	174.5	1.56	967	5.54	5.66
-25	0.8	0.82	774.49	650.6	48.48	10.4	5.24	581.0	1.19	691	581.8	5.20	1342	2.31	7.86
TOTAL	102.2	100.00	120.69	12336.2	72.23	198.5	100.00	11079.8	0.43	4744	11182.0	100.00	17080	1.53	100.00

12.4:1 Si

	KNEL CONC	Mass Processed		4000											
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590	2.5	2.45	40.12	101.1	36.00	0.1	0.03	1.2	155.31	180	3.7	0.09	281	76.37	0.25
420	2.5	2.39	307.72	757.0	96.90	0.4	0.21	8.3	2.92	24	10.8	0.27	781	72.65	0.70
297	8.3	8.02	581.31	4801.6	96.55	6.5	3.21	125.2	1.37	171	133.4	3.34	4973	37.27	4.49
210	20.9	20.30	656.75	13726.1	98.54	37.7	18.68	727.9	0.28	204	748.8	18.72	13930	18.60	12.57
150	30.2	29.36	825.46	24945.4	99.74	68.1	33.70	1313.5	0.05	66	1343.7	33.59	25011	18.61	22.56
105	18.9	18.31	814.90	15360.9	97.71	38.8	19.20	748.4	0.48	359	767.2	19.18	15720	20.49	14.18
75	12.2	11.83	1382.66	16840.8	96.52	27.1	13.42	523.1	1.16	607	535.3	13.38	17448	32.60	15.74
53	4.5	4.32	2485.41	11060.1	90.53	9.6	4.74	184.6	6.27	1157	189.0	4.73	12217	64.63	11.02
38	2.5	2.38	3833.55	9392.2	79.43	9.8	4.85	189.0	12.87	2433	191.5	4.79	11825	61.76	10.67
25	0.4	0.39	7967.39	3187.0	60.21	1.7	0.84	32.6	64.60	2106	33.0	0.82	5293	160.40	4.77
-25	0.3	0.24	8520.12	2130.0	63.18	2.3	1.11	43.4	28.61	1242	43.6	1.09	3372	77.25	3.04
TOTAL	102.9	100.00	993.80	102302.1	92.29	202.1	100.00	3897.1	2.19	8548	4000.0	100.00	110850	27.71	100.00

Lucien Beliveau Test T2-T9 (T2)
4:1 Si

	SPIRL TAILS		Mass Processed			5556									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	1.2	1.12	9.47	11.4	98.55	0.3	0.15	8.3	0.02	0	9.5	0.17	12	1.21	0.26
297	5.6	5.23	6.55	36.7	67.36	6.4	3.27	178.0	0.10	18	183.6	3.31	55	0.30	1.24
210	15.9	14.80	5.32	84.5	44.35	34.6	17.69	963.6	0.11	106	979.5	17.63	190	0.19	4.35
150	29.5	27.48	6.99	206.1	45.40	59.4	30.34	1652.9	0.15	248	1682.4	30.28	454	0.27	10.36
105	23.8	22.21	13.72	327.1	57.26	33.8	17.23	938.9	0.26	244	962.7	17.33	571	0.59	13.03
75	17.7	16.51	25.04	443.7	78.42	24.4	12.45	678.2	0.18	122	695.9	12.53	566	0.81	12.91
53	7.6	7.09	59.68	454.2	71.13	12.3	6.26	341.3	0.54	184	348.9	6.28	638	1.83	14.57
38	4.0	3.76	127.48	515.0	68.89	8.4	4.27	232.6	1.00	233	236.6	4.26	748	3.16	17.06
25	1.1	1.00	282.27	302.0	70.08	2.8	1.43	78.2	1.65	129	79.2	1.43	431	5.44	9.83
-25	0.9	0.80	326.62	280.9	39.13	13.5	6.91	376.7	1.16	437	377.5	6.79	718	1.90	16.38
TOTAL	107.3	100.00	24.80	2661.6	60.73	195.9	100.00	5448.7	0.32	1721	5556.0	100.00	4382	0.79	100.00

4:1 Si

	KNEL. TAILS		Mass Processed			6863									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590	1.1	1.03	29.16	30.6	85.25	0.1	0.04	3.0	1.75	5	4.1	0.06	36	8.81	0.54
420	1.5	1.51	23.93	36.9	38.43	0.8	0.38	25.6	2.31	59	27.1	0.39	96	3.54	1.43
297	6.4	6.22	47.32	300.5	63.89	7.3	3.64	246.2	0.69	170	252.5	3.68	470	1.86	7.02
210	18.0	17.65	23.07	415.7	42.86	35.8	17.82	1204.6	0.46	554	1222.6	17.81	970	0.79	14.47
150	30.4	29.77	15.13	459.8	42.59	63.6	31.62	2137.5	0.29	620	2167.9	31.59	1080	0.50	16.10
105	21.3	20.81	24.19	514.0	38.22	37.4	18.62	1258.8	0.66	831	1280.0	18.65	1345	1.05	20.06
75	12.6	12.36	35.13	443.3	51.03	26.9	13.39	905.3	0.47	425	917.9	13.38	869	0.95	12.96
53	6.2	6.09	60.13	374.0	60.49	13.2	6.57	444.2	0.55	244	450.5	6.56	618	1.37	9.22
38	3.3	3.18	91.71	298.1	57.82	8.6	4.29	289.9	0.75	217	293.1	4.27	515	1.76	7.69
25	0.9	0.87	153.77	136.9	51.42	2.7	1.33	89.8	1.44	129	90.7	1.32	266	2.94	3.97
-25	0.5	0.50	255.62	130.4	29.67	4.6	2.31	156.0	1.98	309	156.6	2.28	439	2.81	6.55
TOTAL	102.1	100.00	30.76	3140.1	46.84	201.0	100.00	6760.9	0.53	3564	6863.0	100.00	6705	0.98	100.00

Lucien Beliveau Test T2-T9 (T2)
4:1 Si

	SPIRL CONC1		Mass Processed			2566									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590	0.1	0.06	475.42	38.0	75.48	0.1	0.05	1.2	10.21	12	1.3	0.05	50	39.06	0.02
420	0.5	0.34	3327.80	1497.5	99.98	0.3	0.13	3.3	0.10	0	3.7	0.14	1498	403.00	0.63
297	4.4	3.29	4656.7	20489.5	99.97	6.2	3.07	74.7	0.07	5	79.1	3.08	20495	259.26	8.68
210	13.4	10.00	3370.6	45031.6	99.95	36.0	17.88	435.0	0.05	22	448.3	17.47	45053	100.49	19.09
150	28.1	21.00	1808.6	50766.8	99.81	60.9	30.29	736.7	0.13	96	764.8	29.80	50863	66.51	21.55
105	35.0	26.18	1109.2	38810.6	99.30	35.5	17.63	428.9	0.64	274	463.9	18.08	39085	84.25	16.56
75	32.8	24.51	926.8	30353.4	98.48	31.3	15.54	378.1	1.24	469	410.8	16.01	30822	75.02	13.06
53	11.4	8.52	1598.6	18207.8	98.55	15.3	7.59	184.5	1.45	268	195.9	7.63	18475	94.31	7.83
38	7.1	5.32	2585.0	18379.4	97.31	12.2	6.07	147.7	3.44	508	154.8	6.03	18888	121.98	8.00
25	0.8	0.58	8794.7	6859.9	91.37	1.9	0.93	22.5	28.79	648	23.3	0.91	7508	322.44	3.18
-25	0.3	0.19	11227.2	2919.1	88.99	1.6	0.82	19.8	18.21	361	20.1	0.78	3280	163.19	1.39
TOTAL	133.6	100.00	1746.14	233353.5	98.87	201.0	100.00	2432.4	1.10	2664	2566.0	100.00	236017	91.98	100.00

4:1 Si

	SPIRL CONC2		Mass Processed			2945									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590	0.7	0.61	219.0	162.0	81.17	0.1	0.06	1.8	20.68	38	2.6	0.09	200	78.04	0.13
420	2.5	2.05	2434.06	6012.1	84.99	0.8	0.39	11.0	96.13	1062	13.5	0.46	7074	523.30	4.52
297	6.8	5.61	4564.0	30806.9	93.93	6.1	3.02	85.3	23.35	1992	92.1	3.13	32799	356.27	20.97
210	13.8	11.46	2597.4	35817.7	96.41	32.1	15.91	449.4	2.97	1335	463.1	15.73	37152	80.22	23.75
150	21.9	18.16	1248.1	27282.8	96.41	57.2	28.33	800.1	1.27	1016	822.0	27.91	28299	34.43	18.09
105	20.5	16.99	1007.4	20600.7	97.80	34.9	17.28	488.2	0.95	464	508.7	17.27	21065	41.41	13.47
75	26.4	21.93	369.9	9761.7	95.63	30.7	15.20	429.4	1.04	447	455.7	15.48	10208	22.40	6.53
53	15.0	12.44	352.8	5281.0	93.91	18.0	8.92	252.0	1.36	343	267.0	9.07	5624	21.06	3.60
38	11.1	9.23	605.2	6723.5	93.57	16.9	8.39	236.9	1.95	462	248.0	8.42	7186	28.97	4.59
25	1.3	1.11	2531.0	3391.5	91.93	3.0	1.48	41.7	7.14	298	43.0	1.46	3689	85.76	2.36
-25	0.5	0.40	6106.0	2930.9	93.84	2.1	1.02	28.8	6.68	192	29.3	0.99	3123	106.63	2.00
TOTAL	120.4	100.00	1236.15	148770.9	95.11	202.0	100.00	2824.7	2.71	7648	2945.0	100.00	156418	53.11	100.00

Lucien Beliveau Test T2-T9 (T3)
4:1 Si

	SPIRL FEED		Mass Processed			7716									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	1.6	1.59	16.45	26.3	51.77	0.6	0.30	22.9	1.07	25	24.5	0.32	51	2.07	0.69
297	3.9	3.87	117.79	459.4	89.52	4.4	2.21	168.0	0.32	54	171.9	2.23	513	2.98	6.99
210	16.4	16.27	30.72	503.8	64.18	40.9	20.51	1561.9	0.18	281	1578.3	20.46	785	0.50	10.69
150	22.7	22.52	30.16	684.6	61.30	49.2	24.67	1878.9	0.23	432	1901.6	24.65	1117	0.59	15.21
105	20.5	20.34	21.48	440.3	50.59	35.2	17.65	1344.2	0.32	430	1364.7	17.69	870	0.64	11.86
75	16.4	16.27	24.48	401.5	40.63	25.6	12.84	977.6	0.60	587	994.0	12.88	988	0.99	13.46
53	11.0	10.91	38.59	424.5	57.52	17.1	8.58	653.0	0.48	313	664.0	8.61	738	1.11	10.05
38	4.7	4.66	81.93	385.1	64.01	8.1	4.06	309.3	0.70	217	314.0	4.07	602	1.92	8.20
25	2.4	2.38	179.14	429.9	65.01	6.0	3.01	229.1	1.01	231	231.5	3.00	661	2.86	9.01
-25	1.2	1.19	466.07	559.3	55.11	12.3	6.17	469.7	0.97	456	470.9	6.10	1015	2.16	13.83
TOTAL	100.8	100.00	42.80	4314.7	58.78	199.4	100.00	7614.7	0.40	3025	7715.5	100.00	7340	0.95	100.00

4:1 Si

	SPIRL TAILS		Mass Processed			6067									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	1.6	1.51	1.87	3.0	56.83	0.4	0.20	12.0	0.19	2	13.6	0.22	5	0.39	0.12
297	4.0	3.76	8.02	32.1	61.38	4.5	2.26	134.6	0.15	20	138.6	2.28	52	0.38	1.22
210	18.7	17.59	5.55	103.8	51.59	40.7	20.42	1217.3	0.08	97	1236.0	20.37	201	0.16	4.71
150	24.1	22.67	9.18	221.2	57.50	49.7	24.94	1486.4	0.11	164	1510.5	24.90	385	0.25	9.01
105	22.4	21.07	16.66	373.2	63.27	34.5	17.31	1031.8	0.21	217	1054.2	17.38	590	0.56	13.82
75	16.6	15.62	23.39	388.3	46.94	25.3	12.69	756.7	0.58	439	773.3	12.75	827	1.07	19.38
53	10.7	10.07	39.16	419.0	65.19	17.0	8.53	508.4	0.44	224	519.1	8.56	643	1.24	15.06
38	4.5	4.23	87.67	394.5	72.80	7.7	3.86	230.3	0.64	147	234.8	3.87	542	2.31	12.70
25	2.3	2.16	164.47	378.3	69.74	5.9	2.96	176.5	0.93	164	178.8	2.95	542	3.03	12.71
-25	1.4	1.32	75.88	106.2	22.11	13.6	6.82	406.8	0.92	374	408.2	6.73	480	1.18	11.26
TOTAL	106.3	100.00	22.76	2419.6	56.69	199.3	100.00	5960.7	0.31	1848	6067.0	100.00	4268	0.70	100.00

Lucien Beliveau Test T2-T9 (T3)
4:1 Si

	SPIRL CONC1	Mass Processed		2035											
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	1.2	0.89	856.54	1027.8	98.01	0.4	0.18	3.5	5.99	21	4.7	0.23	1049	223.76	0.86
297	5.3	3.88	2192.7	11511.4	98.99	4.9	2.43	46.1	2.56	118	51.3	2.52	11629	226.54	9.55
210	9.9	7.31	2325.8	23025.8	99.55	26.8	13.28	252.4	0.41	103	262.3	12.89	23129	88.19	19.00
150	18.0	13.29	1561.2	28085.1	99.64	56.4	27.97	531.4	0.19	101	549.4	27.00	28186	51.30	23.15
105	22.3	16.46	904.8	20159.4	99.14	37.2	18.46	350.7	0.50	175	373.0	18.33	20335	54.52	16.70
75	32.5	24.03	381.5	12408.9	98.31	32.3	16.01	304.1	0.70	213	336.6	16.54	12622	37.49	10.37
53	21.4	15.80	93.5	2000.4	87.22	21.5	10.64	202.1	1.45	293	223.5	10.98	2294	10.26	1.88
38	20.7	15.27	718.9	14860.1	97.03	15.4	7.65	145.3	3.13	455	166.0	8.16	15315	92.26	12.58
25	3.4	2.53	1259.9	4321.5	92.85	3.5	1.75	33.2	10.03	333	36.6	1.80	4654	127.15	3.82
-25	0.8	0.55	2928.8	2196.6	86.14	3.3	1.63	31.0	11.40	353	31.8	1.56	2550	80.30	2.09
TOTAL	135.4	100.00	883.35	119597.0	98.22	201.6	100.00	1899.8	1.14	2166	2035.2	100.00	121763	59.83	100.00

4:1 Si

	SPIRL CONC2	Mass Processed		3312											
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	3.9	3.07	273.07	1065.0	78.36	0.9	0.42	13.5	21.83	294	17.4	0.52	1359	78.22	2.02
297	10.0	7.85	877.3	8755.6	87.08	6.4	3.20	101.9	12.74	1299	111.9	3.38	10054	89.83	14.98
210	13.0	10.19	970.4	12575.7	90.37	29.1	14.51	462.0	2.90	1340	475.0	14.34	13916	29.30	20.73
150	18.5	14.58	696.2	12907.5	95.93	58.6	29.17	929.1	0.59	548	947.6	28.61	13456	14.20	20.04
105	17.4	13.66	478.3	8307.5	97.43	37.4	18.60	592.5	0.37	219	609.8	18.41	8527	13.98	12.70
75	22.1	17.37	239.4	5288.6	95.45	28.9	14.41	458.8	0.55	252	480.9	14.52	5541	11.52	8.25
53	21.5	16.90	130.7	2809.4	92.61	17.7	8.80	280.1	0.80	224	301.6	9.11	3034	10.06	4.52
38	16.0	12.56	284.3	4540.1	93.05	13.8	6.87	218.8	1.55	339	234.8	7.09	4879	20.78	7.27
25	4.0	3.14	726.7	2906.6	91.02	3.6	1.78	56.8	5.05	287	60.8	1.83	3193	52.56	4.76
-25	0.9	0.69	2690.8	2367.9	74.53	4.5	2.24	71.3	11.34	809	72.2	2.18	3177	43.99	4.73
TOTAL	127.2	100.00	483.72	61524.0	91.64	200.9	100.00	3184.8	1.76	5611	3312.0	100.00	67135	20.27	100.00

Lucien Beliveau Test T2-T9 (T4)
4:1 Si

	SPIRL FEED		Mass Processed			7537									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	64.6	77.55	3.61	233.2	28.44	505.4	78.71	5866.8	0.10	587	5931.4	78.70	820	0.14	10.15
297	2.4	2.88	127.02	304.8	67.32	17.0	2.65	197.3	0.75	148	199.7	2.65	453	2.27	5.60
210	1.7	2.04	307.48	522.7	52.65	7.5	1.17	87.1	5.40	470	88.8	1.18	993	11.19	12.29
150	2.7	3.24	178.54	482.1	54.82	11.6	1.81	134.7	2.95	397	137.4	1.82	879	6.40	10.88
105	3.5	4.20	79.59	278.6	44.44	15.0	2.34	174.1	2.00	348	177.6	2.36	627	3.53	7.76
75	3.3	3.96	122.42	404.0	52.89	15.5	2.41	179.9	2.00	360	183.2	2.43	764	4.17	9.45
53	3.0	3.60	154.17	462.5	54.94	20.3	3.16	235.6	1.61	379	238.6	3.17	842	3.53	10.42
38	1.1	1.32	405.03	445.5	63.54	15.4	2.40	178.8	1.43	256	179.9	2.39	701	3.90	8.68
25	0.6	0.72	823.36	494.0	67.53	13.2	2.06	153.2	1.55	238	153.8	2.04	732	4.76	9.05
-25	0.4	0.48	1930.61	772.2	60.84	21.2	3.30	246.1	2.02	497	246.5	3.27	1269	5.15	15.71
TOTAL	83.3	100.00	52.82	4399.7	54.45	642.1	100.00	7453.7	0.49	3680	7537.0	100.00	8080	1.07	100.00

4:1 Si

	SPIRL TAILS		Mass Processed			6334									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	62.4	73.85	0.04	2.5	1.28	439.7	77.11	4818.8	0.04	193	4881.2	77.07	195	0.04	3.04
297	2.7	3.20	17.68	47.7	53.46	15.8	2.77	173.2	0.24	42	175.9	2.78	89	0.51	1.39
210	1.8	2.13	90.83	163.5	47.09	6.6	1.16	72.3	2.54	184	74.1	1.17	347	4.68	5.41
150	3.1	3.67	84.56	262.1	48.45	10.1	1.77	110.7	2.52	279	113.8	1.80	541	4.76	8.44
105	3.8	4.50	67.80	257.6	43.23	12.5	2.19	137.0	2.47	338	140.8	2.22	596	4.23	9.29
75	4.0	4.73	73.23	292.9	53.46	13.0	2.28	142.5	1.79	255	146.5	2.31	548	3.74	8.54
53	3.3	3.91	112.79	372.2	55.38	17.1	3.00	187.4	1.60	300	190.7	3.01	672	3.52	10.48
38	1.7	2.01	220.05	374.1	63.98	12.9	2.26	141.4	1.49	211	143.1	2.26	585	4.09	9.12
25	1.1	1.30	381.62	419.8	61.49	12.3	2.16	134.8	1.95	263	135.9	2.15	683	5.02	10.64
-25	0.6	0.71	489.73	293.8	13.62	30.2	5.30	331.0	5.63	1863	331.6	5.24	2157	6.51	33.64
TOTAL	84.5	100.00	29.42	2486.3	38.77	570.2	100.00	6249.0	0.63	3927	6333.5	100.00	6413	1.01	100.00

Lucien Beliveau Test T2-T9 (T4)

4:1 Si

	SPIRL CONC1		Mass Processed			2941									
	Knelson Conc							Knelson Tails					Feed		
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	1.6	1.50	1680.76	2689.2	94.54	0.6	0.26	7.2	21.44	155	8.8	0.30	2845	321.46	2.46
297	6.5	6.10	2634.0	17120.8	95.33	5.7	2.43	68.9	12.19	839	75.4	2.56	17960	238.31	15.55
210	21.2	19.89	1123.1	23809.7	97.56	53.1	22.63	641.5	0.93	597	662.7	22.53	24406	36.83	21.13
150	24.3	22.80	676.3	16434.1	98.64	66.9	28.52	808.3	0.28	226	832.6	28.31	16660	20.01	14.42
105	17.1	16.04	664.3	11360.2	98.56	33.5	14.28	404.7	0.41	166	421.8	14.34	11526	27.32	9.98
75	16.7	15.67	500.1	8351.7	98.09	30.6	13.04	369.7	0.44	163	386.4	13.14	8514	22.03	7.37
53	12.9	12.10	713.4	9203.1	96.18	25.2	10.74	304.5	1.20	365	317.4	10.79	9568	30.15	8.28
38	4.4	4.13	1689.4	7433.5	94.92	11.8	5.03	142.6	2.79	398	147.0	5.00	7831	53.29	6.78
25	1.5	1.41	4734.7	7102.1	92.52	5.2	2.22	62.8	9.14	574	64.3	2.19	7676	119.33	6.64
-25	0.4	0.38	20267.4	8107.0	94.91	2.0	0.85	24.2	17.98	434	24.6	0.84	8541	347.73	7.39
TOTAL	106.6	100.00	1047.01	111611.4	96.61	234.6	100.00	2834.4	1.38	3918	2941.0	100.00	115530	39.28	100.00

