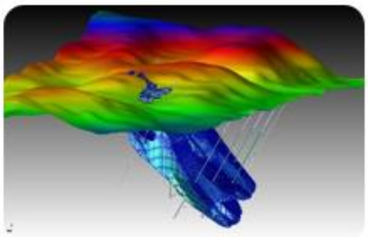
REPORT ON
GEOLOGICAL RESOURCE ASSESSMENT AND MINE DESIGN FOR ESDM B&U PERMIT OF A NICKEL CONCESSION IN SULAWESI, INDONESIA









Prepared for

PT. BINTANG SINAR PERKASA

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PT DMT Exploration Engineering Consulting Indonesia

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Report Details

Project Details			
Proposal Title:	**Report on Geological & Resource Assessment and Mine Design for ESDM B&U Permit of a Nickel Concession in Sulawesi, Indonesia**		
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1 EXECUTIVE SUMMARY

1.1 Introduction

PT. Bintang Sinar Perkasa (BSP) is Indonesian entity that owns the concession for nickel ore exploration on the island of Sulawesi. The majority shareholder (75%) of PTBSP is ultimately Prime Minerals Capital Group.

Prime Minerals S.A. is a company that invests in projects related to the extraction and processing of raw materials. Currently the company is implementing a nickel ore and limestone aggregates open pit mine project in Indonesia through its subsidiaries. The company shares are listed in New Connect alternative trading system on the Warsaw Stock Exchange since November 2013. There are also bonds issued by the company for public trading, which are listed on the Catalyst market also operated by the Warsaw Stock Exchange.

1.2 Background

Currently permission to explore resources (exploration concession) has been obtained for the Morowali Project. The exploration concession covers an area of 2,163 ha located in the Bungku Selatan district and has been issued for a period 8 years. Reconnaissance operations were conducted initially followed by a detailed exploration, which was started in 2010 and continued until the first half of 2016.

1.3 Scope of works

Currently PT BSP holds an Operation and Production IUP License for a Nickel Concession area of 1,867.7 Ha area of in Bungku Selatan district in Morowali regency in Central Sulawesi, Indonesia. BSP's objective is to obtain a Borrow and Use (B&U) licence from ESDMT (Kementerian Energi dan Sumber Daya Mineral Republik Indonesia or Ministry of Energy and Mineral Resources of the Republic of Indonesia) that will enable the operation of a surface Nickel mine in the concession. PTDMT's scope of works was to produce the technical documentation required for the B&U licence application. To do that the following steps were followed

- Initial review of the available geological exploration date will be carried out
- Preparation of a provisional geological model using Surpac software
- Provisional assessment of Mineral Resources including quality
- Yearly movement of the open pit showing the stages of land used for exploitation plans for the 5 years (envisaged life of mine) for the two final pit options

1.4 General information

The concession area is located in village Lamontoli, in subdistrict of South Bungku, Morowali district, Central Sulawesi province covering an area of about 2,163 hectares. Location WIUP can be reached by boat from Bangku, after reaching Bangku by road and air from Jakarta.

The area has a rainfall of 1,909 mm / year with the number of rainy days on an average 18 day / month as recorded from meteorological stations in Morowali Regency. The average monthly temperature ranged from 30.30 to 32.30 ° C and the average annual temperature of 27.15 ° C

1.5 Geology

The general area mainly covered by two main formations based on Regional Geology Map of Kendari.

a. Salodik Formation (Tems)

b. Ophiolites Rocks Formation (Ku)

The Salodik formation consists of oolitic limestone with intercalation of marl and sandstone containing quartz fragments. The abundance of corals, algae and larger foraminifera found in this formation suggest that it was formed in a shallow marine environment. The Salodik formation is in a fault contact with the Ophiolite Complex.

The concession area is mostly composed of Periditite and Pyroxenite type of rocks:

Following Peridotite rocks are reported:

- Harzburgite, green to blackish green, with coarse crystalline texture, composed of mainly olivine and pyroxene.
- Dunite, dark gray to black, with aphanitic texture, deposited in along the fault lines, these rocks are consist of minerals like olivine (± 95%) with minor concentration of pyroxene, plagioclase, serpentine, Talc and magnetite.

1.6 Exploration Data

The following data or reports are providing information on geological exploration carried out in the concession:

- Geological exploration report by PT GEOSURVEY MINING INDONESIA, July 2011
- Laporan Studi Kelayakan or Feasibility study report by PT. BINTANG SINAR PERKASA, November 2013
- Bore hole & Assay data for 284 boreholes
- Topographical Survey files
- IUP document

During the current study PTDMT has been provided with 278 borehole data including location, litho log and assay data which were mostly drilled, sampled and analysed during 2015-2016.

1.7 Geostatistics

Statistical analysis was carried out for the available 278 borehole data (location, lithology, and assay/quality) to understand the geological character of the lateritic nickel deposit in the concession, including average and range of Ni concentration in lateritic nickel, association with other elements, thickness variation, continuity of grade and thickness.

The prospect was explored by core drilling and chemical analysis of the samples for Ni, AL2O3, MgO, Fe2O3, SiO2, P, Cr2O3, MnO, Fe, Co, TIO2 were undertaken. The correlation matrix for Nickel with other elements and radicals are as follows:

Table 1-1 Correlation Coefficient matrix amongst various radicals and metals analysed from borehole core samples (Number of sample=4224)

	NI	*Al2O3*	MgO	Fe2O3	SiO2	P	Cr2O3	MnO	Fe	Co	TiO2

Ni	1										
Al2O3	0.16	1									
MgO	**-0.41**	-0.52	1								
Fe2O3	**0.53**	0.48	-0.65	1							
SiO2	-0.17	-0.24	0.75	-0.65	1						
P	-0.27	0.01	-0.44	-0.15	-0.47	1					
Cr2O3	**0.63**	0.38	-0.59	**0.88**	-0.54	-0.27	1				
MnO	0.52	0.51	-0.65	**0.91**	-0.59	-0.17	0.89	1			
Fe	**0.53**	0.48	-0.65	1	-0.65	-0.15	0.88	0.91	1		
Co	**0.46**	0.37	-0.45	0.74	-0.47	-0.24	0.80	0.73	0.74	1	
TiO2	0.20	0.40	-0.26	0.38	-0.20	-0.12	0.37	0.37	0.38	0.51	1

The correlation matrix indicates: Ni shows positive correlation with Cr2O3, MnO, Fe and Co confirming the enrichment of Ni above redox front. Ni shows negative correlation with MgO, SiO2 and P. Below the redox front geochemical boundary, there is a sharp rise in MgO – a discontinuity, that marks the contact with an overlying ferralite zone. Cobalt analysis for all the samples are not available.

Assay values for Ni, MgO, Fe2O3, Co concentration (%) in all samples (4224 numbers) from cores of all 278 boreholes have been analysed.

The lateritic nickel ore zone is defied with 0.5% Ni and 0.5m width as cut-off grade/width. Lateritic nickel ore widths and assays (thickness of ore & weighted average of Ni% in each borehole considered) of a total of 254 borehole samples could be considered for modeling at, as in 24 boreholes no ore intersected

Geo-statistical analysis was done on DHB- series boreholes in the demarcated concession area. The number of boreholes considered for modelling and geostatistical processing is 254 out of total 278 holes. The total Ni grade and weighted average of the grade on thickness has been considered for Geostatistical analysis.

The Variogram for each of the data sets (weighted average Ni assay grade and width for 254 boreholes) were calculated to know the influence range for the deposit. The drilling of DHB-series boreholes are in a square grid pattern in general but it varies from place to place depending on the ore quality data. So an omni-directional variography was performed in EAST-WEST direction with the objective to construct an experimental semi-variogram for this orientation.

The grid on which the holes are conveniently placed is 50m by 50m, the linear spacing expands to 100m at places. So at such distance the values of experimental semi- variogram γ^* for distances which are multiples of 50m have been computed

Major outcome of Statistical and Geostatistical analysis are as below:

- Statistical analysis of all samples from the concession shows a natural cut off of 0.4% of Ni. However considering the global standard, processing ease and economic parameters lateritic nickel ore zone is defined with 0.5% Ni as cut-off grade.
- Average thickness of ore intercepts is 5.10m, however highly variable with maximum thickness of 20m, where minimum thickness considered as ore body is 0.5m.
- Average Ni% is 0.96%, where maximum Ni concentration is 2.05%. grade continuity of ore zones can be predicted with moderate confidence.

- Within the ore zone MgO & Fe concentration showing bimodal distribution, with a cut off at about 12% and 15% respectively.
- Geostatistical analysis of Ni grade (%) shows continuity of grade up to 24.64m and continuity of width upto 61.02m with high level of confidence. These minimum ranges of influence have been considered for the purpose of geological correlation and resource classification.

1.8 Resource Estimation

PTDMT has carried out resource estimation by preparing SURPAC model for the concession Resource estimation carried out based on database including lithological data, assay data of 278 borehole and topography contours received from PTBSP.
The Nickel ore resources estimated by DMT for the area explored (130 Ha), are given below:

Table 1-2 Resource classification as per DMT estimation

Resoure Category	Volume	Tonnage	Ni%
Measured	1,176,694	1,765,041	1.07
Indicated	741,231	1,111,847	0.98
Inferred	2,274,300	3,411,450	1.43
		6,288,338	

Table 1-3 Grade wise resource estimation

Ni	Measured		Indicated		Inferred		Total
	Tonnage	Ni%	Tonnage	Ni%	Tonnage	Ni%	Tonnage
0.5 -> 1.0	777,703	0.79	615,384	0.74	84,192.5	0.86	1,477,280
1.0 -> 1.5	820,313	1.22	419,541	1.2	372,829.5	1.26	1,612,684
1.5 -> 2.0	162,375	1.66	74,372	1.66	1,774,003	1.74	2,010,750
2.0 -> 2.5	4,650	2.12	2550	2.08	1,180,425	2.22	1,187,625
	1,765,041		1,111,847		3,411,450		6,288,338

It is recommended that further exploration to be carried out to convert Inferred resource to indicated category by infill drilling focusing exploration at 50m X 50m grid pattern.

1.9 Mining

1.9.1 Mining Method

PT. Bintang Sinar Perkasa nickel mining concession is being planned to be an open pit mine with a backfilling system. 2 Ha of waste dump is planned for overburden placement in the first year, and next in the second year and subsequent years of placement of overburden or waste material is in the pit. The mine is planned to be operated for 1 shift and 8 hours a day.

1.9.2 Mining Equipment

List of Mining Equipment required for the operation is given below

Table 1-4: List of Mining Equipment

Equipment	Maximum Number
Drill (100mm Diameter)	2
Explosive Carrier	1

Excavator (4CUM Bucket)	6
Truck	8
Dozer (300HP)	1
Motor Grader - 145 HP	1
Water Sprinkler - 10KL	1
Mobile Crane - 10t	1
Mobile Workshop / Service van	1
Explosive van	1
Diesel bowser - 1000L	1
Ambulance	1
Manager's Car	1
Supervision vehicle	2
Fire tender	1

1.9.3 Reserves Assessment

DMT has developed an optimized pit over an area of 32.78Ha. The total mineable tonnage estimated is 1,764,840 tonnes of ore at 1.27% of Ni.

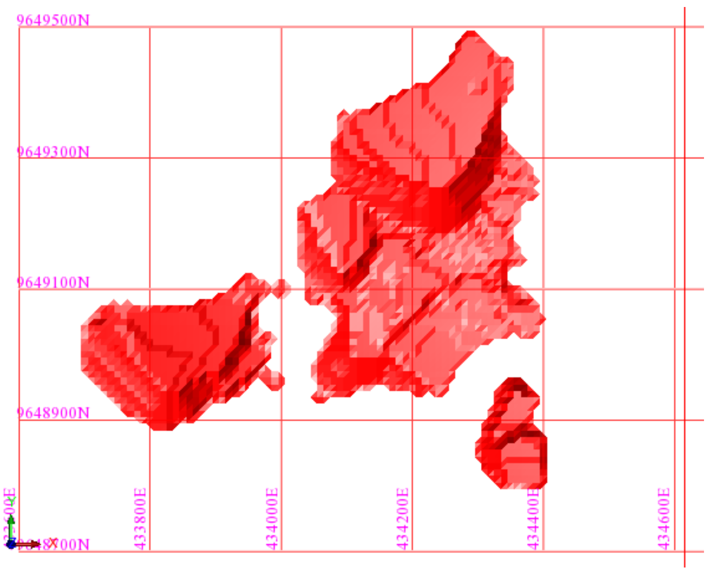


Figure 1-1 Plan view of the final pit

1.9.4 Mining Schedule

The final pit is scheduled to produce targeted quantity on a yearly basis. The annual production schedule is given in Table below:

Table 1-5: Annual production schedule

Year	Ore Tonnage (Tonnes)	Waste Volume (bcm)	Strip Ratio	Ni %
1	280,000	585,199	2.09	1.32
2	299,998	466,668	1.56	1.29
3	299,990	466,673	1.56	1.28
4	299,985	466,677	1.56	1.31
5	300,000	348,932	1.16	1.24
6	284,867	604,000	2.12	1.21
Total	**1,764,840**	**2,938,148**	**1.66**	**1.27**

1.9.5 Reclamation and Revegetation

Reclamation and revegetation are planned to begin in the second year and finish in the sixth year of all openings within the mine. The reclamation area in the APL area of 18.44 Ha includes jetty area, ROM, roads, and other infrastructure facilities, and the reclamation area within the HPK area (forest) of 38.30 includes pit, wastedump, road and settling pond, with a total area of 56.74 Ha. Revegetation is planned in the APL area of 9,220 trees and in the HPK area of 19,150 trees, with a total of 28,370 trees. This information should be included in the B & U license application table.

1.9.6 Borrow and Use license (IPPKH) Documentation

In order to meet the requirements for the application of a B&U licence PTDMT proposes that annual mine designs for the life of mine that meet the licence application criteria and six years of mine schdule are desigend with open pit and backfilling system.

A total Area of Forest for Application of IPPKH is 38.30 Ha that consists in Forest Area (HPK) is proposed.

2 INTRODUCTION

PT. Bintang Sinar Perkasa ("BSP" or the "Client") holds a Nickel concession in Bungku Selatan district in Morowali regency in Central Sulawesi, Indonesia. BSP's objective is to obtain a Borrow and Use (B&U) licence from ESDMT (Kementerian Energi dan Sumber Daya Mineral Republik Indonesia or Ministry of Energy and Mineral Resources of the Republic of Indonesia) that will enable the operation of a surface Nickel mine in the concession. In order to obtain the B&U licence, design of the mining operations is required.

PTBSP is Indonesian entity that owns the concession for nickel ore exploration on the island of Sulawesi. The majority shareholder (75%) of PTBSP is ultimately Prime Minerals Capital Group.

Prime Minerals S.A. is a company that invests in projects related to the extraction and processing of raw materials. Currently the company is implementing a nickel ore and limestone aggregates open pit mine project in Indonesia through its subsidiaries. The company shares are listed in New Connect alternative trading system on the Warsaw Stock Exchange since November 2013. There are also bonds issued by the company for public trading, which are listed on the Catalyst market also operated by the Warsaw Stock Exchange.

PTDMT was requested by BSP to prepare and submit a proposal for mine design that will meet the ESDMT licence approval requirements and also prepare a detailed mine design, so that it can be used by the mining contractors engaged by BSP to operate the mine. DMT is pleased to submit the following proposal.

2.1 Background Information

Currently permission to explore resources (exploration concession) has been obtained for the Morowali Project. The exploration concession covers an area of 2,163 ha located in the Bungku Selatan district and has been issued for a period 8 years. Reconnaissance operations were conducted initially followed by a detailed exploration, which was started in 2010. From March to August 2011 exploratory drilling was conducted in the areas of blocks A, B and C of the concession. In 2012 an additional exploration plan was prepared and in 2013 the additional exploratory drilling was carried out.

The samples collected during the explorations were subjected to laboratory tests and the exploratory data generated was used as a basis for estimation of mineral resources located in the concession area.

In 2013 the PT BSP began work to prepare a complete set of documentation necessary to obtain an environmental permit for mining operations and a feasibility study for the construction of the nickel ore mine.

The completion of the investment and the beginning of the ore deposit's exploitation is planned for the first half of 2017. Extracted raw materials will be sold to local entities involved in their processing.

2.2 DMT's scope of work

The work is to be carried out by DMT in two stages and this report is limited to stage 1 only.

2.2.1 Stage 1: Mine Design for the application of a B&U Licence

In order to meet the strict deadline requirements for the application of a B&U licence DMT proposes that annual mine designs for the life of mine (i.e. 5 years) that meet the licence application criteria will be submitted during the first stage of the project. To achieve that the following steps will be taken:

- Initial review of the available geological exploration
- Preparation of a provisional geological model using Surpac software
- Provisional assessment of Mineral Resources including quality
- Two Pit designs:
  - 1st for the Ni ore 1.9% (average)
    - 2nd for Ni ore between 1.4% and 1.6% i.e., DMT will conduct a number of pit optimisations and associated reserve estimations and in collaboration with the client the preferred option will be decided. It is expected that such optimization would be done for not more than 5 options of output grade. Based on the preferred option the final pit design will be made to meet the B&U licence requirement will be done
- Mining Equipment selection and associated labour requirements considering the two final pit options as agreed by the client
- Yearly movement of the open pit showing the stages of land used for exploitation plans for the 5 years (envisaged life of mine) for the two final pit options agreed by the client will be prepared

2.2.2 Stage 2: Detailed Open Pit Mine Design

In the second stage of the project, detailed open pit design plans will be prepared for one option of the desired average grade. To achieve that the steps below will be followed:

- Site Visit to the Project Area: A site visit will be undertaken by DMT key personnel to observe project area condition and to gather information as required for the detailed mine design.
- Detailed review of the available geological exploration date will be carried out
- Preparation of a comprehensive geological model using Surpac software
- Detailed assessment of Mineral Resources including quality
- Pit optimization
- Life of mine plan for 5 years
- Optimum equipment selection considering the equipment available by the current mining contractor will be carried out
- Detailed Pit design
- Yearly stage plans for the 5 years envisaged life of mine
- Quarterly operational plans for first 2 years

3 GENERAL INFORMATION

3.1 Location

The concession area is located in village Lamontoli, in subdistrict of South Bungku, Morowali district, Central Sulawesi province covering an area of about 2,163 hectares. Location WIUP can be reached by boat from Bangku, after reaching Bangku by road and air from Jakarta.

