In addition to the process plant, the expansion project requires acquisition of additional mobile mining equipment, a new in-pit crusher, expansion of the storage patio including stacker and reclaimer systems, and additional locomotives and rail cars for rail transport. Design and permitting of the 30 million tonne expansion project is currently underway. Vale has provided Pincock with various engineering studies and reports, as well as capital and operating cost estimates to demonstrate the technical and economic viability of the proposed expansion. The resulting product from the expansion plans will be primarily sinter feed and pellet feed.

1.3 *Audit History*

Auditing of the reported resources of the Vale properties began in 1997 in support of the filing of an F-3 Form with the United States Securities and Exchange Commission (SEC) as a requirement of the initial listing and public offering of Vale shares on the New York Stock Exchange. From the initial audit in 1997 through the audit completed of the 1999 reserves, the external auditor was the U.S. based company Mineral Resources Development, Inc. (MRDI). MRDI was acquired by AMEC in May 2000 and subsequent audits through the end of 2002 were done as AMEC but involved essentially the same personnel as the prior MRDI work. Vale changed auditors for 2003 and 2004. The audit of reserves stated as of the end of 2003 was completed by Golder Associates in early 2004.

Pincock completed the audit of year-end 2004 reserves in early 2005. AMEC again audited the reserves for year-end 2005. For 2006, a third-party audit was not conducted, but reserves were reconciled by Vale's technical personnel. In February 2008, Pincock completed a reserve reconciliation review of Vale stated reserves as of December 31, 2007. Pincock also audited the N4E and N4W deposits in late 2008/2009 for the year end 2007 reserve statement. In conjunction with the current reserve review for the N5 deposit, Pincock completed a depletion review for Vale's Brazilian iron ore mining operations, including both the Northern, Southern and Southeastern systems. This review considered the depletion of the most recently audited reserve estimates for actual production from the date of the reserve statement until June 30, 2010.

1.4 *Geology*

The iron deposits of the Northern Iron System are hosted in the Precambrian rocks of the Itacaiunas Supergroup. The basement of the region consists of the Pium Complex ortho-granulites, and Xingu Complex gneiss and migmatites. The volcanics and sediments of the Itacaiunas Supergroup overlie the basement, and are in turn overlain by Águas Claras clastic sediments. Granites, gabbros, and granitoids intrude the sedimentary sequence. The Carajás ores are hosted by the Grão Pará Group of the Itacaiúnas Supergroup, composed of meta-basalts, meta-sediments, ironstones, and meta-rhyolites. The ore deposits lie within an approximately 300 to 400 meters thick banded chert–hematite jaspilite unit that occurs between thick volcanic units.

The Serra dos Carajás basin is cut by major E-W and N70°W trending regional lineaments. The area is affected by numerous minor regional faults (sigmoid form). The most outstanding discontinuity is the

WNW-trending Carajás Fault that divides the basin into two domains, North and South, with the N5 deposit located in the more structurally complex northern domain.

Jaspilite represents the proto-ore of the Carajás region deposits, typically with 15 to 45 percent Fe (but can range up to 57 percent) and 35 to 65 percent SiO_2. Deep leaching of the jaspilite has resulted in the progressive migration of silica, forming hard hematite at depth. With proximity to the surface, the weathering has resulted in the formation of soft hematite. Both hard and soft hematites represent enriched iron mineralization with iron contents typically ranging from 60 to 68 percent Fe. Near-surface weathering has created an iron laterite layer at the surface.

Exploration of the N5 iron deposits was initiated in the 1970s with emphasis on development of iron ore. The efforts were intensified from 2003 to 2008 by Vale. A total of 843 drill holes, with 137,222 meters of drilling have been made for the N5 exploration. All samples are identified and recorded in the field by Vale and/or contractor geologists prior to shipping them to the laboratory. Core material is geologically logged and sample intervals identified for analysis. One half of the core is taken for analysis and one half retained for future reference. Remaining core is stored in a core storage shed facility. The core is photographed with a digital camera prior to sampling, for future reference.

Samples are prepared and analyzed at the Laboratory of Chemical Analysis of Carajás (GADIN), the Vale laboratory located on the mine site. Parameters analyzed for consist of Fe percent, SiO_2 percent, P percent, Al_2O_3 percent, Mn percent, MgO percent, TiO_2 percent, Cao percent, MgO percent, K_2O percent, Cu percent and LOI percent. Industry standard procedures are used and there is a formal QA/QC procedure in place.

Density determinations were performed on core samples and using field in-situ density measurement procedures on outcrops and exposures in the mine and in trenches and test pits. In 2010, Vale performed a new density sampling campaign in order to increase the accuracy on density determinations for the N5 deposit. About 189 new determinations were performed, specifically for the lithologies that had no samples in 2009 and a total of 16 duplicate samples were taken to evaluate the reproducibility of the density determination results.

1.5 *Resource Estimation*

The approach to geostatistical analysis and resource modeling is basically standardized within the Vale Resource Modeling Group for both the Southern System and Northern System. The geologic modeling and resource estimation procedures developed by Vale's Resource Modeling Group are considered by Pincock to be quite adequate for the purpose of supporting the development of Vale's reported statement of resources and reserves.

Vale's Resource Modeling Group for long-term planning is centrally located in Belo Horizonte. This group is responsible for generating geologic models and resource block models, supporting the long-term mine plans for reserve estimation for all the Vale's iron ore mining operations. With this centralization of the

TABLE 1-2
VALE
N5 Reserve Audit
Summary of Reserves

Mine	Reserve Classification	(Mt)	Fe (%)	SiO_2 (%)	P (%)	Al_2O_3 (%)	Mn (%)	LOI (%)
N5 TOTAL	Proven	390.3	66.81	1.31	0.027	0.89	0.431	1.50
	Probable	753.1	67.22	1.34	0.029	0.78	0.245	1.23
	Total	1,143.4	67.1	1.33	0.028	0.81	0.31	1.33

(a) Reserves are as of December 31, 2009
(b) Reserves are stated on a w et tonnes basis and Fe grade is on a dry basis

feed. In recent years both lump ore and pellet feed tonnages have been declining and larger percentages of sinter feed have been produced. The lump ore was produced by dry processing including crushing and screening and historically the sinter feed and pellet feed were produced by wet processing methods.

