PROPOSAL FOR PRELIMINARY EXPLORATION (G-3) FOR POTASH IN BHARUSARI NORTH BLOCK, BHARUSARI SUB BASIN, NORTHWESTERN PART OF RAJASTHAN (10.00 SQ.KM AREA)

DISTRICT- HANUMANGARH, RAJASTHAN

COMMODITY: POTASH

BY

MINERAL EXPLORATION CORPORATION LIMITED

DR. BABASAHAB AMBEDKAR BHAWAN

SEMINARY HILLS

PLACE: NAGPUR

DATE: 20th March 2023

Summary of the Block for Preliminary Exploration (G-3)
GENERAL INFORMATION ABOUT THE BLOCK

	Features	**Details**
	Block ID	Bharusari North Block
	Exploration Agency	Mineral Exploration Corporation Limited (MECL)
	Commodity	Potash
	Mineral Belt	Bharusari Sub Basin, Northwestern Part of Rajasthan
	Completion period with entire Time schedule to complete the project	18 Months
	Objectives	**The Preliminary Exploration (G-3) is proposed with the following Objectives**: i) To confirm the continuity and potentiality of potash bearing zones in the proposed area. ii) To generate data for initial assessment of mineralogy of the potash zones and the K contents. iii) To estimate resources of Potash zones especially with Polyhalite, sylvite & sylvinite zones as per UNFC system.
	Whether the work will be carried out by the proposed agency or through outsourcing and details thereof. Components to be outsourced and name of the outsource agency	Work will be carried out by the proposed agency.
	Name/Number of Geoscientists	Two no Geoscientist (1 Field + 1 HQ)
	Expected Field days (Geology, Geophysics, Surveyor)	Geologist Party days: 240 days

<table>
<tr><td>1.</td><td>Location</td><td>The proposed block in potash bearing Bharusari Sub basin lies in the Survey of India Toposheet No. 44 K/7. The area is well connected by rail (Bikaner-Suratgarh – Ganganagar rail line of Western railway) and by road from Bikaner-Lunkaransar-Rambagh-Hanumangarh. The National Highway (NH-62) passes near to the Bharusari Basin. Suratgarh is the nearest railway station. Bikaner is around 140 km from the study area (Plate No.-I). Bharusari North Block with 10.00 sq.km area is located in the northern part of the Bharusari sub basin having approximately 1120 sq.km area.</td></tr>
<tr><td></td><td>Latitude-Longitude</td><td>
<table>
<tr><th rowspan="2">SL. NO.</th><th rowspan="2">CARDINAL POINTS</th><th colspan="2">DMS (WGS-84)</th><th colspan="2">UTM (m) ZONE-43 (NORTH)</th></tr>
<tr><th>LATITUDE</th><th>LONGITUDE</th><th>NORTHING</th><th>EASTING</th></tr>
<tr><td>1</td><td>A</td><td>29°18'48" N</td><td>74°15'18" E</td><td>3242926.19</td><td>427645.27</td></tr>
<tr><td>2</td><td>B</td><td>29°18'49" N</td><td>74°18'47" E</td><td>3242924.96</td><td>433299.77</td></tr>
<tr><td>3</td><td>C</td><td>29°17'23" N</td><td>74°17'49" E</td><td>3240277.94</td><td>431704.49</td></tr>
<tr><td>4</td><td>D</td><td>29°17'50" N</td><td>74°17'17" E</td><td>3241115.87</td><td>430852.50</td></tr>
<tr><td>5</td><td>E</td><td>29°17'49" N</td><td>74°15'48" E</td><td>3241115.87</td><td>428452.13</td></tr>
<tr><td>6</td><td>F</td><td>29°17'23" N</td><td>74°15'18" E</td><td>3240322.55</td><td>427646.63</td></tr>
</table>
</td></tr>
<tr><td></td><td>Villages</td><td>Jhakhranwali, Jhuriyanwala, Manaktheri, Thakruwala Daultanwali</td></tr>
<tr><td></td><td>Tehsil/Taluk</td><td>-</td></tr>
<tr><td></td><td>District</td><td>Hanumangarh</td></tr>
<tr><td></td><td>State</td><td>Rajasthan</td></tr>
<tr><td>2.</td><td>Area (hectares/ square kilometres)</td><td></td></tr>
<tr><td></td><td>Block Area</td><td>10.00 sq.km</td></tr>
<tr><td></td><td>Forest Area</td><td>Non-Forest area.</td></tr>
<tr><td></td><td>Government Land Area (Bilanam)</td><td>Data not available</td></tr>
<tr><td></td><td>Charagaha</td><td>Data not available</td></tr>
<tr><td></td><td>Private Land Area</td><td>Data not available</td></tr>
<tr><td>3.</td><td>Accessibility</td><td></td></tr>
<tr><td></td><td>Nearest Rail Head</td><td>Suratgarh is the nearest railway station.</td></tr>
<tr><td></td><td>Road</td><td>The area is well connected by road from Bikaner-Lunkaransar-Rambagh-Hanumangarh</td></tr>
<tr><td></td><td>Airport</td><td>Bikaner (140 km)</td></tr>
<tr><td>4.</td><td>Hydrography</td><td></td></tr>
<tr><td></td><td>Local Surface Drainage Pattern (Channels)</td><td>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. Major canal system i.e. Indira Gandhi Canal passes through Bharusari basin.</td></tr>
<tr><td></td><td>Rivers/ Streams</td><td>There is not a single perennial stream in the area. Indira Gandhi Canal</td></tr>
</table>

		passes through Bharusari basin
5.	**Climate**	
	Mean Annual Rainfall	Average annual rainfall is 10 cm to 30 cm
	Temperatures (December) (Minimum) Temperatures (June) (Maximum)	Minimum temperatures 0ºC (Dec-Feb), Maximum temperatures up to 50ºC (March-June)
6.	**Topography**	
	Toposheet Number	44K/7
	Morphology of the Area	The area is almost flat terrain and covered with thick aeolian sand or alluvial sediments. The average height of the area is 150m above MSL.
7.	**Availability of baseline geoscience data**	
	Geological Map (1:50K/25K)	Geophysical map of Bharusari basin (1:50,000 scale)
	Geochemical Map	Not available.
	Geophysical Map (Aeromagnetic, ground geophysical, Regional as well as local scale GP maps)	Geophysical map of Bharusari basin (1:50,000 scale)
8.	**Justification for taking up Reconnaissance Survey/ Regional Exploration**	1. In Bharusari Sub basin, Geological Survey of India has carried out preliminary exploration by drilling 10 nos. of boreholes at wider interval. GSI has estimated resources of the order of 388.31 million tonnes with grade 4.68% K and 17.17% Na, covering 71.0 Sq, km, area. Further, MECL has completed Geophysical Exploration (Gravity and Magnetic Survey) with covering an area of 1119 sq. km. in Bharusari Sub Basin and based on the finding of geophysical studies, 20 exploratory boreholes up to a depth of 700-750m have been recommended to test/validate the veracity of the G-M survey interpretation in the area and the results of the boreholes would dictate the future exploration strategy. 2. In view of the above, drilling of 12 no boreholes with 8600m at 800m X 800m grid has been executed within 14.17 sq. km. in near vicinity of GSI drilled boreholes. The outcome of the exploration result is encouraging. The gross inferred resource of 12.839 m.t and net inferred resource of 10.272 m.t with average grade 5.58% K (6.75% K2O) and gross reconnaissance resource of 5.324 m.t and net reconnaissance resource of 4.259 m.t with average grade of 5.65% K (6.84% K2O) has been estimated at

		5% K cut off in the block. Whereas the gross inferred resource of 49.738 m.t. and net inferred resource of 39.791 m.t. with average grade 4.28% K (5.18% K2O) and gross reconnaissance resource of 22.007 m.t and net reconnaissance resource of 17.606 m.t with average grade of 4.30% K (5.20% K2O) has been estimated at 3% K cut off in the block. Similarly gross inferred resource of 138.965 m.t. and net inferred resource of 111.172 m.t with average grade 3.06% K (3.70% K2O) and gross reconnaissance resource of 64.609 m.t. and net reconnaissance resource as 51.688 m.t with average grade of 3.04% K (3.68% K2O) has been estimated at 2% K cut off. 3. The distribution of Resource in Plan reveals that the potash bearing zones are continuous in North, South and Eastern direction. As a result the Bharusary North Block is the potential area for further establishment of potash resource.

