# DRAFT ENVIRONMENTAL IMPACT ASSESSMENT REPORT & ENVIRONMENTAL MANAGEMENT PLAN (EIA/EMP)

**for**

## Proposed Onshore Oil and Gas Development & Production from KG/ONDSF/KAZA/2018 Block, Krishna District, Andhra Pradesh

## By

## Vedanta Limited. (Division: Cairn Oil & Gas)

**Block Area: 114.93 km$^2$**

**No. of Well: 35**

**Production Capacity: 30,000 Barrels of Oil per Day (BOPD) and 30 Million Metric Standard Cubic Feet (MMSCFD) of gas**

**[ToR Letter No: IA-J-11011/52/2020-IA-II (I) dated 02 April 2020]**

**[Monitoring period: 1st December 2019 to 29th February 2020]**

**[Monitoring done by In-house laboratory (NABL Accreditation TC-6603 MOEFCC No. S.O. 5768 (E).—S.No. 169)**

**[Schedule 1 (b) Category–"A" As per EIA Notification 2006 and its Amendment thereof]**

**ENVIRONMENTAL CONSULTANT**

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**Doc No: 2020_ECSS_EIAI2_2000002**

**October 2020**

# NABET CERTIFICATE

## Quality Council of India

National Accreditation Board for Education & Training

## Certificate of Accreditation

### Eco Chem Sales & Services

Office Floor, Ashoka Pavillion - A,Opp. Kapadia Health Club, New Civil Road
Surat-395001

***Accredited as Category - A*** *organization under the QCI-NABET Scheme for Accreditation of EIA Consultant Organizations: Version 3 for preparing EIA-EMP reports in the following Sectors:*

| | Sector Description | Sector (as per) NABET | Sector (as per) MoEFCC | Cat. |
|---|---|---|---|---|
| 1 | Mining of minerals (Opencast only) | 1 | 1 (a) (i) | A |
| 2 | Offshore and onshore oil and gas exploration, development & production | 2 | 1 (b) | A |
| 3 | Thermal power plants | 4 | 1 (d) | A |
| 4 | Metallurgical industries (ferrous & non-ferrous) | 8 | 3 (a) | A |
| 5 | Cement plants | 9 | 3 (b) | A |
| 6 | Chlor-alkali industry | 13 | 4 (d) | A |
| 7 | Chemical fertilizers | 16 | 5 (a) | A |
| 8 | Pesticides industry and pesticide specific intermediates (excluding formulations) | 17 | 5 (b) | A |
| 9 | Manmade fibers manufacturing | 19 | 5 (d) | B |
| 10 | Synthetic organic chemicals industry (dyes & dye intermediates; bulk drugs and intermediates excluding drug formulations; synthetic rubbers; basic organic chemicals, other synthetic organic chemicals and chemical intermediates) | 21 | 5 (f) | A |
| 11 | Distilleries | 22 | 5(g) | A |
| 12 | Pulp & paper industry excluding manufacturing of paper from wastepaper and manufacture of paper from ready pulp without bleaching | 24 | 5 (i) | A |
| 13 | Oil & gas transportation pipeline (crude and refinery/ petrochemical products), passing through national parks/ sanctuaries/coral reefs /ecologically sensitive areas including LNG terminal | 27 | 6 (a) | A |
| 14 | Isolated storage & handling of Hazardous chemicals (As per threshold planning quantity indicated in column 3 of schedule 2 & 3 of MSIHC Rules 1989 amended 2000) | 28 | 6 (b) | B |
| 15 | Common hazardous waste treatment, storage and disposal facilities (TSDFs) | 32 | 7 (d) | A |
| 16 | Ports, harbours, break waters and dredging | 33 | 7 (e) | A |
| 17 | Highways | 34 | 7 (f) | A |
| 18 | Common Effluent Treatment Plants (CETPs) | 36 | 7 (h) | B |
| 19 | Common Municipal Solid Waste Management Facility (CMSWMF) | 37 | 7 (i) | B |
| 20 | Building and construction projects | 38 | 8 (a) | B |
| 21 | Townships and Area development projects | 39 | 8 (b) | B |

***Note: Names of approved EIA Coordinators and Functional Area Experts are mentioned in SA AC minute dated Nov 16, 2018 and Dec 21, 2018 posted on QCI-NABET website.***

*The Accreditation shall remain in force subject to continued compliance to the terms and conditions mentioned in QCI-NABET's letter of accreditation bearing no. QCI/NABET/ENV/ACO/19/0943 dated March 27, 2019.The accreditation needs to be renewed before the expiry date by Eco Chem Sales & Services following due process of assessment.*

**Sr. Director, NABET**
**Dated: April 16, 2019**

**Certificate No.**
**NABET/EIA/1720/ SA 085(Rev.01)**

**Valid up to**
**Feb 20, 2020**

**For the updated List of Accredited EIA Consultant Organizations with approved Sectors please refer to QCI-NABET website.**

National Accreditation Board
for Education and Training
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July 27, 2020

QCI/NABET/EIA/ACO/20/1399

**Eco Chem Sales and Services**
Office Floor, Ashoka Pavillion - A, Opp. Kapadia Health Club,
New Civil Road, Surat

Sub.: Extension of Validity of Accreditation till Oct 26, 2020 - regarding

Dear Sir/Madam

In view of the outbreak of Corona Virus (COVID-19) and subsequent lockdown declared for its control vide order dated 24th March 2020, issued by Ministry of Home Affairs, Govt. of India, NABET hereby extends the Validity of your Accreditation till Oct 26, 2020.

As soon as, NABET office opens/resumes its operation necessary action regarding issuance of certificate/extension of validity letters / other may be initiated, therefore, ACO to ensure their complete application with NABET, if applicable.

Meanwhile, you may enclose this with your EIA reports along with the certificate/validity letter. The EAC/SEIAA/SEAC/Other are hereby requested to consider the same as a valid document for the preparation of EIA/EMP report.

With best regards.

Sd/-
(A K Jha)
Sr. Director, NABET



Institute of Town Planners India, 6th Floor, 4-A, Ring Road, I.P Estate, New Delhi-1 10 002, India
Tel. • +9 11 -233 23 4 1 6, 417, 18, 419, 420, 421 ,423 E-mail : ceo.nabet@qcin.org Website : www.qcin.org

# DECLARATION OF CONSULTANT

**Declaration by Experts contributing to the EIA report for Proposed Onshore Oil and Gas Development & Production from KG/ONDSF/KAZA/2018 Block, Krishna District, Andhra Pradesh By Vedanta Limited(Division: Cairn Oil & Gas), Schedule 1(b) – Offshore and onshore oil and gas exploration, development & production, Category – "A" as per EIA Notification 2006 and its Amendment thereof.**

I, hereby, certify that I was a part of the EIA team in the following capacity that developed the above EIA.

| | | |
|---|---|---|
| **EIA Coordinator** | : | **Mrs. Rekha Shah** |
| Signature | : | RSShah |
| Date | : | **25/09/2020** |
| Period of involvement | : | **November 2019 – September 2020** |
| Contact information | : | **eco@ecoshripad.com** |

**Functional Area Experts**

| S. No. | Functional areas | Name of Expert | Involvement (Period and task**) | Signature and Date |
|---|---|---|---|---|
| 1. | AP | Mrs. Rekha Shah | **November 2019 – September 2020** Site visits followed by selection of monitoring locations, Supervision of air quality monitoring, Identification of probable impacts of different air emission from the plants/ facilities proposed, suggesting most suitable control device and contribution to EIA documentation. | RSShah |
| 2. | WP | Mrs. Rekha Shah | **November 2019 – September 2020** Site visit & supervision & checking of sampling locations for surface water & Ground water samples & their analysis results, Water use auditing, water balance, water budgeting, water conservation and developing scheme for reuse of water, identification of impacts, finalization of mitigation measures and contribution to EIA documentation. | RSShah |
| 3. | SHW | Mrs. Rekha Shah | **November 2019 – September 2020** Identification of waste generated from the site, confirming adequacy of mitigation measures for management of hazardous waste and contribution to EIA documentation. | RSShah |
| 4. | SE | Mr. Rahul Deshmukh | **December 2019 – February 2020** Conducting baseline socio-economic surveys through interviews / questionnaire from the surrounding area/villages of the proposed project, impact identification and mitigation measures for incorporating to EIA documentation. | Rahul Deshmukh |
| 5. | EB | Mrs. Dipti Patel | **November 2019 – September 2020** Site visit and conduct of ecological survey and preparation of status report for rare endangered and threatened species of animals and plants and also species protected under national laws, assessment of the impacts of proposed project activities on the biological environment and contribution to EIA documentation. | Dipali |

| S. No. | Functional areas | Name of Expert | Involvement (Period and task**) | Signature and Date |
|---|---|---|---|---|
| 6. | HG | Mr. Joshua Anand | **December 2019 – February 2020** Understanding and representing groundwater conditions, supervision of groundwater sampling locations, finalization of survey findings, identification of impacts, suggestion of mitigation measures and contribution to the EIA documentation. | |
| 7. | GEO | Mr. Ravikant Sharma | Not involved as functional area is rationalized as per QCI Scheme for Accreditation Version 3 | -- |
| 8. | SC | Dr. B. K. Patel | **December 2019 – February 2020** Understanding and representing soil conditions, supervision of soil sampling locations, finalization of survey findings, identification of impacts, suggestion of mitigation measures and contribution to the EIA documentation | |
| 9. | AQ | Mr. Dhaval Jhaveri | **November 2019 – February 2020** Evaluation of meteorological data with collected secondary data, modeling and prediction, identification of impacts, finalization of mitigation measures and contribution to EIA documentation. | |
| 10. | NV | Mrs. Dipti Patel | **November 2019 – September 2020** Checking of noise sampling results, analysis of data, identification of impacts and mitigation measures, and contribution to EIA documentation. | |
| 11. | LU | Mr. Joshua Anand | **December 2019 – February 2020** Generation and analysis of data related to land use pattern. Development of land use maps of study area using Arc GIS / related tools, site visit for ground truth survey, finalization of land use maps, contribution to EIA documentation. | |
| 12. | RH | Mr. Vinay Patil | **November 2019 – September 2020** Identification of hazards and hazardous substances Preparation of impacts diagrams & mitigation measures, preparation of disaster management plan, contribution to EIA documentation. | |

**Declaration by the Head of the Accredited Consultant Organization/authorized person**

**I, Rekha S. Shah,** hereby, confirm that the above mentioned experts prepared the EIA for **Proposed Onshore Oil and Gas Development & Production from KG/ONDSF/KAZA/2018 Block, Krishna District, Andhra Pradesh By Vedanta Limited. (Division: Cairn Oil & Gas).** I also confirm that EC has gone through the report, and the consultant organization shall be fully accountable for any mis-leading information mentioned in this statement.
It is certified that No unethical practices including plagiarism have been carried out and external data/text has not been used without proper acknowledgement, while preparing this EIA report.

| | | |
|---|---|---|
| Signature | : | |
| Name | : | **Rekha S. Shah** |
| Designation | : | **CEO** |
| Name of the EIA Consultant Organization | : | **ECO CHEM SALES & SERVICES**<br>Office Floor, Ashoka Pavillion – A, Opp. Kapadia Health club, Surat 395001 (GJ) |
| NABET Certificate No. & Issue Date | : | **NABET/EIA/1720/SA 085 (Rev.01), Valid upto October 26, 2020** |

# CERTIFICATE OF PLAGIARISM CHECK

| | |
|---|---|
| Title of EIA Report: | **Vedanta Limited(Division: Cairn Oil & Gas)** Proposed Onshore Oil and Gas Development & Production from KG/ONDSF/KAZA/2018 Block, Krishna District, Andhra Pradesh |
| **Name of Accredited Organization:** | Eco Chem Sales & Services |
| **Unique Identification Number:** | Company registration number: GUJ/BRT/(10)/15590 |
| **Name of EIA Co-ordinator (EC):** | Mrs. Rekha Shah |
| **Name of the Software:** | Plagiarism Checker X |
| **Date of Check:** | 26.09.2020 |
| **Time of Check:** | 01:00 p.m. |

Declaration by the Head of the accredited consultant organization / authorized person

I hereby certify that this EIA Report has been evaluated using in-house software viz., Plagiarism Checker X version 7.0.2. The report produced has been analyzed by the system and based on it, I certify that the EIA report produced in accordance with good scientific practice.

**Date and Sign of EIA Coordinator:** RSShah

**Name:** Mrs. Rekha Shah

**Designation:** CEO

**Date and Sign of Head of Accredited Organization:** RSShah

**Name of the EIA Consultant Organization:** Eco Chem Sales & Services

**NABET Certificate No. & issue Date:** NABET/EIA/1720/SA 085 (Rev.01), Valid up to October 26, 2020

# UNDERTAKING BY CONSULTANT

ECOCHEM SALES & SERVICES
POLLUTION CONTROL CONSULTANT, ENGINEERS & CONTRACTORS

Dated: 24/09/2020

To,

**The Member Secretary - IA Division (Industry: II)**
Government of India
Ministry of Environment, Forests and Climate Change
Indira Paryavaran Bhavan, Aliganj
Jor Bag Road, New Delhi – 110003.

**Subject:** Undertaking on the compliance of Terms of Reference issued by the MoEF&CC, New Delhi for Proposed Onshore Oil and Gas Development & Production from KG/ONDSF/KAZA/2018 Block, Krishna District, Andhra Pradesh By Vedanta Limited. (Division: Cairn Oil & Gas).

Respected Sir,

We hereby give you an undertaking that the Terms Of Reference (ToR) issued by the MoEF&CC, New Delhi for carrying out Environmental Impact Assessment (EIA) & Environmental management Plan (EMP) studies for Proposed Onshore Oil and Gas Development & Production from KG/ONDSF/KAZA/2018 Block, Krishna District, Andhra Pradesh By Vedanta Limited. (Division: Cairn Oil & Gas).

**Yours Sincerely,**

RSShah

**ECO CHEM SALES & SERVICES**

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# UNDERTAKING BY PROJECT PROPONENT

EC/KAZA/GGN/09/02

28th September 2020

**UNDERTAKING LETTER FOR OWNING EIA & EMP REPORT**

The Member Secretary (IA Division-Industry-2)
Ministry of Environment, Forest and Climate Change (MoEFCC),
Indira Paryavaran Bhavan, Jor Bagh Road,
New Delhi – 110003

**Subject**: Undertaking letter for ownership of EIA/EMP and other documents for the Proposed Onshore Oil and Gas Development & Production from KG/ONDSF/KAZA/2018 Block, Krishna District, Andhra Pradesh By Vedanta Limited. (Division: Cairn Oil & Gas).

**Reference**: MoEFCC OM vide letter No: J-11013/41/2006-IA.II (I), dated: 05/10/2011.

Sir,

We hereby give you an undertaking for owning the contents and information provided in EIA/ EMP report submitted to MoEFCC, New Delhi for Environment Clearance for our Proposed Onshore Oil and Gas Development & Production from KG/ONDSF/KAZA/2018 Block, Krishna District, Andhra Pradesh By Vedanta Limited. (Division: Cairn Oil & Gas).

Yours Sincerely,
For Vedanta Limited (Cairn Oil & Gas)

Pankaj Jain

**Pankaj Jain**
**President Offshore & KG Development**

**VEDANTA LIMITED**
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CIN: L13209MH1965PLC291394

# EXECUTIVE SUMMARY

## 1.0 INTRODUCTION

1. As part of the Government's effort to increase domestic production, Discovered Small Field (DSF) Policy was introduced for fast-tracking the monetization of un-monetized small fields/ discoveries of National Oil Companies (NOCs) under Nomination regime and relinquished discoveries under the PSC regime. KG/ONDSF/KAZA/2018 Onshore Block was awarded to Vedanta Limited under discovered small field (DSF) Policy. This KAZA block was awarded to Vedanta Ltd in DSF Round-II in 2018. Cairn Oil & Gas Division of Vedanta Limited will operate the Kaza block with 100% Participating Interest. The proposed project is green field in nature.
2. KG/ONDSF/KAZA/2018 is onshore Block located in Krishna District of Andhra Pradesh. The 35 wells are located in Kaza Block covering four Mandal's of Krishna District. The proposed 35 no's of the hydrocarbon wells to be drilled are distributed as 14 wells in Mova Mandal; 18 wells in Gudur Mandal; two wells in Kalidindi and one well in Machilipatnam. ONGC has drilled three exploratory wells in the year 1985 in the Kaza structure. Out of the three wells, two wells were found to be dry wells and one well found to have gas discovery. The successful exploration well has discovered gas in Raghavapuram sands, possibility of occurrence of oil cannot be ruled out. Based on the data obtained from the successful gas well, the reservoir properties are moderate. It was noted that further gas extraction is possible through hydro-fracture of the well. All the earlier wells were drilled in the depth of ~ 2300 m below the ground level. It is understood that the accumulated hydrocarbons are due to long distance migration from the deeper parts of the depression adjacent to the Kaza high.
3. As per Environmental Impact Assessment EIA Notification dated 14th September, 2006, the project falls under category 'A' of Schedule 1(b) - Offshore and onshore oil and gas exploration, development & production; and requires prior Environmental Clearance (EC), which is to be obtained from MoEF&CC before the commencement of ground activity. The application for prior EC (Form-1 and Pre-feasibility Report) had been submitted to MoEF&CC on 12th February 2020. In this regard, under the provisions of the EIA Notification 2006 as amended, the Standard TOR has been granted by MOEF&CC vide letter reference F.No. No. IA-J-11011/52/2020-IA-II (I) dated 02nd April 2020 for the purpose of preparing environment impact assessment report and environment management plan.

## 2.0 PROJECT DESCRIPTION

**Project brief**

The proposed project is a Greenfield in nature and to carryout development well drilling, production and export of oil & gas from the block KG/ONDSF/KAZA/2018 at Krishna district of Andhra Pradesh. The geographic location of the block is included within the Survey of India's Topo- Sheet No. E44U15, E44U16, E44V3, E44V4. The following are the three major activities proposed as part of the Kaza Block development.

1. Drilling of 35 hydrocarbon wells within the Kaza block area
2. Development of ten well pads to setup the hydrocarbon processing facilities and produce up to 30,000 Barrels of Oil per day and 30 Million Metric standard Cubic Feet of gas per day. Each well pad will be of size maximum 300 m x 300 m (say 9 hectare each).
3. Laying of separate gas pipeline from the developed well pads and connecting to the main header pipeline already laid by GAIL and MEIL.

**Project-related Facilities**

**A. Process description for Drilling of 35 Hydrocarbon Wells**

The locations for the drilling of 35 wells have been identified, however the actual well location will be fixed once the detailed interpretation of the already acquired seismic data is completed. The proposed well depths vary up to 2400 m due to the subsurface structural configuration and the depth of occurrence of the primary reservoirs. Typically, estimated drilling duration of the well drilling and completion is between 45 – 60 days/ well. In addition, well testing will be carried out for the duration of 30 to 60 days/well to ascertain the reservoir parameters. Water Base Mud (WBM) will be used as drilling fluid for initial, shallower sections. The deeper and difficult to drill geological formations will be drilled using Synthetic Oil Base Mud (SOBM) as drilling fluid. All the proposed 35 wells are within the Block and will be drilled using an Electric Land Rig of around 1500 HP capacity, equipped with a Rotary/Top Drive System. The rig & associated services will have the following provisions:

- Portable Camps – to provide stay facilities for the around 80 drilling crew members.

- Crane-age - cranes for loading/offloading equipment and supplies.
- Emergency Systems - it includes fire detection and protection equipment.
- Environmental Protection – Blow out Prevention (BOP) system, wastewater treatment unit and drill cuttings and drilling mud handling equipment.

Additionally, there will be other ancillary facilities like Drilling mud system, ETP, Cuttings storage pit and disposal facilities, Drill Cementing equipment etc., and utilities to supply Power (DG sets), water, fuel (HSD) to the drilling process. The following are the various phases of the drilling activities and their process respectively.

- Site selection after Subsurface Target Identification;
- Land acquisition either on lease or permanent land;
- Site and access road preparation;
- Drilling activities;
- Well testing;
- Complete the well and suspend for production; and
- Decommissioning & closure of wells in case dry wells (no hydrocarbon found or non-viability of extraction or no commercial value available)

**B. Process description of Hydrocarbon Production up to 30,000 Barrels of Oil per day and 30 Million Metric standard Cubic Feet of gas per day**

**A. Process Description – Crude oil and associated gas produced from the wells**

Each well pad will be a standalone unit and will include single / multiple well heads - a collection header (manifold), phase separation (three phase), oil storage / export and necessary utilities such as warehouse, camp site, power generation, firefighting system and treatment systems.

**Well Fluid Collection**: The well fluids from the wells will be controlled through the opening of the choke valve and routed to inlet separator. Multiphase fluids from the wells / well pads will be processed in at each well pad. Gas will be separated from the oil and will be used as fuel gas within the facility for process heating, power generation etc. Oil will be stored in the well pads and then exported through road tankers. The separated water will be routed through oil water separator, from which it will be disposed through evaporation pond / dump well based on the quantum of generation.

**Phase Separation:** Oil will be separated from the flashed gas in the three-phase separator.

**Product Oil Storage and Export**: Crude oil from the separator flows by gravity to the product oil storage tanks. Crude is stored at atmospheric pressure in multiple tanks. 5 – 8 tanks of capacity 500 barrels each are envisaged. Two crude oil loading pumps of 50 $m^3$/hour capacities each will be installed to load the stabilized crude into the road tanker through loading gantry. Crude oil will be dispatched to the nearby refineries.

**B. Process Description – Natural gas production from the wells**

The gas well - well header will be hooked up for production to three phase separator facility.

**Wellheads:** The wellhead basically comprise of Christmas trees with flow lines, suitable piping and valves. All the gas discovered wells would self-flow initially and SRP at later stage. The requirement of chemical injection facilities at wellheads shall be evaluated during Engineering phase based on the gas composition. However, chemical injection facilities would be certainly required corrosion inhibitor, scale inhibitor, Pour Point Depressant (PPD) etc.

**Flow Lines**: Flow line rationalization study shall be carried out during engineering phase to explore the possibility of the flowing multiple wells through single flow line instead of dedicated flow line for each well. All the individual flow lines will be laid underground with coating to minimize the external corrosion. Appropriate cathodic protection system shall be considered for flow lines. The internal corrosion in gas flow lines shall be controlled through injection of corrosion inhibitors at the wellheads.

**Gas Processing Facilities:** The key sub-systems as a part of facilities two phase separator (Gas); Chemical injection system; $CO_2$ removal facilities (if available in the gas composition); $H_2S$ treatment system (if available in the gas composition); Gas Compression facilities; Dew Point Control facilities; Flaring and Utilities. In addition, the Gas Processing facility will also have filtration unit, pressure regulation system, metering system, odorization system, safety devices, fire fighting system, gas detector system, control room, UPS room and associated piping and further CNG distribution system (CDS) facilities for compression and dispensation.

**Two Phase Gas Separator**: The Well fluids will flow from gas wells through flow lines to local gas phase separator. Gas will be fed to downstream $CO_2$ removal facilities (if necessary). In the initial stage of the gas production, it is estimated that there will be no condensate production no/or less produced water expected. Detailed engineering will address handling of knocked off water if any in the process.

**$CO_2$ removal facilities:** Gas produced from these wells may have $CO_2$, this will be confirmed only after new successful gas wells drilled. If $CO_2$ of higher percentage is found in the total gas, then $CO_2$ removal suitable technique will be finalized based on the parameters such as pressure of gas, degree of removal required, partial pressure of $CO_2$ in gas, moisture content etc. Suitable method can be established only after gas composition available and engineering design is completed along with the techno-commercial evaluation of various options.

**$H_2S$ Treatment facility:** Gas produced from these wells may have $H_2S$, this will be confirmed only after further new successful gas wells drilled. $H_2S$ scavengers and other control mechanism will be planned.

**Gas Compression facilities**: CNG compression will be suitable for this marginal field development. However, engineering review will confirm the suitability of CNG transfer.

**Flaring:** Minimal operational flare will occur under normal operation conditions. Flaring system will be designed in compliance with regulatory requirements (DGMS / EPA /OISD etc.,)

**Utilities:** The utilities required for these facilities includes Electrical power generation; Closed and open drain system; Chemical dosing system; Diesel storage and transfer pumps; Fire fighting system as per OISD and Utility and potable water system. The electrical power will be met by Gas Engine Generator (GEG) with back up Emergency Diesel Generator (EDG). The exact requirement of power will be available after the engineering design is completed.

**Export of gas through pipeline**: Once the commercial supply of gas is being established from Kaza block, the gas export through pipeline will be a viable and safer option. Also, the gas will have better realization of commercial value, as it could be supplied directly to the premises of the end user. With reference to the Kaza Block over the existing gas pipeline network already prevail,

1. From the external boundary of KAZA (i.e. point B) the existing Nandigama GAIL pipeline (via cross-country routes) is 4 KM away and
2. From the external boundary of KAZA (i.e. point C), MEIL Gas Pipeline from Agiripalli to Nuziveedu is 3 KM away.

## 3.0 Resource Requirements

### A. Water:

The water requirement for the drilling, project and operations will be sourced locally through approved/ authorized sources such as PHED bore wells, privately owned bore wells. The quantity of the water requirement for the various activities is detailed below:

**Table 1: Water requirement at various phases of development and operation**

| Purpose | Water Requirements | Remarks |
|---|---|---|
| Drilling | 50 $m^3$/well | Drilling period is ~60 days. Out of 50 $m^3$ of water; drilling & associated activities will require 40 $m^3$ and domestic activities will require 10 $m^3$. |
| Project | 20 $m^3$/day | Each well pad and associated locations will be completed in 60 days of award. |
| Production / Operation | 10 $m^3$/day/well pad | Water required daily for domestic, fire fighting and green belt development |
| Injection water | 1000 $m^3$/ day | This bore well water will be abstracted after obtaining CGWA / APWALTA permission. |

### B. Power

**Drilling Operations:** The power requirement in each drilling site and the campsites will be provided through diesel generator (DG) sets. The rated capacity of the DG sets are Camp sites – 150 kVA – 2No's; Drilling operation – 2 No's – 1500 kVA and 2 No's – 500 kVA.

**Production:** The power requirement will be met through AP state electricity Board / or installation of Diesel/ Gas Engine Generator(s) using produced gas. The capacities of various DGs and or GEGs at each well pad location would be 150 kVA – 2No's and 500 kVA – 2No's. The gas as fuel for the gas engine generators (GEGs) would be sourced from the gas produced in the well pads.

**C. Fuel**

Fuel consumed during the drilling phase will mainly be diesel (HSD) used for various equipment and vehicles operating to transport goods and supplies to site. It is estimated that about 60 KL diesel will be required to power the off-road construction equipment and vehicles during site preparation phase.

During the drilling phase, consumption about 3.5 KLD of High-Speed Diesel (HSD) will be required. Out of this, a major part approximately 85% will be consumed by the rig (also include the DG sets) and about 15% will be required for the campsite.

During the operation phase, consumption about 500 Litres of HSD will be required per well pad.

**D. Manpower**

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 operation phase for few hundreds of people directly and indirectly. It is envisaged that the following persons will be engaged during various stages of project development.

- Project phase (construction of single well pad & associated activities) – 80 no's
- Drilling of well and operation of single rig – 100 no's
- Operation of the each well pad to produce oil & gas including the hydrocarbon transportation through trucks / cascade mounted trailers – 25 no's

**4.0 Project Schedule and Cost**

The proposed projects will be implemented in a phased manner up to ten (10) years period starting the year 2021 beginning onwards. The project will start execution only after obtaining all the necessary approvals. The estimated total project cost is around INR 650 Crores, which includes.

1. Physical Surveys cost estimated to be approximately INR 25.0 Crore.
2. Average drilling cost per well is estimated to be INR 15 Crore. In total 35 wells are planned to be drilled. Thus, total costs towards drilling and associated activities would be around INR 525 Crores.
3. Average cost towards setting up ten well pad's, approach roads, production facilities, pipeline and miscellaneous activities is estimated to be INR 100 Crore.

**5.0 BASELINE ENVIRONMENTAL STATUS**

To understand the existing physical, biological, socio-economic and environment conditions, both primary and secondary data was collected involving stakeholder consultations. The study period for primary data collection was 1$^{st}$ December 2019 to 29$^{th}$ February 2020.

1. **Site Settings** - Kaza Block is located in Makulavaripalem Village; Muvva Mandal; Machilipatnam as district headquarters & revenue division, Krishna district of Andhra Pradesh. The block is easily accessible through the rail and road network. No archeological structures or ecologically sensitive zones are located here. The area is mainly rural and sparsely populated with scattered habitation.
2. **Sub-surface Geology**- Geomorphologically the district can be broadly divided into 3 distinct units, viz., Pediplain, Alluvial plains, and Coastal & Deltaic plains. The pediplain area i.e., northern part of the district consists of an undulated plain with broken ridges. Major part of the district in the southern part is represented by the alluvial plains forming the Krishna delta. The river Krishna and its tributaries have contributed to the formation of this alluvial plain. There is no significant surface drainage in these alluvial plains. The delta is relatively a flat area.
3. **Hydrogeology and Groundwater Quality**- The district is underlain by variety of geological formations comprising from the oldest Archaeans to Recent Alluvium. Hydro-geologically these formations are classified as consolidated (Hard), semi-consolidated (Soft) and unconsolidated (Soft) formations. The depth to water levels during pre-monsoon season (May, 2012) in the district ranges between 2 and 10 m bgl. Water levels more than 5 m bgl occur in the parts of Gannavaram, Jagayyapet, Reddygudem, Visannapeta and Tiruvuru mandals, whereas, water levels less than 2 m bgl occur in parts of the Kalidindi and Ibrahimpatnam mandals. The depth to water level during post monsoon season (Nov, 2012) in general is less than 2m bgl, whereas in parts of Jaggayyapeta, Vijayawada, Musunuru water levels are more 2m bgl.

Ground water levels fluctuate considerably in response to the recharge and draft conditions of ground water reservoir. Overall rise in water levels from pre-monsoon to post-monsoon in the range of 0.83 to 9.37 m exist in the district. Magnitude of the fluctuation is less in the deltaic area when compared to northern part of the district. Long-term trend of water level (2001 to 2011) indicates that during pre-monsoon a raise in the range of 0.0102 to 0.3456 m/yr in Gampalagudem, Vissannapeta, Ibrahimpatnam and Challapalli areas, whereas in the majority of the district a fall in the range of 0.0003 to 0.2379 m/yr is recorded. During post monsoon period a raise in the range of 0.0091 to 0.2217 m/yr and a fall in the range of 0.0016 to 0.2070 m/yr exists in the district.

4. **Ground Water:** To assess the quality of ground water, samples were collected from 19 numbers of locations for the analysis of physico-chemical and microbiological parameters. pH was observed in the range of 6.98 – 7.57, which meets with drinking water desirable norms. Total Dissolved Solid (TDS) were recorded in the range of 582 - 4856 mg/L with minimum at Leggagaruva village and maximum at SN Gollapalem village. Conductivity varies from 910 to 7540 µmho/cm. The ratio of TDS to conductivity was observed in the range of 0.6 to 0.65 which is within the desired range. Total Hardness was in the range of 290 - 1250 mg/L with minimum at Nidumolu village and maximum at SN Gollapalem village. Total Alkalinity was found in the range of 240 - 780 mg/L with minimum at Nidumolu village and maximum at SN Gollapalem village. Chloride was found in the range of 120 to 2319 mg/L and Sulphate varies from 51 to 279 mg/L. Iron was found in the range of 0.05 - 0.28 mg/L. The microbiological parameters Total coliform and Fecal coliform was also carried out and it was found absent.

   During the analysis it was observed that results of all tested parameters are within the permissible limit as per IS 10500: 2012 except Kaza and S.N. Gollapalem. Test results of the parameters such as Total Hardness, TDS and Chloride for the water sample collected from Kaza and S.N. Gollapalem exceed the permissible limit prescribed in the IS 10500: 2012. Ground water in Kaza and S.N.Gollapalem is not used for the drinking purpose but they are being utilized in other domestic purposes as well as in irrigation. Results of water sample collected from other locations are within the permissible range as per IS 10500:2012. These water sources can be used in all domestic purposes including drinking purpose in absence of alternate source of potable water supply. Though water results are within the permissible range, but not in desirable range, thus, it is suggested to treat the water using Reverse Osmosis plant to bring down TDS value below 500 mg/l and use it for drinking. This interpretation and recommendation relate to the samples collected from particular location only.