4:1 Si

	SPRIL CONC2		Mass Processed			2873									
	Knelson Conc							Knelson Tails					Feed		
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	2.2	1.93	1338.69	2945.1	89.48	1.7	0.37	10.1	34.31	346	12.3	0.43	3291	267.78	6.30
297	7.9	6.93	1060.1	8374.5	88.52	14.3	3.08	84.9	12.79	1086	92.8	3.23	9460	101.96	18.09
210	22.7	19.91	323.3	7338.0	91.37	119.2	25.65	707.6	0.98	693	730.3	25.42	8031	11.00	15.36
150	22.4	19.65	276.6	6196.7	95.74	125.4	26.98	744.4	0.37	275	766.8	26.69	6472	8.44	12.38
105	14.3	12.54	358.1	5121.3	98.67	58.1	12.50	344.9	0.20	69	359.2	12.50	5190	14.45	9.93
75	13.7	12.02	238.8	3270.9	95.44	52.7	11.34	312.8	0.50	156	326.5	11.37	3427	10.50	6.56
53	17.9	15.70	257.1	4602.4	94.58	46.3	9.96	274.8	0.96	264	292.7	10.19	4866	16.62	9.31
38	9.3	8.16	284.1	2642.1	90.83	24.7	5.31	146.6	1.82	267	155.9	5.43	2909	18.66	5.56
25	3.1	2.72	950.0	2945.1	87.58	15.5	3.33	92.0	4.54	418	95.1	3.31	3363	35.36	6.43
-25	0.5	0.44	9726.2	4863.1	92.25	6.9	1.48	41.0	9.97	408	41.5	1.44	5271	127.15	10.08
TOTAL	114.0	100.00	423.68	48299.2	92.38	464.8	100.00	2759.0	1.44	3983	2873.0	100.00	52282	18.20	100.00

Lucien Beliveau Test T2-T9 (T5)

4:1 Si

	SPIRL FEED		Mass Processed			7691									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590	38.5	45.94	0.07	2.7	1.02	278.4	42.96	3268.3	0.08	261	3306.8	43.00	264	0.08	3.19
420	27.6	32.94	2.77	76.5	48.53	230.2	35.52	2702.4	0.03	81	2730.0	35.50	158	0.06	1.90
297	1.7	2.03	194.19	330.1	46.80	17.0	2.62	199.6	1.88	375	201.3	2.62	705	3.50	8.51
210	1.7	2.03	297.70	506.1	49.78	8.3	1.28	97.4	5.24	511	99.1	1.29	1017	10.26	12.27
150	3.8	4.53	136.44	518.5	49.11	13.5	2.08	158.5	3.39	537	162.3	2.11	1056	6.51	12.74
105	3.9	4.65	97.49	380.2	47.71	15.3	2.36	179.6	2.32	417	183.5	2.39	797	4.34	9.62
75	3.4	4.06	112.88	383.8	46.64	17.4	2.69	204.3	2.15	439	207.7	2.70	823	3.96	9.93
53	2.2	2.63	244.45	537.8	63.84	18.4	2.84	216.0	1.41	305	218.2	2.84	842	3.86	10.17
38	0.7	0.84	736.64	515.6	70.52	13.6	2.10	159.7	1.35	216	160.4	2.08	731	4.56	8.82
25	0.2	0.24	3540.87	708.2	73.09	13.3	2.05	156.1	1.67	261	156.3	2.03	969	6.20	11.69
-25	0.1	0.12	3885.04	388.5	42.03	22.6	3.49	265.3	2.02	536	265.4	3.45	924	3.48	11.16
TOTAL	83.8	100.00	51.88	4347.9	52.47	648.0	100.00	7607.2	0.52	3938	7691.0	100.00	8286	1.08	100.00

4:1 Si

	SPRIL TAILS		Mass Processed			7984									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590	34.6	41.19	0.04	1.4	4.02	269.3	41.86	3307.1	0.01	33	3341.7	41.86	34	0.01	0.44
420	28.9	34.40	0.00	0.0	0.00	232.2	36.10	2851.5	0.06	171	2880.4	36.08	171	0.06	2.16
297	2.4	2.86	46.61	111.9	33.81	18.2	2.83	223.5	0.98	219	225.9	2.83	331	1.46	4.19
210	1.8	2.14	197.05	354.7	40.25	9.7	1.51	119.1	4.42	527	120.9	1.51	881	7.29	11.15
150	3.2	3.81	180.24	576.8	48.80	14.2	2.21	174.4	3.47	605	177.6	2.22	1182	6.66	14.95
105	1.4	1.67	100.18	140.3	53.41	4.7	0.73	57.7	2.12	122	59.1	0.74	263	4.44	3.32
75	6.6	7.86	111.78	737.7	56.07	24.9	3.87	305.8	1.89	578	312.4	3.91	1316	4.21	16.65
53	2.9	3.45	188.88	547.8	66.84	17.7	2.75	217.4	1.25	272	220.3	2.76	819	3.72	10.37
38	1.1	1.31	448.70	493.6	70.74	12.5	1.94	153.5	1.33	204	154.6	1.94	698	4.51	8.83
25	0.7	0.83	1045.32	731.7	67.69	12.0	1.87	147.4	2.37	349	148.1	1.85	1081	7.30	13.68
-25	0.4	0.48	1081.03	432.4	38.34	27.9	4.34	342.6	2.03	696	343.0	4.30	1128	3.29	14.27
TOTAL	84.0	100.00	49.14	4128.2	52.23	643.3	100.00	7900.0	0.48	3776	7984.0	100.00	7904	0.99	100.00

Lucien Beliveau Test T2-T9 (T5)

4:1 Si

	SPIRL CONC1	Mass Processed		2971.5											
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590	38.0	44.81	6.21	236.0	85.50	179.6	46.22	1334.2	0.03	40	1372.2	46.18	276	0.20	0.33
420	29.6	34.91	42.13	1247.0	100.00	116.1	29.88	862.4	0.00	0	892.0	30.02	1247	1.40	1.48
297	2.9	3.42	2373.6	6883.5	86.05	9.1	2.34	67.6	16.51	1116	70.5	2.37	8000	113.47	9.49
210	2.1	2.48	6542.8	13739.9	93.79	2.2	0.57	16.3	55.71	910	18.4	0.62	14650	794.37	17.38
150	2.6	3.07	6513.0	16933.8	99.31	2.2	0.57	16.3	7.25	118	18.9	0.64	17052	900.21	20.23
105	1.0	1.18	3433.7	3433.7	99.81	1.7	0.44	12.6	0.51	6	13.6	0.46	3440	252.42	4.08
75	4.8	5.66	3457.0	16593.4	97.94	25.4	6.54	188.7	1.85	349	193.5	6.51	16942	87.57	20.10
53	2.5	2.95	4449.9	11124.9	97.20	29.3	7.54	217.7	1.47	320	220.2	7.41	11445	51.99	13.58
38	0.9	1.06	7403.8	6663.4	95.39	14.9	3.83	110.7	2.91	322	111.6	3.76	6986	62.60	8.29
25	0.3	0.35	11069.1	3320.7	90.90	6.8	1.75	50.5	6.58	332	50.8	1.71	3653	71.89	4.33
-25	0.1	0.12	4763.3	476.3	78.69	1.3	0.33	9.7	13.36	129	9.8	0.33	605	62.04	0.72
TOTAL	84.8	100.00	951.09	80652.6	95.68	388.6	100.00	2886.7	1.26	3644	2971.5	100.00	84297	28.37	100.00

4:1 Si

	SPRIL CONC2	Mass Processed		3202											
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590	37.3	45.05	0.01	0.4	0.19	161.4	44.51	1388.2	0.14	194	1425.5	44.53	195	0.14	0.37
420	30.3	36.59	36.46	1104.7	48.87	113.9	31.41	979.6	1.18	1156	1009.9	31.55	2261	2.24	4.25
297	4.2	5.07	893.4	3752.2	67.51	11.8	3.25	101.5	17.79	1806	105.7	3.30	5558	52.58	10.45
210	2.9	3.50	2058.1	5968.3	76.30	5.4	1.49	46.4	39.92	1854	49.3	1.54	7822	158.53	14.71
150	2.1	2.54	3306.4	6943.3	90.18	2.4	0.66	20.6	36.63	756	22.7	0.71	7699	338.55	14.48
105	0.5	0.60	3008.4	1504.2	93.16	1.1	0.30	9.5	11.67	110	10.0	0.31	1615	162.69	3.04
75	2.5	3.02	5680.8	14202.1	97.71	13.9	3.83	119.6	2.79	334	122.1	3.81	14536	119.09	27.33
53	1.7	2.05	2539.4	4317.0	92.54	23.0	6.34	197.8	1.76	348	199.5	6.23	4665	23.38	8.77
38	0.9	1.09	4012.9	3611.6	87.84	17.4	4.80	149.7	3.34	500	150.6	4.70	4111	27.31	7.73
25	0.3	0.36	8356.8	2507.0	77.33	9.7	2.68	83.4	8.81	735	83.7	2.62	3242	38.72	6.10
-25	0.1	0.12	8421.5	842.1	57.15	2.6	0.72	22.4	28.24	632	22.5	0.70	1474	65.61	2.77
TOTAL	82.8	100.00	549.50	44753.0	84.16	362.6	100.00	3118.7	2.70	8425	3201.5	100.00	53178	16.61	100.00

Lucien Beliveau Test T2-T9 (T7)

4:1 Si

	THK UNDERFLOW		Mass Processed			11247.5									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	3.4	3.01	47.02	159.9	66.96	0.6	0.30	33.3	2.37	79	36.7	0.33	239	6.51	2.71
297	5.2	4.61	81.60	424.3	88.85	4.0	1.99	221.9	0.24	53	227.1	2.02	478	2.10	5.41
210	17.2	15.25	32.33	556.1	80.00	35.8	17.84	1986.2	0.07	139	2003.4	17.81	695	0.35	7.88
150	27.5	24.38	19.10	525.3	49.42	57.0	28.40	3162.3	0.17	538	3189.8	28.36	1063	0.33	12.05
105	19.5	17.29	21.78	424.7	45.67	31.4	15.65	1742.1	0.29	505	1761.6	15.66	930	0.53	10.54
75	20.0	17.73	35.69	713.8	49.97	28.0	13.95	1553.4	0.46	715	1573.4	13.99	1428	0.91	16.19
53	12.2	10.82	49.23	600.6	55.59	18.4	9.17	1020.8	0.47	480	1033.0	9.18	1080	1.05	12.25
38	5.0	4.43	110.27	551.4	67.81	8.9	4.43	493.8	0.53	262	498.8	4.43	813	1.63	9.22
25	2.1	1.86	328.54	689.9	69.16	5.9	2.94	327.3	0.94	308	329.4	2.93	998	3.03	11.31
-25	0.7	0.62	729.62	510.7	46.50	10.7	5.33	593.6	0.99	588	594.3	5.28	1098	1.85	12.45
TOTAL	112.8	100.00	45.71	5156.6	58.45	200.7	100.00	11134.7	0.33	3665	11247.5	100.00	8822	0.78	100.00

4:1 Si

	THK OVERFLOW		Mass Processed			5504									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	1.6	1.71	25.12	40.2	65.26	0.5	0.29	15.5	1.38	21	17.1	0.31	62	3.60	1.04
297	3.8	4.06	28.39	107.9	66.82	3.6	2.06	111.6	0.48	54	115.4	2.10	161	1.40	2.73
210	17.4	18.59	17.22	299.6	62.06	31.1	17.82	964.2	0.19	183	981.6	17.84	483	0.49	8.15
150	28.5	30.45	20.02	570.6	65.91	50.1	28.71	1553.2	0.19	295	1581.7	28.74	866	0.55	14.61
105	16.7	17.84	31.04	518.4	73.66	29.9	17.13	927.0	0.20	185	943.7	17.15	704	0.75	11.88
75	13.1	14.00	46.73	612.2	77.03	20.3	11.63	629.3	0.29	183	642.4	11.67	795	1.24	13.41
53	7.0	7.48	101.77	712.4	86.00	12.9	7.39	399.9	0.29	116	406.9	7.39	828	2.04	13.98
38	2.5	2.67	220.26	550.7	87.01	5.2	2.98	161.2	0.51	82	163.7	2.97	633	3.87	10.68
25	1.4	1.50	383.30	536.6	86.66	3.6	2.06	111.6	0.74	83	113.0	2.05	619	5.48	10.45
-25	1.6	1.71	249.37	399.0	51.52	17.3	9.91	536.3	0.70	375	537.9	9.77	774	1.44	13.07
TOTAL	93.6	100.00	46.45	4347.5	73.38	174.5	100.00	5409.9	0.29	1577	5503.5	100.00	5925	1.08	100.00

Lucien Beliveau Test T2-T9 (T7)
4:1 Si

	SPIRL TAILS		Mass Processed				5039.5								
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	1.6	1.58	0.79	1.3	6.16	0.5	0.27	13.6	1.42	19	15.2	0.30	21	1.35	0.56
297	4.2	4.15	6.77	28.4	40.66	3.4	1.87	92.2	0.45	41	96.4	1.91	70	0.73	1.92
210	17.0	16.78	3.08	52.4	26.73	29.4	16.14	797.3	0.18	144	814.3	16.16	196	0.24	5.39
150	26.9	26.55	4.02	108.1	27.77	54.6	29.98	1480.6	0.19	281	1507.5	29.91	389	0.26	10.72
105	19.7	19.45	9.23	181.8	50.73	29.6	16.25	802.7	0.22	177	822.4	16.32	358	0.44	9.87
75	16.3	16.09	18.06	294.4	53.59	23.5	12.90	637.3	0.40	255	653.6	12.97	549	0.84	15.12
53	9.2	9.08	31.36	288.5	61.71	16.1	8.84	436.6	0.41	179	445.8	8.85	468	1.05	12.87
38	3.5	3.46	65.21	228.2	62.97	7.5	4.12	203.4	0.66	134	206.9	4.11	362	1.75	9.98
25	1.7	1.68	264.27	449.3	79.68	4.8	2.64	130.2	0.88	115	131.9	2.62	564	4.28	15.52
-25	1.2	1.18	517.62	621.1	94.75	12.7	6.97	344.4	0.10	34	345.6	6.86	656	1.90	18.05
TOTAL	101.3	100.00	22.25	2253.6	62.03	182.1	100.00	4938.7	0.28	1379	5039.5	100.00	3633	0.72	100.00

4:1 Si

	KNEL TAILS		Mass Processed				9419								
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	3.9	3.37	10.73	41.8	23.74	0.5	0.23	21.4	6.28	134	25.3	0.27	176	6.97	2.77
297	6.3	5.45	17.89	112.7	24.52	4.2	1.93	179.8	1.93	347	186.1	1.98	460	2.47	7.22
210	18.1	15.64	6.69	121.1	27.68	38.9	17.90	1665.3	0.19	316	1683.4	17.87	438	0.26	6.87
150	29.4	25.41	6.31	185.5	26.15	64.4	29.64	2757.0	0.19	524	2786.4	29.58	709	0.25	11.14
105	20.8	17.98	12.29	255.6	40.13	33.0	15.19	1412.8	0.27	381	1433.6	15.22	637	0.44	10.01
75	19.0	16.42	25.02	475.4	44.78	33.4	15.37	1429.9	0.41	586	1448.9	15.38	1062	0.73	16.68
53	11.3	9.77	30.98	350.1	50.31	19.7	9.07	843.4	0.41	346	854.7	9.07	696	0.81	10.93
38	4.6	3.98	138.26	636.0	69.76	9.2	4.23	393.9	0.70	276	398.5	4.23	912	2.29	14.32
25	1.6	1.38	196.59	314.5	55.50	6.2	2.85	265.4	0.95	252	267.0	2.84	567	2.12	8.90
-25	0.7	0.61	889.42	622.6	87.76	7.8	3.59	333.9	0.26	87	334.6	3.55	709	2.12	11.15
TOTAL	115.7	100.00	26.93	3115.4	48.94	217.3	100.00	9302.8	0.35	3250	9418.5	100.00	6365	0.68	100.00

Lucien Beliveau Test T2-T9 (T7)
4:1 Si

	SpC1	Mass Processed		775											
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	0.4	0.34	6738.18	2695.3	99.84	0.4	0.21	1.4	3.21	4	1.8	0.23	2700	1533.02	4.32
297	1.6	1.37	3920.73	6273.2	99.97	4.3	2.22	14.6	0.12	2	16.2	2.10	6275	386.61	10.04
210	10.1	8.65	1621.29	16375.0	99.98	33.1	17.12	112.6	0.03	3	122.7	15.85	16378	133.46	26.20
150	15.9	13.61	680.35	10817.6	99.98	58.8	30.42	200.1	0.01	2	216.0	27.88	10820	50.10	17.31
105	17.7	15.15	485.65	8596.0	99.95	30.6	15.83	104.1	0.04	4	121.8	15.73	8600	70.60	13.76
75	33.6	28.77	191.57	6436.8	99.75	25.4	13.14	86.4	0.19	16	120.0	15.50	6453	53.77	10.32
53	28.3	24.23	186.58	5280.2	99.26	23.1	11.95	78.6	0.50	39	106.9	13.80	5320	49.76	8.51
38	7.3	6.25	416.78	3042.5	99.28	11.5	5.95	39.1	0.56	22	46.4	5.99	3064	66.00	4.90
25	1.7	1.46	1167.93	1985.5	97.18	4.8	2.48	16.3	3.53	58	18.0	2.33	2043	113.31	3.27
-25	0.2	0.17	4333.24	866.6	99.98	1.3	0.67	4.4	0.03	0	4.6	0.60	867	187.48	1.39
TOTAL	116.8	100.00	533.98	62368.6	99.76	193.3	100.00	657.7	0.23	151	774.5	100.00	62520	80.72	100.00

4:1 Si

	SpC2	Mass Processed		1110											
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	1.0	0.97	2206.85	2206.9	75.29	0.4	0.22	2.2	332.23	724	3.2	0.29	2931	921.70	5.86
297	4.7	4.57	1574.20	7398.7	93.34	4.2	2.27	22.9	23.07	528	27.6	2.49	7927	287.29	15.84
210	19.3	18.77	463.69	8949.2	95.52	33.6	18.19	183.1	2.29	419	202.4	18.25	9369	46.28	18.72
150	21.7	21.11	261.70	5678.9	96.60	53.1	28.75	289.4	0.69	200	311.1	28.04	5879	18.89	11.75
105	15.8	15.37	324.51	5127.3	99.02	28.3	15.32	154.2	0.33	51	170.0	15.33	5178	30.45	10.35
75	11.2	10.89	316.77	3547.8	94.54	22.5	12.18	122.6	1.67	205	133.8	12.06	3753	28.04	7.50
53	16.1	15.66	245.66	3955.1	91.15	19.9	10.77	108.5	3.54	384	124.6	11.23	4339	34.83	8.67
38	9.5	9.24	400.35	3803.3	96.01	13.3	7.20	72.5	2.18	158	82.0	7.39	3961	48.31	7.91
25	3.1	3.02	1174.15	3639.9	94.94	7.0	3.79	38.2	5.08	194	41.3	3.72	3834	92.93	7.66
-25	0.4	0.39	6961.04	2784.4	96.70	2.4	1.30	13.1	7.26	95	13.5	1.22	2879	213.59	5.75
TOTAL	102.8	100.00	458.09	47091.5	94.09	184.7	100.00	1006.7	2.94	2958	1109.5	100.00	50050	45.11	100.00

Lucien Beliveau Test T2-T9 (T7)
4:1 Si

	SBMD		Mass Processed			8080									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	1.7	1.72	142.30	241.9	78.84	0.7	0.36	28.3	2.29	65	30.0	0.37	307	10.21	3.78
297	3.9	3.94	99.52	388.1	89.12	3.9	1.98	157.9	0.30	47	161.8	2.00	436	2.69	5.37
210	16.4	16.55	38.98	639.3	74.08	32.5	16.49	1316.0	0.17	224	1332.4	16.49	863	0.65	10.64
150	26.8	27.04	24.21	648.8	47.73	58.5	29.68	2368.8	0.30	711	2395.6	29.65	1359	0.57	16.76
105	20.1	20.28	22.27	447.6	54.99	31.2	15.83	1263.3	0.29	366	1283.4	15.88	814	0.63	10.04
75	14.8	14.93	36.18	535.5	57.33	26.6	13.50	1077.1	0.37	399	1091.9	13.51	934	0.86	11.52
53	9.1	9.18	69.36	631.2	68.85	17.2	8.73	696.5	0.41	286	705.6	8.73	917	1.30	11.30
38	3.6	3.63	144.80	521.3	72.69	7.8	3.96	315.8	0.62	196	319.4	3.95	717	2.24	8.84
25	1.7	1.72	323.50	550.0	69.12	5.1	2.59	206.5	1.19	246	208.2	2.58	796	3.82	9.81
-25	1.0	1.01	516.29	516.3	53.34	13.6	6.90	550.7	0.82	452	551.7	6.83	968	1.75	11.93
TOTAL	99.1	100.00	51.66	5119.9	63.13	197.1	100.00	7980.9	0.37	2990	8080.0	100.00	8110	1.00	100.00

