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Mining District File Summary Sheet

DISTRICT	Rosebud
DIST_NO	4010
COUNTY If different from written on document	Pershing
TITLE If not obvious	Rosebud Mine - Mine Development Associates Reports
AUTHOR	K. Allen; C. Muerhoff
DATE OF DOC(S)	1999
MULTI_DIST Y / [✓ N?] Additional Dist_Nos:	
QUAD_NAME	Sulphur 7.5'
P_M_C_NAME (mine, claim & company names)	Rosebud Mine; Mine Development Associates Hecla Mining Co.; North Zone
COMMODITY If not obvious	gold
NOTES	correspondence, mine report; geology resources; production 14p.

Keep docs at about 250 pages if no oversized maps attached
(for every 1 oversized page (>11x17) with text reduce
the amount of pages by ~25)

SS: DD 3/20/08
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Revised: 1/22/08

MDA Reports

Cindy

MINE DEVELOPMENT ASSOCIATES
MINE ENGINEERING SERVICES

Memorandum to: Kurt Allen
Hecla Mining Company

From: Charlie Muerhoff

Subject: Rosebud North Zone Review and Recommendations

Date: December 23, 1999

Executive Summary

At the request of Hecla Mining Company (Hecla), Mine Development Associates (MDA) performed a review of the North Zone geology and resource models, grade control practices, and production data in order to understand the reasons for a reported production shortfall from the North Zone.

It is important to note that the production shortfall of 30% currently reported by Hecla is relative to the Measured, Indicated, and Inferred Model; ore production to date is only slightly less than that predicted by the Proven and Probable reserve model in most areas of the North Zone, and in some instances, ore production has even exceeded the resource predicted by the Measured, Indicated, and Inferred model. While some of the production shortfall is due to the over-extrapolation of ore grades in the model, MDA believes that the majority of the shortfall could have been avoided by addressing the items listed below. Therefore, MDA does not recommend downgrading the resource/reserve because of the discrepancy between the production and the model.

After a review of all the data, MDA believes the avoidable portion of the production shortfall was due to:

- ineffective grade control practices;
- inappropriate mine scheduling procedures; and
- poor communication between the geology, engineering, and mining departments.

The unavoidable portion of the production shortfall was caused by:

- resource model / real world discrepancies;

MDA believes that, as production becomes increasingly dependent on the North Zone, the ore production rate is likely to decrease, even though the mining rate does not. This is due to the discontinuous nature of the ore resulting in increased waste internal to the stope. However, by

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optimizing the number of available faces, improving grade control procedures, refining the mine schedule, and increasing the level of communication and coordination between the geology, engineering, and mining departments, MDA believes the ore production rate can be maximized and the in-stope ore losses minimized.

Introduction

Mine Development Associates (MDA) was asked by Hecla Mining Company (Hecla) to review the Rosebud North Zone geology, resource/reserve model, grade control practices, and production data and make appropriate recommendations. The reason for the review is the reported production shortfall from the North Zone of approximately 30% in tons and gold ounces, as compared to the resource/reserve model. In addition, Hecla requested that MDA complete a review of the January, 2000 North Zone resource and reserve.

We have discussed most of the following items, and some of the recommendations have already been implemented, but for completeness, they are reiterated in this report.

Geology and Resource Model

The geology and resource models of the North Zone were constructed from drill data (>90% core) and utilized geologic ore controls (structure and stratigraphy) documented from mining in the South Zone. While the modeled ore controls have been verified by mining, recent experience in the North Zone has demonstrated that ore grade mineralization is often considerably less continuous than modeled.

For the most part, ore grade mineralization is strongly concentrated along, and proximal to, north- to northeast-trending, low- to high-angle fracture sets. However, contrary to the resource model, ore grades are much more discontinuous along strike of these structures, and ore widths associated with the structures are considerably less than modeled. Stratigraphy continues to play a strong role in the localizing of ore grades, but rather than acting as a host for disseminated mineralization (as modeled and as seen in the South Zone), certain stratigraphic units in the North Zone are documented as being receptive hosts to mineralized stockwork, fractures, and joint sets. For example, the lower portion of the planar-laminated flows, where in contact with vitrophyre or vitrophryic breccia, appears to be especially amenable to stockwork ore-grade mineralization, though there is little dissemination of gold into the flow itself.

Expanding and updating the working model for the North Zone to include all of the geologic and assay data accumulated to date is essential for successfully mining the remainder of the zone. It is critical that subsequent mine planning incorporate the ‘real world’ ore controls and mineral distribution patterns, rather than rely on the resource model. Given the limited amount of material remaining in the North Zone, MDA believes increasing the understanding of ore controls, improving grade control practices, and modifying the mine plan accordingly is crucial to the success of the North Zone.