5. **Surface Water:** To assess the quality of Surface water, samples were collected from 12 numbers of locations for the analysis of physico-chemical, heavy metal, microbiological and biological parameters. During the analysis pH of the samples was found in the range of 6.95 – 7.74. TDS analysis was also carried out for surface water sample and it was found in the range of 310 - 756 mg/L. TSS was found in the range of 8 – 14 mg/L. Total Hardness ranges from 180 – 340 mg/L with minimum in the water sample of Pampula Cheruvu and maximum at Medum Canal. DO is one of the important parameter to indicate towards the contamination of organic matter. DO level decrease as soon as organic contamination increases. During analysis DO was found in the range of 4.0-4.9 mg/L. COD and BOD analysis was also carried out during the study period and results were found more than the expected value for the surface water. Various literatures show that BOD should be less than 4.0 mg/L for the better survival of aquatic life. Total Nitrogen was found in the range of 2.6 – 4.5 mg/L. Iron was found in the range of 0.05-0.21 mg/L. MPN test was also carried out for the surface water sample and it was found positive.

   Based on test result data comparison study with CPCB Standards (Inland Surface Water Classification), it is interpreted that surface water quality meets with the class D & E. This water can be used for Propagation of wildlife, fisheries and Irrigation, industrial, cooling, controlled waste disposal purpose. COD and BOD have been reported more than 4 mg/L, it indicates towards the organic contamination in water bodies.

6. **Climate and Meteorology** - Approx. 17 % wind blow was in SE-NW direction, it shows that the first dominant wind direction in the study region is SE-NW. Wind speed was in the range of 1 to 28 km/hr. As per the trend analysis of temperature, it reaches up to 47.8°C and minimum average temperature is 20°C. Current temperature has been found in the range 21°C to 31°C. Based on the comparative study of currant data with last ten years data it can be interpreted that there is no increment in temperature has been observed. It shows almost similar pattern of micro meteorological data for the period Dec 19 to Feb 20. On the basis of wind speed and wind direction it can also be

interpreted that chances of maximum dispersion of pollutant during the period of Dec to Feb is NW direction. This interpretation relate to currant data recorded during the study period and last ten years data only.

7. **Ambient Air Quality**- Ambient air quality monitoring has been carried out for total 12 locations during 1st Dec 2019 to 29th Feb 2020. During the study $PM_{10}$ was observed in the range of 40.3 – 65.3 µg/m$^3$. Maximum concentration of $PM_{10}$ was found at Maklavaripalem village and minimum at Chataripalem village. PM2.5 was observed in the range of 19.0 – 35.3 µg/m$^3$. Maximum concentration of $PM_{2.5}$ was found at Chitturu village and minimum at Tarakaturu village. $SO_2$ concentration was observed in the range of 11.1 – 18.5 µg/m$^3$, which is well within the standard limit. $NO_X$ concentration in was observed in the range of 14.2- 22.6 µg/m$^3$, which is well within the standard limit. Monitoring and analysis were also carried out for the parameters CO, $O_3$, $NH_3$, Ni, As, Pb, Benzene, BaP, VOC, Methane and Non-methane HC, all these parameters value were found well within the norms.
   All the location sample results of ambient air quality parameters have been found well within the limit as per NAAQS. Based on comparison study of results for tested parameters with NAAQS, it is interpreted that ambient air quality of studied locations is good. This interpretation relates to the results found for particular locations and study period.
8. **Ambient Noise Levels** - Continuous Noise level monitoring was carried out with the help of sound level meter at 19 different locations. Study area does not fall under industrial area therefore all the noise sampling locations are considered under Residential area. Equivalent noise level was recorded in the range of 50.6 to 52.2 dB (A) during daytime. Equivalent noise level was recorded in the range of 40.5 to 42.1 dB (A) during night time.
   Based on noise level data obtained during the survey, it is interpreted that noise levels are within the standard norms prescribed by MoEF&CC. Looking towards the increase in noise generating sources especially during the drilling phase, it is suggested that there is need to apply noise reducing measures (engineering, path and receiver) control.
9. **Soil Quality** -12 numbers of samples were collected from different locations of study to assess the baseline status of soil. The soils are categorized as loamy sand to clay loam based on different soil separates (sand, silt and clay). They have moderate water holding capacity (42.3 to 50.6 %) and porosity varied from 38.6 – 46.3 %, and very fast to moderate drainage (infiltration rate 4.5 to 35.5 mm/hr) capacity as texture is sandy to clay loam. The pH of the soil samples ranged from 7.38 to 8.00 during the study sample. The soil EC varied from 0.76 to 1.34 dS/m and ESP ranged from 7.4 to 13.6. These parameters indicate that soils are neutral to alkaline in reaction, non-saline to saline (EC > 0.8 dS/m) and non-sodic, as pH is <8.5 and ESP is < 15. Among exchangeable basic cations, predominance of Calcium (4.8 to 15.6 meq/100 g soil) was seen followed by magnesium (1.6 to 7.8 meq/100 g), Na (1.0 to 2.6 meq/100 g soil) and K (0.4 to 1.1 meq/100 g soil). The loss on ignition (0.24 to 0.57 % OC) indicate that soils are low (<0.50 % OC) to medium (0.50 to 0.75 % OC) in organic carbon status. This shows that soils are low to medium in nitrogen status. Considering only 2% available phosphorus based on total P, soils are classified as poor (>28 kg P2O5/ha) in available P. On the basis of exchangeable potassium values soils are categorized as high (>280 kg $K_2O$/ha) in potassium status. Based on CEC (8.8 to 29.9 meq/100 g soil) soils are categorized as poor to moderate with respect to productivity. The results relating to total micronutrients (Fe, Cu, Cr, B and Zn) and heavy metals do not show alarming concentrations in different soil samples.
10. **Ecology–** Farley rich biodiversity is present in the core and buffer zone of the study area. There was no endemic and threatened plant species observed in the study region during the field survey. There is no declared sanctuary park and reserve forest in the study region. In case of avi fauna only schedule IV species have been recorded from the study region and in case of reptile schedule II species like cobra has been observed. No protected/threatened fauna was cited during the survey.
11. **Socio- Economic Conditions**- During the primary survey it was observed that almost proper road facility is available in all villages within 10 km radius. Literacy rate of the study region is between 58.45 to 84.43%. On the basis of survey for literacy rate data, it is interpreted that there is need to promote more and higher education to cover larger people. Almost, all the villages have more than 50 % people as non-workers/having continuous job availability. It indicates that the problem of unemployment can be solved by providing proper skill-based training and education. There is also need, to establish more industries in and around the area, so that employment opportunities can be increased. Basic amenities like Education facilities Health care facilities, water supply, electric power supply, mode of transportation etc., are available in all villages.

## 6.0 IMPACT ASSESSMENT AND MITIGATION MEASURES

1. **Air Quality** – The major sources of emissions during drilling and construction will include dust emissions from earthwork and trenching; $NO_X$ and CO emissions due to operation of DG sets; and flaring of hydrocarbons during well testing. The major sources of emissions during operations will include emissions from continuous flaring (due to operational requirement), operation of gas engine compressors and power generation facilities. An air modelling exercise was carried out to predict the incremental concentrations. The resultant concentrations in the Block were observed to be within the prescribed National Ambient Air Quality Standards. The impact on air quality has been assessed and following mitigation measures suggested.

   **Mitigation Measures:**
   - The construction materials shall be stored in covered area to protect from weather.
   - Water sprinkling shall be done in the work area to suppress dust.
   - Vehicle speeds on unpaved roads shall be limited to 15-25 km/hr.
   - There will be no venting of associated and non-associated gas during routine operations.
   - All new facilities proposed shall be connected to power supply from grid such that need for any new generators shall only be limited to power backup.
   - No cold venting will be resorted instead flaring will be done with proper combustion efficient elevated flare tip.
   - Location of Flare stacks will be chosen by considering the sensitive receptors adjoining the site and predominant wind direction.
   - The flare stack shall be of 30m height to meet regulatory requirement.
   - All emission sources and ambient air quality shall be monitored on periodic basis to ensure compliance with emission standards.
   - Peripheral green belt will be developed to contain pollution.

2. **Water Resources & Quality** – Water resource possible depletion due to the local water usage for preparing drilling fluid and for domestic needs of the campsite. Surface run off (storm water) mixing with the drilling waste such as drill cuttings & drilling mud, hazardous waste (waste oil, used oil etc.) and chemical storage will get contaminated and thereby will also pollute the open soil (land) and also likely to contaminate the receiving water bodies viz. natural drainage channels, lakes, ponds etc., which are used by the villagers for washing and other domestic purposes.

   Wastewater to be generated from the proposed project is from washing, drilling fluid discharge and cleaning of rig floor and other equipment. Water based drilling mud is non-hazardous in nature, however, the drill cutting wash water need to be treated and effectively disposed. The primary pollutants in the wastewater would be suspended solids, dissolved solids and traces of oil from washing of rig floor and other equipment. Effluents can cause significant pollution to water bodies especially ponds and lakes if disposed untreated. Accidental spillage of oil & chemicals will also further contaminate surface water body.

   **Mitigation measures**
   - The drilling fluid will be recycled, and fresh water will be used as makeup water and for general washing and daily maintenance. The water requirement shall be sourced from the approved local sources through water tankers.
   - Since the drilling activity being temporary and water requirement is meagre, no adverse impact on ground/surface water resources is envisaged.
   - Wastewater shall be discharged in HDPE lined pit for solar evaporation, size of the pit is generally 50mx20mx1.5m. Separate pits shall be constructed for oily and non-oily wastewater to avoid contamination. ETP shall be used to treat the drilling fluids.
   - The produced water generated from the well fluid separation activities as part of the production will be treated to achieve MoEF&CC/ CPCB/ APPCB specification (discharge standards) and will be accordingly disposed. The treated effluent (produced water) may also be disposed through deep dump wells (also abandoned wells) having depth > 1000 m after treating for oil (< 10 ppm) & total suspended solids (< 100 ppm) and or solar/ mechanical evaporators depending on actual site feasibility.
   - All spills to be reported and contained to prevent contamination to any surface water body or drainage channel.
   - All runoff should be treated at Oil water separator.

- Storm water shall be planned for rainwater harvesting depending on the feasibility.

3. **Noise** – Drilling and construction activities will result in temporary increase in the ambient noise levels. For drilling operations, the ambient noise standards are estimated to be achieved at a distance of 50 m and 150 m from the center of the well pad site during daytime and night time respectively. During operations, noise levels are not likely to exceed the prescribed standards outside the plant boundary of the well pad.
   **Mitigation measures:**
   - Noise generating activities shall be planned as far as possible from sensitive receptors.
   - Noise generating sources will be provided with acoustic enclosures. DG sets will be provided with mufflers on the exhaust.
   - Workers in high noise areas shall be provided with earplugs / earmuffs.
   - Regular maintenance of equipment and machinery to be carried out.
   - Construction activities shall be limited to daytime, to the extent possible.
   - All production facilities shall be provided with peripheral green belt to attenuate noise.
4. **Soil Quality** – The segregation of waste at the source of generation shall be followed such as hazardous and non-hazardous, recyclable, high calorific value etc. All the recyclable wastes (both hazardous and non-hazardous) shall be disposed to the authorized recyclers. All type of wastes shall be stored on paved and bonded surfaces. The potential for soil contamination is assessed to be low.
   **Mitigation measures**
   - Tie-up with a third-party APPCB approved Treatment, Storage and Disposal Facility (TSDF) for disposal of wastes shall be engaged. High calorific non-recyclable waste such as SBM drill cuttings, oily filter, oily sludge etc., shall be disposed to the cement industries towards co-processing and AFR (Alternate Fuel and Raw material) and regulatory approvals shall be obtained prior to implementation.
   - Inventory of waste generation and disposal shall be maintained for all the facilities.
5. **Ecology** – Site preparation for facilities will involve clearance of vegetation and disturbance to animal habitat. Generation of noise and emissions may also impact wildlife. The impact on the flora in the area is considered to be low as the region has scanty vegetation and significant tree cutting is not envisaged. The impact on fauna due to road kill is however expected due to the increased vehicular movement.
   **Mitigation measures**
   - Minimal disturbance/ damage to vegetation shall be considered during site selection and site preparation.
   - Road safety programs including driving awareness and defensive driving training programs shall be continued. A speed limit on all main roads and village roads shall be strictly implemented.
   - The illumination and lighting facilities at well pads and terminals shall be kept to minimum as required.
   - Only native species shall be selected for green belt development.
6. **Socio Economic Environment** –The project will result in loss of land and may impact the livelihood of the land contributors (irrespective of providing them financial compensation). Vedanta will set up a Contractor Engagement Cell in which the profile of all the land contributors will be maintained and preference in engaging them as contractor/local employment will be considered.
   **Mitigation measures**
   - Agricultural land shall be avoided to the extent possible.
   - Vedanta Land Team shall assess the prevailing rates and expectations of the land owners, in consultation with the Land Acquisition Officer, to finalize the compensation rates.
   - The Vendor Development Cell and Contractor Engagement Cell shall be set up for the engagement of local labour and local vendors.
   - CSR shall extend its existing CSR initiatives to the all affected families. The activities will be done in affected villages of Movva, Gudur, Kalidindi and Machilipatnam mandals i.e. Palankipadu, Kanchakodur, makulavaripalem, Matlamullapalli, Maddipatla, Paddarayuduthota , Kaza, Kollapalem, Reddy naidu Agaraharam, Racharlapalem, Avurupudi Nidumolu, kalapatam, Gurjepalle, kanktav,Veerayelanka, Pinagudurulanka, Parnasala,Tarakaturupalem, Narikedalapalem, Chittiguduru, Guduru, Kokanarayanapalem, Akumarru, Gulabpura, Chittiguduru, Sultannagaram ,Gollapalem, Rayavaram.

## 7.0 RISK ASSESSMENT

A risk assessment exercise has been carried out for the Project. It was observed that the risks to personnel at site and staff within occupied facilities are well within the 'Acceptable Band' of 1E-06 per year. Risks to the community were also assessed to be well within the acceptable range. The maximum damage distance for 6.31 kW/$m^2$ and 37.5 kW/$m^2$ which corresponds to 1% lethality level for a 30 sec exposure for the Gas Pipeline catastrophic rupture has been estimated as 293.2 m and 172.3 m respectively. For the export oil tank, the damage distance has been estimated as 91.39 m. No extra risk reduction options need to be implemented. Detailed emergency response plan in consultation with the district administration shall be prepared before commencement of the work in the Block.

## 8.0 ENVIRONMENT MANAGEMENT AND MONITORING PLAN

**Environment Management Plan**

An Environmental Management and Monitoring Plan detailing mechanism for implementation of the mitigation measures and monitoring of implementation has been formulated. Different types of Management Plan such as waste management plan, Traffic management plan, Oil spill management plan and CSR strategies shall be prepared before start of the activity.

**Environmental Monitoring Plan**

A comprehensive environmental monitoring plan has been developed for the project. Monitoring of ambient air quality, noise levels, soil, surface water and groundwater quality to be carried out by MoEF&CC recognized and NABL accredited laboratories during construction and operation phases to assess the effectiveness of the environment management plan implementation. The periodic compliance report shall be submitted to APPCB, CPCB and MoEF&CC.

**HSE Management System and Organization Structure**

Vedanta Limited has a well laid down Corporate HSE Policy that includes the commitment to HSE legal compliances and well established standard operating procedures (SOP) for reporting on the performance of environmental management system for continual improvement. Further, the administrative order of company to deal with the environmental issues and the reporting mechanism of non-compliance /violation of environmental norms is well established.

Vedanta Limited has already established and certified Environmental Management System as per ISO 14001: 2015 and Environment Management Cell (EMC) in place for managing their day to day operations. The same EMC at east Godavari district managing PKGM-1 Block with additional manpower will support the proposed project and operations. The company has a well-defined hierarchical system or administrative order to deal with the environmental issues and for ensuring compliance with the EMP, Public hearing commitments, EC and Consent order conditions. EMC will coordinate in implementation of the technical and statutory environmental requirements/issues that arise during the project and operational requirements. The system is in place to report any non-compliances/violations of environmental norms to the Board of Directors of the company and/or shareholders or stakeholder.

## 9.0 PROPOSED SOCIAL WELFARE ACTIVITIES

Before starting up the activity in Kaza block, Cairn oil & gas will take up various social initiatives in and around Kaza block for the benefit of the locals.

As per the OM of MOEFCC vide F.No.22-65/2017-IA.III dated 30th September 2020, Vedanta Ltd. (Division: Cairn Oil & Gas) will allocate the budget for compliance to the issues identified/addressed during the public hearing. The compliance status to the issues raised during the public hearing will be submitted in the six monthly progressive Environmental Compliance report.

a) Children's Well-being & Education
b) Skill development
c) Health Care
d) Drinking Water & Sanitation
e) Agriculture & Animal Husbandry
f) Development of Community Infrastructure
g) Participate in the community development programs initiated by central government and Andhra Pradesh

state government and

h) any other program identified based on the social need-based assessment

The exact amount of the budget and timeline to be spent on above mentioned projects or any other areas would be decided after consultation with the District Collector, Krishna District, Andhra Pradesh. The activities will be done in affected villages of Movva, Gudur, Kalidindi and Machilipatnam mandals i.e. Palankipadu, Kanchakodur, makulavaripalem, Matlamullapalli, Maddipatla, Paddarayuduthota , Kaza, Kollapalem, Reddy naidu Agaraharam, Racharlapalem, Avurupudi Nidumolu, kalapatam, Gurjepalle, kanktav,Veerayelanka, Pinagudurulanka, Parnasala,Tarakaturupalem, Narikedalapalem, Chittiguduru, Guduru, Kokanarayanapalem, Akumarru, Gulabpura, Chittiguduru, Sultannagaram ,Gollapalem, Rayavaram.

## 10.0 BUDGET FOR EMS

Around 5% of the total project cost, which is around Rs. 33 Crores is being earmarked towards implementing the proposed EMP. This cost will include meeting the project related expenses towards Pollution Control Measures; Environmental, Health and Safety management measures; environmental and social monitoring; and any contingency cost towards managing the environment and social protection of the proposed Project.

# TOR COMPLIANCE

ToR Letter No.: IA-J-11011/52/2020-IA-II (I) dated 02nd April 2020 under Schedule 1 (b) Category–"A" as per EIA Notification 2006 and its Amendment thereof for Proposed Onshore Oil and Gas Development & Production from KG/ONDSF/KAZA/2018 Block, Krishna District, Andhra Pradesh By Vedanta Limited.

| A | Standard ToR | | Citation |
|---|---|---|---|
| S.No. | ToR Point | Reply | |
| 1. | Executive Summary | Incorporated in EIA/EMP report. | Page VIII to XVII |
| 2. | Project description, project objectives and project benefits | Drilling of 35 nos. of wells has been briefed. Physical, Ecological and Social benefits have been detailed. | Section 2.1, page 8, Chapter 2. Chapter 8 Page 236 |
| 3. | Cost of project and period of completion | The cost of the project has been estimated to be about INR 650 Crores. Work will start after getting Environmental Clearance (EC) from MoEF&CC, New Delhi. | Section 2.7, Page 39 , Chapter 2. |
| 4. | Site details within 1 km of the each proposed well, any habitation, any other installation/activity, flora and fauna, approachability to site, other activities including agriculture/land, satellite imagery for 10 km area. All the geological details shall be mentioned in the Toposheet of 1:40000 scale, superimposing the well locations and other structures of the projects. Topography of the project site. | The details of any habitation, any other installation/activity, flora and fauna, approachability to site, other activities including agriculture/land are incorporated. | Table 2.4, Page 13 , Chapter 2 Figure 3.1 Chapter 3, Page, 41 |
| 5. | Details of sensitive areas such as National Park, Wildlife sanctuary and any other eco-sensitive area Along with map indicating distance. | There is no National Park, Wildlife sanctuary and any other eco-sensitive areas are present within 10 km radius of Project site. Details are Incorporated in the Report. | Table 2.4, Page 13 , Figure 2.3, Page 12 Chapter 2 |
| 6. | Approval for the forest land from the State/Central Govt. under Forest (Conservation) Act, 1980, if applicable. | Not Applicable | - |
| 7. | Recommendation of SCZMA/CRZ clearance as per CRZ Notification dated 6th January, 2011 (if applicable). | Not Applicable | - |
| 8. | Distance from nearby critically/severely polluted area as per Notification, if applicable. Status of moratorium imposed on the area. | Not Applicable | - |

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| 9. | Does proposal involve rehabilitation and resettlement? If yes, details thereof. | Not Applicable | - |
| 10. | Environmental considerations in the selection of the drilling locations for which environmental clearance is being sought. Present any analysis suggested for minimizing the foot print giving details of drilling and development options considered. | Environmental considerations in the selection of the drilling locations is been detailed.<br>Details are incorporated in EIA/EMP. | Chapter 5 Page 174-177 |
| 11. | Baseline data collection for air, water and soil for one season leaving the monsoon season in an area of 10 km radius with center of Oil Field as its center covering the area of all proposed drilling wells. | Baseline environmental study has been conducted for the study region within 10 km radius of the project site for the period 1st December 2019 to 29th February 2020.<br>Details are incorporated in EIA/EMP. | Chapter 3 Page 40 to 134 |
| 12. | Climatology and Meteorology including wind speed, wind direction, temperature rainfall relative Humidity etc. | Climatology and Meteorology study has been conducted.<br>• wind speed - 1 to 28 km/hr<br>• Dominant wind direction - SE-NW direction,<br>• Temperature - 21°C to 31°C<br>• Rainfall -29.9 mm - 39.7 mm<br>• relative Humidity – 47% -91%<br>Details are incorporated in EIA/EMP. | Section 3.4, Page 43 to 52, Chapter 3 |
| 13. | Details of Ambient Air Quality monitoring at 8 locations for PM2.5, PM10, $SO_2$, $NO_x$, CO, VOCs, Methane and non-methane HC. | Details of ambient air Quality monitoring at various locations (12 Nos.) for PM2.5, PM10, $SO_2$, $NO_x$, CO, VOCs, Methane and non-methane HC has been done.<br>Monitoring and analysis were also carried out for CO, Total VOC, Methane HC and Non Methane HC. Result for the CO, Total VOC, Methane HC and Non Methane HC was found well within the norms. Details are incorporated in EIA/EMP. | Section 3.5, Page 52 to 60, Chapter 3 |
| 14. | Soil sample analysis (physical and chemical properties) at the areas located at 5 locations. | 12 numbers of samples were collected from different locations of study to assess the baseline status of soil. Details are incorporated in EIA/EMP. | Section 3.15, Page 84 to 90, Chapter 3 |
| 15. | Ground and surface water quality in the vicinity of the proposed wells site. | **Ground water Quality:** To assess the quality of ground water, samples were collected from 19 numbers of locations for the analysis of physico-chemical and microbiological parameters.<br>During the analysis it was observed that results of all tested parameters are within the permissible limit as per IS 10500: | Section 3.16, Page 91 to 105, Chapter 3 |

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| | | 2012 except Kaza and S.N. Gollapalem.<br>**Surface water Quality:** To assess the quality of Surface water, samples were collected from 12 numbers of locations for the analysis of physico-chemical, Heavy metal, microbiological and biological parameters.<br><br>Details are incorporated in EIA/EMP. | |
| 16. | Measurement of Noise levels within 1 km radius of the proposed wells. | Continuous Noise level monitoring was carried out with the help of sound level meter at 19 different locations. Based on noise level data obtained during the survey, it is interpreted that noise levels are within the standard norms prescribed by MoEF & CC.<br>Details are incorporated in EIA/EMP. | Section 3.6, Page 60 to 64, Chapter 3 |
| 17. | Vegetation and land use; flora/fauna in the block area with details of endangered species, if any. | No REET floral and faunal species found in the study area around the wells during the survey.<br>Details are incorporated in EIA/EMP. | Section 3.17, Page 105 to 120, Chapter 3 |
| 18. | Incremental GLC as a result of DG set operation, flaring *etc*. | Details are Incorporated in the Report. | Section 4.5.1, Page 138 to 155 |
| 19. | Potential environmental impact envisaged during various stages of project activities such as site activation, development, operation/ maintenance and decommissioning. | Description of the potential aspects and impacts during the various stages of project is been incorporated. | Chapter 4 135 to 173 |
| 20. | Actual source of water and 'Permission' for the drawl of water from the Competent Authority. Detailed water balance, wastewater generation and discharge. | The water requirement for the drilling, project and operations will be sourced locally through approved/ authorized sources such as PHED bore wells, privately owned bore wells, Irrigation Dept./ Water Resources Department of AP State Government.<br>Detail for the same is been incorporated. | Section 2.4.3, Page 36 Chapter 2 |
| 21. | Noise abatement measures and measures to minimize disturbance due to light and visual intrusions. | Acoustic enclosures and other required practices will be provided for noise abatement measures.<br>Proposed appropriate shading of lights to prevent scattering.<br>Detail for the same is been incorporated. | Table 4.12, Page 160, Chapter 4 |
| 22. | Details on wastewater generation, treatment and utilization /discharge for produced water/ formation water, cooling waters, other wastewaters, etc. during all project phases. | Domestic waste water would be treated in septic tank and soak pits. Process Waste water will be discharged in HDPE lined evaporation pit for disposal, size of the pit is generally 50 m x20 m x1.5 m | Section 2.5.2, Page 37-38, Chapter 2 |

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|---|---|---|---|
| 23. | Details on solid waste management for drill cuttings, drilling mud and oil sludge, produced sand, radioactive materials, other hazardous materials, etc. including its disposal options during all project phases. | Generation of drill cutting and drilling mud which will be unusable will be disposed in 1 mm HDPE liner.<br>Contaminated soil and drill cutting will be disposed within the site through capping the waste pits by HDPE liner and soil cover. | Section 2.5.3, Page 38, Chapter 2 |
| 24. | Disposal of spent oil and lube. | Used oil will be stored at dedicated storage area. | Table 2.8, Page 38, Chapter 2 |
| 25. | Storage of chemicals and diesel at site. Hazardous material usage, storage and accounting. | Diesel and other chemicals will be stored at dedicated area | - |
| 26. | Commitment for the use of water based mud (WBM) only | Solid based mud and water based mud will be used for drilling. | - |
| 27. | Oil spill emergency plans for recovery/ reclamation. | Oil spill emergency plans for recovery/ reclamation is incorporated. | Section 7.3.25, Page 220, Chapter 7 |
| 28. | $H_2S$ emissions control. | Effective control of H2S emission by addition of suitable scavenger chemicals. Monitoring partial pressure of H2S in the system and wells | Table 10.1 Chapter 10 Page 240 |
| 29. | Produced oil/gas handling, processing and storage/transportation. | Used oils will be stored at dedicated area. Proper manifest as per Hazardous and Other Wastes (Management and Trans boundary Movement) Rules, 2016 and amended thereof will be maintained during storage, transportation and disposal of hazardous waste; *etc.* | - |
| 30. | Details of control of air, water and noise pollution during production phase. | Details of control of air, water and noise pollution during production phase is been detailed in report. | Section 2.5, Page 37-39, Chapter 2 |
| 31. | Measures to protect ground water and shallow aquifers from contamination. | Measures to protect ground water and shallow aquifers from contamination is been incorporated | Section 4.9, Page 164-166, Chapter 4. |
| 32. | Whether any burn pits being utilized for well test operations. | No use of burn pits for well test operations. | - |
| 33. | Risk assessment and disaster management plan for independent reviews of well-designed construction *etc.* for prevention of blow out. Blowout preventer installation. | Detailed discussion on blowout has been addressed in chapter 7. | Section 7.3 chapter 7 Page 182 to 235 |

| | | | |
|---|---|---|---|
| 34. | Environmental management plan. | Environment management plan for air, water, noise, solid/ hazardous waste including OHS, CER and Plantation has been introduced in the report. | Chapter 10 Page 239 to 259 |
| 35. | Total capital and recurring cost for environmental control measures. | Total capital and recurring cost for environmental control measures is incorporated. | Section 10.4 Page 257 Chapter 10 |
| 36. | Emergency preparedness plan. | Emergency preparedness plan is been incorporated | Section 7.4, Page 223 to 235 Chapter 7 |
| 37. | Decommissioning and restoration plans. | Decommissioning and restoration plan is detailed in the report. | Table 10.1 Chapter 10 Page 240 |
| 38. | Documentary proof of membership of common disposal facilities, if any. | TSDF Membership certificate is attached as Annexure III. | Annexure III |
| 39. | Details of environmental and safety related documentation within the company including documentation and proposed occupational health and safety Surveillance Safety Programme for all personnel at site This shall also include monitoring programme for the environmental. | Vedanta Limited (Division: Cairn Oil & Gas) maintains all the required relevant documents and same will be continued. | - |
| 40. | A copy of Corporate Environment Policy of the company as per the Ministry's O.M. No. J-11013/ 41/2006-IA.II (I) dated 26thApril, 2011 available on the Ministry's website. | A copy of Corporate Environment Policy of the company is incorporated in EIA/EMP report. | Annexure II |
| 41. | Any litigation pending against the project and or any direction/order passed by any court of law against the project. If so details thereof. | No Litigation pending against the project. | - |

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# CHAPTER 1

# INTRODUCTION

## 1.0 PRELUDE

Vedanta Limited (Cairn Oil & Gas Division) (hereafter referred to as "Vedanta"/ "Cairn") is one of the largest independent oil and gas exploration and production companies in India. As part of the Government's effort to increase domestic production, Discovered Small Field (DSF) Policy was introduced for fast-tracking the monetization of un-monetized small fields/ discoveries of National Oil Companies (NOCs) under Nomination regime and relinquished discoveries under the PSC regime. KG/ONDSF/KAZA/2018 Onshore Block was awarded to Vedanta Limited under discovered small fields (DSF) Policy.

KG/ONDSF/KAZA/2018 is an onshore Block comprising approximately area of 114.93 $Km^2$. KG/ONDSF/KAZA/2018 Block is located in Makulavaripalem Village; Muvva Mandal; Machilipatnam as district headquarters & revenue division and in Krishna district of Andhra Pradesh.

This chapter describes the purpose of the report, identification of the proposed project and project proponent, justification of project, brief description, nature, size and location of the project, importance to the country and region, scope of the study and methodology of the study. The chapter also describes the scope of the study, details of regulatory scoping carried out as per Terms of Reference (TOR) issued by Ministry of Environment, Forest and Climate Change (MoEF&CC), New Delhi.

## 1.1 PURPOSE OF THE REPORT

As per Environmental Impact Assessment EIA Notification dated 14$^{th}$ September, 2006, the project falls under category 'A' of Schedule 1(b) - Offshore and onshore oil and gas exploration, development & production; and requires prior Environmental Clearance (EC), which is to be obtained from MoEF&CC before the commencement of ground activity.

The application for prior EC (Form-1 and Pre-feasibility Report) had been submitted to MoEF&CC on 12$^{th}$ February 2020. In this regard, under the provisions of the EIA Notification 2006 as amended, the Standard TOR has been granted by MOEFCC vide letter reference F.No. No. IA-J-11011/52/2020-IA-II (I) dated 02 April 2020 for the purpose of preparing environment impact assessment report and environment management plan. A copy of the TOR letter is enclosed as **Annexure-I**.

This draft EIA Report is prepared in line with the TOR issued by MoEF&CC and addresses the anticipated environmental impacts of the proposed project and proposes the mitigation measures for the same for obtaining Environmental Clearance (EC) from MoEF&CC, New Delhi. The report covers the primary data collected during 1$^{st}$ December 2019 to 29$^{th}$ February 2020 representing summer season.

Public Hearing for the proposed project will be done by Andhra Pradesh State Pollution Control (SPCB) in accordance with TOR and the public hearing proceedings and action plan will be included in final EIA report.

## 1.2 IDENTIFICATION OF PROJECT AND PROJECT PROPONENT

### 1.2.1 Identification of the project

As part of the Government's effort to increase domestic production, Discovered Small Field (DSF) Policy was introduced for fast-tracking the monetization of un-monetized small fields/ discoveries of National Oil Companies (NOCs) under Nomination regime and relinquished discoveries under the PSC regime. KG/ONDSF/KAZA/2018 Onshore Block was awarded to Vedanta Limited under discovered small fields (DSF) Policy.

As per the EIA notification- 2006 and its current amendment proposed Onshore project is covered under Schedule 1(b) Offshore & onshore oil & gas exploration, development & production Category "A" and required

Prior Environmental Clearance. This project pre-feasibility report has been prepared as per guidelines issued by the MoEF&CC.

### 1.2.2 Details of the Proponent

**Vedanta Limited (Division: Cairn Oil & Gas)** is one of the largest oil and gas exploration and production companies in India. **Vedanta Limited (Division: Cairn Oil & Gas)** contributed ~25% to India's domestic crude oil production in financial year 2017-18 and has a vision to produce 50% of India's oil and gas.

## 1.3 BRIEF DESCRIPTION OF PROJECT

### 1.3.1 Nature & size of the project

The proposed project KG/ONDSF/KAZA/2018 is a Greenfield oil and gas development project located in Krishna district of Andhra Pradesh. The scope of the project includes carrying out the development oil & gas wells drilling, construction of well pads along with oil & gas production facilities and laying of crude oil & gas pipeline till connecting to the existing pipeline for evacuation of the final products.

The following are the three major activities proposed as part of the Kaza Block development.