PROPOSAL FOR PRELIMINARY EXPLORATION (G-3) FOR POTASH IN BHARUSARI NORTH BLOCK (10.00 Sq Km), BHARUSARI SUB BASIN, NORTHWESTERN PART OF RAJASTHAN DISTRICT- HANUMANGARH, RAJASTHAN

1.0.0 Preamble

1.1.0 Background

1.1.1 Potassium, Nitrogen and Phosphorous (K, N & P) are the key chemical contents used in the Fertilizer Industry. Major production of potash in the world is obtained from Sylvite (KCl) and Polyhalite [$K_2Ca_2Mg(SO_4)_4{\cdot}2H_2O$] associated with Halite (NaCl) bearing evaporite sequences. India produces only meager quantity of potash as by-products during the manufacture of common salt from seawater and the entire requirement of potash is met through imports. Sinha et al (1973) of CGWB, while exploring for Ground Water, reported halite from Lakhasar at a depth of 541m and correlated it with the Kohat salt sequence of Pakistan. Presence of halite at a depth of 469m was further reported by CGWB from Satipura in Shri Ganganagar district.

1.1.2 In February 2009, a meeting was held in New Delhi under the Chairmanship of Secretary (Mines). In which, it was discussed that potash exploration in Northwestern part of Rajasthan should be taken up by MECL.

1.1.3 In 31st meeting of Technical Sub Committee of SCPP held on 14.12.2015 at MECL, Corporate Office, Nagpur, the exploration proposal for exploration in Bharusari Sub Basin was discussed in detailed and committee suggested Geophysical survey (Gravity and Magnetic) at 500 x 500 m grid intervals. Administrative approval / Financial sanction for assessment of potash mineralization in Bharusari Sub Basin at an estimated cost of 99,61,353/- has been received vide letter no. 37/2/20-16-M.I.

1.1.5 Subsequently, MECL outsourced the work to DMT Consulting Private Ltd, Kolkata vide Work Order No/1564/CD/Geophysical Survey-Rajasthan/2016 dated 16th August, 2016. A nine member field crew was deployed at Bharusari site for execution and accomplished the work within specified time period. Gravity-Magnetic-DGPS field data acquisition commenced on 12th Sep 2016 and was completed on 29th January, 2017 and submitted the final report in May, 2017 with recommendation to drill 20 Nos of boreholes to validate the veracity of Gravity–Magnetic Survey.

1.1.6 In accordance with the recommendation of geophysical survey, MECL prepared a proposal to drill 32 Nos of boreholes in G-4 level over an area of 125.56 sq. km located in north central part of Bharusari Sub basin having 725 sq. km area. The proposal was put up to TCC, NMET for evaluation in their 24th meeting held on 7th, 8th and 9th October, 2020 and the committee suggested to explore an area of 14.16 sq. km in G-3 level covering 5 Nos of earlier drilled GSI boreholes by drilling 12 Nos of borehole in 800m X 800 m grid to prove the potash mineralisation and thus recommended for approval of EC, NMET.

1.1.7 The proposal was approved by EC, NMET in their 17th meeting held on 5th November, 2020 with an estimated cost of Rs 17.54 Cr with a time line of 18 months and MECL received the letter of approval vide letter F. No. 6/2/2015-NMET/87 dated 18th November, 2020.

1.1.8 Accordingly, MECL launched exploration campaign on 28th December, 2020 by deploying drilling rig at the borehole number MBP-01 and completed the drilling activity on 16th April, 2022 by closing the borehole number MBP-12. MECL has drilled a total 7868 m in 12 numbers of boreholes along with associated geological and geophysical activity and submitted the Geological Report on October' 2022.

1.1.9 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.

1.1.10 Out of a total sub-basin area of 2,470.51 sq. km, within the Nagaur-Ganganagar basin, only 6.63% of the total area i.e., 164 sq. km area has been explored till date. The remaining unexplored area within the eight sub-basins aggregates to ~2,300 sq. km. This is ~93% of the total sub-basin area. It may be noted that this area was demarcated by GSI based on 2% K isochore boundary (1974-1991).

1.1.11 In the meantime, DMG, Rajasthan, RSMML, Rajasthan and MECL jointly took an initiative (where MECL acted as the Program Manager) to undertake a comprehensive feasibility study through engagement of an international consultant for soulution mining of potash and feasibility of construction of pilot plant in Bikaner district. The main objective of the study was to assess the various requirement of setting up a Pilot Plant for extraction of Potash and to identify the possible methods to de-risk the potential deposits before a sizable investment is made. This study is the pioneering study in the country as mining of potash has not been attempted in any part of the country.

1.1.12 An apex level delegation led by Honorable Minister, Mine and Geology, Govt. of Rajasthan undertook a visit to select solution mining project and potash harvesting facility /manufacturing plant between 12th Sept 2022 and 17th Sept 2022. Several detailed discussions were taken place on the visit made to the solution mining sites and the findings of the report including the benchmarking of the Rajasthan deposit, resources, selection of block, methodology of solution mining, way forward and

action plan etc. The final report had been submitted along with the way forward for Potash mining in the state of Rajasthan in November, 2022.

1.1.13 Moreover Hon'ble Minister, Mine and Geology, Govt. of Rajasthan has also shown his interest to develop potash mining in the state of Rajasthan and also requested to estimate the mineral wise resource in the deposits vide D.O letter No. P.19(12)/Mine/Group-2/2023 dated 13/01/2023. Ministry of Mines, Government of India has also showed further interest to carry out exploration of potash minerals in the state of Rajasthan by approving the Lakhasar East block proposed by MECL in the 28th EC meeting of NMET.

1.1.14 An apex level meeting chaired by Honorable Secretary, Ministry of Mines and Secretary, Ministry of Fertilizer, Govt. of India undertook a visit to possibility solution mining on 24th February 2023. Secretary (Fertilizers) informed that, in Nagaur-Ganganagar Basin, the Polyhalite is associated with NaCl. After treatment of NaCl, the Polyhalite may contain Potassium up to 16%. Secretary (Fertilizers) opined that minerals such as Potash on which we are 100% import-dependent have strategic importance. Secretary, MoM opined that there is a need for further assessment of the deposit through drilling to upgrade the blocks to the G2 stage. This will facilitate a decision on the feasibility of mining.

1.1.15 In this scenario, MECL further wish to take up the exploration work in the Northern continuation of Bharussari Block in Bharusari sub-Basin in Hanumangarh District, Rajasthan to expedite the vision of the ministry.

1.2.0 Location and Accessibility

1.1.1 The proposed block in potash bearing Bharusari Sub basin lies in the Survey of India Toposheet No. 44 K/7. The area is well connected by rail (Bikaner-Suratgarh – Ganganagar rail line of Western railway) and by road from Bikaner-Lunkaransar-Rambagh-Hanumangarh. Suratgarh is the nearest railway station. Bikaner is around 140 km from the study area. Bharusari North Block with 10.00 sq.km area is located in the northern part of the Bharusari sub basin its coordinates are given in following table.

Co-ordinates of the cardinal points of Block Boundary of the Bharusari North Block

SL. NO.	CARDINAL POINTS	DMS (WGS-84)		UTM (m) ZONE-43 (NORTH)		AREA (sq. km)
		LATITUDE	LONGITUDE	NORTHING	EASTING	
1	A	29°18'48" N	74°15'18" E	3242926.19	427645.27	10.00
2	B	29°18'49" N	74°18'47" E	3242924.96	433299.77	
3	C	29°17'23" N	74°17'49" E	3240277.94	431704.49	
4	D	29°17'50" N	74°17'17" E	3241115.87	430852.50	
5	E	29°17'49" N	74°15'48" E	3241115.87	428452.13	
6	F	29°17'23" N	74°15'18" E	3240322.55	427646.63	

1.3.0 Physiography & Climate

1.3.1 The entire area of Nagaur-Ganganagar basin is covered by thick aeolian sand or alluvial sediments except the southern part where scanty outcrops could be seen. The present study area Bharusari Sub basin is entirely covered by thick aeolian or alluvial sediments. The major part of the Bharusari Sub basin presents a monotonous topography of NW-SE trending longitudinal dunes and interdunal areas. The elevation of area varies between 147m to 375m above MSL.

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. Major canal system i.e. Indira Gandhi Canal passes through Bharusari North Block.

1.3.3 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 is mostly received during July-August. However, where irrigation facilities of canal system are developed, there is good vegetation and agricultural crops are grown round the year.

