

Prefeasibility Report for

Expansion of onshore oil and gas production from existing 300,000 barrels of oil per day (bopd) to 400,000 bopd and 165 Million Standard Cubic Feet per Day (MMSCFD) to 750 MMSCFD from RJ-ON-90/1 Block, Barmer, Rajasthan

Prepared & Submitted
by:



Cairn Oil and Gas
Vedanta Limited
DLF Atria, Phase 2, Jacaranda Marg
DLF City Gurgaon - 122002 (Haryana)

January - 2018

Contents

1. Executive Summary	2
2. Introduction of the Project	5
3. Project Description	5
3.1 Location of the Block	6
3.2 Need of Project	6
3.3 Demand and Supply	7
3.4 Importance of Project	8
3.5 Employment Generation	8
4. Brief description of the proposed Project	8
4.1 Upstream Development:	9
4.2 Midstream Development:	10
5. Resource usage and waste generation	11
6. Site and Project Analysis	12
6.1 Environmental Setting	12
6.1.1 Land Use and Land Cover	12
6.1.2 Climate and Meteorology	13
6.1.3 Hydrology	13
6.1.4 Soil Classification	13
6.2.1 Demography	14
6.2.2 Existing Infrastructure	14
6.2.3 Education Facilities	14
6.2.4 Health Care Facilities	15
6.2.5 Veterinary Facilities	15
6.2.6 Road Connectivity and Communication Facilities	15
6.2.7 Electrification	15
6.2.8 Drinking water	15
6.2.9 Other Facilities	16
7. Rehabilitation and Resettlement (R&R) Plan	16
8. Project Inter linkage and EC approval obtained details	16
9. Project Schedule and Cost	17
10. Analysis of Proposal (Final Recommendations)	18

1. Executive Summary

Introduction

The Rajasthan Joint Venture (RJ JV) comprising of Vedanta Limited and Oil and Natural Gas Corporation (ONGC) Limited, is involved in hydrocarbon exploration and production activities in Block RJ-ON-90/1. Cairn Oil and Gas division (Part of Vedanta Group) is the operator of the Block. The Block RJ-ON-90/1 is an onshore pre-New Exploration License Period (NELP) block and is located in Barmer and Jalore Districts of Rajasthan spread over an area of 3,111km². The production from the Block is currently contributing to more than 22 per cent of India's domestic crude oil production.

Vedanta Ltd. has drilled around 180 exploratory and appraisal wells and has made 38 hydrocarbon discoveries in the Block, with the Mangala discovery termed as the largest on-land hydrocarbon discovery in India. The other major discoveries in the block are the Bhagyam field and Aishwariya field, both located in the vicinity of the Mangala field. The current estimate of the resource base in Rajasthan provides a basis for Vedanta Ltd.'s vision to produce up to 400,000 barrels of oil per day (BOPD) from the Block and up to 750 million standard cubic feet per day (MMSCFD) of gas, subject to regulatory and other approvals. It is expected that the number of discoveries would further increase as the Government of India (GoI) has accorded permission to continue further exploration in the Block. The development will require augmentation of existing terminals with associated facilities, development of new well pads and construction of additional inter- field pipelines.

Need of the Project

India's crude oil reserve is estimated to be around 1,241 billion cubic meters (bcm) and presently produces about 858,000 bopd. India's oil consumption is about 3,473,000 bopd, the 5th largest consumer in the world. Thus a demand deficit in excess of 75% exists, which is met by imports. Cairn currently produces approximately 20% of current indigenous production. With the proposed expansion of the production facilities, the share of the contribution from the Rajasthan block to the nation will be further strengthened. The Rajasthan JV has invested over 6.5 billion USD till March 2017 and further investments around 2 billion USD are planned in next seven years period. Additionally, the increase in crude oil and gas plant capacity and flow through pipelines from Barmer to Bhogat with evacuation of additional natural gas through new pipeline and with intermediate booster stations will help Vedanta in reaching higher sales volume of natural gas. On a broader scale, this proposed project will help the Indian Government in addressing its energy security needs. So the project is important from the company and national perspective.

Project Location

The RJ-ON-90/1 Block covers an area of 3,111 km² and is located largely in the Barmer District (94%) with minor portion falling in the adjoining Jalore District (6%). The Block is linked by road with Jaisalmer, Jodhpur, Pali, Jalore, Jaipur, Ajmer and Ahmedabad.

Project Description

Till date about 38 hydrocarbon discoveries has been identified in the Block, of which twelve (12) discoveries have been developed or are being developed. There are two terminals processing the hydrocarbons within the block. Environmental Clearance (EC) has been obtained to produce up to 300,000 BOPD and 165 MMSCFD of gas from the Block.

At present the Raageshwari Gas Terminal (RGT) is designed to produce up to 55 MMSCFD of natural gas. The produced natural gas is used for captive power generation, internal usage within operating of gas engines at various above ground installations and export of the excess gas to Gujarat State Petronet Ltd. (GSPL) grid in Gujarat. The expansion of RGT plant is already underway to produce additional 45 MMSCFD of natural gas (i.e., total 100 MMSCFD) for which the Environmental Clearance (EC) has already been obtained. Condensate will be generated as part of the gas processing. At present the condensate is sent to Mangala Processing Terminal (MPT) through pipeline for processing along with Crude Oil, also provision has been provided to spike stabilized condensate in to export oil pipeline. Raageshwari Gas Terminal (RGT) has a dedicated 12" gas trunk line and supplies Raageshwari gas to the MPT to meet energy demands. A 4" condensate line is also laid connecting the RGT to MPT. Raageshwari deep gas (RDG) is the main source of natural gas for the Barmer-Bhogat crude oil pipeline system fuel requirements.

Gas facilities augmentation

The gas production augmentation is being planned to produce from existing 165 MMSCFD to 750 MMSCFD. The proposed projects will cover the following activities:

- Augmentation of Raageshwari Gas Terminal (RGT) from existing 100 MMSCFD to 400 MMSCFD with condensate processing of 70,000 barrels per day.
- Development of satellite gas fields (standalone well pads) to produce and process up to 100 MMSCFD.
- Handling of associated gas from RJ oil fields from existing 65 MMSCFD to 250 MMSCFD.
- Setting up of CNG and LPG fuel filling stations up to fifty (50) no's in and around Rajasthan.

Oil Terminal and associated facilities augmentation:

Mangala Processing Terminal (MPT) is producing on average around 175,000 BoPD. The expansion of MPT plant is already underway to produce additional 125,000 BoPD (i.e., total 300,000 BoPD) for which the Environmental Clearance has already been obtained. The proposed projects will cover the following activities:

- Oil production augmentation from RJ oil fields 300,000 BOPD to 400,000 BOPD
- Additional processing train from 1.02 Million barrels of fluid per day (BFPD) to 1.60 Million BFPD to handle increased water cut.
- Setting up of additional 30 no's of quick processing facilities to handle well fluids at various fields.

- Alkaline – Surfactant – Polymer (ASP) flooding across various fields within RJ Block.
- Produced Water treatment facility capacity augmentation to treat up to 1.55 Million Barrels of Water per Day (BWPD) along with disposal facilities for 0.2 Million BWPD of effluent and solid waste.
- Enclosed ground flare systems at different well pads.
- Additional 25,000 KLD deep saline ground water abstraction.

Pipeline Development:

Cairn has developed Mangala Development Pipeline (hereafter referred to as MDP), running approximately 700 km through Rajasthan and Gujarat, to evacuate crude oil and natural gas produced from the block. The proposed projects will cover the following facilities:

- Laying of new 30 inch natural gas pipeline of 700 km in the existing right of use (ROU) from Barmer to Bhogat to evacuate up to 500 MMSCFD.
- Laying of new 10 inches pipeline of 100 km from Raageshwari Gas Terminal (RGT) to Mangala Processing terminal (MPT) to evacuate condensate
- Laying of new 10 inches pipeline of 10 km from Raageshwari Gas Terminal (RGT) to (Above Ground Installation) AGI – 5 for stabilized condensate transportation.
- Laying of new 12 inches pipeline at various locations to connect proposed crude from satellite fields to export pipeline.
- Laying of new 12 “pipelines at various locations to connect processed gas from satellite fields to existing and new main gas pipelines.

Environmental and Social Setting

The region is characterized by arid and semi-arid zones, with vast areas of sand covered tracts. The general topography of the area is plain with undulating terrains and sand dunes of varied heights and lengths. The area comprises of scanty xerophyte vegetative cover. No archeologically important monuments or ecologically sensitive zones are located within the Block. The Block area is mainly rural and sparsely populated with scattered habitations.

Rehabilitation and Resettlement

Additional land of around 150 ha would be required to set up the terminal and related expansions in Barmer district and around 30 ha would be required in pipeline project at various locations in Gujarat. Considering the sparsely settled population in Barmer district, land would be acquired ensuring that there is no rehabilitation and resettlement.

Project Schedule and Cost

The total project cost would be INR 12,000 Crores, which includes around INR 8,000 Crores for upstream and INR 4,000 Crores for pipeline development. This project will be implemented in phased manner up to seven (07) years period.

2. Introduction of the Project

Cairn India Limited had merged with Vedanta Limited, effective 11th April 2017. Cairn Oil and Gas is a division, which is now part of the Vedanta Group, is a globally diversified natural resources group with wide ranging interests in aluminum, copper, zinc, lead, silver & iron ore.

The Rajasthan Joint Venture comprising of Vedanta Limited and Oil and Natural Gas Corporation (ONGC) Limited, is involved in hydrocarbon exploration and production activities in Block RJ-ON-90/1. Cairn Oil and Gas division (Part of Vedanta Group) is the operator of the Block. RJ-ON-90/1 is an onshore pre-New Exploration License Period (NELP) block and is located in Barmer and Jalore Districts of Rajasthan. The production from the Block is currently contributing around 22 percent of India's domestic crude oil production.

3. Project Description

The RJ-ON-90/1 Block covers an area of 3,111 km². Vedanta Ltd. has drilled around 180 exploratory and appraisal wells and has made 38 hydrocarbon discoveries in the Block, with the Mangala discovery termed as the largest on-land hydrocarbon discovery in India. The other major discoveries in the block are the Bhagyam field and Aishwariya field, both located in the vicinity of the Mangala field. A comprehensive review of the resource potential in the Block has been carried out through the application of innovative technologies and advanced geo-scientific tools. In addition, DeGolyer and MacNaughton have conducted an independent estimate of reserves and contingent resources. The details of estimates are as follows:

- The potential resource of the Block is estimated to be 6.2 billion barrels of oil equivalent (boe) in place
- The Fatehgarh Formation in the main fields Mangala, Bhagyam and Aishwariya (MBA) hold 2.2 billion boe in-place, out of which the proved and probable recoverable resources base has been estimated to be 410 million boe. MBA fields already produced 405 million boe.
- The other 35 discoveries (including the Barmer Hill Formation) are estimated to hold approximately 4 billion boe in-place, out of which the gross recoverable resource is estimated to be 750 million boe. Some of these fields have already produced oil and gas of about 12 million boe.
- The block also has undiscovered un-risked prospective resource potential of around 2 billion boe.