1. Drilling of 35 hydrocarbon wells within the Kaza block area
2. Development of ten well pads to setup the hydrocarbon processing facilities and produce up to 30,000 Barrels of Oil per day and 30 Million Metric standard Cubic Feet of gas per day. Each well pad will be of size maximum 300 m x 300 m (say 9 hectare each).
3. Laying of separate gas pipeline from the developed well pads and connecting to the main header pipeline already laid by GAIL and MEIL.

### 1.3.3 Location of the Project

KG/ONDSF/KAZA/2018 is an onshore Block comprising approximately area of 114.93 $Km^2$. Longitude and latitude measurements details of the Block are given below Table 1.1. Index Map of the block is shown in Figure 1.1 below.

## 1.4 REGULATORY FRAMEWORK AND NEED OF EIA STUDY

The overview of the regulatory framework and Vedanta Ltd (Cairn Oil & Gas)'s corporate HSE requirements of relevance applicable to the proposed onshore oil and gas development program in the KG/ONDSF/KAZA/2018 Block is detailed in **Annexure - IV**.

The Annexure IV covers the following regulatory requirements in detail:

- Constitutional provisions safeguarding individual rights and environment;
- Institutional Framework;
- Applicable Environmental Laws, Regulations and Policy;
- Social Laws, Regulations and Policy;
- Applicable Permits – Licenses, approvals and consents;
- Applicable Standards.

## 1.5 SCOPE OF THE EIA STUDY

The EIA study scope covers the following key elements to:

- Conduct EIA study as per the terms of reference issued by EAC of MoEF&CC;
- Compile primary environmental and social baseline data as collected during the EIA studies as well as through on-going baseline assessment quality monitoring. Available secondary information is also included to supplement the baseline data;
- Identify and assess potential environmental impacts from the proposed oil & gas development activities in Kaza block; and

- Develop appropriate mitigation measures and environmental management plan with required environmental management systems in place for effective implementation of suggested mitigation measures.

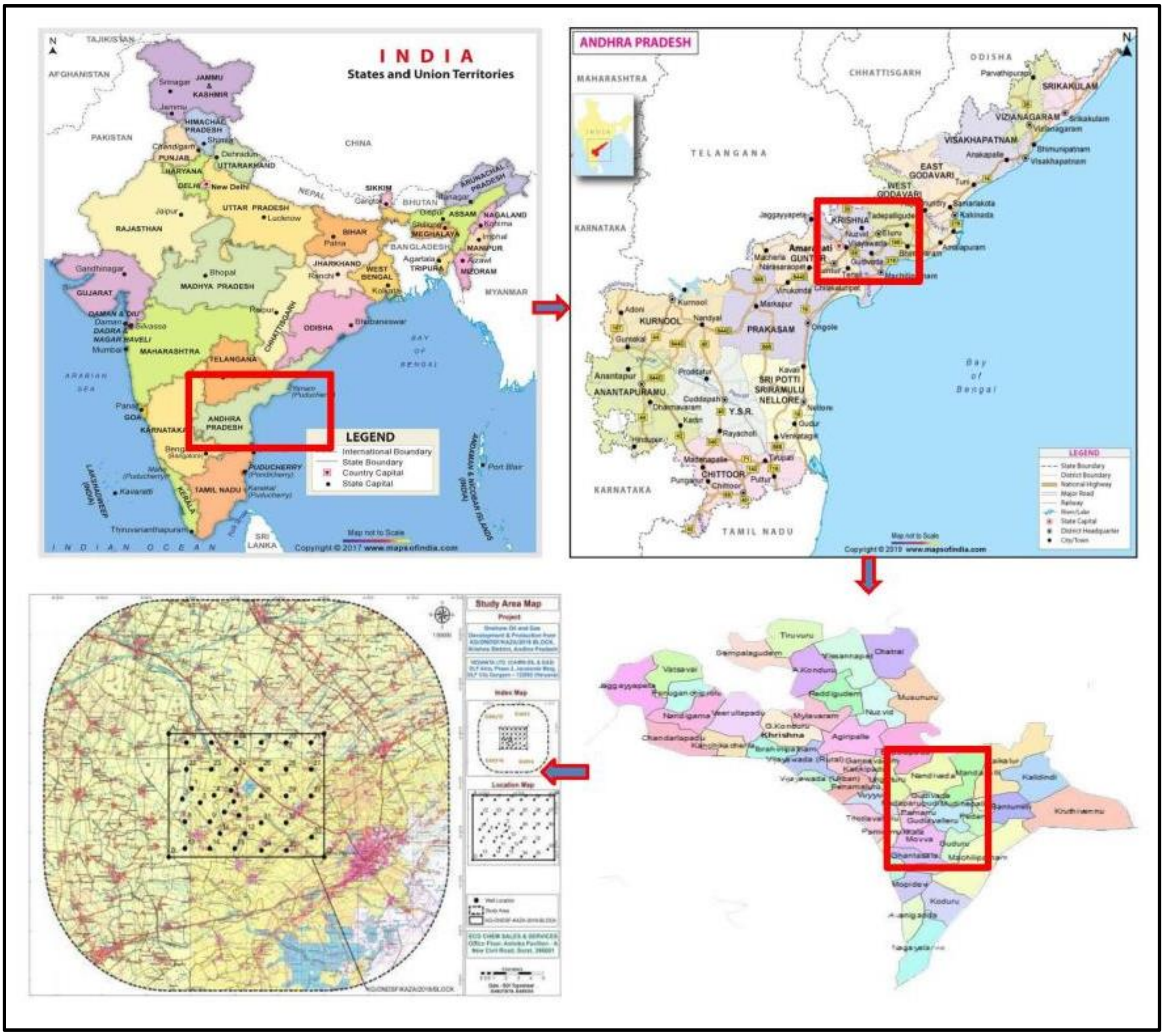



**Figure 1.1 Location map of the KG/ONDSF/KAZA/2018 block**

## 1.6 APPROACH AND METHODOLOGY OF THE EIA STUDY

The approach adopted for the conduct of EIA study is as per the following description:

**Step I: Screening**

The screening exercise involved:

- Reviewing high level Project Description and activities including alternatives considered by Cairn (Oil & Gas) and identifying their potential impacts on the various environmental parameters;
- Reviewing high level applicable regulatory framework for proposed and existing operations;
- Compiling high level available baseline data for the block and other relevant information;
- Categorization of EIA study under the EIA Notification, 2006

**Step II: Scoping Exercise involving submission of Application for Terms of Reference & Appraisal by EAC for Scoping for the EIA study**

The purpose of scoping exercise was to identify the likely project activities (as described in Project Prefeasibility Report) influencing environmental components which should be covered in the environmental information as part of the EIA study to be submitted by the developer (Cairn (Oil & Gas) in this case) to the regulatory agency (MoEFCC in this case) and, in particular to identify the prevailing environmental conditions which are to be studied in detail. The scoping included identification of range of environmental and socioeconomic topics to be studied (technical scope), the geographical area to be covered (spatial scope) and the timeframes over which the Project will be carried out (temporal scope).

As per requirement of the EIA Notification, 2006, an application for terms of reference for the EIA study was developed and submitted to MoEFCC on 12th February 2020. The MoEFCC issued the terms of reference for preparation of EIA/EMP study on 02nd April 2020, based on which this EIA study has been conducted.

**Step III: Project Description**

A detailed section on Project Description was developed as per the Project Prefeasibility Report together with additional Project related information collected from Cairn (Oil & Gas). The Project Description covered in ***Chapter 2*** has been considered as inputs for the impact assessment.

**Step IV: Environmental Baseline Data Compilation**

As assessed through scoping study, environmental baseline information was collected and compiled from primary and secondary sources.
Primary environmental monitoring in the onshore area surrounding the Kaza Block was collected during December 2019 – February 2020 as part of this EIA Study. Socio-economic and other environmental surveys were conducted in and around the study area of the Kaza Block and through review of available secondary information and studies.

**Step V: Impact Assessment & Analysis of Alternatives**

The methodology for assessing impacts associated with the proposed project development in the Kaza block is presented in ***Chapter 4*** on **Impact Assessment**. The section covers identification, prediction and quantification through modelling (where appropriate) of potential impacts due to the proposed Project on terrestrial environment.
Mitigation measures have been suggested for significant adverse impacts before, during and after implementation of the project related activities. The Impact Assessment section discusses the outcomes of the environmental impacts and outlines mitigation measures that are recommended to minimize adverse environmental impacts keeping in mind the compliance with the applicable environmental standards.
The impacts have been assessed based on the proposed activities, conditions of prevailing environmental baseline conditions surrounding the project activities within Kaza Block. The accuracy of predictions depends upon methods used and quality of the input data available at the EIA stage and the prevailing environment conditions. The impacts have been identified and quantified for the intensity using modelling and/or matrix techniques and evaluated as major, medium, minor or insignificant impacts on the environment. Worst-case scenarios have been assumed where uncertainty prevailed, and mitigation measures have been developed

accordingly. Unplanned events have been identified as part of the risk assessment process. Risk mitigation measures have been included to minimize potential risks.
Analysis of alternatives has been presented for significant residual impacts to ensure that implementation of alternatives would result in potential adverse impacts and associated risks within acceptable range.

**Step VII: Environmental Management and Monitoring Plan**

Based on the findings from the impact assessment process, an Environmental Management Plan (EMP) has been developed for the proposed oil and gas development and production in Kaza Block. Specific actions to counter the significant adverse impacts have been highlighted in the EMP. The potential impacts identified, and recommended mitigation measures are based on the following:

- Project information;
- Baseline information within and surrounding the Kaza Block;
- Consultants experience in similar projects; and
- Standard international environmental management practices.

**Step VIII: Statutory Public Consultation**

APPCB conducted Public Consultation is planned for the proposed Project as per the procedure defined in the EIA Notification, 2006. The environmental concerns expressed during the consultation will be incorporated in this final EIA Report.

**Step IX: Project Approvals**

The EIA study assesses impacts and associated risks due to the proposed project activities in Kaza Block and delineates for Cairn (Oil & Gas) to implement agreed specific actions as defined in the EMP together with monitoring plan as part of its environmental management system.
This EIA study becomes guiding documents for decision making for the proposed Project related approvals by MoEFCC under the EIA Notification, 2006.

## 1.7 STRUCTURE OF EIA REPORT

The generic structure of the EIA report as per the guideline provided by MoEF&CC is illustrated in the following tabulated format.

**Table 1.1: Structure of EIA report**

| S. No. | EIA Structure | Contents |
|---|---|---|
| 1. | Introduction | ▪ Purpose of the Report<br>▪ Identification of project and project proponent<br>▪ Brief description of nature, size, location of the project and its importance to the country, region.<br>▪ Scope of the study – details of regulatory scoping carried out (As per terms of reference). |
| 2. | Project Description | ▪ Type of project<br>▪ Need of the project<br>▪ Location details showing general location, specific location, project boundary and project site layout. |

| S. No. | EIA Structure | Contents |
|---|---|---|
| | | ▪ Size or magnitude of operation<br>▪ Project description including drawings showing project layout, components of project *etc*.<br>▪ Proposed schedule for implementation,<br>▪ Technology and process description,<br>▪ Schematic representations of the feasibility drawings which give information important for EIA purpose.<br>▪ Description of mitigation measures incorporated into the project to meet environmental standards, environmental operating conditions, or other EIA requirements |
| 3. | Description of the Environment | ▪ Study area, period, components and methodology.<br>▪ Establishment of baseline for valued environmental components, as identified in the scope.<br>▪ Study Period: 1st December 2019 to 29th February 2020<br>▪ Base maps of all environmental components. |
| 4. | Anticipated Environmental Impacts and Mitigation Measures | ▪ Details of Investigated Environmental impacts due to project location, possible accidents, project design, project construction, regular operations.<br>▪ Measures for minimizing and / or offsetting adverse impacts identified.<br>▪ Assessment of significance of impacts (Criteria for determining significance, Assigning significance),<br>▪ Impact scores and Mitigation measures<br>▪ Air quality modelling<br>▪ Air Quality Index |
| 5. | Analysis of Alternatives (Technology and Site) | In case, the scoping exercise results in need for alternatives:<br>▪ Analysis of Alternatives and Other Technology<br>▪ Selection of alternative |
| 6. | Environmental Monitoring Program | ▪ Technical aspects of environmental monitoring for the effectiveness of mitigation measures (including measurement methodologies, frequency, location, data analysis, reporting schedules, emergency procedures, detailed budget and procurement schedules) |
| 7. | Additional Studies | ▪ Risk Assessment<br>▪ Disaster management Plan |
| 8. | Project Benefits | ▪ Physical Benefits<br>▪ Ecological Benefits<br>▪ Social Benefits<br>▪ Other tangible Benefits |
| 9. | Environmental Cost Benefit Analysis | ▪ Not applicable as it is not recommended on scoping stage |
| 10. | Environment Management Plan | ▪ Description of the administrative aspects of ensuring that mitigation measures are implemented and their effectiveness monitored, after approval of the Clearance. The Chapter consists of:<br>- Mitigation Measures for Impacts<br>- Pollution Prevention Plan |

| S. No. | EIA Structure | Contents |
|---|---|---|
| | | - Greenbelt Development Plan<br>- Waste Management Plan<br>- Environment Management Cell<br>- Budgetary Provisions for EMS |
| 11. | Conclusion | ▪ Overall justification for implementation of the project, |
| 12. | Disclosure of Consultant Engaged | ▪ The names of the Consultants engaged with their brief resume and nature of consultancy rendered. |

***Source: EIA Notification 2006***

## 1.8 SUMMARY

The proposed project is to carryout development of well, drilling, and Production up to 30,000 Barrels of Oil per Day (BOPD) and 30 Million Metric Standard Cubic Feet (MMSCFD) of gas through development of 10 no's of hydrocarbon processing facilities (well pads) in the block KG/ONDSF/KAZA/2018 at Kaza, district Krishna, Andhra Pradesh. Considering the project details, the project falls under the project falls under category 'A' of activity 1(b) - Offshore and onshore oil and gas exploration, development & production requires prior Environmental Clearance (EC) to be obtained from MoEF&CC before the commencement of ground activity. The EIA report is prepared as per TORs given by MOEFCC, New Delhi vide F.No. No. IA-J-11011/52/2020-IA-II(I) dated 02 April 2020.

# CHAPTER 2

# PROJECT DESCRIPTION

## 2.0 GENERAL

This chapter describes type, need, location, geology and stratigraphy, size or magnitude of project, development drilling & related activities, and operation philosophy of the proposed well pads including the production facilities.

## 2.1 PROJECT DESCRIPTION

KG/ONDSF/KAZA/2018 is onshore Block located in Krishna District of Andhra Pradesh. ONGC has drilled three exploratory wells in the year 1985 in the Kaza structure. Out of the three wells, two wells were found to be dry wells and one well found to have gas discovery. The successful exploration well has discovered gas in Raghavapuram sands, possibility of occurrence of oil cannot be ruled out. Based on the data obtained from the successful gas well, the reservoir properties are moderate. It was noted that further gas extraction is possible through hydro-fracture the well. All the wells were drilled in the depth of ~ 2300 m below the ground level. It is understood that the accumulated hydrocarbons are due to long distance migration from the deeper parts of the depression adjacent to the Kaza high.

This Kaza block was awarded to Vedanta Ltd in DSF Round-II in 2018. Cairn Oil & Gas will operate the Kaza block with 100% Participating Interest. The proposed project is green field in nature. There is no interlinked and inter-dependent project.

### 2.1.1 Location, Type and Size of Project

The block KG/ONDSF/KAZA/2018 comprising an area of 114.93 km$^2$. The estimated cost of the proposed project is approximately INR 650 Crores. The tentative drilling locations are presented in satellite image and toposheet which are shown in Figure 2.1 and 2.2 below. The proposed co-ordinates of the block boundary and wells are given in the Table 2.1 & Table 2.2 below. The 35 wells are located in Kaza Block covering four Mandal's of Krishna District. The proposed 35 no's of the hydrocarbon wells to be drilled are distributed as 14 wells in Mova Mandal; 18 wells in Gudur Mandal; two wells in Kalidindi and one well in Machilipatnam.

**Table 2.1 Block boundary Coordinates**

| Point | Latitude | Longitude |
|---|---|---|
| A | 16" 16' 00.00" | 80" 59' 00.00" |
| B | 16" 16' 00.00" | 81" 06' 00.00" |
| C | 16" 11' 00.00" | 81" 06' 00.00" |
| D | 16" 11' 00.00" | 80" 59' 00.00" |

**Table 2.2: Proposed well co-ordinates to be drilled in block KG/ONDSF/KAZA/2018**

| Well ID | Latitude | Longitude | Nearby Villages | Mandal | District |
|---|---|---|---|---|---|
| 1 | 16° 13' 46.661" N | 81° 0' 1.886" E | Palankipadu | Movva | Krishna |
| 2 | 16° 13' 42.160" N | 81° 1' 48.175" E | Kanchakodur, makulavaripalem | Gudur | Krishna |
| 3 | 16° 13' 21.019" N | 80° 59' 36.988" E | Palankipadu | Movva | Krishna |
| 4 | 16° 13' 29.741" N | 81° 1' 2.691" E | Kanchakodur, makulavaripalem | Gudur | Krishna |
| 5 | 16° 13' 12.235" N | 81° 0' 25.142" E | Matlamullapalli | Movva | Krishna |
| 6 | 16° 13' 14.870" N | 81° 1' 55.831" E | Kanchakodur | Gudur | Krishna |
| 7 | 16° 12' 49.232" N | 81° 1' 30.320" E | Maddipatla | Gudur | Krishna |
| 8 | 16° 12' 25.772" N | 80° 59' 43.830" E | Matlamullapalli | Movva | Krishna |
| 9 | 16° 12' 25.771" N | 81° 0' 51.194" E | Paddarayuduthota , Kaza | Movva | Krishna |
| 10 | 16° 12' 41.358" N | 81° 2' 9.505" E | Maddipatla | Gudur | Krishna |
| 11 | 16° 11' 56.955" N | 81° 1' 18.276" E | Kollapalem, Paddarayuduthota, Kaza | Movva | Krishna |

| | | | | | |
|---|---|---|---|---|---|
| 12 | 16° 11' 56.945" N | 81° 2' 25.638" E | Reddy naidu Agaraharam, Kollapalem | Kalidindi | Krishna |
| 13 | 16° 11' 20.682" N | 80° 59' 43.831" E | Kaza | Movva | Krishna |
| 14 | 16° 11' 20.681" N | 81° 0' 51.190" E | Kaza | Movva | Krishna |
| 15 | 16° 11' 20.673" N | 81° 1' 58.549" E | Racharlapalem, Kollapalem | Kalidindi | Krishna |
| 16 | 16° 15' 38.443" N | 80° 59' 47.748" E | Avurupudi | Movva | Krishna |
| 17 | 16° 15' 38.442" N | 81° 0' 55.131" E | Nidumolu | Movva | Krishna |
| 18 | 16° 15' 38.434" N | 81° 2' 2.514" E | Nidumolu, kalapatam | Movva | Krishna |
| 19 | 16° 15' 38.420" N | 81° 3' 9.898" E | kalapatam | Gudur | Krishna |
| 20 | 16° 15' 38.400" N | 81° 4' 17.281" E | Gurjepalle | Gudur | Krishna |
| 21 | 16° 15' 38.374" N | 81° 5' 24.664" E | kanktav | Gudur | Krishna |
| 22 | 16° 14' 33.354" N | 80° 59' 47.749" E | Palankipadu | Movva | Krishna |
| 23 | 16° 14' 33.352" N | 81° 0' 55.126" E | Mantripalem | Movva | Krishna |
| 24 | 16° 14' 33.344" N | 81° 2' 2.503" E | Veerayelanka, Palankipadu, Pinagudurulanka | Movva | Krishna |
| 25 | 16° 14' 33.331" N | 81° 3' 9.880" E | Parnasala,Tarakaturupalem | Gudur | Krishna |
| 26 | 16° 14' 33.311" N | 81° 4' 17.257" E | Narikedalapalem | Gudur | Krishna |
| 27 | 16° 14' 33.285" N | 81° 5' 24.634" E | Narikedalapalem | Gudur | Krishna |
| 28 | 16° 13' 28.241" N | 81° 3' 9.863" E | Parnasala | Gudur | Krishna |
| 29 | 16° 13' 28.221" N | 81° 4' 17.234" E | Chittiguduru | Gudur | Krishna |
| 30 | 16° 13' 28.196" N | 81° 5' 24.604" E | Guduru, Kokanarayanapalem | Gudur | Krishna |
| 31 | 16° 12' 23.151" N | 81° 3' 9.846" E | Kanchakoduru, Akumarru | Gudur | Krishna |
| 32 | 16° 12' 23.132" N | 81° 4' 17.210" E | Gulabpura, Chittiguduru | Gudur | Krishna |
| 33 | 16° 11' 48.130" N | 81° 5' 26.015" E | Sultannagaram Gollapalem | Machilipatnam | Krishna |
| 34 | 16° 11' 15.987" N | 81° 3' 10.719" E | Rayavaram | Gudur | Krishna |
| 35 | 16° 11' 15.967" N | 81° 4' 18.077" E | Akumarru | Gudur | Krishna |

*Note: Actual geographical surface coordinates of well locations and well pad will be within 2000 m radius of the proposed coordinates considering physical site conditions such as land availability, preferably non-agricultural land etc.*

### 2.1.2 Accessibility to the Block

Kaza Block is located in Makulavaripalem Village; Muvva Mandal; Machilipatnam as district headquarters & revenue division, Krishna district of Andhra Pradesh. The block is easily accessible through the rail and road network. The key connectivity linked to this Block is mentioned in the below Table 2.3.

**Table 2.3: Connectivity to block KG/ONDSF/KAZA/2018**

| | |
|---|---|
| **Nearest Road Connectivity** | NH-65 (Machilipatnam to Vijayawada) crosses across the Block. Also the block is well connected by MDR and State Highways. |
| **Nearest Rail Connectivity** | No Railway line passes through the Block area. Nearest Railhead is Machilipatnam which is 12 km from center of block |
| **Nearest Seaport from center of the Block** | Machilipatnam Port is being developed and is at a distance of 18 km. Presently there is only a fishing harbour |
| **Nearest Airport from center of the Block** | Hyderabad airport is 320 km distance and Vijayawada is at 42 km distance, Rajahmundry airport is at 128 km away (All are aerial distances) |
| **Nearest Town/ Village** | Nearest town is Machilipatnam and is 12 km from center of Block. Villages are Kaza, Rayavaram, Tarakaturapalem, Racharlapalem, RN Agraharam, Akamarru, Sultannagaram Gollapalem, Gulabpura, Guduru, Chittiguduru, Kanchakadoru, Maddipatla, Kanchakodur, Makulaveripalem, Palankipadu, Mantripalem, Veerayelanka, Pinagudurulanka, Narikedalapalem, Kankatava, Kalapatam, Nidumolu, Nidumolu Laku, Avurupudi etc., |

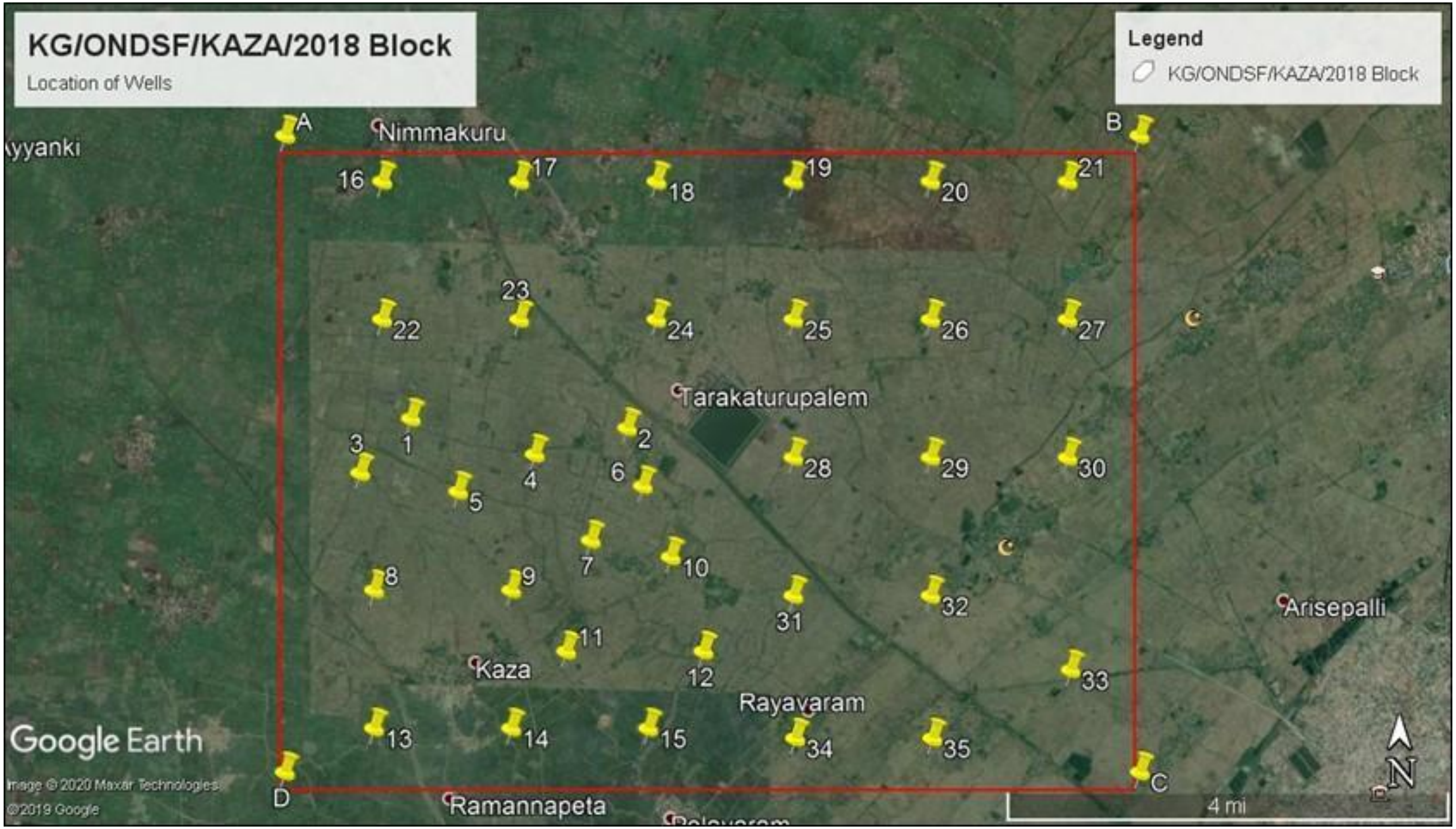



**Figure 2.1 Google Earth Short view of Project Site**

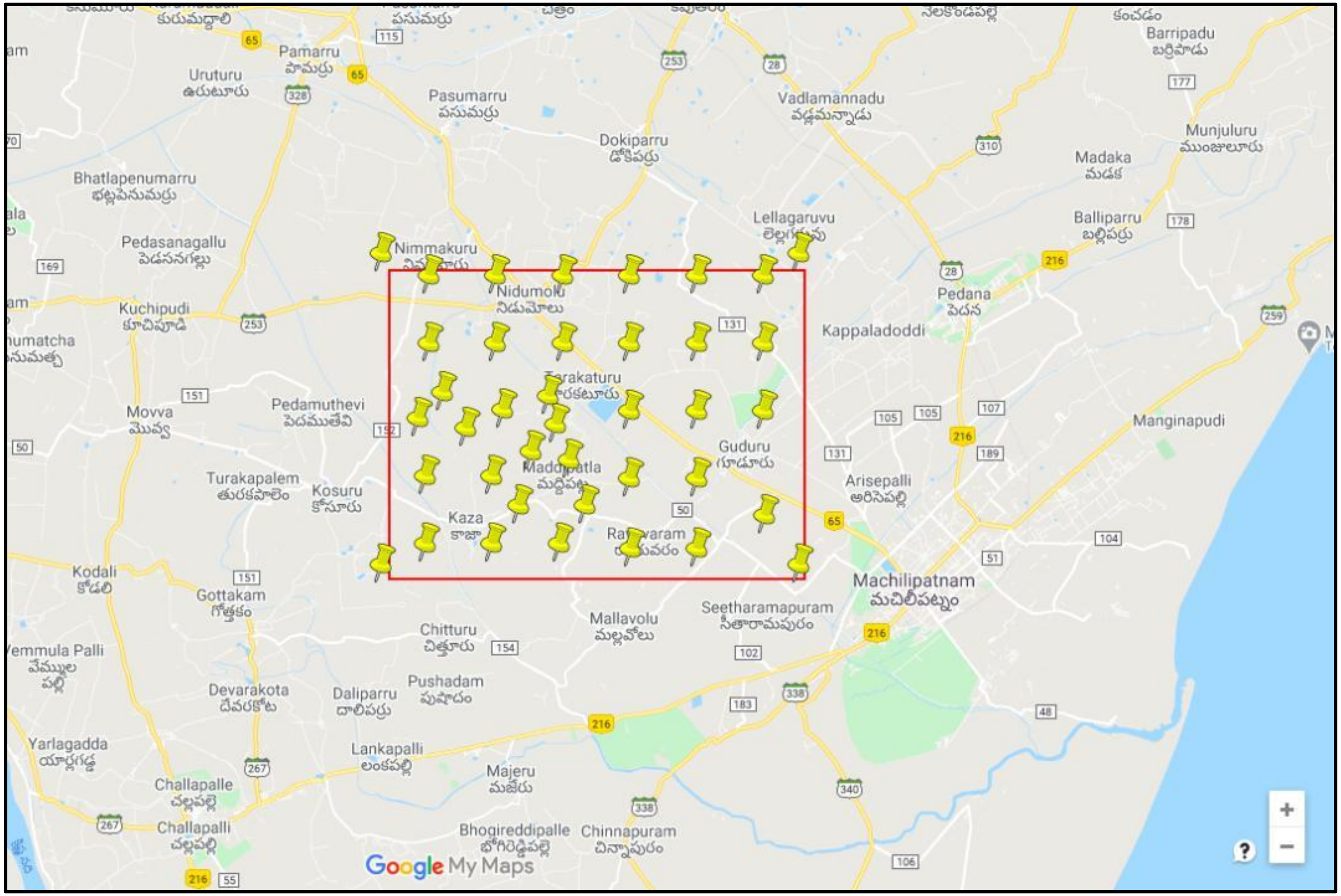



**Figure 2.2 Accessibility Map of the KG/ONDSF/KAZA/2018 Block**

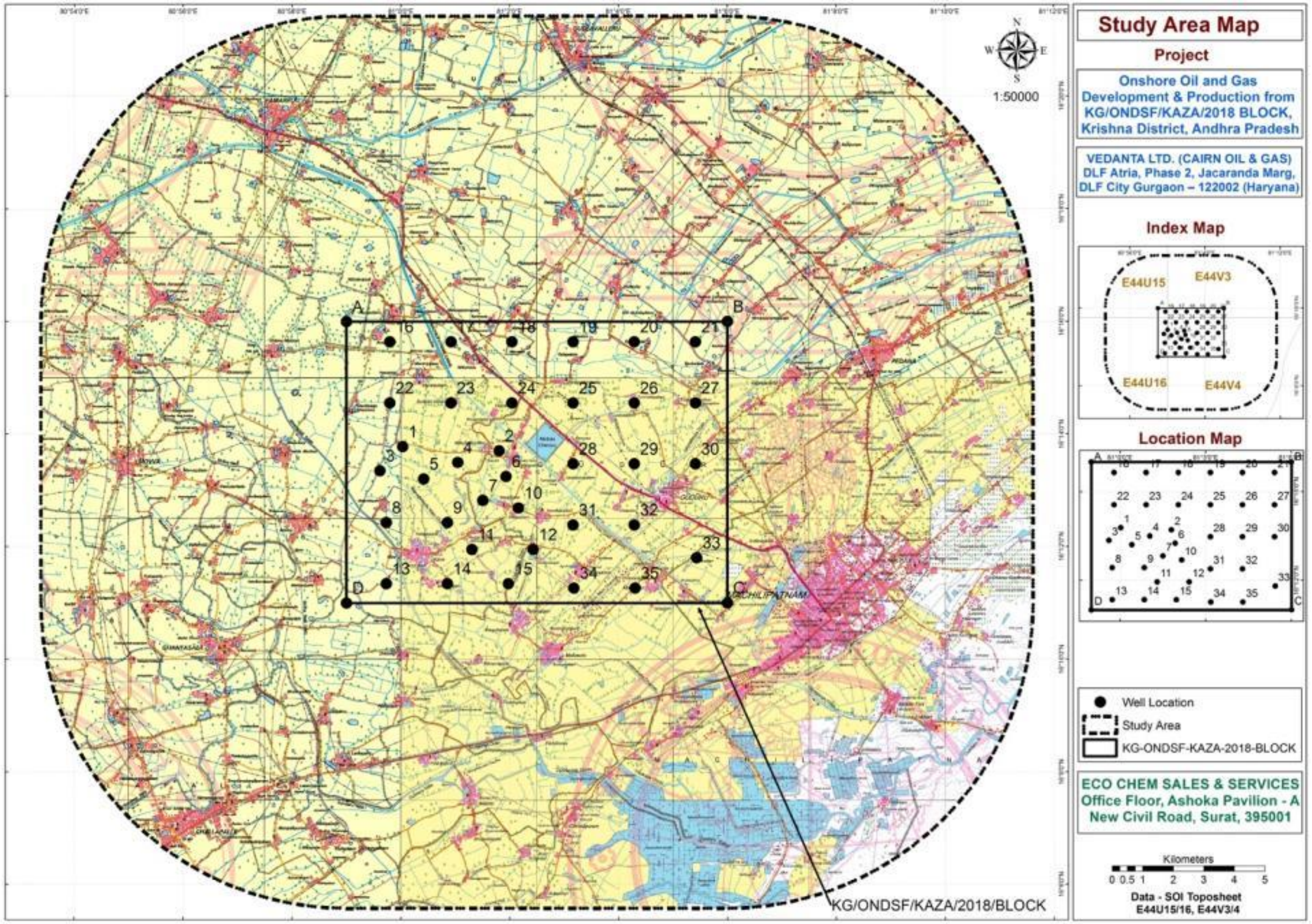



**Figure 2.3: Proposed well Locations in Block KG/ONDSF/KAZA/2018 on Toposheet**

### 2.1.3 Physical Environmental setting of the Block

Physical environmental settings in the vicinity of the block KG/ONDSF/KAZA/2018 have been given below at Table 2.2.

