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

EXECUTIVE SUMMARY

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1.1 Introduction
1) 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 aluminium, copper, zinc, lead, silver and iron ore. The Rajasthan Joint Venture (RJ JV) of RJ-ON-90/1 Block comprises of Vedanta Limited and Oil and Natural Gas Corporation (ONGC) Limited for hydrocarbon exploration, development and production activities in Block. Cairn Oil and Gas division (Part of Vedanta Group) (hereinafter referred to as Cairn) is the operator of the Block. The RJ-ON-90/1 Block 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 3,111 km².

2) As on 31 May 2018, Cairn has got 38 hydrocarbon discoveries in the Block, of which twelve (12) discoveries have been developed or are being developed. Mangala Processing Terminal (MPT) and Raageshwari Gas Terminal (RGT) are two terminals for processing of hydrocarbons within the Block. Environmental Clearance (EC) have been obtained to produce up to 300,000 barrels of oil per day (BOPD) from Mangala Processing Terminal (MPT) and 165 million standard cubic feet per day (MMSCFD) of natural gas from the Block.

3) Mangala Processing Terminal (MPT) is producing on an average 175,000 BOPD. The expansion of MPT is already underway to produce additional 125,000 BOPD (i.e. total 300,000 BOPD) for which the Environmental Clearance has already been obtained.

4) At present, RGT is producing up to 55 MMSCFD of natural gas. The produced natural gas is used for captive power generation, internal usage for operating of gas engines at various Above Ground Installations (AGIs) and export of the excess natural gas to Gujarat State Petronet Ltd. (GSPL) pipeline grid in Gujarat. The expansion of RGT 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.

5) Cairn has developed midstream project of ~700 km long 24” crude oil buried pipeline (from Mangala Processing Terminal in Barmer, Rajasthan to Bhogat, Dev Bhumi Dwarka in Gujarat), electrically heated and insulated, and ~600 km, 8” natural gas pipeline (from RGT to Bhogat) to evacuate crude oil and natural gas produced from the Block. In addition, there are three (3) buffer crude oil storage Terminals at Radhanpur, Viramgam and Bhogat in Gujarat and thirty nine (39) AGIs along the route for electrical heating and intelligent pigging of pipeline.

6) Cairn has obtained separate Environmental Clearances for “exploration & appraisal” and “production & development” in RJ Block and for the pipeline operation in a periodic manner and also obtained No Objection Certificate (NOC) from Principal Chief Conservator of Forests and Chief Wildlife Warden, Rajasthan, Jaipur for the RJ Block development. Coastal regulation Zone (CRZ) approval was obtained for the SPM (Single Point Mooring) operation at Bhogat Village, Dev Bhumi Dwarka District, Gujarat.

1.2 Project Description
7) As on 31 May 2018, Cairn has drilled ~ 500 wells including ~200 exploratory and appraisal wells. According to Cairn’s recent estimates of hydrocarbon reserves and resources, it will be able to produce in peak up to 400,000 BOPD and 750 MMSCFD of gas including 500 MMSCFD of natural gas and up to 250 MMSCFD of associated gas.
considering peak oil production at MPT and standalone satellite fields. The details of proposed development in upstream and midstream is mentioned below including the proposed township and living quarters.

1.2.1 Oil and Gas Processing - Upstream Facilities Augmentation

8) MPT augmentation is proposed to handle a total of ~1.6 million barrels of liquid per day (BLPD). The key projects considered as part of the upstream augmentation includes Sulphate Removal Plant (SRP), Mangala Upgrade Project (MUP), Effluent Treatment Plant (ETP), Aishwariya Barmer Hill (ABH), Enhanced Oil Recovery (EOR) in Mangala, Bhagyam and Aishwariya (MBA) Fields by Alkali Surfactant Polymer (ASP) flooding, local dewatering at MBA Fields, EOR by CO$_2$ injection in gas fields, waste oil treatment facility at MPT, satellite oil and gas fields and gas terminal augmentation.

Note: Refer to Tables A to C at the end on summary augmentation of upstream & midstream project components.

Sulphate Removal Plant (SRP)

9) The use of Thumbli makeup water (reservoir injection water) is the key source of sulphate for the bacteria. Sulphate is the main reactant in the H$_2$S bio generation process in the reservoir fluids of Mangala, Bhagyam and Aishwariya Fields. Thus Sulphate ion free or reduced level in the Thumbli water (from the existing Sulphate level of 550 ppm to 40 ppm) used for injection to the MBA field has been recommended as one of the long term mitigation measures based on pilot trial results. The Sulphate Removal Plant consists of pre-treatment, sulphate removal unit, reject treatment, storage tanks, pumps and distribution pipeline (product and disposal water). Approximately 500,000 barrels of water per day (~3,700 cubic meter per hour (m$^3$/hour)] of sulphate free raw water shall be required to meet the proposed production augmentation.

Mangala Upgrade Project (MUP)

10) The objective of MUP project is to increase the liquid handling capacity at MPT to ~1.6 million BLPD and also augment the injection water and power fluid systems accordingly. The Project mainly consists of augmentation of intra-field pipelines, augmentation of liquid handling capacity for additional liquids (production fluid, produced water, injection water and power fluid) at MPT and augmentation of utility systems at MPT.

Effluent Treatment Plant (ETP) at MPT

11) The current practice of treatment and handling of the oily reject water is carried out in open loop system, thereby exposing the entire wastewater stream to the atmospheric (dissolved) oxygen. Thus making the final treated water unsuitable to take back in to the injection water requirements (because the oxygen content is at ppm level and is required to be reduced to ppb level). To overcome this challenge, ETP is proposed to treat the entire reject in a closed loop system and use the separated treated water for injection and waste oil to MPT system. This proposed ETP will help in conserving the raw water abstraction from Thumbli Reservoir for injection and also effective usage of the waste oil back to the process. The proposed total capacity of the ETP will be 50,000 barrels of water per day (BWPD).

Aishwariya Barmer Hill (ABH) Field

12) The produced gas from Aishwariya Barmer Hill Field is rich in CO$_2$ (~90% on dry basis). Existing fuel gas pipeline from MPT shall be augmented to enrich the hydrocarbon content of the associated gas for proper gas flare. The peak Barmer Hill oil production is expected to be up to 20,000 BOPD. To ensure flow assurance, additional hot injection water shall be circulated. Total gas production from ABH will be ~ 25 MMSCFD (dry basis).
13) Aishwariya Polymer Enhanced Oil Recovery (EOR): Parallel to ABH development, polymer flood will be implemented at Aishwariya Fatehgarh layer in two phases, i.e., lower Fatehgarh and upper Fatehgarh.

14) Bhagyam – Polymer Enhanced Oil Recovery (EOR): Bhagyam EOR development is proposed with polymer flood in Bhagyam well pads, which will result in incremental oil recovery.

Alkali Surfactant Polymer (ASP) Flooding

15) After successful implementation of polymer flood in Mangala, Cairn intends to implement Alkaline Surfactant Polymer (ASP) flood to further improve the recovery from Mangala and other fields. ASP will be implemented in the entire Mangala and other fields progressively. The key surface facility elements include water softening facility, ASP solution preparation, dilution and injection facility, oil – water separation facility, produced water treatment and disposal system, ASP pipelines, well pads augmentation works, ASP storage facilities and utilities.

16) Cairn proposes to use dolomite (hydrated powder form) as source of lime for lime softening package. The package will also have sludge handling and drying facility. The expected lime consumption for Lime softening package is ~175 tonnes per day (TPD). It is estimated during peak production, there will be requirement of alkali of ~1,600 TPD, surfactant of ~170 TPD and polymer of ~300 TPD.

Local Dewatering Facilities at MBA Fields

17) While MPT is upgraded to handle around 1.6 million BLPD, there will be requirement of higher liquid handling to keep oil production constant. Cairn plans to install localized dewatering and re-injection facilities (each designed for handling around 60,000 BLPD of production liquid) at selected well pads / clusters in MBA Fields. In some cases, multiple smaller skids, totalling to 60,000 BLPD can also be installed. Each such skid will consist of a three-phase separator, which will degas the liquid and separate bulk of water by taking a tap-off from the production manifold. The residual water, along with oil, will be pumped back into the manifold.

18) The separated water will be treated, heated and pumped back into the existing power fluid system (in case of Mangala) or injection water system (in case of Bhagyam/Aishwariya) within the respective well pads. The separated gas will be used within the well pads for heating and / or power generation purposes. Any excess gas will be compressed and routed back into the manifold within the well pad, however if the quantity is high it will be flared.