1.4.0 Previous work

1.4.1 The presence of evaporite minerals like gypsum, anhydrite and halite were known from Nagaur and Bikaner areas since 1930's. Halite in Bikaner is reported by P.K. Ghosh 1952, Gypsum in Nagaur by Roy Chowdhury et al 1965 and anhydrite inter section in boreholes drilled by Central Ground Water Board (CGWB) and Oil & Natural Gas Corporation (ONGC). George I. Smith (1968) of the USGS evaluated the data of GSI and identified that Nagaur basin is one of the area geologically most favourable for occurrence of potash bearing marine evaporite deposit.

1.4.2 R.S. Jain and Premchandra (1973), based on the data from ONGC & CGWB, identified several 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.

1.4.3 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 58,733.95m of drilling in 68 closed & 2 abandoned boreholes. All the boreholes were drilled vertical, assuming that the host rock (halite) is disposed horizontally to sub

horizontally with 3° - 5° rolling dips towards NW. In Bharusari Sub basin, GSI drilled eight boreholes, aggregating 5262.45m.

1.4.4 Mineralised Zones intersected in GSI boreholes on different cut offs 1% K & 3% K are given below:

Mineralised Zones Intersected in GSI Boreholes in at 1.00% K cut-off in Bharusari Sub basin

Sl.	Borehole No.	Depth (m)		Thickness (m)	Average K %	Average Na %
		From	To			
1.	P-49	572.71	578.55	5.84	1.33	28.33
		584.25	594.00	9.75	1.45	30.55
2.	P-51	562.29	573.43	11.14	3.03	26.56
		575.27	580.39	5.12	1.50	31.06
		582.65	587.32	4.67	1.00	31.97
		596.40	598.00	1.60	1.10	36.03
		618.55	620.05	1.50	1.81	32.89
		680.99	682.77	1.78	1.28	29.11
3.	P-56	551.00	556.94	5.94	3.09	24.60
		558.48	559.99	1.51	7.19	17.37
		563.19	566.67	3.48	1.50	29.64
		570.07	572.12	2.05	1.01	32.85
4.	P-59	554.55	559.73	5.18	2.42	26.89
		565.80	571.40	5.60	1.08	31.90
		608.19	610.00	1.81	1.31	34.95
5.	P-62	500.95	503.18	2.23	1.95	21.40
		504.24	508.01	3.98	1.30	30.32
		512.59	520.10	7.51	2.71	16.10
		533.10	534.67	1.57	1.00	36.50
		602.95	605.10	2.15	1.40	35.20
6.	P-64	578.15	580.45	2.30	5.06	26.33
		583.24	584.74	1.50	1.97	26.80
		586.52	588.02	1.50	1.19	28.17
		600.65	602.33	1.68	1.10	34.75
		613.96	616.50	2.54	1.05	38.00
		625.42	626.92	1.50	1.19	35.29
7.	P-66	543.11	561.27	8.16	2.36	22.40
		564.33	565.83	1.50	1.38	32.01
		575.25	576.80	1.55	1.30	33.11
		577.75	580.25	2.50	1.05	32.50

Mineralised Zones Intersected in GSI Boreholes in at 3.00% K cut-off in Bharusari Sub basin

Sl.	Borehole No.	Depth along hole (m)		Thickness (m)	Average K %	Average Na %
		From	To			
1.	P-51	562.29	556.21	3.92	5.29	19.51
2.	P-56	551.00	552.97	1.97	5.27	17.37
		558.48	559.99	1.51	7.19	17.37
3.	P-59	556.18	557.99	1.81	3.97	24.22
4.	P-62	516.38	518.23	1.85	3.96	14.15
5.	P-64	578.15	580.45	2.30	5.06	26.33
6.	P-66	543.11	546.65	3.54	3.25	12.09

1.4.5 GSI has computed potash resources in Bharusari Sub basin based on the intersection of potash mineralisation at 3% K and 1.50 m minimum stopping width (MSW). The resources computed in these basins are given below: -

Potash Resource in Bharusari sub basin

Sub basin	Area (Sq.Km.)	Ore Resources (Million Tonnes)		Grade	
		Probable	Possible	K%	Na %
Bharusari	71.00	88.16	300.15	4.68	17.17

Total resource of 388.31million tonnes resources with 4.68% K and 17.17 % Na has been estimated.

1.4.6 During the year 2016-17 and 2017-18, MECL carried out Geophysical Exploration (Magnetic and Gravity Survey) in Bharusari Sub Basin and suggested for further exploration in the area.

1.4.7 Accordingly, MECL launched exploration campaign on 28th December, 2020 by deploying drilling rig at the borehole number MBP-01 and completed the drilling activity on 16th April, 2022 by closing the borehole number MBP-12. MECL has drilled a total 7868 m in 12 numbers of boreholes along with associated geological and geophysical activity.

1.4.8 The exploration in Bharusari block has confirmed the presence and persistence of seven halite cycles (H1, H2, H3, ..., H7) in Hanseran Evaporite Group (HEG). These halite cycles are separated from one another by clays and/or anhydrite or dolomite. The first halite cycle (H1) has the thickness ranges from 24.27 m (MBP-10) to 53.69 m (P-64) with average thickness of 35.31 m whereas the thickness of H2 cycle ranges from 79.79 m (P-62) to 98.55 m (P-49) with average halite thickness of 88.36 m. H3 halite cycle is varying from 19.55 m (MBP-10) to 35.49 m (p-49) with an average thickness of 22.33 m. Similarly the thickness of H4 cycle ranges from 26.35 m (P-49) to 44.09 m (P-51) with average halite thickness of 36.59 m. H-5 is varying from 13.64 m (P-62) to 54.97 m (MBP-01) having average thickness of 48.98 m. H6 and H7 cycles have not intersected in all the boreholes. These two cycles are mostly

developed in northwestern part of the block. H6 cycle in the thinnest cycle varing from 1.86 m (MBP-07) to 4.59 m (P-49) with average thickness of 2.65 m whereas H7 cycle is varying from 6.59 m (MBP-01) to 56.30 m (P-64) with average thickness of 24.45 m.

1.4.9 The potash mineralization in the Bharusari Block is restricted to the three different halite cycles i.e., H1, H2 and H4 in the Hanseran Evaporite Group (HEG). Halite cycle H2 shows potential potash zones delineated at all the 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.

1.4.10 Therefore, the identification of potash minerals based on its color, weight (Sp. Gravity), hardness, feel and luster is extremely difficult. The samples from the suspected potash bearing halite zones have been drawn at 0.50 m interval whereas the rest of the Halite cycle has been sampled by keeping the sample length 1.00 m. The potash zones intersected in the boreholes are identified only on the basis of chemical analysis of the samples and have been delineated at 1%, 2%, 3% and 5% K cut-off after excluding the clots and thin lamellae of the clay minerals. It has been observed that the individual potash zones are very thin. The development of the potash zones is very erratic, discontinuous as well as local. Potash zones have been classified into 11 major bands, i.e., K1A, K1B, K1C, K2A, K2B, K2C, K2D, K2E, K4A, K4B AND K4C bands. Each of the bands show merging and splitting nature with rolling dip in the conformity of the respective Halite cycle showing horizontal to sub horizontal with concentric dip of 1° to 5° towards northern part of the block. The details of Zone calculated at 1% , 3% and 5% has been furnished below.