Lucien Beliveau Test T2-T9 (T8)
4:1 Si

	SBMD		Mass Processed			6992									
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	1.3	1.36	62.09	80.7	44.92	1.1	0.30	21.0	4.71	99	22.3	0.32	180	8.05	2.90
297	3.2	3.34	71.69	229.4	80.60	8.5	2.35	162.4	0.34	55	165.6	2.37	285	1.72	4.59
210	16.6	17.33	19.52	324.0	65.01	65.2	18.06	1245.5	0.14	174	1262.1	18.05	498	0.39	8.04
150	26.6	27.77	14.51	386.0	49.57	108.2	29.97	2066.9	0.19	393	2093.5	29.94	779	0.37	12.56
105	18.3	19.10	19.26	352.5	60.35	52.7	14.60	1006.7	0.23	232	1025.0	14.66	584	0.57	9.42
75	15.6	16.28	30.39	474.1	52.91	47.0	13.02	897.8	0.47	422	913.4	13.06	896	0.98	14.46
53	8.7	9.08	67.00	582.9	67.71	29.7	8.23	567.4	0.49	278	576.1	8.24	861	1.49	13.89
38	3.2	3.34	146.64	469.2	76.39	13.8	3.82	263.6	0.55	145	266.8	3.82	614	2.30	9.91
25	1.5	1.57	284.93	427.4	69.97	9.9	2.74	189.1	0.97	183	190.6	2.73	611	3.20	9.86
-25	0.8	0.84	648.93	519.1	58.32	24.9	6.90	475.7	0.78	371	476.5	6.81	890	1.87	14.36
TOTAL	95.8	100.00	40.14	3845.4	62.05	361.0	100.00	6896.2	0.34	2352	6992.0	100.00	6198	0.89	100.00

Lucien Beliveau Test T2-T9 (T8)
4:1 Si

	THK UNDERFLOW		Mass Processed		7520										
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	2.6	2.37	147.26	382.9	73.28	0.5	0.23	17.4	8.02	140	20.0	0.27	522	26.12	5.09
297	5.1	4.65	146.29	746.1	65.51	3.8	1.78	132.3	2.97	393	137.4	1.83	1139	8.29	11.10
210	14.6	13.31	71.14	1038.6	74.53	34.0	15.97	1183.4	0.30	355	1198.0	15.93	1394	1.16	13.59
150	25.9	23.61	44.96	1164.5	85.45	63.3	29.73	2203.3	0.09	198	2229.2	29.64	1363	0.61	13.28
105	21.3	19.42	34.55	735.9	66.52	36.7	17.24	1277.4	0.29	370	1298.7	17.27	1106	0.85	10.78
75	20.5	18.69	39.31	805.9	66.16	28.2	13.25	981.5	0.42	412	1002.0	13.33	1218	1.22	11.87
53	12.6	11.49	59.96	755.5	70.48	20.2	9.49	703.1	0.45	316	715.7	9.52	1072	1.50	10.45
38	4.8	4.38	95.29	457.4	51.32	9.1	4.27	316.7	1.37	434	321.5	4.28	891	2.77	8.69
25	1.7	1.55	201.14	341.9	55.37	6.0	2.82	208.8	1.32	276	210.5	2.80	618	2.93	6.02
-25	0.6	0.55	850.97	510.6	54.57	11.1	5.21	386.4	1.10	425	387.0	5.15	936	2.42	9.12
TOTAL	109.7	100.00	63.26	6939.2	67.64	212.9	100.00	7410.3	0.45	3319	7520.0	100.00	10259	1.36	100.00

4:1 Si

	THK OVERFLOW		Mass Processed		3340										
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	1.3	1.42	2.11	2.7	2.74	0.6	0.26	8.5	11.41	97	9.8	0.29	100	10.18	3.00
297	3.7	4.04	5.23	19.4	39.64	4.5	1.97	64.1	0.46	29	67.8	2.03	49	0.72	1.46
210	18.0	19.67	8.54	153.7	64.63	39.4	17.27	560.9	0.15	84	578.9	17.33	238	0.41	7.13
150	27.7	30.27	5.37	148.7	28.26	68.0	29.80	968.0	0.39	378	995.7	29.81	526	0.53	15.77
105	18.0	19.67	12.77	229.9	66.54	36.9	16.17	525.3	0.22	116	543.3	16.27	345	0.64	10.35
75	10.9	11.91	36.87	401.9	80.68	26.0	11.39	370.1	0.26	96	381.0	11.41	498	1.31	14.93
53	6.6	7.21	65.57	432.8	85.78	16.8	7.36	239.2	0.30	72	245.8	7.36	505	2.05	15.12
38	2.5	2.73	135.16	337.9	87.53	6.9	3.02	98.2	0.49	48	100.7	3.02	386	3.83	11.57
25	1.3	1.42	199.79	259.7	85.01	4.8	2.10	68.3	0.67	46	69.6	2.08	306	4.39	9.16
-25	1.5	1.64	96.96	145.4	37.86	24.3	10.65	345.9	0.69	239	347.4	10.40	384	1.11	11.51
TOTAL	91.5	100.00	23.30	2132.1	63.90	228.2	100.00	3248.5	0.37	1205	3340.0	100.00	3337	1.00	100.00

Lucien Beliveau Test T2-T9 (T8)
4:1 Si

	SPIRL TAIL		Mass Processed			7475									
	Knelson Conc						Knelson Tails				Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	1.2	1.22	20.45	24.5	41.63	0.8	0.27	19.7	1.75	34	20.9	0.28	59	2.83	1.09
297	3.7	3.77	3.58	13.2	17.62	6.3	2.10	154.9	0.40	62	158.6	2.12	75	0.47	1.39
210	15.8	16.09	3.43	54.2	16.66	52.5	17.49	1290.5	0.21	271	1306.3	17.48	325	0.25	6.03
150	26.3	26.78	5.62	147.8	26.45	88.0	29.32	2163.1	0.19	411	2189.4	29.29	559	0.26	10.35
105	18.8	19.14	7.57	142.3	36.90	49.5	16.49	1216.8	0.20	243	1235.6	16.53	386	0.31	7.15
75	15.9	16.19	21.51	342.0	46.93	34.2	11.40	840.7	0.46	387	856.6	11.46	729	0.85	13.50
53	9.9	10.08	48.35	478.7	58.56	26.5	8.83	651.4	0.52	339	661.3	8.85	817	1.24	15.15
38	3.7	3.77	118.53	438.6	69.47	11.7	3.90	287.6	0.67	193	291.3	3.90	631	2.17	11.70
25	1.8	1.83	290.65	523.2	72.73	8.4	2.80	206.5	0.95	196	208.3	2.79	719	3.45	13.33
-25	1.1	1.12	535.14	588.7	53.70	22.2	7.40	545.7	0.93	508	546.8	7.32	1096	2.00	20.31
TOTAL	98.2	100.00	28.04	2753.2	51.02	300.1	100.00	7376.8	0.36	2644	7475.0	100.00	5397	0.72	100.00

4:1 Si

	KNEL. TAILS		Mass Processed			7253									
	Knelson Conc						Knelson Tails				Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	1.5	1.50	1.84	2.8	5.22	0.8	0.26	18.5	2.71	50	20.0	0.28	53	2.64	0.98
297	3.6	3.61	15.58	56.1	35.00	5.7	1.84	131.8	0.79	104	135.4	1.87	160	1.18	2.96
210	16.9	16.95	5.63	95.1	20.01	51.4	16.62	1188.7	0.32	380	1205.6	16.62	476	0.39	8.79
150	26.9	26.98	6.64	178.6	32.91	92.6	29.94	2141.6	0.17	364	2168.5	29.90	543	0.25	10.03
105	19.0	19.06	10.87	206.5	34.36	53.3	17.23	1232.7	0.32	394	1251.7	17.26	601	0.48	11.11
75	16.1	16.15	18.86	303.6	38.64	41.7	13.48	964.4	0.50	482	980.5	13.52	786	0.80	14.53
53	9.5	9.53	37.95	360.5	49.84	29.6	9.57	684.6	0.53	363	694.1	9.57	723	1.04	13.38
38	3.9	3.91	73.33	286.0	53.25	14.1	4.56	326.1	0.77	251	330.0	4.55	537	1.63	9.93
25	1.7	1.71	162.46	276.2	50.14	9.5	3.07	219.7	1.25	275	221.4	3.05	551	2.49	10.19
-25	0.6	0.60	1361.37	816.8	83.47	10.6	3.43	245.2	0.66	162	245.8	3.39	979	3.98	18.10
TOTAL	99.7	100.00	25.90	2582.3	47.75	309.3	100.00	7153.3	0.40	2826	7253.0	100.00	5408	0.75	100.00

Lucien Beliveau Test T2-T9 (T9)

4:1 Si

	SPIRL TAIL	Mass Processed			10500										
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	1.5	1.47	1.20	1.8	2.02	1.0	0.30	31.6	2.77	87	33.1	0.32	89	2.70	1.36
297	4.0	3.93	6.17	24.7	58.26	7.0	2.13	221.0	0.08	18	225.0	2.14	42	0.19	0.64
210	15.9	15.62	5.08	80.8	14.80	58.9	17.89	1859.9	0.25	465	1875.8	17.86	546	0.29	8.29
150	27.1	26.62	6.88	186.4	23.60	95.6	29.03	3018.7	0.20	604	3045.8	29.01	790	0.26	12.00
105	19.9	19.55	12.83	255.3	44.78	55.4	16.82	1749.3	0.18	315	1769.2	16.85	570	0.32	8.66
75	16.8	16.50	25.70	431.8	52.70	36.1	10.96	1139.9	0.34	388	1156.7	11.02	819	0.71	12.44
53	10.2	10.02	51.81	528.5	58.55	28.9	8.78	912.6	0.41	374	922.8	8.79	903	0.98	13.71
38	3.9	3.83	128.29	500.3	66.01	13.6	4.13	429.4	0.60	258	433.3	4.13	758	1.75	11.51
25	1.7	1.67	288.06	489.7	57.91	9.8	2.98	309.5	1.15	356	311.2	2.96	846	2.72	12.84
-25	0.8	0.79	718.60	574.9	47.07	23.0	6.98	726.3	0.89	646	727.1	6.92	1221	1.68	18.55
TOTAL	101.8	100.00	30.20	3074.2	46.69	329.3	100.00	10398.2	0.34	3510	10500.0	100.00	6585	0.63	100.00

4:1 Si

	KNEL TAILS	Mass Processed			10115										
	Knelson Conc					Knelson Tails					Feed				
Size um	Mass	Mass %	Grade oz/t	Units	Recovery	Mass	Mass %	Total Mass	Grade oz/t	Units	Total Mass	Mass %	Units	Grade oz/t	Dist.
590															
420	1.5	1.50	13.18	19.8	6.36	1.1	0.41	41.3	7.05	291	42.8	0.42	311	7.26	4.52
297	3.6	3.61	9.16	33.0	26.70	6.7	2.51	251.5	0.36	91	255.1	2.52	124	0.48	1.79
210	17.6	17.65	5.52	97.2	28.40	46.6	17.47	1749.3	0.14	245	1766.9	17.47	342	0.19	4.97
150	29.0	29.09	7.84	227.4	24.23	78.9	29.57	2961.8	0.24	711	2990.8	29.57	938	0.31	13.63
105	19.0	19.06	11.44	217.4	24.67	49.1	18.40	1843.1	0.36	664	1862.1	18.41	881	0.47	12.79
75	15.3	15.35	22.22	340.0	37.68	31.2	11.69	1171.2	0.48	562	1186.5	11.73	902	0.76	13.10
53	8.5	8.53	49.79	423.2	38.89	24.6	9.22	923.4	0.72	665	931.9	9.21	1088	1.17	15.80
38	3.2	3.21	130.85	418.7	54.37	11.7	4.39	439.2	0.80	351	442.4	4.37	770	1.74	11.19
25	1.6	1.60	360.94	577.5	65.00	7.6	2.85	285.3	1.09	311	286.9	2.84	888	3.10	12.90
-25	0.4	0.40	885.45	354.2	55.30	9.3	3.49	349.1	0.82	286	349.5	3.46	640	1.83	9.30
TOTAL	99.7	100.00	27.16	2708.2	39.34	266.8	100.00	10015.3	0.42	4177	10115.0	100.00	6885	0.68	100.00

DOME MINES
ROD MILL DISCHARGE
JIG + KNELSON TEST RESULTS

Size (um)	CONCENTRATE Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	TAILS Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	FEED Weight (g)	% Weight	Grade (oz/st)	Rec. (%)
2000	25.3	11.62	2.17	58.70	3512	20.41	0.01	41.30	3537	20.30	0.03	4.70
1168	11.0	5.05	9.64	60.11	2346	13.64	0.03	39.89	2357	13.53	0.07	8.87
840	23.8	10.93	2.58	54.47	2139	12.43	0.02	45.53	2162	12.41	0.05	5.67
600	58.2	26.72	3.44	29.38	1414	8.22	0.34	70.62	1472	8.45	0.46	34.22
420	35.4	16.25	1.70	22.72	998	5.80	0.21	77.28	1033	5.93	0.26	13.31
300	27.9	12.81	3.53	44.70	1032	6.00	0.12	55.30	1060	6.08	0.21	11.07
210	14.3	6.57	3.13	48.18	730	4.24	0.07	51.82	744	4.27	0.12	4.67
150	9.1	4.18	4.26	51.65	648	3.77	0.06	48.35	657	3.77	0.11	3.77
105	4.9	2.25	10.06	62.46	429	2.50	0.07	37.54	434	2.49	0.18	3.97
75	3.3	1.52	9.86	63.69	364	2.11	0.05	36.31	367	2.11	0.14	2.57
53	2.6	1.19	13.07	67.73	360	2.09	0.05	32.27	362	2.08	0.14	2.52
-53	2.0	0.92	13.78	29.89	3233	18.79	0.02	70.11	3235	18.57	0.03	4.64
Total	217.80	100.00	3.71	40.62	17204	100.00	0.07	59.38	17421	100.00	0.11	100.00

DOME MINES
BALL MILL DISCHARGE
KNELSON TEST RESULTS

Size (um)	CONCENTRATE Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	TAILS Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	FEED Weight (g)	% Weight	Grade (oz/st)	Rec. (%)
2000												
1168												
840												
600	60.0	37.74	0.38	6.27	921	9.61	0.37	93.73	981	10.07	0.37	7.03
420	12.1	7.61	1.17	24.49	485	5.06	0.09	75.51	497	5.10	0.12	1.12
300	17.6	11.07	5.01	70.44	925	9.65	0.04	29.56	943	9.67	0.13	2.42
210	18.6	11.70	9.08	66.45	1218	12.71	0.07	33.55	1237	12.69	0.21	4.92
150	20.9	13.14	16.24	67.52	1814	18.93	0.09	32.48	1835	18.83	0.27	9.72
105	13.4	8.43	30.18	69.15	1203	12.55	0.15	30.85	1216	12.48	0.48	11.31
75	8.5	5.35	75.33	72.44	786	8.20	0.31	27.56	795	8.15	1.11	17.10
53	5.2	3.27	130.32	64.90	539	5.62	0.68	35.10	544	5.58	1.92	20.19
-53	2.7	1.70	238.13	47.47	1694	17.67	0.42	52.53	1697	17.41	0.80	26.19
Total	159.00	100.00	18.86	57.99	9585	100.00	0.23	42.01	9744	100.00	0.53	100.00

DOME MINES
PRIMARY CYCLONE UNDERFLOW
JIG + KNELSON TEST RESULTS

Size (um)	CONCENTRATE Weight (g)	CONCENTRATE % Weight	CONCENTRATE Grade (oz/st)	CONCENTRATE Rec. (%)	TAILS Weight (g)	TAILS % Weight	TAILS Grade (oz/st)	TAILS Rec. (%)	FEED Weight (g)	FEED % Weight	FEED Grade (oz/st)	FEED Rec. (%)
2000	6.6	6.20	0.58	• 28.84	949	7.66	0.01	• 71.16	955	7.65	0.01	• 0.22
1168	8.6	8.08	0.72	• 11.09	713	5.75	0.07	• 88.91	721	5.77	0.08	• 0.91
840	8.2	7.63	24.80	• 83.25	814	6.57	0.05	• 16.75	822	6.58	0.30	• 3.93
600	10.4	9.73	17.35	• 53.35	751	6.06	0.21	• 46.65	762	6.10	0.44	• 5.47
420	9.2	8.60	15.51	• 62.09	792	6.39	0.11	• 37.91	801	6.41	0.29	• 3.72
300	14.0	13.09	15.46	• 80.38	1321	10.66	0.04	• 19.62	1335	10.68	0.20	• 4.36
210	14.7	13.75	18.89	• 72.43	1510	12.19	0.07	• 27.57	1524	12.20	0.25	• 6.20
150	16.8	15.71	25.29	• 77.28	2082	16.80	0.06	• 22.72	2098	16.79	0.26	• 8.90
105	9.8	9.16	45.57	• 76.41	1254	10.12	0.11	• 23.59	1264	10.11	0.46	• 9.46
75	5.1	4.77	145.91	• 83.90	751	6.06	0.19	• 16.10	756	6.05	1.17	• 14.35
-75	3.5	3.27	605.00	• 80.64	1452	11.72	0.35	• 19.36	1456	11.65	1.80	• 42.49
Total	106.93	100.00	44.54	• 77.07	12388	100.00	0.11	• 22.93	12495	100.00	0.49	• 100.00

DOME MINES
PRIMARY CYCLONE OVERFLOW
KNELSON TEST RESULTS

Size (um)	CONCENTRATE Weight (g)	CONCENTRATE % Weight	CONCENTRATE Grade (oz/st)	CONCENTRATE Rec. (%)	TAILS Weight (g)	TAILS % Weight	TAILS Grade (oz/st)	TAILS Rec. (%)	FEED Weight (g)	FEED % Weight	FEED Grade (oz/st)	FEED Rec. (%)
840												
600												
420												
300												
210												
150	22.5	37.44	0.17	• 23.39	144	2.92	0.087	• 76.61	167	3.33	0.098	• 4.79
105	6.5	10.82	0.61	• 12.07	321	6.50	0.090	• 87.93	328	6.55	0.100	• 9.63
75	8.7	14.48	1.57	• 27.11	459	9.30	0.080	• 72.89	468	9.36	0.108	• 14.77
53	10.9	18.14	1.74	• 53.48	550	11.14	0.030	• 46.52	561	11.22	0.063	• 10.40
38	5.7	9.48	4.84	• 60.89	443	8.97	0.040	• 39.11	449	8.98	0.101	• 13.28
-38	5.8	9.65	1.67	• 6.03	3021	61.18	0.050	• 93.97	3027	60.56	0.053	• 47.12
Total	60.10	100.00	1.29	• 22.78	4938	100.00	0.053	• 77.22	4998	100.00	0.068	• 100.00

DOME MINES
REGRIND CYCLONE UNDERFLOW
JIG + KNELSON TEST RESULTS

Size (um)	CONCENTRATE Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	TAILS Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	FEED Weight (g)	% Weight	Grade (oz/st)	Rec. (%)
2000	12.4	9.95	0.27	• 7.55	1020	8.71	0.04	• 92.45	1032	8.72	0.04	• 0.65
1168	13.5	10.88	0.52	• 15.42	770	6.58	0.05	• 84.58	784	6.62	0.06	• 0.67
840	10.6	8.52	1.25	• 22.81	894	7.64	0.05	• 77.19	905	7.65	0.06	• 0.85
600	8.2	6.61	3.28	• 23.60	484	4.13	0.18	• 76.40	492	4.16	0.23	• 1.68
420	7.6	6.12	7.35	• 34.42	626	5.35	0.17	• 65.58	634	5.35	0.26	• 2.39
300	13.4	10.80	11.87	• 72.90	1183	10.10	0.05	• 27.10	1196	10.11	0.18	• 3.22
210	15.6	12.57	11.74	• 63.41	1510	12.89	0.07	• 36.59	1526	12.89	0.19	• 4.26
150	20.1	16.19	25.46	• 76.40	2259	19.29	0.07	• 23.60	2279	19.26	0.29	• 9.87
105	12.6	10.15	50.00	• 81.60	1291	11.03	0.11	• 18.40	1304	11.02	0.59	• 11.38
75	6.3	5.08	151.36	• 83.69	743	6.35	0.25	• 16.31	750	6.33	1.52	• 16.80
-75	3.9	3.14	679.16	• 80.95	930	7.94	0.67	• 19.05	934	7.89	3.50	• 48.23
Total	124.12	100.00	41.84	• 76.54	11711	100.00	0.14	• 23.46	11835	100.00	0.57	• 100.00

DOME MINES
REGRIND CYCLONE OVERFLOW
KNELSON TEST RESULTS

Size (um)	CONCENTRATE Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	TAILS Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	FEED Weight (g)	% Weight	Grade (oz/st)	Rec. (%)
840												
600												
420												
300												
210												
150	17.3	31.40	0.38	• 78.32	91	4.09	0.02	• 21.68	108	4.75	0.08	• 2.69
105	8.3	15.06	0.67	• 62.62	166	7.47	0.02	• 37.38	174	7.65	0.05	• 2.85
75	8.3	15.06	0.78	• 52.40	196	8.82	0.03	• 47.60	204	8.97	0.06	• 3.96
53	9.1	16.52	3.43	• 78.09	219	9.85	0.04	• 21.91	228	10.01	0.18	• 12.81
38	5.0	9.07	11.22	• 85.58	189	8.50	0.05	• 14.42	194	8.52	0.34	• 21.00
-38	7.1	12.89	9.58	• 38.43	1362	61.27	0.08	• 61.57	1369	60.10	0.13	• 56.70
Total	55.10	100.00	3.16	• 55.73	2223	100.00	0.06	• 44.27	2278	100.00	0.14	• 100.00