Resource & Reserve

MDA performed an independent review and tabulation of the 2000 North Zone Measured and Indicated (M&I) resource that, when dilution and mining loss are applied, will form the basis for the North Zone

Proven and Probable reserve. MDA received from Rosebud the 3-D block model (7 x 7 x 14 ft) and 3-D solids of the mine/stope designs and the as-built stopes. Blocks inside the as-built stope solids were removed from the model and the blocks above cut off (0.18 oz Au/t) remaining inside the stope design solids were tabulated by level. In contrast, Rosebud assigned a mining code to each block in the model and, on a monthly basis, changed that code to reflect production. The material above cut off within the stope design solids that had not been 'tagged' as mined-out was then tabulated by level. A comparison of the two tabulations is presented in Table 1.

Table 1. Comparison of North Zone M&I Resource (full blocks)
M&I Material >= 0.18 oz Au/t within stope design & outside as-builts

			Rosebud			MDA			% Difference	
Stope	Level	Tons	oz Au/t	AuOz	Tons	oz Au/t	AuOz	Tons	oz Au/t	AuOz
34	4301		mined out							
34	4315	1,839	0.412	758	1,840	0.412	758	0.1%	0.0%	0.0%
34	4329	3,927	0.372	1,461	3,979	0.369	1,468	1.3%	-0.8%	0.5%
34	4343	8,450	0.409	3,456	8,455	0.409	3,458	0.1%	0.0%	0.1%
34	4357	9,246	0.319	2,949	9,300	0.319	2,967	0.6%	0.0%	0.6%
34	4371	9,096	0.316	2,874	9,151	0.315	2,883	0.6%	-0.3%	0.3%
33	4385	3,380	0.275	930	3,481	0.269	936	3.0%	-2.2%	0.7%
33	4399	4,715	0.297	1,400	4,178	0.297	1,241	-11.4%	0.0%	-11.4%
33	4413	11,731	0.407	4,775	12,036	0.405	4,875	2.6%	-0.5%	2.1%
33	4427	9,544	0.428	4,085	9,748	0.423	4,123	2.1%	-1.2%	0.9%
33	4441	9,743	0.320	3,118	10,146	0.319	3,237	4.1%	-0.3%	3.8%
33	4455	8,251	0.348	2,871	8,256	0.348	2,873	0.1%	0.0%	0.1%
32	4469		mined out							
32	4483	2,585	0.350	905	2,686	0.347	932	3.9%	-0.9%	3.0%
32	4497	4,623	0.386	1,784	4,824	0.381	1,838	4.3%	-1.3%	3.0%
32	4511	4,424	0.380	1,681	4,277	0.368	1,574	-3.3%	-3.2%	-6.4%
32	4525	5,816	0.459	2,670	5,819	0.459	2,671	0.1%	0.0%	0.0%
32	4539	5,020	0.689	3,459	5,371	0.721	3,872	7.0%	4.6%	12.0%
31	4553		mined out							
31	4567		mined out							
31	4581		mined out							
31	4595	1,541	0.484	746	1,592	0.478	761	3.3%	-1.3%	2.0%
31	4609	1,243	0.619	769	1,293	0.603	780	4.0%	-2.5%	1.4%
31	4623	398	0.352	140	398	0.352	140	0.0%	0.1%	0.1%
Totals		105,572	0.387	40,831	106,830	0.387	41,387	1.2%	0.2%	1.4%

Given that the resource was tabulated using different methods, the results compare favorably, with an overall difference of 1.2% tons, 0.2% gold grade, and 1.4% gold ounces. Individually, all of the levels compared well, with two exceptions. There are moderate discrepancies between the two tabulations for 33-4399, the majority of which has been mined and 32-4539. While the gold grades of the two tabulations are identical for stope 33-4399, Rosebud reports 11% more tons and gold ounces than MDA; for stope 32-4539, Rosebud reports 7% fewer tons, 5% less gold grade, and 12% fewer gold ounces than MDA. Although the differences between the tabulations of these two levels are minimal in terms of tons and gold ounces (and nearly offset each other), the discrepancies should be investigated to ensure model blocks are being coded properly.

It should be noted that the comparisons in Tables 2a. and 2b. include ore grade material that was left behind in several of the levels after mining was finished (34-4315, 33-4385, 33-4399, 32-4483). Where feasible, Hecla is planning to extract as much of this material as possible from adjacent levels (breast-up or backstope). With the successful extraction of those ore tons, the discrepancy between the models and the mine will decrease.

Rosebud had reported that mining in the North Zone produced substantially less ore than modeled. Therefore, in addition to performing a check of the Measured and Indicated resource, MDA was asked to evaluate the geologic model, resource model, and production data and comment on the remaining North Zone reserves. The production data used for this comparison (and throughout this report) are taken from the Rosebud month-end production reports, which track the grade of each stope round; grades are assigned to individual rounds based on the weighted-average face and rib samples. Examination of the production data and model data shows that mining produced 6% fewer ore tons and 17% fewer gold ounces than predicted by the Measured and Indicated model (Table 2a.). Compared to the Measured, Indicated, and Inferred (MI&I) model, mining has produced 26% fewer ore tons and 33% fewer gold ounces than predicted (Table 2b.).