More recently sinter feed has been produced by a proprietary dry screening method. Vale has converted some of the wet processing lines of the central processing plant to the dry screening process for producing sinter feed. Presently 10 of the 17 lines have been converted and recently 8 of the 10 lines were in continuous service.

In addition, two 10 mtpy nearby remote dry screening plants will supplement the production of sinter feed. The first 10 mtpy dry screening plant became fully operational in April 2010 and the second started in early 2010, with both plants scheduled to be in full production in 2011. The future use of wet processing methods to produce sinter feed will be minimized and will be replaced by dry screening.

Vale's current annual production plans are to produce a very small tonnage of lump ore and about 12 mtpy of pellet feed only for Vale's internal consumption at its pellet plant near the port at San Luis. Vale does not plan to export pellet feed from the Carajás operations. All of Vale's pellet feed export products are planned to come from the Southern system mines.

Vale plans an additional 30 mtpy beneficiation plant expansion adjacent to the existing central beneficiation plant. This additional plant which is scheduled to be commissioned in 2012 will use the dry screening process to only produce sinter feed.

1.8 *Infrastructure*

Infrastructure for support of the Carajás Complex in the Northern System has been established since the project began operation in the mid-1980s. The Urban Núcleo town site was established by Vale for employee housing. Since that time, the next closest community of Parauapebas has grown to provide additional housing and services for the employees and contractors of the Northern System.

3.0 GEOLOGY

3.1 *Regional Geology*

The iron deposits of the Northern Iron System are hosted in the Precambrian rocks of the Itacaiúnas Supergroup. Figure 3-1 presents the geologic map of the region. The basement of the region consists of the Pium Complex ortho-granulites, and Xingu Complex gneiss and migmatites. The Pium and Xingu complexes are dated at 3 Ga and 2.86 Ga, respectively. The volcanics and sediments of the Itacaiunas Supergroup (2.76 Ga to 2.6 Ga) overlie the basement, and are in turn overlain by Águas Claras clastic sediments. Granites, gabbros, and granitoids intrude the sedimentary sequence.

The Carajás ores are hosted by the Grão Pará Group of the Itacaiúnas Supergroup, composed of meta-basalts, meta-sediments, ironstones, and meta-rhyolites. The ore deposits lie within an approximately 300 to 400 meters thick banded chert–hematite jaspilite unit that occurs between thick volcanic units. The lower volcanic unit is the Parauapebas Formation (4,000 to 6,000 meters thick), and consists of bi-modal volcanics (dominantly massive, vesicular and porphyritic flows and agglomerate breccias of meta-basalt, meta-basaltic andesite and meta-trachyandesites), with subordinate (10 to 15 percent) meta-rhyolitic tuffs and flows.

The Carajás Formation hosts the deformed banded-iron formations (BIFs) with some interbedded mafic meta-volcanics. The Cigarra Formation (upper volcanic unit) is similar to that of the Parauapebas Formation with mixed meta-sediments (fine grained tuffs, tuffaceous siltstones, phyllites, cherts and greywacke). The volcanic sequence has generally been weathered to a depth of 100 to 150 meters. The oxidation is observed to a depth of 500 meters in the banded iron formation (BIF) of the ore zone. The local stratigraphic sequence of the Itacaiúnas Supergroup in the area of the Northern System, as shown in Figure 3-2, is as follows:

- **Upper Group**: Igarapé Bahia Aquiri Group – metasedimentary and metavolcanic rocks (including manganese beds in Águas Claras Formation)
- **Middle Group**: Grão Pará Group – meta-sedimentary and meta-volcanic rocks
  - **Upper Formation**: Cigarra Formation – meta-volcanics
  - **Middle Formation**: Carajás Formation – predominantly banded iron formation with lesser mafic meta-volcanic units.
  - **Lower Formation**: Parauapebas Formation – bimodal metavolcanic rocks and metasedimentary rocks with intercalated discontinuous banded iron formations.
- **Lower Group**: Igarapé Pojuca Group, Igarapé Salobo Group, Rio Novo Group

3.2 *Structural Geology*

The Serra dos Carajás basin is cut by major E-W and N70°W trending regional lineaments. The area is affected by numerous minor regional faults (sigmoid form). The most outstanding discontinuity is the WNW-trending Carajás Fault that divides the basin into two domains, North and South, as evidenced by the related iron ore body configuration.

- The structurally most complex northern domain contains folded, faulted, and rotated iron ore bodies (N1 to N9 and Serra Leste). Several N-S oriented minor sympathetic fractures control the orebody configuration.

- The southern domain includes orebodies that dip to the north (S1 to S4). These orebodies are part of the south flank of the major structure, and show no apparent block movement or rotation.

3.3 *Mineralization*

Jaspilite represents the proto-ore of the Carajás region deposits, typically with 15 to 45 percent Fe (but can range up to 57 percent) and 35 to 65 percent SiO_2. The jaspilite is characterized by alternate light and dark colored micro-bands. Light colored layers are generally white to pale red, and consist of crypto- to micro-crystalline quartz with inclusions of cryptocrystalline hematite and lesser martitized magnetite plus occasional sericite. Dark colored layers consist of fine-grained hematite and martitized magnetite.