Statement showing Borehole-wise Potash Zones (at 1% K cut-off with 1.00 m thickness) of MECL boreholes in Bharusari Block

Sl.No	BH. No	From	To	Thickness (In m)	K%	Zone Name
1	MBP-01	466.00	468.80	2.80	1.47	K4C4
2	MBP-01	473.00	474.00	1.00	2.04	K4C2
3	MBP-01	477.00	478.00	1.00	2.12	K4C1
4	MBP-01	548.60	559.28	10.68	2.42	K2E1
5	MBP-01	560.94	572.50	11.56	2.05	K2D1
6	MBP-01	593.00	594.85	1.85	1.58	K2B3
7	MBP-01	596.00	598.00	2.00	1.09	K2B2
8	MBP-01	603.00	604.00	1.00	1.75	K2B1
9	MBP-01	612.00	613.00	1.00	1.49	K2A2
10	MBP-01	617.00	619.00	2.00	1.51	K2A1
11	MBP-02	479.35	480.80	1.45	1.42	K4C5
12	MBP-02	485.11	486.11	1.00	1.22	K4C4
13	MBP-02	502.00	505.46	3.46	1.13	K4B1
14	MBP-02	565.00	577.00	12.00	3.46	K2E1
15	MBP-02	583.50	587.00	3.50	1.28	K2D1
16	MBP-02	603.00	604.00	1.00	1.55	K2B3

Sl.No	BH. No	From	To	Thickness (In m)	K%	Zone Name
17	MBP-02	611.00	612.00	1.00	1.84	K2B2
18	MBP-02	626.00	627.00	1.00	1.80	K2B1
19	MBP-02	631.80	635.00	3.20	1.76	K2A3
20	MBP-02	637.00	638.70	1.70	1.48	K2A2
21	MBP-02	671.15	672.50	1.35	2.37	K1B2
22	MBP-02	677.20	679.00	1.80	1.87	K1B1
23	MBP-03	463.00	464.50	1.50	1.78	K4C5
24	MBP-03	468.01	469.57	1.56	1.92	K4C3
25	MBP-03	472.00	474.00	2.00	2.90	K4C1
26	MBP-03	487.65	488.70	1.05	0.99	K4B1
27	MBP-03	546.30	548.44	2.14	2.29	K2E2
28	MBP-03	549.78	556.00	6.22	1.51	K2E1
29	MBP-03	558.00	559.52	1.52	1.74	K2D3
30	MBP-03	565.00	571.00	6.00	1.58	K2D2
31	MBP-03	579.50	583.00	3.50	1.11	K2C2
32	MBP-03	586.00	587.00	1.00	1.07	K2C1
33	MBP-03	596.00	601.00	5.00	1.32	K2B2
34	MBP-03	608.76	613.00	4.24	1.32	K2B1
35	MBP-04	454.00	457.00	3.00	1.09	K4C5
36	MBP-04	460.00	461.00	1.00	0.96	K4C3
37	MBP-04	465.00	466.00	1.00	0.96	K4C1
38	MBP-04	474.00	475.00	1.00	1.99	K4B2
39	MBP-04	484.98	486.00	1.02	1.34	K4A
40	MBP-04	537.94	540.00	2.06	1.73	K2E2
41	MBP-04	542.10	547.00	4.90	1.70	K2E1
42	MBP-04	548.50	551.00	2.50	1.91	K2D3
43	MBP-04	559.25	562.50	3.25	1.87	K2D2
44	MBP-04	566.50	568.50	2.00	1.41	K2C3
45	MBP-04	570.00	573.00	3.00	0.97	K2C2
46	MBP-04	599.80	602.70	2.90	1.29	K2A3
47	MBP-04	605.50	607.80	2.30	1.64	K2A2
48	MBP-04	613.12	615.00	1.88	1.17	K2A1
49	MBP-04	660.00	661.00	1.00	0.91	K1A1
50	MBP-05	476.00	478.00	2.00	1.39	K4C5
51	MBP-05	481.34	483.00	1.66	3.04	K4C3
52	MBP-05	559.75	561.60	1.85	2.52	K2E2
53	MBP-05	564.39	568.00	3.61	3.09	K2E1
54	MBP-05	576.42	583.60	7.18	2.33	K2D2
55	MBP-05	586.00	587.20	1.20	2.07	K2C3
56	MBP-05	592.00	593.60	1.60	1.75	K2C2
57	MBP-05	625.00	627.29	2.29	1.45	K2A2
58	MBP-05	663.84	665.20	1.36	3.24	K1B2

Sl.No	BH. No	From	To	Thickness (In m)	K%	Zone Name
59	MBP-05	680.00	681.00	1.00	1.06	K1A1
60	MBP-06	455.70	457.00	1.30	0.94	K4C3
61	MBP-06	459.90	463.00	3.10	1.79	K4C1
62	MBP-06	482.00	484.87	2.87	1.92	K4A
63	MBP-06	536.68	543.00	6.32	1.58	K2E1
64	MBP-06	544.84	549.33	4.49	4.40	K2D2
65	MBP-06	550.40	554.00	3.60	1.38	K2D1
66	MBP-06	581.00	587.00	6.00	1.16	K2B1
67	MBP-06	631.50	632.50	1.00	2.18	K1B2
68	MBP-08	434.10	436.00	1.90	1.37	K4C5
69	MBP-08	438.00	439.00	1.00	2.80	K4C4
70	MBP-08	440.00	441.00	1.00	0.95	K4C3
71	MBP-08	442.00	443.00	1.00	1.18	K4C2
72	MBP-08	446.00	447.00	1.00	1.66	K4C1
73	MBP-08	464.64	467.50	2.86	1.89	K4A
74	MBP-08	521.00	527.10	6.10	2.09	K2E1
75	MBP-08	534.20	539.65	5.45	1.49	K2D2
76	MBP-08	542.00	543.00	1.00	1.82	K2D1
77	MBP-08	550.50	551.50	1.00	1.52	K2C1
78	MBP-08	567.00	568.00	1.00	0.98	K2B1
79	MBP-08	578.38	580.77	2.39	1.50	K2A2
80	MBP-08	584.05	586.38	2.33	1.06	K2A1
81	MBP-09	420.42	422.00	1.58	1.34	K4C5
82	MBP-09	429.98	431.00	1.02	1.11	K4C1
83	MBP-09	503.99	514.00	10.01	1.61	K2E1
84	MBP-09	515.35	526.00	10.65	1.55	K2D
85	MBP-09	536.00	538.50	2.50	1.09	K2C2
86	MBP-09	554.00	555.50	1.50	1.14	K2B1
87	MBP-09	566.00	567.60	1.60	1.25	K2A2
88	MBP-09	571.00	574.22	3.22	1.03	K2A1
89	MBP-09	616.61	619.00	2.39	2.41	K1A2
90	MBP-09	622.25	624.26	2.01	1.08	K1A1
91	MBP-10	449.00	451.00	2.00	1.69	K4C5
92	MBP-10	453.00	454.00	1.00	5.20	K4C4
93	MBP-10	455.28	456.28	1.00	1.76	K4C3
94	MBP-10	457.70	458.70	1.00	2.78	K4C2
95	MBP-10	460.00	461.00	1.00	2.79	K4C1
96	MBP-10	482.00	483.00	1.00	1.82	K4A
97	MBP-10	535.00	539.50	4.50	2.33	K2E1
98	MBP-10	542.00	550.00	8.00	1.98	K2D3
99	MBP-10	551.00	556.50	5.50	1.19	K2D2
100	MBP-10	561.00	563.50	2.50	1.81	K2C2

Sl.No	BH. No	From	To	Thickness (In m)	K%	Zone Name
101	MBP-10	566.30	568.75	2.45	1.11	K2C1
102	MBP-10	594.00	597.60	3.60	1.87	K2A2
103	MBP-10	600.00	603.00	3.00	1.58	K2A1
104	MBP-11	448.60	449.80	1.20	1.43	K4C5
105	MBP-11	454.00	456.00	2.00	2.90	K4C3
106	MBP-11	458.72	460.00	1.28	1.82	K4C1
107	MBP-11	471.00	474.20	3.20	1.12	K4B1
108	MBP-11	536.00	541.00	5.00	1.39	K2E1
109	MBP-11	542.10	543.20	1.10	1.47	K2D3
110	MBP-11	547.25	557.00	9.75	1.20	K2D2
111	MBP-11	565.00	567.00	2.00	1.28	K2C2
112	MBP-11	571.50	572.50	1.00	1.67	K2C1
113	MBP-12	466.00	467.00	1.00	1.21	K4C5
114	MBP-12	470.00	471.00	1.00	1.47	K4C4
115	MBP-12	477.00	478.00	1.00	0.99	K4C2
116	MBP-12	481.87	482.87	1.00	1.06	K4C1
117	MBP-12	489.34	492.38	3.04	1.59	K4B1
118	MBP-12	553.94	560.50	6.56	1.34	K2E1
119	MBP-12	565.50	572.50	7.00	1.47	K2D1
120	MBP-12	579.50	580.50	1.00	2.14	K2C3
121	MBP-12	581.50	585.50	4.00	1.25	K2C2
122	MBP-12	589.00	590.00	1.00	1.92	K2C1
123	MBP-12	592.50	594.50	2.00	1.28	K2B3
124	MBP-12	597.30	598.50	1.20	1.37	K2B2
125	MBP-12	604.00	605.00	1.00	1.80	K2B1
126	MBP-12	640.60	647.10	6.50	1.17	K1C
127	MBP-12	657.55	660.00	2.45	2.09	K1B2
128	MBP-12	674.00	675.00	1.00	1.02	K1A1