Sample assay maps, geologic maps, block model plan maps, and production records from each level of the North Zone were examined. Below stope 31, four of the six levels mined out-performed the Measured and Indicated (e.g., Proven and Probable) model and it appears that the majority of the Measured and Indicated tonnage remaining in stopes 33-4399 and 32-4483 will be recovered by breasting up from subsequent levels. Ore production exceeded the Measured, Indicated, and Inferred material above cut off on two of the six mined-out levels. Stope 34-4329 was excluded from the analysis, since it was only 50% (±) completed at the end of November. It is important to note that, while the Measured and Indicated model is performing well below stope 31, in terms of overall tons and gold ounces, the continuity of ore grade mineralization is considerably less than modeled. As a result, more sub-ore grade material is being mined in order to maximize extraction of ore grade material (discussed further in this report).

Table 2a. Comparison of Ore Production to Predicted Ore
(Measured & Indicated Block Model)

Stope	Level	Ore Production (rounds >= 0.18 oz Au/t)			M&I inside mine design (blocks >= 0.18 oz Au/t)			% Difference		
		Tons	oz Au/t	AuOz	Tons	oz Au/t	AuOz	Tons	oz Au/t	AuOz
34	4301	616	0.235	145	348	0.207	72	77%	14%	101%
34	4315	2,719	0.465	1,263	2,387	0.390	931	14%	19%	36%
34	4329	mining in progress			mining in progress			mining in progress		
33	4385	12,714	0.346	4,399	11,190	0.293	3,279	14%	18%	34%
33	4399	10,293	0.356	3,666	11,787	0.357	4,208	-13%	0%	-13%
32	4469	7,983	0.376	2,998	5,570	0.330	1,838	43%	14%	63%
32	4483	3,754	0.296	1,112	5,620	0.392	2,203	-33%	-24%	-50%
31	4553	3,354	0.374	1,255	4,725	0.859	4,059	-29%	-56%	-69%
31	4567	1,385	0.318	440	3,233	0.574	1,856	-57%	-45%	-76%
31	4581	1,551	0.558	866	2,387	0.469	1,120	-35%	19%	-23%
Totals		44,368	0.364	16,144	47,247	0.414	19,565	-6%	-12%	-17%

Table 2b. Comparison of Ore Production to Predicted Ore (Measured, Indicated, & Inferred Block Model)

		Ore Production			MI&I inside mine design					
Stope	Level	(rounds >= 0.18 oz Au/t)			(blocks >= 0.18 oz Au/t)			% Difference		
		Tons	oz Au/t	AuOz	Tons	oz Au/t	AuOz	Tons	oz Au/t	AuOz
34	4301	616	0.235	145	1,542	0.243	375	-60%	-3%	-61%
34	4315	2,719	0.465	1,263	2,984	0.387	1,155	-9%	20%	9%
34	4329	mining in progress			mining in progress			mining in progress		
33	4385	12,714	0.346	4,399	12,682	0.306	3,881	0%	13%	13%
33	4399	10,293	0.356	3,666	12,583	0.352	4,429	-18%	1%	-17%
32	4469	7,983	0.376	2,998	7,361	0.319	2,348	8%	18%	28%
32	4483	3,754	0.296	1,112	9,400	0.357	3,356	-60%	-17%	-67%
31	4553	3,354	0.374	1,255	5,371	0.817	4,388	-38%	-54%	-71%
31	4567	1,385	0.318	440	4,576	0.540	2,471	-70%	-41%	-82%
31	4581	1,551	0.558	866	3,432	0.489	1,678	-55%	14%	-48%
Totals		44,368	0.364	16,144	59,931	0.402	24,081	-26%	-9%	-33%

To date, production from stope 31 has produced 40% fewer tons at 40% less grade, for 64% fewer gold ounces (above cut off), as compared to the Measured and Indicated model. Compared to the Measured, Indicated, and Inferred model, 53% fewer tons at 36% less grade, for 70% fewer gold ounces (above cut off), were produced from stope 31. If stope 31 is removed from the overall comparison of mine to model, mining in the North Zone produced 3% more ore tons and 8% more gold ounces than predicted by the Measured and Indicated model, and 18% fewer ore tons and 13% fewer gold ounces than contained in the Measured, Indicated and Inferred model.

It is interesting to note that, of the levels mined below stope 31, the three most successful levels (in terms of ore production compared to modeled ore) are the initial subdrift cuts of each stope (32, 33, and 34). These three cuts were mined with the intention of exploring the extents of the model on those particular levels. MDA believes the success of these three levels, relative to subsequent levels, is not as much a function of the geology as it is a function of the willingness of all those involved to mine beyond areas of sub-ore grade material internal to the overall ore grade envelope. The discontinuous, often sporadic, nature of the North Zone mineralization may dictate this same approach on subsequent levels in order to maximize ore extraction.