Deep leaching of the jaspilite has resulted in the progressive migration of silica, forming hard hematite at depth. With proximity to the surface, the weathering has resulted in the formation of soft hematite. Both hard and soft hematites represent enriched iron mineralization with iron contents typically ranging from 60 to 68 percent Fe. Near-surface weathering has created an iron laterite layer at the surface.

The main mineralized lithological units of the N5 deposit are shown in the photographs in Figure 3-3.

Hard Hematite: Compact, blue-gray, massive hematite, with a metallic luster, high density, and low porosity. Iron grades range from 65 to 69 percent. It is primarily used in the production of the export lump ore. Hard hematite is an increasingly rare iron oretype in Vale's Carajás operations.

Soft Hematite: Massive hematite occasionally pulverized, highly porous, very weak, and slightly magnetic, with average iron grades of around 65 percent. It is the primary ore mineral, and is generally sufficiently friable to be excavated without blasting. Comprises the main source of sinter feed and pellet feed products.

Canga: Canga is the uppermost unit and consists of a lateritic-saprolitic material that is the product of surface weathering of the underlying iron mineralization (Structural Canga) or barren mafic rocks (Chemical Canga). Mineral Canga consists of blocks of hematite cemented by hydrated iron oxides (goethite and limonite). It is generally 15 to 20 meters thick.

5.0 MINING REVIEW

Pincock engineers visited the N5 operating mines of Vale's Northern Complex during July 2010. The same project team completed the reserve portion of the 2008 audit of the N4E and N4W mines of the same complex. This section provides a discussion of the aspects of the mining planning and reserve estimation done for the operating mines and presents the reserve evaluation for the N5 mines.

5.1 *Mine Operations*

The N5 deposit is being developed with 6 principal mining areas denoted as N5W, N5E-N, N5E, N5S, Morro 1 and Morro 2. N5W commenced production in 1998, N5E in 1999 and N5E-N in 2003. N5S is scheduled to begin production after 2015 with Morro 1 and Morro 2 being mined after 2020. The combined production of the N5 mines accounted for about 50 percent of the ROM for the Carajás Complex operations in 2008 and 2009 and will be 60 to 65 percent of the total production from 2010 to 2028.

The existing N5 mining operations are typical large scale truck-shovel mining operations using 230- to 250-tonne trucks and 17- to 38-cubic-meter hydraulic and electric shovels. Large wheel loaders ($17m^3$) are also used for truck loading. About 65 percent of the friable hematites are estimated to require drilling and blasting. Of the other ore types, 100 percent of the hard hematites and jaspilites require drilling and blasting. Only 20 percent of the decomposed mafic rock requires blasting. Drilling is accomplished with a fleet of rotary blasthole drills, both rubber tired and crawler. Drilling is done with a 251 mm to 311 mm bits and most drills are fitted with a 254 mm bit. Holes are drilled to 16 to 17 meters (15 meter bench with 1-2 meter subdrill). Patterns are variable based on rock type and loading tool. Ammonium nitrate and fuel oil (ANFO), and emulsion are used as the primary explosives and are blended depending on water conditions. The wheel loaders require tighter drill hole spacing than the shovels. Spacing can be as tight as 3 meter by 6 meter in the mafics for the wheel loaders and as wide as 7 meter by 15 meter pattern in soft hematites loaded by the shovels.

Table 5-1 presents the current mining equipment fleet. The life of mine plan developed by Vale's staff considers a change in the size of the mining fleet both to meet increased production demands, as well as to achieve economy of scale with the transition to 400-tonne capacity haul trucks. Table 5-2 presents the planned mining fleet for 2011 to 2020. The capital replacement schedule considers this mining fleet change.

Ore produced from the N5 pits is hauled to semi-mobile in-pit crushers and then conveyed to the central processing plant or direct hauled to one of two 10 mtpy dry process screening plants (no crushing capacity) as discussed in Section 6 of this report. The screened product from the two 100 mtpy plants is conveyed directly to the product stockpiles at the train load-out facility while the oversize material is truck hauled to a crusher and then processed through the central processing plant with the other ROM. It was noted that the two 10 mtpy plants will process primarily low alumina, low manganese ores, therefore, some selectivity in ROM product for these plants will be required, particularly during the rainy season to

6.0 PROCESSING REVIEW

6.1 *Overview of Serra Norte Processing*

Processing of the ore from Vale's Carajás mining complex is done at a nearby central beneficiation plant. It began operation in 1986 and has been expanded with several capital improvement projects to reach its current annual capacity of approximately 100 million tonnes of iron ore products. The plant treats oxidized iron ores, primarily hematite, through crushing, screening, classification desliming and dewatering. Historically three products have been produced including lump ore, sinter feed and pellet feed. In recent years both lump ore and pellet feed tonnages have been declining and larger percentages of sinter feed have been produced. The lump ore was produced by dry processing including crushing and screening and historically the sinter feed and pellet feed were produced by wet processing methods.

More recently sinter feed has been produced by a proprietary dry screening method. Vale has converted some of the wet processing to the dry screening process for producing sinter feed. That conversion began prior to the last audit of the N4E and N4W deposits conducted in late 2008. At that time 6 of 17 wet screening lines of the central beneficiation plant had been converted to dry screening and were being placed into service. Presently 10 of the 17 lines have been converted and recently 8 of the 10 lines were in continuous service.

In addition, two 10 mtpy nearby remote dry screening plants will supplement the production of sinter feed. The first 10 mtpy dry screening plant became fully operational in April 2010 and the second started in early 2010, with both plants scheduled to be in full production in 2011. The future use of wet processing methods to produce sinter feed will be minimized and will be replaced by dry screening.

Vale's current annual production plans are to produce a very small tonnage of lump ore and about 12 mtpy of pellet feed only for Vale's internal consumption at its pellet plant near the port at San Luis. Vale does not plan to export pellet feed from the Carajás operations. All of Vale's pellet feed export products are planned to come from the Southern system mines.