CO₂ Injection in Aishwariya Field

19) Cairn has undertaken a detailed modelling study to assess different options available for disposal of high CO₂ content produced gas with respect to their impact on the estimated ultimate recovery of Aishwariya Field through Carbonated Water Flooding/Injection (CWI). The primary mechanisms involved in CWI are oil swelling and oil viscosity reduction. Through simulation studies, it was observed that CWI could increase recovery factor by ~2% over base water flood if edge water injection was carried out. Implementation of CWI in Aishwariya Field would require installation of a stripper to separate out CO₂ from produced gas, CO₂ injection skid and static mixer. Transfer of CO₂ from water to oil changes the properties of crude (oil swelling and viscosity reduction) thereby leading to improved displacement efficiency. To assess impact of CO₂ injection on other planned EOR processes in Aishwariya Field, Cairn will periodically evaluate the efficiency of polymer flood.
Connecting the satellite oil fields through laying new pipeline:

20) Cairn has discovered multiple satellite fields across RJ Block. Few of these satellite fields are already operational and few of them are under development. Satellite oil fields NI, NE, KW-2, Sara-1, Sara-2, Guda-2, Guda-7 & Guda-S1/S3, Raag Oil WP-1 & Raag Oil Pad -3 etc. are already operational & spread across the RJ Block. Satellite oil fields Shakti, NP, SL-1, KW-1, Sara SW-1, Raag oil WP-2, Guda-3, Guda-5, Guda-S2 and Guda-S7 etc. are the fields under development. The crude oil from the satellite oil fields can be directly spiked to the export crude oil pipeline passing through the AGIs or transfer of the crude oil from satellite oil fields through pipeline to the crude oil storage tanks proposed to be set-up inside the AGIs and thereafter spiking to the stored crude oil to the export pipeline. The crude oil storage tanks of capacity 5,000 barrels each may be installed in all the eight AGIs (AGI 1 to 8) in the Barmer and Jalore districts of Rajasthan.

Cold Cracking

21) A crude oil cold cracking (CC) skid along with a processing vessel and a cooler is proposed to be installed nearby export tank (outside the dyke). Crude oil temperature is ~78°C. Post cold cracking, it will be cooled below 85°C through water based cooler before pumping it back to export oil tanks.

Waste Oil Re-Processing Facility

22) It is proposed to install 1,000 barrels per day of waste oil processing facility at MPT. These waste oil processing facility consist of filtration and centrifuge.

Solid Waste to Energy Conversion

23) It is proposed to install around 10 MT per day capacity mixed industrial waste to energy convertor based on plasma gasification process that will have stack of 30 m height.

Proposed Production from Satellite Fields

24) Satellite field development envisages production of crude oil or gas from various small discoveries spread across the Block. Cairn expects ~ 50,000 BOPD of crude oil from all the identified satellite fields.

Raageshwari Gas Terminal (RGT) (Proposed Augmentation)

25) Cairn proposes to maximize the gas exploration by installing new surface facilities and augmenting of the existing gas processing facilities of RGT to increase gross natural gas production rate from existing 100 MMSCFD to 500 MMSCFD along with 70,000 barrels per day of condensate. Development of the new Raageshwari Gas Processing Terminal (new RGT) will be linked to surface facilities i.e., well pads and well fluid gathering pipelines, related utilities and necessary infrastructure. The new RGT will have produced water evacuation facilities, natural gas liquid (NGL) fractionation unit along with LPG storage & tanker loading system and CNG / LPG filling stations.

1.2.2 Proposed Augmentation of the Export Gas Pipeline- Midstream Development

26) A new 30" cross-country buried gas pipeline of ~600 km long is proposed for laying between RGT (Barmer District, Rajasthan) to Bhogat terminal (Dev Bhumi Dwarka District, Gujarat) with a maximum flow rate of 500 MMSCFD through existing pipeline corridor i.e. Right of Use (ROU). The existing Barmer-Bhogat pipeline corridor does not pass through any ecologically sensitive areas.

1.2.3 Proposed Township

27) Due to the operational areas spread across the RJ Block, new township, living quarters with hostel facilities and office complex are proposed at multiple locations which includes Madpura Purana Gaon Village, Baitu Tehsil; Villages Barmer Magra, Barmer Gadan, Mahabar, Sansiyon Ka Tala, Kau Ka Kheda, Rauji Ki Dhani, Bhurtiya, Bandra, Allaniyon Ki Dhani and villages surrounding MPT & Barmer City Rauji Ki Dhani.
Village, Baytu Tehsil of Barmer District in Villages Banka Nadi, Bhagoniyon Ki Dhani, Khatiyon Meghwalon Ki Dhani, Tehsil & District- Barmer. The details of the township is as below:

- The total number of flats will be around 1,600 nos. This includes single bedroom hall and kitchen (BHK) flat, 2 BHK flat, 2 BHK plus Study flat, 3 BHK flat, 4 BHK flats, hostel and office complex.
- The construction of these flats, township amenities (such as club house, commercial complex, medical centre, 20 bedded hospital, administrative office, fire station, stadium etc.), hostels and office complex is proposed through multiple high rise buildings with the total built-up area of three million square feet.
- In addition to the accommodation facilities and amenities other requirements will be built up such as playground, park, roads, storm water drains, rain water harvesting structures, parking spaces, utility buildings, water tank etc., in 0.7 million square feet.

28) The project structures will be designed after due study of the local architecture. The project area is largely undeveloped and does not bear any significant architectural aspect. Likewise, the building is planned with modern design and facilities with open spaces. The following standards and bye-laws will be followed for designing the various units:
- Relevant IS Codes of Practice Published by the Bureau of Indian standards.
- Manuals on Sewerage and Water issued by the Ministry of Urban Development.
- Building bye laws–Local Municipal Corporation bye-laws.
- Good Engineering Practice.

2.1.1 Resource Requirement

29) Land: For the upstream project component related expansions in Barmer District, there will be additional land requirement of ~150 hectares to set up a) new RGT in 110 ha and b) MPT expansion (including township and living quarters) in 40 ha. Considering the sparsely settled population in Barmer District, land would be acquired away from any settlement thus there will no rehabilitation and resettlement. For the midstream pipeline project there be requirement of ~30 ha additional land (mainly in Gujarat) for setting up of gas boosting stations along the existing cross country pipeline corridor.

30) Water: The water requirement in RJ Block of existing and proposed project components will continue to be sourced only from the various deep saline aquifers as per approval of Central Ground Water Authority (CGWA). No fresh water or surface water will be sourced for the developmental activities. For facilities away from network of saline water with requirement of less than 10 m³/day per location, water will sourced from deep local ground water sources as per prior approval of CGWA.

31) The total saline water abstraction will be 93,500 m³/day, out of which at present Cairn has CGWA permission for 53,500 m³/day, application with CGWA is already under process for 15,000 m³/day and additional permission to be obtained for 25,000 m³/day.

32) Power: Additional 200 MW of captive power for the proposed expansion will be generated using natural and associated gas. In addition, grid power will be withdrawn from the state electricity board, and only emergency power will be generated from diesel generators.

33) Chemicals: A range of chemicals are used to enhance the effective separation of the crude, gas, produced water, condensate from the well stream to protect human health,
asset integrity and environment. Chemicals of various types include inorganic salts, transition metal compounds, organic chemicals, solvents, water-soluble, oil-soluble polymers, surfactants etc. Cairn will comply with requirements of Manufacture, Storage and import of Hazardous Chemical (MSIHC) Rules, 1989 as amended in 2000 for handling and storage of chemicals.

2.1.2 Project Schedule and Cost

34) The proposed project components will be implemented in a phased manner during seven years. The project will start execution after obtaining all the necessary approvals. The tentative plan to start the project will be from the Financial Year 2019 – 2020 onwards up to 2024 - 2025. The total project cost is estimated to be around INR 12,000 Crores.

3.1 Baseline Status

35) The study area for determination of environmental and social baseline is as following:

- **Upstream Study Area:** Entire RJ-ON-90/1 Block by covering 10 km from existing and proposed developments;
- **Midstream Study Area:** 500 m either side of ~600 km pipeline ROU from RGT in Barmer District, Rajasthan to Bhogat in Devbhumi Dwarka District, Gujarat.

36) The primary baseline environment study was collected from mid November 2017 to March 2018 for both upstream and midstream project components. ERM India contracted the environmental baseline monitoring to M/s Avon Food Labs Private Limited, an accredited lab by National Accreditation Board for Testing and Calibration (NABL) and Ministry of Environment, Forests and Climate Change (MoEF&CC).

3.1.1 Topography:

3.1.1.1 **Upstream Study Area**

37) RJ-ON-90/1 Block has a total area of 3,111 km². Of this 94% falls within Barmer District and remaining 6% in adjoining Jalore District. Most part of the Barmer District comes under the Great Indian Desert. In the eastern part of the district and to the west of Barmer city, exposures of hill ranges are seen trending east – west direction. The district is a vast sandy tract. The general topographic elevation in the district is between 125 m to 250 m above mean sea level (msl). Generally, the terrain slopes westwards.