Statement showing Borehole-wise Potash Zones (at 3% K cut-off with 1.00 m thickness) of MECL boreholes in Bharusari Block

Sl.No	BH. No	From	To	Thickness (In m)	K%	Zone Name
1	MBP-01	549.40	553.00	3.36	3.33	K2E1
2	MBP-01	562.67	565.47	2.80	3.58	K2D1
3	MBP-02	565.00	574.00	9.00	3.81	K2E1
4	MBP-03	473.00	474.00	1.00	3.45	K4C1
5	MBP-05	481.86	483.00	1.14	3.86	K4C3
6	MBP-05	566.00	568.00	2.00	3.75	K2E1
7	MBP-05	581.00	582.00	1.00	3.69	K2D2
8	MBP-05	663.84	665.20	1.36	3.24	K1B2

Sl.No	BH. No	From	To	Thickness (In m)	K%	Zone Name
9	MBP-06	544.84	548.00	3.16	5.04	K2D2
10	MBP-08	524.00	525.00	1.00	4.86	K2E1
11	MBP-10	453.00	454.00	1.00	5.20	K4C4
12	MBP-11	455.00	456.00	1.00	4.28	K4C3

Statement showing Borehole-wise Potash Zones (at 5% K cut-off) of MECL boreholes in Bharusari Block

Sl. No	BH. No	From	To	Thickness (In m)	K%	Zone Name
1	MBP-02	572.42	573.48	1.06	5.23	K2E1
2	MBP-06	547.00	548.00	1.00	5.58	K2D2
3	MBP-10	453.00	454.00	1.00	5.20	K4C4

1.4.11 All the borehole drilled by MECL, i.e., total 12 nos (MBP series) and 5 boreholes (P series) drilled by GSI within the Bharusari Block along with its geological and chemical data has been considered for the evaluation of the Potash mineralisation and estimation of resource and grade.

1.4.10 Being the stratified sedimentary deposit with horizontal to sub horizontal bedding and gentle rolling dip of 1° to 5°, the potash beds are almost flat lying beds. The potash beds are very thin, impersistent, irregular and with local development implying the limited extension of potash zones around borehole intersections.

1.4.11 Hence considering this mode of occurrence of potash beds, the resource has been computed by "Area of influence method" for the block at 2%, 3% and 5% K cut off as per previous recommendation with minimum workable thickness of 1.00 m. The mineral resource calculations are compliant with MEMC rule, 2015 (Amended in 2021) and UNFC norms. However, GEOVIA-MINEX model has also been prepared for the Bharusari Block at 3% K cut off to compare the total resource estimated vide Area of Influence method with the resource obtained from the computerised model.

1.4.12 The gross inferred resource (333) of 12.839 m.t and Net inferred resource (333) of 10.272 m.t with average grade of 5.58% K(6.75% K2O) and gross reconnaissance resource (334) of 5.324 m.t and Net reconnaissance resource (334) of 4.259 m.t with average grade of 5.65 % K (6.84% K2O) has been estimated at 5% K cut off in the block.

1.4.13 Whereas the gross inferred resource (333) of 49.738 m.t. and Net inferred resource (333) of 39.791 m.t. with average grade of 4.28% K (5.18% K2O) and gross reconnaissance resource (334) of 22.007 m.t and Net reconnaissance resource (334) of 17.606 m.t with average grade of 4.30% K (5.20% K2O) has been estimated at 3% K cut off in the block.

1.4.14 Similarly gross inferred resource (333) of 138.965 m.t. and Net inferred resource (333) of 111.172 m.t with average grade of 3.06 % K (3.70% K2O) and gross

reconnaissance resource (334) of 64.609 m.t. and Net reconnaissance resource (334) as 51.688 m.t with average grade of 3.04% K (3.68% K2O) has been estimated at 2% K cut off.

1.4.15 An attempt has also been made to estimate the total potash resource from 3D model from GEOVIA MINEX software to compare it with the resource estimated by 'Area of Influence Method' to check the reliability of resource estimation. The total 64.593 m.t of gross potash resource has been estimated from 3D Minex model with average grade of 4.38 % K for the potash zones delineated at 3% K cut-off with minimum workable thickness of 1.00 m.

1.4.16 These outcomes were reviewed by TCC, NMET and after peer review the GR was accepted and submitted in October, 2022.

2.0.0 Regional Geology

2.1.0 The entire area of the Nagaur-Ganganagar basin is covered by thick aeolian sand or alluvium sediments except in the southern part where scanty out crops are observed. The Nagaur-Ganganagar basin is an intra-cratonic basin in which marine sediments of the Marwar Supergroup were deposited on the basement rocks of the Malani Igneous suite and/or Delhi metamorphites. A generalized stratigraphic sequence built up is as follows:

Litho-Stratigraphic Succession of Nagaur-Ganganagar Basin
(After Kumar et. al, 1993 GSI)

Age	Supergroup	Group	Thickness (m)
Recent to Sub recent (Quaternary)	-----	-----	0 – 373
---------- Unconformity ----------			
Lower Eocene (Tertiary)	-----		38 – 120
---------- Unconformity ----------			
Upper Proterozoic to Lower Cambrian	Marwar	Nagaur, Bilara/HEG, Jodhpur	50 - 290 100 - 300 240 - 423
---------- Unconformity ----------			
Precambrian	MalaniIgneous Suite/ Delhi Supergroup	----- Ajabgarh	Basement rocks

2.1.2 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.

2.2.0 Description of Lithounits

2.2.1 Basement Rocks (Malani Igneous suite rocks/Delhi Metamorphites)

The basement rocks of Delhi Supergroup (Ajabgarh Group) are exposed towards East, North and North-Eastern margin and the rocks of Malani Igneous Suites are exposed towards south & south-west margin of Nagaur-Ganganagar basin. Metasediments of the Delhi Supergroup are represented by massive quartzite, quartz-

sericite schist, phyllite, slate and amphibolite intruded by post-Delhi quartz veins. Rocks of the Malani Igneous Suite represented by rhyolite, tuffs and rhyolite porphyry intruded by Jalore and Siwana granites.

2.2.2 Marwar Super Group

The Marwar Supergroup is best developed in the Nagaur- Ganganagar basin which extends from near Jodhpur in the south to Pokaran in the southwest while in the northeast it follows the Aravlli trend in to Haryana and Punjab. In the north it extends up to salt range in Pakistan. It comprises essentially an unfossiliferous marine sedimentary sequence that has been divided into following three groups.

(i) Nagaur Group.

(ii) The Bilara Group and the Hanseran Evaporite Group (HEG) which are homotaxially time equivalent and facies variant.

(iii) Jodhpur Group.

I) Jodhpur Group: The rocks of Jodhpur Group unconformably overlie the basement rocks (Malani Igneous Suite and Delhi Metamorphites) and have gradational contact with the overlying Bilara Group or Hanseran Evaporite Group. The Jodhpur Group mainly comprises reddish to buff and grey coloured, medium to coarse grained, often calcareous, glauconitic & micaceous sandstone, with occasional interbands of shale & siltstones.

II) **Bilara Group:** The Jodhpur Group of rocks is unconformably overlain by Bilara Group, which comprises three calcareous dominant rock formations i) Pondlo Dolomite, ii) Gotan Limestone and iii) Dhanapa Dolomite. Outcrops of the Bilara Group are scanty. The Bilara limestone emits fetid odour when freshly chipped. It also yields small quantity of oil and inflammable gas on distillation (Heron, 1932).

III) Hanseran Evaporite Group (HEG): The Hanseran Evaporite Group (HEG) is sandwiched between the underlying Jodhpur Group and the overlying Nagaur Group of rocks. HEG comprises cyclic deposits of halite (NaCl) with anhydrite, clay, dolomite and magnesite. Halite is the most dominant constituent of the Group with minor polyhalite ($[K_2MgCa_2(SO_4)4.2H_2O]$, occasional sylvite (KCl), rare langbeinite [K_2 SO_4, $2MgSO_4$] and traces of carnallite (KCI, $MgCl_2.2H_2O$). Thickness of HEG ranges from 103.20m to 652.15m. So far seven halite cycles; numbered as H1, H2-to- H7 from bottom to top, have been identified. These halite cycles are separated from one another by clays and/or anhydrite and/or dolomite. It has been divided into eight formations and 17 units on the basis of lithological characters and order of superposition as shown in Table below.