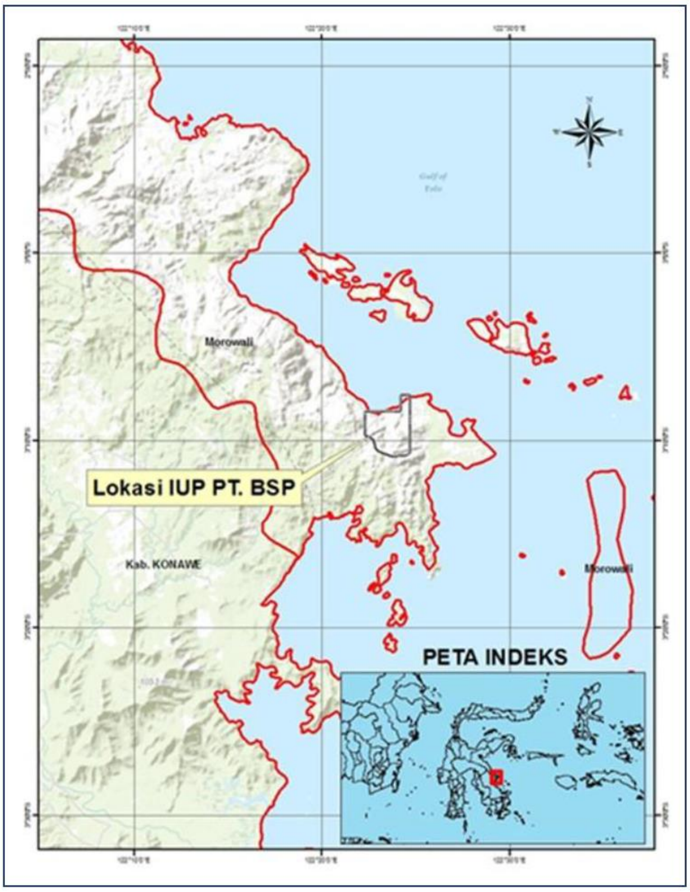


Figure 3-1 Map of PT. BSP Production Operation IUP

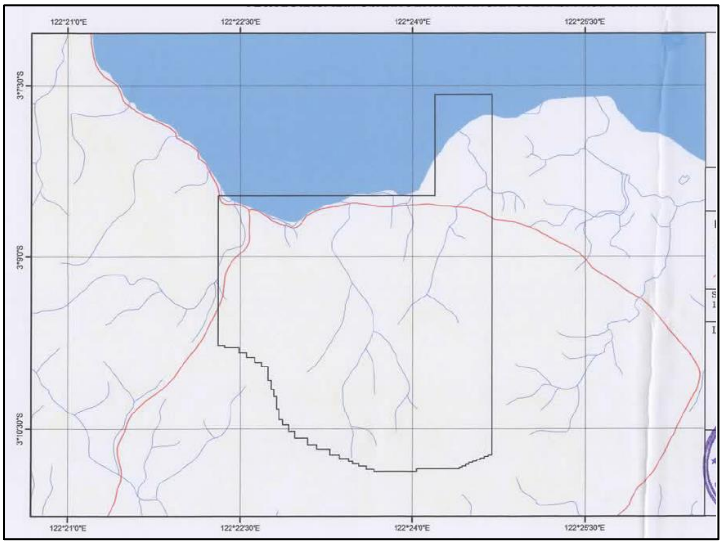


Figure 3-2 PT. BSP Concession Boundary

Table 3-1 PT. BSP Coordinate Concession Boundary

No.	East longitude			Southern Latitude			No.	East longitude			Southern Latitude		
	°	‘	“	°	‘	“		°	‘	“	°	‘	“
1	122	23	40.32	3	10	52.10	36	122	22	41.20	3	9	55.33
2	122	23	40.32	3	10	50.94	37	122	22	37.64	3	9	55.33
3	122	23	36.08	3	10	50.94	38	122	22	37.64	3	9	52.73
4	122	23	36.08	3	10	49.40	39	122	22	33.19	3	9	52.73
5	122	23	32.01	3	10	49.40	40	122	22	33.19	3	9	50.33
6	122	23	32.01	3	10	48.12	41	122	22	29.49	3	9	50.33
7	122	23	28.80	3	10	48.12	42	122	22	29.49	3	9	47.73
8	122	23	28.80	3	10	46.92	43	122	22	21.61	3	9	47.73
9	122	23	26.40	3	10	46.92	44	122	22	21.61	3	9	46.70
10	122	23	26.40	3	10	45.27	45	122	22	18.34	3	9	46.70
11	122	23	21.74	3	10	45.27	46	122	22	18.34	3	8	27.87
12	122	23	21.74	3	10	43.35	47	122	24	11.64	3	8	27.87
13	122	23	17.02	3	10	43.35	48	122	24	11.64	3	7	35.08
14	122	23	17.02	3	10	40.89	49	122	24	41.49	3	7	35.08
15	122	23	9.91	3	10	40.89	50	122	24	41.49	3	10	43.44
16	122	23	9.91	3	10	38.62	51	122	24	39.47	3	10	43.44
17	122	23	5.25	3	10	38.62	52	122	24	39.47	3	10	44.24
18	122	23	5.25	3	10	35.19	53	122	24	37.52	3	10	44.24
19	122	22	58.40	3	10	35.19	54	122	24	37.52	3	10	45.11
20	122	22	58.40	3	10	31.43	55	122	24	35.54	3	10	45.11
21	122	22	55.31	3	10	31.43	56	122	24	35.54	3	10	45.96
22	122	22	55.31	3	10	28.00	57	122	24	33.64	3	10	45.96
23	122	22	52.30	3	10	28.00	58	122	24	33.64	3	10	46.84
24	122	22	52.30	3	10	25.26	59	122	24	31.76	3	10	46.84
25	122	22	50.31	3	10	25.26	60	122	24	31.76	3	10	47.55
26	122	22	50.31	3	10	19.64	61	122	24	29.83	3	10	47.55
27	122	22	48.87	3	10	19.64	62	122	24	29.83	3	10	48.50
28	122	22	48.87	3	10	13.37	63	122	24	27.85	3	10	48.50
29	122	22	47.43	3	10	13.27	64	122	24	27.85	3	10	49.35
30	122	22	47.43	3	10	9.43	65	122	24	25.95	3	10	49.35
31	122	22	46.13	3	10	9.43	66	122	24	25.95	3	10	50.12
32	122	22	46.13	3	10	4.77	67	122	24	24.59	3	10	50.12
33	122	22	44.49	3	10	4.77	68	122	24	24.59	3	10	50.79
34	122	22	44.49	3	9	57.57	69	122	24	2.24	3	10	50.79
35	122	22	41.20	3	9	57.57	70	122	24	2.24	3	10	52.10

3.2 Topography

In general the concession can be divided into three areas namely the block area 1 / priority area 1, the block area 2 / priority area 2, and the block area 3 / priority area 3. .

Block area 1 generally shows plain undulating hills with height varrying between 10 meter and 378 meters above sea level (Bakosurtanal, 1991), condition of the slopes are generally medium to steep slope ranging from 50 ° - 60 °, upper part of the hill/ridges are relatively flat and profile show steep valleys of intermediate level, The shape of the valley is "V" type in the western part and "U" type in the central part of the block 1, dipping towards North West - South East direction. The vegetation in this area has trees and shrubs with moderate to heavy intensity. Undulating plain area occupies the southern and eastern parts of block 1, while the hills occupy the north -central and west.

Soil generally shows the appearance of crocus, brownish red as a result of variable weathering of rocks like laterite, saprolite and low serpentinized peridotite.

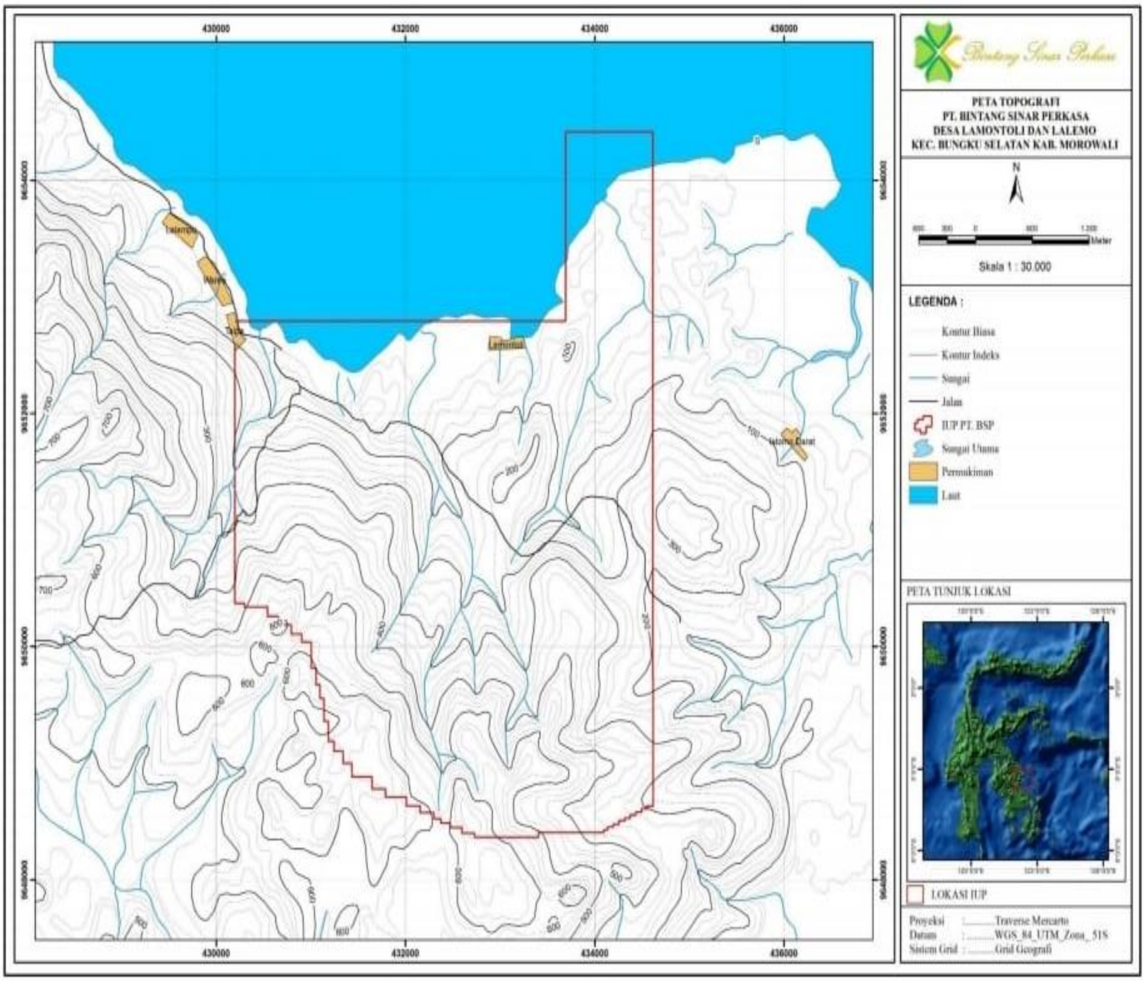


Figure 3-3 PT. BSP Topography map

In the study area there are several north-south trending large rivers that flow throughout the year towards north, along with a number of tributaries. In addition to this, there are some small rivers that are seasonal in nature. Springs are common in the hills as source of groundwater. The area sources potable water from groundwater, surface water, and rain.

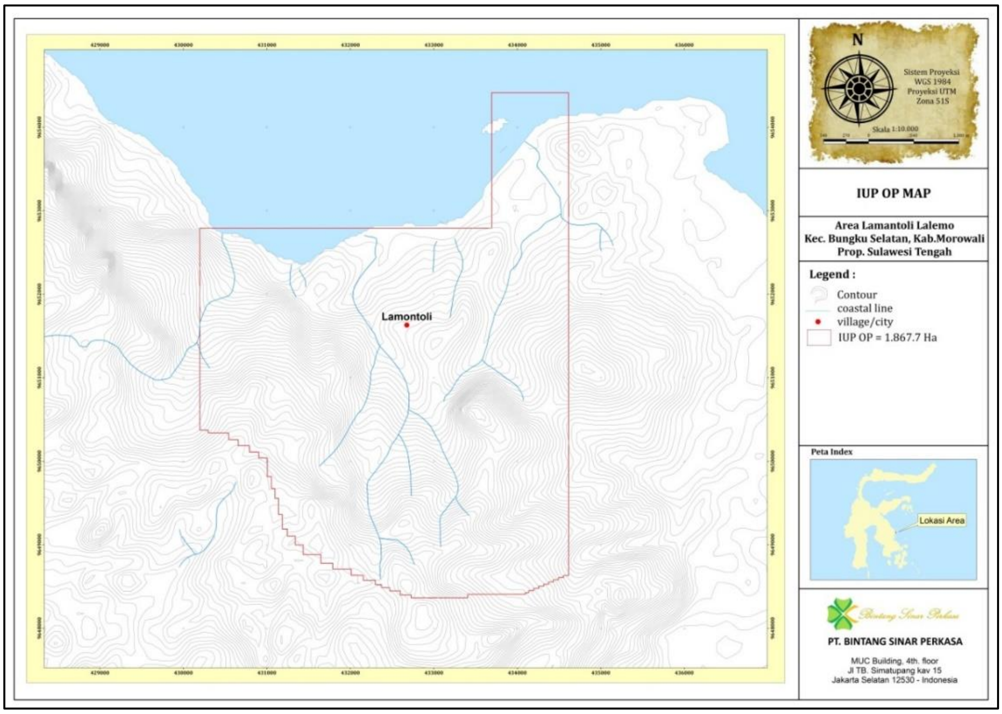


Figure 3-4 PT. BSP Drainage map

3.3 Climate

The area has a rainfall of 1,909 mm / year with the number of rainy days on an average 18 day / month as recorded from meteorological stations in Morowali Regency.

Table 3-2 Average climate Morowali Regency Year 2009

Month	AIR TEMPERATURE			Rainfall (mm)	Rainy Day (mm/bl)	RH (0/o)
	Max (°C)	Min (°C)	Rata-rata ("C)			
January	30,60	22,60	26,60	269.00	19	87
February	30.30	22.30	26.3	235.00	13	83
March	31.20	22.70	26.95	174.00	17	86
April	32.00	23.00	27.50	182.00	20	82
Mei	31.20	22.70	26.95	96.00	15	84
June	32.00	23.00	27.50	133.00	22	79
July	31.70	22.80	27.25	103.00	16	83
Augustus	32.30	22.80	27.55	32.00	15	80
September	31.40	22.90	27.15	254.00	27	80
October	31.40	23.00	27.20	172.00	13	81
November	32.10	23.20	27.65	241.00	21	80
December	31.30	23,10	27.20	18.00	14	86
Total	377.50	274.10	325.80	1909.00	212	991
Average	31.50	22.80	27,20	159,10	17.70	82.6

The highest rainfall occurs in January with a rainfall of 269 mm / month with 19 days of rain, the lowest rainfall occurs in December, I e 18 mm / month with 14 days of rain. Monthly maximum air temperature ranged from 30.30 to 32.30 ° C, minimum temperatures ranged from 22.30 to 23.10 ° C. The average monthly temperature ranged from 30.30 to 32.30 ° C and the average annual temperature of 27.15 ° C. Air humidity (RH) in the region the average monthly humidity ranging between 81-87%.

The area comprises mostly agriculture, forestry and plantation so that air pollution and noise level are below threshold limit of noise.

4 GEOLOGY

4.1 Regional geology

The concession area is part of the Cretaceous to Oligocene complex ultramafic stratigraphic unit of Central Sulawesi province. Sulawesi island is located on the active margin of the Asian plate, along the junction of the Asian, Australian and Pacific plates and suffered at least four major tectonic events in Mid-Cretaceous, Oligo-Miocene, Middle Miocene, and Early Pliocene times. The main orogenic belt of this island is related with the Oligo-Miocene event. Several geodynamic models have been proposed in literature for this belt. The structural and stratigraphic investigations in the central area of Sulawesi lead to an eastward obduction of an ophiolitic nappe of Asian origin onto a continental Gondwana Block, while a west-dipping slab was subducting underneath the western Asiatic margin. Collision between this fragment of Gondwana and the active Asiatic margin in Late Oligocene or Early Miocene time produced the central metamorphic belt of Sulawesi.

The area mainly covered by two main formations based on Regional Geology Map of Kendari.

c. Salodik Formation (Tems)
d. Ophiolites Rocks Formation (Ku)

The Salodik formation consists of oolitic limestone with intercalation of marl and sandstone containing quartz fragments. The abundance of corals, algae and larger foraminifera found in this formation suggest that it was formed in a shallow marine environment. The Salodik formation is in a fault contact with the Ophiolite Complex.

The ophiolite rocks mainly consist of Peridotite, Harzburgite, Dunite, Gabbro and Serpentinite.

Alluvium (Qa) is the youngest aged Holocene sediment composed of silt, clay, sand, gravel, along with lateritic soil and laterites.

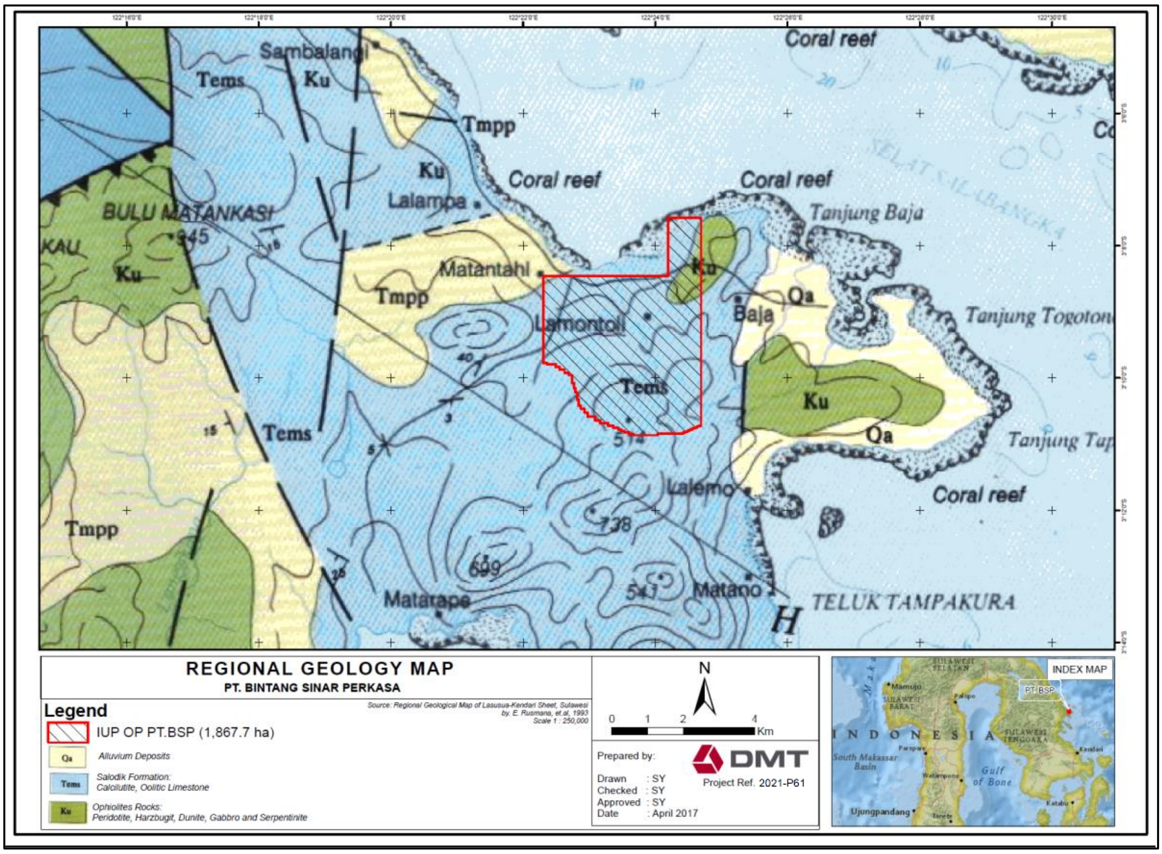


Figure 4-1 Regional geological map of Central Sulawesi area

4.2 Local geology

The concession area is mostly composed of Periditite and Pyroxenite type of rocks:

Following Peridotite rocks are reported:

- Harzburgite, green to blackish green, with coarse crystalline texture, composed of mainly olivine and pyroxene.
- Dunite, dark gray to black, with aphanitic texture, deposited in along the fault lines, these rocks are consist of minerals like olivine (± 95%) with minor concentration of pyroxene, plagioclase, serpentine, Talc and magnetite.

Pyroxenite is pale gray to black coloured, with crystalline texture, composed of pyroxene (>85%), olivine, serpentine. In general, symptoms of deformation in these rocks are marked by high temperature twins in pyroxene.

Surface geological mapping, indicates that the concession area is composed of peridotite ultramafic rocks with low to moderate level of serpentinization, but in some places in central and northern part peridotite rocks contain high level of serpentinite, a common rock-forming hydrous magnesium ironphyllosilicate ((Mg, Fe)3Si2O5(OH)4).

Serpentinite often contain minor amounts of other elements including chromium, manganese, cobalt or nickel. Serpentinised peridotite are glossy, low to medium gray to yellowish green colored rock, containing olivine, pyroxene, serpentine with little silica and garnet. In the southern part of the block silica found as fragments of chalcedony within the serpentinised peridotite.

Megascopic observations and geological exploration indicate presence of sheet like laterite nickel deposit covering parts of the concession. The laterite nickel deposit is spread over the flat topped ridges, gentle slopes and steep cliffs occasionally.

Laterites are the residual products of chemical weathering of rocks at the surface of the earth, in which various original or primary minerals unstable in the presence of water, dissolve or break down and new minerals are formed that are more stable to the environment. Nickel laterites are the product of lateritisation of Mg-rich or ultramafic rocks which have primary Ni contents around 0.2-0.4%. Such rocks are generally dunites, harzburgites and peridotites occurring in ophiolite complexes, and to a lesser extent komatiites and layered mafic-ultramafic intrusive rocks in cratonic platform settings Two stages of weathering can occur in Ni laterite deposits. Initially, the protolith of the Ni laterite may be weathered to serpentinite, which is subsequently weathered into a laterite profile concentrating Ni and Co.

The Ni-Co laterite deposits are formed from the chemical weathering of the ultramafic rocks that removes the most soluble elements (Magnesium(Mg), calcium (Ca), and silicon (Si)) and concentrates the least soluble elements (iron (Fe), Ni, manganese (Mn), Co, zinc, (Zn), yttrium (Y), chromium (Cr), aluminum (Al), titanium (Ti), zirconium (Zr), and copper (Cu)) (Brand and others, 1998). Mechanical weathering of the host material by fractures and faults, increases the surface area exposed to the water driving the chemical weathering. Ni-Co laterites can occur as in situ deposits, buried as karst (Albania and Greece), or as linear/fault-hosted deposits (Urals). The residual material can retain in average as much as 5 % Ni and 0.06 % Co.

Nickel concentration is hosted in a variety of secondary oxides, hydrous Mg silicates and smectites. Concentration of Ni increases as Ni leached downwards to concentrate in neo-formed silicates in the saprolite.

The formation, mineralogy and grade of the deposits are controlled by the interplay of climate, geomorphology (relief), drainage, Eh and pH of the circulating water, tectonism, structure, and mineralogical characteristics of protolith on the development of favorable weathering profiles.

The mineralogical characteristics subdivide the Ni-bearing ores into oxide, clay, or hydrous magnesium (Mg)-silicate types, which have significant differences from a recovery perspective. All three mineralogical types of ore may be present in a single Ni-Co laterite deposit. The metalliferous laterites are mineralogically complex, discontinuous, and often have Ni enrichment in multiple weathering profile zones.

The ultramafic rocks of the concession area have undergone chemical weathering with low-medium and occasionally high oxidation rates; nickel laterite generated in turn by supergene enrichment. However, in some parts, especially in the area of the cliff / slope of the ridge, the process of weathering and oxidation are not going well, because the surface erosion process was faster.

The Nickel laterite profile of the concession can be described as below.

- The lower section consists of the unweathered protolith, primarily serpentinized dunite or peridotites.
- Above this is a saprolite layer consisting of remnants of the protolith.
- At the top of the saprolite a clay-rich layer.
- Above the clays is a limonite layer with Fe.

- Top of the profile is often defined by a hematite- and goethite-rich ferricrete or iron cap or lateritic clay.