For the Northern Mines System Vale plans an additional 30 mtpy beneficiation plant expansion adjacent to the existing central beneficiation plant. This additional plant which is scheduled to be commissioned in 2012 will use the dry screening process to only produce sinter feed. Another large future project known as S11D or Serra Sul, is scheduled to have another dedicated processing plant. This report will not address those two additional projects as the N5 ore is planned to be processed through the two 10 mtpy dry screening plants and the existing process plant.

The previous reserve audit done in late 2008 principally considered processing the N4 iron ore reserves in the existing 100 mtpy wet processing plant. The present 2010 reserve audit is for processing the N5 deposit iron ores in the existing plant and the two new 10 mtpy dry screening plants. This audit also takes into account the fact that 10 of the 17 wet screening sinter feed production lines in the existing plant also have capability for dry screening production of sinter feed.

The remainder of this section will contain the following sections:

- Current Carajás ore processing and products.
- Historical production and future projections.
- Processing facilities descriptions and flowsheets.
- Description of each processing step.
- Conversion from wet to dry screening justification.
- Projected N5 reserves metallurgy and quality.
- Discussion, comments, recommendations and conclusions.

6.2 *Carajás Ore Processing*

The three main types of products of the hematite ore are lump ore, sinter feed and pellet feed. They are basically the same chemical composition and are simply different sized fractions of the run-of-mine ore. There are sub-types of each product that can be produced to meet market demand or for customer preference. Generally, any differences in product quality of any type of product are due to minor changes in granulometry or chemical analysis.

Lump ore is the first product generated by the process. It is the coarsest product consisting of individual ore pieces ranging in size from 11 mm to 25 mm produced by dry screening. It is used as feed for blast furnaces mostly for the domestic market. Vale's future plans are to produce only small tonnages of lump ore at Carajás.

The next coarsest product is sinter feed with individual ore particles ranging in size from 0.5 mm to 16 mm. It can be produced by either wet processing or dry screening. Vale's future plans are to produce larger tonnages of sinter feed at Carajás with increasing percentages coming from the dry screening process. Sinter feed cannot be directly used as feed for a blast furnace because the particles are too small and would plug the furnace. So, the customer must process the sinter feed in a metallurgical furnace at high temperatures where the ore pieces are fused (or sintered) together to make the desired larger sized pieces suitable for feeding the blast furnace.

The third product from the processing is pellet feed consisting of individual ore particles ranging in size from 20 microns to 0.15 mm that are produced only by wet processing. These fine particles are much too fine for blast furnace feed so they must be converted into pellets to become acceptable. This is done by additional grinding, if necessary, to provide a suitable particle size distribution for making pellets. In the pelletizing process the finely ground ore is combined with additives and formed into small balls (6 mm to 18 mm diameter) and then fire hardened in a metallurgical furnace at 1,300 degrees C to make a hard spheres of iron ore that can be fed to a blast furnace.

These three products are quite similar in chemical quality because the iron ore processing at Carajás does include any major steps that significantly change the chemical composition of the ore. The ore is deslimed and simply sorted into different particle sizes for each product. Table 6-1 shows Vale's Master Quality Plan and includes the projected chemical and physical quality for the years 2009 to 2012 for sinter feed, pellet feed and blast furnace pellets. Lump ore is not included because the tonnages are very small and the product is not planned for export.

TABLE 6-1
VALE
N5 Reserve Audit
Quality Parameters for Product

	Quality Parameter (percent)								
	Fe	P	SiO_2	Al_2O_3	Mn	LOI	+6.3mm	+1 mm	-0.15mm
Sinter Feed	66	0.035	1.4	1.3	0.65	1.9	20	55	18
	Fe	P	SiO_2	Al_2O_3	Mn	LOI	+0.15 mm	-0.45mm	
Pellet Feed	65.3	0.04	1.4	1.7	0.65	2.2	5	65	
	Fe	P	SiO_2	Al_2O_3	Mn	S	8-18mm	RD	
Blast Furnace Pellet	65.3	0.03	2	1.25	0.6	0.003	90	65	

Note: all data are for loading port

Vale has provided some historical production data from 2006 to-date and also provided projected production through 2011. The production data in Table 6-2 contains projected chemical quality data that are slightly different from the Master Quality Plan. The differences are not great but do point out some inconsistencies in the provided data.

TABLE 6-2
VALE
N5 Reserve Audit
Process Plant Production Data

	2006	2007	2008	2009	2010 (estimated)	2011 (pred)
Run of Mine Ore (mtpy)	90.7	106.8	118.1	91.3	120.4	129.0
Product (mtpy)	**81.8**	**91.7**	**96.5**	**84.6**	**111.6**	**119.5**
lump	11.4	11.1	7.7	1.5	2.5	4.7
sinter	60.5	67.5	76.9	74.8	96.9	100.5
pellet feed	9.9	13.1	12	8.4	12.2	14.4
Tailings (mtpy)	8.9	15.1	21.6	6.7	8.8	9.5
Production (%)	%	%	%	%	%	%
Run of Mine	100	100	100	100	100	100
Production	**90.2**	**85.8**	**81.7**	**92.7**	**92.7**	**92.7**
lump	12.6	10.4	6.5	1.6	2.1	3.6
sinter	74.0	73.6	79.6	88.4	86.8	84.1
pellet feed	12.1	14.3	12.4	9.9	12.4	12.4
Tailings	8.9	15.1	21.6	6.7	8.8	9.5
Iron Content (%Fe)	% Fe	% Fe	% Fe	% Fe	% Fe	% Fe
Production						
lump	--	65.14	64.12	63.17	63.08	62.95
sinter	--	66.20	66.24	65.72	65.73	65.66
pellet feed	--	65.65	65.43	65.04	65.19	65.00