STRATIGRAPHIC SEQUENCE OF THE HANSERAN EVAPORITE GROUP (H.E.G)
(After GSI)

Age	Super Group	Group	Formation	Unit	Rock Types
	----------Unconformity----------				
		Nagaur	-	-	-
		----------Gradational Contact----------			
Upper Proterozoic to Lower Cambrian	Marwar Super Group	H A N S E R A N	Lakhusar	E 16	Clay, Claystone, Anhydrite.
			Sataiyan	E 15	Halite (H_7) ± Polyhalite
				E 14	Clay, anhydrite, dolomite
			Harsinghpura	E 13	Halite (H_6) ± Polyhalite
				E 12	Clay, anhydrite, dolomite
			Kupli	E 11	Halite (H_5) ± Polyhalite
				E 10	Dolomite, Dolomitic Anhydrite + clay
			Malkisar	E 9	Halite (H_4) ± Polyhalite
				E 8	Dolomite + Anhydrite + clay
			Chattargarh	E 7	Halite (H_3) + Polyhalite
				E 6	Dolomite + Anhydrite + clay
			Kalu	E 5	Halite+Polyhalite(H_2)±sylvite+ Langbeinite
				E 4	Anhydrite + Dolomite+ clay
			Lakhasar	E 3	Halite (H1) + Polyhalite+ sylvite
				E 2	Anhydrite + dolomite
				E 1	Clay with Anhydrite
				E 0	Clay+marl+calcilutite gyp+LS
		----------Gradational Contact----------			
		Jodhpur	-	-	-

IV) **Nagaur Group**: The Nagaur Group is the youngest member of the Marwar Supergroup and has a gradational contact with the underlying HEG. in the northern parts of the basin. In the southern part of the basin the Group overlies the Bilara Group with gradational contact at most of the places. The Nagaur sandstone, comprising a sequence of brick red to red claystone, siltstone and sandstone often with blotches and bands of green clay varies in thickness from 50m to 290m.

Tertiary Sediments

The Nagaur Group rocks are overlain by the Tertiary sediments in parts of Southern & Western sector of Nagaur-Ganganagar basin. The contact is unconformable with the Nagaur Group of rocks. Tertiary sedimentation appears to have taken place along the sea arms extending from SW (Jaisalmer basin) through Pokaran to north of Ganganagar and limiting its eastern extent by the subsurface Dulmera High passing through Kanchian-Suratgarh-Harsinghpura-Lunkaransar-Dulmera and Lakhusar. The Sub surface stratigraphy inferred by Ghosh and Srivastava (1971) is given below:

Stratigraphic sequence of Tertiary in Nagaur-Ganganagar basin

Recent & Sub recent			Thickness (m)
---------- Unconformity ----------			
Teriatry	Jogira Fullers Earth (Eocene)	Shale, marl, fuller's earth, limestone, Forminiferal limestone & siltstones.	116-121m
	Marl Sandstone (Paleocene)	Ferruginous sandstone and glass sand with clay and siltstone; lignite with alternating sandstone and claystone beds.	200-210m
	Palana Shales (Palaeocene)	Variegated shales and clays, associated with carbonaceous c base-not shale; shaly lignite, silt & sandstone.	157m
---------- Unconformity ----------			
Nagaur Group			

Quaternary Sediments

Quaternary Sediments comprising aeolian sand (forming dunes) alluvial sand, clay, kankar, grit, gravel, calcareous sandstone, caliche, gypsite and reworked limestone fragments lie unconformably either over the Nagaur Group of rocks or over the Tertiary sediments varying in thickness from 0.00 to 373.00m in Nagaur-Ganganagar basin.

3.0.0 Structure

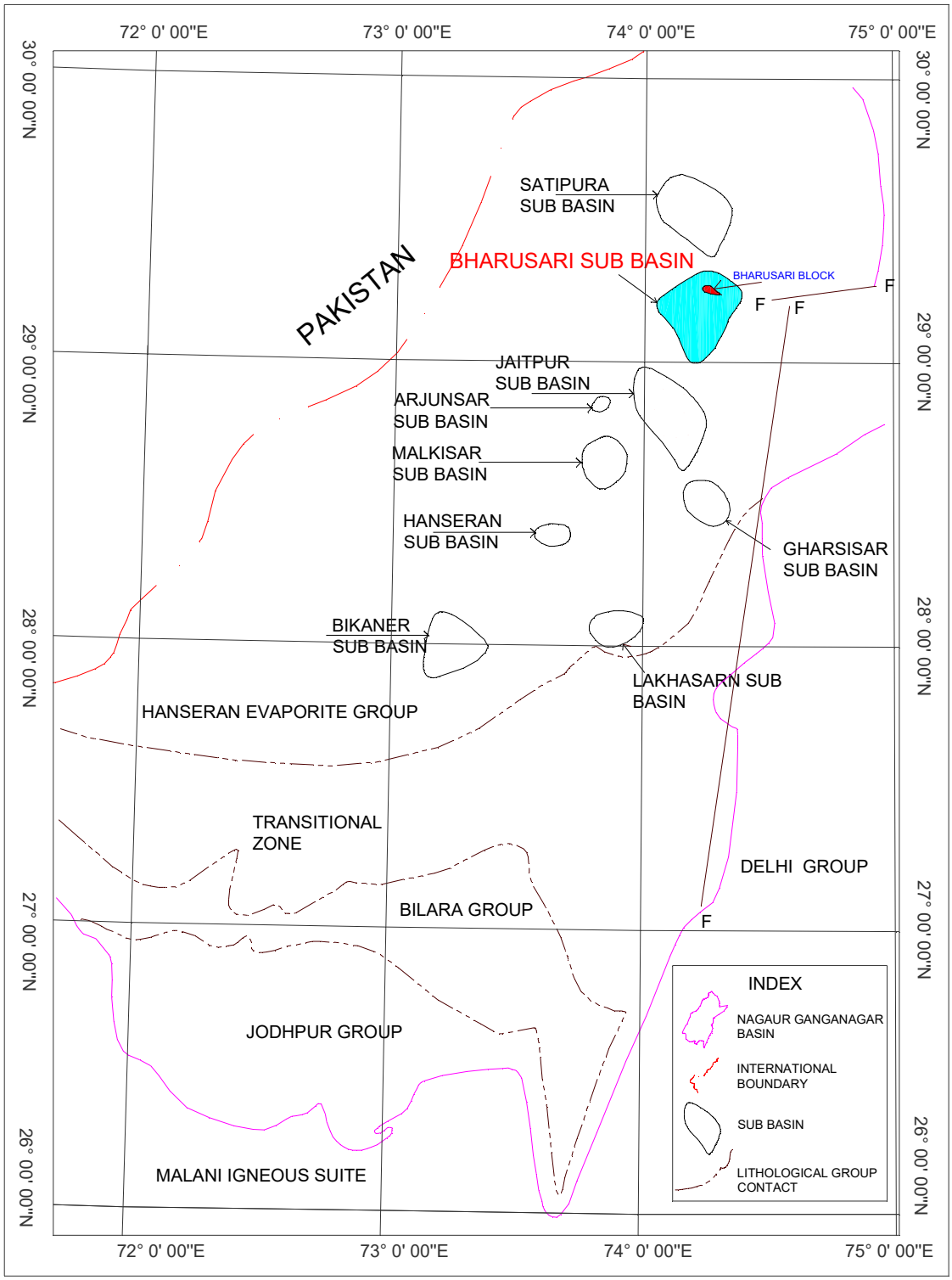
3.1.1 The Nagaur-Ganganagar basin, covering an area of 50,000 sq km is bounded by the Aravalli Range in the east, Lahore-Delhi sub-surface ridge in the north and north-east, Devikot-Nachana sub-surface high in the west and Jodhpur-Pokharan-Chotan-Malani ridge in the south. The basin appears to extend up to Sardarsahar- Bidasar fault in the east; The Sardarsahar fault trend N-S with steep dip towards west and downthrown also towards West and marks the Eastern limit of HEG. The basin appears to merge with the Indus basin in the Northwest. Jones (1970) considers the Nagaur-Ganganagar basin as south-eastern extension of the saline series of salt range of Pakistan (the exposed portion of Nagaur-Ganganagar basin in Pakistan constitutes the Salt Range.)

3.1.2 A number of vertical to sub-vertical faults (FIII to FVII) trending N-S, NE-SW and E-W with downthrow towards W, NW and S respectively has been inferred on the basis of drill data. Evaporite horizons in western part occur at relatively greater depths than in the east as a result of these step faults providing favourable condition for evaporite deposition resulting in increase in thickness of H.E.G. as well as halite together with number of halite cycles in the western and north-western parts of the basin. One E-W trending transverse faults (FVIII) between Lakhasar and Kalu with a down throw of 217m towards south has been inferred.