Generally nickel enrichment is found in limonite and saprolite zone, nickel enrichment slowly descend to the bedrock zones (bedrock).

Structure

The structure and tectonics of this area shows characteristics of an active sub-continent collisional complex. Based on the tectonic and structural aspects the concession area can be divided into two zones namely: 1) allochthonous block including Banggai Sula, lane ophiolite and metamorphic, and 2) autochthon block, Mendala Sulawesi and West Sulawesi Molasa Group.

The tectonic setting of the area generated structures such as faults, thrusts, folds as well as shear zone, fracture zones and joints. Palu-Koro fault system is a major fault trending Northwest - Southeast and show horizontal movement to the left. It is surmised that this fault is still active.

Thrust faults trending north – south, exposed in the western part of the region, is the dividing line between West Sulawesi and East Sulawesi. South east and south west trending Beruapa fault, formed during or after the regional fault passes through the village Towi Mountains. Three types of folds: weak folds, open folds and closed folds are common in the area.

The geological structures like fault plane, zone of brecciation, stocky shear zones (shear joint), joints and fractures, contributed for lateritic nickel deposit formation in the area. These deformed rocks are generally found in the north east of the concession, along top of the ridges, shallow slopes and steep cliffs of the major river basins in the middle and southern part of the concession.

4.3 Exploration details

Data/reports received by PTDMT shows that geological exploration in the concession of PTBSP started in 2010 with reconnaissance survey and continued up to early-2016, in phases. Following data or reports are providing information on geological exploration carried out in the concession:

- Geological exploration report by PT GEOSURVEY MINING INDONESIA, JULY 2011
- Laporan Studi Kelayakan or Feasibility study report by PT. BINTANG SINAR PERKASA, November 2013
- Bore hole & Assay data for 284 boreholes
- Topographical Survey files
- IUP document

During the first phase of exploration reconnaissance survey was conducted to identify potential area for Nickel mineralization e i., lateritic zones. Three potential areas were identified for further exploration: Block A, B and C as shown below.

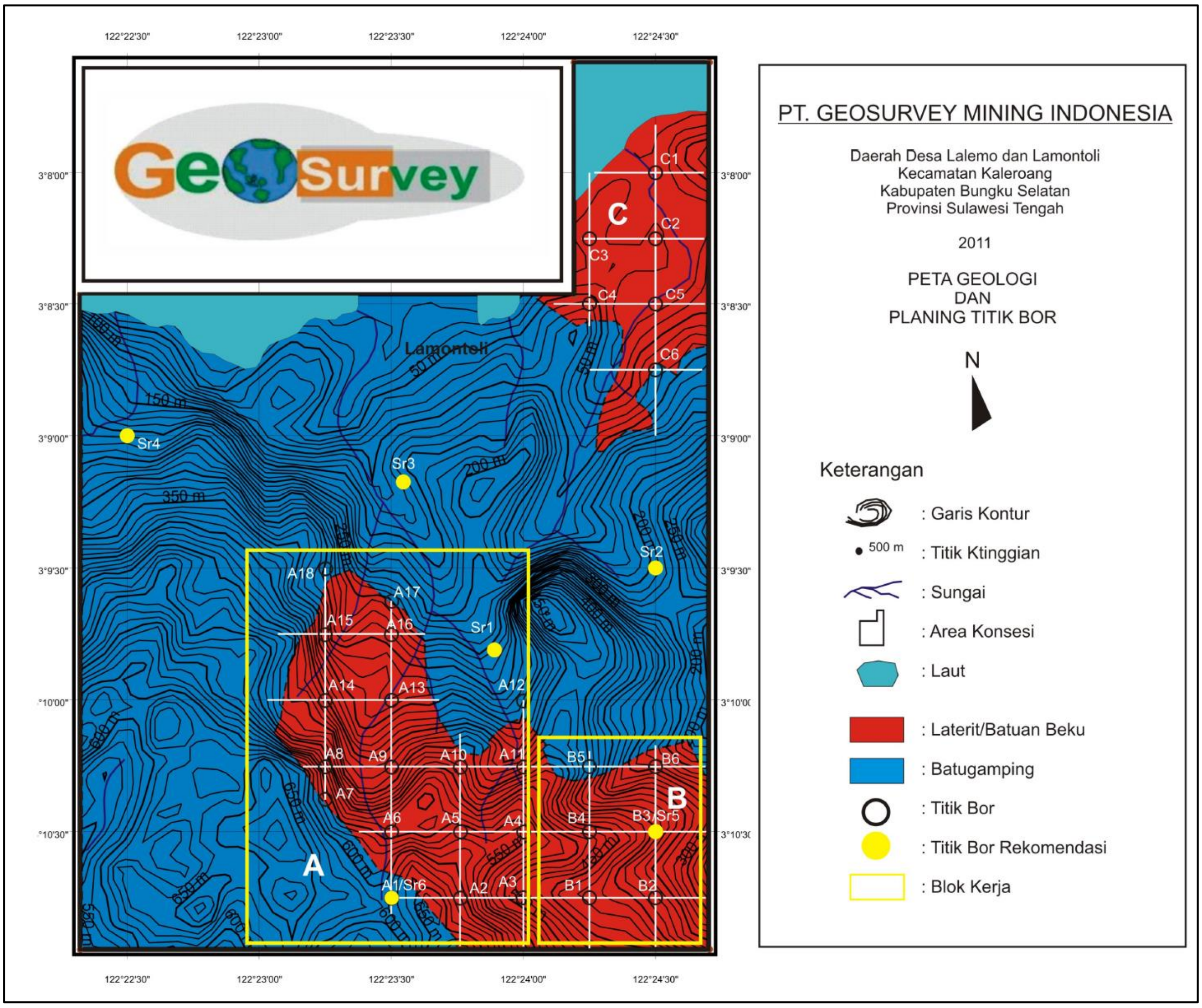


Figure 4-2 Potential area for Lateritic Nickel given in Geological Exploration Report dated 2011

An area of about 430 Ha within the concession was marked as covered with nickel bearing laterite. The block-wise break-up is 80 Ha in Block A, 250 Ha in Block B and 100 Ha in Block C. During March to August 2011, first phase of exploratory drilling was conducted mainly in blocks A and C along with few test pits in Block B. 4 boreholes were drilled in block A and 52 boreholes drilled in block C, 4 test pits were drilled in identified potential area (garnierite rocks) along Block B and part of Block A.

Drilling in block A shows nickel bearing laterite thickness varrying between 1 to 4m, with a very compact crystalline limestone at base. Grade of nickel found 0.2 to 0.6%.

The total number of drilling completed in block C is 52 points with the total depth drilled 710.98 meters. The laterite spread is generally in the north-south, with an average thickness of about 4 meters, while the saprolite has an average thickness of 7 meters. At an average depth of about 11 meters found bedrock in the form of limestone, breccia and conglomerate. Information on grade (average Ni% in each borehole) available from 17 boreholes with maximum grade 1.2% and maximum thickness 13m.

Further 4 test pits done in Block A & B in garnarite rocks along the hills and quality analysis done for 30 samples, among which 2 test pits GR-01 and GR-02, shows high nickel. Ni: 2.76% and 2.82%.

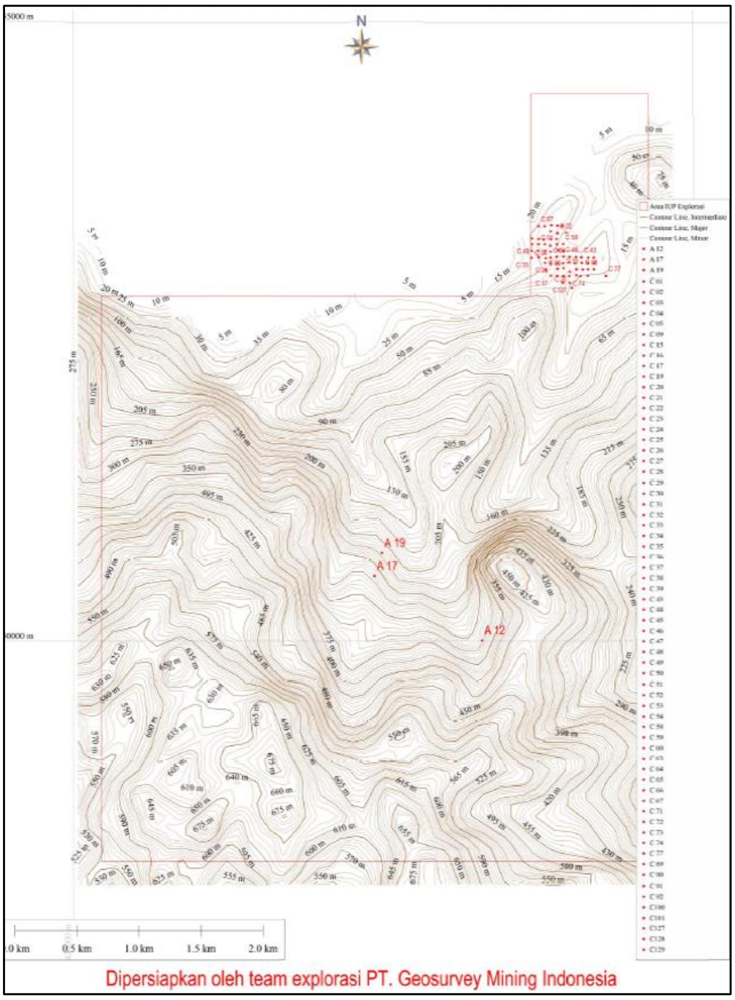


Figure 4-3 Location of boreholes drilled in 2011

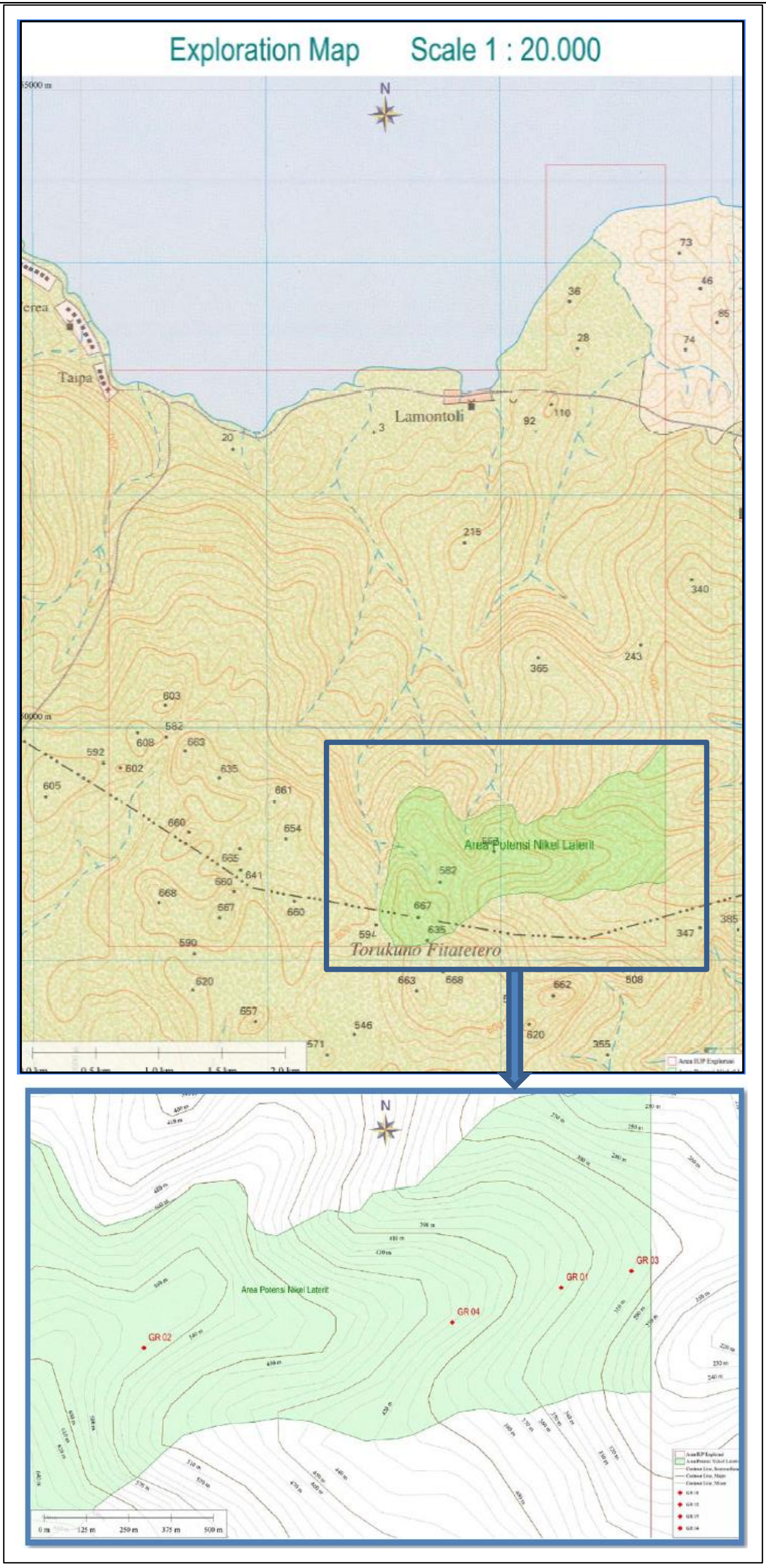


Figure 4-4 Test pits in identified potential area , exploration 2011

Borehole location and lithological data were available for about 35 boreholes among the 56 drilled, however no detail analysis results were included in the exploration report dated 2011 except composite Ni% from 17 boreholes from Block C.

Another phase of exploration carried out during 2012- 2013. A feasibility report for the project was prepared in 2013 based on the exploration completed. Feasibility Report indicates completion of about 100 boreholes in 200m X 200m grid pattern along the south eastern part of the concession area, designated as Block 1, however no data available on the Block 1/Block 2/Block 3- boundary and size, completed borehole numbers and locations, lithological logs, assay or quality data with PTDMT. From the description it is assumed that Block 1 represents mostly Block B & part of Block A shown in Exploration Report.

Exploration activities have been conducted by PT. STAR LIGHT PERKASA since 2011, among others activities are:

- Geodetic Survey
- Geological mapping carried out at 1: 25,000 scale covering the concession area.
- Geophysical Survey by Resistivity measurements
- Drilling: 100 boreholes completed with a total meterage of 2,200 m during drilling activities carried out during January to November of the year 2012,
- Analysis Laboratory: Laboratory analyzes of samples collected during drilling carried out for minerals such as Ni, CO, Al2O3, CaO, Cr203, Fe, Fe2O3, K20, MgO, MnO, Na2O, P, SiO2, TiO2.
- Feasibility Study carried out for the lateritic nickel deposit mining project in November 2013

As described in the report the laterite nickel deposit in Block 1 is mainly composed of limonitic ore with 1.2% Ni Average Grade and saprolitic ore with 1.6% Ni Average Grade. Limonitic Ore zone is found at depth of 0 meters - 8 meters, generally exhibit color reddish brown to dark brown clay, showing very strong weathering and covered by ferricrits of geothite and hematite. Saprolitic ore zone found at a depth of 5 meters - 15 meters, generally yellow - Yellow-green coloured, with medium to strong weathering, with garnierite filled fractures. It is described in the report that the limonitic ore shows concentration of: Ni: 1:05% - 1:20%, Fe: 38.20% - 46.61%, Co: 0.070% - 0.155%; Saprolitic ore shows concentration of Ni: 1:54% - 3.3%, Fe: 12:59% - 34.69%, Co: 0.025% - 0221%, however no detail quality analysis data provided with the report. From limonite to saprolite zone there is high concentration of mineral garnierite, as well as some cobalt and manganese. The bedrock is mostly defined by harzburgite with very less Ni concentration.

Geological reserve of about 15 MT and 14MT at 1.2% cut off and at 1.6% cut off respectively estimated in the feasibility study, using boreholes drilled in 200m grid by polygonal method. No information available with PTDMT on position and size of Blocks, Borehole number, location, log and assay data used for the estimation.

Table 4-1 Balance nickel deposit resource COG 1.2% Ni (Source : Feasibility Report, 2013)

BALANCE OF DEPOSITS RESOURCE MATERIALS NICKEL - COG 1.2% NI			
BLOCK AREA	KLAS CADANGANf WMTI		
	Designated	measurable	Total
BLOK 1	3,645,200.00	-	3,645,200.00
BLOK 2	3,100,800.00	620,887.63	3,721,687.63
BLOK 3	6,938,400.00	860,869.88	7,799,269.88

Table 4-2 Balance surnberdaya nickel deposit COG 1.6% Ni (Source: Feasibility Report, 2013)

BALANCE OF DEPOSITS NICKEL RESOURCE MATERIALS COG 1.6% Ni			
BLOCK AREA	KLAS CADANGAN		
	Designated	measurable	Total
BLOK 1	3,645,200.00	-	3,645,200.00
BLOK 2	3,100,800.00	125,850.40	3,226,650.40
BLOK 3	6,938,400.00	740,780,20	7,679,180.00

Further in the same report 12.67 MT of Minable and Marketable nikel reserve at 1.6% cut off reported estimated using the following formula:

Area X Average Ore thickness X Ore Density and 80% recovery

=1980000 X 5 X 1.6 X 80/100= 12.67 MT

Where 198 Ha Area is considered as prospective mining area, Ore density as 1.6, Average thickness at 5m at 1.6% Ni cut off, Recover factor as 80%.

No map available with 198 Ha area marked.

Table 4-3 Mineable and Marketable nickel deposit at cut-off grade of 1.6% Ni (Source: Feasibility Report, 2013)

Tabel 3.5 Neraca sumberdaya Mineable & Marketable endapan nikel CoG 1.6% Ni

NERACA SUMBERDAYA ENDAPAN BAHAN GALIAN NIKEL_CoG 1.2% Ni VERSUS MASA PENAMBANGAN		
Luas Area Prospect Mining	198	Ha
Rasio Kesuksesan	75%	
Tebal rata-rata Ore	5	meter
Density Ore	1.6	
Mining Recovery	80%	
Potensi Cadangan Ni CoG 1.2% (terkira)	12,672,000	Ton Ore
Target produksi bulanan	100,000.00	Ton Ore
Masa Penambangan	126,72	Bulan

During the current study PTDMT has been provided with 278 borehole data including location, litho log and assay data which were mostly drilled, sampled and analysed during 2015-2016.