3.1.1.2 **Midstream Study Area**

38) The baseline environmental characteristics were studied 500 m either side of the existing pipeline corridor within which the proposed 30” gas pipeline of ~600 km will be laid. The topography in the midstream section is varying. It generally slopes N-S with elevations ranging from 177 m in North at AGI 1 to 45 m at AGI 7 in South. It then elevates to 90 m while traversing further south at AGI 10. The slope is East to West for the pipeline section between Viramgam terminal and Bhogat terminal.

3.1.2 Seismic Zone

3.1.2.1 **Upstream Study Area**

39) As per Bureau of Indian Standards (BIS) seismic zonation maps, Block RJ-ON-90/1 falls under moderate risk zone (Zone III).

3.1.2.2 **Midstream Study Area**

40) The midstream study area falls under high risk zone (Zone IV) and very high risk zone (Zone V).

3.1.3 Geology:

3.1.3.1 **Upstream Study Area**

41) Geologically, Barmer District is underlain with intrusive rock at the basement (post Delhi Formation) consisting of Jalore and Siwana granite and Malani rhyolite and granite followed by Mesozoic and Tertiary formations consisting of sandstone, shale and conglomerate. Mesozoic consists of the Lathi Series of Jurassic and Abur series of Cretaceous period. The surface geology of the Block is windblown sandy, alluvium
while depth to bedrock is in range of 120 m to 200 m, bgl (below ground level), the maximum depth of bedrock is at reported in north of Barmer.

3.1.4 Meteorology

3.1.4.1 Upstream Study Area

The temperature during the study period varied from 7.7 °C (January) to 36.3 °C (March). Predominant wind direction were NE and WSW with mean wind speed 1.4 m/s and highest wind speed 5.8 m/s. As per Rajasthan Groundwater Year Book 2016-17, the annual average rainfall for Barmer and Jalore for the period 1901 to 1970 is 260.0 mm and 400.6 mm respectively mm with majority observed during June to September.

3.1.4.2 Midstream Study Area

During the study period, temperature at Viramgam and Bhogat stations ranged from 10 to 39°C and 10.0 to 36.1 °C respectively. While at Viramgam station, Predominant wind directions were NNE and N with mean wind speed of 1.6 m/s, at Bhogat Station it were noted to be ENE, NE and NW with mean wind speed of 2.1 m/s. Highest wind speed was observed at Bhogat station in December, 2017. No rainfall was recorded during the monitoring period of December 2017 to March 2018.

3.1.5 Ambient Air Quality

Ambient air quality monitoring was conducted for twice a week 24 hourly during the monitoring period at twenty (20) locations in upstream and five (05) locations in midstream study area.

3.1.5.1 Upstream Study Area

In the upstream study area, PM$_{10}$ varied from 49.5 to 112.2 μg/m$^3$ as against corresponding national ambient air quality standards, 2009 (NAAQS) of 100 μg/m$^3$; PM$_{2.5}$ varied from 24.2 to 65.2 μg/m$^3$ as against corresponding NAAQS of 60 μg/m$^3$. Marginal exceedance of PM$_{10}$ and PM$_{2.5}$ concentrations are attributed to prevailing desert conditions in the study area, some local construction activities near RGT during the study period, proximity to vehicular movement on National Highway 112.

Values of SO$_2$ (Sulphur-di-Oxide) varied from below detection limit (BDL) (DL: 4 μg/m$^3$) to 16.2 μg/m$^3$ as against corresponding NAAQS of 80 μg/m$^3$; and NO$_2$ (as Nitrogen di-Oxide) varied from 6.1 to 28.09 μg/m$^3$ as against corresponding NAAQS of 80 μg/m$^3$.

Concentration of other parameters i.e. Lead, Ammonia, Carbon Monoxide, Benzene and Nickel concentrations were observed well below their corresponding standards as stipulated in NAAQS, 2009. The concentrations of Ozone, Arsenic, Benzo(a)Pyrene (BaP) were observed to be below detectable limit at all locations.

The concentrations for Volatile Organic Compound (VOC) in the study area ranged from BDL (DL: 1.0 μg/m$^3$) to 2.6 μg/m$^3$ while methane and non-methane HC varied from BDL (DL: 1.0 ppm) to 1.4 ppm. Currently there are no ambient air quality standards in India for VOCs and HCs.

3.1.5.2 Midstream Study Area

In the midstream area, PM$_{10}$ varied from 61.90 μg/m$^3$ to 92.10 μg/m$^3$ as against corresponding NAAQS of 100 μg/m$^3$; PM$_{2.5}$ varying from 31.80 μg/m$^3$ to 53.40 μg/m$^3$ as against corresponding NAAQS of 60 μg/m$^3$.

Values of SO$_2$ varied from 5.20 μg/m$^3$ to 13.60 μg/m$^3$ as against corresponding NAAQS of 80 μg/m$^3$; and NO$_2$ from 13.7 μg/m$^3$ to 27.50 μg/m$^3$ as against corresponding NAAQS of 80 μg/m$^3$. Concentration of other parameters i.e. Lead, Ammonia, Carbon Monoxide, Benzene, Nickel, Ozone, Arsenic and Benzo(a)Pyrene (BaP) were observed well below their corresponding in NAAQS, 2009.

Concentrations of VOCs in the study area ranged from BDL (DL: 1.0 μg/m$^3$) to 2.6 μg/m$^3$ while methane and non-methane HC varied from BDL (DL: 1 ppm) to 1.4 ppm.
ppm and 2.0 ppm respectively. Currently there are no National Standards for VOCs and HCs.

3.1.6 Ambient Noise Quality
3.1.6.1 Upstream Study Area
52) Ambient noise monitoring in the upstream study area was carried out at twenty (20) locations covering sixteen (16) locations in industrial area and four (4) locations in rural-residential area. The equivalent ambient noise level (Leq) in industrial area for day and night time ranged from 39.90 to 66.04 dB(A) and 38.28 to 64.20 dB(A) as against corresponding Leq day and night time standards of 75 dB(A) and 70 dB(A) respectively. Leq in residential area for day time and night time ranged from 45.17 to 60.85 dB(A) and 36.64 to 62.52 dB(A) as against corresponding day and night time standard of 55dB(A) and 45 dB(A) respectively. While the ambient noise levels were observed within permissible limits for industrial area, these were found exceeding the prescribed norms for residential areas near villages Kawas and Ratanpura due to nearby construction activities.

3.1.6.2 Midstream Study Area
53) Ambient noise monitoring was carried out at five (5) locations in the midstream study area. Leq for day time and night time were observed to be within the corresponding limits for industrial area except at Viramgam, where night time levels (45.56 dBA) was found to be close to the prescribed limits (dBA) for residential area.

3.1.7 Traffic Survey
3.1.7.1 Upstream Study Area
54) Field data was collected for 24-hours duration on major road networks comprising of NH-15 (T1), Jaisalmer to Sanchore (T2), NH-112 (T3) and SH-28 (T4) during the study period. Vehicular traffic density data was collected on each side of the roads on a typical working day. Analysis of the survey indicates that maximum number of vehicles was 1,695 vehicles per hour observed during 9:00 – 10:00 hrs at Jaisalmer – Sanchor road near Barmer i.e., T2 and minimum number of vehicles was 26 vehicles per hour observed during 3:00-4:00 hrs at National highway NH-15 Jaisalmer-Barmer road near village Bhadka i.e., T1.

3.1.7.2 Midstream Study Area
55) Traffic survey was conducted on highway connecting Dwarka to Jamnagar (T5) and at State Highway SH-55 connecting Radhanpur to Shankheswar near Radhanpur (T6) in the midstream study area. Maximum number of vehicles was 9,448 vehicles per hour as observed during 10:00 – 11:00 hrs at T6 and minimum number of vehicles was 180 vehicles per hour during 5:00-6:00 hrs at T5.

3.1.8 Surface and Groundwater Quality
56) Samples for ground and surface water were collected from the study area and analysed for physico-chemical, heavy metals and bacteriological parameters to assess current status of water quality in the upstream study area during the monitoring period.

3.1.8.1 Upstream Study Area
57) The surface water quality of Luni River was not found suitable for any class of water use as per CPCB criteria.