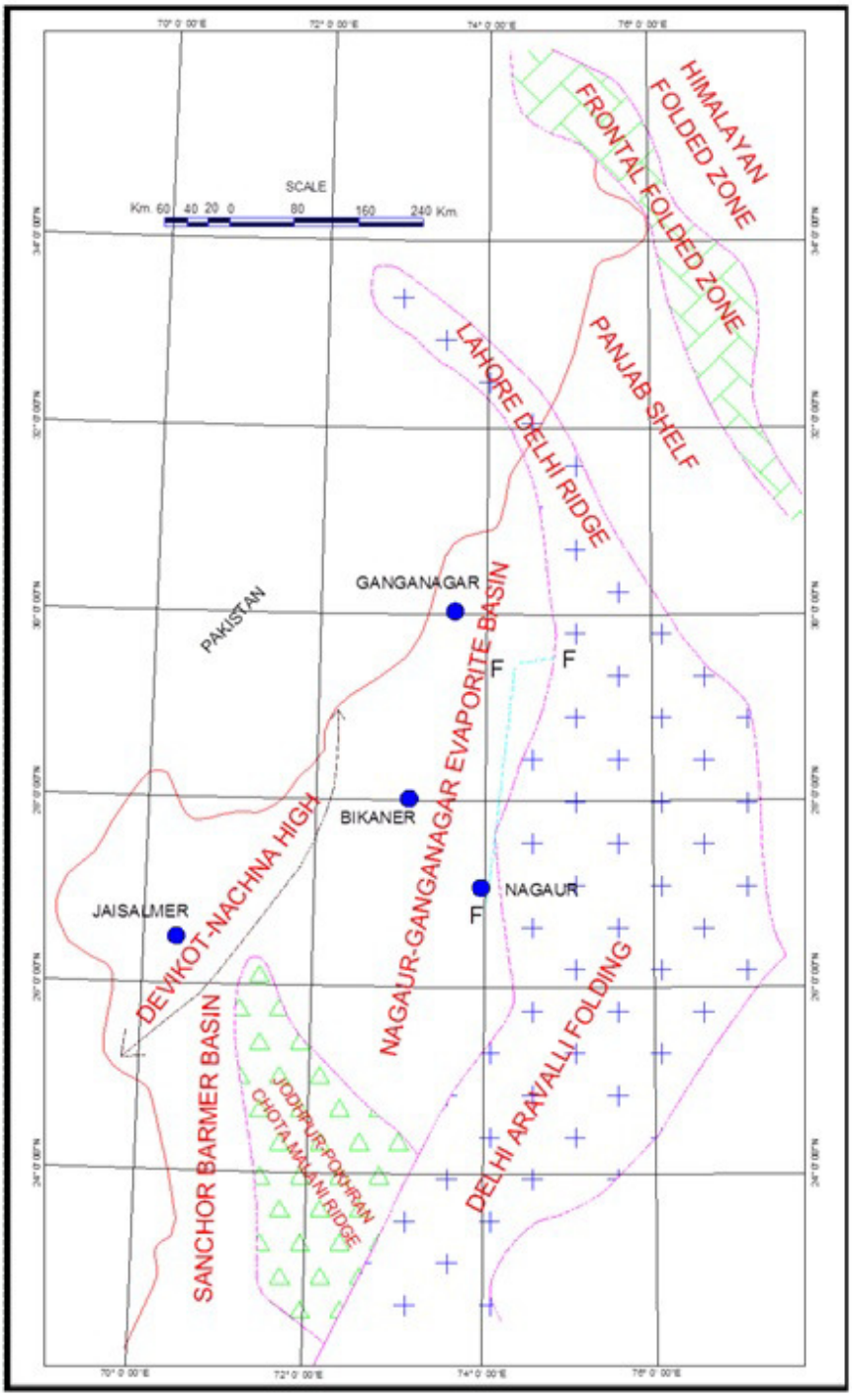
3.1.3 Structures observed in drill cores include bedding, lamination, flow structures, nodular anhydrite, stylolite sutures, breccia and algal structures. Bedding is

horizontal to sub horizontal with 3° to 5° rolling dips towards NW. Flow structures have an oblique relationship with the bedding/lamination due to salt flowage. Locally the halite beds show steep dip due to salt flowage. Presence of nodular anhydrite could indicate their formation in marginal sea environment under arid climate. Stylolite sutures are observed in anhydrite cores indicating solution activity under high pressure. Algal structures in the form of non-phosphatic stromatolites of Collonella Group have been recorded in the cores of dolomite and dolomitic anhydrite in various boreholes.

MAP SHOWING VARIOUS SUB BASINS WITHIN NAGAUR - GANGANAGAR BASIN (AFTER GSI) NORTH WESTERN PART OF RAJASTHAN



TECTONIC SETUP & GEOLOGICAL MAP OF NAGAUR-GANGANAGAR EVAPORATE BASIN (After GSI)



4.0.0 Mineralisation

4.1.0 The Hanseran Evaporite Group (HEG) comprises cyclic deposits of halite (most dominant constituent) alternating with anhydrite, clay-dolomite and magnesite. The most dominant constituent of Group is halite (NaCl) with minor polyhalite [K_2 Mg Ca_2 $(SO_4)_4$ $2H_2O$], sylvinite (KCl, NaCl), sylvite (KCl), langbeinite (K_2 SO_4 2 Mg SO_4) and carnallite (KCl, Mg Cl_2 $6H_2O$), in order of their abundance. A maximum of seven halite cycles, numbered as H1, H2-- H7 from bottom to top have been identified. The halite cycles are separated from one another by intervening zones comprising anhydrite, clay, dolomite and occasionally glauconite.

5.0.0 Proposed Exploration by MECL

5.1.0 Strategy

5.1.1 In the Bharusari Sub Basin, GSI has established 88.16 mt. probable and 300.15 mt. possible resources with an average grade of 4.68% K in 71.00 sq. km. area. During 2016-17 and 2017-18, MECL has completed Geophysical Exploration (Gravity and Magnetic Survey) covering an area of 1119 sq. km. in Bharusari Sub Basin and prepared synergetic gravity and magnetic map of the study area. The entire area has been categorized based on high or low residual gravity and magnetic anomalies. Nine different zones have been delineated based on the residual anomalies. Based on the above analysis, MECL executed G-3 stage exploration in the area of 14.17 sq. km where already drilled boreholes of GSI show potash mineralisation. On basis of encouraging result of Bharusari block, MECL further prepared a preliminary exploration proposal in the Bharusari North block to establish the continuity and resource of potash mineralisation in the area.

5.2.0 Objectives

The Preliminary Exploration (G-3) is proposed with the following Objectives:

i) To confirm the continuity and potentiality of potash bearing zones in the proposed area.

ii) To generate data for initial assessment of mineralogy of the potash zones and the K contents.

iii) To estimate resources of Potash zones as per UNFC system.

5.3.0 Methodology of Exploration

5.3.1 Survey: Co-ordinates of the cardinal points of Block Boundary, Coordinates & R.L. of the boreholes will only be determined by DGPS survey. Hence a total of 6 nos of cardinal point, 14 Nos of boreholes and one base station, i.e., total 21 Nos of points to be surveyed by DGPS.

5.3.2 Geological Mapping: Large scale geological mapping on 1: 10,000 scale will be carried out in the entire block by taking geological traverses and all the geological/structural features will be recorded if any. This map will be the Base map for future work.

5.3.3 Drilling: A total of 14 no. of boreholes are proposed at 800m X 800m grid in the unexplored area of the Bharusari sub basin. A total of 9800 m of drilling in 14 vertical boreholes have been proposed in the block. The location of proposed boreholes is given as Plate No- II and details with proposed depth & total meterage to be drilled is given in following table.

Details of Proposed Boreholes in Bharusari Sub Basin

Sr. No.	BH No.	Proposed depth in meter (m)	Sr. No.	BH No.	Proposed depth in meter (m)
1	PBH-01	700.00	8	PBH-08	700.00
2	PBH-02	700.00	9	PBH-09	700.00
3	PBH-03	700.00	10	PBH-10	700.00
4	PBH-04	700.00	11	PBH-11	700.00
5	PBH-05	700.00	12	PBH-12	700.00
6	PBH-06	700.00	13	PBH-13	700.00
7	PBH-07	700.00	14	PBH-14	700.00
				Total	**9800.00**

The location of these boreholes may change slightly subject to approachability 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.