**Table 2.4 Environmental Setting of Block within Study Area 10 Km Radius**

| S. No. | Particulars | Description |
|---|---|---|
| 1. | Name of Block | KG/ONDSF/KAZA/2018 |
| | District | Krishna |
| | State | Andhra Pradesh |
| 2. | Well site Elevation | 3 m to 7 m above MSL |
| 3. | Site specific | • Climate: Tropical climate<br>• Maximum temperature: $38^0$C<br>• Minimum temperature: $20^0$C<br>• Avg. annual Rainfall: 1011.2 mm<br>• Humidity : 70 to > 80%. |
| 4. | Geographical location in toposheet | E44U15, E44U16,E44V3,E44V4 |
| 5. | Nearest town/city/district | Machilipatnam @4.40 km in SE direction from Block boundary |
| 6. | Nearby Highways | NH-65, NH-216, SH-50, SH-131 |
| 7. | State, National boundaries | None |
| 8. | Nearby Water Bodies | • Bay of Bengal- 12 km in SE direction from Block boundary<br>• Machilipatnam canal- Passes through the center of the block<br>• Krishna River- 12 km in W direction from Block boundary |
| 9. | Archaeological site | None |
| 10. | Seismicity | Zone III Moderate Damage Risk Zone |
| 11. | Eco-sensitive Zone/ National park/ Wildlife sanctuary | Krishna Wildlife Sanctury-19 km from block boundary in S direction |

***Note: All distances mentioned above are aerial distances***

***Source: Topo sheets, Google image and field visits***

### 2.1.4 Need of the Project

As per DGH report referring India Hydrocarbon Outlook, in the year 2017 – 18 India has produced in total 35.68 Million Metric Tons (MMT) of Crude Oil and 32.65 Billion Cubic Meters (BCM) of Natural Gas, which accounts for only < 1% of world oil & gas production. The DGH report also mentioned that Oil and Oil Oil-equivalent gas (O+OEG) of 239.88 MMT is in place accretion and around 108.76 MMT O+OEG Accretion of Reserves. India imports around 82% of its oil needs and aims to bring that down to 67% by 2022 by replacing it with local exploration, renewable energy and indigenous ethanol fuel.

With the proposed expansion of the production facilities, the share of the contribution from this KG/ONDSF/KAZA/2018 Onshore Block to the nation will be further strengthened. On a broader scale, this proposed project will help the Indian Government in addressing its energy security needs. So, this project is important from the company and national perspective.

**Demand and Supply Gap**

DGH has notified that in-place hydrocarbon volume of 10,960.05 MMT of Oil and Oil Equivalent Gas (O+OEG) has been established by all the operators in India under PSC and CBM regime. Ultimate reserves are 4203.64 MMT O+OEG and accretion in ultimate reserves is 108.76 MMT O+OEG. A balanced recoverable reserve is

1917.47 MMT O+OEG. India has 0.5% of world's proven oil reserves; however, it comprises of more than 15% of the world's population. As a result, India imports 82% of its oil needs.

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.

GOI has set an ambitious target of reducing hydrocarbon import. Increasing oil & gas production is one of the measures by which oil & gas import dependency can be reduced. Enhancing domestic oil and gas production by promoting and Production activities by providing more exploration and discovered acreages has always been among Government's highest priorities, thus this Kaza Block was awarded to Vedanta under Discovered Small Fields Policy (DSF).

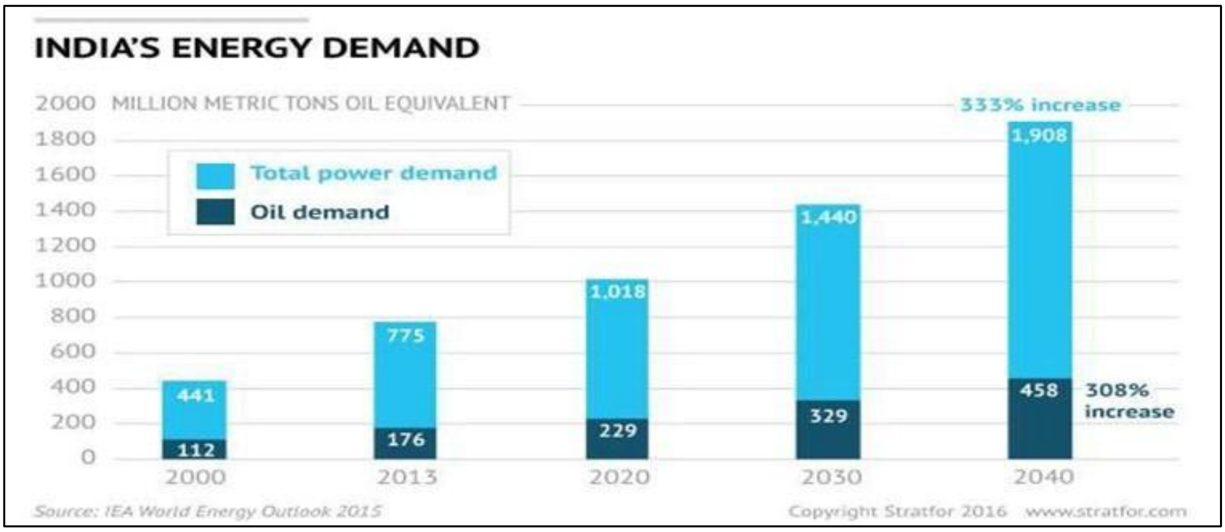



**Figure 2.4: Oil and Gas Consumption Scenario- India**

**Import Vs. Indigenous Production**

Currently, ~76% of the crude oil and ~21% of the natural gas are being 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.

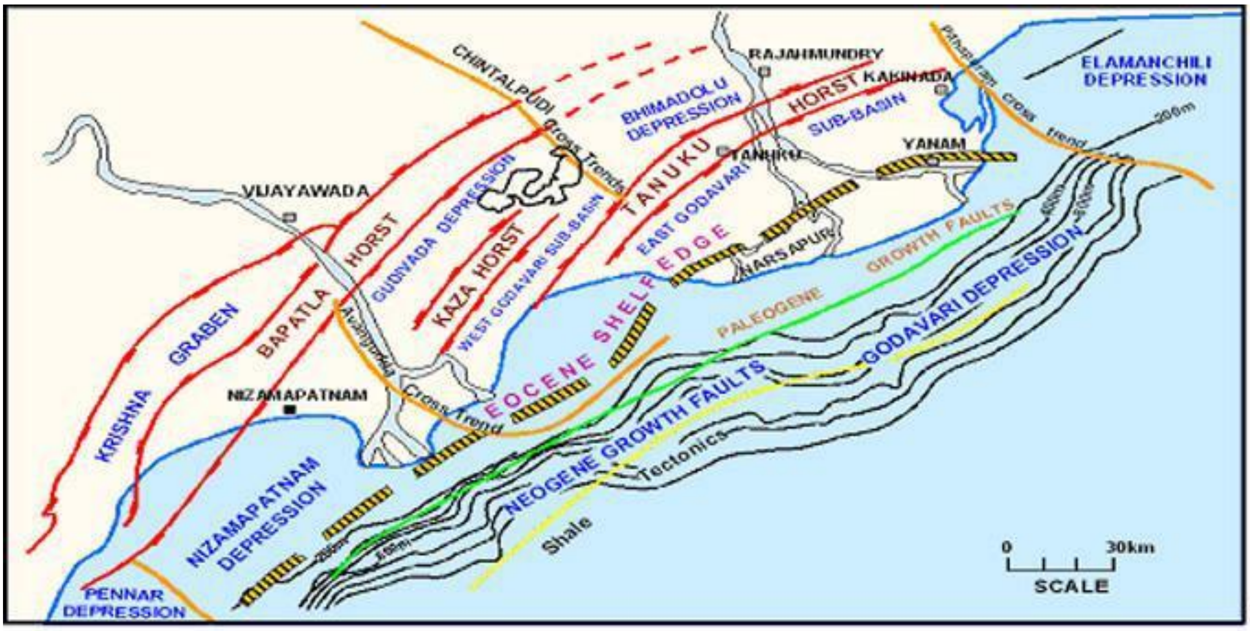
**Export Possibility and Domestic / Export Market**

As India is already shortfall in Crude oil and gas production, thus export is not permitted, however the finished petroleum products can be exported based on the individual manufacturing capacity and capability. This project scope is limited only to production of crude oil and natural gas.

## 2.2 PETROLEUM GEOLOGY OF KG BASIN

### 2.2.1 Regional Geology and Stratigraphy

The Krishna-Godavari (KG) basin has a series of rift axis parallel highs and lows trending NE-SW broadly in an en-echelon pattern. In the inland part, the basin is characterized by sub basins from northwest viz. Krishna, West Godavari (WG) and East Godavari (EG) separated by two basement Highs viz. Bapatla High and Bhimavaram-Tanuku High. The WG Sub-basin is further subdivided into Gudivada and Bantumilli Graben by Kaza-Kaikalur High.




*Source: NDR*

**Figure 2.5: Tectonic Elements of the Basin**

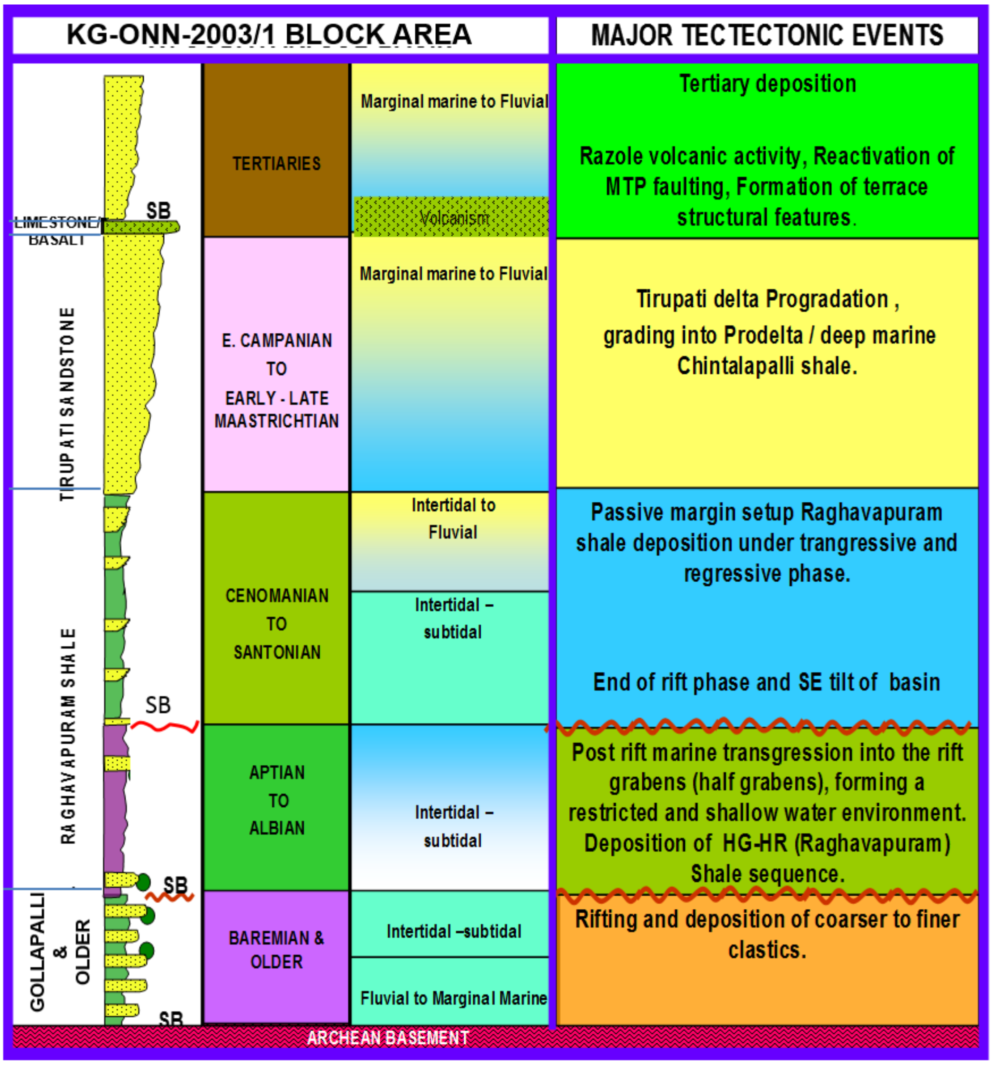
Block KG-ONDSF-KAZA is located on the Kaza-Kaikalur High and is characterized by the presence of a prospective late syn-rift to post-rift Cretaceous sequence that formed in response to rifting of India from Antarctica during the break-up of Gondwana (Majumdar et al. 1995; Biswas, 2003). Structurally, the initial licence area contains a number of rotated fault blocks separated by half- grabens which are arranged in an en-echelon manner and offset by major cross-faults.

The dominant tectonic grain across the area is approximately NE-SW which is orthogonal to an older NW-SE trend expressed by the Permo-Triassic Pranhita-Godavari Basin, immediately to the north outside of the current area of interest. This older Permo/Triassic Pranhita- Godavari trend which is present along the Godavari river valley is observed in the West.

Godavari sub- basin as the cross faults and top basement map. In the Cretaceous, the basin become a pericratonic rift in which thick deposits of marine to fluvial sediments accumulated within the grabenal areas associated with basement block faulting due to the reactivation of northeast-southwest–trending Precambrian faults.

The stratigraphy of the basin is summarized by Rao (2001), and although this published stratigraphy has some limitations, it is used herein as the general stratigraphic framework. Biostratigraphic data is available from outcrop and subsurface wells (Prasad and Pundir, 1999; Rao, 2001) and enables the main stratigraphic units to be dated, although the stratigraphic framework remains largely lithostratigraphic.

The general reference stratigraphic framework is shown in Fig. 2.6.




*Source: NDR*

**Figure 2.6: Generalized Stratigraphy, Depositional Environment and Tectonics**

Gondwana sediments of Carboniferous-Permian-Triassic age rest unconformably on Pre-Cambrian Archean basement. An early Permian Draksharama Formation comprises a fluvial and lacustrine succession, which is overlain by the Triassic Mandapeta Sandstone. The late Triassic is dominated by a continental red mudstone sequence that is dated with palynomorphs and may extend into the early Jurassic. The Cretaceous sequence begins with the sand-dominated Gollapalli Formation in the West Godavari sub-basin, which shales out eastwards into the Pennar Formation in the offshore.

The Gollapalli Formation comprises a series of stacked micaceous and gritty sandstones containing abundant plant fossils that date it as Neocomian, interpreted to represent fluvial deposits draining into marine embayments defined by the graben and horst structures. The overlying Raghavapuram Shale represents the first significant marine transgression and contains a rich fauna of ammonites, brachiopods and foraminifera that indicate a Barremian to early Aptian age (Prasad and Pundir, 1999). This shale thins westwards and onto the structural highs in the basin, where significant sandstones, including the Raghavapuram Sandstone and Tirupati Sandstone, that are derived from the west and northwest, and area considered as Upper Cretaceous in age (Kapoor et al., 1999). The Tirupati Sandstone and its offshore equivalents, the Chinttapalli Shale, are unconformably overlain by the Razole volcanic sequences of well dated to latest Maastrichtian to early

Palaeocene age (Keller et al., 2009). The Razole Formation shows lateral lithological variation as the volcanic flows thin out and is correlated to lime stones of Paleocene age in the Nagayalanka area.

The overlying Tertiary sequence records the deposits of a major prograding delta system that was derived from the west. The Nimmakuru Sandstone and the Matsyapuri Sandstone are the main younger Tertiary sequences overlying the Maastrichtian to Palaeocene Razole Formation. The Nimmakuru sandstone dominantly consists of sandstone in onland part and equivalent Palakollu shale is present in basinward part. The Matsyapuri Sandstone mainly consists of sandstone with thin beds of clay stone and limestone overlying the lower Bhimanapalli Limestone.

### 2.2.2 Brief Exploration History

Krishna-Godavari basin is a proven petroliferous basin with commercial hydrocarbon accumulations in the oldest Permo-Triassic Mandapeta Sandstone onland to the youngest Pleistocene channel levee complexes in deep water offshore.

The horst structures in the basin were considered the sweet spots for hydrocarbon exploration. The well Kaza-1 was drilled as an exploratory "B" category well to test the hydrocarbon potential of the Kaza-Kaikalur ridge in west Godavari sub basin. The well drilled encountered the Lower Tertiary, Cretaceous and basement formations. Four Objects were tested and Object-II was found to be hydrocarbon bearing. It was observed that the pay sands encountered were not correlatable with pay sands of Kaikalur-1. This signified that the sand bodies in Kaza-1 and Kaikalur-1 were not connected.

With the discovery in Kaza-1, two separate closures were brought out and Kaza-2 and Kaza-3 were drilled. The pay sands encountered in Kaza-1 were not encountered in Kaza-2 and Kaza-3. The wells were declared dry and abandoned.

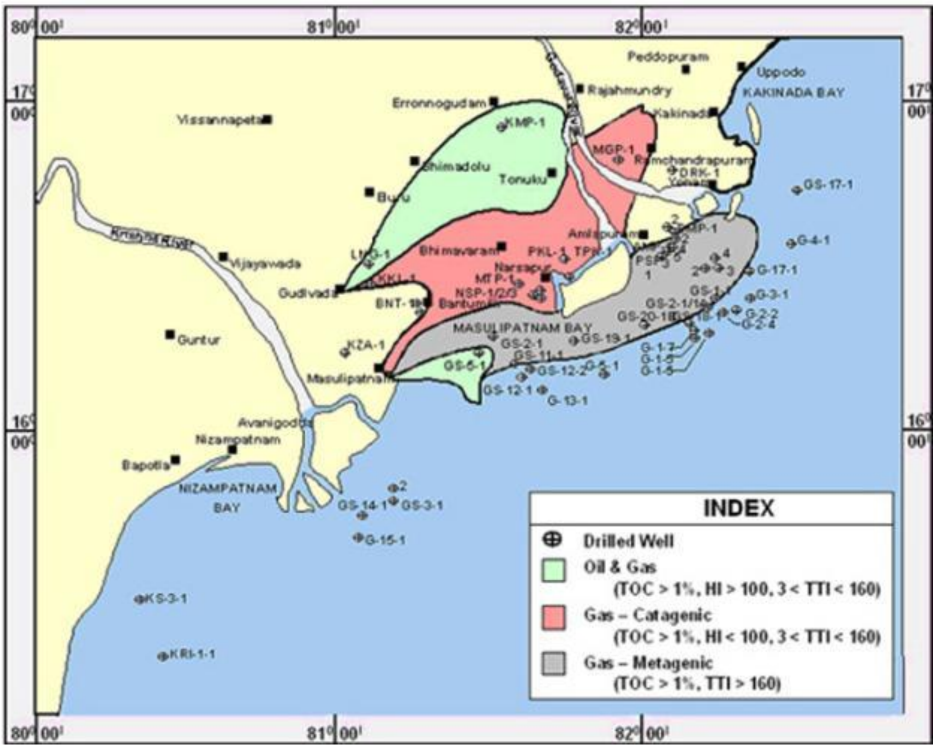
### 2.2.3 Petroleum Systems

Source rocks: Raghavapuram Shale of Lower Cretaceous age is considered as the principal source rock not only for this system but also for the onland part of the basin. Maximum thickness up to 1100 m is recorded in the subsurface. The sequence comprises essentially carbonaceous shale with intervening sands possibly representing brief regressive phases in an otherwise major transgressive phase. The organic matter is dominantly of Type III and III B. The maturity level varies between catagenetic to inadequately matured in different parts of the basin. TOC is recorded up to 2.4%. It has the proclivity for generation of both oil and gas.

Reservoir: Lenticular sands within Raghavapuram Shale possibly representing intervening regressive phases are one of the potential exploration targets; though mapping them seismically poses some challenges as mentioned above. A recent major find in its time equivalent (?) in shallow offshore part of the basin opened up some very exciting exploration opportunities in this sequence. Recent exploratory efforts in deep offshore also indicated prospectivity in Cretaceous sequence Sands within Gollapalli Formation of Late Jurassic-Early Cretaceous in Mandapeta-Endamuru area and its time equivalent Kanukollu Formation in Lingala-Kaikalur area are another potential target in this petroleum system. A northeast southwest trending corridor of Upper Cretaceous Tirupati Sandstone, product of a regressive phase, between south eastern side of Tanuku Horst and MTP fault is emerging as another important target.

Seal: Raghavapuram Shale acts as effective seal for both Gollapalli reservoirs and the sands within Raghavapuram Shale. Shale intercalations within Tirupati Formation appear to act as seal for the accumulations within the Formation. Razole Formation (Deccan Basalt) acts as a regional cap for the pre-trappean hydrocarbon accumulations. It is of interest to note that occasional occurrence of hydrocarbons is noticed within Razole Formation itself, indicating its reservoir potential also.

Trap: While the entrapment style is essentially structural, accumulations in Raghavapuram Shale have strati-structural element in their entrapment.




*Source: NDR*

**Figure 2.7 Hydrocarbon generation centers in Cretaceous**

### 2.2.4 Reservoir Geology

The target interval for KG-ONDSF-KAZA Block is the Raghavpuram Formation of Upper Cretaceous. The Raghavpuram formation is a transgressive sequence deposited due to the tilting of basin during the post-rift thermal sag. Sands were encountered in the basal part of Raghavpuram Shale. The depositional environment is inferred to be marginal marine in nature, with distributary channels depositing sands in the Area of Interest. The reservoir is discrete in nature and has less lateral continuity. The reservoirs encountered in the Kaza-1 and Kaza-2 well are of poor quality and have low poro-perm values.

Average reservoir parameters are summarized below:

**Table 2.5: Summary of reservoir parameters in Kaza Field**

| | |
|---|---|
| Gross Thickness | 15-20m |
| Porosity | 0.10-0.15 p.u. |
| Water Saturation | 60-70% |
| Permeability | 0.08 md |

A schematic representation of logs from Kaza-1 and Kaza-2 are given below:

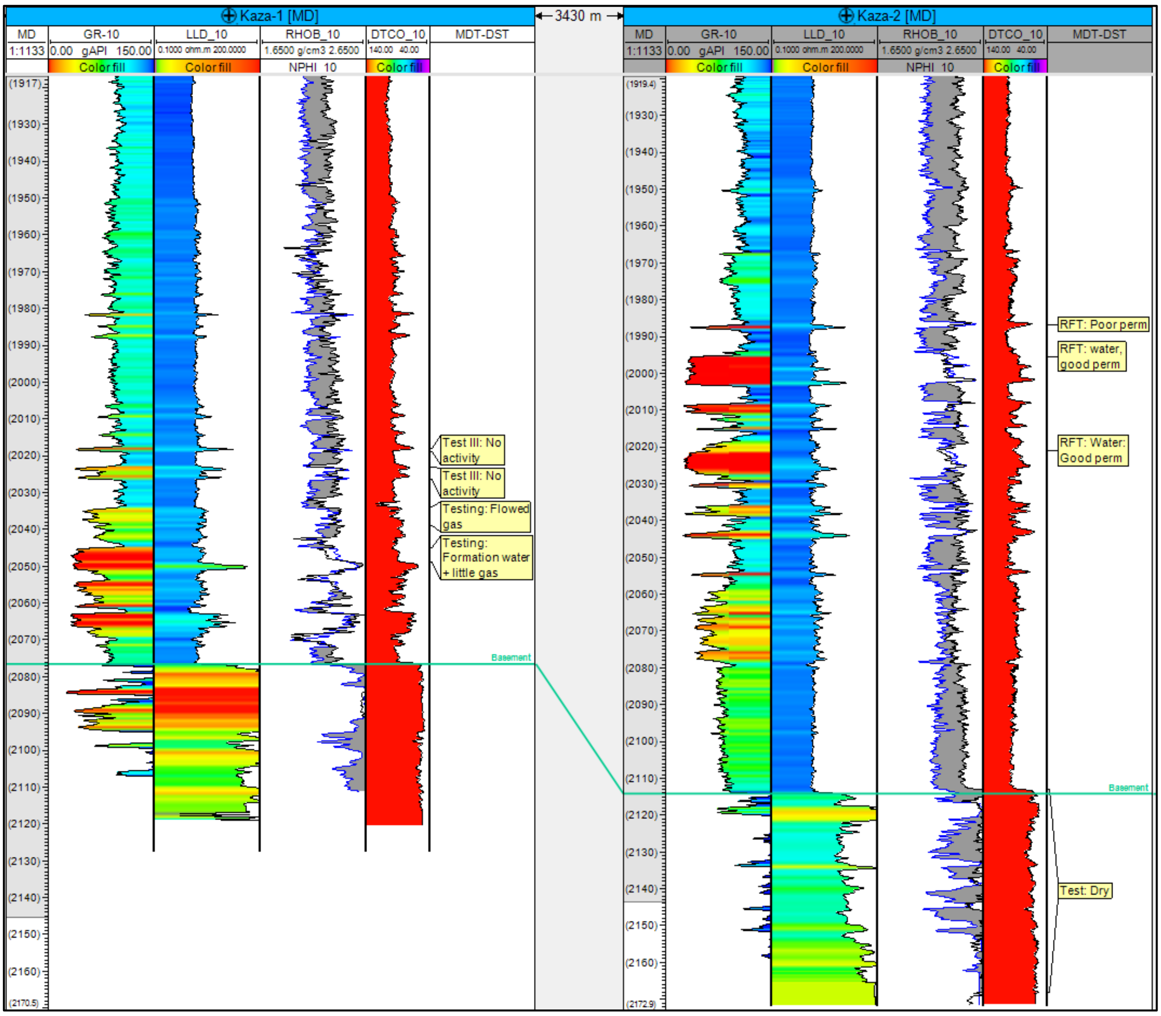



**Figure 2.8: Well Logs and litho-correlation of Kaza-1 and Kaza-2**

### 2.2.5 Available Data and Studies Carried out till March 2020

The KG-ONDSF-KAZA Block is covered with PSDM 3D seismic, in addition to 40 2D lines. As on March 2020, 3 exploratory wells were drilled in the block. These wells are logged with basic triple combo logs and sonic. Petrophysical analysis was performed to estimate reservoir properties. Around 17m conventional core acquired in Kaza-1 and Kaza-2 wells on which sedimentological and petrographic core analyses were conducted. A total of 36 side wall cores were taken in Basement, Raghavpuram Formation and Tirupati Sandstone. Geochemical Prospecting of Kaza-Kaikalur and Source-rock Evaluation Studies of the well Kaza-1 was carried out. Pressure data from RFT and Well tests are available in Kaza-1 and Kaza-2.

Currently (March 2020), subsurface studies are being carried out for volumetric and resource assessment of the Kaza field. Based on the studies, planning for next phase of appraisal and initial development will be carried out.

### 2.2.6 Field Development Philosophy

The Raghavpuram sands in Kaza field are known to be thin discrete and tight in nature. Given the characteristics of the sand bodies, of limited extent, it is believed that the field can be optimally developed by multi-stage hydraulic fracturing of closely spaced vertical wells. Alternate development options with better economic viabilities are also being evaluated.

As per the current understanding, approximately XX wells may be drilled in the field.

### 2.2.7 Reserve Summary

KG-ONDSF-KAZA Block gross reserve estimates are updated at least annually based on the forecast of production profiles, determined on an asset-by-asset basis, using appropriate petroleum engineering techniques. The estimates of reserves and resources have been derived in accordance with the Society for Petroleum Engineers “Petroleum Resources Management System (2007)”. The changes to the reserves are generally on account of future development projects, application of technologies such as enhanced oil recovery techniques and true up of the estimates. The management’s internal estimates of hydrocarbon reserves and resources at the period end as on 31st March 2020, based on the current terms of contract with Government of India, are as follows:

Contingent Resources for Kaza-1 Discovery: 0.4 to 0.8 BCF

In addition, a significant upside is potential is anticipated in the 115 sq. km of Kaza block that can be monetized by Drilling and Hydraulic Fracturing of ~ 50 wells across the area comprising of multiple undrilled structures.

A peak production of ~5-10MMscfd is expected from the field once the full field development campaign is implemented.

## 2.3 TECHNOLOGY AND PROCESS DESCRIPTION

### 2.3.1 Process description for Drilling of 35 Hydrocarbon Wells

The locations for the drilling of 35 wells will be fixed once the detailed interpretation of the already acquired seismic data is completed. The proposed co-ordinates of the drilling wells are given in Table 2.2 above. The proposed well depths vary up to 2400 m due to the subsurface structural configuration and the depth of occurrence of the primary reservoirs. Typically, estimated drilling duration of the well drilling and completion is between 45 – 60 days/ well. In addition, well testing will be carried out for the duration of 30 to 60 days/well to ascertain the reservoir parameters. Water Base Mud (WBM) will be used as drilling fluid for initial, shallower sections. The deeper and difficult to drill geological formations will be drilled using Synthetic Oil Base Mud (SOBM) as drilling fluid. All the proposed 35 wells are within the Block and will be drilled using an Electric Land Rig of around 1500 HP capacity, equipped with a Rotary/Top Drive System. The rig & associated services will have the following provisions:

- Portable Camps – to provide stay facilities for the around 80 drilling crew members.
- Crane-age - cranes for loading/offloading equipment and supplies.
- Emergency Systems - it includes fire detection and protection equipment.
- Environmental Protection – Blow out Prevention (BOP) system, wastewater treatment unit and cuttings handling equipment.

Additionally, there will be other ancillary facilities like Drilling mud system, ETP, Cuttings storage pit and disposal facilities, Drill Cementing equipment etc., and utilities to supply Power (DG sets), water, fuel (HSD) to the drilling process. The following are the various phases of the drilling activities and their process respectively.

- Site selection after Subsurface Target Identification
- Land acquisition either on lease or permanent
- Site and access road preparation
- Drilling activities
- Well testing
- Complete the well and suspend for production
- Decommissioning & closure of wells in case dry wells (no hydrocarbon found or non-viability of

extraction)

**Site Selection:** The previous exploration carried out by ONGC exhibits the potential presence of the gas in the Block. The exact location of the wells and well pads has not been finalized based on the carryout of seismic studies and interpretation of the data.

**Land acquisition:** An area of approximately 300m X 300m (9 hectares) would be taken on temporary lease basis for the construction of well pad (drill site) for drilling of the wells initially. For the approach well pads from the existing roads, it may be necessary to prepare the suitable access roads connecting to the proposed drilling sites (well pads), also accommodating OHL and other utilities in future, thus, a road width of 30m (approximately) will be required towards RoU (Right of Usage). If the drilling of the hydrocarbon wells found to be success, then that particular well pad land area will be considered for the long-term lease or permanently purchased.

**Site & Access road preparation:** The internal village roads will be strengthened for transportation of machineries, equipment and drilling rig. Additionally, strengthening of the existing approach road to the site can be done if required for transportation of drilling rig & associated equipment. A provision will be kept for parking of heavy vehicles and cars within the developed site or adjacent area.

Site preparation will involve all activities required to facilitate the operation of the drilling rig and associated equipment and machineries. At the initial stage, the drilling site will be elevated to few meters more than the existing ground level with minimal clearance of existing ground vegetation. The loose topsoil will be removed by using mechanical means like bulldozer and preserved in the protected place for later use during site restoration or green belt development. Levelling and compaction will be done with the help of graders and mechanical rollers. The land filling materials and rubbles required for the site preparation will be procured from government approved borrow earths and stone & sand quarries.