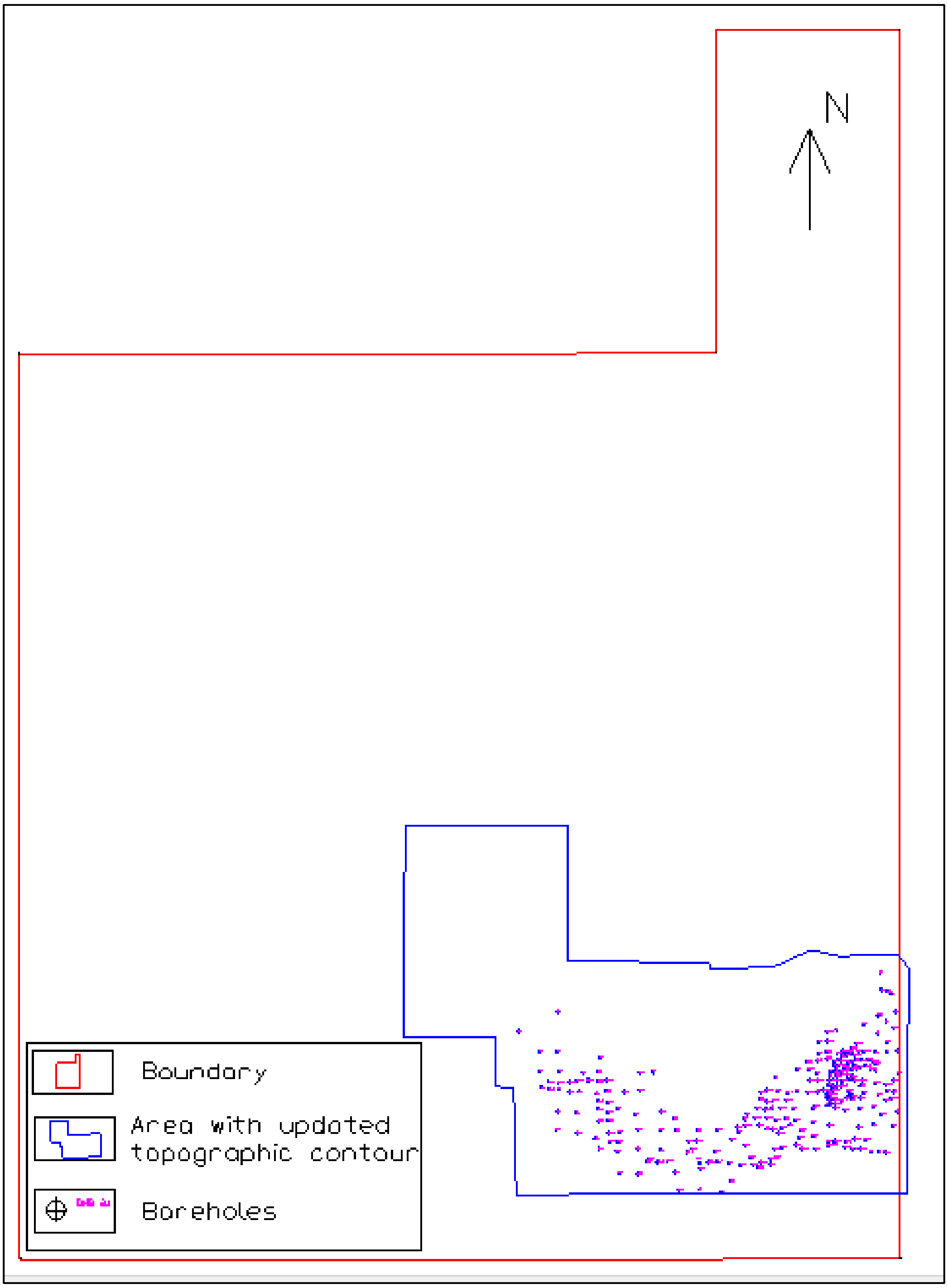


Figure 4-5 Borehole locations for 278 boreholes drilled in 2015-2016 used in current study. Red Boundary id the concession boundary of PTBSP and Blue boundary is the area (about 300 Ha) for which detail topographical survey has been carried out

4.4 Geostatistics

Geo-statistical analysis was done on DHB- series boreholes in the demarcated concession area. The number of boreholes considered for modelling and geostatistical processing is 254 out of total 278 holes. The total Ni grade and weighted average of the grade on thickness has been considered for Geostatistical analysis

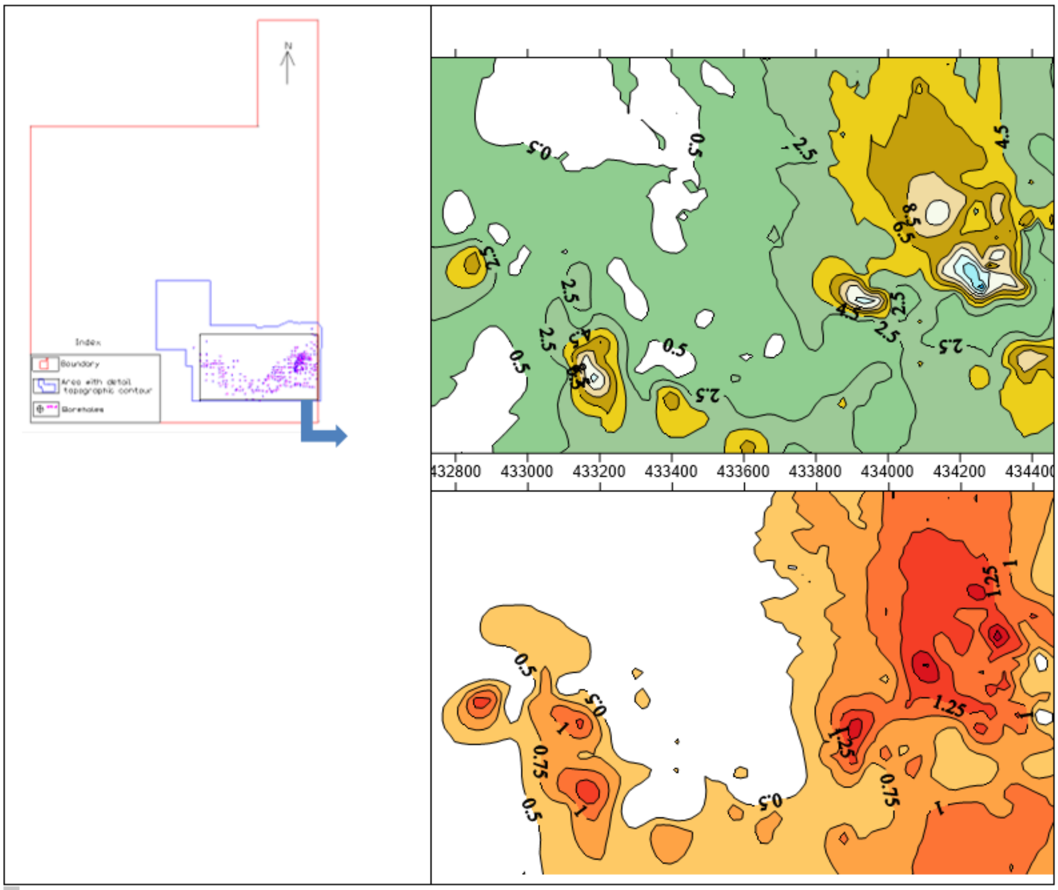


Figure 4-6 Contour map for Nickel ore thickness & grade variation within zone of exploration

4.4.1 Chemical Analysis

Statistical analysis was carried out for the available 278 borehole data (location, lithology, and assay/quality) to understand the geological character of the lateritic nickel deposit in the concession, including average and range of Ni concentration in lateritic nickel, association with other elements, thickness variation, continuity of grade and thickness.

The prospect was explored by core drilling and chemical analysis of the samples for Ni, AL2O3, MgO, Fe2O3, SiO2, P, Cr2O3, MnO, Fe, Co, TIO2 were undertaken. The correlation matrix for Nickel with other elements and radicals are as follows:

Table 4-4 Correlation Coefficient matrix amongst various radicals and metals analysed from borehole core samples (Number of sample=4224)

	NI	*Al2O3*	MgO	Fe2O3	SiO2	P	Cr2O3	MnO	Fe	Co	TiO2
Ni	1										
Al2O3	0.16	1									
MgO	**-0.41**	-0.52	1								
Fe2O3	**0.53**	0.48	-0.65	1							
SiO2	-0.17	-0.24	0.75	-0.65	1						
P	-0.27	0.01	-0.44	-0.15	-0.47	1					

Cr2O3	**0.63**	0.38	-0.59	**0.88**	-0.54	-0.27	1				
MnO	0.52	0.51	-0.65	**0.91**	-0.59	-0.17	0.89	1			
Fe	**0.53**	0.48	-0.65	1	-0.65	-0.15	0.88	0.91	1		
Co	**0.46**	0.37	-0.45	0.74	-0.47	-0.24	0.80	0.73	0.74	1	
TiO2	0.20	0.40	-0.26	0.38	-0.20	-0.12	0.37	0.37	0.38	0.51	1

The correlation matrix indicates: Ni shows positive correlation with Cr2O3, MnO, Fe and Co confirming the enrichment of Ni above redox front. Ni shows negative correlation with MgO, SiO2 and P. Below the redox front geochemical boundary, there is a sharp rise in MgO – a discontinuity, that marks the contact with an overlying ferralite zone. Cobalt analysis for all the samples are not available.

4.4.2 Statistical parameters of some **radicals** for the total explored area

Assay values for Ni concentration (%) in all samples (4224 numbers) from cores of all 278 boreholes have been analysed.

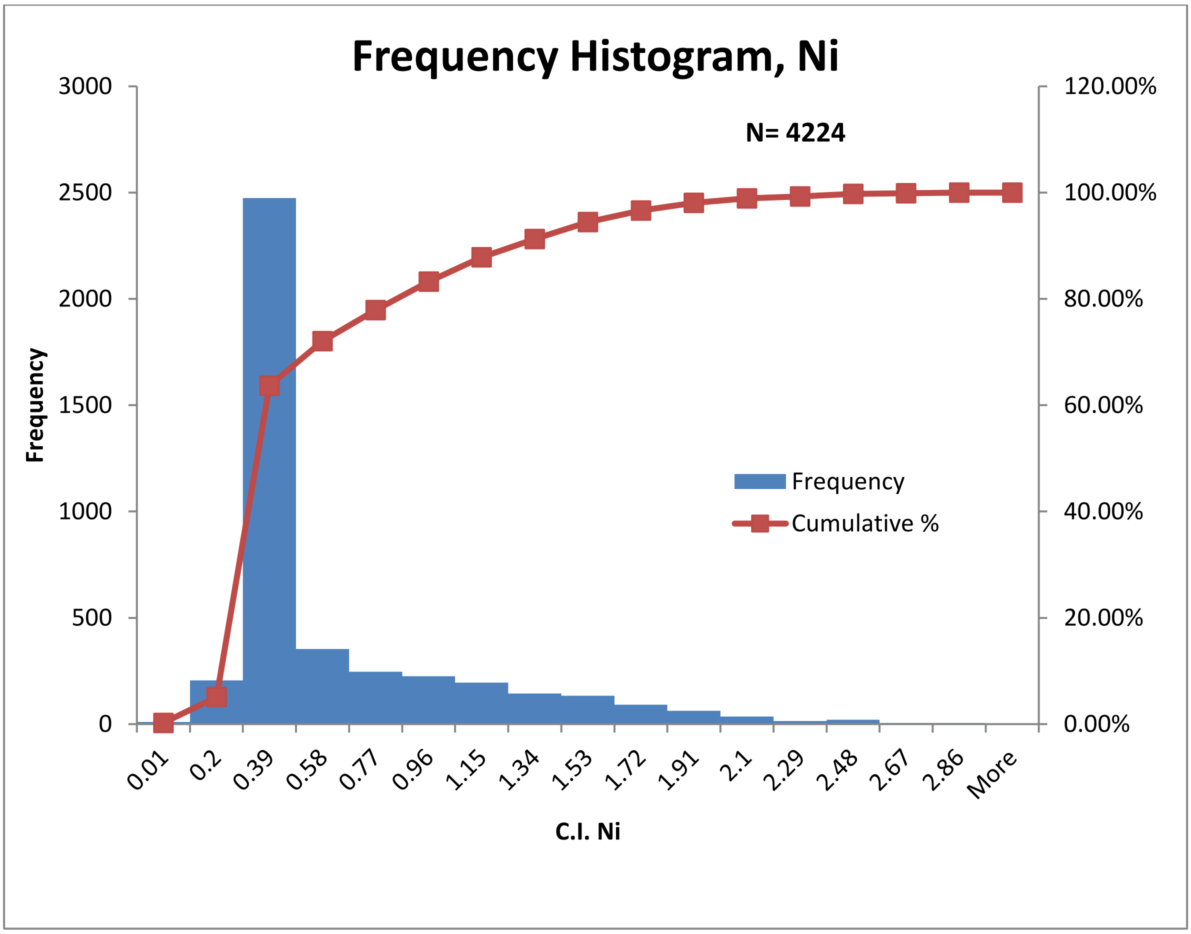


Figure 4-7 Frequency histogram of Ni assay of all the samples of borehole cores (N= 4224) .

Ni concentration (%) distribution is strongly skewed positively. The natural cut-off for Ni% of the population is 0.39%. The basic statistical parameters estimated are as follows.

Table 4-5 Statistical estimation parameters for Ni (%) distribution in all borehole (for 4224 sample data)

Statistical Parameters	Estimated values
MEAN	0.53

Statistical Parameters	Estimated values
MEDIAN	0.3
MODE	0.23
SD	0.47
VARIANCE	0.22
CV %	88.78
SKEWNESS	1.81
KURTOSIS	2.92

Assay values for MgO concentration (%) in all samples (4224 numbers) from cores of all 278 boreholes have been analysed.

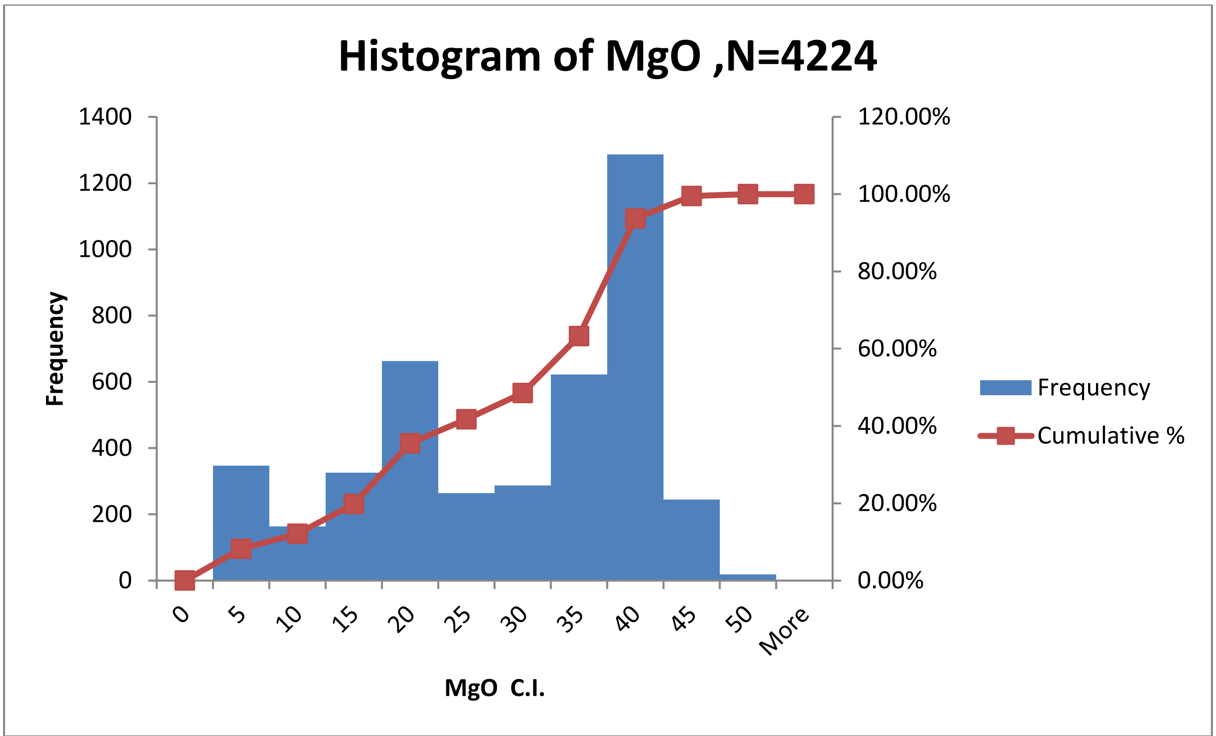


Figure 4-8 Frequency histogram of MgO assay of all the samples of borehole cores (N= 4224)

It is polymodal, negatively skewed distribution, with moderate high CV. Higher modal, median values than mean value points to preponderance of ultrabasic source rock. The basic statistical parameters are as follows.

Table 4-6 Statistical estimation parameters for MgO (%) distribution in all borehole (for 4224 sample data)

Statistical Parameters	Estimated values
MEAN	26.27
MEDIAN	30.80
MODE	36.2
SD	12.29
VARIANCE	151.09
CV%	46.78
SKEW	-0.57

KURT	-0.90

Assay values for Fe2O3 concentration (%) in all samples (4224 numbers) from cores of all 278 boreholes have been analysed.

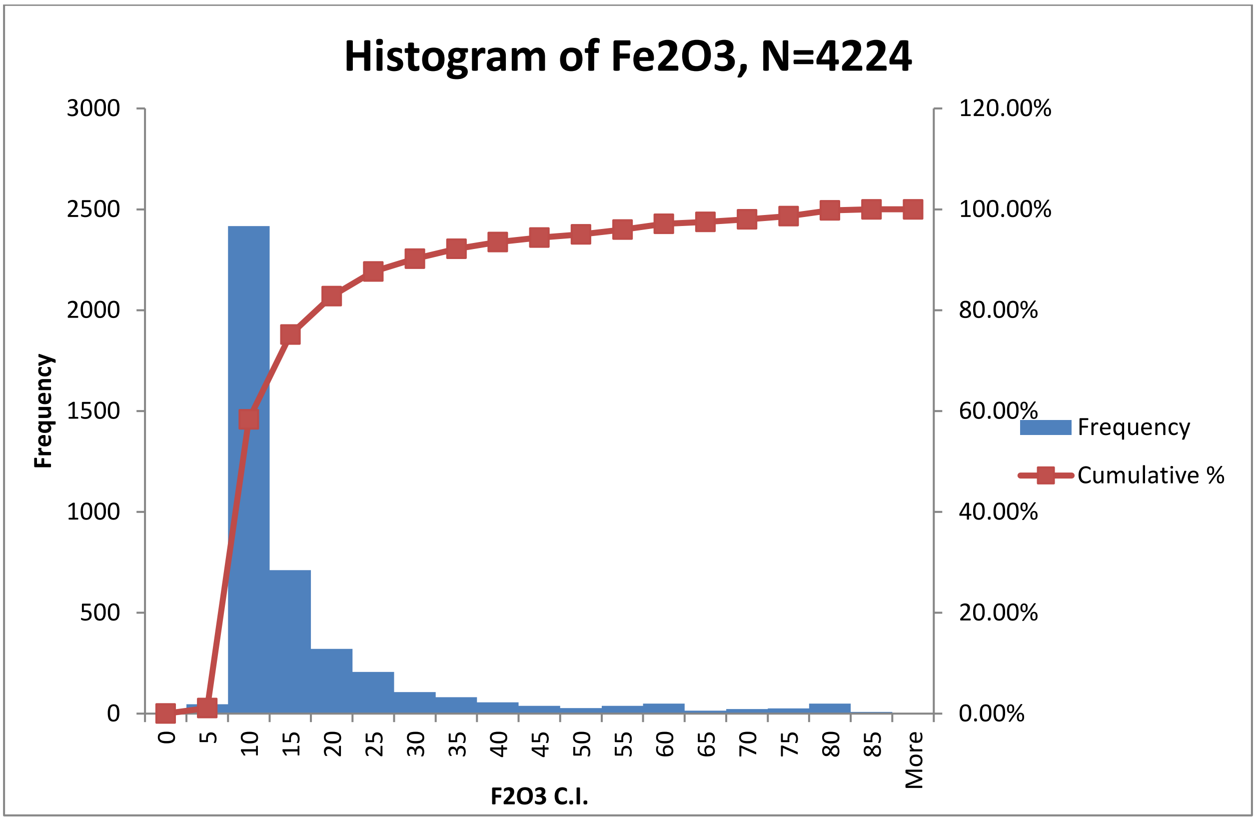


Figure 4-9 Frequency histogram of Fe2O3 assay of all the samples of borehole cores (N= 4224)

The natural cut-off for Fe2O3% of the population is 5%. It is strongly skewed positively and mimics Ni. The basic statistical parameters are as follows.

Table 4-7 Statistical estimation parameters for Fe_2O_3 (%) distribution in all borehole (for 4224 sample data)

Statistical Parameters	Estimated values
Mean	14.84
MEDIAN	9.25
MODE	8.33
SD	14.04
VARIANCE	197.07
CV%	94.59
SKEWNESS	2.80
KURTOSIS	7.96

Assay values for Co concentration (%) in all samples (1546 numbers) from cores of all 278 boreholes have been analysed.

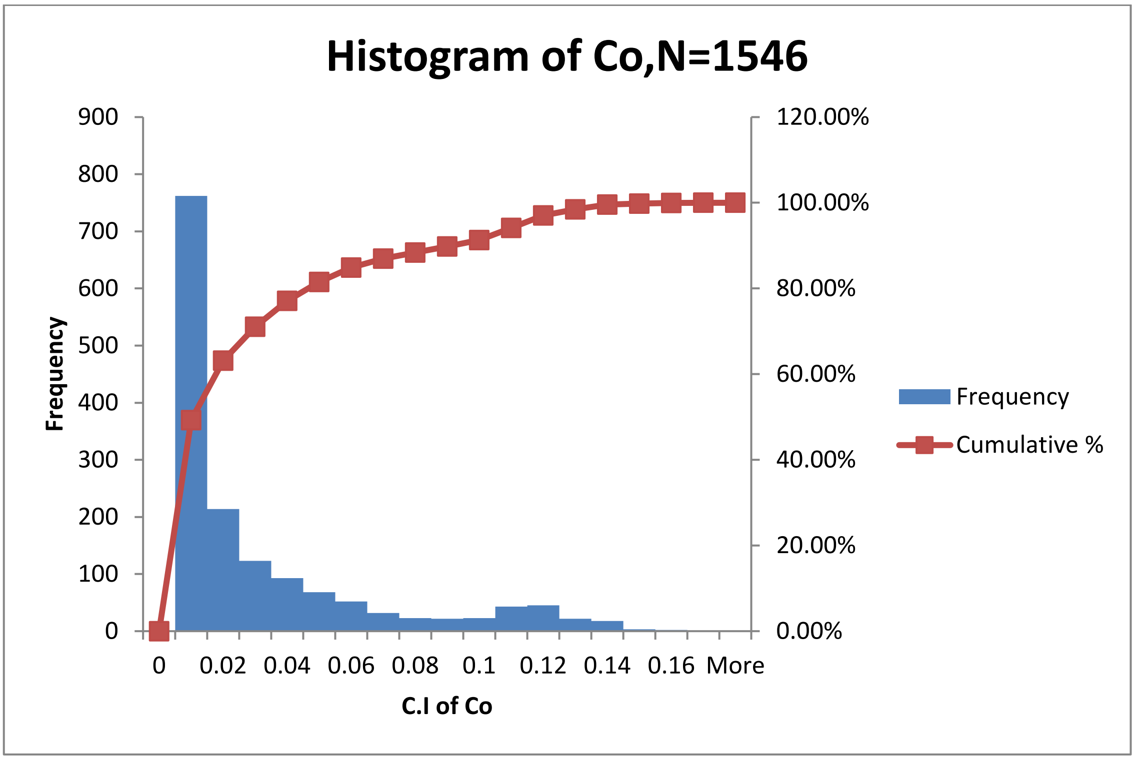


Figure 4-10 Frequency histogram of Co assay of a part samples of borehole cores (N=1546).

The natural cut-off for Co% of the population is 0.02 %. It is strongly skewed positively and shows bimodality towards tail. CV is very high with mean higher than mode and median values. The basic statistical parameters are as follows.