6.3 *Processing Plant*

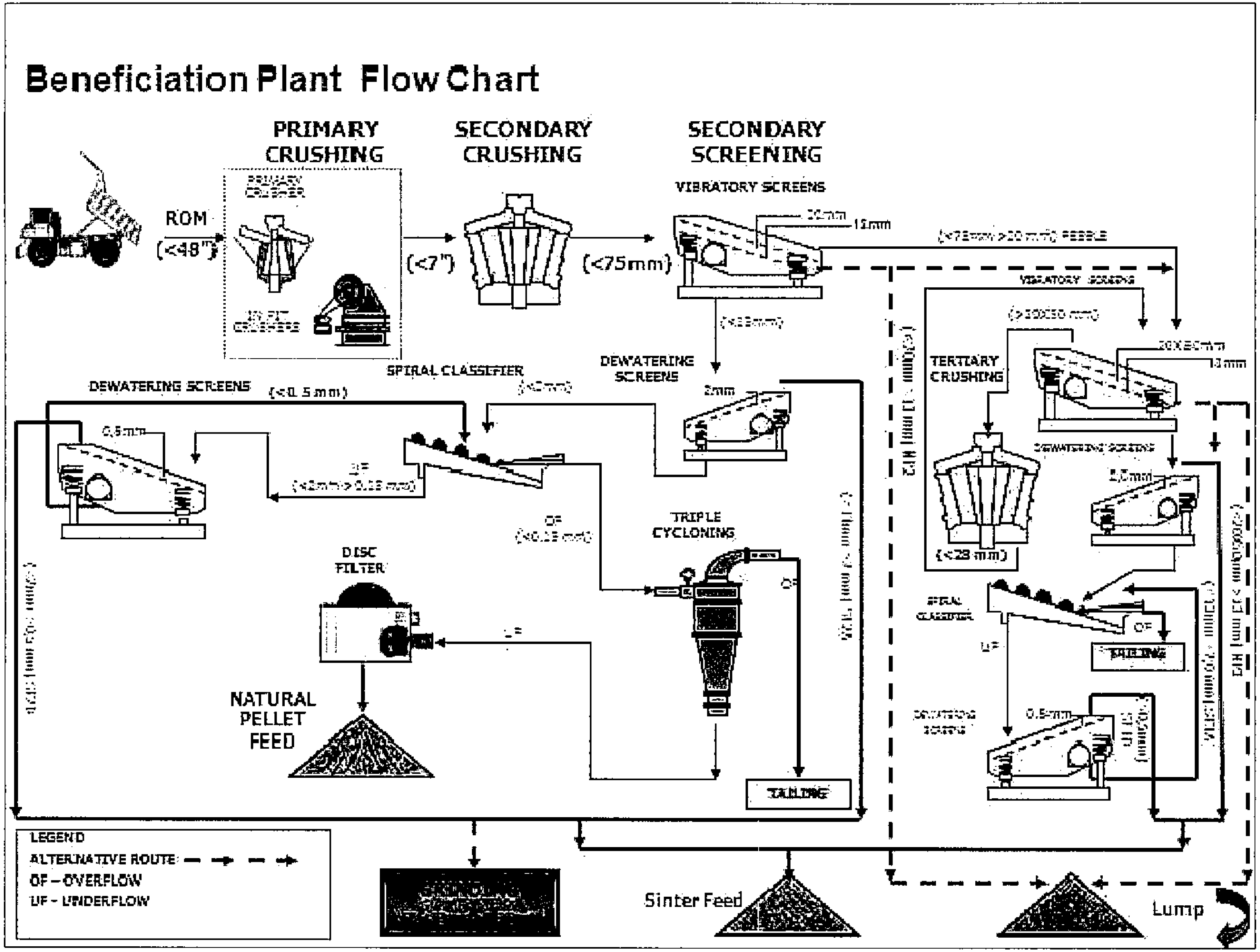
The previous 2008 Reserve Audit reported that production had significantly increased from approximately 82 mtpy in 2006 to 92 mtpy in 2007 and was projected to be 108 mtpy in 2010. The Table 6-2 shows a drop in 2009 production to nearly 85 mtpy due to the worldwide economic downturn but is estimated to be nearly 112 mtpy in 2010. It is predicted to increase to nearly 120 mtpy in 2011. The latest increase will come from the two dry screening plants that are coming on-stream. A significant statistic in the production data is the reduction of tailings losses. The mass recovery was dropping steadily from 2006 to 2008 when it reached a low of approximately 82 percent. For the year 2011 it is predicted to be nearly 93 percent. This significant improvement in mass recovery can be attributed to the conversion and addition of dry screening (and the elimination of some wet processing) to increase sinter feed tonnage from about 60 mtpy in 2006 to nearly 101 mtpy in 2011. In the meantime lump ore production has fallen from about 11 mtpy to less to 4.7 mtpy and pellet feed tonnage has been fairly constant ranging from about 10 mtpy to 14 mtpy.

The previously high tailings losses of nearly 22 mtpy consisted of very fine and high grade iron ore particles that would be considered as very good quality ore at other mines. The vast amount of these high-grade tailings materials that have been produced at Carajás over the years have been stored in tailings retention ponds. Some of these stored tailings have the potential to be recovered and converted into pellet feed by using existing current technology. The exact tonnage of tailings accumulated over the years is unknown but could possibly be as much as 200 Mt. If just 35 percent could be recovered as pellet feed it could feed the Sao Luis pellet plant for nearly 10 years or supplement the feed for 20 to 30 years or more. Much of the needed equipment may eventually be available as production of sinter feed from the current beneficiating plant is shifted from wet to dry methods and pellet feed production is minimal.

The processes used at Carajás to produce the three different sized products simply consist of well known and established methods of size reduction and sizing. The entire processing system consists of the following six steps:

- Secondary crushing and wet and dry screening.
- Tertiary crushing and wet screening.
- Hydrocyclone desliming.
- Ball mill grinding.
- Dewatering and filtration.
- Product stockpiling, blending and shipping.