58) Groundwater samples were collected from fifteen (15) locations in upstream study area during the monitoring period. pH, turbidity and Total Dissolved Solids (TDS) for groundwater ranged from 7.14 to 8.31 pH units, 0.1 to 85.6 NTU and 1,965.7 to 24,855 mg/l respectively. Values for total alkalinity and total hardness were found within their corresponding permissible limits in most samples. Concentrations of heavy metals (cadmium, lead, mercury, molybdenum) and other parameters cyanide, polychlorinated bi-phenyls, PAHs and Arsenic were found below detectable limit at all locations. Ecoli and Fecali coliform were found to be absent in all the water samples.
whereas the total coliform content was below the detection limit of less than 2 MPN/100 ml.

3.1.8.2 Midstream Study Area

Water samples were collected from four (04) surface water (SW) and three (03) groundwater (GW) locations in midstream study area during the monitoring period. pH ranged from 7.16 to 7.87 pH Units and 6.96 to 7.85 pH units for SW and GW samples respectively; value of turbidity ranged from 4.5 to 12.6 NTU and BLQ (LOQ: 1 NTU) to 11.4 NTU while TDS varied from 831 to 3,671 mg/l and 1,204 to 2,008 mg/l respectively for SW and GW samples which exceeded the permissible limit of 5 NTU for turbidity and 2,000 mg/l for TDS at few SW and GW locations. Values for total alkalinity, total hardness and arsenic were found within their corresponding permissible limits in most of the samples. Concentrations for heavy metal such as cadmium, cyanide, lead, mercury, molybdenum, polychlorinated biphenyl and PAHs were found below detectable limit at all locations.

3.1.9 Land Use Pattern

3.1.9.1 Upstream Study Area

60) RJ-ON-90/1 Block: Landuse pattern were studied for an area surrounding 5 km all along the Block (adequately covering 10 km from all the installations within the Block). The study area is dominated by sand dunes (47.2%) followed by barren land (30.9%) and single crop agriculture (19.5%).

61) MPT: Landuse pattern were studied for an area within 2 km, 5 km and 10 km radius from MPT and was found to be 47.4%, 48.8% and 55.2% respectively to be under sand dunes followed by barren land.

62) RGT: Landuse pattern were studied for an area within 2 km, 5 km and 10 km radius from RGT and was found to be 36.4%, 35.4% and 35.9% respectively of the total area to be under sand dune and were followed by barren land.

3.1.9.2 Midstream Study Area

63) Landuse pattern of study area 500 m either side of Pipeline RoU is dominated by agriculture (51.6%) followed by barren land (46.0%).

3.1.10 Soil Quality

3.1.10.1 Upstream Study Area

64) Samples for soil quality monitoring were collected from sixteen (16) locations in the upstream study area. Soil texture in samples from all locations was observed as sandy with pH ranged from 7.48 to 8.24 pH units. The concentrations of heavy metals - Arsenic, Lead, Cadmium, Copper and Mercury (inorganic) were observed to below limit of quantification (BLQ) whereas the values for Zinc and Nickel were found to be much below the soil remediation intervention values as specified in Soil Remediation Circular 2009.

3.1.10.2 Midstream Study Area

65) Soil samples were collected from four (4) locations in the midstream study area. Soil texture was observed sandy with pH ranged from 7.56 to 7.82 pH units. Results of heavy metals in soil samples were much below prescribed values when compared with Dutch Standards, 2009 in absence of any existing Indian Standards for safe heavy metal content in soil.

3.1.11 Ecology

3.1.11.1 Upstream Study Area

66) A total of one hundred and five (105) sample plots were laid in the upstream study area covering various habitats including riparian habitats (5), Vachellia plantation areas (3), forest areas (7), open scrub areas (42), agricultural lands/agricultural fallow lands (32) and sand dunes (16). Maximum Importance Value Index (IVI) was recorded for Vachellia tortilis followed by Vachellia nilotica among tree species and Aerva pseudotomentosa followed by Cassia auriculiformis among herbs and grasses. Also, a total
of 3 amphibian species, 14 herpetofauna species, 97 avifaunal species and 12 species of mammals were reported from the RJ-ON-90/1 Block.

67) None of the species enumerated are listed in threatened category of IUCN red list v2017.3. Bengal Monitor Lizard (*Varanus bengalensis*) and Desert Monitor Lizard (*Varanus griseus*) are protected under Sch. I of Indian Wildlife Protection Act, 1972. Indian Hare *Lepus nigricollis* (Sch. IV), Wild Boar *Sus scrofa* (Sch. III) and Asiatic Wild Cat *Felis sylvestris* (Sch. I) were observed in the greenbelt area of Mangla Processing Terminal (MPT). Greater Mouse-tailed Bat (IUCN LC) is reported from MPT operational base and switch Yard.

68) A total of 97 avifaunal species were observed/reported from the RJ-ON-90/1 Block. Out of 97 species, 31 species are winter visitor and 66 species are resident. Egyptian Vulture species reported from the RJ-ON Block is listed as endangered as per IUCN Red List of Threatened Species v2017.3. A total of fifteen (15) species observed from the RJ-ON Block are protected under Schedule-I of Indian Wildlife Protection Act, 1972.

69) There are no national parks, sanctuaries or reserve forests within 10 km radius from all round the block. The nearest protected area is the Desert National Park located at ~35 km from the RJ-ON-90/1 Block in the northwest direction.

3.1.12.2 Midstream Study Area

70) Ecology survey was conducted along the pipeline route. During the survey, 4 species of amphibians, 15 species of reptiles, 87 avifaunal species and 16 mammal species were observed out of which 3 reptilian species, 10 avifaunal species and 3 mammal species observed are protected under Schedule-I of Indian Wildlife Protection Act, 1972. None of the species enumerated are threatened in the IUCN red list 2017.3 except Egyptian Vulture (*Neophron percnopterus*) and Steppe Eagle (*Aquila nipalensis*).

3.1.12 Socio-Economic

3.1.12.1 Upstream Study Area

71) RJ-ON-90/1 Block area comprises of total 320 villages and one urban settlement (i.e. Uttarlai), out of which major part falls in the Barmer District while a smaller part falls in the Jalore District. The 10 km area surrounding MPT comprises of 35 villages while 10 km surrounding RGT comprises of 27 villages and remaining 258 villages and an urban settlement in other part of RJ-ON-90/1 Block.

72) Total population in the study area is over 3 lakhs with adult sex ratio of 901 female per thousand male population. Entire population falls in the rural category. Percentage of vulnerable groups like SC & ST are 16.4% & 3.9% respectively of total population in the study area. The total literacy in RJ block is 58.6%, such that the male literacy stands at 73.3% while the female literacy figures are relatively very low at 42.2%. The main occupation of the population is agriculture followed by livestock rearing.

73) Cairn has been undertaking various CSR activities pursued through four guiding principles i.e. Partnership with Government; Community Participation; Inclusivity; and Sustainability. Their CSR interventions are targeted at five (5) thematic areas i.e. Nandghar, Barmer green city, education, health and skill training.

3.1.12.2 Midstream Study Area

74) The midstream study area passes through 209 revenue villages and 6 urban settlements scattered across different districts of Rajasthan and Gujarat. Total population of study area villages and urban settlements is over 10 lakhs with the sex ratio of 928 female per thousand male population. Percentage of vulnerable groups like SC & ST are 9.5% & 1% respectively of total population in the study area. Total literacy in pipeline route is 76.9% with female literacy standing at 68.7%.

75) Cairn CSR activities for cross-country pipeline corridor from Barmer to Bhogat consists of programs in four thematic areas: Health, Education, Infrastructure and Economic Development.

4.1 Impact Assessment
4.1.1 Impacts during Construction phase

4.1.1.1 Impact on Land Environment due to upstream and midstream Project Components

76) For the upstream project components, there will be requirement of additional ~150 ha land for development at new RGT, MPT expansion (including township and living quarters) and associated utilities in southern part of RJ Block. For the midstream project, additional ~30 ha of land will be required in Gujarat state for setting up boosting stations for the new gas pipeline proposed within the existing pipeline corridor.

77) Potential impact include long term land use change of the additional land of 150 ha for upstream and 30 ha for midstream projects components; loss of topsoil (during trenching in midstream ~600 km pipeline laying); loss of agricultural land; and potential soil contamination.