In an effort to determine the reasons for the production shortfall in stope 31, and to assess the potential impacts to the remaining resource/reserve, MDA conducted a detailed review of geology, assay, gold domain, and block model level maps and sections. Ore grade mineralization appears to be tightly concentrated along northeast-trending structures with limited strike continuity. Although the majority of sampling to date in stope 31 has been done by random chip sampling of quartered faces, which is not suitable for determining geologic ore controls, it appears that there is very little dissemination of gold into the host rocks. Geologic modeling, for the most part, had accurately determined the location and orientation of the controlling structures. However, the continuity and thickness of ore grades associated with these structures, and the degree of dissemination into the host rocks, were significantly over-estimated when modeling the resource.

This does not imply the remaining resource/reserve for stope 31 should be reduced. Throughout the first three levels mined, the 'core' of the ore grade zone has remained fairly consistent, with production shortfalls due to the over-extrapolation of ore grades along strike, exaggerated ore widths (for both structure and stratigraphy), and reduced gold grades (on a SMU basis). Ore grade material on the remaining three levels (totaling 3300 tons) is situated along the up-dip projection of the 'core' area, with little to no ore projected into areas that failed to meet expectations on the first three levels. Also, despite the significant discrepancy between mined grades and modeled grades (-52%) on the first two levels of stope 31, ore production from the most recent cut (31-4581) averaged 19% higher in grade than modeled (M&I). In other words, the data suggests the problems experienced in stope 31 on the first three levels may not be indicative of the next three levels.

Given the relatively good comparison, overall, between production and the Measured and Indicated model below stope 31, and the reasons cited above for stope 31, MDA recommends that no adjustments be made to the Measured and Indicated resource for January, 2000 reporting. Likewise, no adjustments are necessary to the North Zone Proven and Probable reserve, with the exception of updating the dilution and mining recovery factors applied to the Measured and Indicated model within the designed stopes.

Reconciliation

MDA believes the current practice of reconciling within the as-built stope outlines is providing an erroneous comparison of the mine to the model. On several of the monthly reconciliation reports reviewed, it appeared that mining was outperforming the model (MI&I) by a considerable amount. However, upon further examination, it became clear that mining had, in fact, produced less ore tons than predicted by the model for that level, but due to a difference in location of the model blocks (as compared to the mined areas), they were not included within the as-built tabulation. Tabulation of ore, sub-grade, and waste within the as-built stope outlines should be used to evaluate grade control and mining practices; for a true mine-to-model reconciliation, the designed stope outlines (e.g., proven and probable reserves) should be compared to the as-built stope outlines after each individual level is mined out.

MDA recommends that Hecla complete a reconciliation (as described above) immediately upon the completion of any given level. Tabulate and evaluate a.) reserves/resources expected to be mined, b.) reserves/resources expected, but not mined, and c.) ore not expected, but mined. With updated geology maps, assay maps, and production data, the mine geologists should meet with the mine planning engineer(s), superintendent, and shift bosses to discuss the findings, with the intention of using the data to optimize mining on the next level.

When performing a reconciliation of mine to model, it should always be made clear what production is being compared to – the Proven and Probable reserve, or the combined Measured, Indicated, (Proven and Probable) and Inferred model. Currently, Hecla reconciles production to the Measured, Indicated, and Inferred model, since it is that model on which the mine plan is based. MDA recommends that reconciliations be completed using both models. In addition to production accounting, use the level reconciliations as a tool for optimizing the next cut and forecasting production.

Production and Scheduling

Rosebud currently designs stopes based on the Measured, Indicated, and Inferred model. This is the appropriate approach to mine planning, but the amount of Inferred material and the amount of sub-ore grade material included in the mine plan should be considered when scheduling and forecasting production rates.

MDA tabulated the amount of material extracted above and below the cut off grade from each of the mined levels. The compilation was done using all available production data provided by Hecla, and excludes development tonnage, but includes in-stope waste tonnage. Overall, 35% of the tons mined and shipped to the mill from the North Zone during 1999 were below the economic cut off (Table 3a.) and 48% of the total tons mined were below the economic cut off (Table 3b.). While some of these tons are a result of grade control difficulties, mining rate, miscommunication, and misclassification, the majority of these tons were mined in order to extract the ore tons. The amount of waste internal to each stope reflects the discontinuous and sporadic nature of the mineralization in the North Zone.

Tables 4a. and 4b. are tabulations of total tons and ore tons remaining in the Measured and Indicated and Measured, Indicated, and Inferred models (e.g., with 1999 production excluded), excluding development tons and including in-stope waste tons. The Measured and Indicated model predicts 47% of the tons that will be mined in the remaining levels are below the economic cut off grade; this total is reduced to 34% of the total tons when the mine plan is compared to the Measured, Indicated, and Inferred model.

It appears that much of the internal waste/sub-ore tonnage has been excluded from the production schedule. If so, the time estimates for completing these levels, and the ore production rates forecasted for these levels could be unrealistic if all of the ore tons are extracted. The exclusion of the internal waste tons from the schedule may also inadvertently cause mining to be stopped prematurely on any given level, since mining and backfill cycles in all of the stopes are interdependent. Based on Hecla's past mining experience in the North Zone, MDA recommends that all waste tons internal to the stopes be incorporated into the mine planning and production scheduling.