Subsequently, the proposed well site & campsite will be duly fenced using chain link and barbed wires. Platforms for drill pad and all other heavy equipment systems or machinery, cast in-situ RCC will be used for the construction. The elevated structures will have proper garland drains for storm water with sufficient gradient, made of brick masonry, to take care of surface runoff water. A Campsite of size 100 x 50m, will be set up adjoining the well site.

Specially designed pit of an impervious HDPE liner will be provided as part of the site development for storage of drilling waste in the form of spent drilling mud and cuttings. In addition to that, a drill cuttings storage pit of 28m X 24m for disposal of drill cuttings and two waste pits of 17m X 12m for disposal of drilling mud and rig wash water will be provided within the well pad. Though the rig and related equipment will be directly brought to site, spares, mud preparing chemicals and other materials will be stored at a warehouse near to the site. The materials will be intermittently supplied from warehouse to the drilling site, during the operations - with some stock at the drilling site itself.

**Drilling Activities**

**Drilling Rig Type:** The proposed drilling shall be carried out by using “Mobile Land Rig” for drilling up to the desired depth of 3000 meters (TVDSS). The typical configuration of a Rig is shown in the Figure -06. Other ancillary facilities like Drilling mud system, ETP, Cuttings disposal, Drill Cementing equipment etc. and utilities to supply power (DG sets), water, fuel (HSD) to the drilling process will be set up and refer Figure – 07 for details.

**Drilling Operation:** Wells will be drilled in sections, with the diameter of each section decreasing with increasing depth. Before commencing the actual drilling, large diameter pipe (Conductor) will be lowered into a hole and cemented/grouted. Conductor pipes provide a conduit for the return fluid during drilling next section and also prevent unconsolidated material falling into hole and potential washout problems. The lengths and diameters of each section of the well will be determined prior to the starting of the drilling activities and are dependent on the geological conditions through which the well is to be drilled. Once each section of the well is completed, the drill string is lifted and protective steel pipe or casing lowered into the well and cemented into place. “Casing” provides support to hole wall and secures hole section. Other than that, it isolates problematic hole sections such as loss zones, shale sections, over pressurized formations etc. After running casing, space between hole wall and “Casing” (annulus) will be cemented. This process of drilling and casing the hole section continues until the final well depth (target) is achieved.

**Mud System and Cuttings:** During drilling operations, the drilling fluid (or mud) is pumped through the drill string down to the drilling bit and returns at the drill pipe–casing annulus up to surface back into the circulation system after separation of drill cuttings /solids through solids control equipment. The primary function of drilling fluid is to ensure that the rock cuttings generated by the drill bit are continuously removed from the wellbore. The mud is designed such that it can carry the cuttings to surface while circulating, suspend the cuttings while not circulating and drop the cuttings out of suspension at the surface. The drilled solids are removed at the surface by mechanical devices such as shale shakers, de-sanders and de-silters. The hydrostatic pressure exerted by the mud column prevents influx of formation fluids into the wellbore. The instability caused by the pressure differential between the borehole and the pore pressure can be overcome by increasing the mud weight. Hydration of the clays can be overcome by using non aqueous based muds, or partially addressed by treating the mud with chemicals which will reduce the ability of the water in the mud to hydrate the clays in the formation. Water based mud (WBM) will be used for initial, shallower sections where massive shales are not encountered. The deeper and difficult to drill formations will be drilled using synthetic oil base mud (SOBM / SBM). SBM unlike oil based mud is biodegradable and can be re-used. At the end of drilling a well, the entire amount of the SBM is collected for re-used in next drilling operation within the same location or elsewhere. SBM systems promote good hole cleaning and cuttings suspension properties. They also suppress gas hydrate formation and exhibit improved conditions for well bore stability compared to WBM. WBM typically consists of water, bentonite, polymers and barite. Other chemical additives viz. glycols and salts may be used in conjunction to mitigate potential problems related to hydrate formation. The mud to be used will be continuously tested for its density, viscosity, yield point, water loss, pH value etc and mud is prepared in well pad using centrifugal pumps, hoppers and treatment tanks.

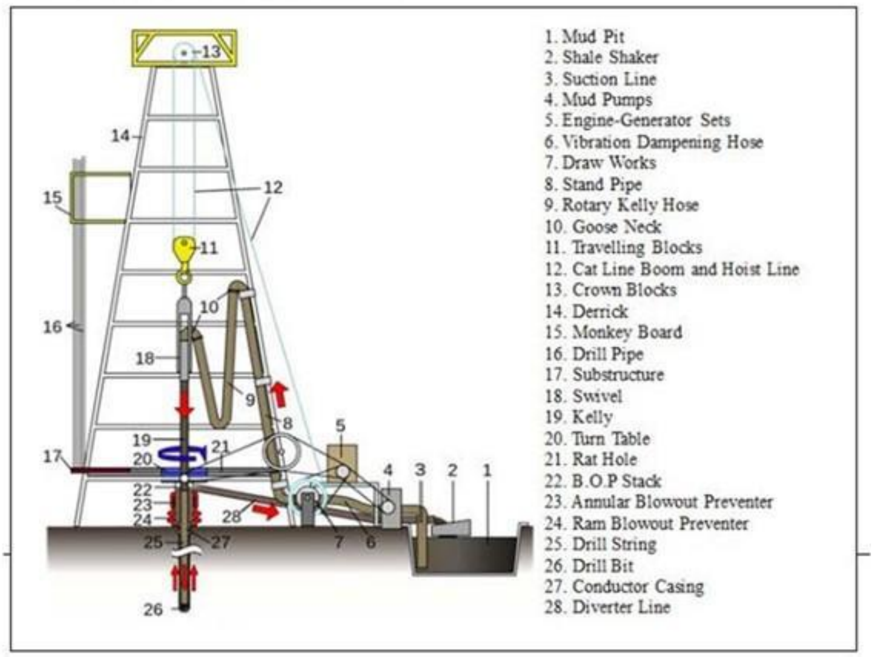



**Figure 2.9 Typical configuration of a drilling rig**

During drilling activity, cuttings will be generated due to crushing action of the drill bit. These cuttings will be removed by pumping drilling fluid into the well via triplex mud pumps. The mud used during such operation will flush out formation cuttings from the well hole. Cuttings will be then separated from drilling mud using solids-control equipment. This will comprise a stepped system of processes consisting of linear motion vibrating screens called shale shakers, hydro-cyclones (including de-sanders and de-silters), and centrifuges to mechanically separate cuttings from the mud.

**Cementing:** Cementing is a necessary aspect of wells. Cement is used to secure/support casing strings and isolate zones for production purposes. Cementing generally utilizes Portland cement with various additives in small quantities as accelerators/retarders, density adjusters, dispersants, fluid loss additives, anti-gas migration additives etc.

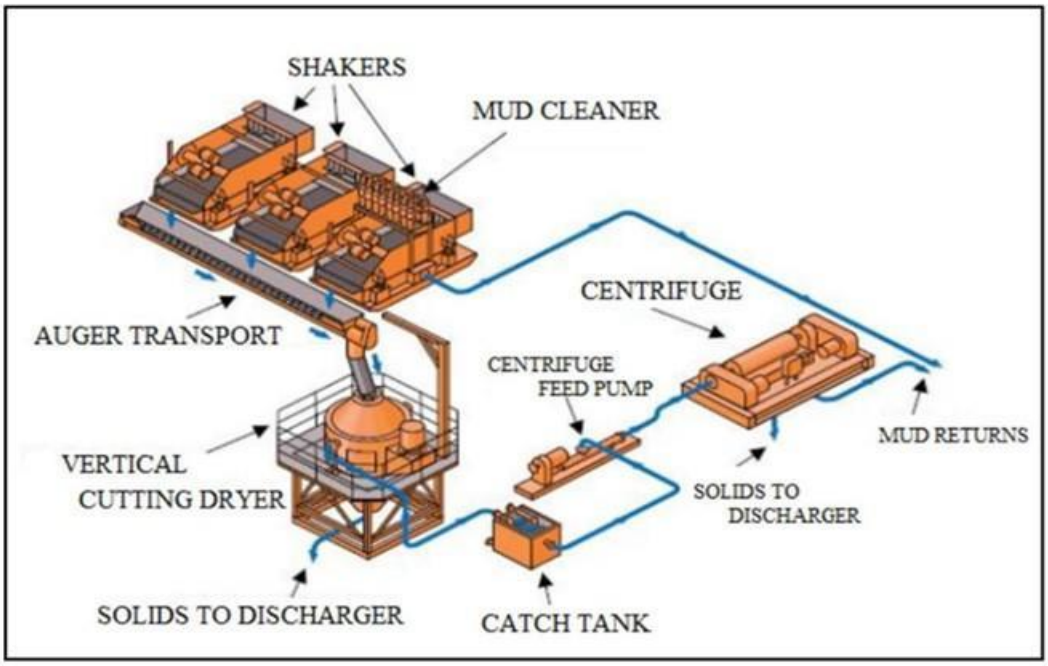



**Figure 2.10: Typical configuration of drilling cutting separation and treatment system**

**Well Evaluation:** During the drilling operations for different zones, logging operations will be undertaken to get information on the potential type and quantities of hydrocarbons present in the target formations. Technicians employed by a specialist logging Service Company do well logging by different well logging techniques including electric, sonic and radioactive techniques. Logging instruments (sensors) are attached to the bottom of a wire line and lowered to the bottom of the well and they are then slowly brought back or are attached to the Bottom Hole Assembly while drilling. The devices read different data as they pass each formation and record it on graphs, which will be interpreted by the geologist, geophysicist and drilling engineer. No emissions to the environment or any environmental harm is associated with wire line logging operations. The radioactive source required for well logging operations will be kept in specially designed container. In this drilling procedure, once the drilling is over, the well evaluation will be done by using electric wire line logs to assess the potential of the reservoir. This typically involves sampling the reservoir formation and pressure points during logging operations and reduces the requirement to flow hydrocarbons to the surface, significantly reducing the atmospheric emissions associated with the testing operation. Normally, in the event that hydrocarbons are encountered in sufficient quantities, as determined by electric wire line logs, a temporary drill stem test string may be run and the well fluids flowed to surface and processed using a surface well testing package, involving the oil being stored and trucked off the site and associated gas being flared to atmosphere.

**Hydraulic Fracturing – for Tight Rock Reservoirs of Hydrocarbons:** Hydraulic fracturing is used in tight rock reservoirs with low permeability, such as shale (i.e., ability of hydrocarbons to flow in the formation is low because of the small pore size in the rock). The goal of hydraulic fracturing in tight reservoir formations is to enable a well to produce the resource or to increase the rate at which a well is able to produce the resource. Hydraulic fracturing may be conducted in wells with low permeability formation and low pressure. Wells requiring hydraulic fracturing and numbers of stages of hydraulic fracturing per well will depend on seismic data acquired & interpreted and data acquired during the drilling phase of the project.

Hydraulic fracturing is a common technique used to stimulate the production of oil and gas by creating fractures or cracks that extend from the well hole into the rock formations. This is accomplished by injecting fluid, which is usually a mixture of water and high viscosity fluid additives, under extremely high pressure. The pressure of the water will then exceed the strength of the rock, causing fractures to enlarge. After the fractures take place, a "propping agent" known as proppant (which is usually sand) is injected into the fractures to keep them from closing. This allows the hydrocarbon to move more efficiently from the rock to the well. For the hydraulic fracturing in a well, proppant mass of 70 – 90 MT per stage and fluid volume of 400 – 600 m$^3$ per stage will be required. Fracturing effluent generated will be discharged in the HDPE lined pits at the drilling well sites. Additional land will be procured wherever required. For effective recycling and reuse of the frac fluid, effluent treatment plant (ETP) will be installed, thus raw water required for fracturing will be minimized.

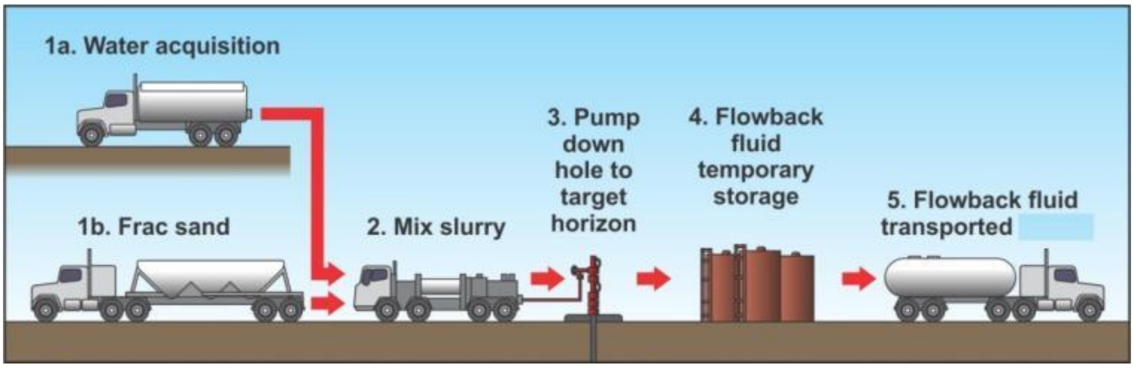



**Figure 2.11: Typical Hydraulic Fracturing Process**

**Well kick situation & Control measures:** While drilling, if the formation pressure exceeds the hydrostatic pressure exerted by the drilling fluid, formation fluids break out in to the well bore. This is called kick. Primary means of well control is to have sufficient over-balance over formation pressure. For some reason if an unexpected over pressurized formation is encountered while drilling and if the well control situation arises, rig is equipped with equipment to control this situation. This set of equipment is called "Blowout Preventers (BOP)". BOP consists of, "Annular Preventer", which can generally close on any size or shape of tubular in the well bore and closes the annular space between drill string and casing. Another type of blowout preventer is a "Ram Preventer". Ram preventers are of two types i.e., Pipe Rams and Shear Rams. Pipe rams also close the annulus between drill string and casing, but they have a fixed size. As such a specific pipe rams can be closed on a specific size of pipe. Shear rams are generally the last choice of preventer to be operated as they shear drill string and shut off the well bore. After determining the formation pressure and other geological complexities from the seismic data, appropriate BOP will be used.

**Well Testing & Flaring:** During the drilling, where a hydrocarbon formation is found, initial well tests for one month will be carried out to establish flow rates, formation pressure and other parameters. However, depending on the need, based on nature of the reservoirs, the wells will be tested for longer/extended durations to ascertain the reservoir parameters. During the well testing, crude oil, natural gas and produced water could be generated and will be treated/ disposed appropriately. Hydrocarbons will be flared. Efficient test flare burner will be used to minimize incomplete combustion. As an alternative option, if feasible, crude oil/ slop oil will be transferred to nearby refinery (terminals/depots) for processing or will be sent to authorized recyclers. However, for flaring all the flaring guidelines for onshore wells will be followed and the design, size and location of flaring stack will be decided based on surrounding habitations and the flaring guidelines. Flare will be located at least 90 m from roads, public works etc. Flare line will be equipped with a pilot flame to ensure continuous Ignition of vented gas and equipped with a guard to protect the flame from being extinguished by the wind. The zones expected to be gas bearing will be identified based on the wire line log data and same will undergo testing to confirm the same. Test separators with facilities for flow metering will be provided which will separate oil, gas and water. The crude oil produced during the well testing will be collected and sent to nearby refineries or processing facility.

**Completion of Drilling:** On completion of well, the well will be either plugged & suspended (if the well evaluations indicate commercial viability) or will be permanently abandoned. In the event of a decision to suspend the well, it will be filled with a brine solution with inhibitors to protect the well. The well will be sealed with cement plugs and some of the wellhead equipment (Blind Flange) will be left on the surface (Cellar). If the well is abandoned, it will be sealed with a series of cement plugs, all the wellhead equipment will be removed, by leaving the surface clear of any debris and the site will be restored.

**Decommissioning & closure of wells:** After the completion of the drilling activity, partial de-mobilization of the drilling rig and associated infrastructure will be initiated. As discussed earlier, well testing may be carried out immediately after the drilling is completed. The complete de-mobilization of the facilities at site will happen once well testing completed successfully. This will involve the dismantling of the rig, all associated equipment and the residential camp, and transporting it out of the project area. It is expected that demobilization will take approximately 30 days and will involve the trucking away of materials, equipment and other materials from the site to bring it back to its original condition. It is estimated that about 50 truckloads will be transported out of site during this period. If no indication of any commercially viable amount of oil or gas is encountered either before or after testing, the well will be declared dry and accordingly will be plugged of and abandoned, and the site will be restored in line with regulations and good industry practice. The following steps will be typically involved to restore and rehabilitate the area:

- The wellhead and all casing string will be cut off to a minimum depth of 3 m BGL.
- All structures will be broken, solids & liquids will be disposed as per the EPA Rules.
- All fencing and access gates will be removed, and all pits will be backfilled.
- Restoration of unusable portion track, removal of pilings and landscaping.

### 2.3.2 Process description of Hydrocarbon Production

Production upto 30,000 Barrels of Oil per Day (BOPD) and 30 Million Metric Standard Cubic Feet (MMSCFD) of gas through development of 10 no's of hydrocarbon processing facilities (well pads). It is expected that some of the wells may have Crude oil with associated gas and some well may have natural gas predominantly and condensate along with the gas extraction. The process description for both oil and gas wells are mentioned below.

**C. <u>Process Description – Crude oil and associated gas produced from the wells</u>**

**Well Fluid Collection:** Each well pad will be a standalone unit and will include single / multiple well heads a collection header (manifold), phase separation (three phase), oil storage / export and necessary utilities such as warehouse, camp site, power generation, fire fighting system and treatment systems. Each well head will be fitted with Christmas tree assembly and the crude oil from the wells are expected to flow under natural reservoir pressure for an initial period and later artificial lift with Sucker rod pumps (SRP) will be used. SRP will be installed appropriately when the reservoir pressure is not enough to bring the well fluids to the surface. The well fluids from the wells will be controlled through the opening of the choke valve and routed to inlet separator. Electrical heat tracing of Hydrocarbon Liquid piping may be required from D/S of choke valve to U/S of bath heater inlet to maintain the liquid temperature at 80 °C above the pour point. Initially wells are expected to flow under natural reservoir pressure. Multiphase fluids from the wells / well pads will be processed in at each well pad. Gas will be separated from the oil and will be used as fuel gas within the facility for process heating, power generation etc. Oil will be stored in the well pads and then exported through road tankers. The separated water will be routed through oil water separator, from which it will be disposed through evaporation pond / dump well based on the quantum of generation.

**Phase Separation:** Oil will be separated from the flashed gas in the three phase separator. Flow of well fluids to the inlet bath heaters is controlled by regulating the choke valve opening. The operating pressure of the separator is selected based on minimum back pressure to allow the oil to flow by gravity to the product oil stock tank. The separator level regulating valve located on the oil outlet line maintains the level of the separator and the oil is sent to product oil storage tank by gravity. Pressure in the separator is maintained as required for each well pad/well head by a pressure regulating valve which sends the flashed gas to the Burn pit. Heating at the well pads is by heater-Treater which is installed to facilitate oil water separation by using fuel gas for heating. The produced gases will also be routed to a fuel gas system and will be utilized as fuel substitute for DG set etc. The separator will be adequately insulated for heat conservation. A bypass line to route the well fluids directly to the storage is provided to bypass the inlet bath heater and separator. The same is required when the GOR is extremely low. Necessary instrumentation is considered for the operation of bath heater and separator.

**Product Oil Storage and Export**: Crude oil from the separator flows by gravity to the product oil storage tanks. Crude is stored at atmospheric pressure in multiple tanks. 5 – 8 tanks of capacity 500 barrels each are envisaged. The total storage capacity at a single well head or a well pad will be four days. Tanks are insulated for heat conservation and each tank has provision for steam coils for maintenance purposes. Two crude oil loading pumps of 50 $m^3$/hr capacity each will be installed to load the stabilized crude in to the road tanker through loading gantry. The loading gantry with two manifolds with a provision for loading two compartments simultaneously is considered. These pumps will also be utilized for re-circulation of the crude to maintain uniform temperature in the tank. The pumps are sized for loading of two 20 KL road tankers simultaneously.

**Utility Units:** The following are the utility units, which are explained below in detail.

a) **Fuel Gas System:** A simple fuel gas system will be provided at well pads /well heads where quantity of produced gas can be effectively and economically used an alternate fuel. The system will include a collection header, piping arrangement for fuel gas KO and distribution header. The fuel gas header pressure will be driven by the minimum pressure required at the bath heating / heater-treater skid battery limit and (or) any other firing equipment.

b) **Power Generation Unit:** The electric power for the well head facility will be provided through a DG power generation unit of suitable capacity located at each well head / well pad. Provision will be made to connect to the state electricity board network in future, besides a proposal to consider Gas engine as operating standby to DG.

c) **Chemical Injection:** Chemical injection at the well heads will include Pour Point Depressant (PPD) and Demulsifier injection. Pour Point Depressant injection will be carried out downstream of the bath heater to avoid flow related problems. A PPD injection skid will include a storage tank of capacity of 2 m3 which is about three days requirement and injection pumps (2 x 100%, electrically driven, positive displacement) with an injection rate of 20 LPH. Demulsifier injection will be carried out downstream of the bath heater to avoid emulsion related problems. A Demulsifier injection skid will include a stack of 6 barrels which is about two days requirement and injection pumps (2 x 100%, electrically driven, positive displacement) with an injection rate of 20 LPH.

d) **Gas Disposal System:** The Horizontal Flare Pit System (HFPS) will receive Hydro carbon gas from the PSV and PRV's of the each well head or well pad facility and its associated equipment during operational upset. HFPS arrangement is considered. The facility is to have a pit which goes elevation -8 m. There would be concrete walls to safe guard flame against high wind. Thermocouple detector is considered which shall act and give a signal. Ignition of flame is to be accomplished by providing a ignition transformer. The system will be installed at a suitable distance from the process equipment to account for the radiation and dispersion limits for safety of man and equipment. Emergency depressurization is not foreseen at either well pad or well head. Diagram of a Typical HFPS is provided below.

e) **Fire Protection system:** The well pad facilities are small production units and are classified as a quick production system (QPS) as per the OISD norms and adequate safety and fire fighting equipment will be provided at each well head site. Each well pad and well head site will include a fire water tank and a mobile trailer pump with a capacity of 108 $m^3/h$ as per OISD 189 requirements. Fusible loop system is also considered for well head, bath heater, Separator and storage areas.

f) **Diesel:** An aboveground diesel storage tank of 12 KL storage capacity and a distribution pump (2 x 100%) with capacity of 6 $m^3/hr$ are provided for meeting the diesel requirement at each well pad / well head.

g) **Nitrogen System:** Nitrogen is required for the SD valve located downstream of the choke for shut down of the facility and also for fusible loop network panel for activation. Each well pad / well head will have a nitrogen cylinder provided with a pressure regulating valve and piping at the respective consumer points.

h) **Drain system:** Closed drain system is not envisaged for the well head installations or well pad facilities. Any maintenance related draining operations will be carried out under atmospheric pressure. The drained oil will be collected in a safe manner into portable drums and will be recycled back for treatment. Open drain network will include suitable civil work for collection of surface water / storm water.

i) **Evaporation Pond:** An HDPE lined evaporation pond will be provided at the well pad to dispose the produced water by natural evaporation. The design capacity will be based on peak water production rates and peak evaporation rates; the same is required to restrict over design of the evaporation pond by considering the extremely low evaporation rates in winter and in higher humidity condition.

**Table 2.6: Main Equipment List proposed in the Well Pads**

| S. No. | Equipment | Capacity | Details |
|---|---|---|---|
| 1 | Sucker Rod Pump | 1/ well | Installed in case the well fails to self-flow |
| 2 | Three phase separator | 1/ well pad | Process train comprising of low, medium and high-pressure separators |
| 3 | Crude oil storage tanks | 2000 barrels/ well pad | Above ground storage tanks with secondary containment |
| 4 | Chemical injection skids | 5 $m^3$ for various chemicals / well pad | Injection of pour point depressant and various chemicals such as de-emulsifier, scale inhibitor, oxygen scavenger, corrosion inhibitor, $H_2S$ scavenger, biocide etc. |
| 5 | Heater Treater | 150 KW | Heater-Treater will only be installed when |

| S. No. | Equipment | Capacity | Details |
|---|---|---|---|
| | | | significant quantity of water is produced. |
| 6 | Diesel Storage tanks | 20 $m^3$ | Above ground storage tank |
| 7 | Fire water tanks | 40 $m^3$ | Trailer pump with a capacity of 100 $m^3$/hour as per OISD 189 requirements |
| 8 | Knock Out Drums | 2/well pad | One for fuel gas and one for flare gas |
| 9 | DG Set | 500 – 1500 KVA | During drilling and Operation Phase<br>1. Up to 1500 kVA – 2 No's<br>2. Up to 500 kVA – 3 No's – Diesel operated<br>3. Up to 500 kVA – 3 No's – Gas operated |
| 10 | Flare Stack | Elevated flare or Horizontal flare | Pilot lamp and monitor will be installed. Vertical or Horizontal flare stack would be installed based on gas pressure and volume |

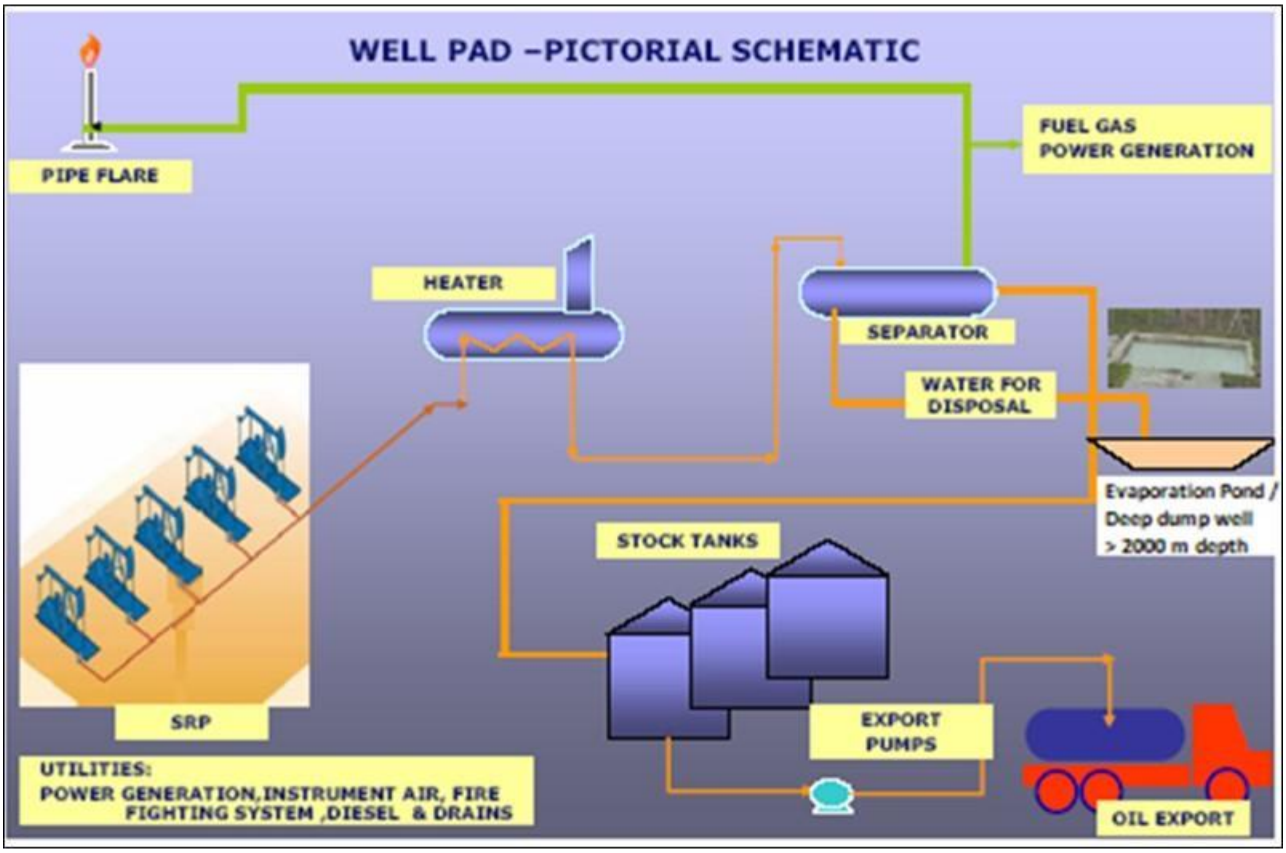



**Figure 2.12: Well pad – process scheme**

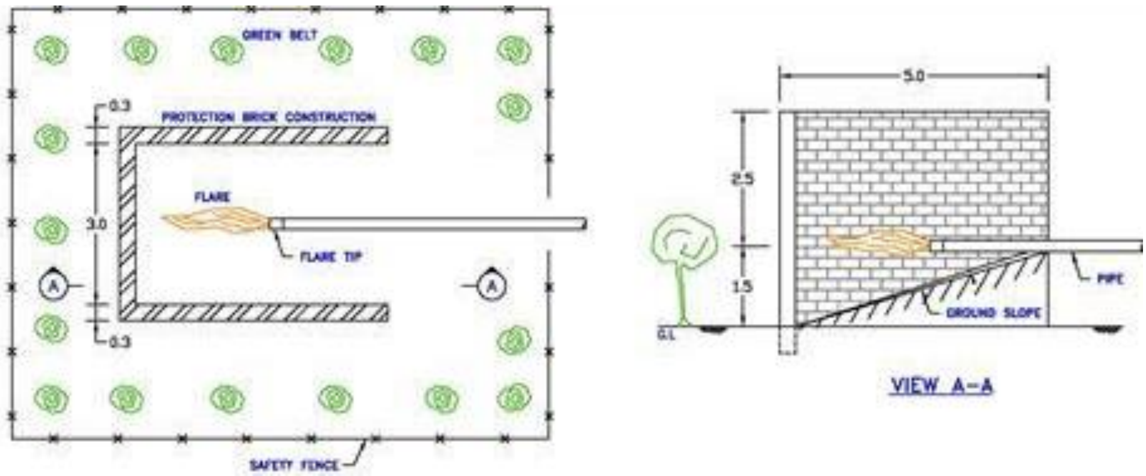



**Figure 2.13: Typical horizontal flare system**

**D. Process Description – Natural gas production from the wells**

The gas well - well header will be hooked up for production to three phase separator facility.

**Wellheads:** The wellhead basically comprise of Christmas trees with flow lines, suitable piping and valves. All the gas discovered wells would self-flow initially and SRP at later stage. The requirement of chemical injection facilities at wellheads shall be evaluated during Engineering phase based on the gas composition. However, chemical injection facilities would be certainly required corrosion inhibitor, scale inhibitor, PPD etc.

**Flow Lines**: Flowline rationalization study shall be carried out during Engineering phase to explore the possibility of flowing multiple wells through single flow line instead of dedicated flowline for each well. All the individual flow lines will be laid underground with coating to minimize the external corrosion. Appropriate cathodic protection system shall be considered for flowlines. The internal corrosion in gas flow lines shall be controlled through injection of corrosion inhibitors at the wellheads.

**Gas Processing Facilities:** The key sub-systems as a part of facilities Two phase separator (Gas); Chemical injection system; $CO_2$ removal facilities (if available in the gas composition); $H_2S$ treatment system (if available in the gas composition); Gas Compression facilities; Dew Point Control facilities; Flaring and Utilities. In addition the Gas Processing facility will also have filtration unit, pressure regulation system, metering system, odorization system, safety devices, firefighting system, gas detector system, control room, UPS room and associated piping and further CNG distribution system (CDS) facilities for compression and dispensation.

**Two Phase Gas Separator**: The Well fluids will flow from gas wells through flowlines to local gas phase separator. Gas will be fed to downstream $CO_2$ removal facilities (if necessary). In the initial stage of the gas production, it is estimated that there will be no condensate production no or less produced water expected. Detailed engineering will address handling of knocked off water if any in the process.

**$CO_2$ removal facilities:** Gas produced from these wells may have $CO_2$, this will be confirmed only after new successful gas wells drilled. If $CO_2$ of higher percentage is found in the total gas, then $CO_2$ removal suitable technique will be finalized based on the parameters such as pressure of gas, degree of removal required, partial pressure of $CO_2$ in gas, moisture content etc. Suitable method can be established only after gas composition available and engineering design is completed along with the techno-commercial evaluation of various options.

**$H_2S$ Treatment facility:** Gas produced from these wells may have $H_2S$, this will be confirmed only after further new successful gas wells drilled. If $H_2S$ of percentage is found in the total gas, then suitable $H_2S$ scavengers and other control mechanism will be planned.

**Gas Compression facilities**: CNG compression will be suitable for these marginal field developments. However, engineering review will confirm the suitability of CNG transfer.