Mitigation Measures

78) Following mitigation measures will be in place:
- Location of additional 150 ha land shall be finalized by avoiding acquisition of agricultural land to the maximum extent possible;
- Areas with dense vegetation or close to the water bodies shall be avoided;
- Distance of 500 m and above will be maintained from nearby settlement to any of the proposed project components;
- Immediate restoration of area trenched for midstream natural gas pipeline (of 600 km from RGT to Bhogat) laying in the existing pipeline corridor. The pipeline corridor will be brought to its best achievable original state after completion of the subsurface pipeline laying activity, thus to merge it with the best achievable surrounding land use;
- All topsoil encountered shall be piled and protected from erosion at appropriate locations for reuse in original landscape in pipeline corridor and greenbelt development in upstream project components premises;
- Ensure all excavated soil is well bunded and protected to minimize soil erosion through rain or wind;
- Remove all wastes from and area surrounding the upstream and midstream project components;
- Adequate provision shall be made for segregation of solid and other wastes, their storage and easy access of dustbins;
- All paints, solvents, oils and wastes must be stored in a dedicated area which shall be weather proof and imperviously floor area with bund wall;
- Preventive maintenance of construction equipment and temporary storage areas, to prevent occasional leaks. Drip pans shall be used to collect any oil drips;
- Hazardous wastes (filters, rags, etc.) shall be collected and stored in leak proof containers for disposal to an approved disposal facility for handling these waste products;
- Cairn will monitor and supervise their contractors for all construction activities to prevent any potential soil and groundwater contamination.

4.1.1.2 Impact on Air Quality due to upstream and midstream Project Components

79) Major source of air emissions during construction will include earth moving, developing building foundations for process equipment construction, development of township and living quarters, pipeline laying, civil works in existing pipeline corridor and other sites, handling of construction material and movement of vehicles. Key pollutants of concern include PM$_{10}$ and PM$_{2.5}$ due to incidental exceedance in their values in baseline air quality data.

Mitigation Measures

80) Following mitigation measures will be in place:
- Enclosures and dust curtains to be provided at all construction sites;
- Water spray, is an effective way to keep dust under control. Misting systems and sprinklers are mechanisms that can be employed to deliver continuous moisture. Keep in mind, however, that fine mists may be used to control fine particulate. The size of the water droplet must be comparable to the size of the dust particle so that the dust adheres to the water;
- All material storages areas/warehouses to be adequately covered and contained so that they are not exposed to situations where winds on site could lead to dust / particulate emissions;
- Reducing vehicle speed. Speed bumps are commonly used to ensure speed bumps. In case where speed reduction cannot effectively reduce fugitive dust, it may be necessary to divert traffic to nearby paved areas;
- Ensure periodic preventive maintenance of vehicles and equipment;
- Regular monitoring of ambient air quality during the construction period to ensure compliance and corrective actions in case of any exceedances;
- Strengthening of existing greenbelt to act as wind shield and also help in preventing soil erosion.

4.1.1.3 Impact on Noise Quality due to upstream and midstream Project Components

81) Potential impacts due to high noise generation during use of heavy machineries, transportation of men and material, and civil construction which will result in temporary increase in the ambient noise levels. The noise generated from some construction activities easily may exceed the OSHA limit of 85 dBA and require the use of hearing protection devices (HPDs). The baseline data indicated that the noise levels in the study area were by and large within the prescribed standards.

Mitigation Measures

82) Following mitigation measures will be in place:
- Acoustic barriers will be placed near construction sites, for the continuous noise sources operating for one hours and beyond with noise levels of more than 85 dB(A);
- The maximum noise levels from construction sites will be aimed to limit to 75 dB(A) Leq(5 min.) at the fence line and comply with L_{eq} day of 55 dB(A) and L_{eq} night of 45 dB(A) at nearby residential area;
- The construction sites will be protected by providing fencing to control entry of outsiders;
- Vehicular speed limit of 40 kmph will be maintained for HMVs and 50 kmph of LMVs thus to minimize any disturbance due to noise to any nearby settlements or wildlife;
- While planning care will be taken such that the living quarters are adequately maintained with setback distance of minimum 300 m from state and national highways;
- Night-time activities shall be restricted to essential activities only;
- Regular maintenance of machineries used for construction will be carried out to ensure minimum noise generation.

4.1.1.4 Impacts on Water Environment due to upstream and midstream Project Components

83) In the absence of supply of surface water resource, potential impacts on water environment will be on groundwater resources due to water requirement for domestic and civil construction activities of upstream and midstream area including for hydrotesting of pipeline. Requirement of water during construction phase will be met from treated terminal water (if nearer to the terminals), which sources saline groundwater as per approved withdrawal by CGWA. For small construction activities requiring less than 10 m³/day of construction water will be sourced through tankers of Cairn treated water supply network. Impact on water quality will be due potential
Mitigation Measures

84) Following mitigation measures will be in place:

- The construction contractors shall maintain a record of water consumption and wastewater generation at site and shall reuse and recycle treated domestic and construction wastewater to the extent possible;
- Only deep saline aquifers to be tapped for groundwater withdrawal as per CGWA approved quantity and locations;
- Water storages will be kept covered and ensure no leakage from them;
- Install rainwater harvesting system prior to start of other construction activities at each upstream major construction sites of MPT expansion, new RGT, township and living quarters;
- Provision of modular toilets for construction sites located at remote locations such as satellite well pads, pipelines ROU. For construction camps and civil construction work at upstream projects, provision of septic tank followed by soak pit will be made as per the IS2470 requirements;
- The runoff from construction areas should not be mixed with the septic tanks or soak pits or allowed to percolate direct into the ground. Separate drains to be provided for domestic wastewater and surface runoff water;
- Areas for storage and handling of construction materials should be water protected/waterproofed and have a drainage system, so that any spills and wash waters can be directed to treatments;
- Avoidance of construction activity during monsoon season;
- Hydro test water will be reused for multiple tests for pipeline/tank testing wherever possible. The final hydro test wastewater will be discharged only after prior treatment to comply with the general standards of discharge as per the requirement of the Environment (Protection) Rules, 1986.

4.1.1.5 Impacts on Ecology of upstream and midstream Project Components

85) Site preparation and civil construction at MPT, RGT and along the Pipeline RoU will involve clearance of vegetation and disturbance to animal habitat. Risks to faunal species includes road kills while relocating habitat, hunting and trapping of wildlife by influx labourers. Some faunal species may have to relocate their habitat and in that process risk themselves to danger of road kills. Some habitat improvement measures like plantation and solar powered water hole for wildlife has been taken by Cairn in the study area.

86) In midstream study area, the pipeline is not passing through any protected area or forest area rather it is mostly located on private and revenue land parcels though may pass close to few water bodies. The water bodies are habitats for migratory species. The construction phase of the pipeline may pose a temporary barrier for movement between hunting/foraging grounds for mammalian species.

Mitigation Measures

Upstream

87) Following mitigation measures will be in place:

- Vegetation removal should be guided by an ecologist to ensure bird nest surveys and relocation of active nests should be undertaken with help of forest department.
- For felling of trees prior approval from State Forest Department shall be obtained;
- In case burrowing animal presence is confirmed by the ecologist at the site clearance location, they also be relocated using assistance from forest department;
All vegetation to be carefully removed, efforts for replantation of larger tree species to be explored;
• Local tree plantation should be undertaken at all avenue locations possible;
• Blanket ban on hunting and trapping of wildlife should be imposed and should be covered under contractual obligations;
• Identification of wildlife road crossings on the roads developed for project and public roads used for project. Usage of sign boards for speed limits @15 km/hr and awareness for drivers for avoiding over speeding on such roads should be carried out; and
• Cairn should look for more opportunities in restoration of degraded forest habitats within the RJ-ON-90/1 Block and installing waterholes in areas where water scarcity has occurred recently and due to human intervention as identified by the forest department. Periodic monitoring for the vegetation survival and effectiveness of these waterholes should be carried out.

Midstream

Following mitigation measures will be in place:
• At sections where the likelihood of animal crossings are more likely, extra caution on wildlife crossings should be taken at these stretch;
• A wildlife rescue team in consultation with forest department should be deployed in the construction areas with a mobile van and basic veterinary facility;
• Vegetation clearance for the existing pipeline should be carefully carried keeping in mind for burrowing animals and under supervision of a trained animal catcher;
• The top soil of the excavated areas should be kept separately for reinstatement after completion of pipeline laying work. Local grass species should be used for reseeding the excavated areas;
• Proper levelling should be done after construction work is over;
• Natural areas, if exposed to be back filled material, to be restored with local grass species;
• Blanket ban on hunting and trapping of wildlife should be imposed and should be included in contractual obligations;
• Proper driver training (for defensive driving) to be provided to regular drivers to avoid any road kills.
• Identification of regular road crossing areas in the pipeline route will further help in minimizing road kill events by installation of wildlife crossing road signs, a series of rumble strips on roads indicating drivers that they are entering a wildlife road kill prone areas.

4.1.1.6 Impacts on Socio-Economic Environment due to upstream and midstream Project Components

Potential source of impact on socio-economic environment have been identified due to additional land requirements for the proposed augmentation of upstream and midstream project components, crop productivity, community health, safety and security risks such as accidents due to movement of heavy vehicle, altercation in community due to influx of migrant workers and interference with common property resources of local community like access roads, water resources etc.

