PROPOSAL FOR REGIONAL EXPLORATION (G-3) FOR POTASH IN LAKHASAR-SUB BASIN, NORTH WESTERN PART OF RAJASTHAN, DISTRICT- BIKANER, RAJASTHAN.

1.0.0 INTRODUCTION

1.1.1 India is the fourth largest consumer of potash in the world but unfortunately the country is 100% reliant on import of potash since its Indigenous production is effectively nil. India produces only a meagre quantity of potash as a by-product during the recovery of common salt from sea water or from nitre (KNO_3) occurring as an efflorescence on the Quaternary 'Reh' soil deposit. The only known occurrence of potash of some possible economic relevance happens to be the potash bearing evaporite sequence of NW Rajasthan also known as Nagaur-Ganganagar evaporite basin (N-G basin). Discovery of potash deposits in the Nagaur-Ganganagar basin of Rajasthan is looked forward to ease the country's situation. This basin was historically explored by GSI over a long gestation period spanning from 1974 to 1991. The above work of GSI could establish the potash exploration potential of the basin. However on account of the much dispersed state of potash and also due to low level K profile characteristic of the prospect and erratic lateral continuity, the deposit could not attract investors interest since the last decade of last century.

1.1.2 In the backdrop of country's continued dependence on import of a very large quantity of potash nutrients with heavy outgo of foreign exchange, the subject was given due consideration at the level of Ministry of Mines, Government of India and the decision was taken to revisit the potash bearing evaporite prospect of Rajasthan and to further work out the exploitation feasibility of the Nagaur-Ganganagar basin so that the prospect can be developed as an auctionable property. In the meeting held on 15th December 2009, under the Chairmanship of Secretary (Fertilizers) possibility of exploration and augmenting indigenous production of rock phosphate and mining for availability of rock phosphate for the indigenous fertilizer industry was discussed. Apart from this the matter related to exploration of Potash and Fertilizer minerals (Phosphorite, Apatite etc) was also discussed in details and decided that exploration of fertilizer mineral deposits in the country should be taken on priority to save a huge foreign exchange for meeting the domestic demand. The matter of Potash exploration of Rajasthan was also discussed in the 1st meeting of National Mineral Exploration Trust (NMET) held on 8th October-2015.

1.1.3 It was suggested that Department of Mining & Geology (DMG), Government of Rajasthan, Mineral Exploration Corporation Ltd.(MECL) and Geological Survey of India (GSI) under Ministry of Mines could take up the exploration work for potash in Nagaur-Ganganagar basin. MECL procured the Geological Report of GSI on Potash Exploration in North-Western part of Rajasthan and formulated the proposal with 4775m of drilling in 7 boreholes and associated sampling and Laboratory Studies. The Committee discussed the proposal in detail in 36th meeting of Technical Sub Committee of SCPP held at 30.10.2017 at MECL, Corporate Office, Nagpur and a few modifications were suggested i.e. committee suggested 800m X 800m grid instead of MECL's 500m X 500m grid. MECL attended the modifications **and the proposal with 4775m of drilling in 7 boreholes with associated sampling and Laboratory studies at an estimated cost of Rs 843.84 Lakhs to be completed in a time period of 16 months was recommended by Technical Sub Committee of SCPP for approval of SCPP. The proposal was discussed in 36th meeting of SCPP held on 16th November 2017 at MoM, New Delhi, but due to non availability of budget provision for exploration, SCPP of MECL decided to defer the exploration proposal of Lakhasar sub basin.**

1.1.4 In the backdrop of the above development, MECL put up same proposal in the 12th meeting of the Technical cum Cost Committee (TCC) of NMET held on 8th & 9th January 2018 and committee, after detail discussion, recommended the proposal of seven boreholes with associated geological work and laboratory studies worth Rs 843.84 Lakh for approval of Executive committee of NMET with the condition that initially four boreholes are to be drilled and other three boreholes will be released only after the review of the status of exploration. Executive Committee of NMET, in its 6th meeting held on 11.01.2018 at MoM, New Delhi approved the regional exploration for potash mineralization in Lakhasar block, District-Bikaner, Rajasthan for an estimated cost of Rs 843.84 Lakh and the exploration work was sanctioned by NMET, MoM, New Delhi vide sanction Letter No.6/4/2015-NMET/447-451 dated 24.02.2018 at an estimated cost of Rs. 843.84 Lakh. The exploration work was commenced in the block on the 26thJanuary 2018.

1.1.5 During the proceeding of the 20th meeting of the TCC of NMET dated 4th & 5th April 2019, the status of the exploration work being carried out by MECL in Lakhasar block was reviewed. It was informed to the committee that the four boreholes had been completed and fifth one was in progress. Committee accorded approval for taking up of drilling of remaining two boreholes and also recommended for time overrun of 10 months for the completion of the work of the project.

1.1.6 CMD, MECL shared a brief presentation outlining the global scenario of salt deposits during the review of status of exploration in the 20th meeting of Technical cum Cost Committee (TCC) of National Mineral Exploration Trust (NMET) held at GSI, Central Region, Nagpur on 4th& 5th April, 2019. He informed that the salt formation is the source of multiple products namely sodium, potassium, magnesium, lithium, chlorine, bromine, iodine and several other elements in various compositions and percentages. All these elements/ compounds can be used in several sectors across the value chain such as fertilizer, chemical, petrochemical and other allied industries. It was deliberated that the auction of the land containing the bedded salt formations such as potash blocks for composite license may not be an appropriate and feasible option with the present level of exploration results and most importantly when the huge potential of the several products that can be extracted simultaneously from the bedded salt deposit instead of only potash. Further, the geological reports should also identify the other possible resource potential and the same needs to be assessed for techno economic feasibility of extraction/mining.

1.1.7 In view of the above MECL proposed to submit an Interim Geological Report in May 2019 (original time schedule for GR submission) considering the exploration data of four MECL and four GSI boreholes and the final Geological report to be submitted as per new time schedule considering the data of all the 11 boreholes (4 no GSI boreholes and 7 no MECL boreholes) by taking a holistic approach towards potash exploration by identifying the other possible resource potential of the bedded salt deposit of Lakhasar block i.e. sodium, potassium, magnesium, lithium, chlorine, bromine iodine etc. All the seven boreholes MLP-1 to MLP-7 has been completed and the final geological report preparation is in progress as on date.

1.2.0 **Location and Accessibility**

1.2.1 The Potash bearing Lakhasar Sub basin in the Nagaur-Ganganagar basin lies in the Survey of India Toposheet No. 44 H/16 & 44 L/4 covered by N Latitude -28°05'00" to 28°20'00" and E Longitude 73°55'00" to 74°10'00". The area is well connected by rail by Bikaner-Shri Dungargarh–Ratangarh-Sikar-Jaipur rail line of western railways and by road from Bikaner-Shri Dungargarh–Ratangarh-Sikar-Jaipur. The Bikaner-Jaipur section of National Highway (NH-11) passes from Shri Dungargarh near to the Lakhasar Basin. Shri Dungargarh is the nearest railway station. Bikaner is around 80 km from the study area (Plate No-I). Lakhasar Block with 13.107 sq.km area is located in the south-central part of the Lakhasar sub basin having approximately 29.90 sq.km area and its coordinates are given in Table-1

Table-1
Co-ordinates of the cardinal points of Block Boundary of the Lakhasar Block, Lakhasar sub basin, Dist: Bikaner, Rajasthan

CARDINAL POINTS	ZONE-43(NORTH)		WGS-84		AREA
	UTM (m)		DMS		
	NORTHING	EASTING	LONGITUDE	LATITUDE	
A	3110076.171	387421.549	73° 51' 13.9327" E	28° 6' 41.1294" N	13.107 Sq. Km.
B	3110291.311	390744.301	73° 53' 15.6223" E	28° 6' 49.1223" N	
C	3108520.920	391608.420	73° 53' 47.8774" E	28° 5' 51.8552" N	
D	3106243.798	389164.517	73° 52' 19.1055"E	28° 4' 37.1396" N	
E	3106237.173	388665.274	73° 52' 0.8189" E	28° 4' 36.7736" N	
F	3106883.797	387319.268	73° 51' 11.2876" E	28° 4' 57.3738" N	
G	3110316.610	389143.988	73° 52' 16.9692" E	28° 06' 49.4651" N	
H	3107034.961	390054.626	73° 52' 51.4466" E	28°05' 03.1127" N	

1.3.0 Physiography& Drainage

1.3.1 The entire area of Nagaur-Ganganagar basin is covered by thick aeolian sand / alluvial sediments except the southern part where scanty outcrops could be seen. The present study area of Lakhasar Sub-basin is also entirely covered by thick aeolian sand and /or alluvial sediments. The major part of the Lakhasar-Sub Basin presents a monotonous topography of NE-SW trending longitudinal dunes and interdunal areas in the north western and south eastern part of the block whereas the sand dunes shows NW-SE orientation in the north eastern and south western part of the block with topographic relief of 30.00 m approximately. The elevation of area varies between 237.98 (T.29) in the east central part to 277.79 (T.109)in the extreme eastern most corner of the block. The highest elevation is in the northern part of the block whereas lowest elevation in the surrounding area of the Lakhasar village in the central part of the block. The general slope of the area is towards the Lakhasar village.