The current estimate of the resource base provides a basis for Vedanta Ltd.'s vision to produce up to 400,000 bopd from the Block and up to 750 MMSCFD of gas, subject to regulatory and other approvals. It is expected that the number of discoveries would further increase as the Government of India (GoI) has accorded permission to continue further exploration in the Block. The development will require augmentation of existing terminals

with associated facilities, development of new well pads and construction of additional inter- field pipelines.

3.1 Location of the Block

The Block is located largely in the Barmer District (94%) of Rajasthan with minor portion falling in the adjoining Jalore District (6%) of Rajasthan. The Block is linked by road with Jaisalmer, Jodhpur, Pali, Jalore, Jaipur, Ajmer and Ahmedabad. Major roads within the block include NH-15, NH-112, SH-16 and SH-28. The study area is connected to Jodhpur, Jaipur and Delhi through rail linkages. The location of the block is depicted below in **Figure 1**.

Figure 1: Indicative Location Map of the Block



3.2 Need of Project

India’s crude oil reserve is estimated to be around 1,241 billion cubic meters (bcm) and presently produces about 858,000 bopd. India’s oil consumption is about 3,473,000 bopd, the fifth largest consumer in the world. Thus a demand deficit in excess of 75% exists, which is met by imports. According to the Approach Paper on the 12th five year plan (2012-17), the gap between crude oil requirement and domestic production is expected to widen further over the next five years; this is observed as a result of India’s projected increasing GDP growth rate.

The vital importance of increasing indigenous crude and natural gas production cannot be understated. Vedanta currently produces approximately 22% of current indigenous production from Rajasthan Block. With the proposed expansion of the production facilities, the share of the contribution from the Rajasthan block to the nation will be further strengthened.

The Rajasthan JV has invested over 6.5 billion USD till March 2017 and further investments around 2 billion USD are planned in next seven years period. The natural gas production

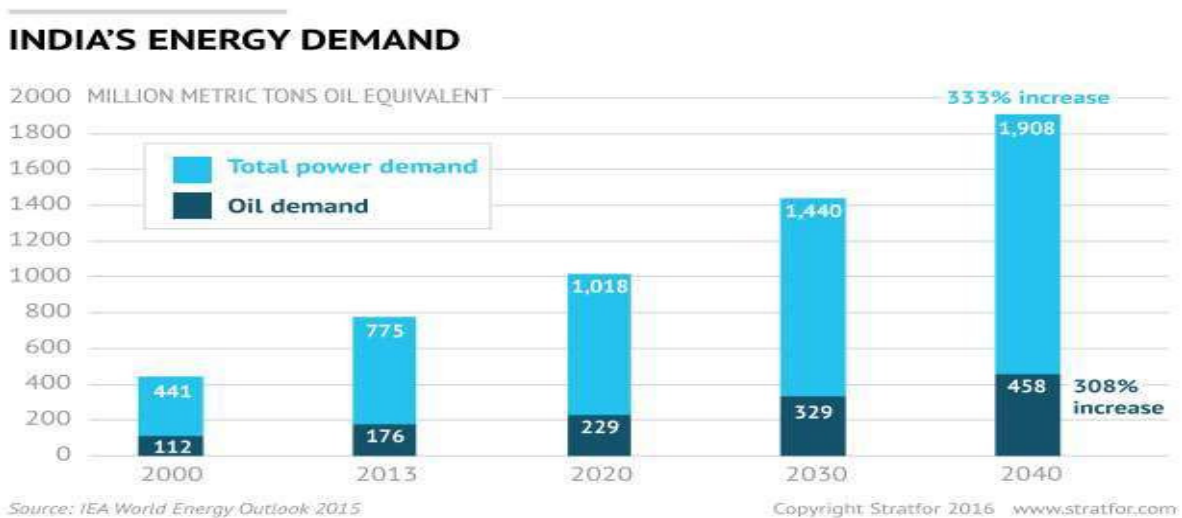
from the Rajasthan block is yielding significant revenue to the Central Government and the Government of Rajasthan and will continue to do so throughout the field life.

3.3 Demand and Supply

India has 0.5% of world’s proven oil reserves; however it comprises of more than 15% of the world’s population. India has 1,241 billion cubic meters (bcm) of proven and indicated reserves, which is 0.6% of the world’s total proven gas reserves. At the existing production levels of 50.9 bcm per year, the country has a Gas Reserves-to-Production ratio of ~ 26.9 years.

As a result, the volume of crude oil imports has been increasing steadily in India reaching more than 75% of its total crude requirement. As per forecast made by the Working group on energy sector for the 12th Plan, the country requires energy supply to grow at Compound Annual Growth Rate (CAGR) of 6.5% to maintain the growth rate of 9% over the next five years.

Figure 2: Oil and Gas Consumption Scenario- India



India is highly dependent on imports for both crude oil and natural gas and with increasing demand and reducing domestic supplies, this dependence is expected to increase further. It is projected that the oil and gas (O&G) requirement by the terminal year of the 12th Plan would be 204.80 million tonnes of oil equivalent (mtoe) and 87.22 mtoe respectively. This demand for O&G would be fulfilled by import of 164.8 mtoe (80.5%) crude oil and 24.8 mtoe (28.4%) natural gas in 2016-17. The Ministry of Petroleum and Natural Gas (MoPNG) estimated that the share of natural gas in India’s energy basket is likely to reach 20% by the year 2025. The increased consumption of natural gas is expected to be met both by increased domestic production and import of natural gas.

Currently, ~76% of the crude oil and ~21% of the natural gas is imported. The challenge for India is to secure a sustainable and reliable supply of crude oil. Thus a “No project scenario” is undesirable and shall not be in the greater interest of the nation.

3.4 Importance of Project

The increase in hydrocarbon plant capacity and flow through pipelines from Barmer, Rajasthan to Bhogat, Gujarat with evacuation of additional natural gas through new pipeline will help Vedanta in higher sales volume of natural gas. On a broader scale, this proposed project will help the Indian Government in addressing its energy security needs. So the project is important from the company and national perspective. The project will engage local contractors during construction stage thereby providing immediate livelihood to a local people and also providing significant long term employment opportunities during operations for few thousands of people directly and indirectly. However, Vedanta will continue to focus on community development programs in the existing development area as part of its corporate responsibility

3.5 Employment Generation

The livelihood pattern has already changed with the increase of job opportunities in Barmer, Rajasthan in terms of contract and labor work. Due to this, the labor rates have also increased thus, bringing about a decrease in the outflow of migrants from the region and in retaining the population in the area. In addition to this existing scenario, with this new project to start, there will be huge increase in laborious work during construction and commissioning phase. This phase will exist up to seven years period, thereafter directly and indirectly additionally around two thousand (~2000) people would be employed.

4. Brief description of the proposed Project

Till date about 38 hydrocarbon discoveries has been identified in the Block, of which 12 discoveries have been developed or are being developed. Refer **Annexure – 1** for details. There are two terminals processing the hydro carbons within the block. Environmental Clearance (EC) has been obtained to produce up to 300,000 BOPD in Mangala Processing Terminal (MPT) and 165 MMSCFD of gas.

MPT is located near Nagana village in Barmer Tehsil and District and RGT is located near Dhandalwas Village in Gudamalani Tehsil of Barmer District. Both the terminals receive well fluids from various well pads located within the Block. The Mangala, Bhagyam and Aishwariya well pads are currently connected through in-field pipelines to the Mangala Processing Terminal (MPT). The gas well pads are connected through in-field pipelines to the Raageshwari Gas Terminal (RGT). The well pads of Saraswati, Raageshwari, NI, NE and Guda are presently stand- alone satellite fields, from which processed crude oil is trucked through road tankers to the MPT.

Raageshwari Deep Gas is a tight, lean gas condensate reservoir, with excellent gas quality of approximately 80% methane, low CO₂ and no H₂S. Wells have tested at gas production rates in the range 2 to 4 mmscf and producing condensate gas ratios in 40 to 50 bbl/mmscf range. Raageshwari Gas Terminal (RGT) is under operation and a dedicated 12" gas trunk line supplies Raageshwari gas to MPT to meet energy demands. A 4" condensate line is also laid connecting the RGT to the MPT. Raageshwari deep gas is

also the main source of natural gas for the Barmer-Bhogat crude oil pipeline system fuel requirements.

Figure 3: RJ-ON-90/1 Block map location



4.1 Upstream Development:

Gas Terminal and associated facilities augmentation:

Raageshwari Deep Gas (RDG) is a tight, lean gas condensate reservoir, with excellent gas quality of approximately 80% methane, low CO₂ and no H₂S. At present the Raageshwari Gas Terminal (RGT) is designed to produce up to 55 MMSCFD of natural gas. The produced natural gas is used for captive power generation, internal usage within operating of gas engines at various above ground installations and export of the gas to GSPL grid in Gujarat. The expansion of RGT plant is already underway to produce additional 45 MMSCFD of natural gas (i.e., total 100 MMSCFD) for which the Environmental Clearance has already been obtained. At present the condensate is sent to Mangala Processing Terminal (MPT) through pipeline for processing along with Crude Oil, also provision has been provided to spike stabilized condensate in to export oil pipeline.

The gas production augmentation is being planned to produce from existing 165 MMSCFD to 750 MMSCFD. The proposed projects will cover the following activities:

- Augmentation of Raageshwari Gas Terminal (RGT) from existing 100 MMSCFD to 400 MMSCFD with condensate processing of 70,000 barrels per day.
- Development of satellite gas fields (standalone well pads) to produce and process up to 100 MMSCFD.
- Handling of associated gas from RJ oil fields from existing 65 MMSCFD to 250 MMSCFD.
- Setting up of CNG and LPG fuel filling stations up to fifty (50) no's in and around Rajasthan.

Oil Terminal and associated facilities augmentation:

Mangala Processing Terminal (MPT) is producing on average around 175,000 BoPD.

The expansion of MPT plant is already underway to produce additional 125,000 BoPD (i.e., total 300,000 BoPD) for which the Environmental Clearance has already been obtained. The augmentation and new projects will cover the following facilities:

- Oil production augmentation from RJ oil fields 300,000 BOPD to 400,000 BOPD
- Additional processing train from 1.02 Million barrels of fluid per day (BFPD) to 1.6 Million BFPD to handle increased water cut.
- Setting up of total thirty (30) numbers of quick processing facilities (three phase separation) of the well fluids at various fields such as Mangala, Bhagyam and Aishwariya. The separated produced water will be injected back to the reservoir of that field. The associated gas will be used for captive power generation within the field or otherwise sent to MPT or RGT. The separated crude oil will be sent to MPT for further processing & export or direct export to the refineries through trucks.
- ASP (Alkaline – 4000 MT per day; Surfactant – 600 MT per day and Polymer – 600 MT per day) flooding across various fields within RJ Block. Permission to manage, store and handle hazardous ASP chemicals as per the MISHC and applicable Rules.
- Produced Water treatment facility capacity augmentation to treat up to 1.55 Million Barrels of Water per Day (BWPD) along with disposal facilities for 0.2 Million BWPD of effluent and solid waste. The effluent after treatment will be disposed in deep dump well.
- Enclosed ground flare system at well pads.
- Additional 25,000 KLD deep saline ground water abstraction (i.e., total 93,500 KLD abstraction), considering already CGWA abstraction permission obtained for 53,500 KLD and CGWA application under consideration for 15,000 KLD).
- Setting up waste/slope oil processing facility up to 10,000 barrels per day.
- Setting up waste 100 TPD (ton per day) to energy based facility to process oily sludge (including tank bottom sludge, oily media filters etc.,) using appropriate technology.