Mitigation Measures

Following mitigation measures will be in place:
• Agriculture and pasture land should be avoided to the extent possible in site selection process for proposed satellite gas fields;
• The shortest distance should be considered for access road, with additional care to avoid division of land parcels into agriculturally unviable fractions;
- Land owners of required land parcels should be properly consulted and compensation rate should be arrived based on guidelines provided in Land Acquisition, Rehabilitation and Resettlement (LARR) Act, 2013;
- The alignment of the inter and intra well pads/terminals pipelines should be selected to avoid the number of residential structures within pipeline ROUs (though Barmer District has scattered population) and minor deviation of route should be considered where feasible;
- Any affected group other than land owners/titleholders like sharecroppers, should also be identified and considered for appropriate compensation in the process of assessing loss of livelihood opportunities and other assets of project affected group due to land procurement for the project;
- The village road identified for accessing proposed project footprints, should be strengthened and widen as per requirement before starting construction work;
- Appropriate awareness program on grievance redressal mechanism, should be designed and implemented for local community around proposed project footprints;
- Concerns of local panchayat regarding any impact on their common property resources (like of use of village road, water resource etc.) due to project activities, should be proactively identified and addressed;
- Losses incurred on account of decreased agriculture produce due to due to any disturbance should be adequately assessed and compensated;
- Villages along pipeline corridor, should be informed in advance about the schedule and duration of construction work areas to avoid conflict with any social functions or religious ceremonies besides general awareness;
- Temporary labour shed/colony set up by contractors, should be provided with basic amenities such as sanitation, water arrangement for drinking & other domestic uses, fuel for cooking, lighting etc., as mentioned in Cairn SOP for workers accommodation.

### 4.1.2 Impacts during Operation Phase

#### 4.1.2.1 Impact on Land Environment due to upstream and midstream Project Components

91) Potential impacts on land environment for the upstream and midstream operations mainly includes soil contamination from improper handling and storage of hazardous wastes, spillage of oil and chemicals and discharge of untreated domestic and industrial wastewater on land. The hazardous waste generated from the process units consists of used/waste oil, tank bottom sludge, ETP sludge, paint drums, oil filters, etc. In addition, there will be small quantity of biomedical waste from the occupational health centre mainly needles, discarded medicines etc. Apart from this, domestic waste is generated from the operation and development facilities, which mostly consist of biodegradable organic matter and recyclable wastes. The recyclable wastes are disposed through scrap vendor for further recycling process. There will be organic waste generated from the canteen, township and living quarters etc. This waste shall be processed using organic waste converter and will be used as a manure for the greenbelt.

92) From midstream inter and intra field and cross country pipeline project components, there is a potential for impact on soil quality due to activities such as cleaning and maintenance (e.g. pigging of pipelines) and handling and storage of hazardous waste and chemicals (e.g. waste oil, oil contaminated filters).

#### Mitigation Measures

93) Following mitigation measures will be in place:
- All the wastes shall be segregated at the source of generation and disposed as per authorization of RSPCB in the legally acceptable manner;
- All recyclable hazardous wastes such as used oil, waste oil, used containers etc., and recyclable non-hazardous waste such as metals and non-metals (paper, cardboard, wood, plastic etc..) are disposed to RSPCB/ CPCB/MoEF&CC.
authorized vendors for upstream and midstream projects and to GPCB/CPCB/MoEFCC authorized vendors for cross country pipeline related operations in Gujarat;

- The assessment of all temporary storage area for hazardous wastes shall be carried out every quarter to check on its adequacy;
- Cairn shall continue to maintain the inventory of all hazardous and non-hazardous wastes including the biomedical wastes generated at site including that from the proposed expansion project.

4.1.2.2 Impact on Air Quality due to upstream and midstream Project Components

Potential impacts on air quality for the upstream and midstream operations will be due to the emissions from stationary point sources, flaring, vehicular emissions and greenhouse gas emissions. In order to understand the impacts on air quality from the proposed oil and gas augmentation and other associated utilities was carried out using air dispersion model AERMOD based on one year (Jan. 2017 to Dec. 2017) meteorological data by Lakes Environmental. The predicted maximum concentrations from the proposed expansion project was found to be within the prescribed limits at all receptor locations. The maximum 24 hourly GLC of Particulate Matter, Sulphur Dioxide and Nitrogen dioxide and 8-hourly Carbon Monoxide predicted for proposed expansion was 0.8, 3.21, 28.8 and 44.0 µg/m³ respectively. The projected concentrations of all the pollutants Particulate Matter, Sulphur Dioxide, Oxides of Nitrogen and Carbon Monoxide from the proposed project expansion in the study area were found to be within the prescribed limits (NAAQS) for all pollutants except for PM at some locations (AAQ3, AAQ7, AAQ13 and AAQ16). The reason for exceedance in PM concentrations are solely due to their exceeding background concentrations. The results indicate that impacts from the point and flare source emissions during the operation phase are not anticipated to cause any significant adverse impact to the air quality of the RJ-ON-90/1 Block.

Mitigation Measures

Following mitigation measures will be in place:

- High efficiency flare tips to be installed in all flares;
- All emission sources to be monitored regularly to ensure compliance;
- Green belts and landscaping should be strengthened to act as an effective means to control air pollution;
- Install low NOx generating new gas turbine generators to reduce NOx emissions.
- Cairn shall ensure periodic preventive maintenance of all of its vehicles including that of the subcontractors. Effective strategies focusing on vehicle maintenance have the following key elements:
  - Emissions testing, which provides a mechanism to identify vehicles that are not performing according to regulations;
  - Driver and fleet manager education and training, which is important in facilitating the acceptance of emissions testing components, such as inspection and maintenance programmes, and such training can specifically target high-kilometrage drivers;
- Driver training to also include aspects related to use of cleaner fuels, avoid congestions to reduce idling time, switching off engines for long duration waiting etc.;
- Maintaining optimum vehicle speed. Speed bumps are commonly used to ensure speed bumps;
- Regular monitoring of ambient air quality to ensure compliance and corrective actions in case of any exceedances.

4.1.2.3 Impact on Noise Quality due to upstream and midstream Project Components

Potential impacts on noise quality in upstream and midstream study area can be due to operation of equipment’s, machineries, DG sets, power generation process etc.
Prediction of noise levels for the proposed project was undertaken using SoundPLAN 7.2. The modelling results indicate that the incremental noise levels from the proposed augmentation will range from 37.0 dBA (at oil well pad) to 59.6 dBA (at RGT). The resultant day and night time noise levels (together with baseline) range from 45.8 dBA to 66.1 dBA (at oil well pad) and from 41.0 dBA (at oil well pad) to 64.5 dBA (at RGT) respectively. The noise prediction outputs indicate that the noise generated from various equipment’s from the proposed project augmentation at MPT, RGT and typical well pads will be within the prescribed limits within the boundaries and attain the background levels outside the project components’ boundary.

Mitigation Measures

97) Following mitigation measures will be in place:

- Efficient engineering controls during installation of equipment and machineries shall be ensured to reduce noise emission levels at source;
- Maintaining adequate offset distances from noise generating equipments;
- The machinery deployed in the plant should be designed with the sufficient noise and vibration controls for minimizing noise at source and purchased through reputed manufacturers and vendors;
- DG sets shall be provided with acoustic enclosures conform to the maximum permissible sound pressure level of 75 dB(A) at 1 m from the enclosure surface. The DG sets are also fitted with a proper exhaust muffler to ensure that an insertion loss of minimum 25 dB(A) is achieved to meet the requirements of The Environment (Protection) second Amendment Rules, 2002;
- Preventive maintenance of equipment and machineries shall be undertaken regularly;
- Periodic audiometric tests for employees working close to high noise levels, such as compressors, DG sets, the loading and unloading sections shall be conducted;
- Periodic job rotation shall be provided to the employees, who are working continuously in the high noise areas;
- Personal protective equipments (PPE) like ear plugs/muffs shall be provided to workers and staff at the site;
- Green belts and landscaping should be strengthened to act as an effective means to control noise pollution.

4.1.2.4 Impact on Water Resource and Quality due to upstream and midstream Project Components

98) Saline water of ~93,500 m³/day quantity will be abstracted from deep aquifers in Thumbli, Fatehgarh and Jagadia formations for mainly injecting in reservoirs to maintain well pressure. The impact of saline water abstraction on these aquifer was evaluated using MODFLOW (Flow model) and MT3DM model (solute transport model) and it has been observed that there will not be significant change in the aquifer pressure and water quality in the fresh water zone. Also the groundwater modelling was used to assess the impact of aquifer de-saturation and it was found that estimated withdrawal will not lead to any land subsidence in the project area. Other water requirements include boiler water make-up, chemical dilution, firewater utilities, greenbelt and domestic usage.