1.3.2 There is not a single perennial stream in the area. The drainage in the area is served by the old course of river Ghaggar forming a narrow alluvial belt in which a network of canals has been developed.

1.3.3 About 21% of the total area of the Bikaner district is cultivated, net area sown varying from 15 to 23% depending on the rainfall occurrence. The percentage of fallow lands in the district varies from 7 to 15% again depending on the rainfall characteristics. About 64% of the area constitutes the cultivable waste. Forest and permanent pastures accounts for 0.3 % and 1.00 % respectively of the total area and about 4.2% constitute the barren lands.

1.3.4 Agriculture is the dominant occupation in the economy of the district. Average size of land holding is 5.67 ha and average number of fragments per holding is 2.76, the number of fragments increasing with the size of holding.

1.4.0 Climate & Vegetation

1.4.1 The area experiences extreme climate with temperature varying from 0°C during winter to as high as 50°C during summer months. Dust storms are common during summer months. Rainfall is scanty and averages 10 cm to 30 cm annually and mostly received during July-August. However, where irrigation facilities of canal system are developed, there is good vegetation and agricultural crops are gown round the year.

2.0.0 Previous work

2.1.1 The presence of evaporate minerals like gypsum, anhydrite and halite were known from Nagaur and Bikaner area since 1930's. Halite in Bikaner is reported by (P.K. Ghosh-1952), Gypsum in Nagaur by Roy Chowdhury et al 1965 and anhydrite intersection in boreholes by Central Ground Water Board (CGWB) and Oil & Natural Gas Commission.

2.1.2 R.S. Jain (1973) and Premchandra, based on the data from ONGC & CGWB, identified general negative Bouguer Gravity anomalies and related these to the presence of a thick evaporite sequence in the Nagaur basin. A total of 12 gravity low sites, mostly in the southern part of the basin were recommended for drilling.

2.1.3 Based on the above studies, GSI has launched exploration programme for Potash in 1974. GSI has carried out Potash exploration in an area of 28,500 Sq.Km. out of the total area of 50,000 Sq.Km. of Nagaur-Ganganagar basin. GSI has drilled a total of 58,733.95 mts of in 68 closed & 2 abandoned boreholes over an area of 28,500 sq.km. Based on the exploration results eight depo-centres for potash mineralisation containing over 2% K were identified, namely Lakhasar, Bikaner, Gharsisar, Hanseran, Arjunsar, Jaitpur, Bharusari and Satipura. GSI has carried out detailed exploration in three sub basins i.e. Satipura, Bharusari and Lakhasar for computing the resources of Potash Minerals and halite. GSI estimated a total of 2476.58 mt (409.19 mt probable and 2072.39 mt possible) potash resources with 4.70 % K and 23.54% Na in Satipura, Bharusari and Lakhasar basins. In Jaitpur block, a total of 2115.35 m drilling was completed in 2 closed (P-48 & P-50) and suspended (P-69) boreholes.

2.1.4 Mineralised Zones intersected in GSI boreholes drilled in Lakhasar sub basin on different cut offs 1% K , 2% K, 3% K, 4 % K & 5% K are given below:

TABLE-2

Borehole wise Potash Zones (at 1% K cut-off) of GSI boreholes in Lakhasar Block					
P-03	540.00	547.50	7.50	8.38	K2C
P-03	554.55	556.37	1.82	1.25	K2B
P-04	540.70	545.34	4.64	3.56	K2C
P-04	547.57	547.73	0.16	1.14	L
P-04	549.80	550.80	1.00	0.80	K2B2
P-04	553.47	554.30	0.83	1.71	K2B1
P-04	561.00	562.61	1.61	0.83	K2A2
P-04	563.61	564.75	1.14	2.11	K2A1
P-04	566.21	566.52	0.31	1.70	L
P-04	567.35	567.75	0.40	1.25	L
P-04	579.80	580.47	0.67	6.16	L
P-04	615.45	615.70	0.25	1.40	K1B2
P-04	622.11	623.35	1.24	0.82	K1B1
P-04	647.55	647.93	0.38	0.75	K1A2
P-09	538.60	543.31	4.71	3.80	K2C
P-09	550.81	552.41	1.60	3.69	K2B2
P-09	556.01	557.31	1.30	0.97	K2B1
P-09	560.40	567.70	7.30	3.70	K2A
P-09	637.65	638.55	0.90	0.84	K1B1
P-09	657.77	658.16	0.39	1.28	K1A2
P-09	660.05	662.78	2.73	2.88	K1A1
P-10	537.53	538.31	0.78	1.10	L
P-10	542.01	544.85	2.84	2.12	K2C2
P-10	548.42	549.52	1.10	2.68	K2C1
P-10	557.00	558.04	1.04	0.77	K2B2
P-10	559.08	560.01	0.93	6.65	K2B1
P-10	571.20	573.02	1.82	3.36	K2A2
P-10	573.12	575.00	1.88	1.08	K2A1
P-10	620.27	621.30	1.03	0.83	K1B2
P-10	651.11	651.45	0.34	0.66	K1A2
P-10	661.14	662.80	1.66	1.26	K1A1

TABLE-3

Borehole wise Potash Zones (at 2% K cut-off) of GSI boreholes in Lakhasar Block					
P-03	540.00	547.50	7.5	8.38	K2C
P-03	555.02	555.17	0.15	2.86	K2B1
P-03	556.20	556.37	0.17	3.22	K2B2
P-04	540.70	542.70	2	6.56	K2C1
P-04	543.11	543.24	0.13	4.00	K2C2
P-04	543.44	543.56	0.12	8.72	K2C3
P-04	545.05	545.34	0.29	3.92	K2C4

P-04	553.47	553.57	0.1	7.00	K2B1
P-04	564.16	564.46	0.3	4.37	K2A1
P-04	579.80	580.47	0.67	6.16	L
P-09	538.60	543.31	4.71	3.80	K2C
P-09	550.81	552.41	1.6	3.69	K2B2
P-09	560.40	567.70	7.3	3.70	K2A
P-09	661.30	662.78	1.48	4.45	K1A1
P-10	542.83	543.38	0.55	3.20	K2C2/a
P-10	544.70	544.85	0.15	7.55	K2C2/B
P-10	548.42	549.02	0.6	4.10	K2C1
P-10	559.08	560.01	0.93	6.65	K2B1
P-10	571.20	573.02	1.82	3.36	K2A2

TABLE-4

Borehole wise Potash Zones (at 3% K cut-off) of GSI boreholes in Lakhasar Block					
P-03	540.00	547.50	7.50	8.38	K2C
P-03	555.02	555.17	0.15	2.86	K2B1
P-03	556.20	556.37	0.17	3.22	K2B2
P-04	540.70	542.70	2.00	6.56	K2C1
P-04	543.11	543.24	0.13	4.00	K2C2
P-04	543.44	543.56	0.12	8.72	K2C3
P-04	545.05	545.34	0.29	3.92	K2C4
P-04	553.47	553.57	0.10	7.00	K2B1
P-04	564.16	564.46	0.30	4.37	K2A1
P-04	579.80	580.47	0.67	6.16	L
P-04	538.60	543.31	4.71	3.80	K2C
P-09	550.81	552.41	1.60	3.69	K2B2
P-09	560.40	567.70	7.30	3.70	K2A
P-09	661.30	662.78	1.48	4.45	K1A1
P-10	542.83	543.38	0.55	3.20	K2C2/a
P-10	544.70	544.85	0.15	7.55	K2C2/B
P-10	548.42	549.02	0.60	4.10	K2C1
P-10	559.08	560.01	0.93	6.65	K2B1
P-10	571.20	573.02	1.82	3.36	K2A2

2.1.5 GSI has computed Potash Resources in three sub basins i.e. Satipura (10 boreholes), Bharusari (6 boreholes) and Lakhasar (4 boreholes), based on the intersection of potash mineralisation at 3% K and 1.50 m minimum stopping width cut off (Satipura , Bharusari and Lakhasar).