4.2 Midstream Development:

Vedanta Ltd. has developed Mangala Development Pipeline (hereafter referred to as MDP), running approximately 700 km through Rajasthan and Gujarat, to evacuate crude oil and natural gas produced from the block. The crude oil is sold to refineries of Essar Oil and Reliance Industries Limited at Jamnagar, Gujarat and Indian Oil Corporation Limited at Radhanpur and Viramgam, Gujarat. Through marine export facilities periodically crude oil is also exported to Mangalore Refinery and other refineries in coastal region through the sea route from already installed single point mooring (SPM) and Bhogat Terminal. Natural gas up to 35 MMSCFD can be sold through GSPL network in Gujarat.

The additional natural gas being planned to produce from existing 100 MMSCFD to 400 MMSCFD will be evacuated to the distributors in Gujarat through laying of new 30 inches gas pipeline. However the new 30 inches gas pipeline will be laid to evacuate natural gas of quantity up to 500 MMSCFD through installation of additional booster compressors.

The gas evacuation projects will cover the following facilities:

- Laying of new 30 inches natural gas pipeline of 700 km from Barmer to Bhogat to evacuate capacity up to 500 MMSCFD of natural gas
- Laying of new 10 inches gas pipeline of 100 km from RDG to MPT to evacuate condensate
- Laying of new 10 inches gas pipeline of 100 km from RDG to AGI – 5 for stabilized condensate transportation
- Laying of new 12 inches pipeline at various locations to connect processed crude from satellite fields to main export pipeline.
- Laying of new 12 inches pipeline at various locations to connect processed gas from satellite fields to main gas pipelines

5. Resource usage and waste generation

Land Acquisition:

Additional land of around 150 hectares (ha) would be required to set up the terminal & related expansions and new satellite well pads in Barmer district. Considering the sparsely settled population in Barmer district, land would be acquired ensuring that there is no rehabilitation and resettlement. Any further expansion would be set up in already requested land for acquisition as per the previous Environmental Clearances.

For development of the midstream operations around 30 ha of land would be required start from Raageshwari to Bhogat location. Preferably the land would be acquired adjacent to the existing Above Ground Installations (AGIs), an additional land of maximum 1 ha would be required at each of these AGI locations. The land would be acquired ensuring that there is no rehabilitation and resettlement.

Raw materials required:

There are no raw materials involved in the production of crude oil and natural gas. Naturally occurring hydrocarbons will be pumped from the reservoir. The well fluid, comprises of condensate, natural gas and produced water will be separated (primarily physical separation) in to individual components and utilized. However the required chemicals would be used towards processing the crude oil and natural gas such as biocide, ASP (Alkali-Surfactant-Polymer), Mono- ethylene Glycol (MEG), Tri-ethylene Glycol (TEG), oxygen scavenger, scale inhibitor, de-emulsifiers, coagulants, biocide etc.

Water requirement:

Additional water required for upstream will be around 25,000 KLD and pipeline operation will be around 100 KLD. The ground water shall be abstracted only after obtaining necessary permissions from Central Ground Water Authority (CGWA) and only in remote locations, where water consumption is ~ 10 KLD will be sourced locally through approved authorities.

Power requirement:

Additional captive power required for the proposed expansion will be 200 MW using the natural and associated gas. In addition grid power will be drawn from the state electricity board, and only emergency power will be generated from diesel generators.

Waste management

Segregated waste shall be stored in the designated area protected from weather. All recyclable hazardous (such as used/waste oil, barrels etc.) and non-hazardous waste (metals & non-metals) shall be sold to the authorized recyclers. Non-recyclable hazardous waste, which has a value of “Alternate fuel and or raw material”, shall be disposed to the cement industries towards co-processing. Any non-recyclable hazardous & non-hazardous material, which is not suitable for co-processing, will be disposed in the secured landfill.

Waste oil recycling

Waste/slope oil processing facility up to 10,000 barrels per day capacity is proposed to be set up. The processed oil will be co-mingled with the crude oil. New waste to energy based facility of capacity 100 TPD (ton per day) is proposed to be set up to process oily sludge (including tank bottom sludge, oily media filters etc.,) using appropriate technology such as plasma gasification technology.

6. Site and Project Analysis

The block comprises of small scale and cottage industries using gypsum and lime as raw material. The nearest industrial area is Balotra, at about 100 km from MPT and 50 km from the Block boundary. Barmer District has rich reserves of lignite managed by the Rajasthan State Mines and Minerals Limited (RSMML). There are two operational thermal power plants near the Block; operated by Raj West Power Limited (RWPL) and Rajasthan Rajya Vidyut Utpadan Nigam Ltd. (RRVUNL) of capacity 1080 MW and 150 MW respectively. The power plants are located at a distance of 3 km and 7 km towards West and Northwest of the Block. The power plant of RWPL uses lignite as fuel, sourced from two captive lignite mines at nearby villages of Kapurdi and Jalipa. The region is characterized by arid and semi-arid zones, with vast areas of sand covered tracts. The general topography of the area is plain with undulating terrains and sand dunes of varied heights and lengths. The area comprises of scanty xerophytic vegetative cover. In the Block, there is no archeologically monuments or ecologically sensitive zones present. The Block is sparsely populated with scattered habitations.

6.1 Environmental Setting

6.1.1 Land Use and Land Cover

In reference to the EIA carried out in the year 2014 and referring to the satellite image processing, the result of land use analysis is provided below in **Table 1**.

Table 1: Land Use Classification of the Study Area

Land Use	Study Area in sq.km	Study Area in % coverage
Dense Vegetation	137.8	4.5
Agriculture Land	1056.4	33.9
Fallow Land	1479.8	47.5

Land Use	Study Area in sq.km	Study Area in % coverage
Sand Dunes	365.9	11.7
Settlements	39.3	1.3
River	34.2	1.0
Total Land Area	3113.4	100.0

A total of 47.5% of the study area is covered under fallow land while agriculture land covers about 34%. Human habitation however, is relatively lower in the study area with barely 1.3% of land being used for settlements. The only river in southern part of the block is Luni River. There is no eco sensitive or designated biodiversity located within the block area.

6.1.2 Climate and Meteorology

The Block experiences hot and arid climate typical of desert region. The predominant wind direction is from west and southwest during the months of April to August and from north and northeast during the months of September to March. The annual average wind speed was observed to be 7.4 kmph and 7.8 kmph in Barmer and Jalore Districts respectively. As per long term trends, the total annual precipitation of Barmer and Jalore Districts is 260mm/year and 412.5mm/year respectively.

6.1.3 Hydrology

There are no perennial watercourses in the Block. However there are few seasonal rivers and streams and several ephemeral tanks. The Block falls in the catchment of Luni River Basin and has a regional slope in NE-SW direction.

6.1.4 Soil Classification

In reference to the EIA carried out in the year 2014, the physical and chemical concentrations of the soil samples were determined and compared with the standard soil classification provided by the Indian Council of Agricultural Research (ICAR) and as given below in Table 2.

Table 2: Standard Soil Classification

Soil Parameters	Classification	
pH (northern field: 8.6-9.3 & Southern field: 8.3-9.6)	Normal to saline	6.0 to 8.5
	Tending to become alkaline	8.5-9.0
	Alkaline	Above 9.0
Electrical conductivity (mmhos/cm) (northern field: 0.08 - 13.3 mmhos/cm & Southern field: 0.07 - 8.78 mmhos/cm)	Up to 1.00 – Normal	
	1.01- 2.00- Critical to germination	
	2.01-4.00- Critical for growth of the sensitive crops	
	Above 4.00 – Injurious to most crops	

Soil Parameters	Classification	
Organic Carbon (northern field: 0.06-0.72% & Southern field: 0.06-0.53%)	Low Below	0.5 %
	Medium	0.5 to 0.75 %
	High Above	0.75 %

6.2 Socio economic settings of the study area

The potential socio economic impacts envisaged in the study area due to the setting up of this expansion projects are mainly Loss of land and livelihood and Issues pertaining to the compensation (due to acquire of the land). Thus the proposed management / mitigation measures that would be adopted are detailed below

- Any required land (site) will be selected after considering options to avoid agricultural land with preference for any fallow land in the vicinity;
- Shortest possible distance between identified site and road head will be considered for developing new access road;
- Consultations will be carried out with land owners for finalizing compensation packages;
- Information disclosure will be done to community and individual land owners about the project activities;
- Adequate compensation for any standing crops and loss of income for the lease period shall be provided

This project does not envisage any rehabilitation and resettlement of the project affected persons, since the parcel of land would be required less. Terminals are set up mainly in fallow land or sand dune areas where there is no human settlement available.

6.2.1 Demography

According to the 2011 Census, the total population of Barmer District is 2,604,453 of which male and female population constitutes 52.6% (1,370,494) and 47.3% (1,233,959) of the total population respectively. Jalore District's total population is 1,830,151 in 2011, of which male and female population comprises 51.2% (937,918) and 48.7% (892,233) respectively.

6.2.2 Existing Infrastructure

Availability or non-availability of social infrastructure amenities and facilities indicates the development pattern of the area and the well-being and quality of life of the population. The particulars of the existing public amenities in both Barmer and Jalore Districts have been mentioned in this sub-section.

6.2.3 Education Facilities

According to the District Elementary Education (Provisional) Report Card 2011-12, Barmer & Jalore Districts have a total of 5789 and 2928 schools respectively. In 2007-08, there were 4 colleges catering to the arts, science & commerce streams in Barmer District. In addition, there was one (01) college pertaining to professional education and four (04) for

imparting vocational education/ Industrial Training Institute (ITI) courses. In Jalore District, there were 5 colleges and 2 technical (including ITI) colleges in the district in the year 2010-11.

6.2.4 Health Care Facilities

In 2007-08, Barmer District had 1 allopathic district hospital, 14 community health centers, 58 primary health centers, 478 deputy health centers, 4 dispensaries, 888 allopathic hospital, 10 private nursing homes, 95 Ayurveda and Unani hospital and 5 Ayurveda and Unani clinic. In Jalore District as in March 2011, there was 1 district hospital, 8 community health centers, 53 public health centers, 394 sub centers, 1 T.B. hospital, 3 Ayurveda hospitals, 72 dispensaries, 4 homeopathic clinics and 12 private hospitals.