99) Out of total wastewater generated from these activities, only treated sewage will be used for green belt development, other wastewater streams will be comingled with the injection water.

100) The operation of midstream pipeline will not result in impact on water resource. However, pigging waste from pipelines, if not managed, will result in potential contamination of subsurface aquifers.

Mitigation Measures

101) Following mitigation measures will be in place:

- Garland drains shall be provided along the well pad site;
• The reject from the desalination process is co-mingled with the injection water and injected back into the oil reservoir for pressure maintenance and/or disposed to the existing deep disposal (dump) well;
• Compliance to all CGWA permit conditions;
• Bulk of raw water is used as injection water. The injection water is treated in injection water treatment system to meet the required water quality;
• Reject from desalination is routed to injection water treatment system and is pumped back into the reservoir;
• Runoff from well pad shall be channelized through a silt trap to prevent discharge of silt from project area to nearby rain water storages (ponds and tanks);
• Provision shall be made for installing dump wells for disposal of any effluent/liquid discharge, which cannot be co-mingled with the injection water. The discharge standards specified for TSS and OIW shall be maintained before discharge to existing deep dump/disposal wells;
• Rain water collection and ground water recharge systems shall be developed to collect runoff from paved areas in the augmentation area of MPT and RGT;
• Existing rainwater harvesting at community locations such as schools, hospitals, local body office building etc. to continue to further strengthen the watershed management practices.

4.1.2.5 Impact on Ecology due to upstream and midstream Project Components

102) Operations of RJON Block and pipeline from Barmer to Bhogat will have limited impacts to biodiversity. The potential impacts from the operation stage are road kills due to movement of the vehicles, and hunting and trapping of wildlife.

Mitigation Measures

103) Following mitigation measures will be in place:
• Identification of locations where maximum road kill incidents are reported;
• Vegetative barriers to be created on such roads with road kill incidents;
• Inventory of species killed in road kill to be made by incident reporting system covering the drivers and Health, Safety and Environment (HSE) Managers to further make modifications to the mitigation measures targeting the species and road stretch in question;
• All the wild animals killed by the road accident shall also be reported to the District Forest Officer (DFO) and as per the Cairn’s Standard Operating Procedure (SOP), the dead animals shall be handed over for burial with the permission of DFO.
• Changing driver behaviour such as attitude to wildlife crossings by increasing public awareness, increasing awareness of location where maximum road kills occur and slowing speed when a wildlife crossing is observed;
• Provide signage to alert drivers that they are entering a wildlife crossing zone and including advisory signs including rumble strips on roads to reduce speed and be careful to avoid any road kill of wildlife;
• Changing species behaviour includes discouraging wildlife from grazing on roadsides, preventing wildlife from crossing roads or providing safe crossings;
• Electrocution reduction programme should be actively implemented along all project facility by replicating the existing programme at terminals and well pads;
• Minimal ground clearance of 6-8 m to all power line towers should be maintained in areas where the road stretch is elevated in later developments;
• At stretches where the minimal ground clearance cannot be maintained additional protection measures should be provided to avoid Indian Peafowl to fly to these Power line towers.
• Night road travel shall be minimized and controlled through Journey Management Plan.
• Develop greenbelt surrounding the proposed project components immediately from their date of commissioning.
4.2.1.6 Impacts on Socio-Economic Environment due to upstream and midstream Project Components

104) Potential impacts as anticipated on socioeconomic environment during upstream and midstream project components operations include light and visual impacts due to flaring, community health and safety and employment generation and local area development.

Mitigation Measures

105) Following mitigation measures will be in place:
- The village road identified for accessing proposed project footprints, should be strengthened and widened as per requirement before starting construction work;
- Appropriate awareness program on grievance redressal mechanism, should be designed and implemented for local community around proposed project footprints;
- Concerns of local panchayat regarding any impact on their common property resources (like of use of village road, water resource etc.) due to project activities, should be proactively identified and addressed;
- Ensure proper bunding all along the well pads or facilities involved with storage of oil and chemicals. All oil and liquid chemicals shall be provided with secondary containments to ensure no escape of pollution to outside fields;
- Losses incurred on account of decreased agriculture produce and effect on animal husbandry due to impacts such as exposure to flaring, oil spillage etc.; should be adequately assessed and compensated.

4.2.1.6 Decommissioning / Restoration related impacts

106) After completion of project life, the potential impacts from the RJ Block Upstream and Midstream operations will be due to abandonment and restorations operations of following sections:
- Plugging and abandonment (P&A) of all drilled wells and well-site restoration.
- Decontamination and Decommissioning of the upstream processing facilities at Mangala Processing Terminal (MPT), Raageshwari Gas Terminal (RGT) and satellite fields.
- Decontamination and Decommissioning of the midstream pipeline operation facilities, which includes Viramgam Crude Oil Storage Terminal, Radhanpur Crude Oil Storage Terminal, Bhogat Crude Oil Storage Terminal, Sectionalizing Valve and Above Ground Installations.
- Decontamination and Decommissioning of the marine facilities at Bhogat offshore, which includes crude oil and wastewater subsea pipeline, SPM (Single Point Mooring) and restoration of the sea bed.
- Decontamination and Decommissioning of infield and export gas/oil transportation pipelines.
- Other associated facilities such as warehouses, mud plant, polymer processing facilities, water treatment plants, sewage treatment plants, effluent treatment plants, living quarters, electrical sub stations, townships, above ground installations
- Restoration of the captive land fill sites (hazardous and non-hazardous) including dismantling of the incinerators.

Mitigation Measures

107) Following mitigation measures will be in place:
- Cairn will carry out the Decommissioning, Abandonment and Restoration (DAR) and Environment Management Plan (EMP) report specific to the project activities in the end of life of the operating assets, at least two (02) years before the start of decommissioning and restoration activities.
This plan shall be prepared in line with the “Site Restoration and Abandonment Guidelines for Petroleum Operations” document no 20557/2017/DIR (EXPL-I)-PNG, April 2017 issued by Directorate General of Hydrocarbons (DGH).

5.1 Public Hearing and Risk Assessment

108) The Public Hearing for the Proposed expansion Project was supposed to be held on August 20th 2018 at Rajkiya Uchh Prathmik Vidhyalaya, Sar Ka Paar, Gram Panchayat Dhunda, Kawas, District Barmer, Rajasthan. However, District Collector stating the law and order issue cancelled the Public Hearing. The rescheduled Public Hearing was held on September 28th 2018 at 11.00 am at the same above venue. The Public hearing was conducted in presence of District Collector, Barmer, Shri Shiv Prasad M Nakate and Regional Officer RS PCB Balotra, Barmer, Shri Vinay Katta. The list of villagers of region and members present in Public Hearing.

109) Risk assessment from different facilities – MPT, RDG, satellite oil and gas well pad, storage tanks and pipelines due to potential hazards such as pool fire, jet fire, vapour cloud explosion, leaks etc. was assessed. As per the consequence modelling results, the effect zones are expected to remain within the Project premises. Detailed emergency response plan is already in place and shall be revised to include the proposed project components.

6.1 Environment Monitoring Plan

110) A comprehensive environmental monitoring plan has been prepared to monitor ambient air quality, noise level, soil and groundwater quality through MoEF&CC approved and NABL accredited laboratory during construction and operation phases. This will help to assess the implementation and effectiveness of environmental management plan.

7.1 Environment Management Plan

111) Environmental Management Plan detailing implementation mechanism for the identified mitigation measures and related monitoring plans has been formulated. The management plan comprises of detailed plans for Waste Management, Water and Wastewater Management, Occupational Health and Safety Management, Oil Spill Management, Emergency Response etc.

112) Approximately 10% of the Project cost will be included as a budget for Pollution Control, Environmental, Health and Safety management, environmental monitoring and contingency cost for the proposed entire oil and gas development Project.

7.1.1 HSE Organization Structure

113) Cairn has a well-defined Organization for HSE Management System. Rajasthan and midstream pipeline operations are certified with ISO 14001: 2015 and OHSAS 18001: 2007. The team under the Head Operations and Head Projects oversees the total activity on a day-to-day basis. All individual departments are accountable for the HSE compliance in and around them.

114) The HSE department consists of officers from various HSE specialists such as Fire, Risk, Environment, Sustainability, HSE design, compliance & governance, process safety, construction safety (including experts of occupational health, electrical safety, confined space, scaffolding, lifting, work at height etc.), drilling & petroleum Engineering, environmental laboratory, horticulture, waste management etc., to co-ordinate the activities concerned with the management and implementation of the HSE control measures.