**Flaring:** Minimal operational flare will occur under normal operation conditions. Flaring system will be designed in compliance with regulatory requirements (DGMS / EPA /OISD etc.,)

**Utilities:** The utilities required for these facilities includes Electrical power generation; Closed and open drain system; Chemical dosing system; Diesel storage and transfer pumps; Firefighting system as per OISD and Utility and potable water system. The electrical power will be met by Gas Engine Generator (GEG) with back up Emergency Diesel Generator (EDG). The exact requirement of power will be available after the engineering design is completed.

**Technological aspects of the CDS model**: The supply of CNG in bulk consists of acquisition, receiving, compression, storage, delivery, commercialization and quality control. The CDS system is based on modular technology, which in turn allows scaling up of the system proportional to the demand. Gas producing wells are commonly integrated and gas from wells is collected with pipelines with its gas gathering station (GGS). The Gas is filtered for removal of dust particles and moisture at the GGS. After filtration it is transported through pipeline and custody transfer meter to the compression facility. Moisture and other impurities from the gas is removed by using a conditioning skid and dew point skid. After receipt of the gas the clean and dry gas is fed to the gas compressors. The CNG compressors are normally reciprocating compressors with compact design with Electric driven or Gas engine driven prime movers. They can be designed to be fitted into sound-proof canopy which can be moved from place to place. Gas compressor compresses the Natural gas to 250 bars for filling into the truck mounted cascades. Gas is filled into truck mounted cascades at a pressure of 200-250 bars for ease in transportation.

**High Pressure CNG cascades**: Cascades are a bank of interconnected high pressure cylinders. They also have a higher working, test and burst pressure parameters than CNG cylinders used in vehicles. CNG Cascades are classified in two categories:

**Stationary CNG Cascades**: - Stationary CNG stations are commonly installed in utility companies or other locations including automotive service stations, bus depots, and fleet garages. The stationary CNG station consists of an assembly of components, which include a compressor, a dispenser, valves and piping, and a storage system. The compressor is used to draw the gas from a distribution pipeline and compress it into the storage system. Then the CNG is dispensed from the storage system into cylinders mounted on motor vehicles.

**Mobile CNG Cascades**: - A mobile CNG station consists of an assembly of components, which include a compressor and a dispenser, mounted on a vehicle. Mobile stations are designed to draw CNG from a CNG supply source and dispense it into vehicle mounted cylinders.

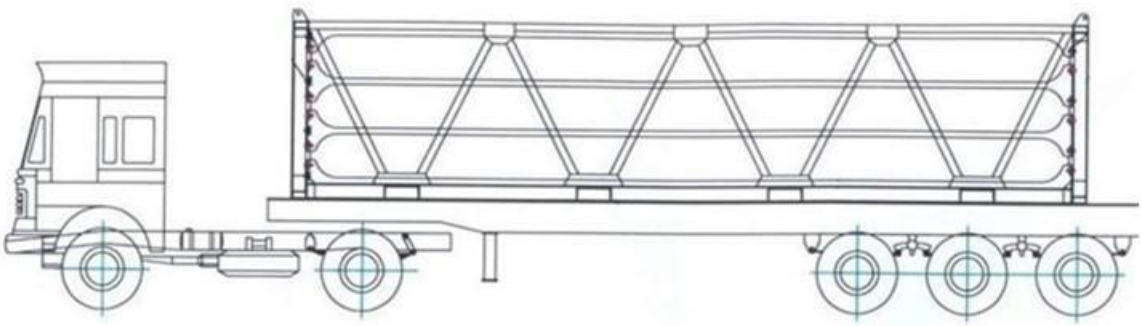


**Figure 2.14: Mobile CNG Cascades**

These Jumbo cascades are available in various combinations and capacity ranging from water KL capacity of 18 to 22 KL. They can carry gas in the range of 4000 scm to 5000 scm in one filling. These tubes are particularly well-suited for the storage of gases under high pressure up to 15,000 psi and range from 6' to 40' with diameters up to 24 inches. Smaller sized Cascades of 4.5 KL water capacity with a gas carrying capacity of about

900 scm to 1200 scm depending upon the gas pressure. These cascades are fixed on trucks and Transported from filling point to end user and also for the gas storage at customer premises. Truck mounted cascades then ply to customer premises, where the gas has to be used.

**Export of gas through pipeline**: Once the commercial supply of gas is being established from Kaza block, the gas export through pipeline will be a viable and safer option. Also, the gas will have better realization of commercial value, as it could be supplied directly to the premises of the end user. With reference to the Kaza Block over the existing gas pipeline network already prevail,

3. From the external boundary of KAZA (i.e. point B) the existing Nandigama GAIL pipeline (via cross-country routes) is 4 KM away and
4. From the external boundary of KAZA (i.e. point C), MEIL Gas Pipeline from Agiripalli to Nuziveedu is 3 KM away.

Megha Engineering & Infrastructures Ltd. (MEIL) is supplying natural gas to households and commercial establishments in Krishna district of Andhra Pradesh. MEIL has setup gas filling stations at Agiripalli and Kanuru in Krishna district and an underground pipeline system for supply of gas has been put in place. The pipeline already carrying the natural gas to various end users supplied by ONGC operated oil and gas field at Nagayalanka Block, Krishna district.

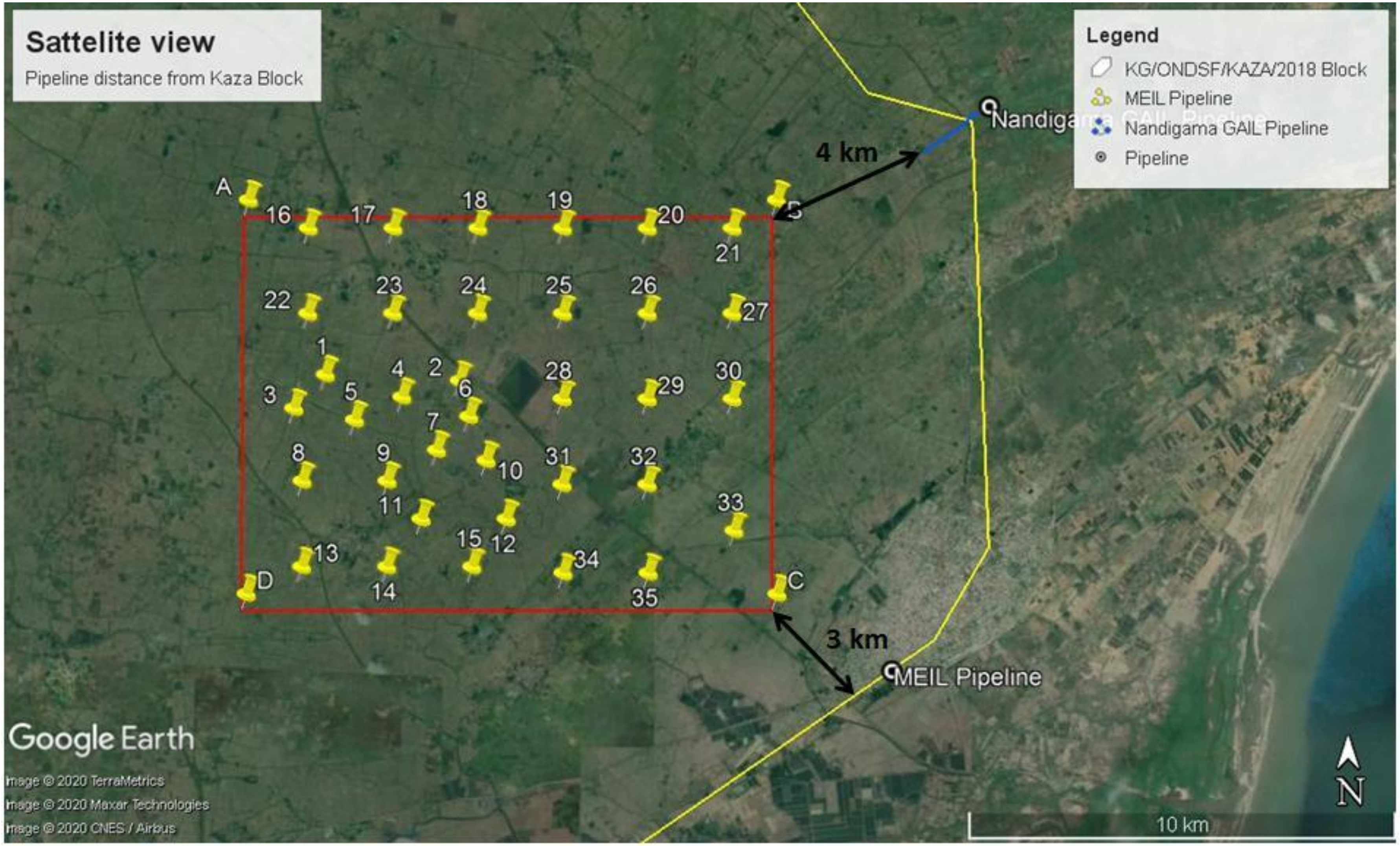



**Figure 2.15: Gas pipelines already existing surrounding the Kaza Block – Google map**

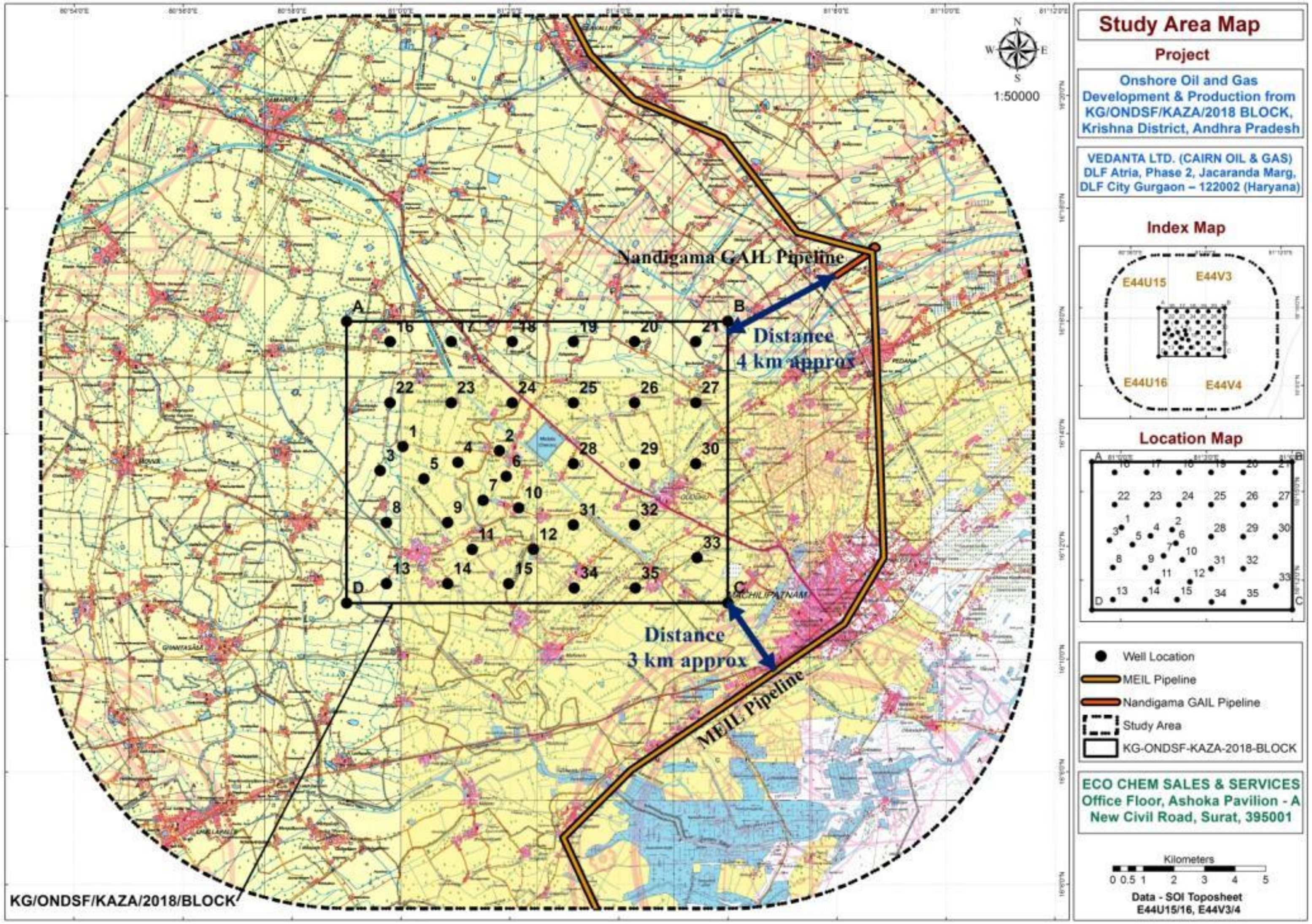



**Figure 2.16: Gas pipelines already existing surrounding the Kaza Block superimposed on Toposheet**

### 2.3.3 Schematic representation of the facilities

The well pad is a standalone facility consisting of the producing wells (oil & gas or only gas wells) and injector wells (as applicable). The produced well fluid is separated, processed, stored and exported from the same well pad location through quick processing facilities.

The typical layout of a well pad/ drill site is mentioned in the Figure – 2.17. The various activities or facilities carried out in any typical well pad is detailed below.

- Potable office cabins / rest rooms (container type cubicles);
- Drilling rig foundation and cellar;
- Foundation / Pits for equipment;
- Space for drill rig equipment, working area and materials lay down area;
- Waste storage pits;
- Cutting disposal (impervious lined) pits;
- Solar evaporation pits (waste drilling fluid disposal);
- Fire water storage pits
- Drill cutting storage pit (Water based mud pit and Synthetic oil-based mud pit and Septic tank with soak pits);
- Paved and contained chemical storage area;
- Above ground Diesel storage tanks with paved and bunded area;
- Flare facility either elevated flare or ground level flare pit;
- Secondary contain area for chemical storage;
- Diesel Generator area / Gas Engine Generator area;
- Crude oil storage area;
- Loading bay;
- Provisional space for definitive fracking program.
- Provisional space for Well Testing Unit;
- Radio room;
- Storm water drainage system / garland drain;
- Internal roads and fencing.
- Dedicated place for green belt development
- Vehicle parking area
- Security cabin

The drill site is restricted access area and is fenced all round with round the clock watch. Entry of vehicles into the drilling site area is prohibited except for material movement. Adequate parking will be provided outside the drilling location.

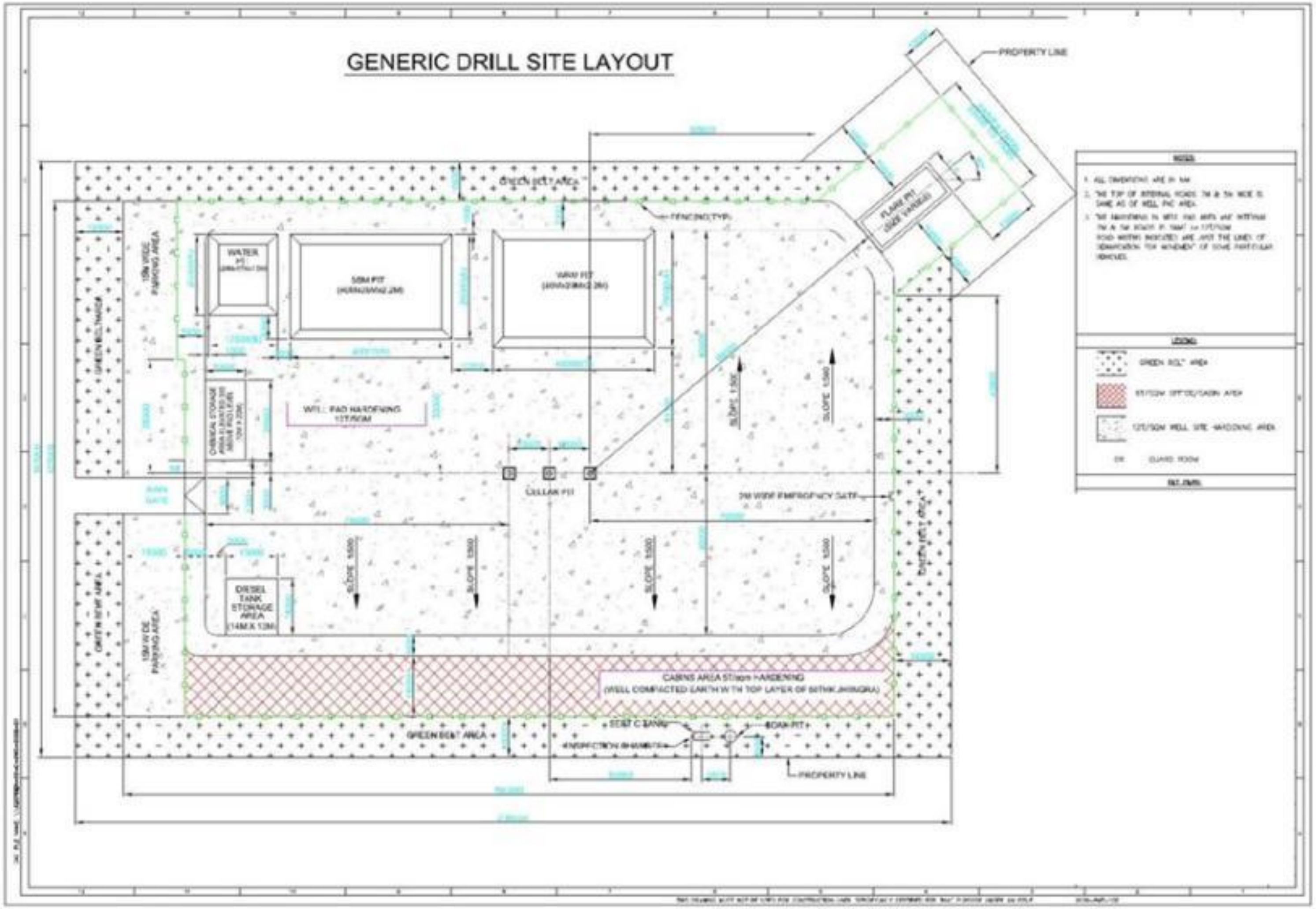



**Figure 2.17: Typical well layout plan**

## 2.4 RESOURCE REQUIREMENT

### 2.4.1 Raw material & its source and mode of transport of raw material and product

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 crude oil / condensate, natural gas / associate 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, Mono- ethylene Glycol (MEG), Tri-ethylene Glycol (TEG), oxygen scavenger, scale inhibitor, de-emulsifiers, coagulants, biocide etc.

Drilling related material like HSD, Steel (in the form of casings & tubulars) and chemicals like barite, oil well cement and bentonite will be required. Other production equipment's like tubular (Casing and tubing), wellhead assembly, packer etc., and chemicals for mud and cementing required for the drilling operations and shall be procured by the company from within the country and from abroad before the commencement of operations. These chemicals if imported are transported through sea and by road reaches to the site location. Construction materials are locally sourced.

**Drilling Mud**

Water based mud will be used for initial, shallower sections where massive shales are not encountered. The deeper and difficult to drill formations will be drilled using synthetic base mud (SBM). Synthetic base mud unlike oil-based mud (OBM) is biodegradable but can be re-used. WBM typically consists of water, bentonite, polymers and barite. Other chemical additives viz. glycols and salts may be used in conjunction to mitigate potential problems related to hydrate formation. Requirement of WBM is around 800-1000 $m^3$/well and SBM around 600-800 $m^3$/well.

**Finished Product Transportation**

The finished product will be crude oil and gas. Both the products will be sold to the authorized vendors nominated by GoI. The mode of transport for the crude oil will be tankers and gas will be cascaded fitted in trucks and or either through gas pipeline being laid by GAIL and MEIPL.

### 2.4.2 Resource optimization / recycling and reuse envisaged in the project

Maximum care will be taken for resource optimization, wherever possible with an aim of

- Resource Conservation
- Elimination of Waste Streams
- Minimizing Waste
- Reuse /Recycle of Wastes
- The WBM drill cuttings will be used for filling low lying areas as a sub grade construction material in construction of well pads and surface facilities.
- SBM is biodegradable and separated SBM will be re-used in further drilling activities.
- SBM drill cutting will be disposed to the cement industry towards co-processing.

### 2.4.3 Water requirement

The water requirement for the drilling, project and operations will be sourced locally through approved/ authorized sources such as PHED bore wells, privately owned bore wells, Irrigation Dept./ Water Resources Department of AP State Government. The quantity of the water requirement for the various activities is detailed below:

**Table 2.7: Water requirement at various phases of development and operation**

| Purpose | Water Requirements | Remarks |
|---|---|---|
| Drilling | 50 $m^3$/well | Drilling period is ~60 days. Out of 50 $m^3$ of water; drilling & |

| | | |
|---|---|---|
| | | associated activities will require 40 $m^3$ and domestic activities will require 10 $m^3$. |
| Project | 20 $m^3$/day | Each well pad and associated locations will be completed in 60 days of award. |
| Production / Operation | 10 $m^3$/day/well pad | Water required daily for domestic, fire fighting and green belt development |
| Injection water | 1000 $m^3$/ day | This bore well water will be abstracted after obtaining CGWA / APWALTA permission. |

### 2.4.4 Power Requirement

**Drilling Operations:** The power requirement in each drilling site and the campsites will be provided through diesel generator (DG) sets. The rated capacity of the DG sets are Camp sites – 150 kVA – 2No's; Drilling operation – 2 No's – 1500 kVA and 2 No's – 500 kVA.
**Production:** The power requirement will be met through AP state electricity Board / or installation of Diesel/ Gas Engine Generator(s) using produced gas. The capacities of various DGs and or GEGs at each well pad location would be 150 kVA – 2No's and 500 kVA – 2No's. The gas as fuel for the gas engine generators (GEGs) would be sourced from the gas produced in the well pads.

### 2.4.5 Fuel Requirement

Fuel consumed during the drilling phase will mainly be diesel (HSD) used for various equipment and vehicles operating to transport goods and supplies to site. It is estimated that about 60 KL diesel will be required to power the off-road construction equipment and vehicles during site preparation phase.
During the drilling phase, consumption about 3.5 KLD of High-Speed Diesel (HSD) will be required. Out of this, a major part approximately 85% will be consumed by the rig (also include the DG sets) and about 15% will be required for the campsite.
During the operation phase, consumption about 500 Liters of HSD will be required per well pad. Fuel will be supplied onsite by local supplier through mobile tankers.

### 2.3.6 Manpower

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 operation phase for few hundreds of people directly and indirectly.
It is envisaged that the following persons will be engaged during various stages of project development.

- Project phase (construction of single well pad & associated activities) – 80 no's
- Drilling of well and operation of single rig – 100 no's
- Operation of the each well pad to produce oil & gas including the hydrocarbon transportation through trucks / cascade mounted trailers – 25 no's

## 2.5 POLLUTION POTENTIAL AND ITS CONTROL MEASURES

The various types of pollution from the proposed project operations are:

- Liquid Waste;
- Air Emission;
- Solid Waste Generation & disposal ; and
- Noise Generation.

Exhaust gases from DG sets, wastewater, drilling wastes and noise from the drilling operations are the major sources of the pollutants generated during the proposed drilling operations which is temporary activity lasting for maximum of 45-60 days at each of the well locations.

### 2.5.1 Air Emissions Management

Vehicular emissions are likely to occur during the transportation of construction materials, equipment and workforce to onshore drilling location.

**Project, Drilling and Operations**

The emissions to the atmosphere from the drilling operations shall be from the diesel engines, and power generator and temporary from flaring activity (during testing). Appropriate air emission control measures will be taken such as effective stack height, elevated flaring etc.

### 2.5.2 Wastewater Management

**Drilling operations:** The drilling operation would generate wastewater in the form of wash water due to washing of equipment, string and cuttings etc. The other source of wastewater generated from drilling operation is domestic wastewater around 8 $m^3$/day, which shall be disposed through septic tanks/soak pits in the well pads. It is expected that wastewater in the form of Drill cutting washing + Rig washing + cooling etc. shall be generated at an average rate of around 30 $m^3$/day during the drilling operations from a single well. This wastewater will be treated and used back for mud preparation and the final wastewater will be discharged in HDPE lined evaporation pit for natural evaporation.

**Project activities:** No wastewater would be generated from the project activities except domestic wastewater around 8 $m^3$/day, which shall be disposed through septic tanks/soak pits in the well pads.

**Operations:** The produced water separated from the well fluid shall be treated and as required will be blended with the ground water and injected back to the reservoir towards maintaining the formation zone pressure. Any rejected wastewater will be treated in the ETP for the removal of oil and suspended solids and will be injected back to the deep dump well > 1000 m depth below the ground level.

### 2.5.3 Solid/Hazardous Waste Management

Various categories of solid waste will be generated at different stages of field development, which includes drilling, project, operational and restoration stages. Solid wastes consist of two types - hazardous and non-hazardous and further classified as recyclable and non-recyclable waste. All the wastes are segregated at the source of generation and will be disposed 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.,) will be disposed to the authorized recyclers. The high calorific non-recyclable hazardous waste such as oily rags, oily sludge, synthetic oil based mud drill cutting etc., will be disposed to the cement industries towards co-processing and as alternate fuel and raw material. The non-recyclable non-hazardous waste mainly includes water based mud drill cuttings, inert and construction demolition materials, which are normally used for filling low-lying earth and preparation of sub-grade in well pad / terminal construction. The various quantities of hazardous waste to be generated are mentioned in the below Table.

**Table 2.8: Hazardous waste including E-waste & BMW generation**

| S. No. | Type of Hazardous Waste | HW Category | HW during drilling phase | HW during Operation phase | Hazardous waste Disposal Practice |
|---|---|---|---|---|---|
| 1. | Drill Cutting containing oil | 2.1 | 500 MT/Well | - | SLF/Co-processing |
| 2. | Sludge containing oil | 2.2 | 1 MT/well | 1 MT/ annum | SLF/Co-processing |

| | | | | | |
|---|---|---|---|---|---|
| 3. | Drilling mud and other drilling wastes | 2.3 | 300 MT/Well | - | SLF/Co-processing |
| 4. | Discarded containers/ barrels/ | 33.3 | 4 MT/well | 5 MT/ annum | Sales to registered recyclers |
| 5. | Used Oil | 5.1 | - | 1.0 TPA | Sales to registered recyclers/Re-process |
| 6. | Spent / waste oil | 5.1 | 4.00 MT/Well | 5 MT/ annum | Sales to registered recycler/Reprocess |
| 7. | Wastes/ residues containing oil | 5.2 | 1.00 MT/Well | 1 MT/ annum | Sales to registered recycler /Incineration |
| 8. | Lead Acid batteries | - | - | 0.5 MT / annum | Sales to registered recyclers |
| 9. | E-Waste | - | - | 0.2 MT / annum | Sales to registered recyclers |
| 10. | Bio Medical waste | - | 5 Kg | 10 Kg | SLF/Incineration |

### 2.5.4 Noise Environment

**Construction Activity**

Noise will occur from operation of construction equipment like loaders, tippers, bull dozers etc., for onshore well pads. The expected noise generated will be around 60-65 dB (A). During erection offshore rigs noise will be generated in the range of 80 to 85 dB (A).

**Project, Drilling and Operation Phase**

The operations of drilling rig and associated machinery including diesel generators will lead to noise emissions. The diesel generators would be provided with acoustic enclosures to comply with the regulatory requirements.

Noise emissions during drilling of wells at the rig include the following:

- Diesel Generators: 75 to 85 dB(A) at 1 m from enclosure
- Mud Pumps at the Rig: 90 to 95 dB (A)
- Miscellaneous: 80 to 85 dB (A)
- Control Room and living quarters at the rig: 50 to 60 dB (A)

## 2.6 DRILLING HAZARDS

Loss of well control / blow-out, fire, explosion and oil spills are the major potential hazards associated with drilling for oil and gas. Effective response plans to foreseeable emergencies will be developed by Vedanta Limited (Division: Cairn Oil & Gas) and communicated to project teams. A risk assessment will be carried out as part of this draft EIA will also contribute towards identification of hazards, risks and formulation of management plans for emergency response, blowout, oil spills etc.

## 2.7 PROJECT SCHEDULE & COST

The proposed projects will be implemented in a phased manner up to ten (10) years period starting the year 2021 beginning onwards. The project will start execution only after obtaining all the necessary approvals. The estimated total project cost is around INR 650 Crores, which includes.

1. Physical Surveys cost estimated to be approximately INR 25.0 Crore.
2. Average drilling cost per well is estimated to be INR 15 Crore. In total 35 wells are planned to be drilled. Thus, total costs towards drilling and associated activities would be around INR 525 Crores.

3. Average cost towards setting up ten well pad's, approach roads, production facilities, pipeline and miscellaneous activities is estimated to be INR 100 Crore.

# CHAPTER 3

# DESCRIPTION OF ENVIRONMENT

## 3.1 GENERAL

The baseline environmental quality is assessed through field studies within the probable impact zone for various components of the environment viz. Air, Water, Soil, Noise, Ecology & Bio diversity, Traffic and Socio-economy. The baseline study has been conducted for the study region within 10 km radius. An exhaustive attempt has been made in the current chapter to disclose all possible baseline status of environmental quality in the study area, which further serves as the basis for identification, prediction and evaluation of impacts.

## 3.2 BASELINE STUDY AREA AND PERIOD

The baseline environmental study has been conducted for the period 1$^{st}$ Dec 2019 to 29$^{th}$ Feb 2020. Study area map covering all the villages are shown in the **Figure 3.1.**

## 3.3 METHODOLOGY

The baseline environmental study was carried out for the various environmental components viz, Air, Water, Soil, Ecology and Biodiversity, Socio Economy and Noise. A desktop discussion conducted and it was decided that monitoring carried out at proposed locations fall within the study area. Before starting the survey activity for ecology and bio diversity, secondary data were used as reference during the desktop survey for listing the species of study zone and planning the survey. In case of socio economy, secondary data have also been used for deciding the parameters to be surveyed during socio economic data collection. Various publications by the government of India and literature available on internet site were used.