6.2.5 Veterinary Facilities

As the population in both the districts own and rear huge numbers of cattle wherein livestock rearing and dairy production are important occupations, therefore, it is important to have good animal health centers in the area as well. In 2007-08, Barmer District had 5 first class veterinary hospitals, 50 veterinary hospitals, 3 veterinary dispensaries, 47 animal sub centers and 1 district disease diagnostic center. In 2010, Jalore District had 48 veterinary hospitals, 4 dispensaries, 37 sub centers and 1 integrated animal development center.

6.2.6 Road Connectivity and Communication Facilities

Barmer is connected with proper road and railway connectivity. The length of the road (asphalt) in Barmer in 2007-08 was 7494.37 km. While in 2006-07, there were 6078 km of Bituminous Tar Roads. Further, the district had 481 post offices and 84 telephonic facilities. In Jalore District, as on March 2010, the total length of the National Highway was 38.10 km. In addition, the length of the State Highway was 261 km, major district road was 261 km, other district road was 311.40 km and village road was 2588.80 km. The district in 2010-11 had 268 post offices and 24,413 telephonic connections.

6.2.7 Electrification

In terms of electricity consumption by domestic connection, Barmer District ranked 21st among 32 districts and 18th in non-domestic connection consumption. By far, agriculture is the largest consumer with 2175.77 lakh unit consumption in 2006-07. In addition, 1931 villages had been electrified in 2006-07. In Jalore District, in 2010-11, there were 786 villages which were electrified. The total consumers were 208,774 where in the domestic users were 146,684, the commercial users were 11,211, industries were 2173, public lighting was 133, agriculture consumers were 47,097 and others were 1476 respectively.

6.2.8 Drinking water

Potable drinking water is a great concern in Barmer District. As per the norm stated by the National Commission on Integrated Water Resources Development (NCIWRD) for

rural areas, 70 liters of water per capita per day have been recommended to be supplied for human consumption, but in an arid area like Barmer, it is difficult to find adequate water. In December 2005, there were 243 piped water schemes, 37 hand pump schemes, 1311 regional schemes, 13 traditional source schemes/Janta Jal Yojana and 8 diggi and others. On the whole the district was served by 1612 schemes. In reference to the drinking water scheme, a total of 697 villages were brought under this scheme. The total hand pump in the rural areas was 1541 and in urban areas it was 175.

6.2.9 Other Facilities

As Barmer is frequented by droughts, fair price shops are a source of cheap food items which caters to the large population. There were 78 such shops in urban areas and 830 in rural areas in 2007-08 This means that on an average a shop in urban areas serves 2308 persons and a shop in rural areas serves 2503 persons. In addition, there were 750 cooperatives present in the district. While in Jalore District in 2010-11 there were 558 fair price shops and 841 cooperative societies.

7. Rehabilitation and Resettlement (R&R) Plan

The land would be acquired ensuring that there is no rehabilitation and resettlement.

8. Project Inter linkage and EC approval obtained details

This brown field project will be developed in the existing Block area. The upstream and pipeline projects are inter linked in operation. The natural gas produced in the “upstream process” will be exported through the pipeline laid in the “midstream process”. The Environmental Clearances obtained related to development are detailed below in **Table 3**.

Table 3: Environmental Clearance – Upstream and Midstream details

S. No.	File No	Issue Date	EC Details
RJ-ON-90/1 Onshore Block – UPSTREAM (Production and Development related)			
1	J-11011/382/2005 - IA II (I)	21-Mar-06	Hydrocarbon development in Barmer - Mangala, Aishwarya, Saraswati & Raageshwari fields
2	J-11011/175/2007 - IA II (I)	17-May-07	Hydrocarbon development and production of Guda field in Barmer and Jalore Districts
3	J-11011/174/2007 - IA II (I)	12-Mar-08	Hydrocarbon development in Bhagyam field
4	J-11011/98/2010 - IA II (I)	23-Nov-10	Augmentation of crude oil production & processing capacity (140000 - 160000 BOPD & 20.4 - 32 MMSCFD) at MPT and well pads
5	J-11011/98/2010 - IA II (I)	16-Oct-12	Augmentation of crude oil production capacity in MPT (160000-175000 BOPD & 32-35 MMSCFD)

S. No.	File No	Issue Date	EC Details
6	J-11011/108/2012 - IA II (I)	14-Jun-13	Increase in crude oil production capacity from MPT (175,000-200,000 BOPD & 35- 40 MMSCFD)
7	J-11011/80/2013 - IA II (I)	11-Aug-14	Augmentation of hydrocarbon production (2,00,000 - 3,00,000 BOPD)
RJ-ON-90/1 Onshore Block – PIPELINE			
8	J-11011/234/2007-IA II (I)	28-Apr-08	Oil Evacuation pipeline with associated facilities from Mangala Terminal, Barmer, District Rajasthan to Salaya Terminal in Jamnagar District via Viramgam
9	11-34/2009-IA-III	24-Aug-09	CRZ and Environmental clearance for the installation and operation of two Single Point Mooring (SPM) and interconnecting pipelines to evacuate crude oil and import diluents to the storage terminal & installation & operation of crude oil terminal at Vill: Bhogat, Taluka: Kalyanpur, District Jamnagar, Gujarat
10	J-11011/444/2011-IA II (I)	5-Sep-12	Increase in Carrying Capacity of Crude Oil Pipeline (150,000 to 175,000 bopd) in existing Barmer (Raj) to Bhogat (Gujarat) pipeline
11	J-11011/444/2011-IA II (I)	23-May-14	Increase in Carrying Capacity of Crude Oil Pipeline (175,000 to 200,000 BOPD) in existing Barmer (Raj) to Bhogat (Gujarat) pipeline
12	<u>J-11011/234/2007-IA II (I)</u>	31-Oct-16	Expansion in existing crude oil carrying capacity from 200,000 BOPD to 300,000 BOPD and Natural gas carrying capacity from 6.3 MMSCFD to 40 MMSCFD along with development of new gas pipeline from Raageshwari to Palanpur in Existing project to Bhogat (Gujarat) pipeline, District Barmer, Rajasthan

This project will be applied for single Environmental Clearances covering both upstream and midstream operations as discussed in this project feasibility report.

9. Project Schedule and Cost

The proposed projects will be implemented in a phased manner. The project will start execution after obtaining all the necessary approvals.

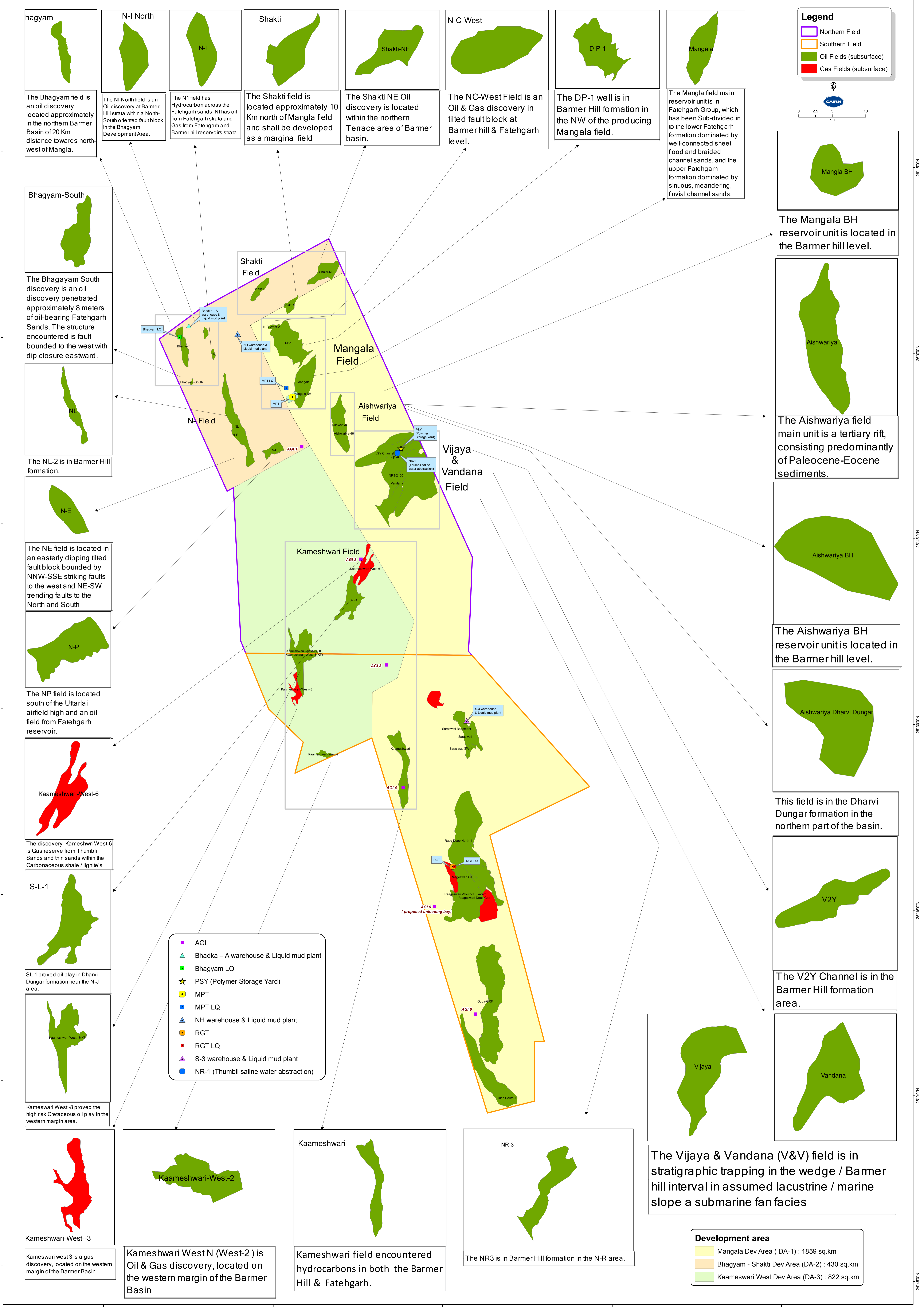
The total project cost would be INR 12000 Crores, which includes around INR 8000 Crores for upstream and INR 4000 Crores for midstream. This project will be implemented in phased manner up to seven (07) years period.

10. Analysis of Proposal (Final Recommendations)

Considering the potential hydrocarbon reserves of the RJ-ON-90/1 Block and on-going and planned exploration and appraisal activities, this proposed project will help the Indian Government in addressing its energy security needs. The project also anticipates in providing immediate livelihood to a large number of local people directly and indirectly.