Table 3a. Rosebud North Zone - 1999 Production - Material Shippped as Ore

		Rounds Shipped as Ore (regardless of grade)					Rounds >= 0.18 ozAu/t					Rounds < 0.18 ozAu/t Shipped as Ore							
Stope	Level	Tons	ozAu/t	ozAg/t	AuOz	AgOz	Tons	ozAu/t	ozAg/t	AuOz	AgOz	Tons	ozAu/t	ozAg/t	AuOz	AgOz	%Tons	%AuOz	%AgOz
34	4301	616	0.235	1.76	145	1,083	616	0.235	1.76	145	1,083	0			0	0	0%	0%	0%
34	4315	3,277	0.395	0.49	1,293	1,612	2,719	0.465	0.56	1,263	1,525	559	0.053	0.16	30	87	17%	2%	5%
34	4329	4,371	0.199	0.40	872	1,731	2,161	0.281	0.49	608	1,056	2,210	0.120	0.31	264	675	51%	30%	39%
33	4385	18,923	0.273	0.57	5,157	10,852	12,714	0.346	0.60	4,399	7,676	6,210	0.122	0.51	758	3,176	33%	15%	29%
33	4399	16,454	0.265	1.00	4,353	16,378	10,293	0.356	1.10	3,666	11,310	6,162	0.112	0.82	687	5,069	37%	16%	31%
32	4469	11,321	0.293	0.41	3,315	4,628	7,983	0.376	0.50	2,998	3,963	3,338	0.095	0.20	317	664	29%	10%	14%
32	4483	6,046	0.225	0.36	1,359	2,204	3,754	0.296	0.43	1,112	1,620	2,292	0.108	0.25	247	584	38%	18%	26%
31	4553	5,531	0.257	0.37	1,421	2,021	3,354	0.374	0.52	1,255	1,740	2,177	0.076	0.13	166	281	39%	12%	14%
31	4567	2,859	0.201	0.26	573	745	1,385	0.318	0.39	440	534	1,474	0.091	0.14	134	212	52%	23%	28%
31	4581	2,182	0.421	0.60	920	1,308	1,551	0.558	0.75	866	1,160	631	0.086	0.23	54	148	29%	6%	11%
Totals		71,582	0.271	0.59	19,408	42,563	46,529	0.360	0.68	16,752	31,667	25,052	0.106	0.43	2,657	10,897	35%	14%	26%

Table 3b. Rosebud North Zone - 1999 Production - All In-Stope Material

		All In-Stope Rounds					Rounds >= 0.18 ozAu/t					In-Stope Rounds < 0.18 ozAu/t							
Stope	Level	Tons	ozAu/t	ozAg/t	AuOz	AgOz	Tons	ozAu/t	ozAg/t	AuOz	AgOz	Tons	ozAu/t	ozAg/t	AuOz	AgOz	%Tons	%AuOz	%AgOz
34	4301	616	0.235	0.23	145	1,083	616	0.235	1.76	145	1,083	0			0	0	0%	0%	0%
34	4315	3,908	0.350	0.45	1,368	1,753	2,719	0.465	0.56	1,263	1,525	1,190	0.088	0.19	105	228	30%	8%	13%
34	4329	4,623	0.193	0.39	894	1,801	2,161	0.281	0.49	608	1,056	2,462	0.116	0.30	287	746	53%	32%	41%
33	4385	21,901	0.241	0.52	5,284	11,429	12,714	0.346	0.60	4,399	7,676	9,187	0.096	0.41	885	3,754	42%	17%	33%
33	4399	19,675	0.231	0.88	4,539	17,331	10,293	0.356	1.10	3,666	11,310	9,383	0.093	0.64	873	6,021	48%	19%	35%
32	4469	15,003	0.239	0.34	3,590	5,120	7,983	0.376	0.50	2,998	3,963	7,020	0.084	0.16	591	1,157	47%	16%	23%
32	4483	7,841	0.186	0.30	1,456	2,389	3,754	0.296	0.43	1,112	1,620	4,087	0.084	0.19	344	770	52%	24%	32%
31	4553	9,385	0.171	0.25	1,605	2,340	3,354	0.374	0.52	1,255	1,740	6,031	0.058	0.10	350	600	64%	22%	26%
31	4567	4,147	0.166	0.23	688	972	1,385	0.318	0.39	440	534	2,762	0.090	0.16	248	439	67%	36%	45%
31	4581	2,268	0.406	0.58	921	1,321	1,551	0.558	0.75	866	1,160	717	0.077	0.22	55	161	32%	6%	12%
Totals		89,368	0.229	0.51	20,489	45,540	46,529	0.360	0.68	16,752	31,667	42,838	0.087	0.32	3,737	13,874	48%	18%	30%

Table 4a. Rosebud - North Zone

Tabulation of Measured & Indicated Resource Inside Stope Design, as of Dec. 1, 1999 (including in-stope waste; excluding development)