Table 4-8 Statistical estimation parameters for CO (%) distribution in all borehole (for 4224 sample data)

Statistical Parameters	Estimated values
MEAN	0.03
MEDIAN	0.02
MODE	0.01
SD	0.03
VARIANCE	0.001
CV%	106.28
SKEW	1.70
KURT	1.89

4.4.3 Statistical parameters of Lateritic Nickel within Ore zones/ mineralized zone

The lateritic nickel ore zone is defied with 0.5% Ni and 0.5m width as cut-off grade/width. Lateritic nickel ore widths and assays (thickness of ore & weighted average of Ni% in each borehole considered) of a total of 254 borehole samples could be considered for modeling at, as in 24 boreholes no ore intersected. These are placed below.

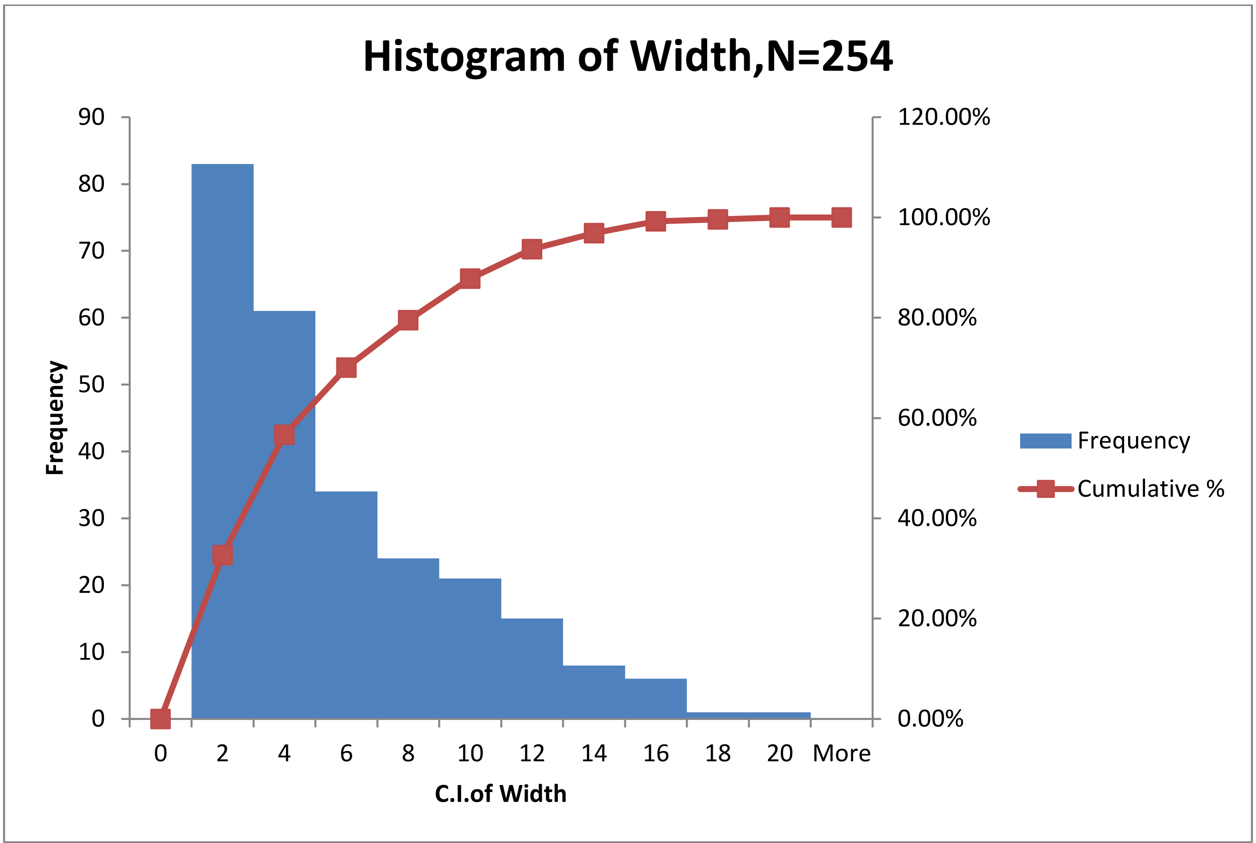


Figure 4-11 Frequency histogram of width of ore zone (Ni 0.5% and above)

Histogram shows a much higher mean than mode and median; high CV % and strong positive skewness indicate uncertainty in thickness of ore intercepts and continuity in the mineralized zone.

Table 4-9 Statistical estimation parameters for width of Nickel ore (m) distribution in all borehole (for 254 sample data)

Statistical Parameters	Estimated values
MEAN	5.10
MED	4
MODE	2
SD	3.91
CV%	76.56
SKEW	1.11
KURT	0.70

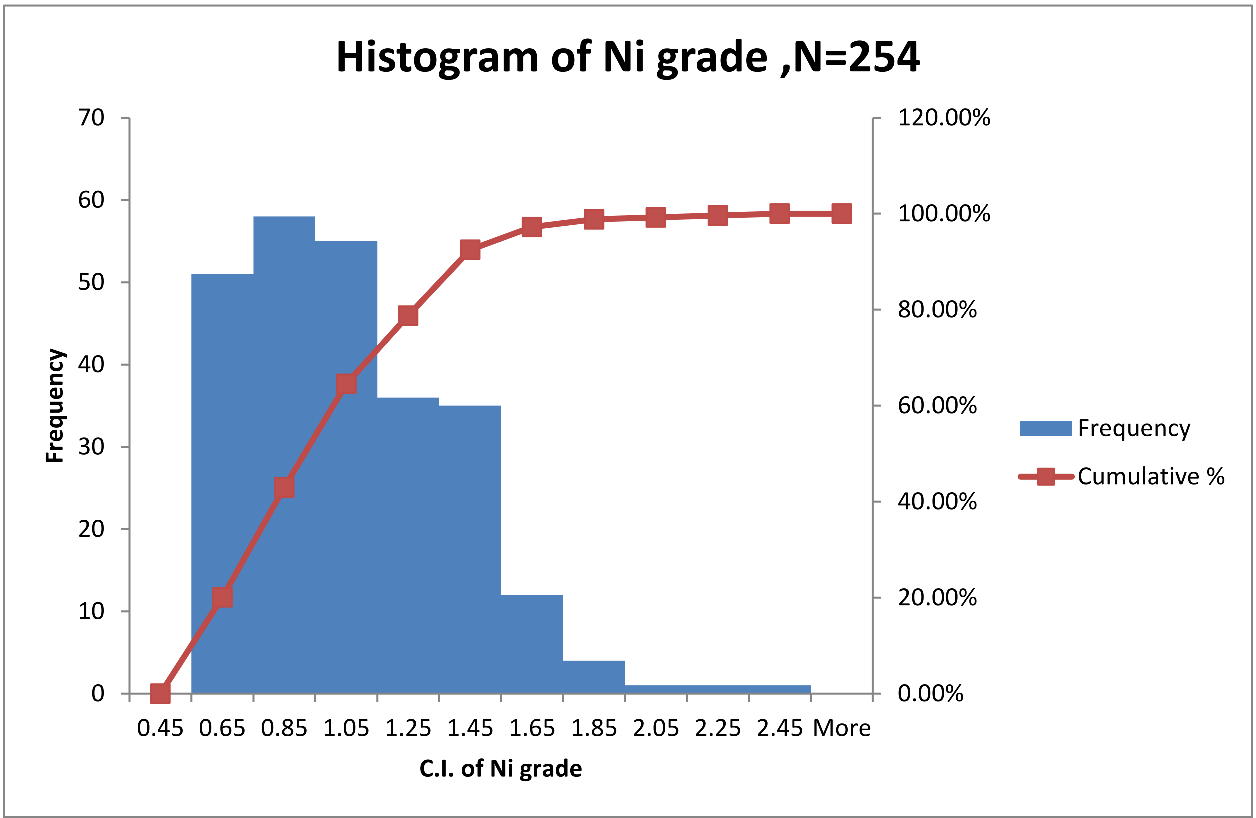


Figure 4-12 Frequency histogram of grade of ore zones (Ni 0.5% and above).

The mean is higher than modal value with moderate CV and positive skewness. These indicate grade continuity of ore zones with moderate confidence.

Table 4-10 Statistical estimation parameters for grade of Nickel ore (Ni %) distribution in all borehole (for 254 sample data)

Statistical Parameters	Estimated values
Mean	0.96
Med	0.92
Mode	0.61
SD	0.33
VAR	0.11
CV%	34.23
SKEW	0.78
KURT.	0.59

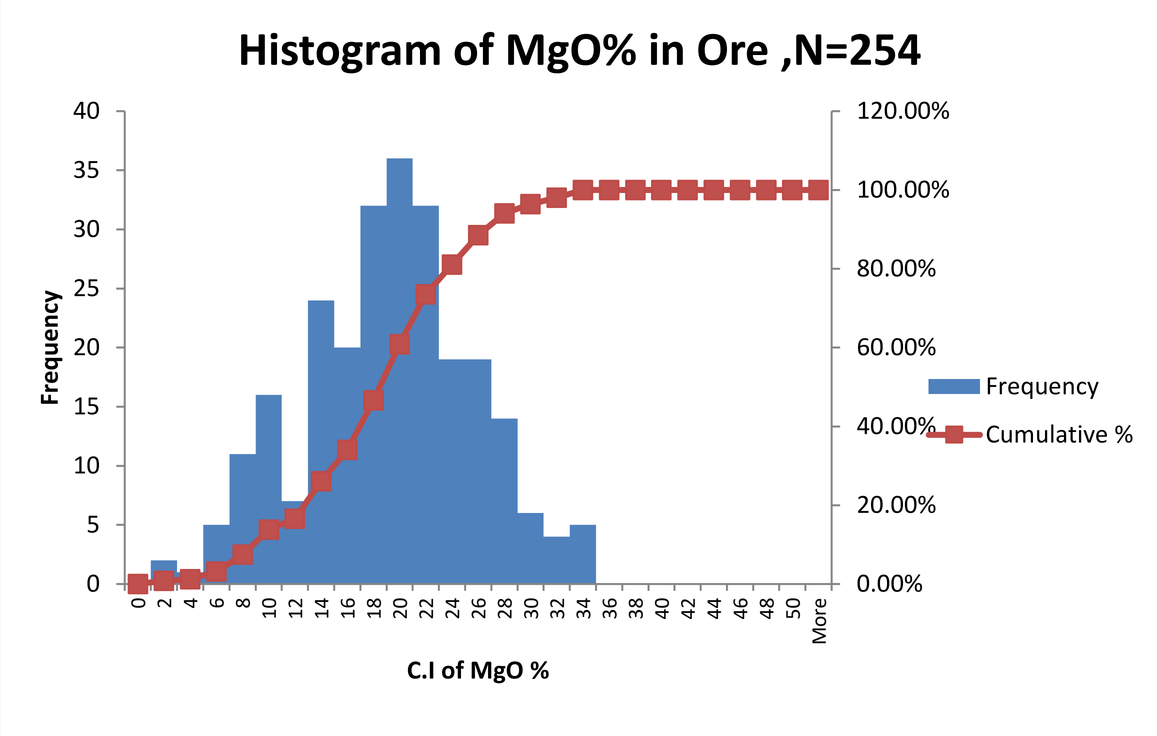


Figure 4-13 Frequency histogram of MgO% in ore zones.

Showing slightly poly –modal, negetively skewed distribution, Mode is higher than Mean value with moderate CV and. These indicate grade continuity of ore zones with moderate confidence. A natural cutoff of MgO distribution can be seen at about 12%.

Table 4-11 Statistical estimation parameters for grade of MgO (%) distribution in all borehole (for 254 sample data)

Statistical Parameters	Estimated values
Mean	18.18
Med	18.84
Mode	20.26
SD	6.51
VAR	0.36
CV%	42.32
SKEW	0.14
KURT.	0.21

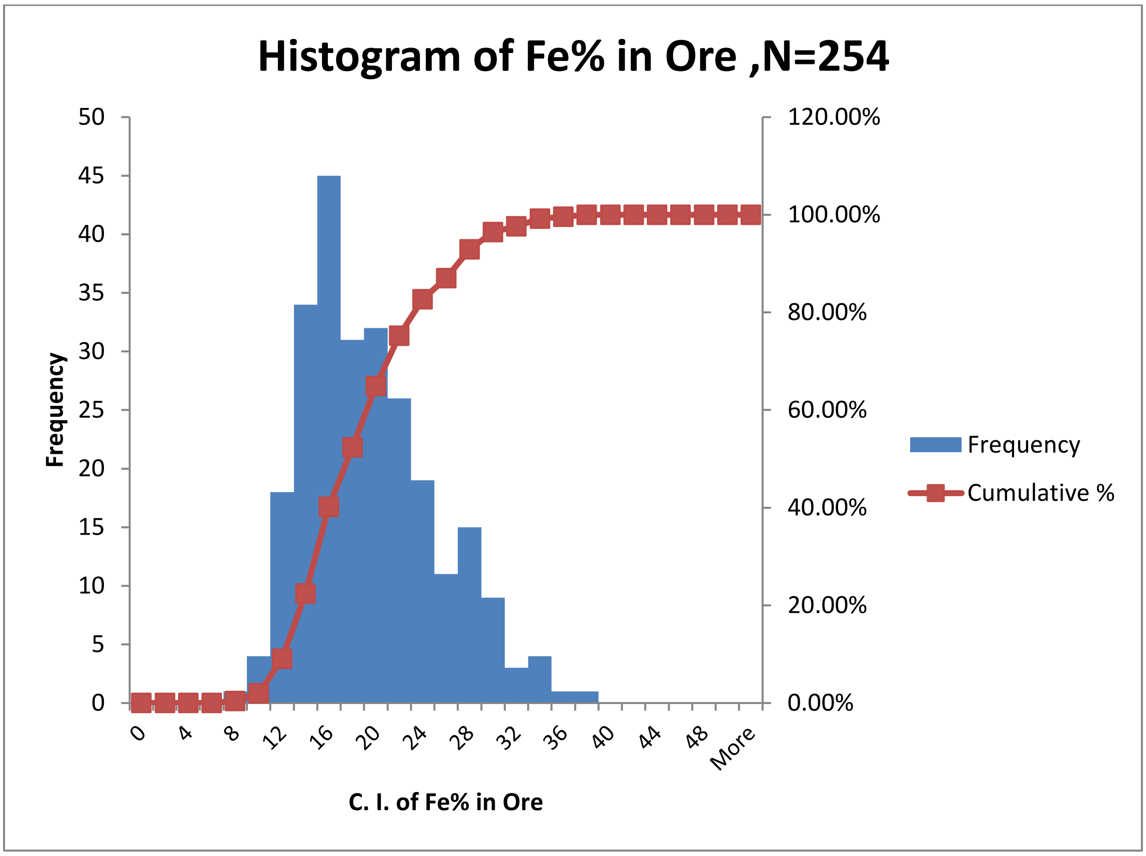


Figure 4-14 Frequency histogram of Fe% in ore zones.

Mean is higher than Mode value with low to moderate CV with strongly negatively skewed distribution. These indicate grade continuity of ore zones with moderate confidence. A natural cutoff of Fe distribution can be seen at about 10%.

Table 4-12 Statistical estimation parameters for grade of Fe (%) distribution in all borehole (for 254 sample data)

Statistical Parameters	Estimated values
Mean	18.51
Med	17.46
Mode	11.43
SD	5.67
VAR	0.31
CV%	32.16
SKEW	0.67
KURT.	0.04

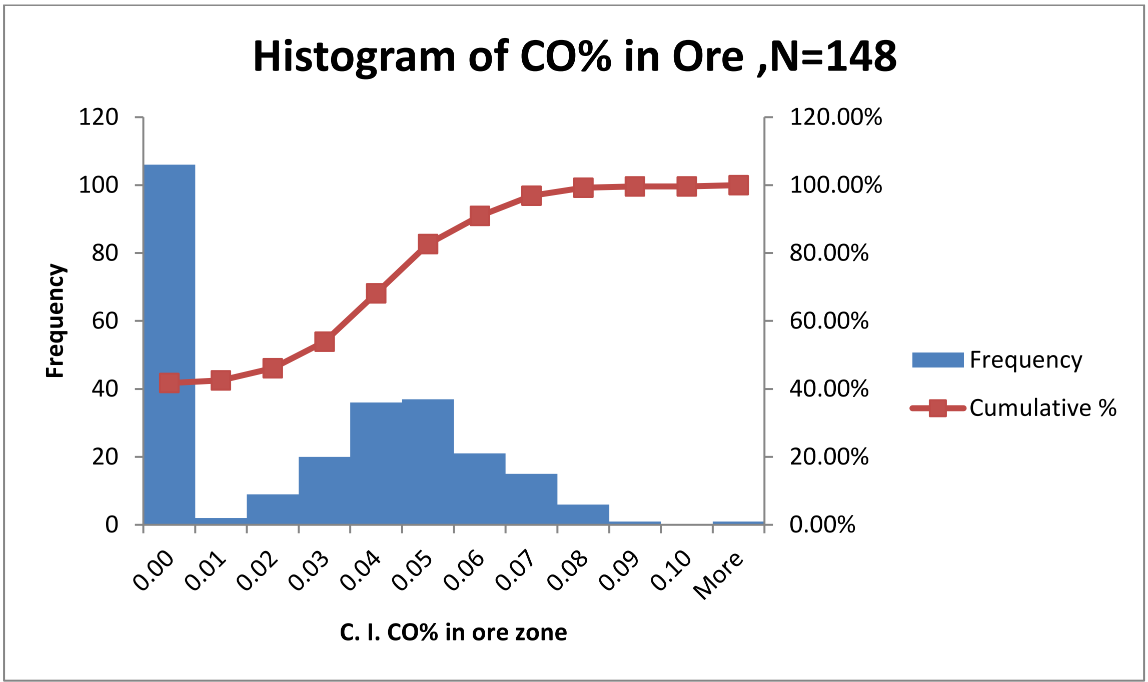


Figure 4-15 Frequency histogram of CO% in ore zones

Positively skewed polymodal distribution. These indicate grade continuity of ore zones with low to moderate confidence.

Table 4-13 Statistical estimation parameters for grade of CO (%) distribution in all borehole (for 254 sample data)

Statistical Parameters	Estimated values
Mean	0.04
Med	0.04
Mode	0.04
SD	0.02
VAR	0.36
CV%	0.000258
SKEW	0.53
KURT.	0.78

4.4.4 Geostatistical analysis

4.4.4.1 Data description

Geo-statistical analysis was done on DHB- series boreholes in the demarcated concession area. The total number of boreholes considered for modelling is 278 with x, y coordinates. Total number of boreholes with no ore grade intercept of Ni (<0.5% Ni) and width is 24. The remaining 254 boreholes are considered for modelling and geostatistical processing. The total Ni grade and weighted average of the grade on thickness has been considered for geostatistical analysis. The preliminary exercise of statistical parameters and inference has been presented earlier chapter.

4.4.4.2 Variography

The Variogram for each of the data sets (weighted average Ni assay grade and width for 254 boreholes) were calculated to know the influence range for the deposit. The drilling of DHB-series boreholes are in a square grid pattern in general but it varies from place to place depending on the ore quality data. So an omni-directional variography was performed in EAST-WEST direction with the objective to construct an experimental semi-variogram for this orientation.

The grid on which the holes are conveniently placed is 50m by 50m, the linear spacing expands to 100m at places. So at such distance the values of experimental semi- variogram γ^* for distances which are multiples of 50m have been computed. The variograms for thickness-weighted average of the grade and width are shown in Fig 4-16 to 4-21.

The theoretical variogram that fits the experimental variogram for Ni grade and width are also shown in Figures 4-16 to 4-21. The maximum lag distance is 730m and the number of lags is 25 for both grade and width attributes.