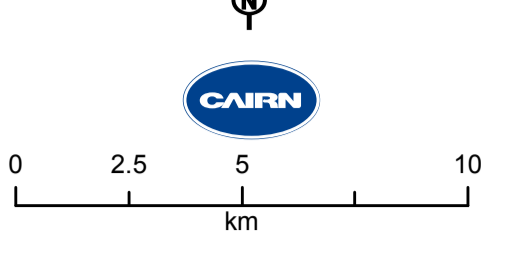
Annexure 1

Hydrocarbon Discoveries of the Block RJ-ON-90/1



Legend

- Northern Field
- Southern Field
- Oil Fields (subsurface)
- Gas Fields (subsurface)



hagyam

The Bhagyam field is an oil discovery located approximately in the northern Barmer Basin of 20 Km distance towards north-west of Mangla.

N-I North

The NI-North field is an Oil discovery at Barmer Hill strata within a North-South oriented fault block in the Bhagyam Development Area.

N-I

The N1 field has Hydrocarbon across the Fatehgarh sands. NI has oil from Fatehgarh strata and Gas from Fatehgarh and Barmer hill reservoirs strata.

Shakti

The Shakti field is located approximately 10 Km north of Mangla field and shall be developed as a marginal field

Shakti-NE

The Shakti NE Oil discovery is located within the northern Terrace area of Barmer basin.

N-C-West

The NC-West Field is an Oil & Gas discovery in tilted fault block at Barmer hill & Fatehgarh level.

D-P-1

The DP-1 well is in Barmer Hill formation in the NW of the producing Mangala field.

Mangala

The Mangla field main reservoir unit is in Fatehgarh Group, which has been Sub-divided in to the lower Fatehgarh formation dominated by well-connected sheet flood and braided channel sands, and the upper Fatehgarh formation dominated by sinuous, meandering, fluvial channel sands.

Mangla BH

The Mangala BH reservoir unit is located in the Barmer hill level.

Aishwariya

The Aishwariya field main unit is a tertiary rift, consisting predominantly of Paleocene-Eocene sediments.

Aishwariya BH

The Aishwariya BH reservoir unit is located in the Barmer hill level.

Aishwariya Dharvi Dungar

This field is in the Dharvi Dungar formation in the northern part of the basin.

V2Y

The V2Y Channel is in the Barmer Hill formation area.

Vijaya

The Vijaya & Vandana (V&V) field is in stratigraphic trapping in the wedge / Barmer hill interval in assumed lacustrine / marine slope a submarine fan facies

Vandana

Bhagyam-South

The Bhagyam South discovery is an oil discovery penetrated approximately 8 meters of oil-bearing Fatehgarh Sands. The structure encountered is fault bounded to the west with dip closure eastward.

NL

The NL-2 is in Barmer Hill formation.

N-E

The NE field is located in an easterly dipping tilted fault block bounded by NNW-SSE striking faults to the west and NE-SW trending faults to the North and South

N-P

The NP field is located south of the Uttarlai airfield high and an oil field from Fatehgarh reservoir.

Kaameshwari-West-6

The discovery Kameshwri West-6 is Gas reserve from Thumbli Sands and thin sands within the Carbonaceous shale / lignite's

S-L-1

SL-1 proved oil play in Dharvi Dungar formation near the N-J area.

Kaameshwari-West-8

Kameswari West-8 proved the high risk Cretaceous oil play in the western margin area.

Kaameshwari-West-2

Kameswari West 2 is Oil & Gas discovery, located on the western margin of the Barmer Basin

Kaameshwari-West-3

Kameswari west 3 is a gas discovery, located on the western margin of the Barmer Basin.

AGI

- AGI
- ▲ Bhadka – A warehouse & Liquid mud plant
- Bhagyam LQ
- ★ PSY (Polymer Storage Yard)
- MPT
- MPT LQ
- ▲ NH warehouse & Liquid mud plant
- RGT
- RGT LQ
- ▲ S-3 warehouse & Liquid mud plant
- NR-1 (Thumbli saline water abstraction)

Kaameshwari-West-2

Kameswari West N (West-2) is Oil & Gas discovery, located on the western margin of the Barmer Basin

Kaameshwari

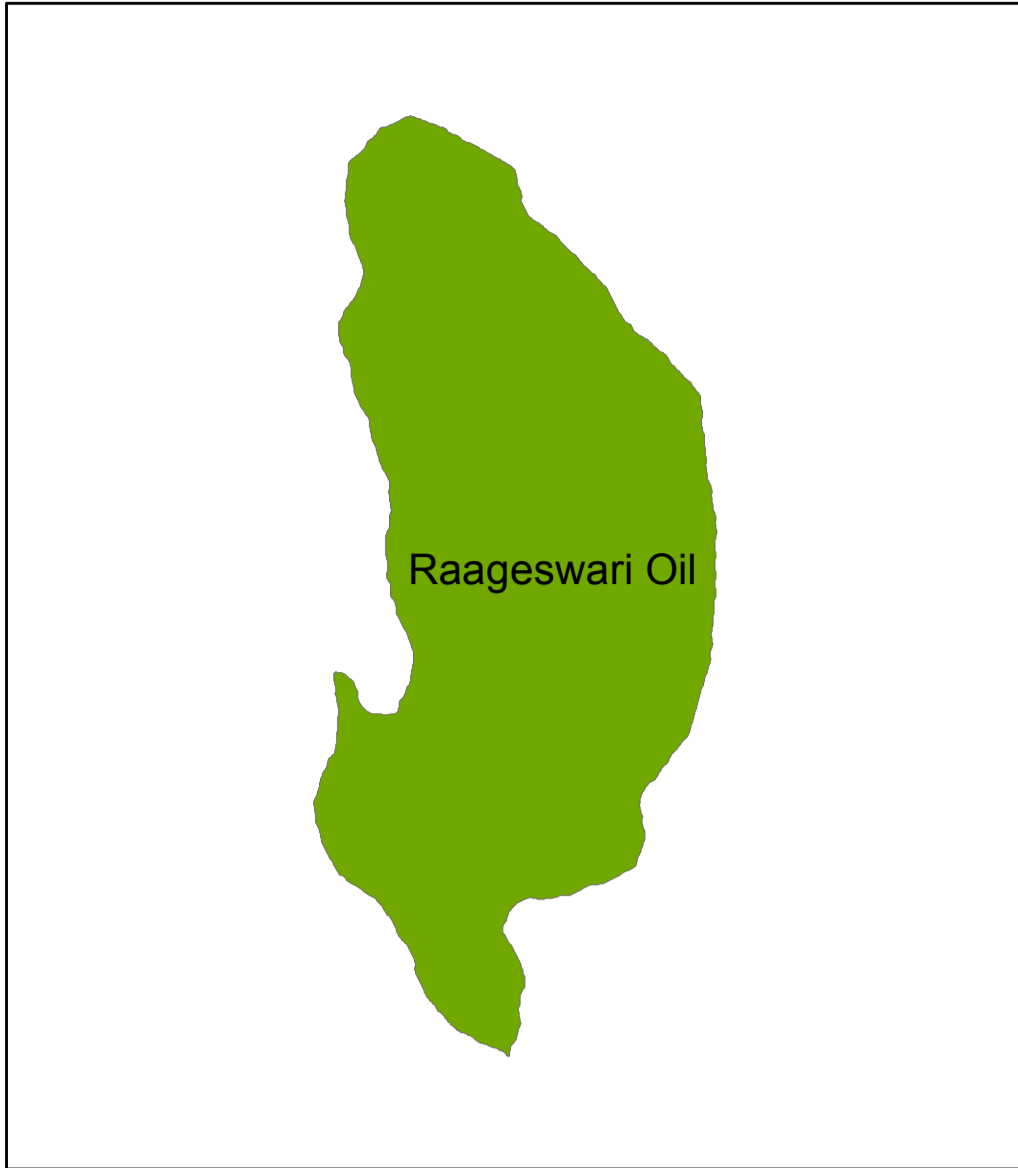
Kameswari field encountered hydrocarbons in both the Barmer Hill & Fatehgarh.

NR-3

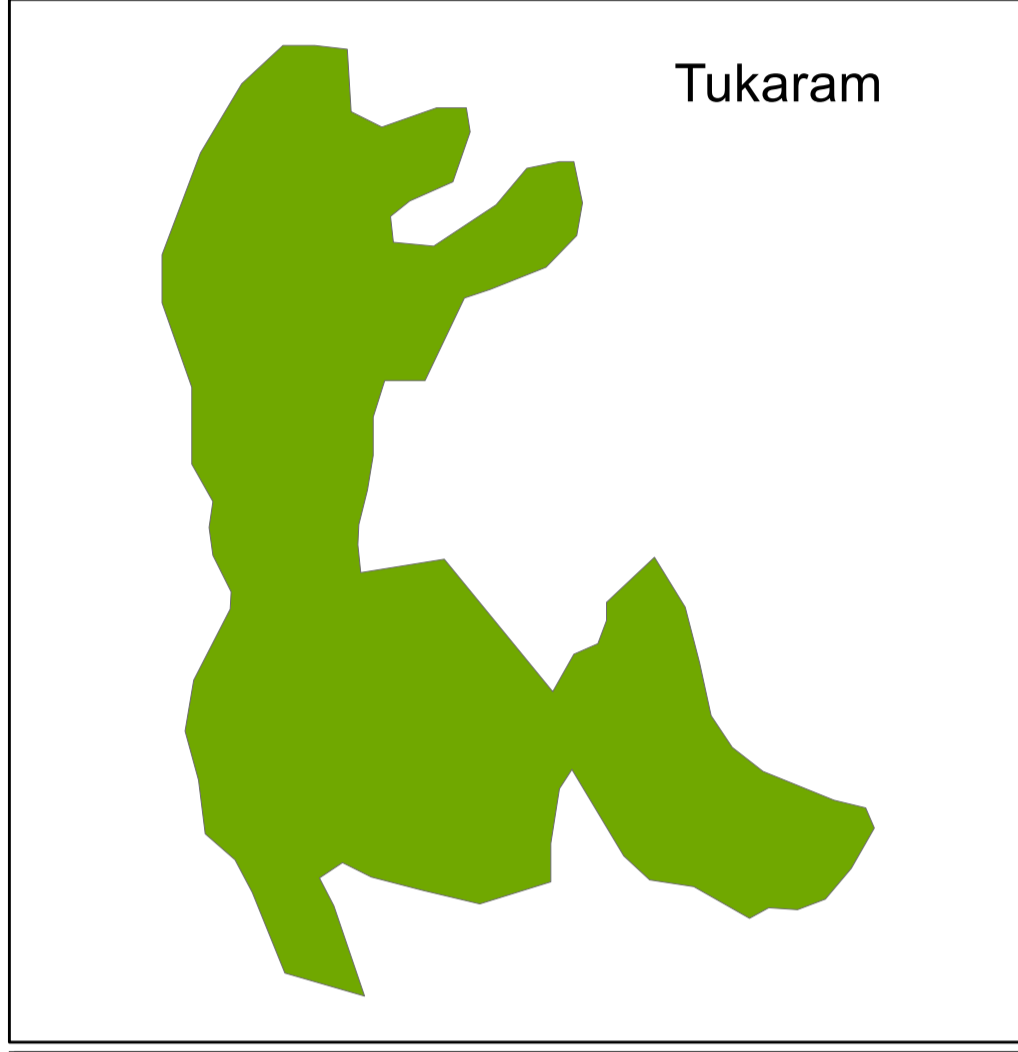
The NR3 is in Barmer Hill formation in the N-R area.