The Resources computed in these basins is given below:

TABLE-5

Sub basin	Area (Sq.Km.)	Ore Resources (Million Tonnes)			Grade	
		Probable	Possible	Total Resources	K%	Na %
Satipura	245.61	202.30	1429.95	1632.25	4.80	25.08
Bharusari	71.00	88.16	300.15	388.31	4.68	17.17
Lakhasar	29.50	113.73	342.29	456.02	4.39	23.51
Total	**346.11**	**404.19**	**2072.39**	**2476.58**	**4.70**	**23.54**

2.1.6 MECL started its exploration campaign in the Lakhasar block with commencement of drilling in BH No.MLP-1 (PBH-1) on 26.01.2018 and ended completion of drilling in BH No MLP-7. MECL carried out a total of 3964.00 m of drilling in seven boreholes against 4775.00 m approved in the Lakhasar block. Besides drilling, topographical surveying and detailed geological mapping of (13.107 Sq.Km.) in the block has been completed on 1:5000 scale with contour intervals of 2m.

2.1.7 It was decided in the 20th meeting of Technical cum Cost Committee (TCC) of NMET that Interim Geological Report of Lakhasar Block considering the data of four boreholes each drilled by GSI and MECL will be submitted in May 2019 and rest of the boreholes/exploration will be completed by taking a holistic approach towards potash exploration by identifying the other possible resource potential of the bedded salt deposit of Lakhasar block i.e. sodium, potassium, magnesium, lithium, chlorine, bromine iodine etc. The interim geological report on exploration for potash in Lakhasar block has been submitted on 23rd July 2019 and preparation of final geological report is in progress. The TCC of NMET in its 22nd meeting held at Bhubaneswar suggested to put up a new proposal for regional (G-3) exploration by proposing boreholes at 800m X 800m grid in the remaining part of the Lakhasar basin by taking holistic approach.

2.1.8 The outcome of the present exploration in the Lakhasar block has been documented in the Interim Geological Report (G-3) and the findings has been enumerated in the following paragraphs. The thickness of various formation and Halite cycles intersected in the boreholes drilled so far is given in the following table. The potash mineralization in the Lakhasar Block is restricted to the two different halite cycles i.e. H1, H2 in the Hanseran Evaporite Group (HEG). Halite cycle H1 does not show potential potash zones delineated at 1% K cut-off and having thickness more than 1.00 m. The concentration of potash is mainly due to the concentration of potash minerals i.e. mainly polyhalite & occasionally sylvite in the halite.

Table-6
Thickness Ranges of Various Formations and Halite Cycles in Lakhasar Block

Formation/ Halite cycle	Thickness (m)	
	Minimum	Maximum
Quaternary	76.00 (MLP-1)	140.00 (P-10)
Tertiary	91.67 (P-9)	160.40 (P-3)
Nagaur	195.55 (P-3)	225.78(P-9)
HEG	217.35 (P-4)	232.50 (MLP-4)
H_2	41.20 (MLP-3)	59.29 (P-10)
H_1	56.98 (P-4)	60.51 (P-9 &MLP-2)
Jodhpur	4.55 (P-9)	55.50 (P-4)

2.1.9 The potash zones delineated at 1%, 2% & 3% K cut-off are very thin, irregular and impersistent in lateral continuity and shows rapid lateral thickness and grade variation. On account of the much dispersed state of potash and also due to low level K profile characteristic of the prospect, the development of the potash zones is very erratic, discontinuous and shows local development. Apart from the presence of low-level potash concentration in the range of 1% to 3%, there are sporadic potash zones showing significant level of K concentration. e. g. 8.38% K in zone no K2C (BH No P-3), 7.42% K in zone no K2A1 (BH No MLP-2), 6.65 % K in zone no K2B1 (BH No P-10) and 6.16 %K in zone no L-1 (BH No P-4)

2.1.10 A total 14 correlatable main potash zones and eleven local zones have been identified in Lakhasar block. Among all these, potash zones K1A1, K2A, K2A1, K2A2, K2C, K2C1 and K2C2 are well developed but neither persistent nor potential throughout the Lakhasar block. Potash zone K2C is the most prominent, persistent and potential zone occurring in Halite cycle H2 i.e. its thickness ranges from 2.18m (minimum) in BH No MLP-3 to 7.50m (maximum) in BH No P-3 and grade ranges from 1.77% K (minimum) in BH No MLP-3 to 8.38 % K (maximum) in BH No P-3 and gets splitted in to two sub zones e.g. K2C1 and K2C2 in BH No P-10.

TABLE-7

Borehole wise Potash Zones (at 1% K cut-off) of MECL boreholes in Lakhasar Block

Borehole No	From	To	Zone Thickness	% K	ZONE Correlation
MLP-1	546.80	551.00	4.20	2.04	K2C
MLP-1	560.00	563.00	3.00	2.95	K2A2
MLP-1	563.97	564.17	0.20	1.64	K2A1
MLP-1	622.37	622.57	0.20	0.99	K1B2
MLP-1	624.05	624.71	0.66	1.37	K1B1
MLP-2	536.30	539.00	2.70	1.40 (GPL)	K2C
MLP-2	548.20	548.80	0.60	1.10	K2B
MLP-2	552.00	553.02	1.02	1.06	K2A2

MLP-2	554.00	554.82	0.82	7.42	K2A1
MLP-2	616.38	616.60	0.22	0.98	K1B2
MLP-3	543.54	545.72	2.18	1.77	K2C
MLP-3	549.20	549.41	0.21	1.74	K2B2
MLP-3	550.52	551.00	0.48	1.16	K2B1
MLP-3	554.60	554.80	0.20	1.82	L
MLP-3	556.20	561.85	5.65	2.77	K2A
MLP-3	620.40	620.60	0.20	0.95	K1B2
MLP-3	642.10	642.32	0.22	0.92	K1A2
MLP-4	539.60	539.80	0.20	3.25	L
MLP-4	540.64	544.57	3.93	1.90	K2C
MLP-4	545.40	545.60	0.20	1.45	L
MLP-4	546.00	546.23	0.23	6.03	L
MLP-4	548.01	548.48	0.47	2.95	L
MLP-4	556.48	556.70	0.22	0.95	K2B2
MLP-4	558.00	558.78	0.78	3.82	K2B1
MLP-4	570.00	571.04	1.04	1.95	K2A2
MLP-4	573.38	577.41	4.03	1.52	K2A1
MLP-4	628.23	628.44	0.21	1.24	K1B2
MLP-4	635.58	636.00	0.42	2.48	K1B1
MLP-4	637.31	637.51	0.20	0.97	L
MLP-4	647.09	647.30	0.21	1.74	L
MLP-4	660.00	660.20	0.20	0.95	K1A2
MLP-4	670.53	670.75	0.22	3.49	K1A1
MLP-5	538.35	542.53	4.18	1.56	K2C
MLP-5	547.65	548.25	0.60	1.12	K2B2
MLP-5	551.00	551.20	0.20	1.44	K2B1
MLP-5	556.20	559.41	3.21	2.26	K2A
MLP-5	560.46	560.67	0.21	1.09	L
MLP-5	562.00	562.21	0.21	2.83	L
MLP-5	617.41	617.74	0.33	3.04	K1B2
MLP-5	619.20	619.40	0.20	2.40	K1B1
MLP-5	621.80	622.00	0.20	2.49	L
MLP-5	633.13	633.39	0.26	0.99	K1A2
MLP-5	649.30	649.50	0.20	4.32	K1A1
MLP-6	535.84	538.27	2.43	2.67	K2C
MLP-6	541.66	542.14	0.48	1.27	K2B2
MLP-6	549.42	550.89	1.47	1.33	K2A2
MLP-6	551.93	554.23	2.30	2.74	K2A1
MLP-6	555.69	557.20	1.51	1.10	L
MLP-6	614.44	614.72	0.28	2.44	K1B2
MLP-6	617.43	617.65	0.22	2.53	K1B1
MLP-6	647.16	649.00	1.84	1.11	K1A1
MLP-7	535.50	535.80	0.30	1.68	K2C2
MLP-7	537.45	538.50	1.05	1.45	K2C1
MLP-7	545.20	546.49	1.29	1.68	K2B2

MLP-7	556.90	557.10	0.20	1.27	L
MLP-7	558.06	559.10	1.04	1.17	K2A2
MLP-7	560.40	561.30	0.90	1.90	K2A1
MLP-7	565.05	565.50	0.45	1.98	L
MLP-7	650.39	650.71	0.32	0.98	K1A1