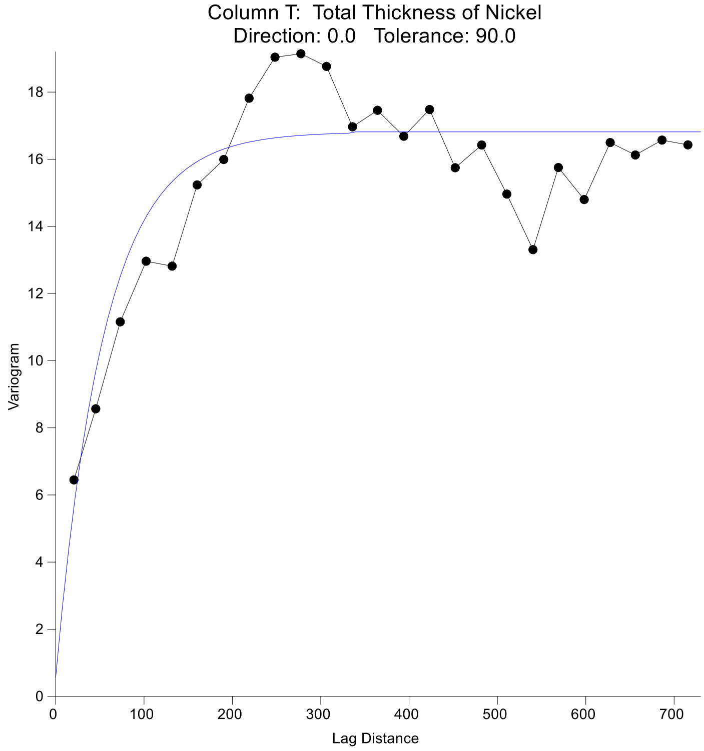


Figure 4-16 Experimental omnidirectional Semivariogram for width of ore zones with exponential model

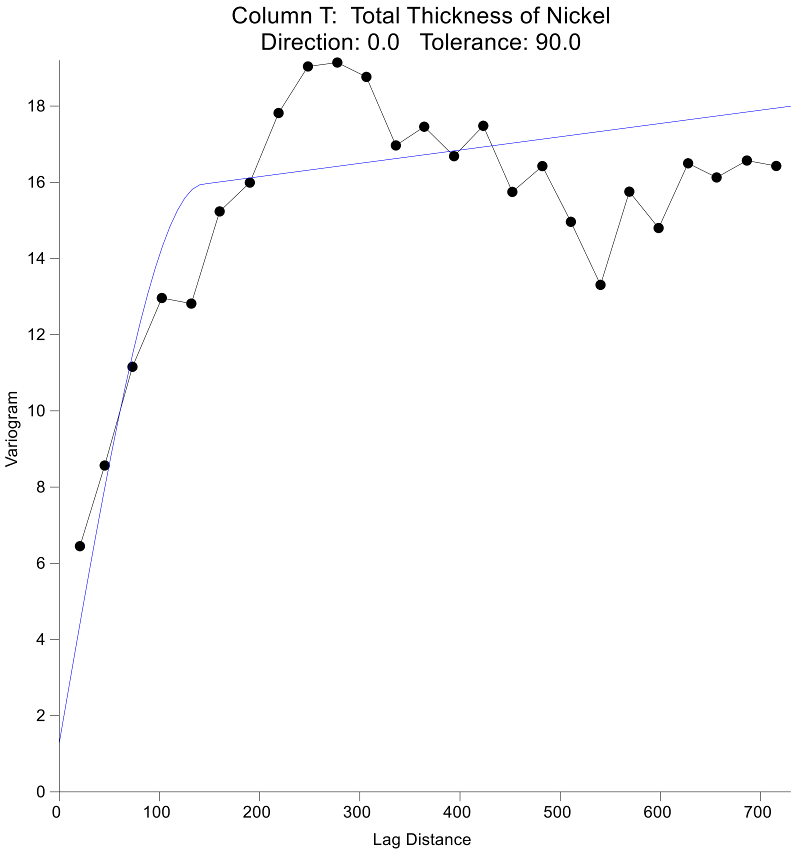


Figure 4-17 Experimental omnidirectional Semivariogram for width of ore zones with spherical model

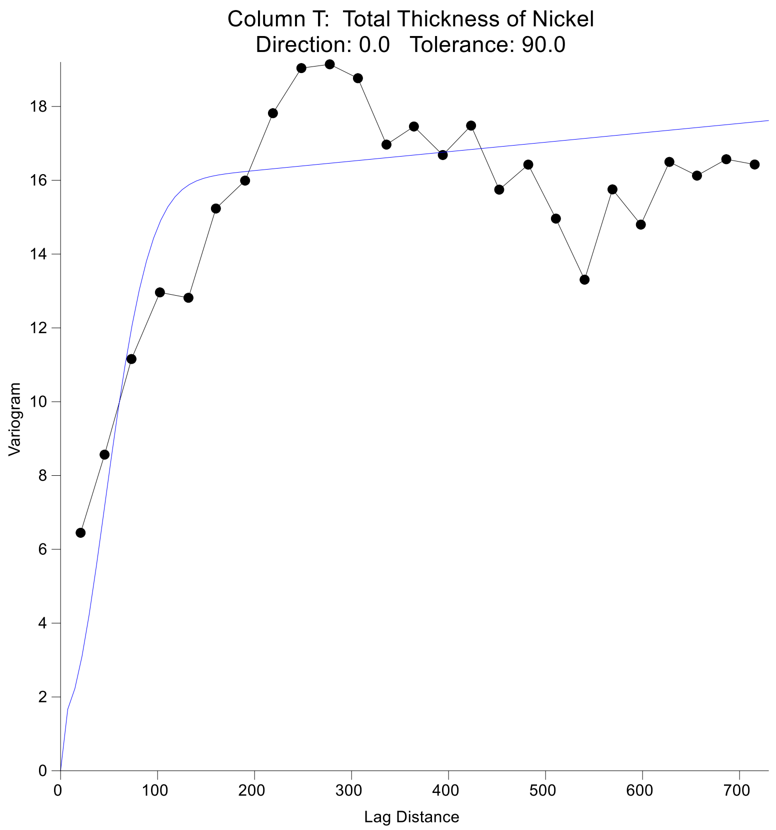


Figure 4-18 Experimental omnidirectional Semivariogram for width of ore zones with Gaussian model

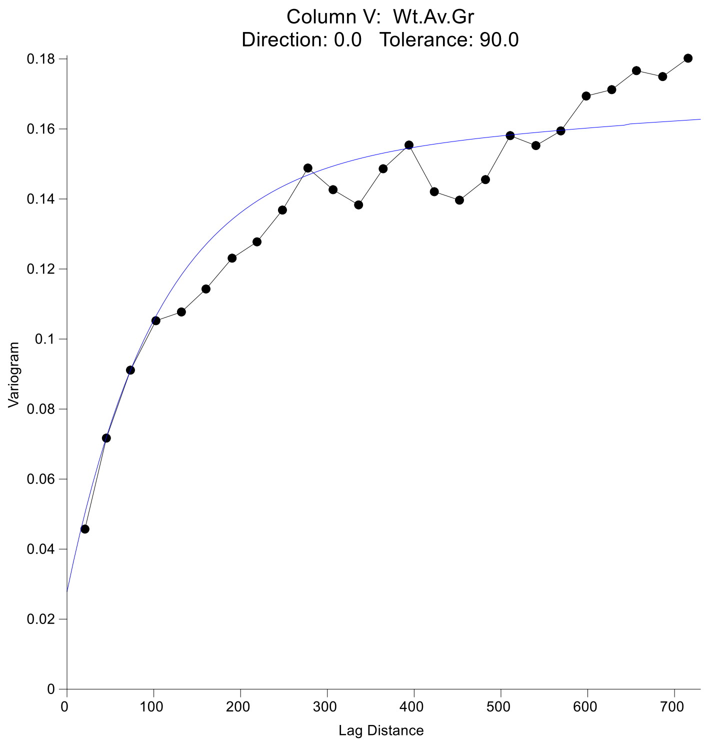


Figure 4-19 Experimental omnidirectional Semivariogram for Ni grade of ore zones with exponential model

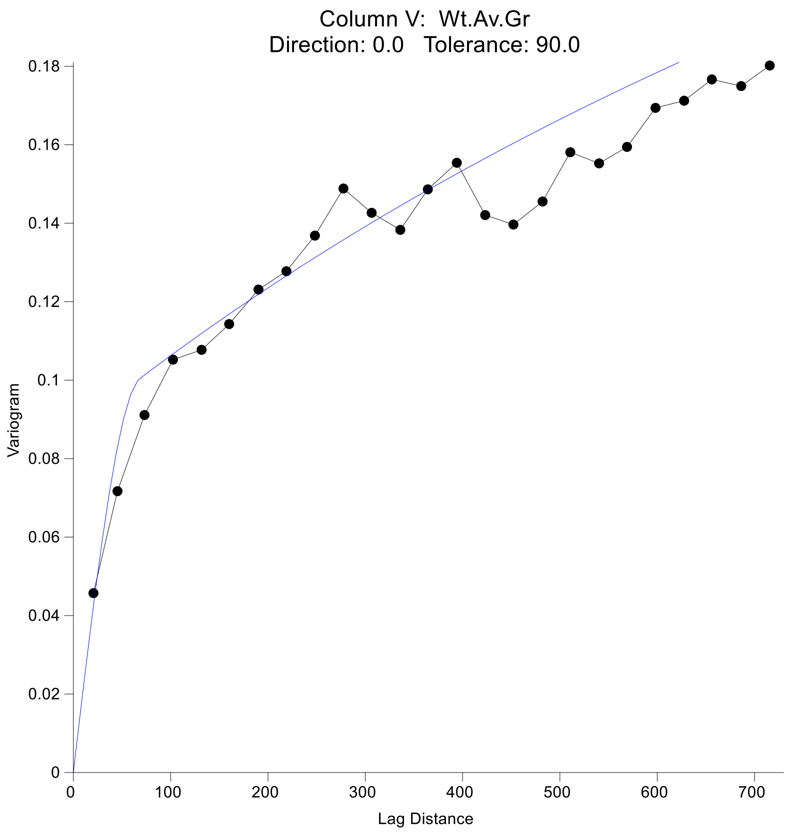


Figure 4-20 Experimental omnidirectional Semivariogram for grade of ore zones with spherical model

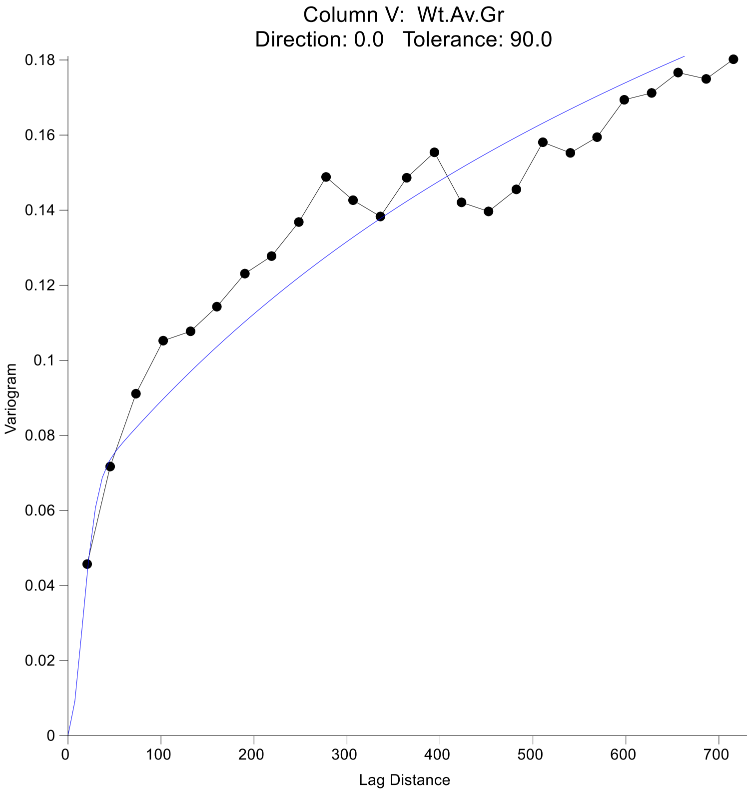


Figure 4-21 Experimental omnidirectional Semivariogram for grade of ore zones with Gaussian model.

The curve fitting exercise results are tabulated below:

Sl.No.	Variable	Exponential Model	Spherical Model	Gaussian Model
1	Width	Scale-16.25(%)^2, A=61.02m	Scale-14.17 (%)^2,,A=165.9m	Scale -14.29(%)^2, A= 72.41m
2	Grade Ni	Scale- 0.1231(%)^2, A= 208.4	Scale-0.0872(%)^2, A= 82.79m	Scale- 0.06052(%)^2, A=24.64m

Omni-directional Semivariogram of Ni grade (%) over a maximum lag distance of 730m and a best fit Gaussian model onto it shows the range of influence of 24.64m with a sill of 0.06052(%)2 .In case of width the exponential model shows the minimum range of influence as 61.02m. So these minimum ranges of influence have been considered for the purpose of resource estimation and classification.

4.4.5 Outcome of Statistical and Geostatistical Analysis

Major outcome of Statistical and Geostatistical analysis are as below:

- Statistical analysis of all samples from the concession shows a natural cut off of 0.4% of Ni. However considering the global standard, processing ease and economic parameters lateritic nickel ore zone is defined with 0.5% Ni as cut-off grade.
- Average thickness of ore intercepts is 5.10m, however highly variable with maximum thickness of 20m, where minimum thickness considered as ore body is 0.5m.
- Average Ni% is 0.96%, where maximum Ni concentration is 2.05%. grade continuity of ore zones can be predicted with moderate confidence.
- Within the ore zone MgO & Fe concentration showing bimodal distribution, with a cut off at about 12% and 15% respectively.

- Geostatistical analysis of Ni grade (%) shows continuity of grade up to 24.64m and continuity of width upto 61.02m with high level of confidence. These minimum ranges of influence have been considered for the purpose of geological correlation and resource classification.

4.5 Resource estimation

PTDMT has carried out resource estimation by preparing a geology model in SURPAC for the deposit.
Resource estimation has been carried out based on the database which includes lithological data and assay data of 278 boreholes and the topography contours received from PTBSP.

No map with outcrop boundary of ore bearing laterite is available. However boreholes are drilled in clusters along the hill top and gentle hill slopes areas along the south-eastern part of the concession area.
Based on bore hole data and distribution of the lithological units extent of lateritic nickel ore assumed upto 150m from the last borehole drilled which intersected lateritic nickel ore however this need to be confirmed with further exploration. It is found about 160 Ha area is explored and within that about 30Ha area is found as non-mineralized/ contains no ore.

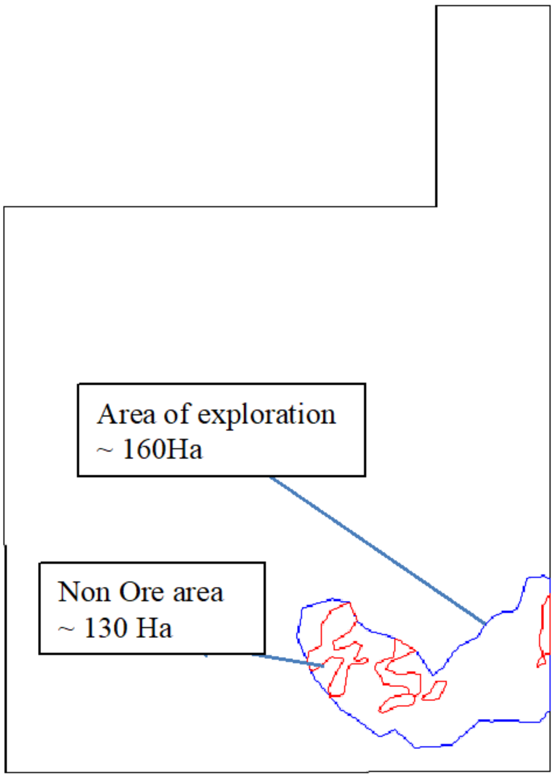


Figure 4-22 **Area of exploration completed till date**

The lateritic nickel ore zone is defied with 0.5% Ni and 0.5m width as cut-off grade/width. It is found 24 boreholes do not contain any lateritic nickel ore.

This is to note here that discrepancy observed in RL values of boreholes and topography contours given in the topographical map provided by client. Many borehole RL are falling above or below the topography. This may affect estimated resource volume as well as volume estimation of overburden.

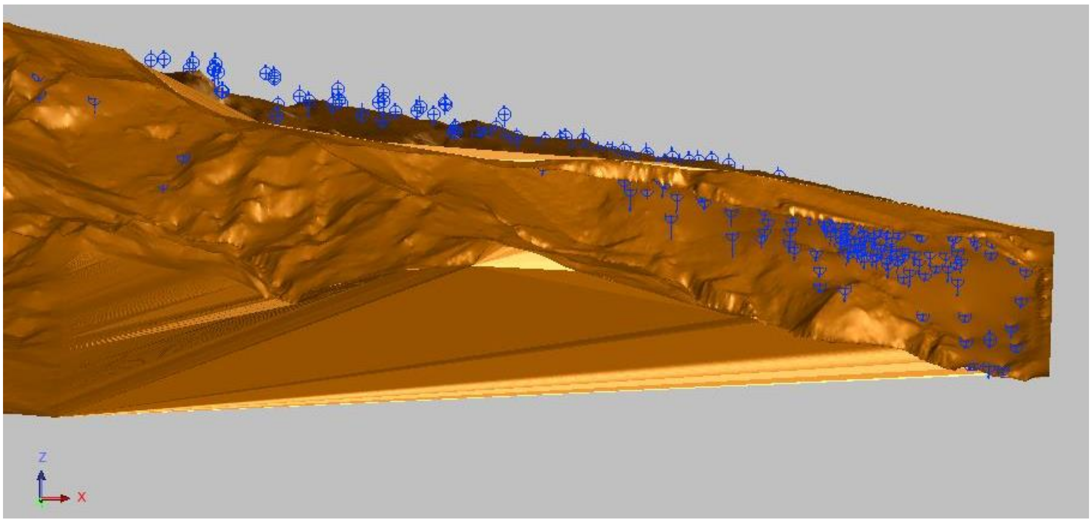


Figure 4-23 **Figure indicates discrepancy in Borehole RL and topography**

Exploration grid is different in different part of the explored area, varrying from 25m X 25m, 50m X 50m grid to 100m X 100m grid. The resource is classified in different categories described below, based on geostatistical analysis.

- Measured Category: Up to 25m from the borehole
- Indicated Category: Geologically co-relatable part of the orebody based on available data; up to 50m influence distance of borehole (or extended up to a geologically co-relatable distance)
- Inferred Category: Up to 150m from the borehole.

Apart from it, following parameters have been used for the estimation:

- Resource estimation has been carried out from 1m downhole composited grade values.
- Resource is estimated with cut off cutoff grade of Ni concentration at 0.5%.
- A uniform Density of 1.5 has been assumed for the resource estimation work in absence of any laboratory test data on Density.
- The top and bottom surfaces of the nickel ore have been constructed from the borehole intercepts based on lithological correlation.

Geological Cross Section & Solid model

Geological logs of the 278 boreholes show a lithological sequence of limonite, saprolite, altered /serpintinized ultramafic rock and bed rock composed of mostly ultramafic rock from surface to downward. Bedrock in some areas is defined as Limestone. In some boreholes the upper part is described as boulders and gravels. The zone enriched in Ni is mostly composed of limonite- saprolite rocks and showing a maximum thickness of 35m. Maximum nickel concentration is 2.8% as indicated by the quality analysis data (analysis with 1m downhole core samples).

Statistical analysis of the available quality analysis data for MgO, Fe indicates that the ore zone (>0.5% Ni concentration) can be classified in zones with high and low MgO concentration. It can be noted that the MgO is considered harmful in metallurgical processes when a grade greater than 9% is used. Accordingly Lateritic iron ore have been classified into the following: Limonite, Magnesium Hydrous Silicate and Saprolite; defined by High Fe (above 15%) and low MgO (less than 10%) concentration, low Fe and high MgO (>10%) concentration and high Al2O3 (>10%) concentration respectively. Change in lithology is mostly defined by sharp change in concentration of the elements: MgO, Fe, Al2O3. Based on the above said lithological classification criteria, lithology in each borehole were defined.

East-West trending Geological cross sections along the boreholes have been prepared by considering borehole interception of the above said lithological divition of the nickel ore and their correlation. Influence of borehole interception considered upto half distance between two adjacent boreholes. Lower boundary of litho-units drown by adopting principle of gradual curved-line changes of ore interceptions in boreholes.

Another set of cross sections along the same section lines are prepared for nickel ore based on grade cut off (Ni% > 0.5).

Solid model with three segments prepared for the three lithological variations of ore is prepared by stitching the cross sections.