5.3.4 Geophysical Studies.

As per the existing exploration practice, Dual Density, Neutron, Resistivity, spectral Gamma and caliper logging to be carried out in all the boreholes. Based on the geophysical interpretation, sampling of potash bearing zones shall be taken up.

5.3.5 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.

5.3.6 Sampling:

The primary samples will be drawn at the length interval of 0.50m in the potash bearing (Polyhalite & Potash) zones depending upon the variation in the potash characteristics and at 1.00m length interval in the non potash bearing Halite zones. Also, lithological units 3.00 m above and below the Halite cycle will be sampled at 1.00m to 2.00m 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 4000 no of Primary samples for 9 radicals. Thus 200 no (5% of primary samples) internal check samples and 400 no (10% of primary samples) external check samples will also be generated.

Composite samples shall be prepared at 2%, 3% and 5% K cut off after delineation of potash bearing zones. Thus 110 Nos of Composite samples are expected to be generated.

5.3.7 Laboratory Studies

Chemical Analysis:

a) All the Primary, composite and Internal & External Check samples [4710 no; = 4000 Primary & 200 Internal Check (5%), 400 External Check (10%) of Primary samples, 110 composite samples] will be analyzed for 9 radicals i.e. K, Na, Mg, Cl, Br, I, Li, $CaSO_4$ & Water insolubles.

X.R.D. Studies: X-ray Diffraction studies will be carried out on about 50 samples from 3% and 5% K cut off to identify the different mineral phases occurring in the mineralized zones.

Specific gravity determination: Specific Gravity will be determined on 20 nos. drill core specimen of halite and other rock types of Hanseran Evaporite Group.

Petrographic Study: 10 Nos of borehole core samples shall be subjected to petrographic study.

Geotechnical Study: Geotechnical study involves the study of physical and mechanical characteristics of the strata with a series of recommendations on technical advice necessary for the development of a mining project. This study helps to determine the pit slopes, dump slope & design and maximum depth permissible for open cast operation. For underground design, it is required to design the roof support and method of mining to be adopted.

The rock-mechanical layout and dimensioning of potash production caverns will have to be based on site-specific material parameters of the salt rock and overburden layers that are to be determined by laboratory tests on core material. The test program will have to assess the short-term strength and long-term creep behavior of the salt rock and the shear strength of interfaces between different rock layers.

The actual number of tests is defined by the variation in lithology of the geological sequence. 300 nos of Core samples from one representative borehole shall be subjected to the geotechnical study. It is recommended that test work and interpretation is done by an internationally acknowledge laboratory that has some track record in salt rock testing for cavern construction.

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

5.3.9 Quantum of work:

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

Quantum of work proposed for Potash Exploration in Bharusari North Block, Bharusari Sub Basin, District- Hanumangarh, Rajasthan.

Sl. No.	Item of work	Unit	Quantum
1.	Geological Mapping on 1:10,000 scale	Sq. Km.	10.00
2	DGPS survey of 14 Nos of BHs, 6 Nos of Cardinal Points & 1 Nos of Base Station	Nos	21
3.	Drilling: i) 14 boreholes on 800m X 800m Grid	m.	9800 m (14 BHs)
4.	Geophysical Studies		
	i) Borehole Geophysical Logging Dual Density, Resistivity, Spectral Gamma, Neutron & Caliper	m.	9800 m (14 BHs)
5.	**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.	4000
	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.		200
	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.	400
	iv. Composite Samples for 9 radicals i.e. K, Na, Mg, Cl, Br, I, Li, $CaSO_4$ & Water insolubles from External NABL Lab.	Nos	110
	iv. X-Ray Diffraction Studies	Nos.	50
6.	Petrographic Study	Nos	10
7.	Specific Gravity Determination	Nos.	20

Sl. No.	Item of work	Unit	Quantum
8.	Geotechnical Study (1 Borehole)	Nos	300
8.	Report Preparation (Digital Format)	Nos.	1

6.0.0 Manpower Deployment

6.0.1 Manpower deployment List may be provided later.

7.0.0 Time Schedule and Cost Estimates:

7.1.0 Time Schedule: The proposed exploration programme like drilling, Geology, Laboratory work including Camp setting & winding and Laboratory studies will be completed in 15 months time. Report writing will take additional 5 months including 2 months overlap with laboratory studies. Thus, the total time proposed for completion of work is **18 months**. The bar chart showing Action Plan/time schedule is given in Table-6.1.

7.2.0 Cost Estimate: Cost for 2020-21, 2021-22 and 2022-23 has been estimated based on rates of SOC of NMET dated 01.04.2020. However, the rates for consecutive financial years 2021-22 and 2022-23 will be estimated as per actual escalation based on RBI indices. The total estimated cost is **Rs 2329.71 Lakhs**. The details of cost estimates are given in Table 6.2 and summary is given below.

Summary of Cost Estimates

Sl. No.	Item	Estimated Cost INR (₹)
1	Exploratory Drilling	133,413,900
2	Geology & Survey	8,068,440
3	Geophysical Logging	5,160,400
4	Laboratory Studies	38,717,420
5	Geotechnical Study	9,683,100
	Sub total	**195,043,260**
6	Report	2,000,000
7	Peer Review	10,000
8	Proposal Prepration	380,000
	Total	**197,433,260**
9	GST (18%)	35,537,987
Total cost including 18% GST		**232,971,247**
SAY, in Lakhs		**2,329.71**

8.0.0 Justification:

8.1.1 In Bharusari Sub basin, Geological Survey of India has carried out preliminary exploration by drilling 10 nos. of boreholes at wider interval. GSI has estimated resources of the order of 388.31 million tonnes with grade 4.68% K and 17.17% Na, covering 71.0 Sq, km, area. Further, MECL has completed Geophysical Exploration (Gravity and Magnetic Survey) with covering an area of 1119 sq. km. in Bharusari Sub Basin and based on the finding of geophysical studies, 20 exploratory boreholes up to a depth of 700-750m have been recommended to test/validate the veracity of the

G-M survey interpretation in the area and the results of the boreholes would dictate the future exploration strategy.

8.1.2 In view of the above, drilling of 12 no boreholes with 8600m at 800m X 800m grid has been executed within 14.17 sq. km. in near vicinity of GSI drilled boreholes. The outcome of the exploration result is encouraging. The gross inferred resource of 12.839 m.t and net inferred resource of 10.272 m.t with average grade 5.58% K (6.75% K2O) and gross reconnaissance resource of 5.324 m.t and net reconnaissance resource of 4.259 m.t with average grade of 5.65% K (6.84% K2O) has been estimated at 5% K cut off in the block. Whereas the gross inferred resource of 49.738 m.t. and net inferred resource of 39.791 m.t. with average grade 4.28% K (5.18% K2O) and gross reconnaissance resource of 22.007 m.t and net reconnaissance resource of 17.606 m.t with average grade of 4.30% K (5.20% K2O) has been estimated at 3% K cut off in the block. Similarly gross inferred resource of 138.965 m.t. and net inferred resource of 111.172 m.t with average grade 3.06% K (3.70% K2O) and gross reconnaissance resource of 64.609 m.t. and net reconnaissance resource as 51.688 m.t with average grade of 3.04% K (3.68% K2O) has been estimated at 2% K cut off.

8.1.3 The distribution of Resource in Plan reveals that the potash bearing zones are continuous in North, South and Eastern direction. As a result, the Bharusari North Block is the potential area for further establishment of potash resource.

8.1.4 Out of a total sub-basin area of 2,470.51 sq. km, within the Nagaur-Ganganagar basin, only 6.63% of the total area i.e., 164 sq. km area has been explored till date. The remaining unexplored area within the eight sub-basins aggregates to ~2,300 sq. km. This is ~93% of the total sub-basin area. It may be noted that this area was demarcated by GSI based on 2% K isochore boundary (1974-1991).

8.1.5 Polyhalite potash mineral is not water soluble, and with the present technology can only be mined by conventional underground Mining method. Whereas the mineable soluble Potash i.e., Sylvite/Sylvinite zones are also found. The current exploration practice does not involve separate delineation of these bands. Thus, these bands have to be separately delineated into specific Sylvite/Sylvinite zones. The availability of such data is for planning a solution mining operation as these bands have to be separately delineated during exploration to establish their continuity and disposition for planning any mining activity.