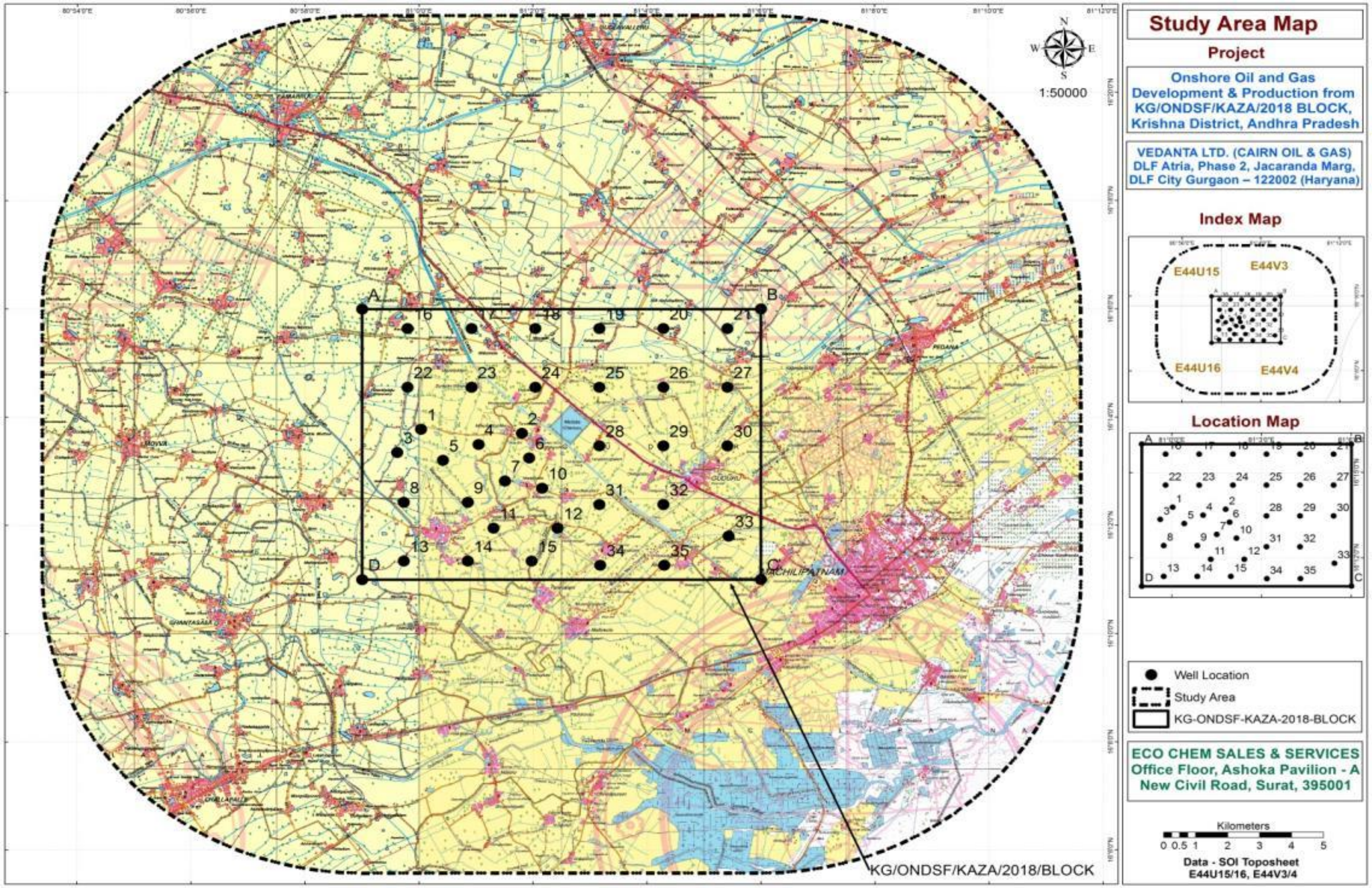



**Figure 3.1 Study Area Map**

### .3.1 Frequency of Sampling

Details of frequency of environmental sampling considered for the study are illustrated in **Table 3.1.**

**Table 3.1 Frequency of Environmental Monitoring**

| Attributes | Sampling | | |
|---|---|---|---|
| | Locations | Parameters | Frequency |
| **A. Air Environment** | | | |
| Micro-meteorological Data | Nimmakuru village Nr. Machilipatnam | Temperature, Relative Humidity, Precipitation Wind direction, Wind Speed, Rainfall and Cloud cover | Hourly data for the period 1st Dec 2019 to 29th Feb 2020. |
| Ambient Air Quality | 12 numbers | $PM_{2.5}$, $PM_{10}$, $SO_2$, $NO_x$, CO, $O_3$, Benzene, BaP, Pb, As, Ni, $NH_3$, Methane and Non-methane HC, Total VOC | 24 hour basis, twice a week during study period |
| **B. Noise** | 12 numbers | Ld, Lmin, Lmax, Ln and Leq | Once in Study Period. |
| **C. Water** | | | |
| Ground Water | 12 numbers | Physical, Chemical, Microbiological and Heavy Metal. | Once in Study Period. |
| Surface Water | 12 numbers | Physical, Chemical, Microbiological, Biological, Benthos and Heavy Metal. | Once in Study Period. |
| **D. Soil Quality** | 12 numbers | Physical, Chemical Characteristics, Soil Texture. | Once in Study Period. |
| **E. Traffic Study** | 4 | Traffic density of various types of vehicle to calculate LOS. | Once in Study Period. |
| **F. Land Use** | - | 10 km radius from the project site. | Once in Study Period. |
| **G. Ecology and Biodiversity** | - | 10 km radius from the project site. | Once in Study Period. |
| **H. Socioeconomic** | - | 10 km radius from the project site. | Once in Study Period. |
| **I. Geology** | - | Krishna District | Once in Study Period. |
| **J. Hydrogeology** | - | Krishna District | Once in Study Period. |

### 3.3.2 Method of Environmental Sampling and Analysis

The methods adopted for environmental sampling and analysis are illustrated in following **Table 3.2**

**Table 3.2 Method of Environmental Sampling and Analysis**

| Attributes | Methods | |
|---|---|---|
| | **Sampling/Preservation** | **Analysis/data analysis** |
| **A. Air Environment** | | |
| Micro-meteorological Data | Data collected on hourly basis using wind monitor as per CPCB Guideline. as per IS 8829 | IS 8829 |
| Ambient air quality | As per IS: 5182, CPCB & AWMA. | IS:5182,CPCB & AWMA |
| **B. Noise** | Instrument : Sound level meter | Survey carried out as per CPCB guideline. |
| **C. Water** | | |
| Ground Water and Surface Water | Standard Methods for Examination of Water and Wastewater, 23rd edition, APHA 2017. | IS 3025 & Standard Methods for Examination of Water and Wastewater, 23rd edition, APHA 2017. |
| **D. Soil Quality** | IS 2720, Soil Testing in India (Department of Agriculture & Cooperation). | IS 2720, Laboratory developed Method as per NABL requirement and Book - Soil Testing in India (Department of Agriculture & Cooperation). |
| **E. Traffic Study** | Manual count for different types of vehicles | Statistical calculation for LOS |
| **F. Land Use** | Using United States Geological Survey (USGS) Satellite Data: Land sat 8 cloud free data for Land use /Land cover analysis, Satellite Sensor–OLITIRS multi-spectral digital data. | - |
| **G. Ecology and Biodiversity** | Faunal survey- opportunistic observation/ species list method/direct sighting /intensive search/ bird calls/nests, burrows, dropping or scats and conformation with local public.<br><br>Floral survey – visual observation and public consultation<br><br>Aquatic survey – APHA 23rd Edition, 2017 | Group wise species classification as per the requirement. |
| **H. Socio economic** | Primary survey and census 2011 | Data analysis as per the requirement |
| **I. Geology** | Secondary data as per CGWB | |
| **J. Hydrogeology** | Secondary data as per CGWB | |

## 3.4 CLIMATE AND MICROMETEOROLOGY

The study of micro meteorological data helps to understand the variations in the ambient air quality status in that region. The prevailing micrometeorological condition at project site plays a crucial role in transport and dispersion of air pollutants. The persistence of the predominant wind direction and wind speed at the project site decide the direction and extent of the air pollution impact zone. The principal variables which affect the micrometeorology are horizontal transport and dispersion, convective transport and vertical mixing and topography of the area towards local influences. Micrometeorological data were collected by using the wind monitor as per CPCB guideline which was installed near the well locations in Krishna District. All the micrometeorological data were collected on hourly basis. Meteorological conditions of the Krishna district for temperature, humidity and wind speed of the study area are presented in **Table 3.3.**

**Table 3.3 Meteorological Condition of Study Area**

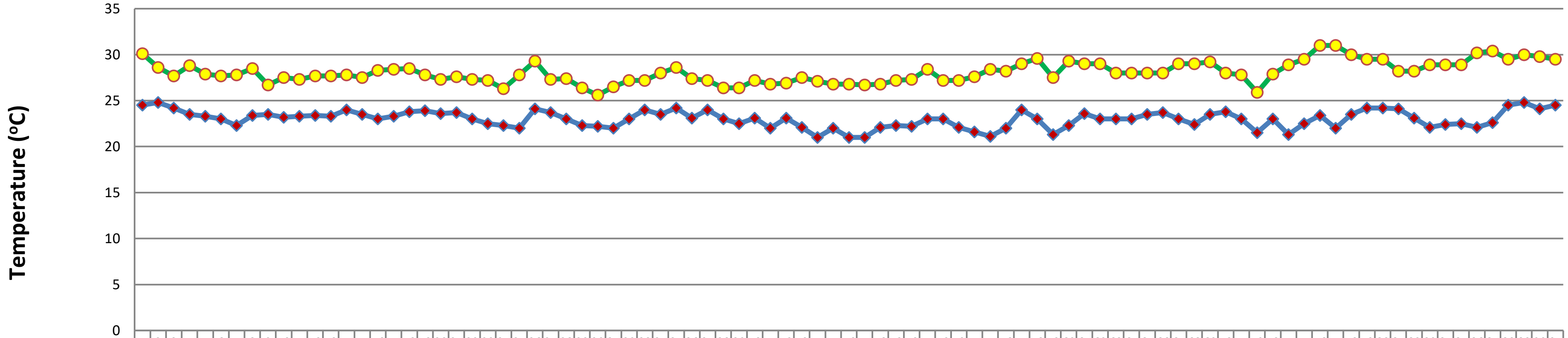
| Month | Dry bulb Temperature (°C) | | Relative Humidity (%) | | Wind Speed (km/hr) | |
|---|---|---|---|---|---|---|
| | Min. | Max. | Min. | Max. | Min. | Max. |
| Dec 2019 | 22.0 | 30.1 | 57 | 89 | 1.0 | 27.0 |
| Jan 2020 | 21.0 | 29.6 | 58 | 91 | 2.0 | 27.0 |
| Feb 2020 | 21.3 | 31.0 | 47 | 90 | 1.0 | 28.0 |

### 3.4.1 Temperature

Last 10 years data analysis for temperature (2009 to 2019), it is found that average temperature varies from 20$^0$C to 29$^0$C in winters and 29$^0$C to 40$^0$C in summers. The study region experience high temperature than other part of India, the highest maximum temperature has been recorded up to 47.8$^0$C in the month of May. May is the hottest month of the year and the temperature fall up to 20$^0$C during the month of January.

***Source :** https://www.worldweatheronline.com/machilipatnam-weather-averages/andhra-pradesh/in.aspx*

During the study period minimum temperature was recorded 21°C in the month of Jan 2020 and maximum temperature was recorded as 31°C in the month of Feb 2020.Temperature data were collected on hourly basis during the study period. Variation of temperature is graphically presented in **Figure 3.2.**




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Max. | 30 | 29 | 28 | 29 | 28 | 28 | 28 | 29 | 27 | 28 | 27 | 28 | 28 | 28 | 28 | 28 | 28 | 29 | 28 | 27 | 28 | 27 | 27 | 26 | 28 | 29 | 27 | 27 | 26 | 26 |
| Min. | 25 | 25 | 24 | 24 | 23 | 23 | 22 | 23 | 24 | 23 | 23 | 23 | 23 | 24 | 24 | 23 | 23 | 24 | 24 | 24 | 24 | 23 | 23 | 22 | 22 | 24 | 24 | 23 | 22 | 22 |

| | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Max. | 27 | 27 | 27 | 28 | 28 | 27 | 27 | 26 | 26 | 27 | 26 | 26 | 27 | 27 | 26 | 26 | 26 | 26 | 27 | 27 | 28 | 27 | 27 | 27 | 28 | 28 | 29 | 29 | 27 | 29 |
| Min. | 22 | 23 | 24 | 23 | 24 | 23 | 24 | 23 | 22 | 23 | 22 | 23 | 22 | 21 | 22 | 21 | 21 | 22 | 22 | 22 | 23 | 23 | 22 | 21 | 21 | 22 | 24 | 23 | 21 | 22 |

| | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Max. | 29 | 29 | 28 | 28 | 28 | 28 | 29 | 29 | 29 | 28 | 27 | 25 | 27 | 28 | 29 | 31 | 31 | 30 | 29 | 29 | 28 | 28 | 28 | 28 | 28 | 30 | 30 | 29 | 30 | 29 | 29 |
| Min. | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 22 | 23 | 23 | 23 | 21 | 23 | 21 | 22 | 23 | 22 | 23 | 24 | 24 | 24 | 23 | 22 | 22 | 22 | 22 | 22 | 24 | 24 | 24 | 24 |

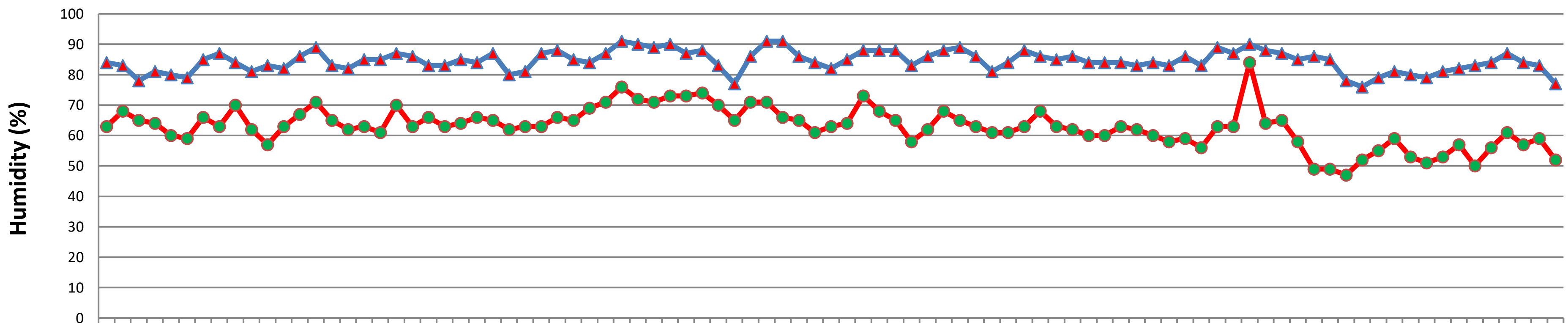
**Figure 3.2 Graphical Presentation for the month wise Temperature Variation**

### 3.4.2 Humidity

Last 10 years data analysis for temperature (2009 to 2019), it is found that average humidity remains considerably high from September to November. Maximum average humidity 84 % in the month of September 2019 and minimum average humidity in the month of June 2012. Humidity affects the nature and characteristics of pollutants in the atmosphere as it is the measure of amount of moisture in the atmosphere. Humidity helps suspended particulate matter to coalesce and grow in size to settle under the gaseous pollutants by providing them aqueous medium.

***Source :** https://www.worldweatheronline.com/machilipatnam-weather-averages/andhra-pradesh/in.aspx*

During the study period minimum Humidity was recorded 47% in the month of Feb 2020 and maximum Humidity was recorded as 91% in the month of Jan 2020. The variation in humidity is represented graphically in **Figure 3.3.**




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Max. | 84 | 83 | 78 | 81 | 80 | 79 | 85 | 87 | 84 | 81 | 83 | 82 | 86 | 89 | 83 | 82 | 85 | 85 | 87 | 86 | 83 | 83 | 85 | 84 | 87 | 80 | 81 | 87 | 88 | 85 |
| Min. | 63 | 68 | 65 | 64 | 60 | 59 | 66 | 63 | 70 | 62 | 57 | 63 | 67 | 71 | 65 | 62 | 63 | 61 | 70 | 63 | 66 | 63 | 64 | 66 | 65 | 62 | 63 | 63 | 66 | 65 |

| | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Max. | 84 | 87 | 91 | 90 | 89 | 90 | 87 | 88 | 83 | 77 | 86 | 91 | 91 | 86 | 84 | 82 | 85 | 88 | 88 | 88 | 83 | 86 | 88 | 89 | 86 | 81 | 84 | 88 | 86 | 85 | 86 |
| Min. | 69 | 71 | 76 | 72 | 71 | 73 | 73 | 74 | 70 | 65 | 71 | 71 | 66 | 65 | 61 | 63 | 64 | 73 | 68 | 65 | 58 | 62 | 68 | 65 | 63 | 61 | 61 | 63 | 68 | 63 | 62 |

| | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Max. | 84 | 84 | 84 | 83 | 84 | 83 | 86 | 83 | 89 | 87 | 90 | 88 | 87 | 85 | 86 | 85 | 78 | 76 | 79 | 81 | 80 | 79 | 81 | 82 | 83 | 84 | 87 | 84 | 83 | 77 |
| Min. | 60 | 60 | 63 | 62 | 60 | 58 | 59 | 56 | 63 | 63 | 84 | 64 | 65 | 58 | 49 | 49 | 47 | 52 | 55 | 59 | 53 | 51 | 53 | 57 | 50 | 56 | 61 | 57 | 59 | 52 |

**Figure 3.3 Graphical Presentation for the month wise Humidity Variation**

### 3.4.3 Cloud cover

Cloud cover refers to the fraction of the sky obscured by clouds when observed from a particular location. Okta is the usual unit of measurement of the cloud cover. The cloud cover is correlated to the sunshine duration as the least cloudy locales are the sunniest ones while the cloudiest areas are the least sunny places. Clouds cover data collected by dividing the visible area of sky in 8 parts by the surveyor. During the study period cloud cover was observed in the range 0 to 3 okta in the study region. As per the trend analysis of cloud for ten years data it has been observed in the range of 4% - 64% and minimum cloud 4% in February 2012 and maximum cloud 64% in September 2019. It was 41%, 31% and 18% in the month of Dec 2019, Jan 2020 and Feb 2020 respectively.

### 3.4.4 Rain fall

Rainfall data has been collected using the weather station. Total rain fall during the study period was 100.8 mm in Machilipatnam. Maximum rain fall was 39.7 mm in the month of Feb 2020 and 29.9 mm in the month of Dec 2019 in Machilipatnam. Month wise rainfall data are presented in Table 3.4.

**Table 3.4 Rain fall data**

| Month | Rain fall (mm) |
|---|---|
| Dec 2019 | 29.9 |
| Jan 2020 | 31.2 |
| Feb 2020 | 39.7 |
| **Total** | **100.8** |

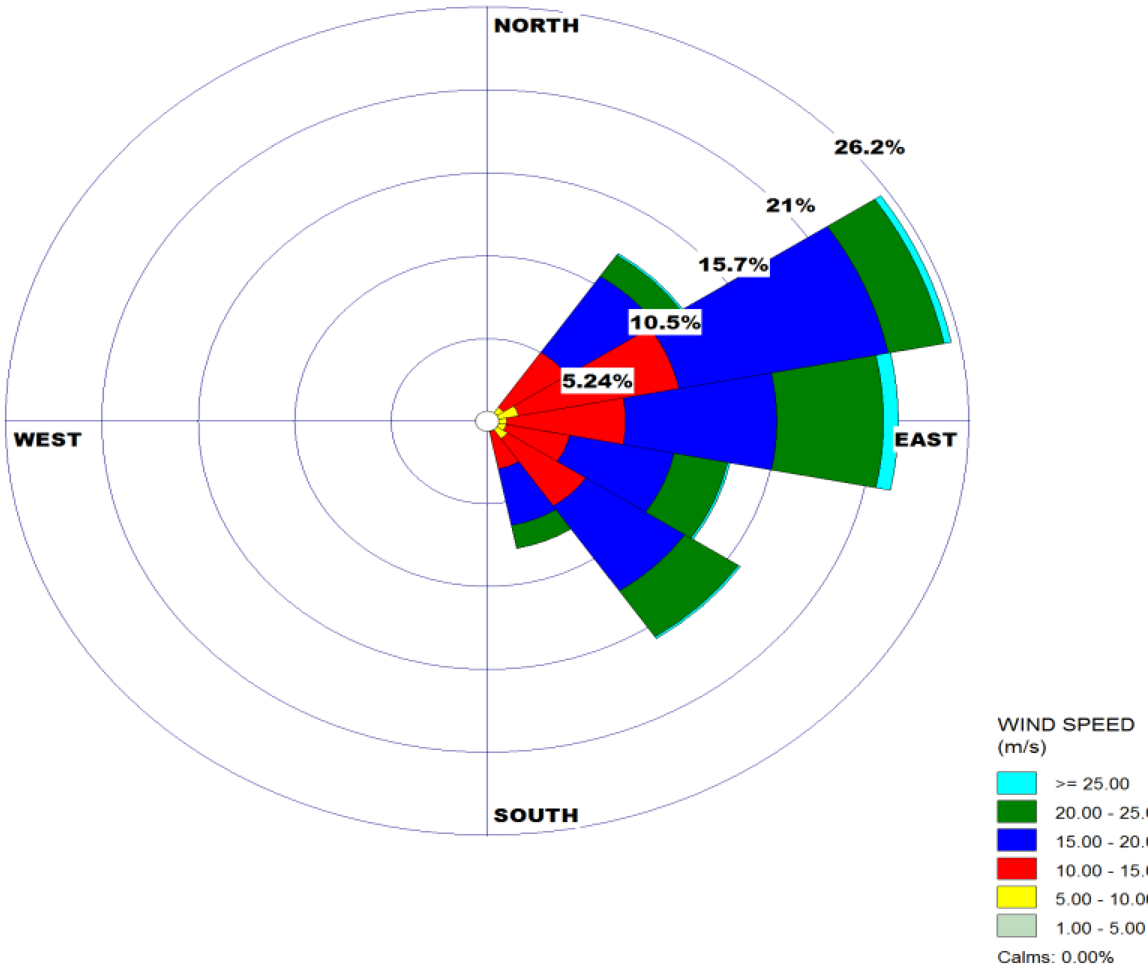
### 3.4.5 Wind Speed and Wind Direction

Hourly wind speed data were collected for the period Dec 2019 to Feb 2020 with the help of wind monitor. The rate of dispersion, diffusion and transportation of pollutants in the atmosphere mainly depend on wind speed and its direction. Wind direction and velocity data have been collected during the study period. Dominant wind direction in the study period was from SE – NW during the study period. Wind speed was observed from 1.0 to 27.0 km/hr in the month of Dec 2019, 2.0 to 27.0 km/hr in the month of Jan 2020 and from 1.0 to 28.0 km/hr in the month of Feb 2020. Month-wise maximum and minimum wind speed data are tabulated in **Table 3.3.**

### 3.4.6 Wind Rose

Wind rose diagram is a graphical representation of the magnitude and direction of wind speed considering all the directions. From the knowledge of wind rose one can easily predict the direction and extent of spreading of the gaseous and particulate matter from the source. Month wise wind rose diagram is presented in **Figure 3.4 to 3.7.**

| WIND ROSE PLOT:<br>M/s. Vedanta Limited.<br>Kaza | DISPLAY:<br>Wind Speed<br>Direction (blowing from) |
|---|---|




| COMMENTS: | DATA PERIOD:<br>Start Date: 01-12-2019 - 00:00<br>End Date: 31-12-2019 - 23:00 | COMPANY NAME:<br>M/s. Vedanta Limited. | |
|---|---|---|---|
| | | MODELER:<br>M/s. Eco Chem Sales & Services | |
| | CALM WINDS:<br>0.00% | TOTAL COUNT:<br>744 hrs. | |
| | AVG. WIND SPEED:<br>16.12 m/s | DATE:<br>17-08-2020 | PROJECT NO.: |

WRPLOT View - Lakes Environmental Software

**Figure 3.4 Wind Rose Diagram (December 2019)**

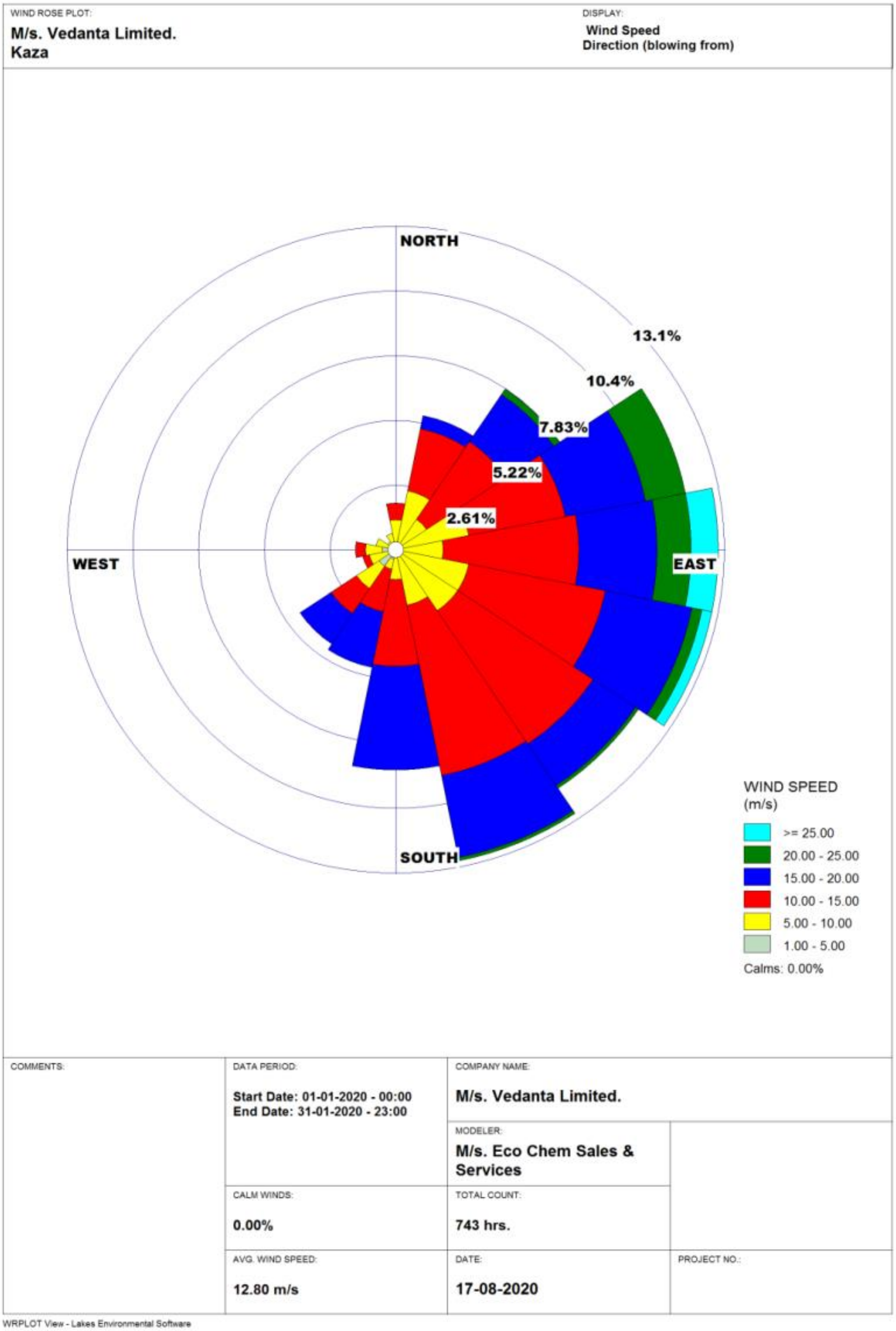



**Figure 3.5 Wind Rose Diagram (January 2020)**

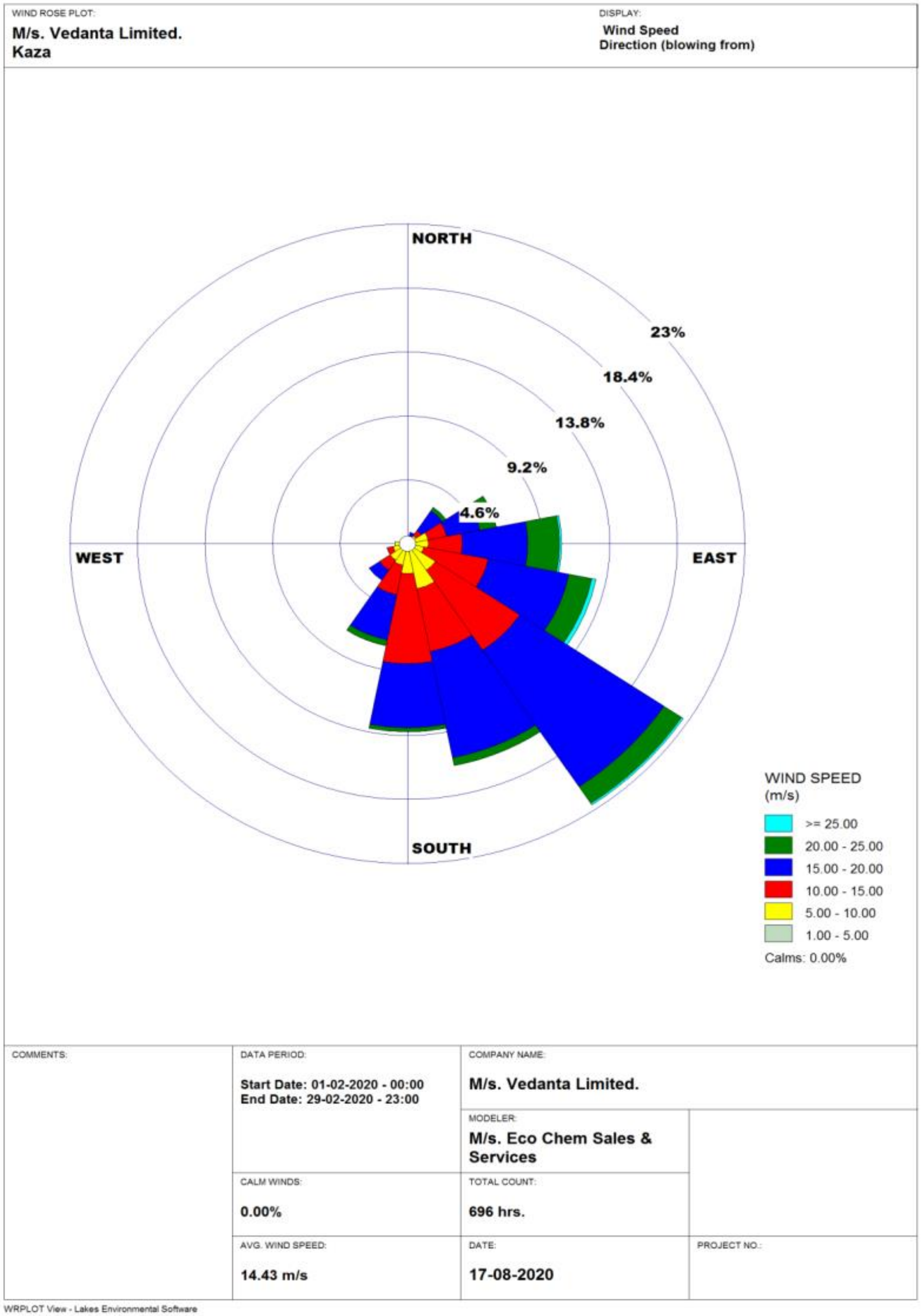
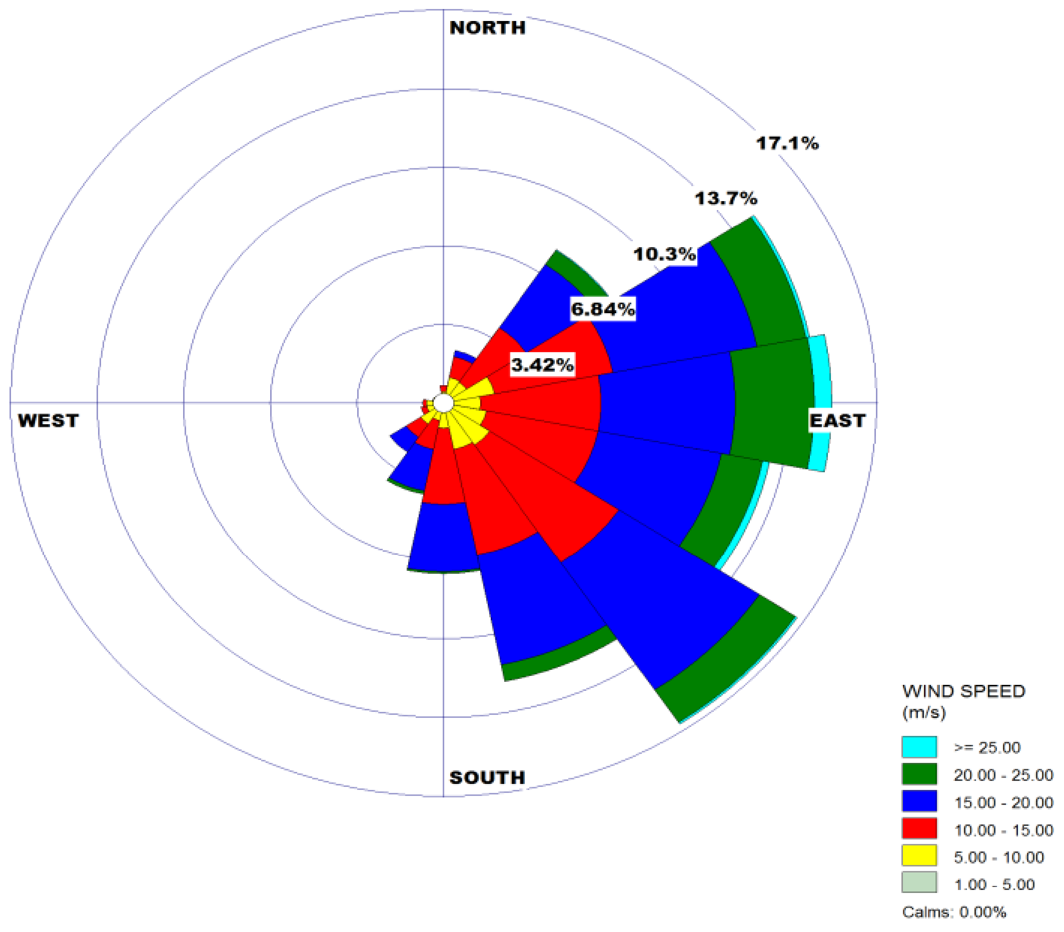



**Figure 3.6 Wind Rose Diagram (February 2020)**

| WIND ROSE PLOT:<br>M/s. Vedanta Limited.<br>Kaza | DISPLAY:<br>Wind Speed<br>Direction (blowing from) |
|---|---|




| COMMENTS: | DATA PERIOD:<br>Start Date: 01-12-2019 - 00:00<br>End Date: 29-02-2020 - 23:00 | COMPANY NAME:<br>M/s. Vedanta Limited. | |
|---|---|---|---|
| | | MODELER:<br>M/s. Eco Chem Sales & Services | |
| | CALM WINDS:<br>0.00% | TOTAL COUNT:<br>2184 hrs. | |
| | AVG. WIND SPEED:<br>14.45 m/s | DATE:<br>17-08-2020 | PROJECT NO.: |

WRPLOT View - Lakes Environmental Software

**Figure 3.7 Wind Rose Diagram (December 2019 to February 2020)**

### 3.4.5 Interpretation of Micrometeorological Data

Approx 17 % wind blow was in SE-NW direction, it shows that the first dominant wind direction in the study region is SE-NW. Wind speed was in the range of 1 to 28 km/hr. As per the trend analysis of temperature, it reaches up to 47.8°C and minimum average temperature is 20°C. Current temperature has been found in the range 21°C to 31°C. Based on the comparative study of currant data with last ten years data it can be interpreted that there is no increment in temperature has been observed. It shows almost similar pattern of micro meteorological data for the period Dec 19 to Feb 20. On the basis of wind speed and wind direction it can also be interpreted that chances of maximum dispersion of pollutant during the period of Dec to Feb is NW direction. This interpretation relate to currant data recorded during the study period and last ten years data only.