Three simplified processing flowsheets for the Carajás operations are shown in Figures 6-1, 6-2 and 6-3. The first is the beneficiation flowsheet for the production of lump ore, sinter feed and natural pellet feed. The second is for the production of processed pellet feed by additional wet grinding and wet processing of sinter feed material. The third is for the dry screening process.



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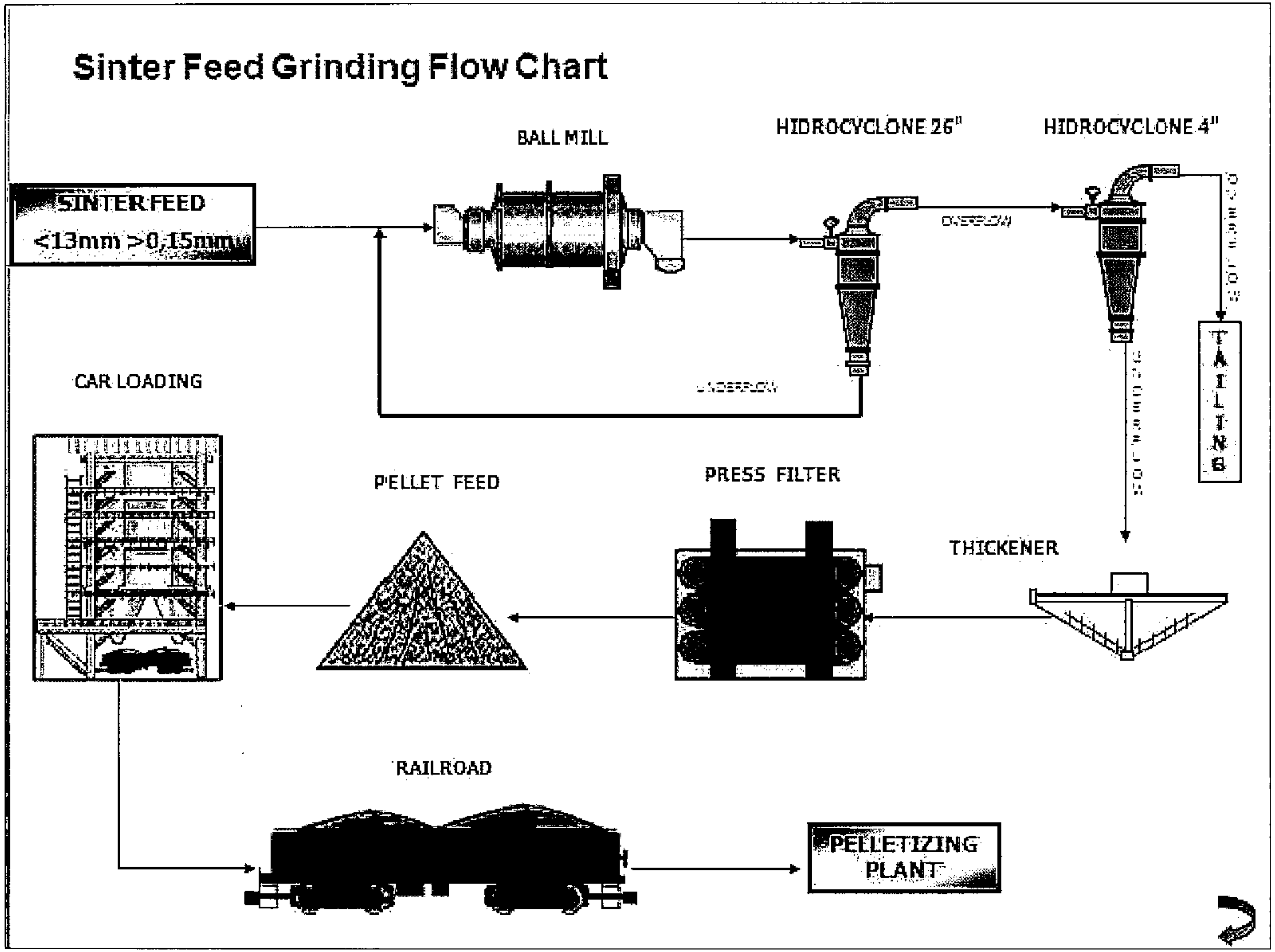
Project Name N5 Reserve Audit