		All In-Stope Material			Material >=0.18 ozAu/t					Material <0.18 ozAu/t				
Stope	Level	Tons	ozAu/t	AuOz	Tons	ozAu/t	AuOz	% Tons	% AuOz	Tons	ozAu/t	AuOz	% Tons	% AuOz
34	4301		mined out											
34	4315	2,685	0.308	827	1,840	0.412	758	69%	92%	845	0.081	68	31%	8%
34	4329	5,968	0.280	1,671	3,979	0.369	1,468	67%	88%	1,989	0.102	203	33%	12%
34	4343	13,976	0.289	4,043	8,455	0.409	3,458	60%	86%	5,521	0.106	585	40%	14%
34	4357	16,263	0.231	3,760	9,300	0.319	2,967	57%	79%	6,963	0.114	794	43%	21%
34	4371	17,607	0.212	3,735	9,102	0.316	2,876	52%	77%	8,505	0.101	859	48%	23%
33	4385	8,504	0.157	1,333	3,481	0.269	936	41%	70%	5,023	0.079	397	59%	30%
33	4399	7,262	0.217	1,577	4,178	0.297	1,241	58%	79%	3,084	0.109	336	42%	21%
33	4413	18,700	0.292	5,466	11,737	0.407	4,777	63%	87%	6,963	0.099	689	37%	13%
33	4427	17,656	0.274	4,839	9,649	0.426	4,110	55%	85%	8,007	0.091	729	45%	15%
33	4441	19,645	0.209	4,100	10,096	0.320	3,231	51%	79%	9,549	0.091	869	49%	21%
33	4455	15,766	0.232	3,662	8,256	0.348	2,873	52%	78%	7,510	0.105	789	48%	22%
32	4469		mined out											
32	4483	8,853	0.146	1,290	2,686	0.347	932	30%	72%	6,167	0.058	358	70%	28%
32	4497	11,389	0.194	2,206	4,824	0.381	1,838	42%	83%	6,565	0.056	368	58%	17%
32	4511	10,146	0.200	2,032	4,277	0.368	1,574	42%	77%	5,869	0.078	458	58%	23%
32	4525	11,190	0.271	3,036	5,819	0.459	2,671	52%	88%	5,371	0.068	365	48%	12%
32	4539	9,051	0.460	4,167	5,371	0.721	3,872	59%	93%	3,680	0.080	294	41%	7%
31	4553		mined out											
31	4567		mined out											
31	4581		mined out											
31	4595	3,184	0.270	858	1,592	0.478	761	50%	89%	1,592	0.061	97	50%	11%
31	4609	1,890	0.444	839	1,293	0.603	780	68%	93%	597	0.100	60	32%	7%
31	4623	1,343	0.126	169	398	0.352	140	30%	83%	945	0.031	29	70%	17%
Totals		201,078	0.247	49,611	106,333	0.388	41,264	53%	83%	94,745	0.088	8,347	47%	17%

Table 4b. Rosebud - North Zone

Tabulation of Measured, Indicated, and Inferred Resource Inside Stope Design, as of Dec. 1, 1999 (including in-stope waste; excluding development)

		All In-Stope Material			Material >=0.18 ozAu/t					Material <0.18 ozAu/t				
Stope	Level	Tons	ozAu/t	AuOz	Tons	ozAu/t	AuOz	% Tons	% AuOz	Tons	ozAu/t	AuOz	% Tons	% AuOz
34	4301	mined out												
34	4315	2,736	0.344	941	2,139	0.412	881	78%	94%	597	0.100	60	22%	6%
34	4329	5,968	0.287	1,711	4,178	0.362	1,512	70%	88%	1,790	0.111	199	30%	12%
34	4343	14,075	0.300	4,217	9,300	0.398	3,701	66%	88%	4,775	0.108	516	34%	12%
34	4357	16,264	0.243	3,956	10,196	0.316	3,222	63%	81%	6,068	0.121	734	37%	19%
34	4371	17,656	0.246	4,335	11,091	0.321	3,560	63%	82%	6,565	0.118	775	37%	18%
33	4385	4,354	0.250	1,087	3,879	0.269	1,043	89%	96%	475	0.092	44	11%	4%
33	4399	7,261	0.229	1,665	4,625	0.290	1,341	64%	81%	2,636	0.123	324	36%	19%
33	4413	18,700	0.314	5,865	12,782	0.407	5,202	68%	89%	5,918	0.112	663	32%	11%
33	4427	17,656	0.311	5,487	11,389	0.424	4,829	65%	88%	6,267	0.105	658	35%	12%
33	4441	19,645	0.249	4,900	11,737	0.342	4,014	60%	82%	7,908	0.112	886	40%	18%
33	4455	15,766	0.259	4,090	9,997	0.337	3,369	63%	82%	5,769	0.125	721	37%	18%
32	4469	mined out												
32	4483	9,002	0.231	2,080	5,421	0.315	1,708	60%	82%	3,581	0.104	372	40%	18%
32	4497	11,688	0.273	3,195	7,112	0.392	2,788	61%	87%	4,576	0.089	407	39%	13%
32	4511	10,146	0.277	2,813	6,466	0.369	2,386	64%	85%	3,680	0.116	427	36%	15%
32	4525	11,290	0.334	3,767	7,908	0.437	3,456	70%	92%	3,382	0.092	311	30%	8%
32	4539	9,151	0.505	4,619	6,615	0.655	4,333	72%	94%	2,536	0.113	287	28%	6%
31	4553	mined out												
31	4567	mined out												
31	4581	mined out												
31	4595	3,183	0.372	1,183	2,586	0.435	1,125	81%	95%	597	0.097	58	19%	5%
31	4609	1,890	0.467	883	1,542	0.549	847	82%	96%	348	0.105	37	18%	4%
31	4623	1,342	0.259	348	845	0.365	308	63%	89%	497	0.080	40	37%	11%
Totals		197,773	0.289	57,143	129,808	0.382	49,626	66%	87%	67,965	0.111	7,517	34%	13%