DOME MINES
JIG TAILS
JIG + KNELSON TEST WORK

Size (um)	CONCENTRATE Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	TAILS Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	FEED Weight (g)	% Weight	Grade (oz/st)	Rec. (%)
2000	2.9	2.40	0.85	• 3.75	1059	7.37	0.06	• 96.25	1062	7.33	0.06	• 0.73
1168	11.2	9.21	0.66	• 22.74	834	5.80	0.03	• 77.26	845	5.83	0.04	• 0.36
840	21.1	17.46	10.16	• 95.68	971	6.75	0.01	• 4.32	992	6.84	0.23	• 2.48
600	10.6	8.75	1.67	• 27.62	773	5.38	0.06	• 72.38	784	5.41	0.08	• 0.71
420	9.5	7.84	12.72	• 66.96	852	5.93	0.07	• 33.04	861	5.94	0.21	• 2.00
300	14.7	12.14	13.47	• 68.71	1503	10.46	0.06	• 31.29	1518	10.47	0.19	• 3.19
210	15.8	13.05	15.62	• 69.67	1791	12.46	0.06	• 30.33	1807	12.47	0.20	• 3.92
150	17.4	14.37	29.15	• 73.73	2582	17.97	0.07	• 26.27	2599	17.94	0.26	• 7.61
105	10.0	8.26	68.18	• 83.31	1518	10.56	0.09	• 16.69	1528	10.54	0.54	• 9.05
75	4.7	3.88	195.73	• 85.09	895	6.23	0.18	• 14.91	900	6.21	1.20	• 11.96
53	2.2	1.82	592.83	• 86.86	506	3.52	0.39	• 13.14	508	3.51	2.96	• 16.61
38	0.7	0.58	1702.50	• 86.91	206	1.44	0.87	• 13.09	207	1.43	6.62	• 15.17
-38	0.3	0.25	6866.16	• 86.98	881	6.13	0.35	• 13.02	881	6.08	2.69	• 26.20
Total	121.11	100.00	61.70	• 82.68	14370	100.00	0.11	• 17.32	14491	100.00	0.62	• 100.00

DOME MINES
JC1W1
JIG + KNELSON TEST RESULTS

Size (um)	CONCENTRATE Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	TAILS Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	FEED Weight (g)	% Weight	Grade (oz/st)	Rec. (%)
2380	22.4	12.53	2.88	17.46	517	7.61	0.59	82.54	539	7.74	0.69	0.60
2000	32.1	17.96	149.90	81.80	907	13.35	1.18	18.20	939	13.47	6.26	9.50
1168	19.2	10.74	96.26	85.90	660	9.71	0.46	14.10	679	9.74	3.17	3.48
840	18.5	10.35	73.62	49.91	683	10.06	2.00	50.09	702	10.07	3.89	4.41
600	13.1	7.33	138.04	59.02	587	8.64	2.14	40.98	600	8.60	5.11	4.95
420	11.3	6.32	197.57	57.60	498	7.33	3.30	42.40	509	7.30	7.61	6.26
300	14.9	8.34	263.40	72.44	685	10.08	2.18	27.56	700	10.04	7.74	8.75
210	13.9	7.78	349.28	76.91	642	9.45	2.27	23.09	656	9.41	9.62	10.20
150	14.6	8.17	329.87	72.09	770	11.34	2.42	27.91	785	11.26	8.51	10.79
105	9.2	5.15	587.68	80.67	429	6.32	3.02	19.33	438	6.29	15.29	10.83
75	5.9	3.30	1042.01	82.71	270	3.97	4.76	17.29	276	3.96	26.94	12.01
-75	3.6	2.01	2657.23	84.74	146	2.14	11.82	15.26	149	2.14	75.61	18.23
Total	178.70	100.00	262.14	75.67	6794	100.00	2.22	24.33	6973	100.00	8.88	100.00

JC1E1
JIG + MLS TEST RESULTS

Size (um)	CONCENTRATE Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	TAILS Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	FEED Weight (g)	% Weight	Grade (oz/st)	Rec. (%)
2380	19.9	16.58	801.03	98.92	27	3.01	6.42	1.08	47	4.62	343.58	12.59
2000	23.1	19.25	372.98	91.34	167	18.64	4.89	8.66	190	18.71	49.62	7.37
1168	23.8	19.83	748.64	96.84	246	27.46	2.36	3.16	270	26.56	68.19	14.38
840	5.8	4.83	1432.11	83.55	242	27.01	6.76	16.45	248	24.39	40.12	7.77
600	7.4	6.17	2343.56	64.50	98	10.94	97.38	35.50	105	10.37	255.08	21.01
420	23.3	19.42	875.28	95.98	56	6.25	15.26	4.02	79	7.81	267.95	16.61
300	11.7	9.75	1325.37	95.02	33	3.68	24.62	4.98	45	4.40	365.08	12.75
210	2.7	2.25	19.98	11.86	9	1.00	44.55	88.14	12	1.15	38.88	0.36
150	0.3	0.25	14349.56	88.26	5	0.56	114.50	11.74	5	0.52	920.26	3.81
105	0.6	0.50	1425.41	82.77	4	0.45	44.51	17.23	5	0.45	224.63	0.81
75	0.3	0.25	2228.75	90.26	3	0.33	24.04	9.74	3	0.32	224.47	0.58
53	0.4	0.33	419.73	44.27	1	0.11	211.37	55.73	1	0.14	270.90	0.30
38	0.2	0.17	481.79	75.96	1	0.11	30.50	24.04	1	0.12	105.72	0.10
-38	0.5	0.42	84.22	2.10	4	0.45	490.63	97.90	5	0.44	445.47	1.57
Total	120.00	100.00	917.60	86.05	896	100.00	19.92	13.95	1016	100.00	125.94	100.00

DOME MINE JC2W1
JIG + MLS TEST RESULTS

Size (um)	CONCENTRATE Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	TAILS Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	FEED Weight (g)	% Weight	Grade (oz/st)	Rec. (%)
2380	27.6	12.25	5.08	51.69	37	2.50	3.57	48.31	64	3.80	4.22	0.06
2000	25.3	11.23	109.06	69.10	151	10.30	8.16	30.90	177	10.42	22.62	0.85
1168	18.8	8.34	772.00	82.28	245	16.70	12.75	17.72	264	15.59	66.82	3.76
840	16.6	7.37	1598.72	83.19	290	19.77	18.47	16.81	307	18.12	103.94	6.81
600	9.7	4.31	3022.89	82.53	257	17.48	24.18	17.47	266	15.73	133.37	7.58
420	31.2	13.85	1216.28	88.56	227	15.44	21.62	11.44	258	15.23	166.15	9.14
300	38.5	17.09	3165.89	97.49	146	9.92	21.56	2.51	184	10.87	679.12	26.68
210	31.3	13.89	2880.45	97.93	33	2.21	58.68	2.07	64	3.77	1443.03	19.65
150	15.9	7.06	5771.27	98.32	20	1.38	77.24	1.68	36	2.14	2578.21	19.92
105	6.2	2.75	1902.82	86.25	16	1.09	117.56	13.75	22	1.31	616.15	2.92
75	1.1	0.49	5085.76	73.79	19	1.27	106.26	26.21	20	1.17	382.90	1.62
53	1.5	0.67	1298.91	83.51	13	0.85	30.78	16.49	14	0.83	166.65	0.50
38	0.7	0.31	2538.63	91.86	9	0.63	17.12	8.14	10	0.58	195.41	0.41
-38	0.9	0.40	479.45	85.94	7	0.46	10.54	14.06	8	0.45	66.07	0.11
Total	225.30	100.00	1937.77	93.16	1468	100.00	21.83	6.84	1694	100.00	276.71	100.00

DOME MINE JC2E1
JIG + MLS TEST RESULTS

Size (um)	CONCENTRATE Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	TAILS Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	FEED Weight (g)	% Weight	Grade (oz/st)	Rec. (%)
2380	37.8	10.11	285.75	92.84	29	1.81	28.74	7.16	67	3.38	174.17	2.14
2000	45.8	12.25	137.32	36.42	186	11.60	59.02	63.58	232	11.73	74.49	3.18
1168	58.6	15.68	399.87	61.11	167	10.42	89.29	38.89	226	11.41	169.96	7.06
840	43.5	11.64	902.47	80.10	122	7.61	79.94	19.90	166	8.37	296.13	9.03
600	20.6	5.51	1487.56	80.67	104	6.49	70.59	19.33	125	6.30	304.86	7.00
420	36.5	9.76	1052.32	71.22	99	6.18	156.78	28.78	136	6.85	398.01	9.94
300	37.8	10.11	1444.56	80.36	112	6.99	119.16	19.64	150	7.58	453.61	12.52
210	24.8	6.63	1836.80	82.90	146	9.11	64.37	17.10	171	8.64	321.73	10.12
150	39.3	10.51	739.60	56.28	223	13.91	101.27	43.72	262	13.27	196.91	9.52
105	14.6	3.91	1135.55	27.67	253	15.78	171.30	72.33	268	13.54	223.91	11.04
75	7.4	1.98	1568.38	15.93	122	7.61	502.13	84.07	129	6.55	563.11	13.42
53	4.6	1.23	2913.02	85.77	17	1.06	130.74	14.23	22	1.09	723.26	2.88
38	1.3	0.35	7323.58	96.30	6	0.37	60.97	3.70	7	0.37	1354.31	1.82
-38	1.2	0.32	1270.62	86.10	17	1.06	14.48	13.90	18	0.92	97.30	0.33
Total	373.80	100.00	884.66	60.92	1603	100.00	132.31	39.08	1977	100.00	274.58	100.00

DOME MINES
JC3W1
JIG + KNELSON TEST RESULTS

Size (um)	CONCENTRATE Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	TAILS Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	FEED Weight (g)	% Weight	Grade (oz/st)	Rec. (%)
2380	13.9	6.13	15.08	• 33.05	36	0.48	11.93	• 66.95	50	0.65	12.81	• 0.40
2000	29.3	12.92	15.28	• 15.35	265	3.58	9.31	• 84.65	294	3.86	9.90	• 1.84
1168	22.6	9.96	92.05	• 35.52	565	7.63	6.69	• 64.48	587	7.70	9.98	• 3.69
840	22.9	10.10	103.24	• 20.58	740	10.00	12.33	• 79.42	763	10.01	15.06	• 7.23
600	24.0	10.58	142.48	• 47.21	438	5.92	8.74	• 52.79	462	6.05	15.70	• 4.56
420	24.3	10.71	759.80	• 79.42	674	9.11	7.10	• 20.58	698	9.16	33.29	• 14.63
300	20.4	8.99	528.16	• 63.86	927	12.53	6.58	• 36.14	947	12.43	17.81	• 10.62
210	21.0	9.26	290.51	• 48.96	959	12.97	6.63	• 51.04	980	12.86	12.71	• 7.84
150	24.5	10.80	732.42	• 79.75	1332	18.01	3.42	• 20.25	1356	17.80	16.59	• 14.16
105	13.8	6.08	1241.20	• 89.49	757	10.23	2.66	• 10.51	770	10.11	24.85	• 12.05
75	6.9	3.04	2301.36	• 90.24	472	6.38	3.64	• 9.76	479	6.28	36.77	• 11.08
-75	3.2	1.41	5135.21	• 86.82	233	3.15	10.71	• 13.18	236	3.10	80.17	• 11.91
Total	226.80	100.00	490.50	• 70.02	7395	100.00	6.44	• 29.98	7622	100.00	20.84	• 100.00

JC3E1
JIG + MLS TEST RESULTS

Size (um)	CONCENTRATE Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	TAILS Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	FEED Weight (g)	% Weight	Grade (oz/st)	Rec. (%)
2380	21.6	9.06	1.32	• 48.51	34	1.69	0.89	• 51.49	56	2.48	1.06	• 0.05
2000	12.5	5.24	1392.81	• 98.23	96	4.79	3.26	• 1.77	109	4.83	163.35	• 15.18
1168	23.3	9.77	272.14	• 71.46	254	12.66	9.97	• 28.54	277	12.36	32.00	• 7.60
840	13.2	5.54	638.62	• 67.46	417	20.79	9.75	• 32.54	430	19.17	29.05	• 10.70
600	12.8	5.37	499.62	• 87.19	283	14.11	3.32	• 12.81	296	13.18	24.80	• 6.28
420	29.7	12.46	355.50	• 86.81	207	10.32	7.75	• 13.19	237	10.55	51.38	• 10.41
300	48.4	20.30	232.47	• 84.86	193	9.62	10.40	• 15.14	241	10.76	54.92	• 11.35
210	27.4	11.49	369.70	• 87.95	165	8.23	8.41	• 12.05	192	8.57	59.86	• 9.86
150	32.5	13.63	246.38	• 71.54	142	7.08	22.43	• 28.46	175	7.77	64.14	• 9.58
105	12.3	5.16	514.58	• 67.44	116	5.78	26.34	• 32.56	128	5.72	73.15	• 8.04
75	2.1	0.88	682.85	• 22.55	64	3.19	76.96	• 77.45	66	2.95	96.21	• 5.45
53	1.3	0.55	1461.52	• 76.58	18	0.90	32.28	• 23.42	19	0.86	128.55	• 2.12
38	0.7	0.29	4427.78	• 92.73	8	0.40	30.36	• 7.27	9	0.39	384.18	• 2.86
-38	0.6	0.25	763.84	• 76.08	9	0.45	16.01	• 23.92	10	0.43	62.75	• 0.52
Total	238.40	100.00	384.95	• 78.58	2006	100.00	12.47	• 21.42	2244	100.00	52.03	• 100.00

DOME MINE JC4W1
JIG + MLS TEST RESULTS

Size (um)	CONCENTRATE Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	TAILS Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	FEED Weight (g)	% Weight	Grade (oz/st)	Rec. (%)
2380	14.8	9.88	575.06	98.65	10	2.42	11.30	1.35	25	4.36	343.72	4.08
2000	22.5	15.02	165.43	51.33	41	9.55	86.71	48.67	63	10.97	114.74	3.43
1168	28.9	19.29	465.85	78.80	90	21.10	40.29	21.20	119	20.63	143.81	8.08
840	19.6	13.08	1213.88	85.08	103	24.10	40.61	14.92	122	21.24	228.64	13.23
600	16.9	11.28	683.95	89.68	67	15.65	19.94	10.32	84	14.52	154.17	6.10
420	22.5	15.02	699.01	82.53	49	11.48	68.08	17.47	71	12.40	266.90	9.02
300	12.0	8.01	1683.89	87.59	34	7.96	84.44	12.41	46	7.97	502.60	10.91
210	5.5	3.67	4299.85	93.85	14	3.22	113.14	6.15	19	3.33	1312.46	11.92
150	3.8	2.54	8350.46	97.12	7	1.74	126.95	2.88	11	1.94	2917.07	15.46
105	1.0	0.67	28760.94	96.90	6	1.29	167.02	3.10	7	1.13	4566.08	14.04
75	0.5	0.33	8059.62	94.25	2	0.49	116.99	5.75	3	0.45	1644.42	2.02
53	0.4	0.27	5481.46	91.90	1	0.14	322.12	8.10	1	0.17	2385.86	1.13
38	0.2	0.13	4621.06	87.58	1	0.16	187.17	12.42	1	0.16	1172.48	0.50
-38	1.2	0.80	89.74	66.90	3	0.70	17.76	33.10	4	0.73	38.33	0.08
Total	149.80	100.00	1257.53	89.12	426	100.00	53.96	10.88	576	100.00	367.02	100.00

DOME MINE JC4E1
JIG + KNELSON TEST RESULTS

Size (um)	CONCENTRATE Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	TAILS Weight (g)	% Weight	Grade (oz/st)	Rec. (%)	FEED Weight (g)	% Weight	Grade (oz/st)	Rec. (%)
2380	10.5	5.84	7830.00	99.68	15	0.53	17.66	0.32	26	0.85	3234.51	15.60
2000	6.7	3.73	1551.87	78.75	54	1.90	51.97	21.25	61	2.01	217.53	2.50
1168	6.9	3.84	2795.06	74.77	130	4.59	50.07	25.23	137	4.54	188.42	4.88
840	9.0	5.01	1778.97	54.97	203	7.16	64.61	45.03	212	7.03	137.39	5.51
600	4.0	2.22	4048.92	66.15	207	7.30	40.03	33.85	211	7.00	116.03	4.63
420	30.2	16.80	917.86	73.99	311	10.97	31.34	26.01	341	11.32	109.81	7.09
300	24.7	13.74	1852.72	80.29	421	14.85	26.69	19.71	446	14.78	127.89	10.78
210	31.9	17.74	1309.00	81.50	415	14.64	22.84	18.50	447	14.82	114.65	9.69
150	14.2	7.90	3749.30	74.28	472	16.65	39.05	25.72	486	16.13	147.41	13.56
105	19.7	10.96	1809.14	69.18	345	12.17	46.03	30.82	365	12.10	141.27	9.75
75	12.9	7.17	1883.92	76.28	165	5.82	45.80	23.72	178	5.90	179.09	6.03
53	5.4	3.00	4868.52	89.02	56	1.98	57.91	10.98	61	2.04	480.99	5.59
38	2.1	1.17	9053.80	97.54	21	0.74	22.85	2.46	23	0.77	843.85	3.69
-38	1.6	0.89	2027.08	85.12	20	0.71	28.35	14.88	22	0.72	176.40	0.72
Total	179.80	100.00	2341.89	79.65	2835	100.00	37.96	20.35	3015	100.00	175.36	100.00

DOME MINES
WILFLEY TABLE TAILS
JIG + MLS TEST WORK

Size (um)	CONCENTRATE Weight (g)	CONCENTRATE % Weight	CONCENTRATE Grade (oz/st)	CONCENTRATE Rec. (%)	TAILS Weight (g)	TAILS % Weight	TAILS Grade (oz/st)	TAILS Rec. (%)	FEED Weight (g)	FEED % Weight	FEED Grade (oz/st)	FEED Rec. (%)
2380	6.9	3.43	1.29	1.69	84	4.93	6.19	98.31	90	4.77	5.82	0.68
2000	16.1	8.01	5.59	4.89	264	15.60	6.62	95.11	281	14.80	6.56	2.39
1168	22.8	11.34	72.69	46.96	266	15.67	7.05	53.04	288	15.21	12.24	4.58
840	25.3	12.58	153.93	78.76	146	8.63	7.18	21.24	172	9.05	28.82	6.41
600	18.5	9.20	162.28	86.57	64	3.76	7.31	13.43	82	4.34	42.19	4.50
420	23.5	11.69	168.06	84.36	52	3.04	14.19	15.64	75	3.96	62.34	6.07
300	13.9	6.91	512.24	87.65	62	3.66	16.15	12.35	76	4.01	106.88	10.54
210	21.5	10.69	522.15	90.07	102	5.99	12.18	9.93	123	6.49	101.25	16.16
150	10.4	5.17	1190.35	61.78	204	12.05	37.51	38.22	215	11.32	93.38	25.99
105	23.4	11.64	176.60	41.67	239	14.11	24.18	58.33	263	13.85	37.76	12.86
75	12.7	6.32	185.68	49.50	156	9.18	15.47	50.50	168	8.87	28.32	6.18
53	4.2	2.09	132.60	36.68	45	2.68	21.18	63.32	50	2.62	30.61	1.97
38	1.3	0.65	480.92	71.87	11	0.65	22.04	28.13	12	0.65	70.15	1.13
-38	0.6	0.30	550.13	78.32	1	0.04	130.5	21.68	1	0.07	324.18	0.55
Total	201.10	100.00	255.25	66.57	1695	100.00	15.21	33.43	1896	100.00	40.67	100.00

DEISTER TABLE TAILS
JIG + KNELSON TEST WORK

Size (um)	CONCENTRATE Weight (g)	CONCENTRATE % Weight	CONCENTRATE Grade (oz/st)	CONCENTRATE Rec. (%)	TAILS Weight (g)	TAILS % Weight	TAILS Grade (oz/st)	TAILS Rec. (%)	FEED Weight (g)	FEED % Weight	FEED Grade (oz/st)	FEED Rec. (%)
2380	7.4	5.30	2.54	2.86	214	3.11	2.98	97.14	221	3.15	2.97	1.27
2000	8.9	6.38	4.44	3.25	434	6.30	2.71	96.75	443	6.30	2.74	2.35
1168	11.4	8.17	1.66	1.17	655	9.51	2.44	98.83	666	9.48	2.43	3.13
840	11.8	8.45	30.65	32.46	836	12.14	0.90	67.54	848	12.06	1.31	2.15
600	18.2	13.04	65.86	39.78	950	13.79	1.91	60.22	968	13.78	3.11	5.82
420	14.7	10.53	120.36	34.27	766	11.12	4.43	65.73	781	11.11	6.61	9.98
300	19.1	13.68	151.27	37.75	949	13.78	5.02	62.25	968	13.78	7.91	14.79
210	18.1	12.97	371.33	66.45	780	11.32	4.35	33.55	798	11.36	12.67	19.55
150	17.4	12.46	470.82	81.70	768	11.15	2.39	18.30	785	11.18	12.77	19.38
105	8.9	6.38	732.65	92.39	349	5.07	1.54	7.61	358	5.09	19.72	13.64
75	2.9	2.08	714.06	88.31	145	2.11	1.89	11.69	148	2.10	15.85	4.53
-75	0.8	0.57	1830.19	83.00	42	0.61	7.14	17.00	43	0.61	41.22	3.41
Total	139.60	100.00	223.96	60.43	6888	100.00	2.97	39.57	7028	100.00	7.36	100.00

APPENDIX D

Appendix D.1: Mass balance results of the various tests

D.1: Mass Balance Results of the Various Streams

Lucien Béliveau Mill, January 4 1991

Residual sum of squares: 11.7888 Final Results

Stream	Absolute Solids Flowrate	Pulp Mass Flowrate Meas	Calc	S.D.	Adjust
1 SAGF	67.81	67.0	67.8	2.0	0.8
2 SAGD	114.12		114.1		
3 FLCC	0.36	0.4	0.4	0.0	0.0
4 CYOF	67.45		67.5		
5 CUF1	46.31	55.0	46.3	10.0	-8.7
6 CUF2	56.95	55.0	57.0	10.0	2.0
7 BMID	56.95		57.0		