Development area

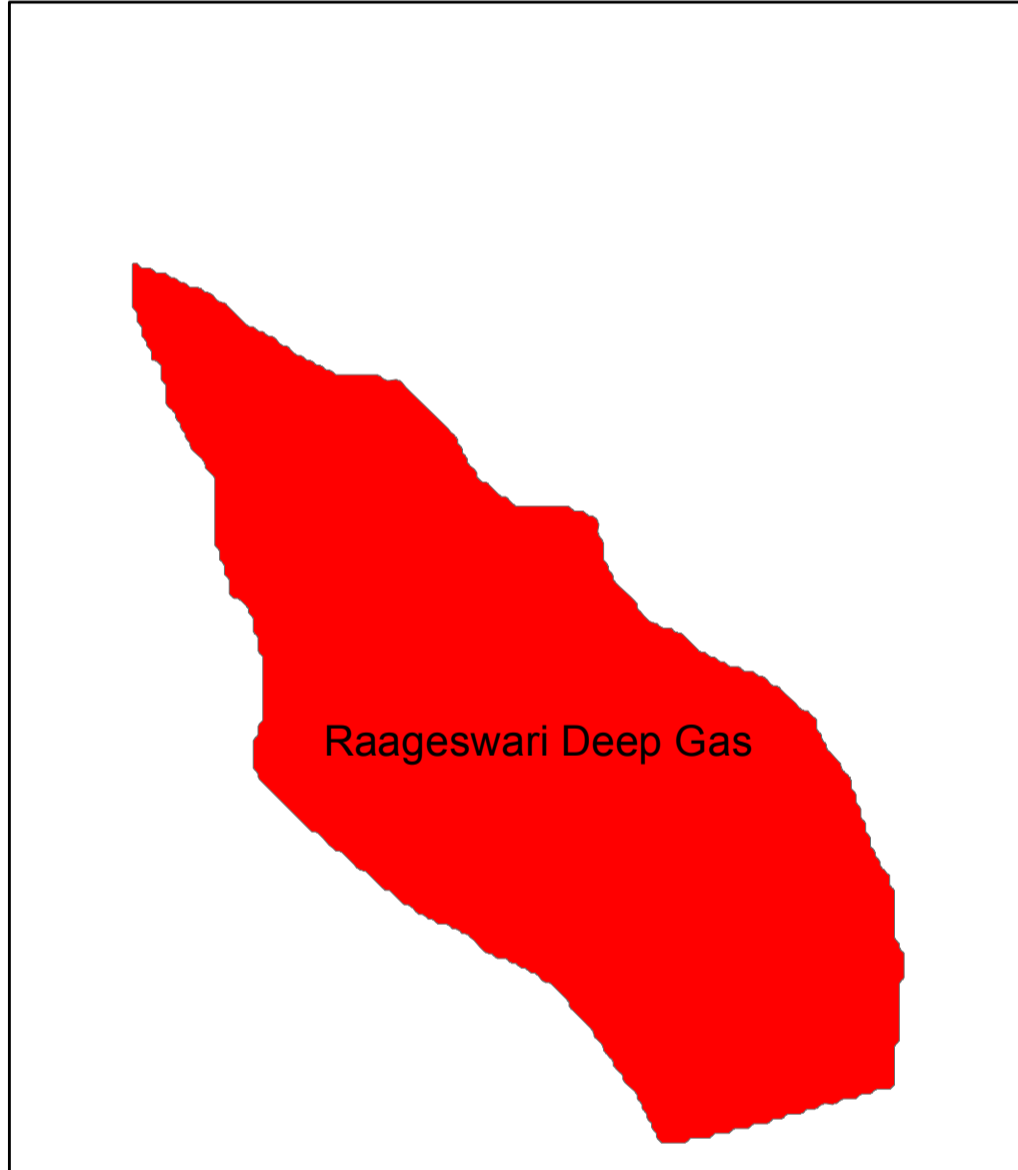
- Mangala Dev Area (DA-1) : 1859 sq.km
- Bhagyam - Shakti Dev Area (DA-2) : 430 sq.km
- Kaameswari West Dev Area (DA-3) : 822 sq.km



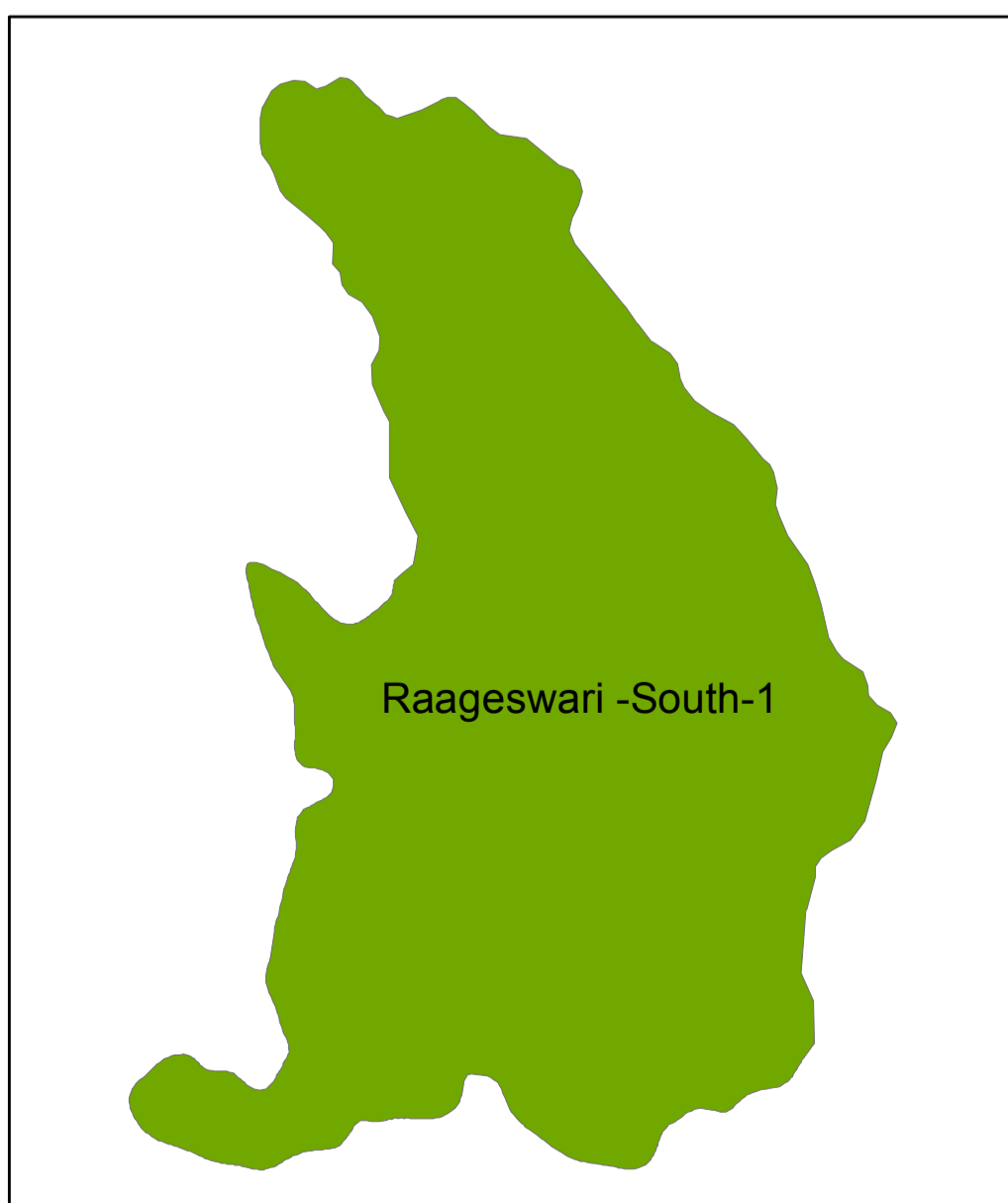
Raageswari Oil is an Oil Discovery in Thumbli Formation



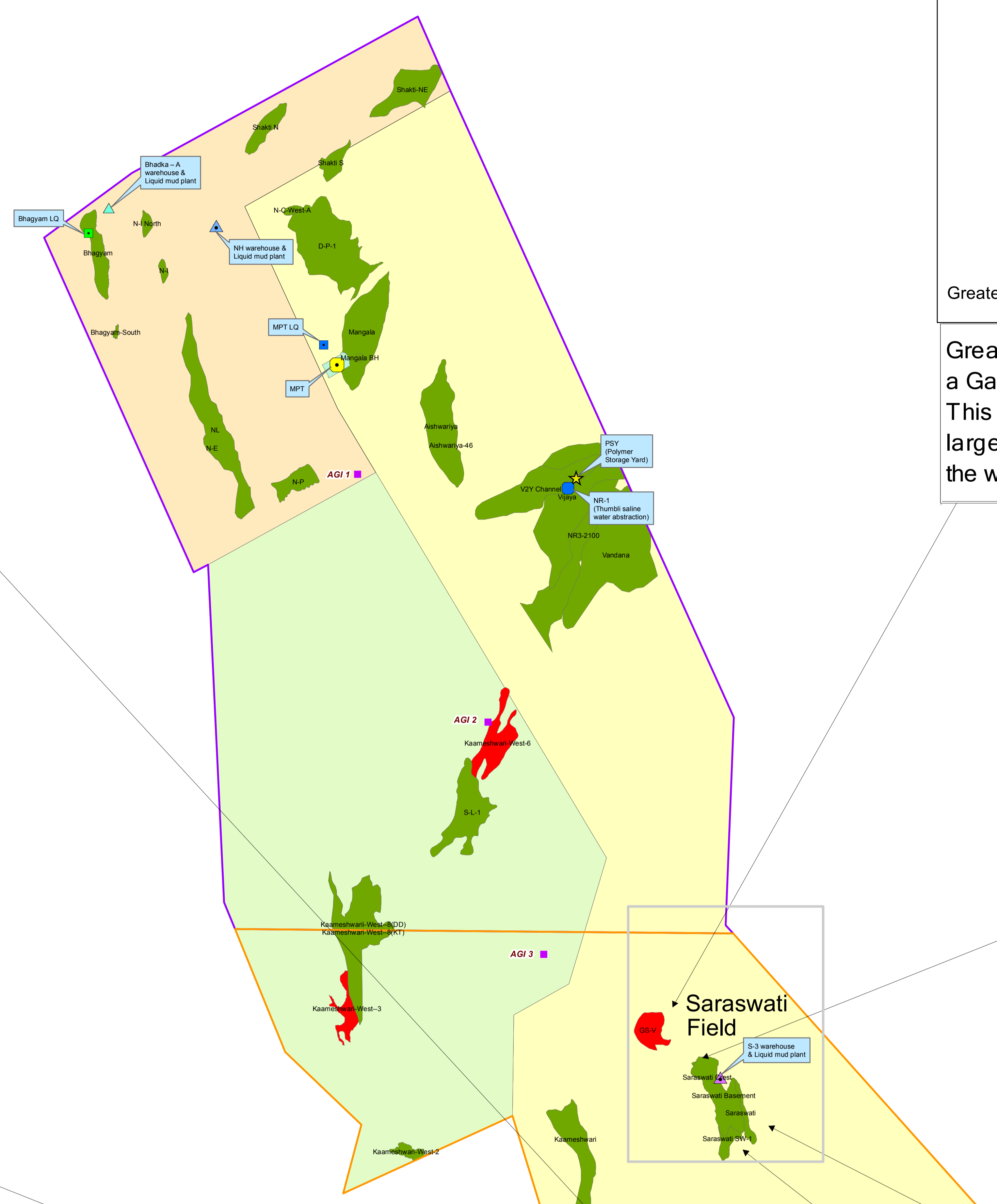
The Raageswari-East (Tukaram Ombale) discovery is located about 1.5Km north-east of Raageswari oil field in the northern Part of Central Basin High (CBH) This is in a large separate fault block to east of the main field



The Raageswari Deep Gas field was positioned at the shallowest part of the CBH, and found Gas Charged volcanics.