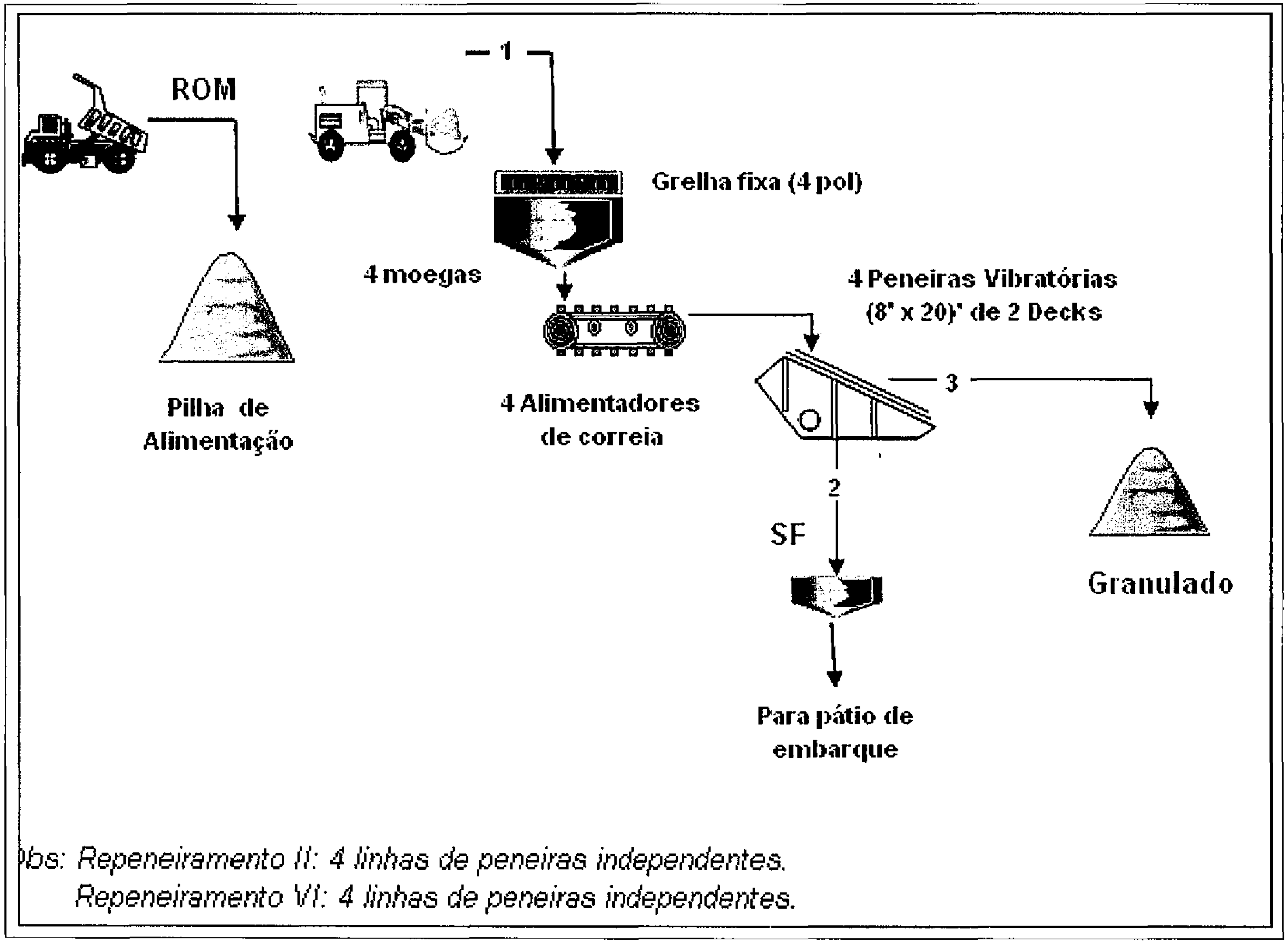
FIGURE 6-1
Beneficiation Plant Flow Sheet

Date of Issue Aug 2010

Drawing Name Fig.6-1.dwg



Prepared by **pincock, allen & holt** 165 S. Union Boulevard, Suite 950 Lakewood, Colorado 80228 Phone (303) 986-6950	Drawing Provided by/Prepared for VALE	FIGURE 6-2 Sinter Feed Grinding Flow Sheet	Date of Issue Aug 2010
Project No. BH-00015	Project Name N5 Reserve Audit		Drawing Name Fig.6-2.dwg



Prepared by	Drawing Provided by/Prepared for		Date of Issue
pincock, allen & holt 165 S. Union Boulevard, Suite 950 Lakewood, Colorado 80228 Phone (303) 986-6950	VALE	FIGURE 6-3 Process Flow Sheet for 10 Mtpy Dry Screen Plants	Aug 2010
Project No. BH-00015	Project Name N5 Reserve Audit		Drawing Name Fig.6-3.dwg

6.3.1 Crushing and Wet and Dry Screening

After the ROM ore has been crushed at one of the stationary or semi-mobile primary crushing stations it is transferred by belt conveyor to storage silos ahead of secondary crushing where the ore processing begins. In secondary crushing the ore is dry screened at 75 mm with the oversize going to cone crushers operating in closed circuit with the screens. The screen undersize is conveyed to silo storage ahead of secondary screening Most of the time the ore requires very little crushing so the screen oversize and the crushing feed tonnage is very low.

Secondary screening is the main part of the ore processing system at Carajás. It is the beginning of where the first finished product is produced and provides an intermediate product which passes on downstream for further wet processing or dry screening. This is considered the heart of the beneficiation operations at Carajás. There are 17 parallel secondary screening lines for wet or dry screening of the minus 75 mm ore feed. Ten of the 17 lines can be operated as dry screens and eight of those lines have recently been in continuous operation. In addition, two 10 mtpy remotely located dry screening plants will operate to produce only sinter feed. The screen oversize (granular material) from the two remote dry screening plants will be stockpiled and used as feed to the existing beneficiation plant. It was reported that 10 percent of the ROM feed to dry screening becomes screen oversize granular product. The remaining 90 percent becomes sinter feed with no additional processing losses.

The screens in the existing plant are double deck with 20 mm openings on the top deck and 13 mm openings on the bottom desk. The top deck oversize (-75 mm +20 mm) is crushed in the tertiary crushers and the bottom deck oversize (-20 mm +13 mm) is stored as lump ore product or sent to feed the tertiary crusher double deck screens. The screen undersize feeds another group of single deck screens that make a +2 mm sinter feed product. The sinter feed can be produced either wet or dry. Since the dry screening is proprietary no additional details are available. The single deck screen undersize is processed in spiral classifiers to classify the -2 mm product and provide a -2 mm +0.15 mm product to feed dewatering screens with 0.5 mm openings. The dewatering screen oversize forms the second part of the sinter feed product and the -0.5 mm screen undersize is closed circuit with the spiral classifier. The spiral classifier overflow provides the feed to the downstream desliming hydrocyclone process.