Stream	Relative Solids Flowrate
1 SAGF	100.00
2 SAGD	168.29
3 FLCC	0.53
4 CYOF	99.47
5 CUF1	68.29
6 CUF2	83.98
7 BMID	83.98

Assay Data

Au	Meas.	Calc.	Std. Dev.	Adjust.	% Rec
SAGD	0.340	0.289	0.034	-0.051*	
FLCC	5.390	5.402	0.300	0.012	
CYOF	0.320	0.347	0.032	0.027	
CUF1	0.150	0.166	0.030	0.016	
CUF2	0.300	0.336	0.030	0.036*	
BMID	0.400	0.336	0.040	-0.064*	

Fractional Size Distribution Data

Size	SAGD Meas	SAGD Calc	SAGD SD.	SAGD Adj.	FLCC Meas	FLCC Calc	FLCC SD.	FLCC Adj.
28 MESH	12.80	12.86	0.5	0.1	0.10	0.10	0.1	-0.0
35 MESH	5.80	5.52	0.5	-0.3	0.80	0.80	0.4	0.0
48 MESH	6.50	6.44	0.5	-0.1	2.40	2.40	0.5	0.0
65 MESH	10.70	10.80	0.5	0.1	6.80	6.80	0.5	-0.0
100 MESH	12.60	12.95	0.5	0.4	12.00	12.00	0.5	-0.0
150 MESH	8.20	8.50	0.5	0.3	12.10	12.10	0.5	-0.0
200 MESH	6.00	6.15	0.5	0.2	13.00	13.00	0.5	-0.0
270 MESH	4.10	4.41	0.5	0.3	10.80	10.80	0.5	-0.0
325 MESH	2.50	2.37	0.5	-0.1	7.10	7.10	0.5	0.0
400 MESH	1.60	1.48	0.5	-0.1	5.00	5.00	0.5	0.0

Size	CYOF Meas	CYOF Calc	CYOF SD.	CYOF Adj.	CUF1 Meas	CUF1 Calc	CUF1 SD.	CUF1 Adj.
28 MESH	0.00	-0.00	0.1	-0.0	16.30	16.28	0.5	-0.0
35 MESH	0.00	0.00	0.1	0.0	6.50	6.61	0.5	0.1
48 MESH	0.10	0.10	0.1	0.0	9.10	9.12	0.5	0.0
65 MESH	0.60	0.58	0.3	-0.0	16.80	16.76	0.5	-0.0
100 MESH	5.50	5.29	0.5	-0.2	18.80	18.66	0.5	-0.1
150 MESH	9.30	9.12	0.5	-0.2	8.80	8.68	0.5	-0.1
200 MESH	9.30	9.21	0.5	-0.1	5.10	5.04	0.5	-0.1
270 MESH	7.20	7.02	0.5	-0.2	2.80	2.67	0.5	-0.1
325 MESH	5.10	5.17	0.5	0.1	1.40	1.45	0.5	0.1
400 MESH	3.70	3.77	0.5	0.1	0.70	0.73	0.4	0.0

Size	CUF2 Meas	CUF2 Calc	CUF2 SD.	CUF2 Adj.	BMID Meas	BMID Calc	BMID SD.	BMID Adj.
28 MESH	14.80	14.77	0.5	-0.0	2.20	2.23	0.5	0.0
35 MESH	7.90	8.04	0.5	0.1	2.50	2.36	0.5	-0.1
48 MESH	10.30	10.33	0.5	0.0	5.00	4.97	0.5	-0.0
65 MESH	17.80	17.75	0.5	-0.1	10.40	10.45	0.5	0.1
100 MESH	19.10	18.92	0.5	-0.2	14.30	14.48	0.5	0.2
150 MESH	8.70	8.55	0.5	-0.2	9.30	9.45	0.5	0.2
200 MESH	4.70	4.62	0.5	-0.1	7.30	7.38	0.5	0.1
270 MESH	2.70	2.54	0.5	-0.2	4.10	4.26	0.5	0.2
325 MESH	0.80	0.84	0.4	0.0	3.50	3.44	0.5	-0.1
400 MESH	0.10	0.10	0.1	0.0	2.30	2.24	0.5	-0.1

Balancing the first Knelson Test at Lucien Béliveau (Jan 4/91)

Residual sum of squares: 1.416142 Iteration Limit

	Stream	Absolute Solids Flowrate	Pulp Mass Flowrate Meas	Calc	S.D.	Adjust
1	Feed1	1213.78	1203.0	1213.8	30.0	10.8
2	Feed2	1207.97	1203.0	1208.0	30.0	5.0
3	Feed3	1205.54	1203.0	1205.5	30.0	2.5
4	Feed4	1208.99	1203.0	1209.0	30.0	6.0
5	Tail1	1195.97	1203.0	1196.0	30.0	-7.0
6	Tail2	1200.48	1203.0	1200.5	30.0	-2.5
7	Tail3	1187.02	1203.0	1187.0	30.0	-16.0
8	Tail4	1205.81	1203.0	1205.8	30.0	2.8
9	Conc	47.00	70.0	47.0	25.0	-23.0

	Stream	Relative Solids Flowrate
1	Feed1	100.00
2	Feed2	99.52
3	Feed3	99.32
4	Feed4	99.61
5	Tail1	98.53
6	Tail2	98.90
7	Tail3	97.80
8	Tail4	99.34
9	Conc	3.87

Assay Data

Au, oz/st	Meas.	Calc.	Std. Dev.	Adjust.	% Rec
Feed1	5.110	5.115	0.200	0.005	100
Feed2	5.430	5.435	0.200	0.005	106
Feed3	5.180	5.185	0.200	0.005	101
Feed4	5.840	5.845	0.200	0.005	114
Tail1	2.510	2.507	0.150	-0.003	48
Tail2	2.750	2.747	0.150	-0.003	53
Tail3	3.160	3.157	0.150	-0.003	60
Tail4	3.530	3.527	0.150	-0.003	69
Conc	252.700	250.897	20.000	-1.803	190

LUCIEN BELIVEAU T2 GRINDING CIRCUIT (-20M removed)

Residual sum of squares: 11.63678

Final Results

Stream	Absolute Solids Flowrate	Pulp Mass Flowrate Meas	Calc	S.D.	Adjust
1 SAGF	70.89	78.0	70.9	8.0	-7.1
2 SAGD	143.87		143.9		
3 COF	70.89		70.9		
4 CUF1	72.98	65.0	73.0	10.0	8.0
5 CUF2	68.87	65.0	68.9	10.0	3.9
6 BMD	68.87		68.9		

Stream	Relative Solids Flowrate
1 SAGF	100.00
2 SAGD	202.95
3 COF	100.00
4 CUF1	102.95
5 CUF2	97.15
6 BMD	97.15

Assay Data

Au oz/t	Meas.	Calc.	Std. Dev.	Adjust.	% Rec
SAGD	0.160	0.166	0.010	0.006	
COF	0.060	0.057	0.010	-0.003	
CUF1	0.300	0.272	0.030	-0.028	
CUF2	0.240	0.245	0.020	0.005	
BMD	0.250	0.245	0.020	-0.005	

Fractional Size Distribution Data

	SAGD				COF			
Size	Meas	Calc	SD.	Adj.	Meas	Calc	SD.	Adj.
28 MESH	3.62	3.77	0.5	0.2	0.00	-0.00	0.1	-0.0
35 MESH	4.81	4.95	0.5	0.1	0.00	-0.00	0.1	-0.0
48 MESH	8.41	8.31	0.5	-0.1	0.00	0.00	0.1	0.0
65 MESH	10.67	10.25	0.5	-0.4	0.38	0.42	0.2	0.0
100 MESH	13.47	13.59	0.5	0.1	3.43	3.37	0.5	-0.1
150 MESH	10.58	10.24	0.5	-0.3	8.55	8.72	0.5	0.2
200 MESH	7.44	7.46	0.5	0.0	11.17	11.16	0.5	-0.0
270 MESH	4.47	4.69	0.5	0.2	8.34	8.23	0.5	-0.1
400 MESH	6.34	6.60	0.5	0.3	12.23	12.10	0.5	-0.1
500 MESH	4.31	4.30	0.5	-0.0	8.34	8.34	0.5	0.0

Size	CUF1 Meas	CUF1 Calc	CUF1 SD.	CUF1 Adj.	CUF2 Meas	CUF2 Calc	CUF2 SD.	CUF2 Adj.
28 MESH	4.17	4.09	0.5	-0.1	4.46	4.39	0.5	-0.1
35 MESH	6.29	6.22	0.5	-0.1	5.91	5.84	0.5	-0.1
48 MESH	11.82	11.87	0.5	0.0	11.65	11.70	0.5	0.0
65 MESH	16.06	16.27	0.5	0.2	14.96	15.16	0.5	0.2
100 MESH	20.71	20.65	0.5	-0.1	20.56	20.50	0.5	-0.1
150 MESH	12.83	13.00	0.5	0.2	12.56	12.72	0.5	0.2
200 MESH	5.88	5.87	0.5	-0.0	7.15	7.14	0.5	-0.0
270 MESH	2.99	2.88	0.5	-0.1	3.24	3.13	0.5	-0.1
400 MESH	4.01	3.88	0.5	-0.1	4.22	4.10	0.5	-0.1
500 MESH	1.70	1.70	0.5	0.0	1.97	1.97	0.5	0.0

Size	BMD Meas	BMD Calc	BMD SD.	BMD Adj.
28 MESH	0.79	0.84	0.4	0.0
35 MESH	2.02	2.09	0.5	0.1
48 MESH	6.95	6.90	0.5	-0.0
65 MESH	11.64	11.44	0.5	-0.2
100 MESH	17.42	17.48	0.5	0.1
150 MESH	14.26	14.10	0.5	-0.2
200 MESH	9.27	9.28	0.5	0.0
270 MESH	4.74	4.85	0.5	0.1
400 MESH	6.76	6.88	0.5	0.1
500 MESH	3.38	3.38	0.5	-0.0

Assays of size fractions for SAGD

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	0.190	0.528	0.500	0.338	
35 MESH	0.450	0.484	0.050	0.034	
48 MESH	0.440	0.428	0.050	-0.012	
65 MESH	0.190	0.211	0.050	0.021	
100 MESH	0.110	0.108	0.050	-0.002	
150 MESH	0.110	0.111	0.050	0.001	
200 MESH	0.120	0.099	0.050	-0.021	
270 MESH	0.110	0.123	0.050	0.013	
400 MESH	0.120	0.089	0.050	-0.031	
500 MESH	0.120	0.205	0.100	0.085	
PAN	0.050	0.049	0.010	-0.001	

Assays of size fractions for COF

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	0.000	0.000	0.000	0.000	
35 MESH	0.000	0.000	0.000	0.000	
48 MESH	0.000	0.000	0.000	0.000	
65 MESH	1.950	1.948	0.100	-0.002	
100 MESH	0.080	0.080	0.010	0.000	
150 MESH	0.020	0.020	0.010	-0.000	
200 MESH	0.020	0.021	0.010	0.001	
270 MESH	0.070	0.070	0.010	-0.000	
400 MESH	0.080	0.081	0.010	0.001	
500 MESH	0.130	0.049	0.100	-0.081	
PAN	0.040	0.040	0.010	0.000	

Assays of size fractions for CUF1

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	0.660	0.653	0.100	-0.007	
35 MESH	0.600	0.578	0.050	-0.022	
48 MESH	0.540	0.548	0.050	0.008	
65 MESH	0.200	0.183	0.050	-0.017	
100 MESH	0.100	0.102	0.050	0.002	
150 MESH	0.150	0.149	0.050	-0.001	
200 MESH	0.180	0.188	0.050	0.008	
270 MESH	0.200	0.196	0.050	-0.004	
400 MESH	0.200	0.209	0.050	0.009	
500 MESH	1.260	1.243	0.100	-0.017	
PAN	0.410	0.413	0.050	0.003	

Assays of size fractions for CUF2

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	0.530	0.522	0.100	-0.008	
35 MESH	0.870	0.792	0.100	-0.078	
48 MESH	0.370	0.378	0.050	0.008	
65 MESH	0.200	0.185	0.050	-0.015	
100 MESH	0.110	0.112	0.050	0.002	
150 MESH	0.100	0.099	0.050	-0.001	
200 MESH	0.150	0.159	0.050	0.009	
270 MESH	0.190	0.186	0.050	-0.004	
400 MESH	0.160	0.169	0.050	0.009	
500 MESH	0.610	0.605	0.050	-0.005	
PAN	0.140	0.143	0.050	0.003	

Assays of size fractions for BMD

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	1.140	1.141	0.100	0.001	
35 MESH	1.530	1.641	0.200	0.111	
43 MESH	0.580	0.561	0.100	-0.019	
65 MESH	0.190	0.201	0.050	0.011	
100 MESH	0.100	0.099	0.050	-0.001	
150 MESH	0.080	0.080	0.010	0.000	
200 MESH	0.120	0.108	0.050	-0.012	
270 MESH	0.110	0.116	0.050	0.006	
400 MESH	0.210	0.194	0.050	-0.016	
500 MESH	0.590	0.598	0.050	0.008	
PAN	0.320	0.315	0.050	-0.005	

LUCIEN BELIVEAU T2 GRINDING CIRCUIT REVISED(-20M removed)

Residual sum of squares: 11.70517 Final Results

Stream	Absolute Solids Flowrate	Pulp Mass Flowrate Meas	Calc	S.D.	Adjust
1 SAGF	72.44	78.0	72.4	8.0	-5.6
2 SAGD	145.52		145.5		
3 COF	72.44		72.4		
4 CUF1	73.08	65.0	73.1	10.0	8.1
5 CUF2	71.22	65.0	71.2	10.0	6.2
6 BMD	71.22		71.2		
7 SBMF	0.00	0.8	0.0	5.0	-0.8
8 FLTL					

Stream	Relative Solids Flowrate
1 SAGF	100.00
2 SAGD	200.88
3 COF	100.00
4 CUF1	100.88
5 CUF2	98.31
6 BMD	98.31
7 SBMF	0.00

Assay Data

Au oz/t	Meas.	Calc.	Std. Dev.	Adjust.	% Rec
SAGD	0.160	0.166	0.010	0.006	
COF	0.060	0.057	0.010	-0.003	
CUF1	0.300	0.274	0.030	-0.026	
CUF2	0.240	0.245	0.020	0.005	
BMD	0.250	0.245	0.020	-0.005	
SBMF	4.430	4.430	0.500	-0.000	

Fractional Size Distribution Data

Size	SAGD Meas	SAGD Calc	SAGD SD.	SAGD Adj.	COF Meas	COF Calc	COF SD.	COF Adj.
28 MESH	3.62	3.78	0.5	0.2	0.00	-0.00	0.1	-0.0
35 MESH	4.81	4.96	0.5	0.1	0.00	-0.00	0.1	-0.0
48 MESH	8.41	8.31	0.5	-0.1	0.00	0.00	0.1	0.0
65 MESH	10.67	10.23	0.5	-0.4	0.38	0.42	0.2	0.0
100 MESH	13.47	13.56	0.5	0.1	3.43	3.39	0.5	-0.0
150 MESH	10.58	10.22	0.5	-0.4	8.55	8.73	0.5	0.2
200 MESH	7.44	7.46	0.5	0.0	11.17	11.16	0.5	-0.0
270 MESH	4.47	4.70	0.5	0.2	8.34	8.23	0.5	-0.1
400 MESH	6.34	6.60	0.5	0.3	12.23	12.10	0.5	-0.1
500 MESH	4.31	4.31	0.5	0.0	8.34	8.34	0.5	-0.0

Size	CUF1 Meas	Calc	SD.	Adj.	CUF2 Meas	Calc	SD.	Adj.
28 MESH	4.17	4.09	0.5	-0.1	4.46	4.38	0.5	-0.1
35 MESH	6.29	6.22	0.5	-0.1	5.91	5.84	0.5	-0.1
48 MESH	11.82	11.87	0.5	0.1	11.65	11.70	0.5	0.0
65 MESH	16.06	16.28	0.5	0.2	14.96	15.18	0.5	0.2
100 MESH	20.71	20.67	0.5	-0.0	20.56	20.52	0.5	-0.0
150 MESH	12.83	13.01	0.5	0.2	12.56	12.74	0.5	0.2
200 MESH	5.88	5.87	0.5	-0.0	7.15	7.14	0.5	-0.0
270 MESH	2.99	2.88	0.5	-0.1	3.24	3.13	0.5	-0.1
400 MESH	4.01	3.88	0.5	-0.1	4.22	4.09	0.5	-0.1
500 MESH	1.70	1.70	0.5	-0.0	1.97	1.97	0.5	-0.0

Size	BMD Meas	Calc	SD.	Adj.	SBMF Meas	Calc	SD.	Adj.
28 MESH	0.79	0.84	0.4	0.1	0.00	-0.00	0.1	-0.0
35 MESH	2.02	2.09	0.5	0.1	0.57	0.57	0.3	-0.0
48 MESH	6.95	6.90	0.5	-0.0	1.54	1.54	0.5	0.0
65 MESH	11.64	11.42	0.5	-0.2	4.37	4.37	0.5	0.0
100 MESH	17.42	17.46	0.5	0.0	8.76	8.76	0.5	-0.0
150 MESH	14.26	14.08	0.5	-0.2	12.76	12.76	0.5	0.0
200 MESH	9.27	9.28	0.5	0.0	12.12	12.12	0.5	0.0
270 MESH	4.74	4.85	0.5	0.1	12.92	12.92	0.5	-0.0
400 MESH	6.76	6.89	0.5	0.1	8.68	8.68	0.5	-0.0
500 MESH	3.38	3.38	0.5	0.0	9.85	9.85	0.5	0.0

Assays of size fractions for SAGD

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	0.190	0.526	0.500	0.336	
35 MESH	0.450	0.483	0.050	0.033	
48 MESH	0.440	0.427	0.050	-0.013	
65 MESH	0.190	0.211	0.050	0.021	
100 MESH	0.110	0.108	0.050	-0.002	
150 MESH	0.110	0.111	0.050	0.001	
200 MESH	0.120	0.099	0.050	-0.021	
270 MESH	0.110	0.123	0.050	0.013	
400 MESH	0.120	0.088	0.050	-0.032	
500 MESH	0.120	0.202	0.100	0.082	
PAN	0.050	0.049	0.010	-0.001	

Assays of size fractions for COF

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	0.000	0.000	0.000	0.000	
35 MESH	0.000	0.000	0.000	0.000	
48 MESH	0.000	0.000	0.000	0.000	
65 MESH	1.950	1.948	0.100	-0.002	
100 MESH	0.080	0.080	0.010	0.000	
150 MESH	0.020	0.020	0.010	-0.000	
200 MESH	0.020	0.021	0.010	0.001	
270 MESH	0.070	0.070	0.010	-0.000	
400 MESH	0.080	0.081	0.010	0.001	
500 MESH	0.130	0.051	0.100	-0.079	
PAN	0.040	0.041	0.010	0.001	

Assays of size fractions for CUF1

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	0.660	0.653	0.100	-0.007	
35 MESH	0.600	0.579	0.050	-0.021	
48 MESH	0.540	0.549	0.050	0.009	
65 MESH	0.200	0.183	0.050	-0.017	
100 MESH	0.100	0.102	0.050	0.002	
150 MESH	0.150	0.149	0.050	-0.001	
200 MESH	0.180	0.188	0.050	0.008	
270 MESH	0.200	0.196	0.050	-0.004	
400 MESH	0.200	0.209	0.050	0.009	
500 MESH	1.260	1.244	0.100	-0.016	
PAN	0.410	0.416	0.050	0.006	

Assays of size fractions for CUF2

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	0.530	0.522	0.100	-0.008	
35 MESH	0.870	0.793	0.100	-0.077	
48 MESH	0.370	0.379	0.050	0.009	
65 MESH	0.200	0.185	0.050	-0.015	
100 MESH	0.110	0.111	0.050	0.001	
150 MESH	0.100	0.099	0.050	-0.001	
200 MESH	0.150	0.160	0.050	0.010	
270 MESH	0.190	0.186	0.050	-0.004	
400 MESH	0.160	0.170	0.050	0.010	
500 MESH	0.610	0.605	0.050	-0.005	
PAN	0.140	0.145	0.050	0.005	

Assays of size fractions for BMD

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	1.140	1.141	0.100	0.001	
35 MESH	1.530	1.640	0.200	0.110	
48 MESH	0.580	0.560	0.100	-0.020	
65 MESH	0.190	0.201	0.050	0.011	
100 MESH	0.100	0.099	0.050	-0.001	
150 MESH	0.080	0.080	0.010	0.000	
200 MESH	0.120	0.107	0.050	-0.013	
270 MESH	0.110	0.116	0.050	0.006	
400 MESH	0.210	0.194	0.050	-0.016	
500 MESH	0.590	0.598	0.050	0.008	
PAN	0.320	0.311	0.050	-0.009	

Assays of size fractions for SBMF

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	0.000	0.000	0.000	0.000	
35 MESH	22.540	22.539	5.000	-0.001	
48 MESH	13.220	13.220	5.000	0.000	
65 MESH	8.160	8.160	1.000	-0.000	
100 MESH	6.360	6.360	1.000	0.000	
150 MESH	3.270	3.270	1.000	-0.000	
200 MESH	5.290	5.290	1.000	0.000	
270 MESH	4.770	4.770	1.000	-0.000	
400 MESH	5.060	5.060	1.000	0.000	
500 MESH	4.430	4.430	1.000	-0.000	
PAN	2.240	2.240	0.500	0.000	