A separate solid model prepared based on the cross sections prepared grade wise (Ni% >0.5)

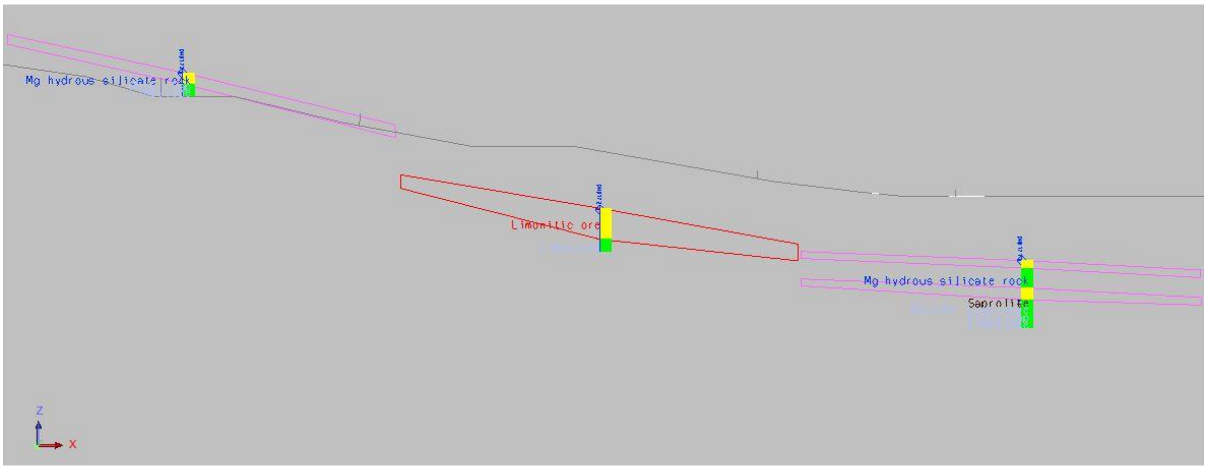


Figure 4-24 East West trending Cross section along section line 2. Ni% <0.5% is denoted by green line and >0.5% by Yellow line. Limonite ore defined by red putline, Magnesium Hydrous Silicate defined by Magenta outline

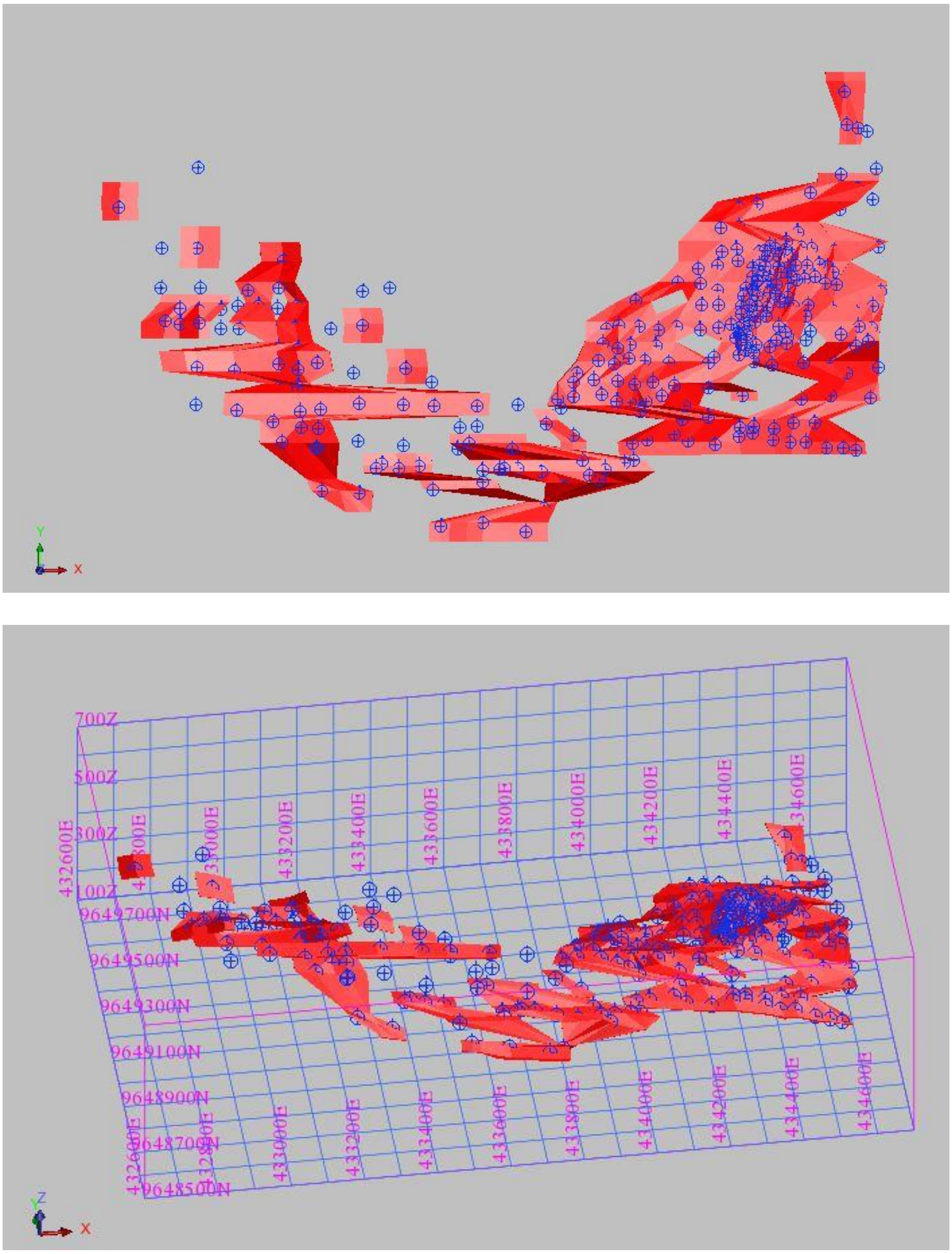


Figure 4-25 Ore body with (Ni%>0.5%); Plan view at top and rotated view at bott

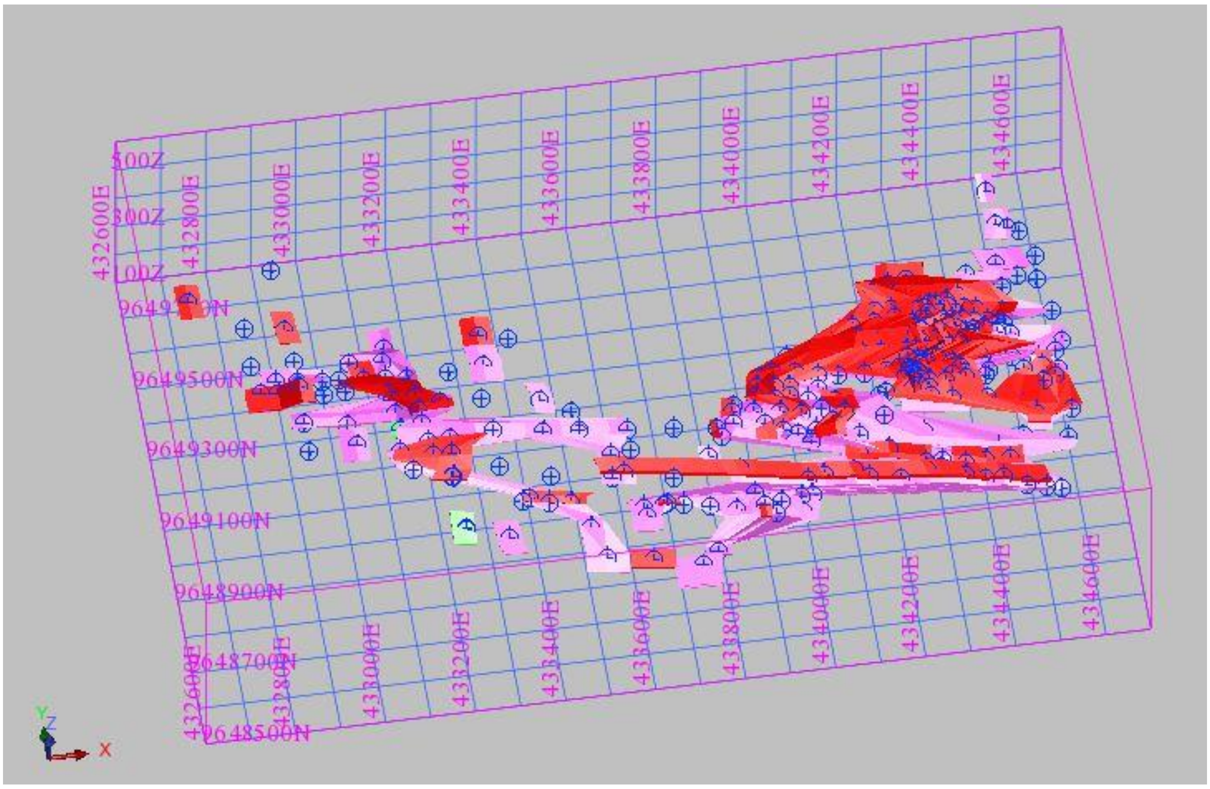


Figure 4-26 Ore body with different lithology; limonite layer in red, Magnesium Hydrous Silicate in pink and Saprolite in light green

Compositing

Compositing has been carried out for all the deposits by 1m downhole method. This is to normalize the data density and dilute the effective sample value where subgrade (<0.5% Ni) ore occurs within mining grade zone.

Block Model

The Surpac model is prepared with 10m X 10m X 2m block size and 5 X 5 X1m sub block size. The block size is kept smaller keeping in view the thin and patchy nature of ore occurrence. Block size smaller than ¼th of borehole spacing (sample density) generally tend to skew the grade tonnage curve in favour of higher grade and lower tonnage. Keeping in view the disjointed and patchy nature of ore occurrences, the impact will be negligible.

The grade estimations of all blocks were carried out by Inverse Square Distance (ISD) interpolation method with spheroid search influence. The major search parameters used by DMT for grade estimation is given below.

Table 4-14 Parameters Used for Block Modeling by DMT

Search Distance		Anisotropy Factor	
Horizontal	Vertical	Semi Major Axis	Minor Axis
300	10	1	1

4.6 Resources

The Nickel ore resources estimated by DMT for the area explored (130 Ha) , are given below:

Table 4-15 Resource classification as per DMT estimation

Resoure Category	Volume	Tonnage	Ni%
Measured	1,176,694	1,765,041	1.07
Indicated	741,231	1,111,847	0.98
Inferred	2,274,300	3,411,450	1.43
		6,288,338	

Table 4-16 Grade wise resource estimation

Ni	Measured		Indicated		Inferred		Total
	Tonnage	Ni%	Tonnage	Ni%	Tonnage	Ni%	Tonnage
0.5 -> 1.0	777,703	0.79	615,384	0.74	84,192.5	0.86	1,477,280
1.0 -> 1.5	820,313	1.22	419,541	1.2	372,829.5	1.26	1,612,684
1.5 -> 2.0	162,375	1.66	74,372	1.66	1,774,003	1.74	2,010,750
2.0 -> 2.5	4,650	2.12	2550	2.08	1,180,425	2.22	1,187,625
	1,765,041		1,111,847		3,411,450		6,288,338

It is recommended that additional exploration is to be carried out at 50m X 50m grid pattern by infill drilling to convert Inferred resource to indicated category.

5 MINING

5.1 Mining Method

PT. Bintang Sinar Perkasa nickel mining concession is being planned to be an open pit mine with a backfilling system. 2 Ha of waste dump is planned for overburden placement in the first year, and next in the second year and subsequent years of placement of overburden or waste material is in the pit.. The mine is planned to be operated for 1 shift and 8 hours a day.

5.2 Mining Equipment

List of Mining Equipment required for the operation is given below

Table 5-1: List of Mining Equipment

Equipment	Maximum Number
Drill (100mm Diameter)	2
Explosive Carrier	1
Excavator (4CUM Bucket)	6
Truck	8
Dozer (300HP)	1
Motor Grader - 145 HP	1
Water Sprinkler - 10KL	1
Mobile Crane - 10t	1
Mobile Workshop / Service van	1
Explosive van	1
Diesel bowser - 1000L	1
Ambulance	1
Manager's Car	1
Supervision vehicle	2
Fire tender	1

5.3 Mine Infrastructure

In mining infrastructure planning, PTDMT has received input from PTBSP for several location plans such as jetty locations, ROMs, road positions, and areas that can be used as offices, warehouses, workshops, fuel storage and camps that can be used as consideration in mine planning.

The jetty location is planned in the North West section of the concession with an area of 0.73 Ha. There are two ROM locations located on the right and left south of the Jetty with each area ranging from 1.5 Ha. The road used in the APL area with a length of 6.07 Km connects the location of jetty, ROM, and other infrastructure facilities. The road within the 1.7 km HPK (Forest) area connects the pit and wastedump to the forest boundary. The road width of 15 m is designed with the consideration of 12 m minimum road width for hauling from pit to jetty using a maximum truck of 30 ton and 3 m for embankment. The 5.5 ha area is planned to be placed in the middle of a concession in the APL area for offices, warehouses, workshops and camps with morphological considerations that are sloping and suitable for such infrastructure facilities.

Pit is planned to be mined for 6 years. The 32.78 ha area is designated as an active open pit area by considering bundwall and trench planning to drain water from the pit to the settling pond.

Wastedump is planned with an area of 2 Ha for placement of top soil and waste material in the first year for material of 585,199 bcm by using benching design. In the second year and so on in mining, waste material disposal into the pit by using backfilling system. Settling pond is made as much as 4 pieces around the pit with the area of each 0.25 ha, to precipitate water discharged out of the pit before flowed into the rivers. In 1 setling pond divided minimum 2 blocks with a depth of 10-20 m or adjusted to the needs until the water resulting from the settling pond is clear.

5.4 Reserves Assessment

DMT has developed an optimized pit over an area of 32.78Ha. The total mineable tonnage estimated is 1,764,840 tonnes of ore at 1.27% of Ni.

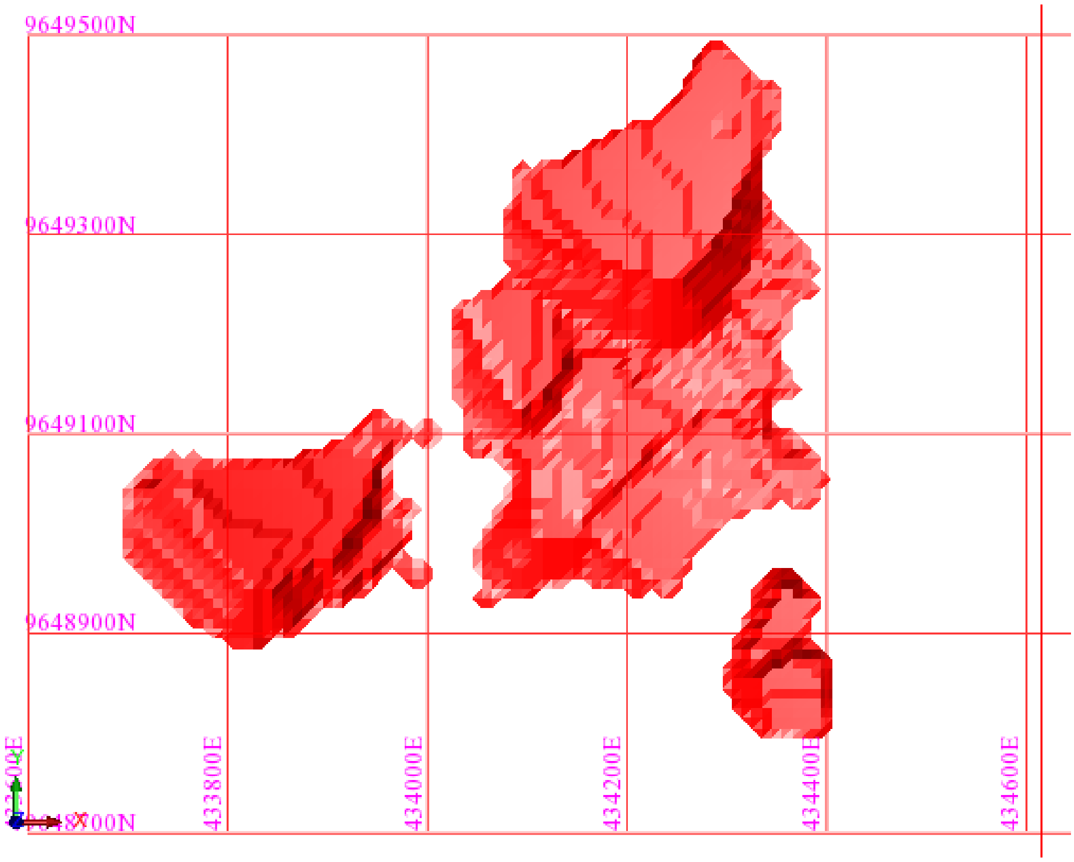


Figure 5-1 Plan view of the final pit

5.5 Mining Schedule

The final pit is scheduled to produce targeted quantity on a yearly basis. The annual production schedule is given in Table below:

Table 5-2: Annual production schedule

Year	Ore Tonnage (Tonnes)	Waste Volume (bcm)	Strip Ratio	Ni %
1	280,000	585,199	2.09	1.32
2	299,998	466,668	1.56	1.29
3	299,990	466,673	1.56	1.28
4	299,985	466,677	1.56	1.31
5	300,000	348,932	1.16	1.24
6	284,867	604,000	2.12	1.21
Total	**1,764,840**	**2,938,148**	**1.66**	**1.27**

5.6 Reclamation and Revegetation

Reclamation and revegetation is planned to begin in the second year and finish in the sixth year of all openings within the mine. The reclamation area in the APL area of 18.44 Ha includes jetty area, ROM, roads, and other infrastructure facilities, and the reclamation area within the HPK area (forest) of 38.30 includes pit, wastedump, road and settling pond, with a total area of 56.74 Ha. Revegetation is planned in the APL area of 9,220 trees and in the HPK area of 19,150 trees, with a total of 28,370 trees. This information should be included in the B & U license application table.

5.7 Borrow and Use license (IPPKH) Documentation

In the present section comprises the supporting documentation that needs to be submitted to MINERBA with the Borrow and Use license application for the PT BSP nickel mine project. The documentation includes:

1) Maps of Mine Plan for B&U License (Figure 5-2)
2) Map of Reclamation Plan for B&U License (Figure 5-3)
3) Map of Revegetation Plan for B&U License (Figure 5-4)
4) Table of Working Plan of Production Operation for B&U License (Table 5-3)
5) Table of Land Used Area and Production Plan According to Life of Mine Plan (Table 5-4)

Total Area of Forest for Application of IPPKH is 38.30 Ha that consists in Forest Area (HPK).

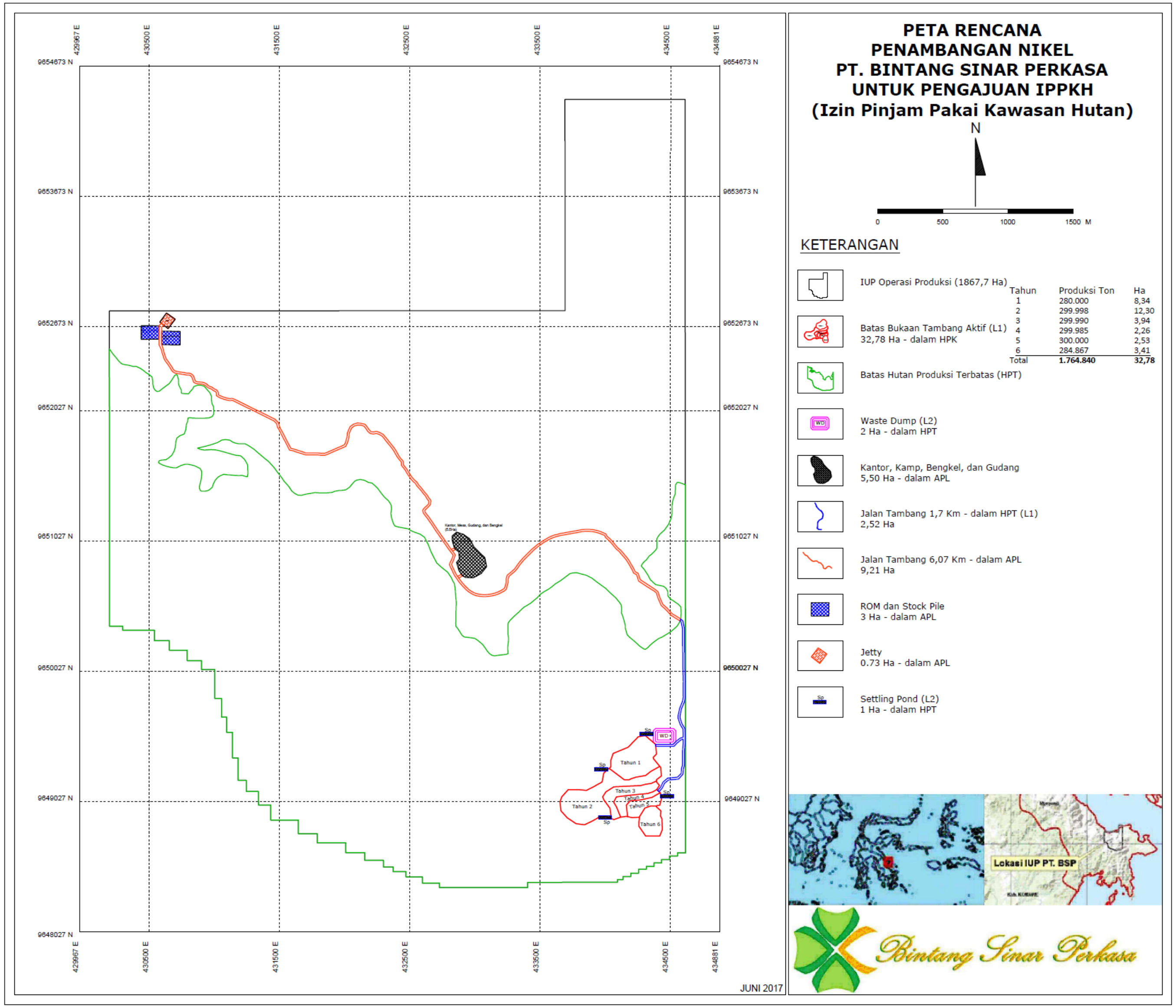
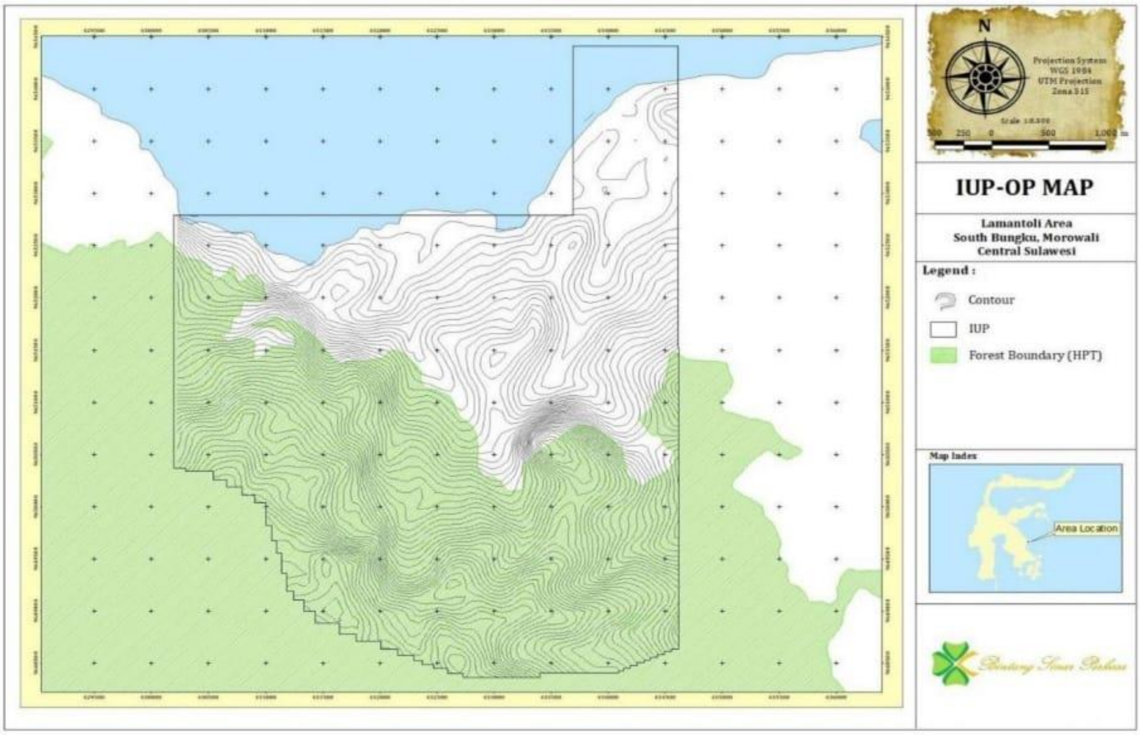