TABLE-8

Borehole wise Potash Zones (at 2% K cut-off) of MECL boreholes in Lakhasar Block

Borehole No	From	To	Zone Thickness	% K	ZONE Correlation
MLP-1	549.22	551.00	1.78	3.22	K2C
MLP-1	561.22	563.00	1.78	4.35	K2A2
MLP-1	624.49	624.71	0.22	2.01	K1B1
MLP-2	554.00	554.82	0.82	7.42	K2A1
MLP-3	544.00	545.26	1.26	2.20	K2C
MLP-3	556.40	556.80	0.4	2.45	K2A
MLP-3	557.42	557.84	0.42	2.23	K2A
MLP-3	558.68	560.25	1.57	6.63	K2A
MLP-3	561.05	561.25	0.2	2.07	K2A
MLP-4	539.60	539.80	0.2	3.25	L
MLP-4	540.64	541.49	0.85	4.13	K2C2
MLP-4	543.22	543.45	0.23	2.08	K2C1/2
MLP-4	544.33	544.57	0.24	3.81	K2C1/1
MLP-4	546.00	546.23	0.23	6.03	L
MLP-4	548.01	548.48	0.47	2.95	L
MLP-4	558.00	558.78	0.78	3.82	K2B1
MLP-4	570.00	570.83	0.83	2.07	K2A2
MLP-4	573.59	574.02	0.43	3.86	K2A1/2
MLP-4	575.50	576.21	0.71	2.10	K2A1/1
MLP-4	635.58	635.79	0.21	3.64	K1B1
MLP-4	670.53	670.75	0.22	3.49	K1A1

TABLE-9

Borehole wise Potash Zones (at 3% K cut-off) of MECL boreholes in Lakhasar Block

Borehole No	From	To	Zone Thickness	% K	ZONE Correlation
MLP-1	549.22	551.00	1.78	3.22	K2C
MLP-1	561.69	563.00	1.31	5.07	K2A2
MLP-2	554.00	554.82	0.82	7.42	K2A1
MLP-3	544.00	544.40	0.40	3.29	K2C
MLP-3	558.68	560.00	1.32	7.44	K2A
MLP-4	539.60	539.80	0.20	3.25	L
MLP-4	540.64	541.49	0.85	4.13	K2C2

MLP-4	544.33	544.57	0.24	3.81	K2C1
MLP-4	546.00	546.23	0.23	6.03	L
MLP-4	548.25	548.48	0.23	3.81	L
MLP-4	558.00	558.78	0.78	3.82	K2B1
MLP-4	570.00	570.26	0.26	4.00	K2A2
MLP-4	573.59	573.81	0.22	5.28	K2A1/2
MLP-4	575.50	575.71	0.21	3.64	K2A1/1
MLP-4	635.58	635.79	0.21	3.64	K1B1
MLP-4	670.53	670.75	0.22	3.49	K1A1

2.1.11 The gross (Inferred + Reconnaissance) resources at 3% K cut-off in the Lakhasar block is estimated at **92.354** m.t. and net resource of **73.883** m.t with average grade **4.65**%K. Similarly, **97.222** m.t. of gross and **77.777** m.t of net resource (Inferred + Reconnaissance) with average grade **4.43%K** at 2% K cut off and **214.163** m.t of gross and **171.330** m.t net resource (Inferred + Reconnaissance) with average grade **2.98%K** at **1% K** cut-off has been estimated separately after considering the 20% depreciation factor. The potash resource has been estimated in **10.04 sq.km area** of the Lakhasar block.

2.1.12 Summary of category wise resource as per 'Radius of Influence Method' at ≥1% K, ≥2% K and ≥3% K cut-off grade separately is given in Table-9.

Table-10

Summary of Potash Resource as per 'Radius of Influence Method' at ≥1% K, ≥2% K and ≥3% K cut-off grade separately.

CUT-OFF CATEGORY	GROSS Inferred Resource of Potash (333) (Million Tonnes)	NET Inferred Resource of Potash (333) (Million Tonnes)	Grade (% K)	GROSS Reconnaissance Resource of Potash (334) (Million Tonnes)	NET Reconnaissance Resource of Potash (334) (Million Tonnes)	Grade (% K)	TOTAL GROSS Inferred + Reconnaissance Resource of Potash (Million Tonnes)	Grade (% K)	TOTAL NET Inferred+ Reconnaissance Resource of Potash (Million Tonnes)	Grade (% K)
AT 1% K CUT OFF	80.690	64.552	3.15	133.472	106.778	2.88	214.163	2.98	171.330	2.98
AT 2% K CUT OFF	38.337	30.670	4.70	58.884	47.107	4.25	97.222	4.43	77.777	4.43
AT 3% K CUT OFF	36.615	29.292	4.90	55.739	44.591	4.49	92.354	4.65	73.883	4.65

Note: 1. 20% deduction was considered due to unknown geological reasons from gross resources to arrive at net resource.

2.1.13 4.679 sq. km. area with grade more than 5% K at 3% K cut off has been delineated in the Lakhasar block and resource has been estimated separately. The four potash zones i.e. K2C2/2, K2C, K2A2 & K2A1 delineated at 3% K cut off and intersected in BH No. P-4, P-3, MLP-01 & MLP-03 respectively contribute net 29.123 million tonnes reconnaissance + inferred category resource (334+333) in 4.679 sq.km. area against net 73.883 m.t estimated in 10.04 sq.km. area of the Lakhasar block with 13.007 sq.km. area and are potential for potash exploration.

2.1.14 Summary of category wise resource as per 'Radius of Influence Method' at ≥3% K cut-off grade is given in Table-10 below.

Table-11

Sr. No	Zone Name	BH No	Zone Thick-ness (m)	Grade (%K)	Gross Inferred Resource of Potash Bearing Halite (Million Tonne) (333)	Net Inferred Resource of Potash Bearing Halite (Million Tonne) (333)	Gross Reconnaissance Resource of Potash Bearing Halite (Million Tonne) (334)	Net Reconnaissance Resource of Potash Bearing Halite (Million Tonne) (334)	Total Gross Inferred + Reconnaissance Resource of Potash Bearing Halite (Million Tonne) (334)+ (333)	Total Net Inferred+ Reconnaissance Resource of Potash Bearing Halite (Million Tonne) (334)+ (333)	Grade (% K)
1	K2C2/2	P-04	2.00	6.56	2.163	1.730	3.775	3.020	5.938	4.750	6.56
2	K2C	P-03	7.50	8.38	8.084	6.468	4.447	3.557	12.531	10.025	8.38
3	K2A2	MLP-01	1.31	5.07	1.574	1.259	2.319	1.855	3.892	3.114	5.07
4	K2A1	MLP-03	1.32	7.44	2.256	1.805	4.506	3.605	6.762	5.409	7.44
TOTAL					14.077	11.261	15.046	12.037	29.123	23.299	7.348

2.1.15 A total 3294.3857 m.t. of inferred category resource of halite with 33.36% Na & 0.43% K has been estimated in 13.107 sq. km. area of the Lakhasar block.

Table-12

Halite Cycle No	Area (in Sq. M)	Volume (Cu. m)	Sp. Gravity	Tonnage (Thousand Tonnes)	Tonnage (Million Tonnes)	Grade in %	
						Na	K
H2	13106560.88	622357605.21	2.40	1493658252.499	1493.6582	32.20	0.74
H1	13106508.48	750303152.36	2.40	1800727565.657	1800.7275	34.32	0.18
				3294385818.156	3294.3857	33.36	0.43

2.1.16 The potash/halite deposit of Lakhasar block can be coded as (333) as per UNFC system (Inferred Mineral Resource Category).

3.0.0 General Geology

3.1.0 The entire area of the basin is covered by thick Aeolian sand/or alluvium sediments.

3.1.1 The Nagaur-Ganganagar basin is an intra-cratonic basin in which marine sediments of the Marwar Super group were deposited on the basement rocks of the Malaini Igneous suite and/or Delhi metamorphites. A generalized Stratigraphic sequence built up is as follows:

Table-13

Age	Super group	Group	Thickness (m)
Recent to Sub recent	Quaternary	--	0 – 373
---------- Unconformity ----------			
Lower Eocene	Tertiaries		38 – 120
---------- Unconformity ----------			
Upper Proterozoic to Lower Cambrian	Marwar	Nagaur Bilara/ HEG Jodhpur	50 – 290
---------- Unconformity ----------			
Pre Cambrian	Malaini Igneous Suite Delhi Super group	----- Ajabgarh	Basement rocks

3.1.2 The Hanseran Evaporite Group (HEG) appears to be homotaxially time equivalent and Facies Variant of the Bilara Group and comprises cyclic deposits of halite (most dominant constituents) alternating with anhydrite, clay, dolomite & magnesite.

3.2.0 Geology of the block

3.2.1 The Lakhasar block having an area of 13.107sq. km is located in the Lakhasar sub basin in the east-central part of Nagaur-Ganganagar Basin. The entire area of the block is covered with thick aeolian sand/alluvial sediments. The major part of the Lakhasar-sub basin presents a monotonous topography of longitudinal dunes and interdunal areas with maximum topographic relief of 30.00 m approximately.

Out of total eight boreholes drilled by GSI and MECL, the 6 boreholes have been drilled through complete stratigraphic sequence of the area. The generalized stratigraphic sequence built up for the block based on the subsurface information obtained from the boreholes is presented in the following Table-13. The Topographical and Geological map of Lakhasar block with proposed borehole locations is given as Plate No-II.