LUCIEN BELIVEAU T2 SPIRAL CIRCUIT (4:1 silica)

Residual sum of squares: 13.08757

Final Results

Stream	Absolute Solids Flowrate	Pulp Mass Flowrate Meas	Calc	S.D.	Adjust
1 THKUF	563.89	570.0	563.9	30.0	-6.1
2 SPC1	2.96	2.8	3.0	0.4	0.1
3 SPC2	1.66	1.6	1.7	0.2	0.0
4 SPTLS	559.27		559.3		

Stream	Relative Solids Flowrate
1 THKUF	100.00
2 SPC1	0.52
3 SPC2	0.29
4 SPTLS	99.18

Assay Data

Au oz/t	Meas.	Calc.	Std. Dev.	Adjust.	% Rec
THKUF	1.530	1.468	0.100	-0.062	100
SPC1	91.980	94.629	9.000	2.649	34
SPC2	53.110	53.568	5.000	0.458	11
SPTLS	0.790	0.820	0.070	0.030	55

Fractional Size Distribution Data

Size	THKUF Meas	Calc	SD.	Adj.	SPC1 Meas	Calc	SD.	Adj.
28 MESH	0.07	0.03	0.1	-0.0	0.01	0.01	0.1	0.0
35 MESH	0.42	0.22	0.2	-0.2	0.14	0.14	0.1	0.0
48 MESH	3.67	3.49	0.5	-0.2	3.08	3.08	0.5	0.0
65 MESH	16.60	17.12	1.0	0.5	17.48	17.48	0.5	-0.0
100 MESH	29.67	29.97	0.5	0.3	29.82	29.82	0.5	-0.0
150 MESH	17.72	17.53	0.5	-0.2	18.09	18.09	0.5	0.0
200 MESH	13.37	12.96	0.5	-0.4	16.02	16.02	0.5	0.0
270 MESH	6.96	6.62	0.5	-0.3	7.64	7.64	0.5	0.0
400 MESH	4.76	4.52	0.5	-0.2	6.04	6.04	0.5	0.0
500 MESH	1.56	1.49	0.5	-0.1	0.91	0.91	0.5	0.0

Size	SPC2 Meas	Calc	SD.	Adj.	SPTLS Meas	Calc	SD.	Adj.
28 MESH	0.09	0.09	0.1	0.0	0.01	0.03	0.1	0.0
35 MESH	0.46	0.46	0.3	0.0	0.17	0.22	0.1	0.1
48 MESH	3.13	3.13	0.5	0.0	3.31	3.49	0.5	0.2
65 MESH	15.73	15.73	0.5	-0.0	17.63	17.12	1.0	-0.5
100 MESH	27.91	27.91	0.5	-0.0	30.28	29.98	0.5	-0.3
150 MESH	17.27	17.27	0.5	0.0	17.33	17.52	0.5	0.2
200 MESH	15.48	15.48	0.5	0.0	12.52	12.93	0.5	0.4
270 MESH	9.07	9.07	0.5	0.0	6.28	6.61	0.5	0.3
400 MESH	8.42	8.42	0.5	0.0	4.26	4.50	0.5	0.2
500 MESH	1.46	1.46	0.5	0.0	1.43	1.50	0.5	0.1

Assays of size fractions for THKUF

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	6.490	1.020	8.000	-5.470	100
35 MESH	7.460	5.735	1.000	-1.725*	100
48 MESH	5.120	2.446	3.000	-2.674	100
65 MESH	1.110	0.948	0.500	-0.162	100
100 MESH	0.690	0.702	0.100	0.012	100
150 MESH	1.050	1.104	0.200	0.054	100
200 MESH	1.430	1.404	0.100	-0.026	100
270 MESH	2.200	2.334	0.500	0.134	100
400 MESH	3.710	3.917	0.500	0.207	100
500 MESH	5.540	6.114	0.800	0.574	100
PAN	2.310	2.183	0.500	-0.127	25

Assays of size fractions for SPC1

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	125.760	125.824	20.000	0.064	23
35 MESH	402.770	405.032	20.000	2.262	23
48 MESH	259.160	259.711	20.000	0.551	49
65 MESH	100.460	100.808	10.000	0.348	57
100 MESH	66.480	65.827	10.000	-0.653	49
150 MESH	84.220	83.489	10.000	-0.731	41
200 MESH	75.000	76.671	10.000	1.671	35
270 MESH	94.280	93.956	10.000	-0.324	24
400 MESH	121.940	119.622	20.000	-2.318	21
500 MESH	322.330	321.183	20.000	-1.147	17
PAN	163.130	163.164	10.000	0.034	6

Assays of size fractions for SPC2

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	78.040	78.120	10.000	0.080	71
35 MESH	523.300	527.463	20.000	4.163	55
48 MESH	356.270	356.584	20.000	0.314	38
65 MESH	80.220	80.396	10.000	0.176	23
100 MESH	34.430	34.344	5.000	-0.086	13
150 MESH	41.410	41.312	5.000	-0.098	11
200 MESH	22.400	22.626	5.000	0.226	6
270 MESH	21.060	21.006	5.000	-0.054	4
400 MESH	28.970	28.857	5.000	-0.113	4
500 MESH	85.760	85.502	10.000	-0.258	4
PAN	106.630	106.654	10.000	0.024	3

Assays of size fractions for SPTLS

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	0.060	0.060	0.010	0.000	6
35 MESH	1.220	1.237	0.100	0.017	21
48 MESH	0.300	0.303	0.100	0.003	12
65 MESH	0.190	0.192	0.050	0.002	20
100 MESH	0.270	0.267	0.050	-0.003	38
150 MESH	0.590	0.536	0.200	-0.054	48
200 MESH	0.810	0.835	0.100	0.025	59
270 MESH	1.830	1.698	0.500	-0.132	72
400 MESH	3.160	2.956	0.500	-0.204	75
500 MESH	5.440	4.870	0.800	-0.570	79
PAN	1.900	2.027	0.500	0.127	23

LUCIEN BELIVEAU T3 SPIRAL CIRCUIT (4:1 silica)

Residual sum of squares: 9.527356 Final Results

Stream	Absolute Solids Flowrate	Pulp Mass Flowrate Meas	Calc	S.D.	Adjust
1 THKUF	900.00	900.0	900.0	50.0	0.0
2 SPC1	2.10	2.1	2.1	0.3	0.0
3 SPC2	1.70	1.7	1.7	0.2	0.0
4 SPTLS	896.20		896.2		

Stream	Relative Solids Flowrate
1 THKUF	100.00
2 SPC1	0.23
3 SPC2	0.19
4 SPTLS	99.58

Assay Data

Au oz/t	Meas.	Calc.	Std. Dev.	Adjust.	% Rec
THKUF	0.950	0.913	0.100	-0.037	100
SPC1	59.830	60.048	5.000	0.218	15
SPC2	20.270	20.298	2.000	0.028	4
SPTLS	0.700	0.737	0.100	0.037	80

Fractional Size Distribution Data

Size	THKUF Meas	Calc	SD.	Adj.	SPC1 Meas	Calc	SD.	Adj.
35 MESH	0.32	0.26	0.2	-0.1	0.23	0.23	0.2	0.0
48 MESH	2.23	2.26	0.5	0.0	2.52	2.52	0.5	-0.0
65 MESH	20.46	20.40	0.5	-0.1	12.89	12.89	0.5	0.0
100 MESH	24.65	24.78	0.5	0.1	27.00	27.00	0.5	-0.0
150 MESH	17.69	17.54	0.5	-0.2	18.33	18.33	0.5	0.0
200 MESH	12.88	12.82	0.5	-0.1	16.54	16.54	0.5	0.0
270 MESH	8.61	8.59	0.5	-0.0	10.98	10.98	0.5	0.0
400 MESH	4.07	3.98	0.5	-0.1	8.16	8.16	0.5	0.0
500 MESH	3.00	2.97	0.5	-0.0	1.80	1.80	0.5	0.0

Size	SPC2 Meas	Calc	SD.	Adj.	SPTLS Meas	Calc	SD.	Adj.
35 MESH	0.52	0.52	0.3	0.0	0.22	0.26	0.1	0.0
48 MESH	3.38	3.38	0.5	-0.0	2.28	2.25	0.5	-0.0
65 MESH	14.34	14.34	0.5	0.0	20.37	20.43	0.5	0.1
100 MESH	28.61	28.61	0.5	-0.0	24.90	24.77	0.5	-0.1
150 MESH	18.41	18.41	0.5	0.0	17.38	17.53	0.5	0.2
200 MESH	14.52	14.52	0.5	0.0	12.75	12.81	0.5	0.1
270 MESH	9.11	9.11	0.5	0.0	8.56	8.58	0.5	0.0
400 MESH	7.09	7.09	0.5	0.0	3.87	3.96	0.5	0.1
500 MESH	1.83	1.83	0.5	0.0	2.95	2.98	0.5	0.0

Assays of size fractions for THKUF

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
35 MESH	2.070	1.190	1.000	-0.880	100
48 MESH	2.980	1.228	2.000	-1.752	100
65 MESH	0.500	0.415	0.100	-0.085	100
100 MESH	0.590	0.500	0.100	-0.090	100
150 MESH	0.640	0.679	0.100	0.039	100
200 MESH	0.990	1.096	0.500	0.106	100
270 MESH	1.110	1.198	0.500	0.088	100
400 MESH	1.920	2.363	0.500	0.443	100
500 MESH	2.860	3.062	0.500	0.202	100
PAN	2.160	1.706	0.500	-0.454	46

Assays of size fractions for SPC1

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
35 MESH	232.720	233.455	20.000	0.735	41
48 MESH	226.540	226.996	20.000	0.456	48
65 MESH	88.180	89.432	10.000	1.252	32
100 MESH	51.300	51.869	5.000	0.569	26
150 MESH	54.520	54.282	5.000	-0.238	19
200 MESH	37.490	37.458	5.000	-0.032	10
270 MESH	10.260	10.259	1.000	-0.001	3
400 MESH	92.260	91.412	10.000	-0.848	19
500 MESH	127.150	127.036	10.000	-0.114	6
PAN	80.300	80.403	10.000	0.103	3

Assays of size fractions for SPC2

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
35 MESH	79.760	80.096	10.000	0.336	26
48 MESH	89.830	89.954	10.000	0.124	21
65 MESH	29.300	29.582	5.000	0.282	9
100 MESH	14.200	14.278	2.000	0.078	6
150 MESH	13.980	13.949	2.000	-0.031	4
200 MESH	11.520	11.516	2.000	-0.004	2
270 MESH	10.060	10.059	1.000	-0.001	2
400 MESH	20.780	20.631	5.000	-0.149	3
500 MESH	52.560	52.537	5.000	-0.023	2
PAN	43.990	44.019	5.000	0.029	1

Assays of size fractions for SPTLS

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
35 MESH	0.390	0.399	0.100	0.009	33
48 MESH	0.380	0.384	0.100	0.004	31
65 MESH	0.160	0.245	0.100	0.085	59
100 MESH	0.250	0.339	0.100	0.089	67
150 MESH	0.560	0.521	0.100	-0.039	76
200 MESH	1.070	0.964	0.500	-0.106	87
270 MESH	1.240	1.153	0.500	-0.087	96
400 MESH	2.310	1.871	0.500	-0.439	79
500 MESH	3.030	2.829	0.500	-0.201	92
PAN	1.180	1.634	0.500	0.454	44

LUCIEN BELIVEAU T4 SPIRAL CIRCUIT (calc. without silica)

Residual sum of squares: 6.051812

Final Results

Stream	Absolute Solids Flowrate	Pulp Mass Flowrate Meas	Calc	S.D.	Adjust
1 THKUF	667.00	667.0	667.0	50.0	0.0
2 SPC1	2.91	2.9	2.9	0.3	0.0
3 SPC2	1.53	1.5	1.5	0.2	0.0
4 SPTLS	662.56		662.6		

Stream	Relative Solids Flowrate
1 THKUF	100.00
2 SPC1	0.44
3 SPC2	0.23
4 SPTLS	99.33

Assay Data

Au oz/t	Meas.	Calc.	Std. Dev.	Adjust.	% Rec
THKUF	5.360	5.727	1.000	0.367	100
SPC1	196.410	195.770	20.000	-0.640	15
SPC2	90.990	90.906	10.000	-0.084	4
SPTLS	5.060	4.696	1.000	-0.364	81

Fractional Size Distribution Data

Size	THKUF Meas	Calc	SD.	Adj.	SPC1 Meas	Calc	SD.	Adj.
35 MESH	0.41	0.41	0.2	-0.0	0.41	0.41	0.2	0.0
48 MESH	1.23	1.23	0.5	0.0	1.23	1.23	0.5	0.0
65 MESH	3.91	3.91	0.5	0.0	3.91	3.91	0.5	0.0
100 MESH	8.75	8.75	0.5	0.0	8.75	8.75	0.5	0.0
150 MESH	13.51	13.51	0.5	0.0	13.51	13.51	0.5	0.0
200 MESH	12.78	12.78	0.5	0.0	12.78	12.78	0.5	0.0
270 MESH	14.48	14.48	0.5	-0.0	14.48	14.48	0.5	0.0
400 MESH	9.31	9.31	0.5	0.0	9.31	9.31	0.5	0.0
500 MESH	9.95	9.95	0.5	0.0	9.95	9.95	0.5	0.0

Size	SPC2 Meas	Calc	SD.	Adj.	SPTLS Meas	Calc	SD.	Adj.
35 MESH	0.41	0.41	0.2	0.0	0.41	0.41	0.2	0.0
48 MESH	1.23	1.23	0.5	0.0	1.23	1.23	0.5	0.0
65 MESH	3.91	3.91	0.5	0.0	3.91	3.91	0.5	-0.0
100 MESH	8.75	8.75	0.5	0.0	8.75	8.75	0.5	0.0
150 MESH	13.51	13.51	0.5	0.0	13.51	13.51	0.5	0.0
200 MESH	12.78	12.78	0.5	0.0	12.78	12.78	0.5	0.0
270 MESH	14.48	14.48	0.5	0.0	14.48	14.48	0.5	0.0
400 MESH	9.31	9.31	0.5	0.0	9.31	9.31	0.5	0.0
500 MESH	9.95	9.95	0.5	0.0	9.95	9.95	0.5	0.0

Assays of size fractions for THKUF

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
35 MESH	132.660	46.543	100.000	-86.118	100
48 MESH	24.420	19.819	5.000	-4.601	100
65 MESH	16.850	12.615	5.000	-4.235	100
100 MESH	6.670	6.614	1.000	-0.056	100
150 MESH	3.080	3.663	1.000	0.583	100
200 MESH	3.970	3.964	1.000	-0.006	100
270 MESH	3.860	4.061	1.000	0.201	100
400 MESH	5.000	5.340	1.000	0.340	100
500 MESH	4.880	5.489	1.000	0.609	100
PAN	3.280	5.109	2.000	1.829	39

Assays of size fractions for SPC1

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
35 MESH	1179.550	1179.926	100.000	0.376	11
48 MESH	2482.470	2490.499	100.000	8.029	55
65 MESH	1061.210	1068.601	100.000	7.391	37
100 MESH	323.710	324.325	50.000	0.615	21
150 MESH	145.050	144.033	20.000	-1.017	17
200 MESH	113.260	113.262	10.000	0.002	12
270 MESH	112.340	112.252	10.000	-0.088	12
400 MESH	143.010	142.862	10.000	-0.148	12
500 MESH	131.160	130.894	10.000	-0.266	10
PAN	56.570	56.520	5.000	-0.050	2

Assays of size fractions for SPC2

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
35 MESH	1397.090	1397.287	100.000	0.198	7
48 MESH	1338.520	1342.742	100.000	4.222	16
65 MESH	357.480	358.452	50.000	0.971	7
100 MESH	128.730	128.782	20.000	0.052	4
150 MESH	66.860	66.726	10.000	-0.134	4
200 MESH	46.670	46.670	5.000	0.000	3
270 MESH	58.490	58.478	5.000	-0.012	3
400 MESH	54.380	54.361	5.000	-0.019	2
500 MESH	58.820	58.785	5.000	-0.035	2
PAN	35.740	35.714	5.000	-0.026	1

Assays of size fractions for SPTLS

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
35 MESH	37.590	38.445	10.000	0.855	82
48 MESH	5.730	5.913	1.000	0.183	30
65 MESH	7.010	7.178	1.000	0.168	57
100 MESH	4.880	4.936	1.000	0.056	74
150 MESH	3.480	2.901	1.000	-0.579	79
200 MESH	3.380	3.386	1.000	0.006	85
270 MESH	3.660	3.460	1.000	-0.200	85
400 MESH	4.960	4.623	1.000	-0.337	86
500 MESH	5.420	4.815	1.000	-0.605	87
PAN	6.630	4.813	2.000	-1.817	36

LUCIEN BELIVEAU T5 SPIRAL CIRCUIT (4:1 25M silica)

Residual sum of squares: 11.23437 Final Results

	Stream	Absolute Solids Flowrate	Pulp Mass Flowrate			
			Meas	Calc	S.D.	Adjust
1	THKUF	830.00	830.0	830.0	50.0	0.0
2	SPC1	3.00	3.0	3.0	0.4	0.0
3	SPC2	1.68	1.7	1.7	0.2	0.0
4	SPTLS	825.32		825.3		

	Stream	Relative Solids Flowrate
1	THKUF	100.00
2	SPC1	0.36
3	SPC2	0.20
4	SPTLS	99.44

Assay Data

Au oz/t	Meas.	Calc.	Std. Dev.	Adjust.	% Rec
THKUF	1.080	1.100	0.100	0.020	100
SPC1	28.370	28.189	5.000	-0.181	9
SPC2	16.610	16.594	2.000	-0.016	3
SPTLS	0.990	0.970	0.100	-0.020	88

Fractional Size Distribution Data

	THKUF				SPC1			
Size	Meas	Calc	SD.	Adj.	Meas	Calc	SD.	Adj.
28 MESH	43.00	42.44	1.0	-0.6	46.18	46.18	0.5	0.0
35 MESH	35.50	35.78	0.5	0.3	30.02	30.02	0.5	-0.0
48 MESH	2.62	2.73	0.5	0.1	2.37	2.37	0.5	-0.0
65 MESH	1.29	1.40	0.5	0.1	0.62	0.62	0.3	-0.0
100 MESH	2.11	2.16	0.5	0.1	0.64	0.64	0.3	-0.0
150 MESH	0.87	0.79	0.4	-0.1	0.46	0.46	0.3	0.0
200 MESH	4.21	4.06	0.5	-0.1	6.51	6.51	0.5	0.0
270 MESH	2.84	2.81	0.5	-0.0	7.41	7.41	0.5	0.0
400 MESH	2.08	2.02	0.5	-0.1	3.76	3.76	0.5	0.0
500 MESH	2.03	1.94	0.5	-0.1	1.71	1.71	0.5	0.0

	SPC2				SPTLS			
Size	Meas	Calc	SD.	Adj.	Meas	Calc	SD.	Adj.
28 MESH	44.53	44.53	0.5	0.0	41.86	42.42	1.0	0.6
35 MESH	31.55	31.55	0.5	-0.0	36.08	35.81	0.5	-0.3
48 MESH	3.30	3.30	0.5	-0.0	2.83	2.73	0.5	-0.1
65 MESH	1.54	1.54	0.5	-0.0	1.51	1.40	0.5	-0.1
100 MESH	0.71	0.71	0.4	-0.0	2.22	2.17	0.5	-0.1
150 MESH	0.31	0.31	0.2	0.0	0.74	0.80	0.4	0.1
200 MESH	3.81	3.81	0.5	0.0	3.91	4.06	0.5	0.1
270 MESH	6.23	6.23	0.5	0.0	2.76	2.79	0.5	0.0
400 MESH	4.70	4.70	0.5	0.0	1.94	2.00	0.5	0.1
500 MESH	2.62	2.62	0.5	0.0	1.85	1.94	0.5	0.1

Assays of size fractions for THKUF

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	0.080	0.011	0.070	-0.069	100
35 MESH	0.060	0.064	0.010	0.004	100
48 MESH	3.500	2.717	0.800	-0.783	100
65 MESH	10.260	10.254	0.100	-0.006	100
100 MESH	6.510	7.174	1.000	0.664	100
150 MESH	3.880	4.574	0.700	0.694	100
200 MESH	4.200	4.555	0.500	0.355	100
270 MESH	3.860	4.066	0.500	0.206	100
400 MESH	4.560	4.785	0.500	0.225	100
500 MESH	6.200	6.900	1.000	0.700	100
PAN	3.480	3.405	0.500	-0.075	50

Assays of size fractions for SPC1

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	0.200	0.200	0.050	0.000	7
35 MESH	1.400	1.370	0.500	-0.030	6
48 MESH	113.470	115.008	20.000	1.538	13
65 MESH	794.370	795.250	30.000	0.880	12
100 MESH	900.210	899.570	30.000	-0.640	13
150 MESH	252.420	251.234	20.000	-1.186	11
200 MESH	87.570	86.747	10.000	-0.823	11
270 MESH	51.990	51.794	5.000	-0.196	12
400 MESH	62.600	61.993	10.000	-0.607	9
500 MESH	71.890	71.667	10.000	-0.223	3
PAN	62.040	62.049	10.000	0.009	3