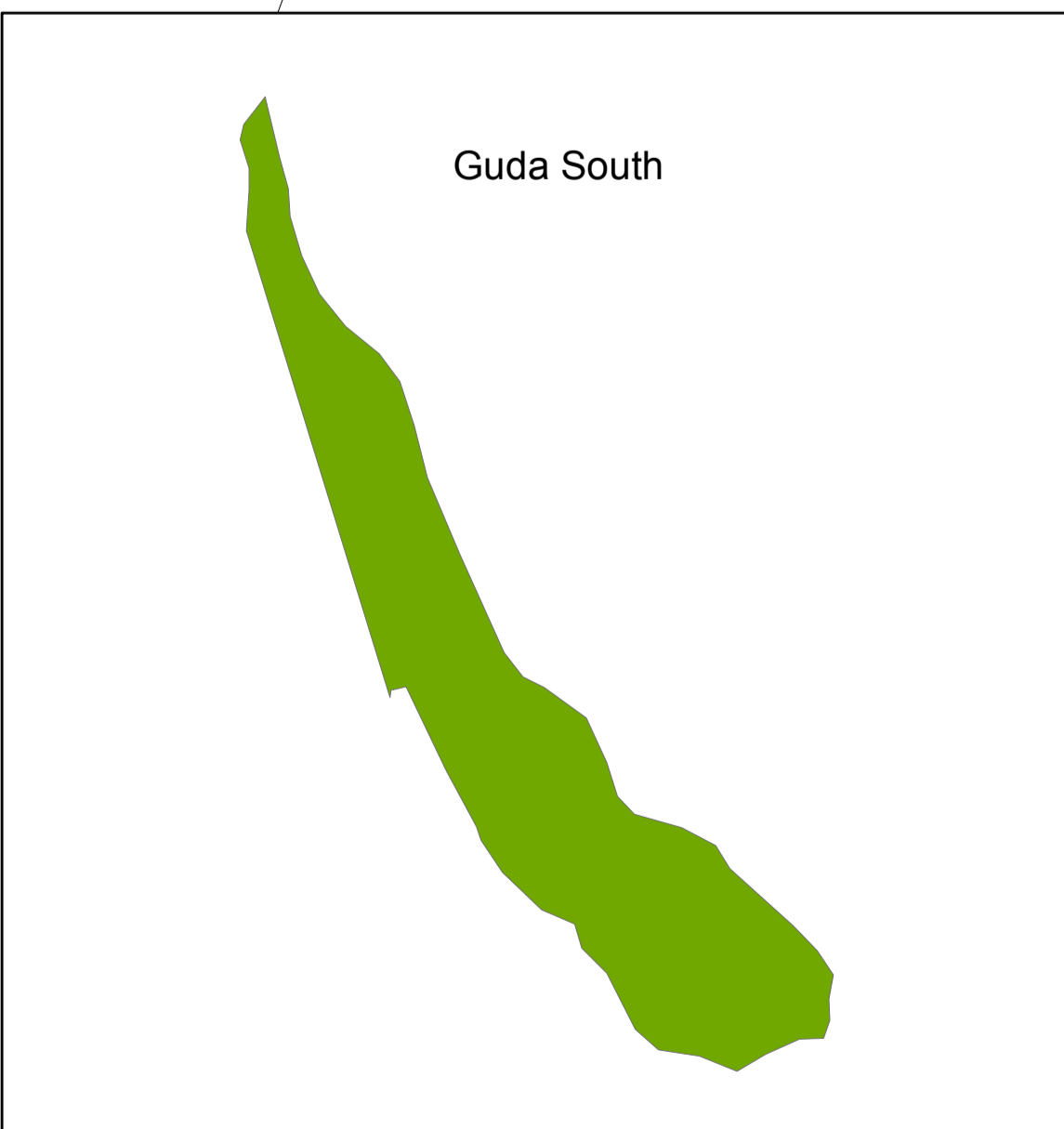
The Raag S-1 oil discovery was made when the Dharvi Dungar formation.



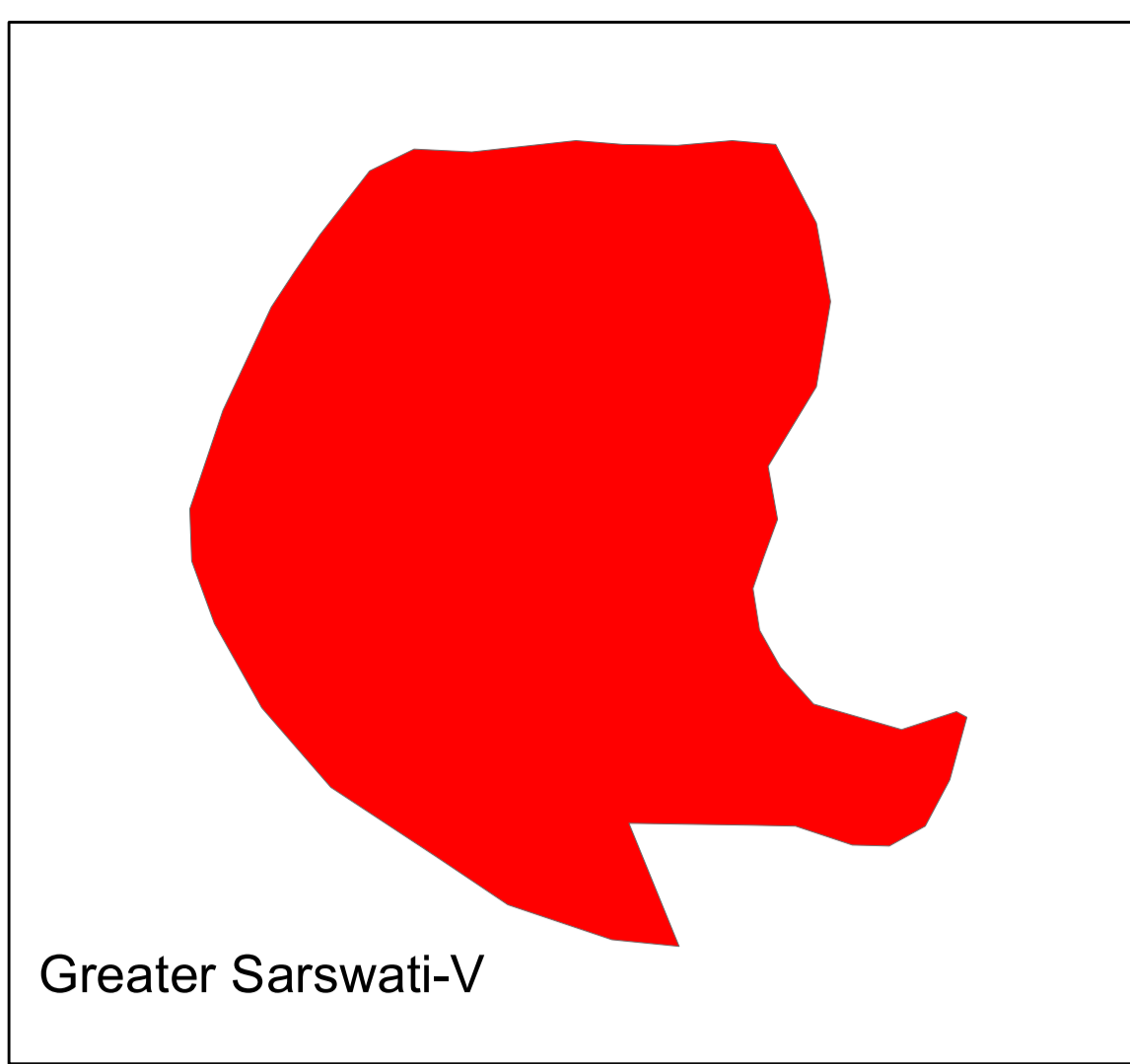
- AGI
- ▲ Bhadka – A warehouse & Liquid mud plant
- Bhagyam LQ
- ★ PSY (Polymer Storage Yard)
- MPT
- MPT LQ
- ▲ NH warehouse & Liquid mud plant
- RGT
- RGT LQ
- ▲ S-3 warehouse & Liquid mud plant
- NR-1 (Thumbli saline water abstraction)