Table-14
Stratigraphic Sequence in Lakhasar Block

Age	Super group	Group	Thickness (m)
Recent to Sub recent	Quaternary	----	76.00 (MLP-1) to 140.00 (P-10).
---------- Unconformity ----------			
Lower Eocene	Tertiaries		91.67 (P-9) to 160.40 (P-3).
---------- Unconformity ----------			
Upper Proterozoic to Lower Cambrian	Marwar	Nagaur	195.55 (P-3) - 225.78 (P-9)
		HEG	HEG: 217.35 (P-4)- 232.50 (MLP-4)
			H2: 41.20 (MLP-3)-59.29 (P-10)
			H1: 56.98 (P-4)-60.51(P-9 & MLP-2)
		Jodhpur	4.55 (P-9)- 55.50 (P-4)
---------- Unconformity ----------			
Pre Cambrian	Malaini Igneous Suite/Delhi Super group	---- Ajabgarh	Basement rocks not intersected

3.2.2 Quaternary sediments comprising aeolian sand (forming dunes), alluvial sand, silt/siltstone, clay/claystone, kankar and argillaceous sandstone lie unconformably over the tertiaries in the Lakhasar block. The thickness of this formation ranges from 76.00m (MLP-1) to 140.00m (P-10).

The Quaternary sediments have a gradational contact with its underlying Tertiary sediments having thickness varying from 91.67m (P-9) to 160.40m (P-3).The Nagaur Group of rocks of Marwar Super Group is unconformably overlain by the Tertiary sediments. The Marwar Super Group consists of (i) the Jodhpur Group, (ii) the Hanseran Evaporite Group (H.E.G) and (iii) the Nagaur Group. The Nagaur Group is the youngest member of the Marwar Super Group and has a gradational contact with the underlying Hanseran Evaporite Group (H.E.G) in the Lakhasar block. The Nagaur sandstone, comprising a sequence of brick red, red to maroon claystone, siltstone and sandstone were intersected in the eight boreholes drilled in the block with a thickness ranging from 195.55m (P-3) - 225.78m (P-9). Hanseran Evaporite Group underlies the Nagaur Group of rocks with clays at the top followed by second halite cycle and its thickness ranges from 41.20m (MLP-3) to 59.29m (P-10). It comprises claystone, dolomite, anhydrite and halite. Halite is the most dominant constituent of this Group with minor polyhalite and occasional sylvite. Out of the seven halite cycles, numbered H1, H2 …. H7 from the bottom to top identified by GSI in the Nagaur Ganganagar basin only two halite cycles seems to be developed in the Lakhasar block/sub basin. These halite cycles are separated from one another by clays and/or anhydrite/dolomite. The first halite cycle (H1) is the thickest of the two cycles and its thickness ranges from 56.98 (P-4) to 60.51 (MLP-2). Details of the thickness ranges of various formations and halite cycles are given in the Table 13.

Jodhpur Group of rocks is intersected in all MECL and GSI boreholes except the MECL boreholes no MLP-1 and GSI borehole no P-3 whereas basement i.e. Delhi Super group is not intersected in any of the GSI and MECL boreholes.

3.2.3 Description of Different Litho Units intersected in the Boreholes.

Description of the different litho units intersected in the boreholes is given below:

A) Quaternary Sediments:

i) Sand/sandstone: Quaternary sediments contains aeolian sand/ alluvial sand and calcareous sandstone having yellowish brown to yellowish grey, whitish colour and is fine to medium grained, moderately rounded and moderate to well sorted and associated with sticky clay Kankar/Calcrete and few deflated gravel lags.

ii) Kankar/Calcrete: Dull white to grayish Kankar/Calcrete showing fine grained texture often occurring as randomly distributed lumps/ nodules within Aeolian Sand and Sticky Clay

iii) Clay: Yellowish brown sticky clay, mostly unconsolidated and is often associated with Kankar/Calcrete and gravel lags.

iv) Gravel: Dark Grey Gravels, granule to pebble size, moderate to ill sorted with sub rounded to sub angular clasts of deflated gravel lags often associated with Aeolian sand and Clay.

B) Tertiary Sediments:

i) Sandy Clay: Yellowish brown to grey to brick red sandy clay, unconsolidated and is associated with minor carbonaceous shale/clasts and random lumps of kankar nodules.

ii) Gritty Sand/Sandstone: Yellowish gritty sandstone, coarse to medium grained, semi consolidated often associated with clay

C) Marwar Super Group:

a) Nagaur Group:

i) Nagaur sandstone comprises a sequence of brick red to red, maroon, light brown, dull white to brownish coloured claystone, siltstone and sandstone. The sandstone is fine, medium to coarse grained with clay, shale and siltstone bands and lenses at places. The sandstone is medium to coarse grained in upper part (230 to 300m) whereas fine grained at lower part (300 to 340 m). Sandstone is mostly moderately sorted to well-sorted but is occasionally poorly sorted wherever it is associated with gravels. Sandstone grains are sub rounded to sub angular showing mature to sub mature texture. Sandstone is often interbedded with clay bands or lenses, siltstone and is frequently horizontally laminated/bedded to cross laminated/Cross bedded. The lamination/bedding often shows alternating colours from white to Brick red. Sandstone occasionally shows secondary formation of calcite precipitated along inclined fracture forming “geode” structure with well to moderately grown calcite crystal. Mica flakes are scattered.

ii) **Siltstone:** it is fine grained, brick red to brownish rock, often laminated/bedded which shows continuous to discontinuous and regular to irregular lamination/bedding. Siltstone is always intercalated with clay bands/lenses and often has secondary formation of calcite precipitated along fracture/weak bedding with partially grown calcite crystals. This calcite veins shows discordant, irregular nature with bedding of siltstone.

b) Hanseran Evaporite Group (HEG):

i) Halite/polyhalite: It has been recorded at the top of each of the two halite cycles (H1 &H_2). It contains impurities/intercalations of clay, anhydrite, dolomite and glauconite. It is the host rock for polyhalite & sylvite mineralisation. Halite contains around 80-95% NaCl. It is a medium to coarse grained, semi-translucent, crystalline (cubic to granular) rock with light orange tint. At places it shows smoky grey to light brown colour. The rock consists of halite & polyhalite as major minerals, anhydrite, gypsum and opaques as minor or accessory minerals. White to greyish white, fine grained polyhalite occur as radiating specs and randomly

scattered irregular lumps/nodes often associated with Halite and Anhydrite.Under microscope, halite/ polyhalite occur as medium to course cubic grains showing compact contacts. Gypsum is present as fine to very fine prismatic aggregates in association with halite/ polyhalite. Anhydrite occurs as fine prismatic grains and as clustered pockets.

ii) Claystone/Siltstone: Claystone is variegated (reddish brown to grey and light fleshy coloured), very fine grained massive rock and occurs as individual beds, laminae, stringers or as matrix. When the grain size of the rock is large enough it is termed as siltstone. It is mainly composed of clay minerals (illite, kaolinite, montmorillonite etc.) together with quartz, mica, carbonates and ferruginous material. It is often intercalated with minor minerals such as clasts of dolomite, anhydrite, halite and gypsum and shows nodular structure. The accessory minerals are opaques and mica. Clay is often unconsolidated and friable.

iii) Dolomite/ Dolostone: Dolomite, calcareous dolomite and anhydritic dolomite have been recorded at the base of each evaporate cycle. Dolomite is mostly micritic and massive and / or contains stromatolitic algal structures at places. The grey dolomite at places has a pitted appearance and gives out fetid odour on breaking.Fetid Dolomite is friable and highly fragmented in nature.It is a dark grey to white coloured very fine grained compact/massive or thinly laminated rock showing semi-translucent patches. The major mineral comprising the rocks is dolomite. Dolomite is often associated with clasts / patches of Anhydrite which gives nodular / chicken wire structure.Dolomite is gives effervescence when tested with diluted HCL acid. Under microscope rock seems to consist of fine aggregates of dolomite rhombs showing thin laminations. Halite is present as very thin filings along inter lamina spaces. Anhydrite is seen associated with halite. Gypsum occurs as fine prismatic grains and aggregates.

iv) Anhydrite: It is seen to occur as massive, thinly laminated, nodular or as pseudomorphs after gypsum. It is one of the main constituents of the H.E.G. and occurs almost in all the two halite cycles in varying proportions as well as in the intervening zones. It is a whitish grey coloured, very fine grained compact and massive rock showing greasy luster, vesicles and ferruginous stains at places. The rock consists of anhydrite as major mineral, dolomite & gypsum as minor mineral and opaque and ferruginous material as accessory minerals. Anhydride occurs as massive aggregate of very fine anhedral to euhedral grains showing pseudo-cubic cleavage traces and higher order birefringence. Gypsum occurs as fibrous and anhedral granular aggregates in pockets replacing anhydride. Anhydrite is often associated with clasts / patches of Dolomite which gives nodular / chicken wire structure and intercalated with clay bands/patches and minor gypsum. Colourless, transparent crystalline gypsum occurs as veins. Most of the gypsum is found to be altered to anhydrite. Dolomitic anhydrite gives weak effervescence when tested with diluted HCL acid.

c) Jodhpur Group:

i) Jodhpur sandstone: It is micaceous sandstone, reddish/brownish to buff and gray coloured, fine to medium grained and often calcareous and glauconitic with occasional interbands of shale and siltstone. Jodhpur Group has been intersected in GSI boreholes P-4,P-9 & P-10 but not in P-3. The minimum and maximum thickness intersected in GSI boreholes is 4.55 m (P-9) and 55.50 m (P-4) respectively. In MECL boreholes the minimum and maximum thickness of the Jodhpur group intersected is 4.67 m (MLP-4) and 11.00 m (MLP-3) respectively. This formation is not intersected in the MECL borehole no MLP-1 as it was closed immediately after intersection of halite cycle.