Figure 5-2 Maps of Mine Plan for B&U License



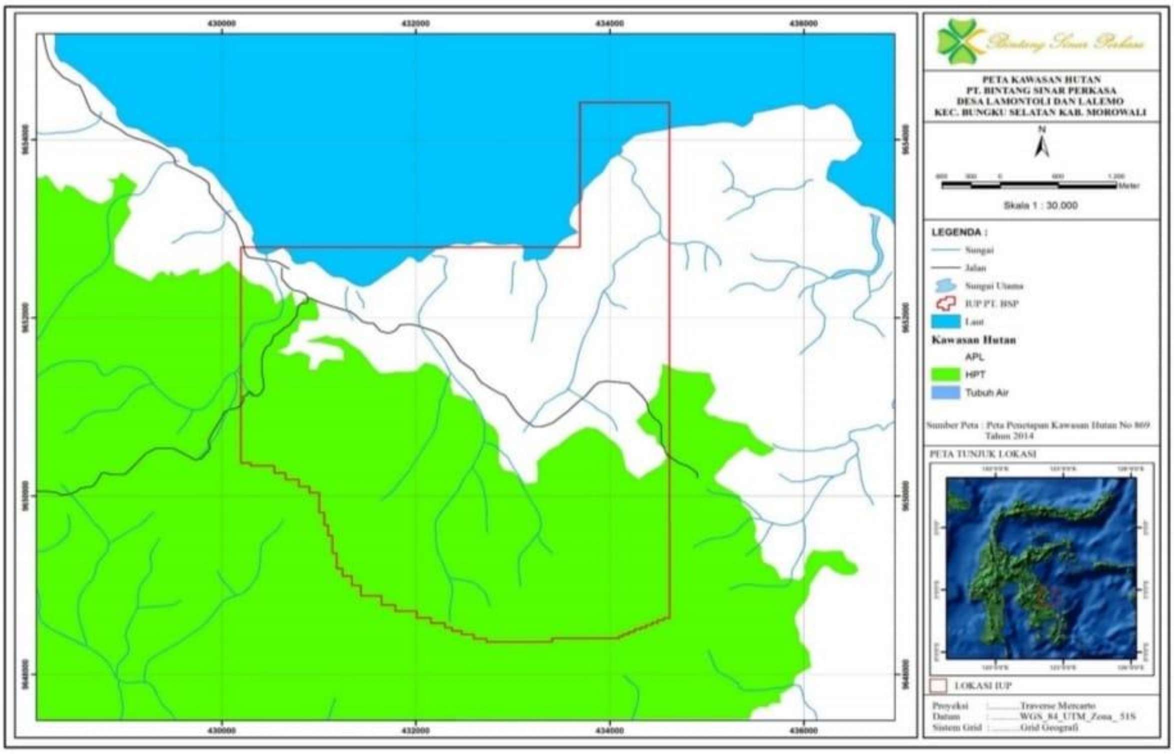
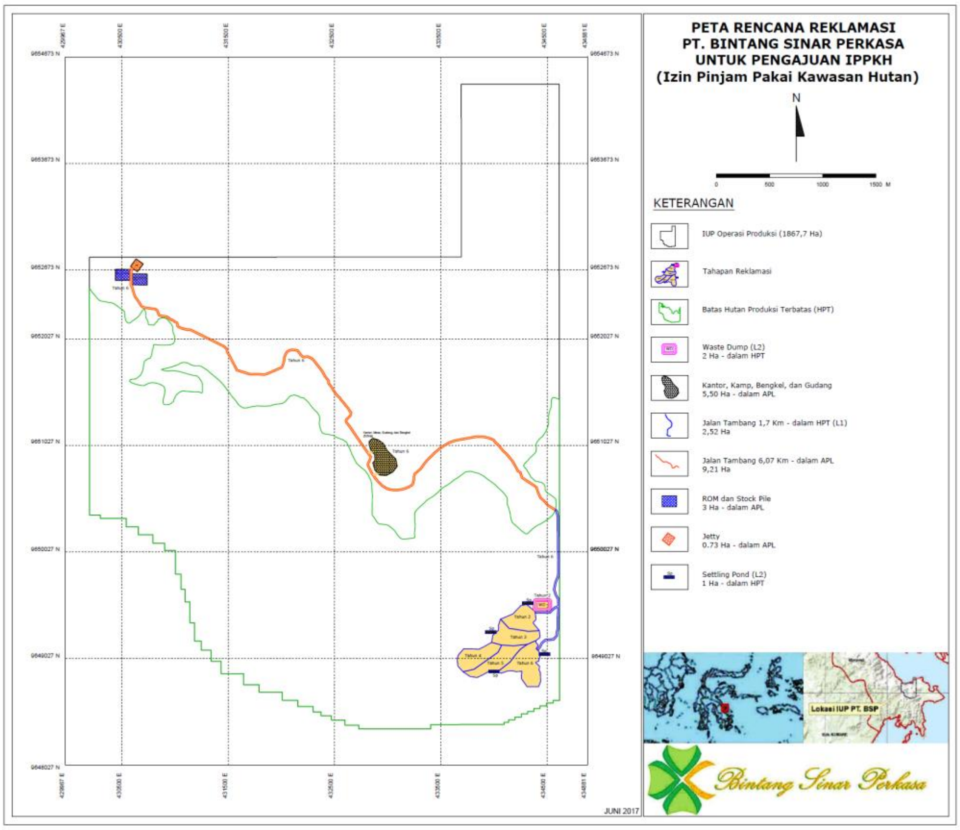


Figure 5-3 Map of Forest Area



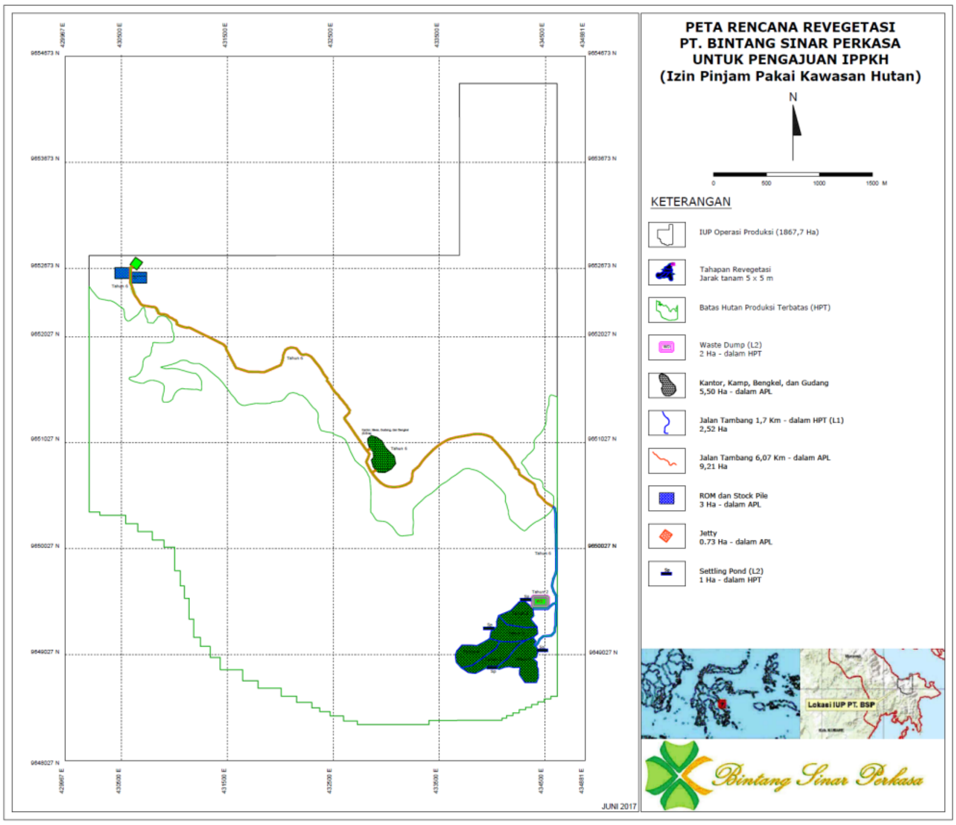


Figure 5-4 Map of Reclamation and Revegetation Plan for B&U License

Table 5-3 Working Plan of Production Operation for B&U License

Working Plan of Production Operation for B&U License
Rencana Kerja Operasi Produksi untuk Izin Pinjam Pakai Kawasan Hutan

1	a	Luas Wilayah Perizinan Operasi Produksi / IUP OP Area	a	1,867.7 Ha	
	b	Luas Project Area / Project Area	b	56.74 Ha	38.30 Ha (HPT) dan 18.44 Ha (APL)
	c	Luas yang dimohon Rekomendasi Teknis / Applied Area for Technical Recommendations	c	38.30 Ha	dalam HPT
2		Sumberdaya dan Cadangan Nikel / Nickle Resource and Reserve		1,764,840 Ton	
				RENCANA / Plan	**KETERANGAN / Remarks**
3		Luas Lahan yang dibuka / Area that will be opened		56.74 Ha	38.30 Ha (HPT) dan 18.44 Ha (APL)
4		Areal Tambang / Mining Area			
	a	Areal Penambangan (Pit) dalam HPK dan APL / Mining Area (Pit)		32.78 Ha	dalam HPT
	b	Settling pond		1 Ha	dalam HPT
	c	Disposal Area		2 Ha	dalam HPT
5		Sarana Penunjang / Infrastructure			
	a	Pabrik/Instalasi Pengaolahan/Pemurnian / Plant - CPP		- Ha	
	b	Kantor, Kamp, Bengkel, Gudang / Facilities (Office, Camp, Workshop, Storage)		5.5 Ha	dalam APL
	c	Jalan tambang / Hauling Road		11.73 Ha	2.52 Ha (HPT) dan 9.21 Ha (APL)
	d	*Stockpile*		3.73 Ha	dalam APL
6		Reklamasi / Reclamation Revegetasi / Revegetation		56.74 Ha 56.74 Ha	38.30 Ha (HPT) dan 18.44 Ha (APL)
7				**JENIS**	**JUMLAH/Ha**
		Jumlah dan Jenis Tanaman Penghijauan / Amount and Types of vegetation Tanaman / Vegetation		Tanaman hutan mudah tumbuh *(easy growing species) dan* tanaman penutup *(lagume cover crop)* Akasia, Sengon, Kayu Putih, Kemiri, Trembesi	500 pohon/Ha / 500 Trees/Ha
	a	Jarak Tanam / Growing Distance		5 x 5 m	
	b	Jumlah Pohon		19,150 pohon dalam HPT 9,220 pohon dalam APL	Total pohon 28,370

IPPKH plan for mining area

a Total Area of Forest for Application of IPPKH is 38.30 Ha that consists in Forest Area (HPK)

Table 5-4 Land Used Area and Production Plan According to Life of Mine Plan

Land Used Area and Production Plan According to Life of Mine Plan Rencana Penggunaan Lahan Dan Produksi Nikel PT. Bintang Sinar Perkasa										
Year	Pit No	Mining Area (Ha)	Nickle Facilities (Ha)	Haul Road (Ha)	Mine Facilities (Disposal area; settling pond; and stockpile) (Ha)	Reclamation / Revegetation (ha)			Production rate (tonnes)	Remarks
						PIT/ Dump (Ha)	Mine Facilities (Ha)	Coal Facilities + Haul Road (Ha)		
		HPT	**HPT**	**HPT**	**HPT**	**HPT**	**HPT**	**HPT**		Total OB = 2,938,148 BCM
Ke-1	I	8.34		2.52	3.00				280,000	
Ke-2	I	12.30				5.43	2.00		299,998	
Ke-3	I	3.94				6.22			299,990	
Ke-4	I	2.26				6.18			299,985	
Ke-5	I	2.53				6.30			300,000	
Ke-6	I	3.41				8.65	1.00	2.52	284,867	
Total		**32.78**		**2.52**	**3.00**	**32.78**	**3.00**	**2.52**	**1,764,840**	

APPENDIX I

Appendix Table 1 Mine Plan and Schedule

August 2021

Rencana Penambangan Nikel PT. Bintang Sinar Perkasa (PT. BSP)

Tahun	Ore Tonnage	Waste Volume	Strip Ratio	Ni %	Luas Blok Tambang (Ha)	Keterangan
1	280,000	585,199	2.09	1.32	8.34	Dalam HPT
2	299,998	466,668	1.56	1.29	12.3	Dalam HPT
3	299,990	466,673	1.56	1.28	3.94	Dalam HPT
4	299,985	466,677	1.56	1.31	2.26	Dalam HPT
5	300,000	348,932	1.16	1.24	2.53	Dalam HPT
6	284,867	604,000	2.12	1.21	3.41	Dalam HPT
Total	**1,764,840**	**2,938,148**	**1.66**	**1.27**	**32.78**	

August 2021

Appendix Table 2 Reclamation and Revegetation Plan

Rencana Reklamasi Dan Revegetasi

TAHUN	LUAS (Ha)	LOKASI	JUMLAH POHON (500 pohon/Ha)	KETERANGAN
2	2.00	WD	1000	Dalam HPT
	5.43	PIT	2715	Dalam HPT
3	6.22	PIT	3110	Dalam HPT
4	6.18	PIT	3090	Dalam HPT
5	6.30	PIT	3150	Dalam HPT
6	8.65	PIT	4325	Dalam HPT
	2.52	Jalan Tambang dalam HPT	1260	Dalam HPT
	1	Settling Pond	500	Dalam HPT
	9.21	Jalan Tambang dalam APL	4605	Dalam APL
	5.5	Kantor, Gudang, Bengkel	2750	Dalam APL
	3	Stockpile	1500	Dalam APL
	0.73	Jetty	365	Dalam APL
Total	**56.74**		**28,370**	

Area Reklamasi	Ha	Jumlah Pohon
Total Reklamasi di Daerah HPT	38.30	19150
Total Reklamasi di Daerah APL	18.44	9220
Total	**56.74**	**28,370**

Appendix Table 3 Infrastructure Plan Area

August 2021

Penggunaan Lahan Untuk Sarana dan Prasarana

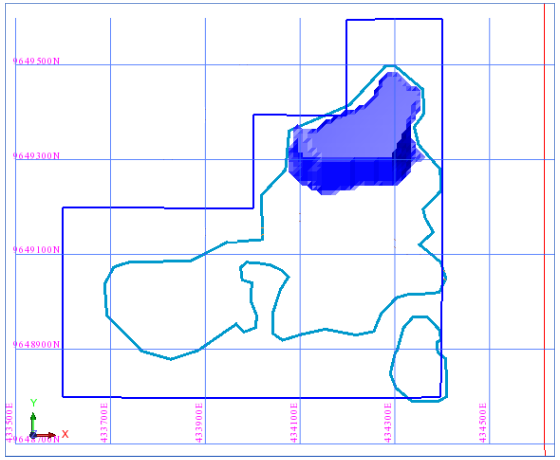
Sarana dan Prasarana dalam HPT	Ha
Jalan Tambang dalam HPT	2.52
Waste Dump	2.00
Settling Pond	1.00
Total	**5.52**

Sarana dan Prasarana dalam APL	Ha
Jalan Tambang dalam APL	9.21
Kantor, Gudang, Bengkel	5.50
Stockpile	3.00
Jetty	0.73
Total	**18.44**

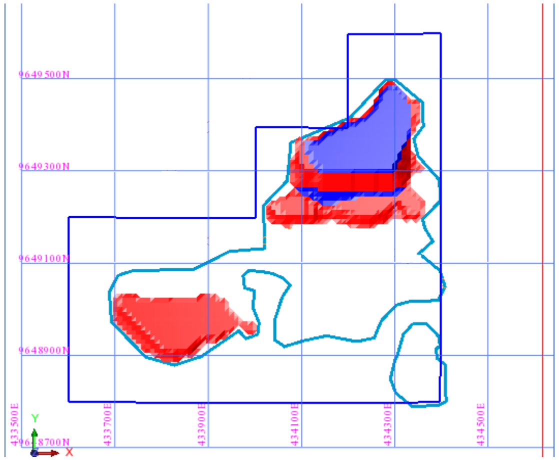
Appendix Table 4 Technical Area Reccomendation within HPK for Mining

August 2021

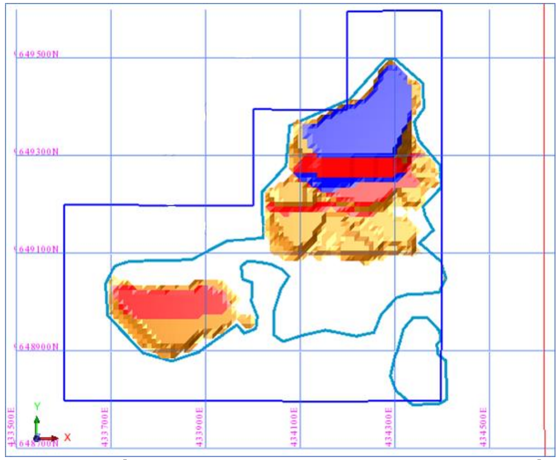
Rekomendasi Teknis Untuk Area Dalam HPT	Luas (Ha)
PIT	32.78
WD	2.00
Settling Pond	1.00
Jalan Tambang dalam HPT	2.52
Total	**38.30**



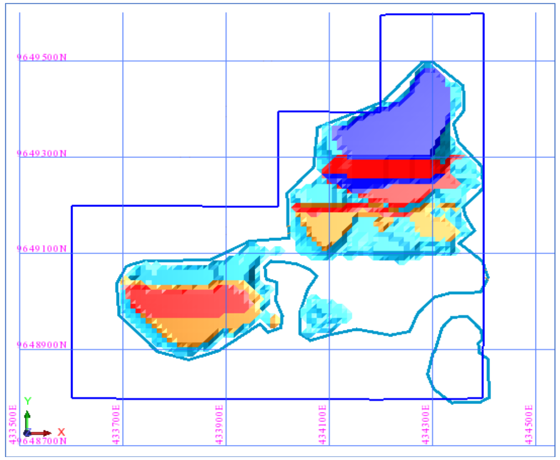
Appendix Figure a: 1st Year mining pit



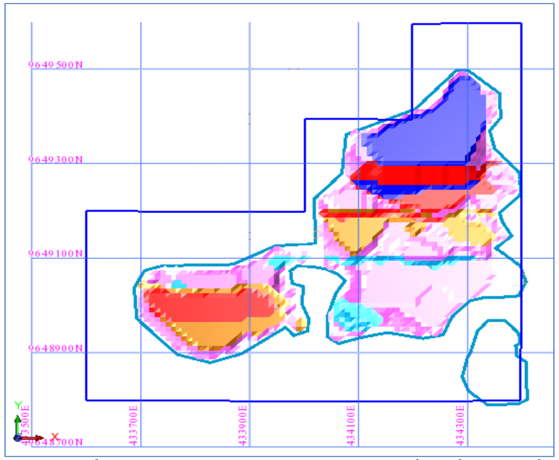
Appendix Figure b: 2nd Year mining pit with 1st year pit inside



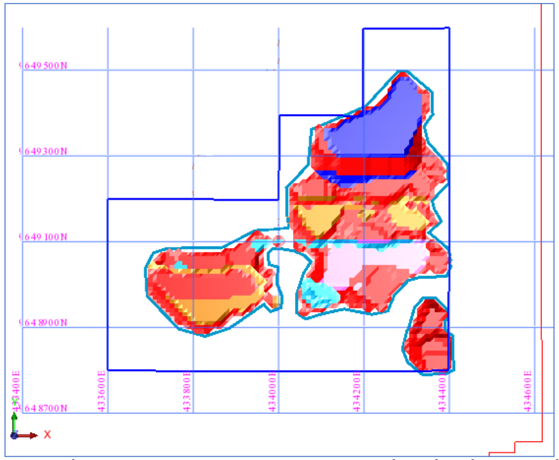
Appendix Figure c: 3rd Year mining pit with 1st and 2nd year pit inside



Appendix Figure d: 4th Year mining pit with 1st, 2nd and 3rd year pit inside



Appendix Figure e: 5th Year mining pit with 1st, 2nd, 3rd and 4th year pit inside



Appendix Figure f: 6th Year mining pit with 1st, 2nd, 3rd, 4th and 5th year pit inside