As the East and South zones become depleted, the North Zone will become the dominant supplier of ore. Assuming a constant mining rate for the North Zone similar to the current mining rate, it does not appear that maintaining an ore production rate equal to that experienced from the South and East zones is realistic. Improved grade control procedures, optimized mining plans, an increased number of active faces, and improved coordination/communication between all those involved will certainly compensate for a portion of the probable decrease in ore production rates. However, the inherent nature of the North Zone combined with the physical limitations of mining (manpower, fleet size, haul distances, etc.) may dictate a decreased ore production rate.

As mentioned in the preceding paragraph, increasing the number of active faces in any given level will help to keep the production rate up. Sequencing panels within a stope should be done with consideration to geology and grade control complexities; the longest panel in a stope may not always be the critical path to completing the entire level. Panels that require a 'one round at a time' approach may, in fact, take the longest to complete and should be sequenced accordingly.

Mine Geology and Grade Control

The North Zone represents the most consistently difficult grade control challenge encountered to date at Rosebud, yet until recently, there appeared to be little change in how grade control was done on a daily basis. If the mine geologists are responsible for grade control, dilution, etc., they need to have some degree of authority during the mining process. However, in order to gain the confidence of the superintendent, shift bosses, and miners, they need to be better prepared to make decisions and have the data to support those decisions. The role of the mine geologists needs to change from reactive to proactive.

Currently, there are too many faces that are not being sampled or even seen by a geologist. The North Zone has demonstrated it is not very forgiving in terms of ore continuity on any given level or projecting grades from one level to another (although in many instances, there were inadequate attempts to investigate the continuity of mineralization). It is difficult to practice sufficient grade control if no one is there to see or sample the face. Since there is a relatively large staff of geologists and samplers, consider adjusting schedules to add additional underground grade control coverage. Either schedule a geologist/sampler shift during the dead time between regular shifts and extending into second shift, or add a geologist and sampler(s) to the second shift full-time. In addition to gaining a better understanding of ore controls, this would also allow extra time for the mine geologists to think 'ahead of the face'.

There was considerable discussion concerning the inability of the mine geologists to see as many faces as possible due to the mining cycle (e.g., panels are not mucked out). Every effort should be made to ensure that headings, especially where determining ore/waste is difficult, are mucked out as soon as possible. The geologists cannot provide adequate grade control or document ore controls if they are unable to have access to the face; once again they will be relegated to a passive role. This has long been an issue between the geologists and the miners/shift bosses, but it is not an insurmountable problem. It will require good communication and coordination between the mine geologists, the superintendent, and the shift bosses. Once again, the geologists will need to be prepared, with adequate documentation and logical arguments, if they wish to specifically direct the mining cycle according to grade control requirements.

On each of the levels examined, there is simply too much ore left in the ground. Poor communication between the geologists and the miners, lack of preparedness on the part of the mine geologists, and inadequate planning appear to be the culprits here. The faces and ribs that were left in ore only tell you of the immediate ore loss and do not address the potential for ore beyond the face or rib that was not mined.

MDA suggests Hecla implement the following recommendations immediately:

- When mapping underground, the mine geologists should make clear distinctions between ore-bearing and non ore-bearing structures. Many people will need to understand and rely on these maps (often in their absence) if grade control and mine scheduling are going to meet the challenges presented by the North Zone. Ore controls on many of the current maps are not adequately represented and some are obviously not documented at all. It is imperative that the geology and assay maps are updated on a daily basis.

- The mine geologists should map each face and round in every heading. These maps will be invaluable in determining and documenting ore controls.

- Face and rib samples should be taken based on geology – anything less is substandard. This is probably more important in the North Zone than any other place in the mine encountered to date, due to the difficulty in discerning ore controls and making calls at the face to determine ore/waste. In addition, improper sampling could result in misclassification of material.

Other comments and recommendations include:

- Coordinate with the mining engineers, superintendent, and shift bosses in order to plan as many active headings as possible in any given stope. Increase the geologist's role in the day-to-day mine planning. On the current cuts of stopes 32 and 33, I foresee you setting yourselves up for the same problems you experienced in the previous cuts, where backfilling of the stope was held up because of one panel.