Assays of size fractions for SPC2

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	0.140	0.140	0.010	0.000	3
35 MESH	2.240	2.222	0.500	-0.018	6
48 MESH	52.580	52.880	10.000	0.300	5
65 MESH	158.530	159.074	20.000	0.544	3
100 MESH	338.550	338.373	20.000	-0.177	3
150 MESH	162.090	161.643	20.000	-0.447	3
200 MESH	119.090	118.820	10.000	-0.270	5
270 MESH	23.380	23.288	5.000	-0.092	3
400 MESH	27.310	27.204	5.000	-0.106	3
500 MESH	38.720	38.672	5.000	-0.048	2
PAN	65.610	65.621	10.000	0.011	3

Assays of size fractions for SPTLS

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	0.010	0.010	0.001	0.000	90
35 MESH	0.060	0.056	0.010	-0.004	87
48 MESH	1.460	2.239	0.800	0.779	82
65 MESH	7.290	8.659	1.500	1.369	84
100 MESH	6.660	5.997	1.000	-0.663	83
150 MESH	4.440	3.932	0.600	-0.508	86
200 MESH	4.210	3.857	0.500	-0.353	84
270 MESH	3.720	3.517	0.500	-0.203	85
400 MESH	4.510	4.288	0.500	-0.222	89
500 MESH	7.300	6.605	1.000	-0.695	95
PAN	3.290	3.365	0.500	0.075	49

LUCIEN BELIVEAU T7 GRAVITY CIRCUIT (4:1 SILICA)

Residual sum of squares: 13.19656 Final Results

Stream	Absolute Solids Flowrate	Pulp Mass Flowrate Meas	Calc	S.D.	Adjust
1 SBMD	1105.54		1105.5		
2 THKUF	743.41	740.0	743.4	50.0	3.4
3 SPC1	1.65	1.7	1.6	0.2	-0.0
4 SPC2	1.25	1.3	1.2	0.2	-0.0
5 THKOF	362.13	367.0	362.1	40.0	-4.9
6 SPTLS	740.52		740.5		

Stream	Relative Solids Flowrate
1 SBMD	100.00
2 THKUF	67.24
3 SPC1	0.15
4 SPC2	0.11
5 THKOF	32.76
6 SPTLS	66.98

Assay Data

Au oz/t	Meas.	Calc.	Std. Dev.	Adjust.	% Rec
SBMD	1.000	0.991	0.300	-0.009	100
THKUF	0.780	0.933	0.200	0.153	63
SPC1	80.720	80.312	7.000	-0.408	12
SPC2	45.110	45.009	4.000	-0.101	5
THKOF	1.080	1.111	1.000	0.031	37
SPTLS	0.720	0.682	0.100	-0.038	46

Fractional Size Distribution Data

Size	SBMD Meas	SBMD Calc	SBMD SD.	SBMD Adj.	THKUF Meas	THKUF Calc	THKUF SD.	THKUF Adj.
35 MESH	0.37	0.32	0.2	-0.0	0.33	0.33	0.2	-0.0
48 MESH	2.00	2.01	0.5	0.0	2.02	1.96	0.5	-0.1
65 MESH	16.49	17.11	1.0	0.6	17.81	16.78	1.0	-1.0*
100 MESH	29.65	29.52	0.5	-0.1	28.36	29.88	2.0	1.5
150 MESH	15.88	16.12	0.5	0.2	15.66	15.66	0.5	0.0
200 MESH	13.51	13.34	0.5	-0.2	13.99	14.04	0.5	0.0
270 MESH	8.73	8.55	0.5	-0.2	9.18	9.08	0.5	-0.1
400 MESH	3.95	3.87	0.5	-0.1	4.43	4.30	0.5	-0.1
500 MESH	2.58	2.55	0.5	-0.0	2.93	2.79	0.5	-0.1

Size	SPC1 Meas	Calc	SD.	Adj.	SPC2 Meas	Calc	SD.	Adj.
35 MESH	0.23	0.23	0.2	0.0	0.29	0.29	0.2	0.0
48 MESH	2.10	2.10	0.5	0.0	2.49	2.49	0.5	0.0
65 MESH	15.85	15.85	0.5	0.0	18.25	18.25	0.5	0.0
100 MESH	27.88	27.88	0.5	-0.0	28.04	28.04	0.5	-0.0
150 MESH	15.73	15.73	0.5	-0.0	15.33	15.33	0.5	-0.0
200 MESH	15.50	15.50	0.5	0.0	12.06	12.06	0.5	0.0
270 MESH	13.80	13.80	0.5	0.0	11.23	11.23	0.5	0.0
400 MESH	5.99	5.99	0.5	0.0	7.39	7.39	0.5	0.0
500 MESH	2.33	2.33	0.5	0.0	3.72	3.72	0.5	0.0

Size	THKOF Meas	Calc	SD.	Adj.	SPTLS Meas	Calc	SD.	Adj.
35 MESH	0.31	0.32	0.2	0.0	0.30	0.33	0.2	0.0
48 MESH	2.10	2.10	0.5	-0.0	1.91	1.96	0.5	0.1
65 MESH	17.84	17.79	0.5	-0.1	16.16	16.78	1.0	0.6
100 MESH	28.74	28.78	0.5	0.0	29.91	29.88	1.0	-0.0
150 MESH	17.15	17.07	0.5	-0.1	16.32	15.66	1.0	-0.7
200 MESH	11.67	11.90	1.0	0.2	12.97	14.04	2.0	1.1
270 MESH	7.39	7.45	0.5	0.1	8.85	9.07	0.5	0.2
400 MESH	2.97	3.00	0.5	0.0	4.11	4.29	0.5	0.2
500 MESH	2.05	2.06	0.5	0.0	2.62	2.79	0.5	0.2

Assays of size fractions for SBMD

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
35 MESH	10.210	5.470	5.000	-4.740	100
48 MESH	2.690	2.036	1.000	-0.654	100
65 MESH	0.650	0.543	0.200	-0.107	100
100 MESH	0.570	0.433	0.200	-0.137	100
150 MESH	0.630	0.640	0.100	0.010	100
200 MESH	0.860	0.913	0.100	0.053	100
270 MESH	1.300	1.373	0.500	0.073	100
400 MESH	2.240	2.335	0.500	0.095	100
500 MESH	3.820	3.808	0.500	-0.012	100
PAN	1.750	1.716	0.500	-0.034	39

Assays of size fractions for THKUF

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
35 MESH	6.510	6.340	1.000	-0.170	78
48 MESH	2.100	2.250	0.500	0.150	73
65 MESH	0.350	0.565	0.200	0.215*	69
100 MESH	0.330	0.373	0.100	0.043	59
150 MESH	0.530	0.583	0.100	0.053	60
200 MESH	0.910	0.940	0.100	0.030	73
270 MESH	1.050	1.116	0.500	0.066	58
400 MESH	1.630	1.822	0.500	0.192	58
500 MESH	3.030	3.186	0.500	0.156	62
PAN	1.850	1.948	0.500	0.098	32

Assays of size fractions for SPC1

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
35 MESH	1533.020	1551.659	200.000	18.639	30
48 MESH	386.610	385.966	40.000	-0.644	30
65 MESH	133.460	132.706	10.000	-0.754	34
100 MESH	50.100	50.000	5.000	-0.100	16
150 MESH	70.600	69.280	10.000	-1.320	16
200 MESH	53.770	53.356	5.000	-0.414	10
270 MESH	49.760	49.720	5.000	-0.040	9
400 MESH	66.000	65.676	10.000	-0.324	6
500 MESH	113.310	113.201	10.000	-0.109	4
PAN	187.480	187.448	20.000	-0.032	6

Assays of size fractions for SPC2

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
35 MESH	921.700	925.312	90.000	3.612	17
48 MESH	287.290	286.964	30.000	-0.326	20
65 MESH	46.280	46.115	5.000	-0.165	10
100 MESH	18.890	18.814	5.000	-0.076	5
150 MESH	30.450	30.206	5.000	-0.244	5
200 MESH	28.040	27.796	5.000	-0.244	3
270 MESH	34.830	34.805	5.000	-0.025	4
400 MESH	48.310	48.234	5.000	-0.076	4
500 MESH	92.930	92.798	10.000	-0.132	4
PAN	213.590	213.540	20.000	-0.050	8

Assays of size fractions for THKOF

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
35 MESH	3.600	3.662	1.000	0.062	22
48 MESH	1.400	1.624	1.000	0.224	27
65 MESH	0.490	0.499	0.100	0.009	31
100 MESH	0.550	0.561	0.100	0.011	41
150 MESH	0.750	0.747	0.100	-0.003	40
200 MESH	1.240	0.849	0.500	-0.391	27
270 MESH	2.040	2.019	0.500	-0.021	42
400 MESH	3.870	3.846	0.500	-0.024	42
500 MESH	5.480	5.532	2.000	0.052	38
PAN	1.440	1.456	0.500	0.016	9

Assays of size fractions for SPTLS

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
35 MESH	1.350	2.539	2.000	1.189	31
48 MESH	0.730	0.728	0.100	-0.002	23
65 MESH	0.240	0.204	0.100	-0.036	25
100 MESH	0.260	0.241	0.100	-0.019	38
150 MESH	0.440	0.381	0.100	-0.059	39
200 MESH	0.840	0.772	0.100	-0.068	60
270 MESH	1.050	0.881	0.600	-0.169	46
400 MESH	1.750	1.489	0.500	-0.261	47
500 MESH	4.280	2.780	1.600	-1.500	53
PAN	1.900	1.820	0.500	-0.080	30

LUCIEN BELIVEAU T7 KNELSON CONCENTRATOR (adjusted data)

Residual sum of squares: 8.274099E-02 Final Results

Stream	Absolute Solids Flowrate	Pulp Mass Flowrate Meas	Calc	S.D.	Adjust
1 SPTLS	741.00	741.0	741.0	20.0	0.0
2 THKOF	362.00	362.0	362.0	20.0	0.0
3 KNTLS	1100.00	1100.0	1100.0	100.0	0.0
4 KNCON	3.00		3.0		

Stream	Relative Solids Flowrate
1 SPTLS	100.00
2 THKOF	48.85
3 KNTLS	148.45
4 KNCON	0.40

Assay Data

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjust.	% Rec
SPTLS	0.682	0.673	0.100	-0.009	100
THKOF	1.111	1.003	0.500	-0.108	73
KNTLS	0.680	0.693	0.100	0.013	153
KNCON	30.000	33.212	30.000	3.212	20

LUCIEN BELIVEAU T8 GRAVITY CIRCUIT (4:1 SILICA)

Residual sum of squares: 13.99445 Final Results

	Stream	Absolute Solids Flowrate	Pulp Mass Flowrate Meas	Calc	S.D.	Adjust
1	SBMD	1300.00		1300.0		
2	THKUF	800.00	800.0	800.0	50.0	0.0
3	THKOF	500.00	500.0	500.0	50.0	0.0
4	SPTLS	800.00		800.0		

	Stream	Relative Solids Flowrate
1	SBMD	100.00
2	THKUF	61.54
3	THKOF	38.46
4	SPTLS	61.54

Assay Data

Au oz/t	Meas.	Calc.	Std. Dev.	Adjust.	% Rec
SBMD	0.890	0.991	0.500	0.101	100
THKUF	1.360	1.009	0.500	-0.351	63
THKOF	1.000	0.961	0.500	-0.039	37
SPTLS	0.720	1.009	0.500	0.289	63

Fractional Size Distribution Data

Size	SBMD Meas	Calc	SD.	Adj.	THKUF Meas	Calc	SD.	Adj.
35 MESH	0.32	0.29	0.2	-0.0	0.27	0.28	0.2	0.0
48 MESH	2.37	2.09	0.5	-0.3	1.83	2.06	0.5	0.2
65 MESH	18.05	17.00	2.0	-1.0	15.93	16.79	1.0	0.9
100 MESH	29.94	29.68	0.5	-0.3	29.64	29.54	0.5	-0.1
150 MESH	14.66	16.47	2.0	1.8	17.27	16.62	1.0	-0.6
200 MESH	13.06	12.63	1.0	-0.4	13.33	13.28	0.5	-0.0
270 MESH	8.24	8.42	0.5	0.2	9.52	9.13	0.5	-0.4
400 MESH	3.82	3.71	0.5	-0.1	4.28	4.12	0.5	-0.2
500 MESH	2.73	2.57	0.5	-0.2	2.80	2.84	0.5	0.0

Size	THKOF Meas	Calc	SD.	Adj.	SPTLS Meas	Calc	SD.	Adj.
35 MESH	0.29	0.30	0.2	0.0	0.28	0.28	0.2	0.0
48 MESH	2.03	2.14	0.5	0.1	2.12	2.06	0.5	-0.1
65 MESH	17.33	17.36	0.5	0.0	17.48	16.79	1.0	-0.7
100 MESH	29.81	29.91	0.5	0.1	29.29	29.54	0.5	0.3
150 MESH	16.27	16.23	0.5	-0.0	16.53	16.62	0.5	0.1
200 MESH	11.41	11.58	1.0	0.2	11.46	13.28	2.0	1.8
270 MESH	7.36	7.29	0.5	-0.1	8.85	9.13	0.5	0.3
400 MESH	3.02	3.06	0.5	0.0	3.90	4.12	0.5	0.2
500 MESH	2.08	2.14	0.5	0.1	2.79	2.84	0.5	0.1

Assays of size fractions for SBMD

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
35 MESH	8.050	6.200	5.000	-1.850	100
48 MESH	1.720	0.606	2.000	-1.114	100
65 MESH	0.390	0.343	0.100	-0.047	100
100 MESH	0.370	0.380	0.100	0.010	100
150 MESH	0.570	0.558	0.100	-0.012	100
200 MESH	0.980	1.094	0.500	0.114	100
270 MESH	1.490	1.570	0.500	0.080	100
400 MESH	2.300	2.624	0.500	0.324	100
500 MESH	3.200	3.382	0.500	0.182	100
PAN	1.870	1.786	0.500	-0.084	36

Assays of size fractions for THKUF

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
35 MESH	26.150	2.850	25.000	-23.300	28
48 MESH	8.290	0.532	10.000	-7.758	53
65 MESH	1.160	0.287	1.000	-0.873	51
100 MESH	0.610	0.287	0.500	-0.323	46
150 MESH	0.850	0.504	0.500	-0.346	56
200 MESH	1.220	0.998	0.500	-0.222	59
270 MESH	1.500	1.343	0.500	-0.157	57
400 MESH	2.770	2.113	1.000	-0.657	55
500 MESH	2.930	2.935	0.500	0.005	59
PAN	2.420	2.367	0.500	-0.053	33

Assays of size fractions for THKOF

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
35 MESH	10.180	11.243	6.000	1.063	72
48 MESH	0.720	0.721	0.100	0.001	47
65 MESH	0.410	0.429	0.100	0.019	49
100 MESH	0.530	0.526	0.100	-0.004	54
150 MESH	0.640	0.645	0.100	0.005	44
200 MESH	1.310	1.270	0.500	-0.040	41
270 MESH	2.050	2.023	0.500	-0.027	43
400 MESH	3.830	3.727	0.500	-0.103	45
500 MESH	4.390	4.332	0.500	-0.058	41
PAN	1.110	1.291	1.000	0.181	8

Assays of size fractions for SPTLS

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
35 MESH	2.830	2.850	0.500	0.020	28
48 MESH	0.470	0.532	0.500	0.062	53
65 MESH	0.250	0.287	0.100	0.037	51
100 MESH	0.260	0.287	0.200	0.027	46
150 MESH	0.310	0.504	0.300	0.194	56
200 MESH	0.850	0.998	0.500	0.148	59
270 MESH	1.240	1.343	0.500	0.103	57
400 MESH	2.170	2.113	0.500	-0.057	55
500 MESH	3.450	2.935	1.000	-0.515	59
PAN	2.000	2.367	1.000	0.367	33

LUCIEN BELIVEAU T8 CLASSIFIER CIRCUIT (4:1 SILICA)

Residual sum of squares: 9.655424 Final Results

Stream	Absolute Solids Flowrate	Pulp Mass Flowrate Meas	Calc	S.D.	Adjust
1 SBMD	1300.00		1300.0		
2 THKUF	800.00	800.0	800.0	50.0	0.0
3 THKOF	500.00	500.0	500.0	50.0	0.0

Stream	Relative Solids Flowrate
1 SBMD	100.00
2 THKUF	61.54
3 THKOF	38.46

Assay Data

Au oz/t	Meas.	Calc.	Std. Dev.	Adjust.	% Rec
SBMD	0.890	1.107	0.500	0.217	100
THKUF	1.360	1.226	0.500	-0.134	68
THKOF	1.000	0.916	0.500	-0.084	32

Fractional Size Distribution Data

	SBMD				THKUF			
Size	Meas	Calc	SD.	Adj.	Meas	Calc	SD.	Adj.
35 MESH	0.32	0.29	0.2	-0.0	0.27	0.28	0.2	0.0
48 MESH	2.37	2.07	0.5	-0.3	1.83	2.02	0.5	0.2
65 MESH	18.05	16.62	2.0	-1.4	15.93	16.15	1.0	0.2
100 MESH	29.94	29.79	0.5	-0.2	29.64	29.73	0.5	0.1
150 MESH	14.66	16.79	3.0	2.1	17.27	17.12	1.0	-0.1
200 MESH	13.06	12.68	1.0	-0.4	13.33	13.39	0.5	0.1
270 MESH	8.24	8.53	0.5	0.3	9.52	9.34	0.5	-0.2
400 MESH	3.82	3.80	0.5	-0.0	4.28	4.29	0.5	0.0
500 MESH	2.73	2.59	0.5	-0.1	2.80	2.88	0.5	0.1

	THKOF			
Size	Meas	Calc	SD.	Adj.
35 MESH	0.29	0.30	0.2	0.0
48 MESH	2.03	2.15	0.5	0.1
65 MESH	17.33	17.36	0.5	0.0
100 MESH	29.81	29.87	0.5	0.1
150 MESH	16.27	16.25	0.5	-0.0
200 MESH	11.41	11.56	1.0	0.1
270 MESH	7.36	7.25	0.5	-0.1
400 MESH	3.02	3.03	0.5	0.0
500 MESH	2.08	2.13	0.5	0.1

Assays of size fractions for SBMD

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
35 MESH	8.050	8.364	2.000	0.314	100
48 MESH	1.720	3.172	2.000	1.452	100
65 MESH	0.390	0.409	0.100	0.019	100
100 MESH	0.370	0.555	0.200	0.185	100
150 MESH	0.570	0.748	0.200	0.178	100
200 MESH	0.980	1.156	0.500	0.176	100
270 MESH	1.490	1.612	0.500	0.122	100
400 MESH	2.300	2.868	0.600	0.568	100
500 MESH	3.200	3.322	0.500	0.122	100
PAN	1.870	1.741	0.500	-0.129	38

Assays of size fractions for THKUF

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
35 MESH	26.120	7.188	20.000	-18.932	52
48 MESH	8.290	4.803	4.000	-3.487	91
65 MESH	1.160	0.414	0.800	-0.746	61
100 MESH	0.610	0.582	0.100	-0.028	64
150 MESH	0.850	0.822	0.100	-0.028	69
200 MESH	1.220	1.106	0.500	-0.114	62
270 MESH	1.500	1.418	0.500	-0.082	59
400 MESH	2.770	2.496	0.500	-0.274	60
500 MESH	2.930	2.846	0.500	-0.084	59
PAN	2.420	2.476	0.500	0.056	37

Assays of size fractions for THKOF

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
35 MESH	10.180	10.149	1.000	-0.031	48
48 MESH	0.720	0.719	0.100	-0.001	9
65 MESH	0.410	0.402	0.100	-0.008	39
100 MESH	0.530	0.512	0.100	-0.018	36
150 MESH	0.640	0.623	0.100	-0.017	31
200 MESH	1.310	1.248	0.500	-0.062	38
270 MESH	2.050	2.010	0.500	-0.040	41
400 MESH	3.830	3.709	0.500	-0.121	40
500 MESH	4.390	4.351	0.500	-0.039	41
PAN	1.110	1.184	0.500	0.074	8

LUCIEN BELIVEAU T9 GRAVITY CIRCUIT (4:1 silica, avg T7&T8 results)

Residual sum of squares: 2.03993 Final Results

Stream	Absolute Solids Flowrate	Pulp Mass Flowrate Meas	Calc	S.D.	Adjust
1 SBMD	1230.00		1230.0		
2 THKUF	780.00	780.0	780.0	50.0	0.0
3 THKOF	450.00	450.0	450.0	50.0	0.0

Stream	Relative Solids Flowrate
1 SBMD	100.00
2 THKUF	63.41
3 THKOF	36.59

Assay Data

Au oz/t	Meas.	Calc.	Std. Dev.	Adjust.	% Rec
SBMD	0.950	0.999	0.500	0.049	100
THKUF	1.010	0.979	0.500	-0.031	62
THKOF	1.050	1.032	0.500	-0.018	38

Fractional Size Distribution Data

Size	SBMD Meas	Calc	SD.	Adj.	THKUF Meas	Calc	SD.	Adj.
35 MESH	0.35	0.31	0.2	-0.0	0.30	0.32	0.2	0.0
48 MESH	2.17	2.05	0.5	-0.1	1.94	2.02	0.5	0.1
65 MESH	17.21	17.25	0.5	0.0	17.06	17.03	0.5	-0.0
100 MESH	29.78	29.06	1.0	-0.7	28.87	28.98	0.5	0.1
150 MESH	15.32	16.45	2.0	1.1	16.31	16.27	0.5	-0.0
200 MESH	13.31	13.04	2.0	-0.3	13.72	13.89	2.0	0.2
270 MESH	8.50	8.57	0.5	0.1	9.32	9.27	0.5	-0.0
400 MESH	3.89	3.87	0.5	-0.0	4.37	4.38	0.5	0.0
500 MESH	2.65	2.61	0.5	-0.0	2.88	2.91	0.5	0.0