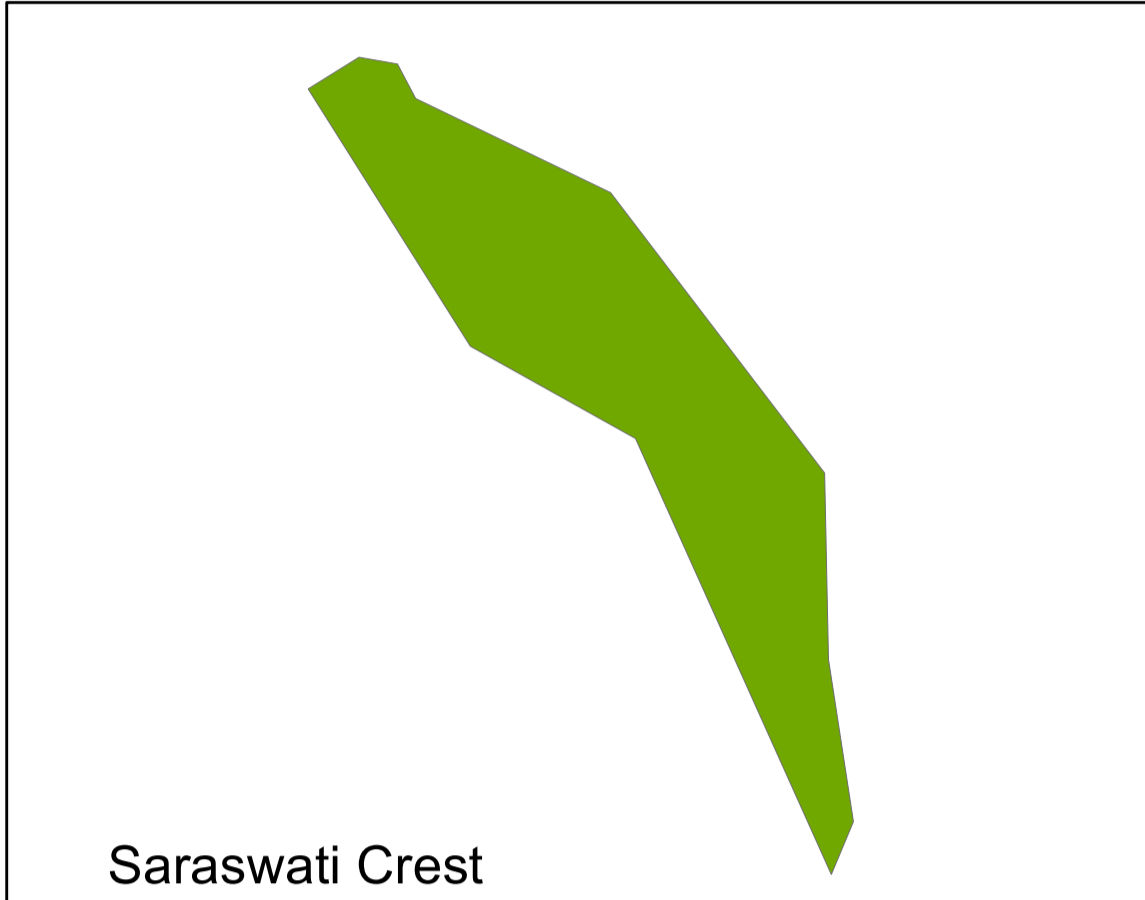
The Guda field is located in the southern central part of the block. Guda-2 is an oil reserve from the Dharvi Dungar formation.



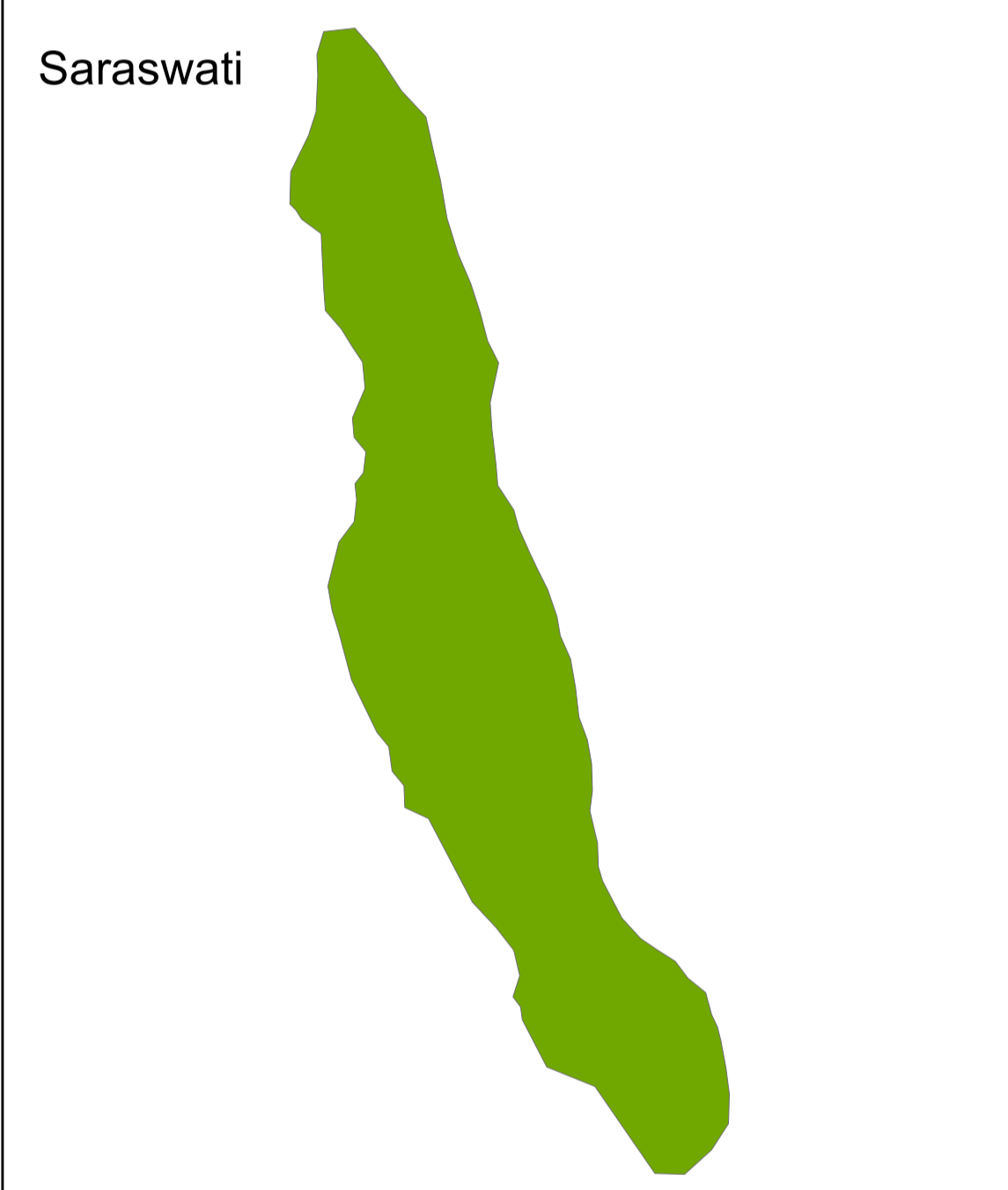
The Guda-South targeted the Dharvi Dungar formation



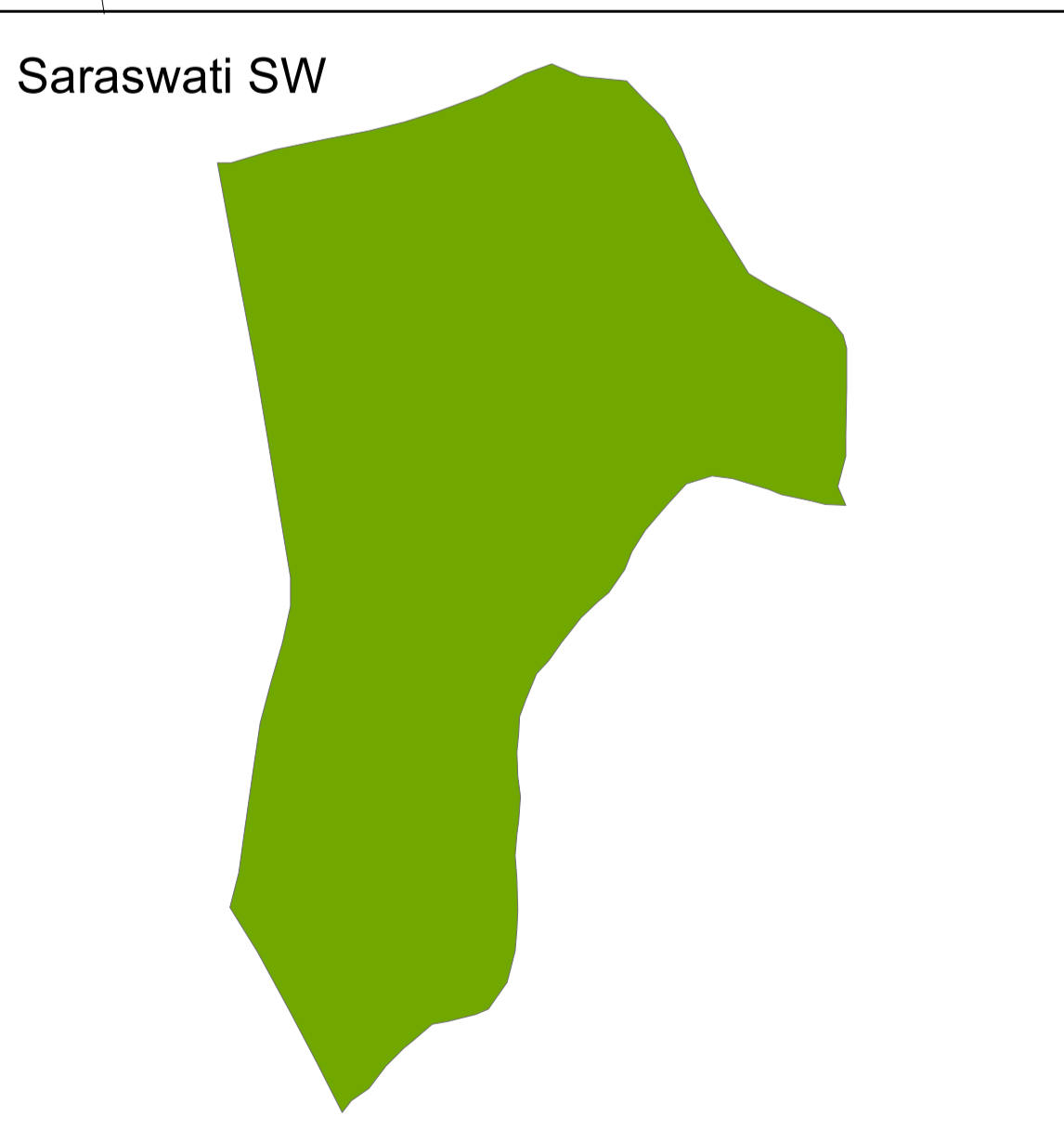
Greater Sarswati-V (GSV) field is a Gas and condensate discovery. This field is on a crestal horst of a larger downthrown fault block to the west of the Saraswati field.



The Saraswati-Crest-1 is an oil discovery demonstrated in the three zones (on MDT): Dharvi Dungar carbonate, Dharvi Dungar sandstone and lower and lower Barmer Hill sandstones. Sarswati-crest-1 is located west of the Sarswati Field on the Saraswati Terrace.



The Saraswati field is located approximately 50 km south-east of the Mangla field and an oil reserve. The Sarswati field is situated in a crestal position on the easterly -dipping basement-controlled fault block.



The Saraswati-Swis in the existing Saraswati field targeted the Mesozoi.

- Development area**
- Mangala Dev Area (DA-1) : 1859 sq.km
 - Bhagyam - Shakti Dev Area (DA-2) : 430 sq.km
 - Kaameswari West Dev Area (DA-3) : 822 sq.km

Legend

- Northern Field
- Southern Field
- Oil Fields (subsurface)
- Gas Fields (subsurface)