6.3.2 Tertiary Crushing and Wet Screening

The tertiary crushing and screening simply crush, screen and dewater the ore. Cone crushers and double deck screens in closed circuit are used to produce -50 mm +20 mm lump ore and a +13 mm bottom deck oversize product that can be directed to either the lump ore or the sinter feed. The -13 mm screen undersize is dewatered at 2.0 mm. The oversize joins the sinter feed and the -2.0 mm undersize passes through a spiral classifier and a 0.5 mm dewatering screen to provide additional sinter feed. The -0.5mm dewatering screen undersize is recycled to the spiral classifier and the classifier overflow goes to the tailings pond.

6.3.3 Hydrocyclone Desliming

The -0.5 mm slurry from the secondary screening plant spiral classifier overflow is deslimed in three stages of desliming using 10 inch- and 4 inch-diameter hydrocyclones. The final overflow is the slime tailing that goes to tailings thickeners and then to the tailings pond. The desliming hydrocyclone underflow produces a pellet feed product called natural pellet feed. The pellet feed is dewatered in thickeners and vacuum disc filters. This pellet feed product, which up to now has been exported, will slowly be eliminated as more secondary screening is converted from wet to dry screening. The Vale pellet plant at Sao Luis will also be supplied with pellet feed from Carajás that is derived from sinter feed that has been ground in ball mills and is known as processed pellet feed.

6.3.4 Ball Mill Grinding

In the event that additional pellet feed is needed it can be produced to different specifications by grinding some of the -13 mm +0.15 sinter feed in ball mills to produce an artificial or processed pellet feed. Ball mills are operated in closed circuit with classifying hydrocyclones. The classifying hydrocyclone overflow is fed to a thickening hydrocyclone which produces an underflow product of pellet feed and an overflow slime tailing product. The thickening hydrocyclone underflow goes to a concentrate thickener to prepare it for feeding the filters and the overflow goes to a tailings thickener before it is pumped to the tailings storage basin. The tailings thickener overflow is recycled back to the plant as process water.

6.3.5 Dewatering and Filtration

The dewatering of various processing products is done to enable recycling of process water to the plant and to remove sufficient water from pellet feed for ease in storing, shipping and handling. The slime tailings from the secondary screening plant are treated in two tailings thickeners. The underflow is pumped to the Gelado tailings basin and the overflow is pumped back to the plant for reuse as process water. The slime tailings from the ball mill grinding and desliming are treated in a dedicated tailings thickener. The underflow and overflows similarly are pumped respectively to the Gelado tailings basin and the plant reuse process water system.

Pellet feed products must be thickened and filtered for handling and shipping. The natural pellet feed is thickened in dewatering hydrocyclones and filtered in vacuum disc filters resulting in filtercake moistures of 10.5 to 12 percent. The processed pellet feed is thickened in a conventional thickener and filtered in pressure filters to a moisture level of about 9.5 percent.

6.3.6 Product Stockpiling, Blending and Shipping

All the iron ore products from the Carajás complex are stored in stockpiles for blending and eventual rail car loading. The stockyard is divided into sections reserved for different quality products. The equipment consists of conveyor belt stacking machines, bucket wheel reclaimers and one stacker-reclaimer. The products are loaded into 100 tonne rail cars and shipped in 33,000 tonne trains for the 892 kilometers to the marine terminal at Ponta da Madeira at Sao Luis.

6.4 *Conversion from Wet to Dry Screening*

The conversion from wet to dry screening has been justified by a number of factors including, but not limited to, lower production costs, better mass recoveries, higher equipment availability and improved environmental impact. Sinter feed production is expected to increase from about 60 mtpy in 2006 to over 100 mtpy by 2011. This significant increase is due to the conversion of wet screening to dry screening in the existing plant and the addition of two remote 10 mtpy dry screening plants. The reported overall production costs for wet screening are R$3.8 per tonne product and R$2.5 per tonne for dry screening. It has also been reported by Vale that the two remote dry screening plants have production costs of R$2.2 per tonne. These costs are reasonable in the opinion of Pincock. The mass recovery from dry screening is nearly 100 percent which has improved the overall mass recoveries from the low 80 percent range up to the mid 90 percent range. Operating availability of the screening equipment has improved from 87 to 93 percent and utilization has increased from 93 to 95 percent. There is much less equipment to operate and maintain for the dry screening which is beneficial to availability and utilization.

More sinter feed can be produced in the existing plant not only due to the conversion of more lines but also to the improvements in dry screening performance since the 2008 audit of the N4E and N4W deposits. These improvements include better screening surface, or screen cloth, material (improved materials and larger open area), optimized screen feed distribution onto the screen and improved screen operating conditions (frequency, amplitude and angle). So the combination of 10 converted dry screens (versus 6 in 2008) and improved dry screening performance will increase sinter feed production by more than 20 mtpy from 60 mtpy to over 80 mtpy. The other 20 mtpy will come from the two new remote dry screening plants.

The sinter feed product generated from the dry process has nearly the same chemical composition as the wet process. There is only a slight difference in granulometry with the dry product being slightly finer mainly in the -0.15 mm fraction. The dry system has cost, operational, and environmental advantages in reduced water consumption, no tailings to handle and less equipment to operate (spiral classifiers, slurry pumps and water pumps). The two flowsheets shown in Figure 6-4 and 6-5 show the wet screening equipment followed by the dry screening equipment.

The seasonal performance of the dry screening process varies from the dry to rainy seasons. During the rainy season the ore becomes more wet and sticky and difficult to classify on the dry screens. The feed rate to screening is reduced to 60 percent of what is normal in the dry season. Because the beneficiation plant has the option to operate either wet or dry screening the number of operating dry screens is increased when the ore becomes wet from rainfall and converted back to wet screens during dry periods.

6.5 *Discussion*

The primary ore that has been processed over the last 5 years of operation are from the N4W, N5E and N5W mine areas. It is the opinion of Pincock that the historical processing of ROM ore from these mining areas at Carajás by both wet processing and dry screening is based upon reliable technology and