Size	THKOF Meas	Calc	SD.	Adj.
35 MESH	0.30	0.31	0.2	0.0
48 MESH	2.07	2.11	0.5	0.0
65 MESH	17.65	17.63	0.5	-0.0
100 MESH	29.14	29.21	0.5	0.1
150 MESH	16.81	16.78	0.5	-0.0
200 MESH	11.57	11.58	0.5	0.0
270 MESH	7.38	7.35	0.5	-0.0
400 MESH	2.99	3.00	0.5	0.0
500 MESH	2.07	2.09	0.5	0.0

Assays of size fractions for SBMD

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
35 MESH	9.290	9.844	5.000	0.554	100
48 MESH	1.840	2.234	2.000	0.394	100
65 MESH	0.670	0.605	0.500	-0.065	100
100 MESH	0.480	0.481	0.100	0.001	100
150 MESH	0.600	0.617	0.100	0.017	100
200 MESH	0.920	0.932	0.100	0.012	100
270 MESH	1.390	1.450	0.500	0.060	100
400 MESH	2.270	2.467	0.500	0.197	100
500 MESH	3.520	3.563	0.500	0.043	100
PAN	1.810	1.714	0.500	-0.096	39

Assays of size fractions for THKUF

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
35 MESH	13.430	12.013	10.000	-1.417	78
48 MESH	4.430	2.896	5.000	-1.534	81
65 MESH	0.650	0.691	0.500	0.041	72
100 MESH	0.450	0.447	0.200	-0.003	59
150 MESH	0.670	0.572	0.300	-0.098	58
200 MESH	1.030	0.819	0.500	-0.211	59
270 MESH	1.230	1.189	0.500	-0.041	56
400 MESH	2.080	1.939	0.500	-0.141	56
500 MESH	2.990	2.960	0.500	-0.030	59
PAN	2.080	2.124	0.500	0.044	34

Assays of size fractions for THKOF

Au oz/ton	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
35 MESH	6.000	5.992	1.000	-0.008	22
48 MESH	1.150	1.141	0.500	-0.009	19
65 MESH	0.460	0.461	0.100	0.001	28
100 MESH	0.540	0.540	0.100	-0.000	41
150 MESH	0.700	0.694	0.100	-0.006	42
200 MESH	1.270	1.169	0.500	-0.101	41
270 MESH	2.040	2.021	0.500	-0.019	44
400 MESH	3.860	3.804	0.500	-0.056	44
500 MESH	5.070	5.020	1.000	-0.050	41
PAN	1.310	1.361	0.500	0.051	9

Dome Grinding Circuit

Residual sum of squares: 5.588763 Final Results

Stream	Absolute Solids Flowrate	Pulp Mass Flowrate Meas	Calc	S.D.	Adjust
1 rmd	100.00	100.0	100.0	0.0	0.0
2 bmd	361.50		361.5		
3 pof	100.00		100.0		
4 puf	388.57		388.6		
5 jtl	388.57		388.6		
6 rof	27.07	25.0	27.1	10.0	2.1
7 ruf	361.50	350.0	361.5	100.0	11.5

Stream	Relative Solids Flowrate
1 rmd	100.00
2 bmd	361.50
3 pof	100.00
4 puf	388.57
5 jtl	388.57
6 rof	27.07
7 ruf	361.50

Fractional Size Distribution Data

Size	rmd Meas	Calc	SD.	Adj.	bmd Meas	Calc	SD.	Adj.
28 mesh	44.90	44.93	0.5	0.0	9.90	9.99	0.5	0.1
35 mesh	6.10	6.16	0.5	0.1	4.80	5.03	0.5	0.2
48 mesh	6.90	6.79	0.5	-0.1	10.00	9.59	0.5	-0.4
65 mesh	4.70	4.71	0.5	0.0	12.50	12.54	0.5	0.0
100 mesh	4.40	4.32	0.5	-0.1	18.80	18.49	0.5	-0.3
140 mesh	3.10	3.15	0.5	0.0	12.40	12.56	0.5	0.2
200 mesh	2.70	2.74	0.5	0.0	8.20	8.36	0.5	0.2
270 mesh	2.70	2.75	0.5	0.0	5.60	5.77	0.5	0.2
400 mesh	2.10	2.15	0.5	0.1	2.80	2.98	0.5	0.2

Size	pof Meas	Calc	SD.	Adj.	puf Meas	Calc	SD.	Adj.
28 mesh	0.01	0.01	0.1	-0.0	20.70	20.86	0.5	0.2
35 mesh	0.01	0.01	0.1	-0.0	6.20	6.26	0.5	0.1
48 mesh	0.10	0.12	0.2	0.0	10.50	10.64	0.5	0.1
65 mesh	0.50	0.50	0.2	-0.0	12.70	12.77	0.5	0.1
100 mesh	3.00	3.08	0.5	0.1	17.80	17.83	0.5	0.0
140 mesh	6.60	6.55	0.5	-0.0	11.50	11.35	0.5	-0.2
200 mesh	9.40	9.36	0.5	-0.0	6.70	6.70	0.5	0.0
270 mesh	11.20	11.15	0.5	-0.0	3.90	3.90	0.5	-0.0
400 mesh	8.90	8.85	0.5	-0.1	1.70	1.64	0.5	-0.1

Size	jtl Meas	jtl Calc	jtl SD.	jtl Adj.	rof Meas	rof Calc	rof SD.	rof Adj.
28 mesh	20.70	20.86	0.5	0.2	0.01	0.01	0.1	-0.0
35 mesh	6.50	6.26	0.5	-0.2	0.01	0.01	0.1	0.0
48 mesh	10.60	10.64	0.5	0.0	0.10	0.10	0.1	-0.0
65 mesh	13.00	12.77	0.5	-0.2	0.20	0.20	0.1	0.0
100 mesh	18.10	17.83	0.5	-0.3	4.40	4.42	0.5	0.0
140 mesh	11.40	11.35	0.5	-0.1	7.70	7.71	0.5	0.0
200 mesh	6.90	6.70	0.5	-0.2	9.00	9.01	0.5	0.0
270 mesh	3.90	3.90	0.5	-0.0	10.00	10.00	0.5	0.0
400 mesh	1.60	1.64	0.5	0.0	8.50	8.50	0.5	0.0

Size	ruf Meas	ruf Calc	ruf SD.	ruf Adj.
28 mesh	22.80	22.42	0.5	-0.4
35 mesh	6.80	6.73	0.5	-0.1
48 mesh	11.20	11.43	0.5	0.2
65 mesh	13.60	13.71	0.5	0.1
100 mesh	18.30	18.83	0.5	0.5*
140 mesh	11.60	11.62	0.5	0.0
200 mesh	6.50	6.53	0.5	0.0
270 mesh	3.60	3.44	0.5	-0.2
400 mesh	1.30	1.13	0.5	-0.2

DOME GRINDING CIRCUIT (ASSAYS AND SIZE DISTRIBUTION)

Residual sum of squares: 24.33171 Final Results

Stream	Absolute Solids Flowrate	Pulp Mass Flowrate Meas	Calc	S.D.	Adjust
1 RMD	100.00	100.0	100.0	0.0	0.0
2 BMD	360.40		360.4		
3 POF	100.00		100.0		
4 PUF	387.82		387.8		
5 JTL	387.82		387.8		
6 ROF	27.42	25.0	27.4	10.0	2.4
7 RUF	360.40	350.0	360.4	100.0	10.4

Stream	Relative Solids Flowrate
1 RMD	100.00
2 BMD	360.40
3 POF	100.00
4 PUF	387.82
5 JTL	387.82
6 ROF	27.42
7 RUF	360.40

Assay Data

Au, oz/t	Meas.	Calc.	Std. Dev.	Adjust.	% Rec
RMD	0.110	0.095	0.020	-0.015	100
BMD	0.530	0.544	0.050	0.014	2063
POF	0.080	0.095	0.020	0.015	100
PUF	0.490	0.515	0.050	0.025	2103
JTL	0.620	0.515	0.150	-0.105	2103
ROF	0.140	0.140	0.010	-0.000	40
RUF	0.570	0.544	0.050	-0.026	2063

Fractional Size Distribution Data

Size	RMD Meas	Calc	SD.	Adj.	BMD Meas	Calc	SD.	Adj.
28 MESH	44.90	44.92	0.5	0.0	9.90	9.98	0.5	0.1
35 MESH	6.10	6.16	0.5	0.1	4.80	5.03	0.5	0.2
48 MESH	6.90	6.79	0.5	-0.1	10.00	9.59	0.5	-0.4
65 MESH	4.70	4.71	0.5	0.0	12.50	12.55	0.5	0.0
100 MESH	4.40	4.33	0.5	-0.1	18.80	18.54	0.5	-0.3
150 MESH	3.10	3.15	0.5	0.0	12.40	12.57	0.5	0.2
200 MESH	2.70	2.74	0.5	0.0	8.20	8.36	0.5	0.2
270 MESH	2.70	2.75	0.5	0.0	5.60	5.77	0.5	0.2
400 MESH	2.10	2.15	0.5	0.1	2.80	2.98	0.5	0.2

Size	POF Meas	POF Calc	POF SD.	POF Adj.	PUF Meas	PUF Calc	PUF SD.	PUF Adj.
28 MESH	0.01	0.01	0.1	-0.0	20.70	20.85	0.5	0.2
35 MESH	0.01	0.01	0.1	-0.0	6.20	6.26	0.5	0.1
48 MESH	0.10	0.10	0.1	0.0	10.50	10.64	0.5	0.1
65 MESH	0.50	0.50	0.3	-0.0	12.70	12.76	0.5	0.1
100 MESH	3.00	3.07	0.5	0.1	17.80	17.87	0.5	0.1
150 MESH	6.60	6.55	0.5	-0.0	11.50	11.35	0.5	-0.2
200 MESH	9.40	9.36	0.5	-0.0	6.70	6.70	0.5	0.0
270 MESH	11.20	11.15	0.5	-0.0	3.90	3.90	0.5	-0.0
400 MESH	8.90	8.85	0.5	-0.1	1.70	1.65	0.5	-0.1

Size	JTL Meas	JTL Calc	JTL SD.	JTL Adj.	ROF Meas	ROF Calc	ROF SD.	ROF Adj.
28 MESH	20.70	20.85	0.5	0.2	0.01	0.01	0.1	-0.0
35 MESH	6.50	6.26	0.5	-0.2	0.01	0.01	0.1	0.0
48 MESH	10.60	10.64	0.5	0.0	0.10	0.10	0.1	-0.0
65 MESH	13.00	12.76	0.5	-0.2	0.20	0.20	0.1	0.0
100 MESH	18.10	17.87	0.5	-0.2	4.40	4.41	0.5	0.0
150 MESH	11.40	11.35	0.5	-0.1	7.70	7.71	0.5	0.0
200 MESH	6.90	6.70	0.5	-0.2	9.00	9.01	0.5	0.0
270 MESH	3.90	3.90	0.5	-0.0	10.00	10.00	0.5	0.0
400 MESH	1.60	1.65	0.5	0.0	8.50	8.50	0.5	0.0

Size	RUF Meas	RUF Calc	RUF SD.	RUF Adj.
28 MESH	22.80	22.44	0.5	-0.4
35 MESH	6.80	6.74	0.5	-0.1
48 MESH	11.20	11.44	0.5	0.2
65 MESH	13.60	13.72	0.5	0.1
100 MESH	18.30	18.89	0.6	0.6
150 MESH	11.60	11.62	0.5	0.0
200 MESH	6.50	6.52	0.5	0.0
270 MESH	3.60	3.43	0.5	-0.2
400 MESH	1.30	1.12	0.5	-0.2

Assays of size fractions for RMD

Au oz/t	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	0.110	0.109	0.020	-0.001	100
35 MESH	0.260	0.263	0.030	0.003	100
48 MESH	0.210	0.211	0.020	0.001	100
65 MESH	0.120	0.120	0.010	-0.000	100
100 MESH	0.110	0.110	0.010	0.000	100
150 MESH	0.180	0.180	0.020	0.000	100
200 MESH	0.140	0.140	0.010	-0.000	100
270 MESH	0.140	0.140	0.010	0.000	100
400 MESH	0.030	0.030	0.010	-0.000	100
PAN	0.030	0.025	0.050	-0.005	10

Assays of size fractions for BMD

Au oz/t	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	0.370	0.110	0.300	-0.260	81
35 MESH	0.120	0.121	0.010	0.001	135
48 MESH	0.130	0.171	0.050	0.041	413
65 MESH	0.210	0.207	0.020	-0.003	1657
100 MESH	0.270	0.283	0.030	0.013	3965
150 MESH	0.480	0.501	0.050	0.021	4004
200 MESH	1.110	1.078	0.100	-0.032	8455
270 MESH	1.920	1.944	0.200	0.024	10506
400 MESH	0.800	0.638	0.200	-0.162	10657
PAN	0.800	0.704	0.150	-0.096	1332

Assays of size fractions for POF

Au oz/t	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	0.000	0.000	0.000	0.000	0
35 MESH	0.000	-0.000	0.000	-0.000	-0
48 MESH	0.000	-0.000	0.000	-0.000	-0
65 MESH	0.000	0.000	0.000	0.000	0
100 MESH	0.370	0.369	0.040	-0.001	238
150 MESH	0.100	0.100	0.010	-0.000	115
200 MESH	0.110	0.110	0.010	0.000	268
270 MESH	0.060	0.060	0.010	-0.000	174
400 MESH	0.100	0.100	0.010	0.000	1380
PAN	0.050	0.246	0.200	0.196	382

Assays of size fractions for PUF

Au oz/t	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	0.200	0.109	0.100	-0.091	181
35 MESH	0.290	0.157	0.200	-0.133	235
48 MESH	0.200	0.178	0.050	-0.022	513
65 MESH	0.250	0.201	0.050	-0.049	1757
100 MESH	0.260	0.265	0.030	0.005	3848
150 MESH	0.460	0.516	0.060	0.056	4007
200 MESH	1.170	1.231	0.100	0.061	8326
270 MESH	1.800	2.686	0.950	0.886	10560
400 MESH	0.800	1.069	0.300	0.269	10606
PAN	0.800	0.804	0.060	0.004	903

Assays of size fractions for JTL

Au oz/t	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	0.110	0.109	0.020	-0.001	181
35 MESH	0.210	0.157	0.060	-0.053	235
48 MESH	0.190	0.178	0.040	-0.012	513
65 MESH	0.200	0.201	0.030	0.001	1757
100 MESH	0.260	0.265	0.030	0.005	3848
150 MESH	0.540	0.516	0.050	-0.024	4007
200 MESH	1.200	1.231	0.100	0.031	8326
270 MESH	2.960	2.686	0.600	-0.274	10560
400 MESH	6.620	1.069	6.000	-5.551	10606
PAN	2.690	0.804	2.000	-1.886	903

Assays of size fractions for ROF

Au oz/t	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	0.000	0.000	0.000	0.000	0
35 MESH	0.000	0.000	0.000	0.000	0
48 MESH	0.000	0.000	0.000	0.000	0
65 MESH	0.000	0.000	0.000	0.000	0
100 MESH	0.080	0.080	0.010	-0.000	20
150 MESH	0.050	0.050	0.010	-0.000	19
200 MESH	0.060	0.060	0.010	-0.000	39
270 MESH	0.180	0.180	0.020	-0.000	128
400 MESH	0.340	0.339	0.030	-0.001	1228
PAN	0.130	0.130	0.030	-0.000	53

Assays of size fractions for RUF

Au oz/t	Meas.	Calc.	Std. Dev.	Adjustment	%Rec
28 MESH	0.080	0.109	0.040	0.029	181
35 MESH	0.020	0.157	0.200	0.137	235
48 MESH	0.180	0.178	0.020	-0.002	513
65 MESH	0.190	0.201	0.020	0.011	1757
100 MESH	0.290	0.268	0.030	-0.022	3828
150 MESH	0.590	0.540	0.060	-0.050	3989
200 MESH	1.520	1.354	0.170	-0.166	8287
270 MESH	3.500	3.241	0.700	-0.259	10432
400 MESH	1.500	1.489	0.200	-0.011	9378
PAN	0.800	1.561	0.900	0.761	1113

DOME GRINDING & GRAVITY CIRCUIT (ASSAYS AND SIZE DISTRIBUTION)

Residual sum of squares: 10.80831 Final Results

Stream	Absolute Solids Flowrate	Pulp Mass Flowrate Meas	Calc	S.D.	Adjust
1 RMD	100.00	100.0	100.0	0.0	0.0
2 BMD	365.78		365.8		
3 POF	99.98		100.0		
4 PUF	390.37		390.4		
5 JTL	390.36		390.4		
6 ROF	24.57	25.0	24.6	10.0	-0.4
7 RUF	365.78	350.0	365.8	100.0	15.8
8 JGC	0.02	20.0	0.0	10.0	-20.0*

Stream	Relative Solids Flowrate
1 RMD	100.00
2 BMD	365.78
3 POF	99.98
4 PUF	390.37
5 JTL	390.36
6 ROF	24.57
7 RUF	365.78
8 JGC	0.02

Assay Data

Au, oz/t	Meas.	Calc.	Std. Dev.	Adjust.	% Rec
RMD	0.110	0.109	0.020	-0.001	100
BMD	0.530	0.540	0.050	0.010	1817
POF	0.080	0.081	0.020	0.001	75
PUF	0.490	0.522	0.050	0.032	1874
JTL	0.620	0.515	0.150	-0.105	1848
ROF	0.140	0.140	0.010	-0.000	32
RUF	0.570	0.540	0.050	-0.030	1817
JGC	162.710	162.690	20.000	-0.020	25

Fractional Size Distribution Data

Size	RMD Meas	RMD Calc	RMD SD.	RMD Adj.	BMD Meas	BMD Calc	BMD SD.	BMD Adj.
28 MESH	44.90	44.93	0.5	0.0	9.90	10.02	0.5	0.1
35 MESH	6.10	6.16	0.5	0.1	4.80	5.02	0.5	0.2
48 MESH	6.90	6.78	0.5	-0.1	10.00	9.57	0.5	-0.4
65 MESH	4.70	4.70	0.5	0.0	12.50	12.51	0.5	0.0
100 MESH	4.40	4.32	0.5	-0.1	18.80	18.49	0.5	-0.3
150 MESH	3.10	3.14	0.5	0.0	12.40	12.55	0.5	0.1
200 MESH	2.70	2.74	0.5	0.0	8.20	8.35	0.5	0.2
270 MESH	2.70	2.75	0.5	0.0	5.60	5.77	0.5	0.2
400 MESH	2.10	2.15	0.5	0.1	2.80	2.99	0.5	0.2

Size	POF Meas	POF Calc	POF SD.	POF Adj.	PUF Meas	PUF Calc	PUF SD.	PUF Adj.
28 MESH	0.01	0.01	0.1	-0.0	20.70	20.90	0.5	0.2
35 MESH	0.01	0.01	0.1	-0.0	6.20	6.28	0.5	0.1
48 MESH	0.10	0.10	0.1	0.0	10.50	10.68	0.5	0.2
65 MESH	0.50	0.50	0.3	-0.0	12.70	12.81	0.5	0.1
100 MESH	3.00	3.08	0.5	0.1	17.80	17.92	0.5	0.1
150 MESH	6.60	6.56	0.5	-0.0	11.50	11.37	0.5	-0.1
200 MESH	9.40	9.36	0.5	-0.0	6.70	6.70	0.5	-0.0
270 MESH	11.20	11.15	0.5	-0.0	3.90	3.88	0.5	-0.0
400 MESH	8.90	8.85	0.5	-0.1	1.70	1.62	0.5	-0.1

Size	JTL Meas	JTL Calc	JTL SD.	JTL Adj.	ROF Meas	ROF Calc	ROF SD.	ROF Adj.
28 MESH	20.70	20.90	0.5	0.2	0.01	0.01	0.1	-0.0
35 MESH	6.50	6.28	0.5	-0.2	0.01	0.01	0.1	0.0
48 MESH	10.60	10.68	0.5	0.1	0.10	0.10	0.1	-0.0
65 MESH	13.00	12.81	0.5	-0.2	0.20	0.20	0.1	0.0
100 MESH	18.10	17.92	0.5	-0.2	4.40	4.40	0.5	0.0
150 MESH	11.40	11.37	0.5	-0.0	7.70	7.71	0.5	0.0
200 MESH	6.90	6.70	0.5	-0.2	9.00	9.01	0.5	0.0
270 MESH	3.90	3.88	0.5	-0.0	10.00	10.00	0.5	0.0
400 MESH	1.60	1.62	0.5	0.0	8.50	8.50	0.5	0.0

Size	RUF Meas	RUF Calc	RUF SD.	RUF Adj.	JGC Meas	JGC Calc	JGC SD.	JGC Adj.
28 MESH	22.80	22.30	0.5	-0.5	51.57	51.57	0.5	-0.0
35 MESH	6.80	6.70	0.5	-0.1	10.07	10.07	0.5	-0.0
48 MESH	11.20	11.39	0.5	0.2	9.85	9.85	0.5	0.0
65 MESH	13.60	13.66	0.5	0.1	7.83	7.83	0.5	-0.0
100 MESH	18.30	18.83	0.6	0.5	8.85	8.85	0.5	0.0
150 MESH	11.60	11.61	0.5	0.0	6.33	6.33	0.5	-0.0
200 MESH	6.50	6.54	0.5	0.0	3.45	3.45	0.5	-0.0
270 MESH	3.60	3.47	0.5	-0.1	1.29	1.29	0.5	-0.0
400 MESH	1.30	1.16	0.5	-0.1	0.31	0.31	0.2	-0.0