7.1.2 Proposed CSR Strategy

115) Cairn has a separate budget for CSR activities, which is taken up and spent in consultation with the local administration on annual basis for CSR development in the RJ Block. The tentative budget considered annually is INR 50 Crores, consolidating to the commitment of INR 300 Crores over 7 years’ periods.
In addition, Cairn also commit to spend additional INR 15 Crores as one time spent towards Corporate Environmental Responsibility (CER) requirements as specified by the MoEF&CC office order dated 1st May ’18 on CER. The cost to be spent for CER, will be in addition to the cost envisaged for the implementation of the EIA/EMP.

8.1 Conclusion

The overall assessment of impacts and effective implementation of mitigation measures, as included in the EMP, shows that the impact significance due to the existing and proposed expansion of upstream and midstream oil and gas development and production would remain within acceptable levels.

Cairn will continue monitoring during the project life cycle of all emissions and discharges to ensure conformance to the prescribed environmental standards and compliance of regulatory requirements. Where required, necessary actions and control measures will be implemented to ensure compliance throughout the project life cycle.

Summary of Proposed Capacity Augmentation

Table A

Proposed Project Summary

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Facility</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>OIL AUGMENTATION TO PRODUCE UP TO 400,000 BOPD &amp; 250 MMSCF ASSOCIATED GAS</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Total fluid handling capacity (in oil processing facility)</td>
<td>1.6 million BLPD</td>
</tr>
<tr>
<td>2.</td>
<td>Local de-watering facilities in MBA Field to additionally handle the fluid</td>
<td>60,000 BLPD each of 10 nos.</td>
</tr>
<tr>
<td>3.</td>
<td>CO2 separation from the associated gas and injection to the reservoir</td>
<td>50 MMSCF</td>
</tr>
<tr>
<td>4.</td>
<td>Total associated gas production from the oil fields</td>
<td>250 MMSCF</td>
</tr>
<tr>
<td>5.</td>
<td>Additional oil production</td>
<td>100,000 BOPD</td>
</tr>
<tr>
<td>6.</td>
<td>Sulphate Removal Plant (to remove sulphates from deep saline water and injection water)</td>
<td>500,000 BWPD</td>
</tr>
<tr>
<td>7.</td>
<td>ETP Upgrade to handle overall wastewater of quantity</td>
<td>50,000 BWPD</td>
</tr>
<tr>
<td>8.</td>
<td>Enhanced Oil Recovery (EOR) flooding using Alkali, Surfactant and Polymer</td>
<td>Covering all fields at RJ-ON-90/1 Block in a phased manner</td>
</tr>
<tr>
<td>9.</td>
<td>ASP Chemicals to be stored at the site</td>
<td>Alkali - 1,600 TPD, Surfactant - 170 TPD, Polymer - 300 TPD</td>
</tr>
<tr>
<td>10.</td>
<td>Lime softening package to treat injection water</td>
<td>660,000 BWPD, Lime - 175 TPD</td>
</tr>
<tr>
<td>11.</td>
<td>Solid waste to energy facility</td>
<td>10 TPD</td>
</tr>
<tr>
<td>12.</td>
<td>Waste oil reprocessing facility</td>
<td>1,000 BOPD</td>
</tr>
<tr>
<td>13.</td>
<td>Connecting the satellite oil fields through laying new pipeline</td>
<td>10,000 Barrel of crude oil storage tanks at eight AGI locations (AGI 1 to 8)</td>
</tr>
<tr>
<td>14.</td>
<td>Additional land for oil facilities</td>
<td>40 hectares</td>
</tr>
<tr>
<td>B</td>
<td>GAS AUGMENTATION TO PRODUCE UP TO 500 MMSCF NATURAL GAS</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Total gas production (in gas processing terminal)</td>
<td>400 MMSCF</td>
</tr>
<tr>
<td>2.</td>
<td>Total CNG production from gas satellite fields</td>
<td>100 MMSCF</td>
</tr>
<tr>
<td>3.</td>
<td>Condensate production</td>
<td>70,000 BPD</td>
</tr>
<tr>
<td>4.</td>
<td>LPG Production</td>
<td>500 TPD</td>
</tr>
<tr>
<td>5.</td>
<td>CNG and LPG fuel filling stations</td>
<td>50 nos.</td>
</tr>
<tr>
<td>6.</td>
<td>Additional land for gas facilities</td>
<td>110 hectares</td>
</tr>
<tr>
<td>7.</td>
<td>Captive power requirement for oil and gas facilities</td>
<td>200 MW</td>
</tr>
<tr>
<td>C</td>
<td>EXPORT PIPELINE</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>New Export Gas pipeline of 30” diameter from RGT to Bhogat</td>
<td>600 km length with gas export capacity of 500 MMSCF</td>
</tr>
<tr>
<td>2.</td>
<td>Additional land for gas facilities</td>
<td>30 hectares</td>
</tr>
<tr>
<td>D</td>
<td>TOWNSHIP &amp; OFFICE COMPLEX</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Proposed in multiple locations within Barmer District consisting of</td>
<td>Total 1600 nos of flats including hostel, living quarters, township amenities and office complex to be constructed at different locations in multi-storey buildings consisting of total three million square feet built-up area.</td>
</tr>
</tbody>
</table>

ERM EIA STUDY FOR THE PROPOSED EXPANSION OF ONSHORE OIL AND GAS PRODUCTION - CAIRN OIL & GAS (VEDANTA LTD.)
PROJECT # 0423192 FROM RJ-ON-90/1 BLOCK, BARMER, RAJASTHAN, NOVEMBER 2018
ES-XXII
### Table B

**Proposed Project Emission Summary**

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Plant</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>RGT New Plant</td>
<td>HP Flare - 5 nos., Capacity - 200 MMSCFD each</td>
</tr>
<tr>
<td>2.</td>
<td>Dewatering</td>
<td>Gas Engine Generator - 20 nos., Capacity - 3 MW each</td>
</tr>
<tr>
<td>3.</td>
<td>Sulphate Removal Plant</td>
<td>Emergency Diesel Generator - 1 no., Capacity - 1.5 MW</td>
</tr>
<tr>
<td>4.</td>
<td>Inside MPT Layout</td>
<td>IWBH - 4 nos., Capacity - 5 MW each</td>
</tr>
<tr>
<td>5.</td>
<td>MPT - Expansion</td>
<td>IWBH or Heater Treater – 50 nos., Capacity - 2 MW each</td>
</tr>
<tr>
<td>6.</td>
<td>Typical Oil Producing Satellite Field</td>
<td>IWBH or Heater Treater – 10 nos., Capacity - 5 MW each</td>
</tr>
<tr>
<td>7.</td>
<td>Typical Gas Producing Satellite Field</td>
<td>Gas Engine Generator– 10 Nos., capacity - 500 kW each</td>
</tr>
<tr>
<td>8.</td>
<td>Solid waste to energy facility</td>
<td>Plasma gasification reactor - 1 no., 10 TPD capacity</td>
</tr>
<tr>
<td>9.</td>
<td>Midstream</td>
<td>Pipeline Booster compressor - 8 nos., Capacity - 25 MW each</td>
</tr>
</tbody>
</table>

### Table C

**Water and Wastewater Summary**

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Plant</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Sulphate removal Plant</td>
<td>Treatment Plant Capacity - 80,000 m³/day</td>
</tr>
<tr>
<td>2.</td>
<td>Dewatering</td>
<td>Reject from the SRP – 10,000 m³/day</td>
</tr>
<tr>
<td>3.</td>
<td>Multiple Stage RO treatment plant</td>
<td>Treatment Plant Capacity - 10,000 m³/day</td>
</tr>
<tr>
<td>4.</td>
<td>ASP - Produced water treatment plant</td>
<td>Reject from the ASP produced water treatment facilities - 25,000 m³/day</td>
</tr>
<tr>
<td>5.</td>
<td>Dewatering</td>
<td>Liquid reject from the dewatering wells – total capacity - 1,000 m³/day</td>
</tr>
<tr>
<td>S.N.</td>
<td>Plant</td>
<td>Description</td>
</tr>
<tr>
<td>------</td>
<td>-------------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>8.</td>
<td>RGT Produced water</td>
<td>Produced water treatment plant capacity - 2,000 m³/day</td>
</tr>
<tr>
<td>9.</td>
<td></td>
<td>RGT RO treatment plant - 1,500 m³/day</td>
</tr>
<tr>
<td>10.</td>
<td></td>
<td>RGT RO reject - 400 m³/day</td>
</tr>
<tr>
<td>11.</td>
<td>Satellite Field</td>
<td>Produced water reject disposal - 200 m³/day</td>
</tr>
<tr>
<td>12.</td>
<td></td>
<td>Produced water for natural evaporation – 20 m³/day at each location</td>
</tr>
</tbody>
</table>