3.3.0 Potash Mineralization in the Lakhasar Block:

3.3.1 The potash minerals i.e. polyhalite & sylvite are associated with the halite horizon/halite cycles. Therefore, the identification of potash minerals based on its color, weight (Sp. Gravity), hardness, feel and luster is extremely difficult. However a brief description of polyhalite and sylvite identified in the borehole cores and under microscope is as follows:

i) **Polyhalite [$K_2MgCa_2(SO_4)_4$, $2H_2O$]** – It is brick red to grey in colour, fine grained, massive, tasteless mineral and occurs as disseminated specks, pods, stringers, laminae, thin beds, blebs, knots and clusters, within halite and/or anhydrite. It is usually associated with sylvite and at places with maroon clays.

ii) **Sylvite (KCl)** – Sylvite is the main ore mineral of potassium. It is colourless or white to off-white in colour. It dissolves in water as a result of which cavities are formed on the surface of drill cores containing sylvite crystals.

3.3.2 The potash zones intersected in the boreholes are identified only on the basis of chemical analysis and have been delineated on the basis of 1%, 2% & 3% K cut-off. The thickness of potash zones varies from 0.20 m (K1B2 in BH No MLP-1 & MLP-3 and K2A1 in BH No MLP-1) to as much as 7.50 m (K2C, BH No P-3). The details of potash zones together with their average grade and thickness are furnished in Table 14 & 15. Potash mineralization containing over 1% K spread over a wide area covering MECL BH No MLP-1, 2, 3 & 4 and BH No P-3, P-4, P-9 & P-10 of GSI compared to potash zones delineated on 2% & 3% K cut-off. The development of the potash zones is very erratic, discontinuous and local.

TABLE – 15
Borehole wise intersection & correlation of potash zones (at 3% cut off) with thickness and grade

Borehole wise intersection & correlation of potash zones (at 3% cut off) with thickness and grade																														
Borehole No	MLP-03				MLP-01				P-09				MLP-02				P3				P4				MLP-04				P-10			
RL	253.25 m				253.85 m				258.13 m				247.98 m				251.56 m				245.18 m				250.20 m				248.21 m			
Depth	From	To	Thickness	Grade	From	To	Thickness	Grade	From	To	Thickness	Grade	From	To	Thickness	Grade	From	To	Thickness	Grade	From	To	Thickness	Grade	From	To	Thickness	Grade	From	To	Thickness	Grade
L-11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	539.6	539.8	0.2	3.245	-	-	-	-
K2C2/2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	540.70	542.70	2.00	6.56	-	-	-	-	542.83	543.38	0.55	3.2
K2C2/1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	543.11	543.24	0.13	4	-	-	-	-	544.7	544.85	0.15	7.55
K2C2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	540.64	541.49	0.85	4.1335	-	-	-	-
K2C1/2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	543.44	543.56	0.12	8.72	-	-	-	-	-	-	-	-
K2C1/1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	545.05	545.34	0.29	3.92	-	-	-	-	-	-	-	-
K2C1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	544.33	544.57	0.24	3.8075	548.42	549.02	0.6	4.1
K2C	544.00	544.40	0.40	3.29	549.22	551.00	1.78	3.22	538.60	543.31	4.71	3.80	ND				540.00	547.50	7.50	8.38	-	-	-	-	-	-	-	-	-	-	-	-
L-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L-09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	546	546.23049	0.23	6.03	-	-	-	-
L-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	548.25	548.48049	0.23	3.81	-	-	-	-
L-07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K2B2	ND				ND				550.81	552.41	1.6	3.69	-	-	-	-	ND				ND				-	-	-	-	ND			
K2B1	ND				ND				ND				-	-	-	-	556.20	556.37	0.17	3.22	553.47	553.57	0.10	7.00	558.00	558.78	0.78	3.82	559.08	560.01	0.93	6.65
K2B	-	-	-	-	-	-	-	-	-	-	-	-	ND				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L-06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-	-	-	-	-	-	-
K2A2/2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-	-	-	-	-	-	-
K2A2/1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K2A2	ND				561.69	563.00	1.31	5.07	-	-	-	-	ND				-	-	-	-	ND				570.00	570.26	0.26	4.00	571.20	573.02	1.82	3.36
K2A1/2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	573.59	573.81	0.22	5.28	-	-	-	-
K2A1/1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	575.50	575.71	0.21	3.64	-	-	-	-
K2A1	558.68	560.00	1.32	7.44	ND				-	-	-	-	554.00	554.82	0.82	7.42	-	-	-	-	564.16	564.46	0.30	4.37	-	-	-	-	ND			
K2A	-	-	-	-	-	-	-	-	560.40	567.70	7.30	3.70	-	-	-	-	NDB				-	-	-	-	-	-	-	-	-	-	-	-
L-05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L-04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L-03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	579.80	580.47	0.67	6.16	-	-	-	-	-	-	-	-
K1B2	ND				ND				ND				ND				NDB				ND				-	-	-	-	ND			
K1B1	ND				ND				ND				ND				NDB				ND				635.58	635.79	0.21	3.64	ND			
L-02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L-01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K1A2	ND				NDB				ND				ND				NDB				ND								ND			
K1A1	ND				NDB				661.30	662.78	1.48	4.45	ND				NDB				ND				670.53	670.75	0.22	3.4925	ND			
HEG/ JODHPUR	666.00				NDB				667.80				668.10				NDB				667.35				682.33				674.96			
TD	677.00				646.00				672.35				677.00						564.00		722.85				687.00				683.00			

(Note: Potash zones highlighted in green colour having thickness >1.00 m and average grade >3% K has been considered for resource estimation)

3.3.3 Apart from the presence of low-level potash concentration in the range of 1% to 3%, there are sporadic potash zones showing significant level of K concentration ranging from 6% to 8% which is enumerated in the following table No 15.

Table No- 16
Sporadic potash zones showing significant level of K concentration
ranging from 6% to 8%

BH. No.	Depth (m)		Thickness (m)	Grade	Zone Correlation
	From	To			
P-3	540.00	547.50	7.50	8.38	K2C
P-10	559.08	560.01	0.93	6.65	K2B1
MLP-2	554.00	554.82	0.82	7.42	K2A1
P-4	579.80	580.47	0.67	6.16	L-1

3.4.0 Structure of the block:

3.4.1 Lakhasar block with 13.007 sq.km area forms the considerable part and lies in the south central part of the Lakhasar sub basin. Geological mapping and drilling in Lakhasar block reveals that the area is occupied by the thick sequence of stratified marine sedimentary deposit with horizontal to sub horizontal disposition. The area of the block is covered either by Quaternary aeolian sand or alluvial sediments and different litho units of other formations are scarcely exposed on the surface making it difficult to measure the attitude of the beds. The strike of the beds as evident from the floor contour drawn for H1 and H2 Halite cycle varies from NE to SW with local swing in some part of the block and dip of 1° to 3° towards NNW, NW to W and dips are rolling.

3.4.2 Minor structures observed in drill cores include bedding, lamination, flow structures and stylolite sutures. Flow structures have an oblique relationship with the bedding/lamination and locally the halite beds show steep dips due to salt flowage. Stylolite sutures are observed in anhydrite cores indicating solution activity under high pressure

3.4.3 The major faults are neither traced on the surface during geological mapping as the area is completely covered by aeolian sand or alluvial sediments nor interpreted on the available sub-surface data in the block. However, faults of minor nature cannot be ruled out in the area. The Floor Contour of Halite cycle H1 depicting structure of the block is given as Plate No – II.

4.0.0 Proposed Exploration by MECL

4.1.0 Strategy

4.1.1 An area of 10.04 sq.km. with grade more than 5% K have been delineated out of total 13.001 sq.km. area in the Lakhasar block based on the exploration work completed

so far i.e. 4 boreholes by GSI and 4 boreholes by MECL. The present proposal for regional exploration (G-3) in balance unexplored sub basin with 19 sq. km. area has been prepared on directives of TCC of NMET in the 22nd meeting held on 10.2019 at Bhubaneswar. The basic idea behind it is to establish the potentiality of the Lakhasar sub basin so that a few blocks with grade more than 5% K can be established for auctioned and developed in to a working mine.