- Make better use of the geologic data collected from underground mapping when stope planning. Real world ore controls (e.g., including those not identified nor incorporated into the model) should drive the planning process, not the model.

- Dedicate someone full time (about two weeks?) to complete the detailed North Zone cross sections started by Travis. In addition to plotting geology and assay information from the stope maps, review the drill log data, core photographs, and existing cross sections. However, since you now have better, more refined data from the stope mapping to incorporate with the drill data, do not rely solely on the cross sections to determine stratigraphic contact locations. The sections should be constructed with the intention of discerning ore controls (what, why, where) and how the mineralized/mineralizing structures relate to stratigraphy for the levels still remaining.

- Examine trends of mineralization, as well as geologic/structural trends, when planning for the next level. Be aware of the data from the levels above you as well; be cautious not to rely solely on the data from the level just completed. Continue to update and build on the structure contour map and ore zone plan map started by Travis.

- The mine geologists should always carry with them current copies of the geology and assay maps for every heading they are working in, and copies of maps for the level below and/or above them. What someone else observed last week may be pertinent to the decision to be made today.

- Some of the level maps are deficient in geologic data. There are many instances where what appear to be significant structures on one level are not found (or not documented) on the next. Continually attempt to correlate structure, stratigraphy, etc. from one level to another to better plan for subsequent cuts.

- Explore for the potential up-rake extension of high-grade mineralization associated with the flexure in the South Ridge Fault, as encountered in stope 33.

- Consider sampling several faces in detail from each stope to better understand the distribution and occurrence of mineralization. Sample each individual structure, stockworked wall rock, and wallrock that appears to be devoid of obvious mineralization structures.

- Do a brief study of sampling methods. Compare random chip sampling to channel sampling (along lines perpendicular to the dominant trend of mineralization) on both faces and ribs - all done by geology. Compare the results to see if biases are being introduced by either method.

- Question the reliability of rib sample assays; understand the limitations of the samples. If rib samples are taken sub-parallel to the main mineralizing trend, do they adequately represent the material one foot into the rib? In an extreme example (stope 33), a secondary panel was not mined based on sub-grade rib samples, yet ore grades were recorded for the face samples taken on the two adjacent primary panels. Rely more on the face samples to determine secondary panels if you're mining along the strike of the mineralized structures.

- It appears that (additional) longholes were justified in many places to investigate extensions of ore grade areas. Use your geology/geologic interpretation to plan the longholes; some of the longholes examined were either not oriented properly (e.g., drilled along the strike direction of structures instead of across the structural trend) or were drilled short of the target area. Be cautious about using longhole assay data quantitatively; the information can be useful as an aid in determining ore/waste from a qualitative standpoint, but longhole samples are notorious for contamination (especially with the clays encountered at Rosebud).

- When sub/low-grade is encountered unexpectedly when mining, check to see if the grade is within the domain range of what was modeled. Experience has taught us that the actual grades mined almost always vary from the modeled grades (we wouldn't expect otherwise), but more often than not, the domains used to model the mineralization have held up. In the North Zone, the economic cut off grade occurs internal to the 0.10 to 0.25 oz Au/t domain. Mining in some panels may be ending too soon without the ore potential fully investigated (e.g., mining is stopped prematurely due to a sub-ore grade face, when there is potential for ore to occur beyond that face).

- Currently the assay lab provides a 24-hour turn-around for up to 80 samples per day. Investigate to see if it is feasible for the lab to decrease the turn-around time for a limited number of high-priority samples. There could be tremendous benefits if the sample assays from a couple of 'critical path' panel faces could be reported in the morning rather than the afternoon.

Summary and Conclusions

The production shortfall currently reported by Hecla is relative to the Measured, Indicated, and Inferred Model; ore production is only slightly less than that predicted by the Proven and Probable reserve in most areas.

Upon review of the geology, resource/reserve model, and production data for the North Zone, MDA believes the production shortfall currently experienced is due to a combination of:

- resource model / real world discrepancies;
- ineffective grade control practices;
- current mine scheduling procedures; and
- poor communication between the geology, engineering, and mining departments.

While some of the production shortfall is due to the over-extrapolation of ore grades in the model, MDA believes that much of the shortfall experienced in the past can be avoided in the remainder of the North Zone by addressing the items listed above. Therefore, MDA does not recommend downgrading the resource/reserve because of the current discrepancy between the mine and model. Performing level reconciliations using both models, the as-built stope solids, and the designed stope solids will help to monitoring the models' performance and could aid in near-term forecasting and stope sequencing.

As the South and East zones become depleted, ore production will become increasingly dependent on the North Zone. Based on this analysis, it appears that the ore production rate is likely to decrease, even though the mining rate does not due to discontinuous ore and increased internal waste. By optimizing the number of available faces, improving grade control procedures, refining the mine schedule, and increasing the level of communication and coordination between the geology, engineering, and mining departments, the ore production rate can be maximized and the in-stope ore losses minimized.