A total of 41 no. of boreholes with a total of 27720 m of drilling at 800m X 800m grid in the area i.e. 19 sq. km has been proposed.

4.2.0 Objectives:

4.2.1 The general exploration (G-3) is proposed with the following Objectives

i) To confirm the strike-wise and dip-wise continuity of Potash bearing zones having grade more than 5% K in remaining unexplored area (10.04 sq.km.) of Lakhasar sub basin outside the explored part of the Lakhasar block.

ii) To confirm the thickness of Sylvite / Sylvinite & Polyhalite bearing Potash bands in the area.

iii) To delineate areas with more than 5% K in the entire Lakhasar sub basin so that a detail exploration (G-2) can be taken up in such areas to establish the potash resource with more than 5% K grade to facilitate the state government of Rajasthan for auctioning of the block to develop a potash mines in the state.

The exploration proposal is prepared based on data of 4 borehole drilled by GSI and 7 boreholes drilled by MECL in Lakhasar sub- basin for G-3 exploration to prove the Potash resource having grade more than 5% K.

4.3.0 Methodology of Exploration

4.3.1 Topographic Survey: Proposed area has been tied up with triangulation network and contouring has been done on 1: 5,000 scale with 2m contour intervals during G-3 stage exploration in the Lakhasar block. The proposed exploration area (the remaining unexplored area of the Lakhasar sub basin) will be covered for topographic contouring at 2m contour interval. Co-ordinates & R.L. of the new boreholes will be determined with reference to this network.

4.3.2 Geological Mapping: The mapping has been completed in 13.007 sq. km. area of the block and geological map has been presented in 1:5000 scale. The entire area is covered with alluvial / Aeolian deposits (Quaternary sediments) and outcrops of Marwar Super Group / Basement rocks are not exposed on the ground in the block as it is covered under alluvial/sand. Further, the geological map will be updated in 1:2000

scale. Geological mapping in the remaining part of the Lakhasar sub basin will be carried out and all the geological/structural features will be recorded. This map will be the Base map for future work.

4.3.3 Drilling: A total of 41 no. of boreholes are proposed at 800m X 800m grid in the unexplored area of the Lakhasar sub basin. A total of 27720 m of drilling in 41 vertical boreholes have been proposed in the block. The details of the proposed boreholes with proposed depth & total meterage to be drilled is given in the table no 16 and location of proposed boreholes is given as Plate No- II. The location of these boreholes may change slightly subject to approachibility owing to terrain conditions.

All the formations i.e. Quaternary / Tertiary sediments, Nagaur Group, Hanseran Evaporite Group and Jodhpur Group will be drilled by coring.

Table No- 17
Details of Proposed Boreholes in Lakhasar Sub Basin
Nagaur - Ganganagar basin, North Western Rajasthan,
District: Bikaner, Rajasthan

Sr. No.	BH No.	Proposed depth in meter (m)	Sr. No.	BH No.	Proposed depth in meter (m)
1	PBH-1	710	21	PBH-21	680
2	PBH-2	710	22	PBH-22	680
3	PBH-3	700	23	PBH-23	670
4	PBH-4	700	24	PBH-24	670
5	PBH-5	700	25	PBH-25	670
6	PBH-6	700	26	PBH-26	670
7	PBH-7	700	27	PBH-27	670
8	PBH-8	700	28	PBH-28	660
9	PBH-9	690	29	PBH-29	660
10	PBH-10	690	30	PBH-30	660
11	PBH-11	690	31	PBH-31	660
12	PBH-12	690	32	PBH-32	660
13	PBH-13	690	33	PBH-33	650
14	PBH-14	690	34	PBH-34	650
15	PBH-15	690	35	PBH-35	650
16	PBH-16	690	36	PBH-36	650
17	PBH-17	680	37	PBH-37	650
18	PBH-18	680	38	PBH-38	650
19	PBH-19	680	39	PBH-39	650
20	PBH-20	680	40	PBH-40	650
			41	PBH-41	650
Total					**27720**

4.3.4 Geophysical Studies.

Borehole Geophysical Logging is proposed in all the boreholes in the Lakhasar block. Borehole Geophysical logging will be carried for all the 41 boreholes (27720m).

4.3.5 **Drill core Logging and Sampling**

Detailed core logging will be carried out for all the boreholes and various details i.e., litho units/formations, intercalations and parting, core recovery, colour, structures and textures etc will be recorded. In the Hanseran Evaporite Group, special attention is required to identify Polyhalite and other Potash bearing minerals.

4.3.6 **Sampling:** The primary samples will be drawn at every **0.20m** in the potash bearing (Polyhalite & Potash) zones and at 1.00m length in the non potash bearing Halite zones. Also, lithological units 5.00 m above Halite cycle H2 and 5.00 m below Halite cycle H1 and non halite parting between two halite cycles will be sampled at 1.00 m interval. Thereafter composite samples will be prepared after delineation of Potash mineralized zones at different cut-offs. Standard procedure will be adopted for preparation of samples.

This will generate about 16000 no of Primary samples along with 800 no (5% of primary samples) internal check samples 1600 no (10% of primary samples) external check samples. Composite Samples will be prepared borehole wise and potash zone wise based on the result of Primary samples. A total of 600 nos. of Composite samples are likely to be generated.

5.0.0 **Laboratory Studies**

5.1.0 Chemical Analysis:

a) All the Primary and Internal & External Check samples [18400 no; = 16000 Primary & 800 Internal Check (5%), 1600 External Check (10%) of Primary samples] will be analyzed for 9 radicals i.e. K, Na, Mg, Cl, Br, I, Li, $CaSO_4$ & Water insolubles.

b) A total of 600 numbers of Composite samples are likely to be generated from the Potash mineralized zones of 41 boreholes which will be subjected to analysis of 9 radicals K, Na, Mg, Cl, Br, I, Li, $CaSO_4$ & Water insolubles.

5.2.0 X.R.D. Studies: - About 100 composite samples will be sent for X-ray Diffraction studies.

5.3.0 Petrographic Studies: - A total of 100 numbers of borehole core samples from different lithology will be subjected to petrographic studies.

5.4.0 Specific gravity determination - Specific Gravity will be determined on 100 nos. drill core specimen of halite and other rock types of Hanseran Evaporite Group.

5.5.0 Exploration Report: Data generated from proposed exploration along with integration of earlier data of GSI & MECL will be utilized in Report preparation.

5.6.0 **Quantum of work:**

5.6.1 The quantum of work proposed in the present exploration scheme is given in Table below:

Table-18:
Quantum of work proposed for Potash Exploration in Lakhasar Sub Basin, District-Bikaner, Rajasthan.

Sl. No.	Item of work	Unit	Quantum
1.	Topographic Survey & Geological mapping on 1:5,000 scale	Sq. Km.	16.793
2.	Drilling : i) 41 boreholes on 800m X 800m Grid	m.	27720m (41 BHs)
3.	Geophysical Studies		
	i) Borehole Geophysical Logging	m.	27720m (41 BHs)
4.	**Laboratory Studies**		
	A. Primary + Check Samples		
	i. **Primary samples** for 9 radicals i.e. K, Na, Mg, Cl, Br, I, Li, $CaSO_4$ & Water insolubles	Nos.	16000
	ii**. Internal check samples** (5% of Primary samples) for 9 radicals i.e. K, Na, Mg, Cl, Br, I, Li, $CaSO_4$ & Water insolubles from MECL Lab.		800
	iii. **External check samples** (10% of Primary samples) for 9 radicals i.e. K, Na, Mg, Cl, Br, I, Li, $CaSO_4$ & Water insolubles from External NABL Lab.	Nos.	1600
	B. Composite Samples		
	i. for 9 radicals (K, Na, Mg, Cl, Br, I, Li, $CaSO_4$ & Water insolubles $_4$)	Nos.	600
	ii. X-Ray Diffraction Studies	Nos.	100
5.	Petrographic Studies	Nos.	100
6.	Specific Gravity Determination	Nos.	100
7.	Report Preparation (Digital Format)	Nos.	1

6.0.0 Time Schedule and Cost Estimates:

6.1.0 Time Schedule: The proposed exploration programme like drilling, Geology, Laboratory work including Camp setting & winding and Laboratory studies will be completed in 30 months time. Report writing will take additional 6 months including

one month overlap with laboratory studies. Thus the total time proposed for completion of work is **35 months**. The bar chart showing Action Plan/time schedule is given in Table-6.1.

6.2.0 Cost Estimate: Cost for 2020-21, 2021-22 and 20122-23 has been estimated based on 5% escalation (provisional) on rates of 31-03-19 since SOC of NMET is yet to be finalized. The cost of the project will be estimated as per new SOC of NMET once the SOC is finalized. The total estimated cost is **Rs 5937.88 Lakhs**. The details of cost estimates are given in Table 6.2 and summary is given in table no 18 below;

Table-19
Summary of Cost Estimates

Sl. No.	Item	Estimated Cost (Rs.)
1	Drilling	35,63,62,928/-
2	Geophysical Studies	1,63,61,999/-
3	Geology	2,45,43,019/-
4	Laboratory	8,71,00,163/-
5	Core Preservation	1,38,60,000/-
6	Exploration Report	49,82,281/-
7	GST @ 18%	9,05,77,870/-
	Total	59,37,88,260/-

Say- Rs 5937.88 Lakhs.

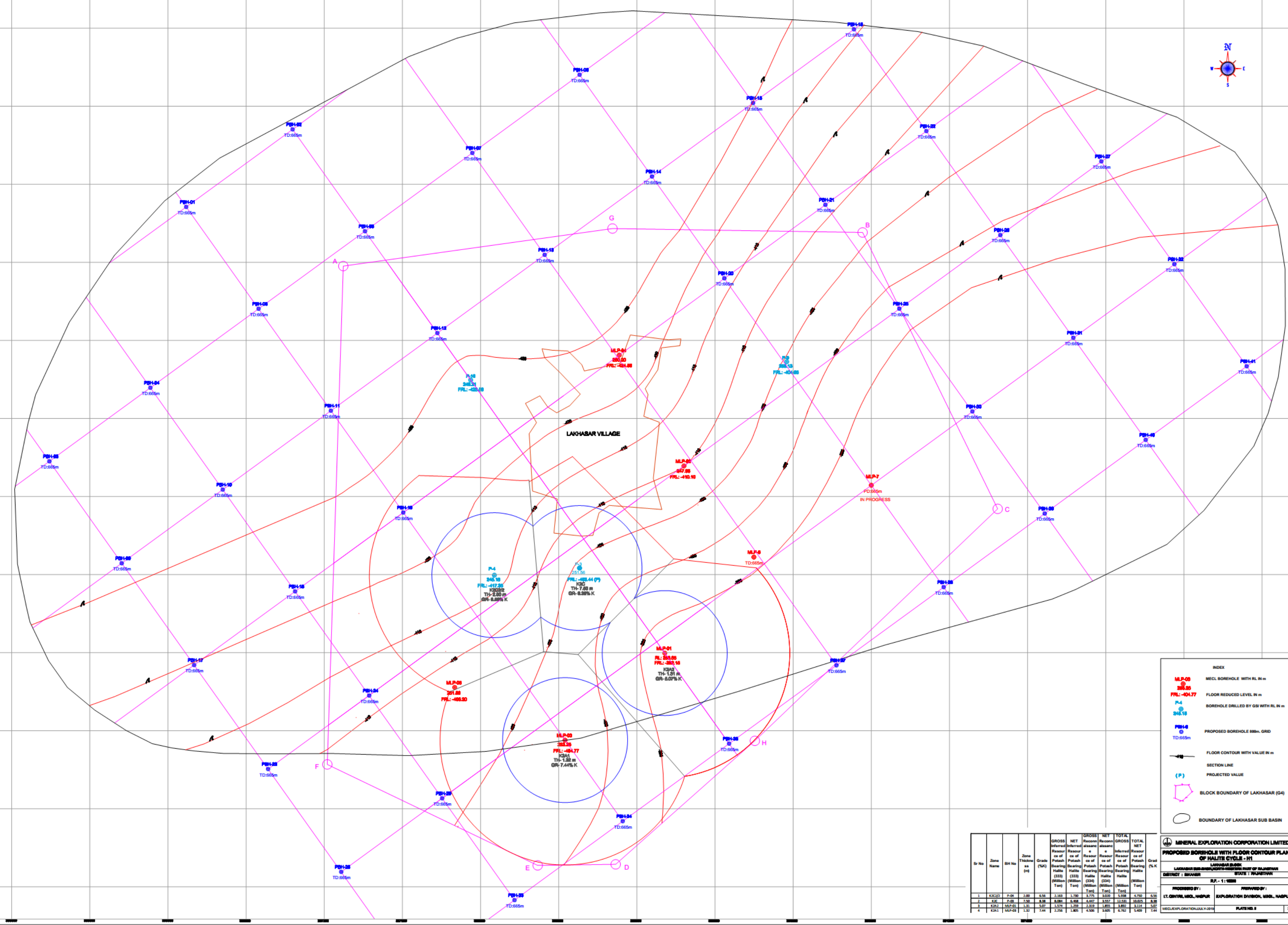
7.0.0 Justification

7.1.1 As an outcome of G-3 stage exploration in the Lakhasar block a total 14 correlatable main potash zones and eleven local zones have been identified in Lakhasar block. Among all these, potash zones K1A1, K2A, K2A1, K2A2, K2C, K2C1 and K2C2 are well developed but neither persistent nor potential throughout the Lakhasar block. Potash zone K2C is the most prominent, persistent and potential zone occurring in Halite cycle H2 i.e. its thickness ranges from 2.18m (minimum) in BH No MLP-3 to 7.50m (maximum) in BH No P-3 and grade ranges from 1.77% K (minimum) in BH No MLP-3 to 8.38 % K (maximum) in BH No P-3 and gets splitted in to two sub zones e.g. K2C1 and K2C2 in BH No P-10.

7.1.2 The gross (Inferred + Reconnaissance) resources at 3% K cut-off in the Lakhasar block is estimated at **92.354** m.t. and net resource of **73.883** m.t with average grade **4.65**% K in **10.04 sq.km area** out of total 13.007 sq.km. area of the Lakhasar block.

7.1.3 The area with grade more than 5% K at 3% K cut off has been delineated in the Lakhasar block and resource has been estimated separately for it in 4.679 sq. km. area. The four potash zones i.e. K2C2/2, K2C, K2A2 and K2A1 intersected in BH No. P-4, P-3, MLP-01 & MLP-03 respectively contribute net 29.123 million tonnes reconnaissance + inferred category resource (334) + (333) in 4.679 sq.km. area against net 73.883 m.t estimated for the Lakhasar block in 10.04 sq.km. area out of total 13.007 sq. km. area of the block and is potential for potash exploration in Lakhasar block.

7.1.4 In view of the above, it is imperative to delineate such an area with more than 5%K grade within the entire Lakhasar sub basin by carrying out regional exploration on 800m X 800m grid so that it can be auctioned and developed in to a potash mines.



INDEX

- MLP-03 — MECL BOREHOLE WITH RL IN m
- FRL: -404.77 — FLOOR REDUCED LEVEL IN m
- P-4 248.18 — BOREHOLE DRILLED BY GSI WITH RL IN m
- TD:665m — PROPOSED BOREHOLE 800m. GRID
- FLOOR CONTOUR WITH VALUE IN m
- SECTION LINE
- (P) — PROJECTED VALUE
- BLOCK BOUNDARY OF LAKHASAR (G4)
- BOUNDARY OF LAKHASAR SUB BASIN

Sr No	Zone Name	BH No	Zone Thickness (m)	Grade (%K)	GROSS Inferred Resource of Potash Bearing Halite (333) (Million Ton)	NET Inferred Resource of Potash Bearing Halite (333) (Million Ton)	GROSS Reconnaissance Resource of Potash Bearing Halite (334) (Million Ton)	NET Reconnaissance Resource of Potash Bearing Halite (334) (Million Ton)	TOTAL GROSS Inferred Resource of Potash Bearing Halite (Million Ton)	TOTAL NET Resource of Potash Bearing Halite (Million Ton)	Grad (% K
1	K2C2/2	P-04	2.00	6.56	2.163	1.730	3.775	3.020	5.938	4.750	6.56
2	K2C	P-03	7.50	8.38	8.084	6.468	4.447	3.557	12.531	10.025	8.38
3	K2A2	MLP-01	1.31	5.07	1.574	1.259	2.319	1.855	3.892	3.114	5.07
4	K2A1	MLP-03	1.32	7.44	2.256	1.805	4.506	3.605	6.762	5.409	7.44

MINERAL EXPLORATION CORPORATION LIMITED

PROPOSED BOREHOLE WITH FLOOR CONTOUR PLAN OF HALITE CYCLE - H1

LAKHASAR BLOCK
LAKHASAR SUB-BASIN, NORTH-WESTERN PART OF RAJASTHAN

DISTRICT : BIKANER STATE : RAJASTHAN

R.F. - 1 : 16000

PROCESSED BY :	PREPARED BY :	
I.T. CENTRE, MECL, NAGPUR	EXPLORATION DIVISION, MECL, NAGPUR	
MECL/EXPLORATION/JULY-2019	PLATE NO. II	2