## 3.5 AIR ENVIRONMENT

Air is the Earth's atmosphere having the gases in which living organisms live and breathe but air is being deteriorated day by day due to the anthropogenic and natural sources. In present scenario Industrialization, Energy production and the burning of fossil fuels has polluted the air environment. Ambient air quality monitoring was carried out for the assessment of the existing status of background air quality in the study area. This will be useful for assessing the conformity of the ambient air quality to the standards even after commencement of the proposed project.

### 3.5.1 Selection of Sampling Locations

Following points are considered during the selection of Ambient Air Quality Monitoring locations.

- Topography/terrain of the study area,
- Regional synoptic scale climatologically norm's,
- Densely populated areas within the region,
- Location of surrounding Industries,
- Representation of regional background,
- Facility for Ambient Air Monitoring,
- Representation of valid cross – sectional distribution in downwind direction,
- Avoidance of proximity of roads, construction activity or any other perturbing activity which may be temporary in nature, which may lead to some erroneous conclusions.
- Availability of manpower, electricity, approach, sturdy structure and protection of samplers.
- Dominant Wind Direction.

Ambient air quality monitoring has been carried out for total 12 locations during Dec 2019 to Feb 2020. At the time of location selection previous micrometeorological data was referred and general wind pattern in the study region was considered for the selection of minimum one location in the downwind direction and one upwind direction. 2 locations have been selected in downwind direction and 1 location in upwind direction. However, ambient air monitoring locations were selected in all the directions looking towards the possibility of change in wind pattern during the study period. Ambient Air Quality monitoring locations are presented in **Figure 3.8 and Table 3.5**. Sampling photographs are presented in **Figure 3.9.**

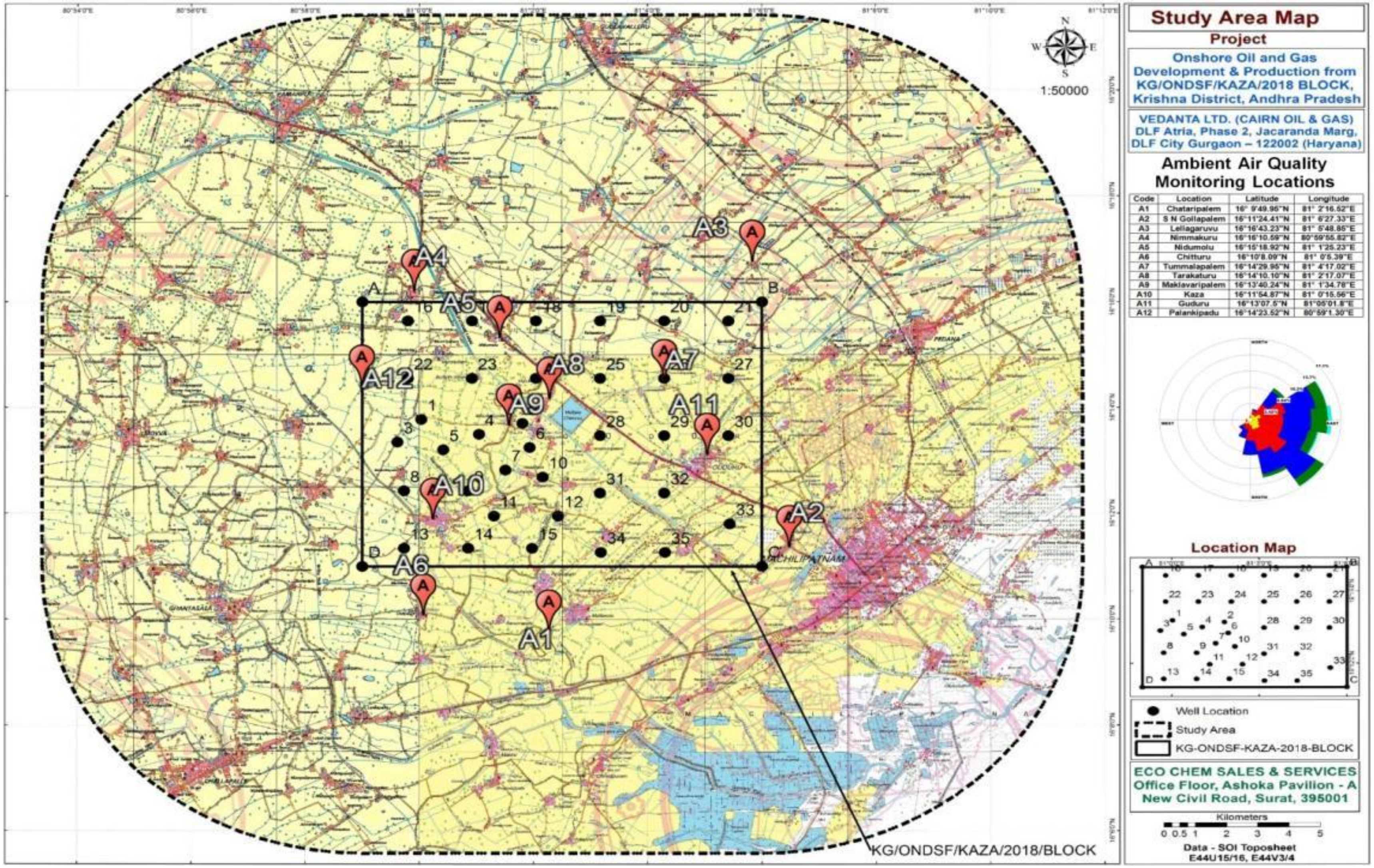



**Figure 3.8 Map showing the Study Region location of Ambient Air**

**Table 3.5 Ambient Air Quality Monitoring Locations in the Study Region**

| Code | Location | Latitude | Longitude | Selection Criteria |
|---|---|---|---|---|
| A1 | Chataripalem | 16°9'49.95"N | 81°2'16.52"E | Crosswind |
| A2 | S N Gollapalem | 16°11'24.41"N | 81° 6'27.33"E | Upwind |
| A3 | Lellagaruvu | 16°16'43.23"N | 81° 5'48.85"E | Crosswind |
| A4 | Nimmakuru | 16°16'10.59"N | 80°59'55.82"E | Crosswind |
| A5 | Nidumolu | 16°15'18.92"N | 81° 1'25.23"E | Crosswind |
| A6 | Chitturu | 16°10'8.09"N | 81° 0'5.39"E | Crosswind |
| A7 | Tummalapalem | 16°14'29.95"N | 81° 4'17.02"E | Crosswind |
| A8 | Tarakaturu | 16°14'10.10"N | 81° 2'17.07"E | Crosswind |
| A9 | Maklavaripalem | 16°13'40.24"N | 81° 1'34.78"E | Downwind |
| A10 | Kaza | 16°11'54.87"N | 81° 0'15.56"E | Crosswind |
| A11 | Guduru | 16°13'07.5"N | 81°05'01.8"E | Crosswind |
| A12 | Palankipadu | 16°14'23.52"N | 80°59'1.30"E | Downwind |


**Ambient air – Guduru**


**Ambient air – Kaza**


Ambient air – Lellagaruvu


Ambient air – Nidumolu

**Figure 3.9 Photographs of Ambient air Monitoring**

### 3.5.2 Frequency and Parameters for Sampling

Sampling and analysis was carried out as per CPCB, IS 5182 & EPA and instrument operation manual for the parameters $PM_{2.5,}$ $PM_{10,}$ $SO_2$, NOx, CO, $O_3$, Benzene, BaP, Pb, As, Ni, $NH_3$, Methane and Non-methane HC, VOC. After the completion of sampling, samples were brought to the laboratory in Ice box and filter box for analysis. Frequency of sampling was twice a week during study period.

### 3.5.3 Methodology for Sampling and Analysis

Samples were collected by using the $PM_{10}$ and $PM_{2.5}$ micron dust samplers at suitable height from obstruction free area as per the availability of the facility. Sampling and Analysis was carried out as per CPCB Guideline, instrument operational manual and National Environmental Engineering Research Institute. Detail of reference method is presented in **Table 3.6.**

**Table 3.6 Details of Analysis Method**

| Sr. No. | Parameters | Test Method |
|---|---|---|
| 1. | Particular matter (PM $_{2.5}$) | SOP No. WI/5.4/02-B/03,Issue No.1 Date:01/01/2010, CPCB Guideline |
| 2. | Particulate Matter ($PM_{10}$) | IS 5182 (Part 13):2006/Reaffirmed 2012 |
| 3. | Sulphur Dioxide ($SO_2$) | IS 5182 (Part 2):2001/Reaffirmed 2012 |
| 4. | Oxide of Nitrogen ($NO_x$) | IS 5182 (Part 6):2006 |
| 5. | Carbon monoxide(CO) | Methods of Air Sampling & Analysis AWMA, APHA (CO Analyser) |
| 6. | Ozone ($O_3$) | IS 5182 (Part 9):1974 |
| 7 | Ammonia ($NH_3$) | SOP No. WI/5.4/02-B/06,Issue No.1 Date:01/01/2010 |
| 8. | Benzene | IS 5182 (Part 11):2006 (GC) |
| 9. | Benzo Pyrine (BaP) | CPCB Guideline, Volume –I (GC) |
| 10. | Lead (Pb) | IS 5182 (Part 22):2004 (AAS) |

| | | |
|---|---|---|
| 11. | Arsenic(As) | CPCB Guideline, Volume –I(AAS) |
| 12. | Nickel(Ni) | CPCB Guideline, Volume –I (AAS) |
| 13. | Methane and Non-methane HC | Methods of Air Sampling & Analysis AWMA, APHA (Multi Gas Analyser) |
| 14. | Total VOC | Methods of Air Sampling & Analysis AWMA, APHA (VOC Analyser) |

### 3.5.4 Quality of Ambient Air

Minimum, maximum, average and 98th percentile values for the parameters $PM_{2.5}$, $PM_{10}$, $SO_2$, $NO_x$, CO, $O_3$, $NH_3$, Benzene, BaP, Pb, As, Ni, Methane and Non-methane HC and VOC are tabulated in **Table 3.7** to describe the quality of Ambient Air.

**Table 3.7 Ambient air Quality Results**

| Parameters | Result | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 | A12 | NAAQS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PM 10 ($\mu g/m^3$) | Min | 40.3 | 44.4 | 48.0 | 42.3 | 48.3 | 50.6 | 41.2 | 40.8 | 48.3 | 42.4 | 45.8 | 49.0 | **100** |
| | $98^{th}$ Percentile | 53.0 | 57.2 | 62.8 | 51.0 | 60.2 | 63.0 | 52.1 | 55.4 | 63.9 | 52.4 | 58.1 | 64.5 | |
| | Max | 53.2 | 57.4 | 63.3 | 51.1 | 60.5 | 63.2 | 52.3 | 55.4 | 65.3 | 52.6 | 58.3 | 65.2 | |
| | Avg | 46.4 | 51.6 | 55.1 | 47.1 | 54.7 | 56.6 | 47.1 | 47.4 | 55.2 | 47.6 | 53.2 | 55.0 | |
| PM 2.5 ($\mu g/m^3$) | Min | 19.9 | 22.7 | 24.7 | 20.2 | 22.5 | 24.8 | 20.4 | 19.0 | 25.1 | 21.2 | 23.3 | 24.7 | **60** |
| | $98^{th}$ Percentile | 27.4 | 29.3 | 33.0 | 26.8 | 31.3 | 35.3 | 27.5 | 28.8 | 33.7 | 27.0 | 28.7 | 33.7 | |
| | Max | 27.7 | 29.7 | 33.3 | 27.2 | 31.6 | 35.3 | 27.8 | 29.0 | 34.5 | 27.6 | 29.3 | 34.4 | |
| | Avg | 24.1 | 25.6 | 27.6 | 24.5 | 27.8 | 29.2 | 24.4 | 24.0 | 28.5 | 24.3 | 26.3 | 27.9 | |
| $SO_2$ ($\mu g/m^3$) | Min | 11.1 | 11.6 | 12.7 | 12.6 | 11.9 | 13.5 | 11.3 | 11.4 | 12.4 | 11.3 | 12.2 | 13.3 | **80** |
| | $98^{th}$ Percentile | 16.1 | 16.8 | 17.6 | 16.2 | 17.3 | 18.2 | 16.6 | 16.6 | 17.6 | 16.3 | 16.9 | 18.1 | |
| | Max | 16.2 | 17.3 | 17.6 | 16.2 | 17.6 | 18.5 | 16.6 | 16.6 | 17.6 | 16.3 | 17.2 | 18.3 | |
| | Avg | 13.6 | 14.6 | 15.3 | 14.6 | 14.9 | 15.8 | 15.0 | 14.7 | 15.3 | 14.6 | 14.9 | 15.8 | |
| NOx ($\mu g/m^3$) | Min | 15.0 | 14.2 | 17.5 | 14.8 | 15.8 | 18.1 | 15.6 | 14.5 | 17.2 | 14.8 | 16.1 | 17.6 | **80** |
| | $98^{th}$ Percentile | 19.3 | 19.9 | 22.2 | 19.0 | 20.0 | 22.5 | 19.4 | 19.2 | 22.0 | 19.6 | 20.3 | 21.6 | |
| | Max | 19.5 | 20.3 | 22.4 | 19.2 | 20.1 | 22.6 | 19.5 | 19.2 | 22.1 | 19.6 | 20.9 | 21.6 | |
| | Avg | 17.0 | 17.6 | 19.8 | 17.1 | 18.2 | 20.6 | 17.9 | 17.6 | 19.8 | 17.8 | 18.0 | 19.6 | |
| $O_3$ ($\mu g/m^3$) | Min | 12.3 | 12.5 | 11.3 | 8.5 | 9.2 | 12.1 | 9.2 | 12.3 | 11.0 | 12.0 | 15.1 | 11.1 | **180** |
| | $98^{th}$ Percentile | 17.3 | 16.7 | 15.3 | 13.2 | 12.8 | 15.7 | 13.0 | 16.4 | 15.4 | 16.7 | 19.6 | 16.5 | |
| | Max | 17.6 | 16.9 | 15.4 | 13.7 | 12.8 | 15.7 | 13.1 | 16.5 | 15.4 | 16.9 | 19.8 | 16.5 | |
| | Avg | 14.5 | 14.2 | 13.3 | 10.6 | 10.7 | 13.9 | 11.2 | 14.4 | 13.3 | 14.3 | 17.1 | 13.8 | |
| $NH_3$ ($\mu g/m^3$) | Min | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | **400** |
| | $98^{th}$ Percentile | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |
| | Max | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |
| | Avg | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Benzene ($\mu g/m^3$) | Min | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | **05** |
| | $98^{th}$ Percentile | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |
| | Max | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |
| | Avg | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |
| BaP ($ng/m^3$) | Min | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | **01** |
| | $98^{th}$ Percentile | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |
| | Max | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |
| | Avg | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |
| Arsenic ($ng/m^3$) | Min | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | **06** |
| | $98^{th}$ Percentile | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |
| | Max | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |
| | Avg | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |
| Lead ($\mu g/m^3$) | Min | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | **01** |
| | $98^{th}$ Percentile | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |
| | Max | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |
| | Avg | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |
| Nickel ($ng/m^3$) | Min | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | **20** |
| | $98^{th}$ Percentile | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |
| | Max | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |
| | Avg | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |
| CO ($\mu g/m^3$) | Min | 226 | 220 | 377 | 236 | 248 | 314 | 266 | 226 | 318 | 204 | 218 | 322 | **2000** |
| | $98^{th}$ Percentile | 316 | 293 | 445 | 303 | 318 | 391 | 324 | 291 | 383 | 282 | 263 | 392 | |
| | Max | 318 | 294 | 448 | 304 | 318 | 392 | 326 | 292 | 384 | 284 | 266 | 394 | |
| | Avg | 274 | 267 | 406 | 269 | 284 | 362 | 291 | 261 | 355 | 253 | 232 | 359 | |
| Methane HC($\mu g/m^3$) | Min | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | **NA** |
| | $98^{th}$ | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Percentile | | | | | | | | | | | | | |
| | Max | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |
| | Avg | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |
| Non - methane HC (µg/m$^3$) | Min | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | **NA** |
| | 98$^{th}$ Percentile | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |
| | Max | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |
| | Avg | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |
| Total VOC as Iso butylene | Min | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | **NA** |
| | 98$^{th}$ Percentile | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |
| | Max | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |
| | Avg | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | |

Note: NAAQS = National Ambient Air Quality Standards; BDL = Below Detection Limit; NA = Not Available

DL = Detection Limit; BDL for of O3 – 20 µg/m3, BDL of NH3 – 1 µg/m3, BDL of Benzene – 2 µg/m3 , BDL of BaP – 0.5 ng/m3 , BDL of Arsenic – 2 ng/m3 , BDL of Lead – 0.01 µg/m3 , BDL of Nickel – 10 ng/m3, BDL of Methane HC – 0.1 ppm, BDL of Non-methane HC – 0.1 ppm, BDL of VOC – 1.0 ppm

### 3.5.5 Summary of Ambient Air Quality

- During the study $PM_{10}$ was observed in the range of 40.3 – 65.3 µg/m$^3$. Maximum concentration of $PM_{10}$ was found at Maklavaripalem village and minimum at Chataripalem village.
- $PM_{2.5}$ was observed in the range of 19.0 – 35.3 µg/m$^3$. Maximum concentration of $PM_{2.5}$ was found at Chitturu village and minimum at Tarakaturu village.
- $SO_2$ concentration was observed in the range of 11.1 – 18.5 µg/m$^3$, which is well within the standard limit.
- $NO_x$ concentration in was observed in the range of 14.2- 22.6 µg/m$^3$, which is well within the standard limit.
- Monitoring and analysis were also carried out for CO, $O_3$, $NH_3$, Ni, As, Pb, Benzene, BaP, VOC, Methane and Non-methane HC. Results for the CO, $O_3$, $NH_3$, Ni, As, Pb, Benzene, BaP, VOC, Methane and Non-methane HC were found well within the norms.

### 3.5.6 Interpretation of Ambient Air Quality Data

All the results of ambient air quality parameters have been found well within the limit as per NAAQS. Based on comparison study of results for tested parameters with NAAQS, it is interpreted that ambient air quality of studied locations is good. This interpretation relate to the results found for particular locations and study period.

## 3.6 NOISE ENVIRONMENT

The objective of the baseline noise survey was to identify existing noise sources and to measure background noise levels at the sensitive receptors within the study area. Peoples' perception of noise varies depending on number of factors including their natural sensitivity and hearing ability, past experience of sound, cultural factors and the time of day at which sound is experienced. Continuous sound is perceived quite differently from intermittent sound at the same level. High or continuous noise levels may cause permanent loss of hearing ranging from reduced perception at certain frequencies to total deafness. At comparatively lower levels noise may have psychological effects including disturbance of sleep, annoyance and irritation.

### 3.6.1 Sources of Noise Pollution

The sources of noise pollution in the study area are industrial noise, noise due to commercial activities, noise generated by Community, Vehicular traffic etc.

### 3.6.2 Noise Level in the Study Area

Continuous Noise level monitoring was carried out with the help of sound level meter at 19 different locations. Study area does not fall under industrial area therefore all the noise sampling locations are considered under Residential area. Noise sampling locations are presented in **Figure 3.10** and **Table 3.8**. Analysis results are presented in **Table 3.9** and **Table 3.10**. Photograph of sampling activity are presented in **Figure 3.11.**

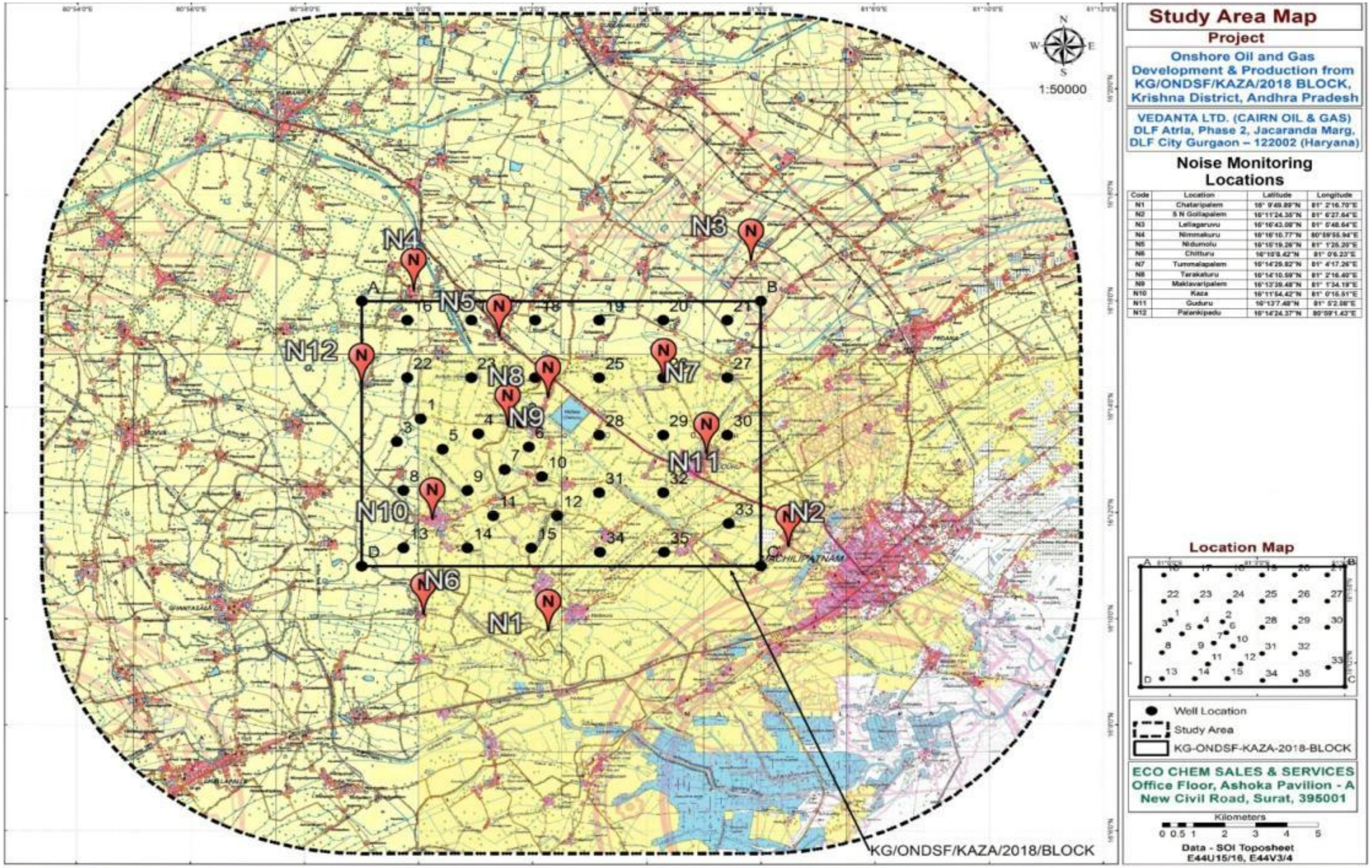



**Figure 3.10 Map showing the study region location of Noise**

**Table 3.8 Noise Monitoring Locations in the Study Region**

| Code | Location | Latitude | Longitude | Selection Criteria |
|---|---|---|---|---|
| N1 | Chataripalem | 16°9'49.89"N | 81°2'16.70"E | Residential Area |
| N2 | S N Gollapalem | 16°11'24.35"N | 81° 6'27.64"E | Residential Area |
| N3 | Lellagaruvu | 16°16'43.08"N | 81° 5'48.64"E | Residential Area |
| N4 | Nimmakuru | 16°16'10.77"N | 80°59'55.94"E | Residential Area |
| N5 | Nidumolu | 16°15'19.26"N | 81° 1'25.20"E | Residential Area |
| N6 | Chitturu | 16°10'8.42"N | 81° 0'6.23"E | Residential Area |
| N7 | Tummalapalem | 16°14'29.82"N | 81° 4'17.26"E | Residential Area |
| N8 | Tarakaturu | 16°14'10.59"N | 81° 2'16.40"E | Residential Area |
| N9 | Maklavaripalem | 16°13'39.48"N | 81° 1'34.19"E | Residential Area |
| N10 | Kaza | 16°11'54.42"N | 81° 0'15.51"E | Residential Area |
| N11 | Guduru | 16°13'07.48"N | 81°5'02.08"E | Residential Area |
| N12 | Palankipadu | 16°14'24.37"N | 80°59'1.43"E | Residential Area |


**Noise – Guduru**


**Noise – Kaza**


**Noise – Lellaguruvu**


**Noise - Nidumolu**

**Figure 3.11 Photographs of Noise Monitoring**

**Table 3.9 Noise Monitoring report during day time**

| Code | $L_{min}$ dB | $L_d$ dB(A) | $L_{max}$ dB | Leq dB(A) | Limit dB(A) as per Noise Pollution (Regulation and Control) Rules, 2000 |
|---|---|---|---|---|---|
| N1 | 48.4 | 51.2 | 53.6 | 51.5 | **55** |
| N2 | 48.8 | 51.5 | 53.8 | 51.7 | **55** |
| N3 | 48.1 | 51.1 | 53.2 | 51.3 | **55** |
| N4 | 48.6 | 51.4 | 53.5 | 51.6 | **55** |
| N5 | 48.8 | 51.6 | 53.8 | 51.8 | **55** |
| N6 | 48.0 | 50.3 | 52.6 | 50.6 | **55** |
| N7 | 48.3 | 50.6 | 52.5 | 50.8 | **55** |
| N8 | 48.2 | 50.4 | 52.4 | 50.6 | **55** |
| N9 | 48.7 | 50.8 | 53.5 | 51.1 | **55** |
| N10 | 48.1 | 50.4 | 52.6 | 50.7 | **55** |
| N11 | 48.8 | 52.0 | 54.1 | 52.2 | **55** |
| N12 | 48.4 | 50.6 | 52.7 | 50.9 | **55** |

**Table 3.10 Noise Monitoring report during night time**

| **Code** | $L_{min}$ dB | $L_n$ dB(A) | $L_{max}$ dB | Leq dB(A) | Limit dB(A) as per Noise Pollution (Regulation and Control) Rules, 2000 |
|---|---|---|---|---|---|
| N1 | 38.1 | 41.2 | 44.5 | 41.5 | **45** |
| N2 | 38.6 | 41.7 | 44.8 | 42.0 | **45** |
| N3 | 38.9 | 41.8 | 44.0 | 42.0 | **45** |
| N4 | 38.2 | 41.3 | 44.4 | 41.6 | **45** |
| N5 | 38.8 | 41.9 | 43.8 | 42.1 | **45** |

| | | | | | |
|---|---|---|---|---|---|
| N6 | 38.1 | 40.2 | 43.3 | 40.5 | **45** |
| N7 | 38.3 | 41.6 | 44.5 | 41.8 | **45** |
| N8 | 38.1 | 41.2 | 44.3 | 41.4 | **45** |
| N9 | 38.3 | 41.5 | 43.7 | 41.7 | **45** |
| N10 | 38.5 | 41.4 | 44.6 | 41.6 | **45** |
| N11 | 39.0 | 41.8 | 44.1 | 42.1 | **45** |
| N12 | 38.4 | 41.3 | 44.4 | 41.6 | **45** |

**Note: Day time –6.00 AM to 10.00 PM, Night time – 10.00 PM to 6.00 AM**

Noise standards have been designated for different types of land use i.e. residential, commercial, industrial areas and silence zones, as per 'The Noise Pollution (Regulation and Control) Rules, 2000, Notified by Ministry of Environment and Forests, New Delhi, February 14, 2000. Different standards have been stipulated for day (6 AM to 10 PM) and night (10 PM to 6 AM). The noise level study shows that the noise levels are meeting the acceptable norms.

### 3.6.3 Summary of Noise Data

- Equivalent noise level was recorded in the range of 50.6 to 52.2 dB (A) during day time.
- Equivalent noise level was recorded in the range of 40.5 to 42.1 dB (A) during night time.

### 3.6.4 Interpretation of Noise Data

Based on noise level data obtained during the survey, it is interpreted that noise levels are within the standard norms prescribed by MoEF & CC. Looking towards the increase in noise generating sources it is suggested that there is need to apply noise reducing devices at noise generating sources and generate public awareness.

## 3.7 LAND ENVIRONMENT

### 3.7.1 Land Use Pattern of the Study area

Studies on land use aspects of eco system play an important role to identify sensitive issues and to take appropriate action for maintaining ecological homeostasis in the region. The main objective of this section is to provide a baseline status of the area, so that temporal changes due to the proposed project on the surroundings can be assessed in future.

**Data Used:** United States Geological Survey (USGS) Satellite Data: Land sat 8 cloud free data has been used for Land use /Land cover analysis, Satellite Sensor–OLITIRS multi-spectral digital data has been used for the preparation of land use/ land cover map of present study. Survey of India reference map on 1:50,000 scales have been used for the preparation of base map and geometric correction of satellite data. Ground trothing has been carried out to validate the interpretation accuracy and reliability of remotely sensed data, by enabling verification of the interpreted details and by supplementing with the information, which cannot be obtained directly on satellite imagery.

**Methodology:** The methodology used for the study consists of following components.

**Methodology Adopted for Thematic Data Extraction from the Satellite Imageries**

ERDAS image processing 10.0 software and ARC/GIS 10.0 software were used for the project. ERDAS 10.0 image processing software was used for digital processing of the spatial data. Digital image processing techniques were applied for the mapping of the land use land cover classes of the provided area from the satellite data. Methodology used for land use classification and mapping is presented in **Figure 3.12.** Land use map is presented in **Figure 3.13.** Land Use Statistic is presented in **Figure 3.14 and Table 3.11.**

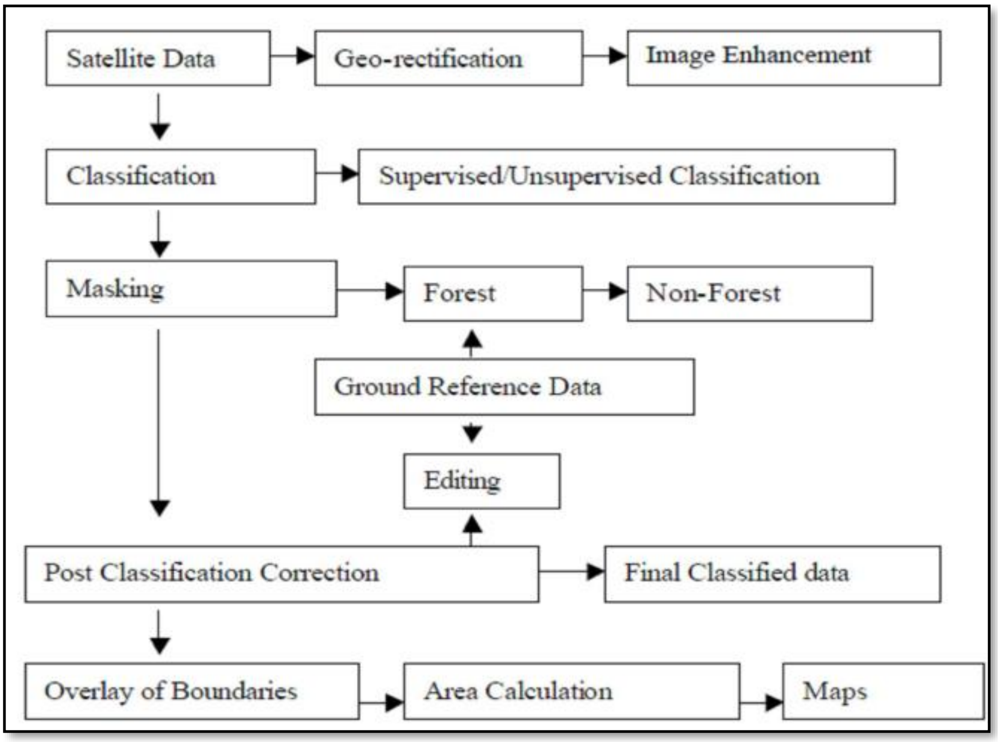



**Figure 3.12 Methodology Used for Land use Classification**

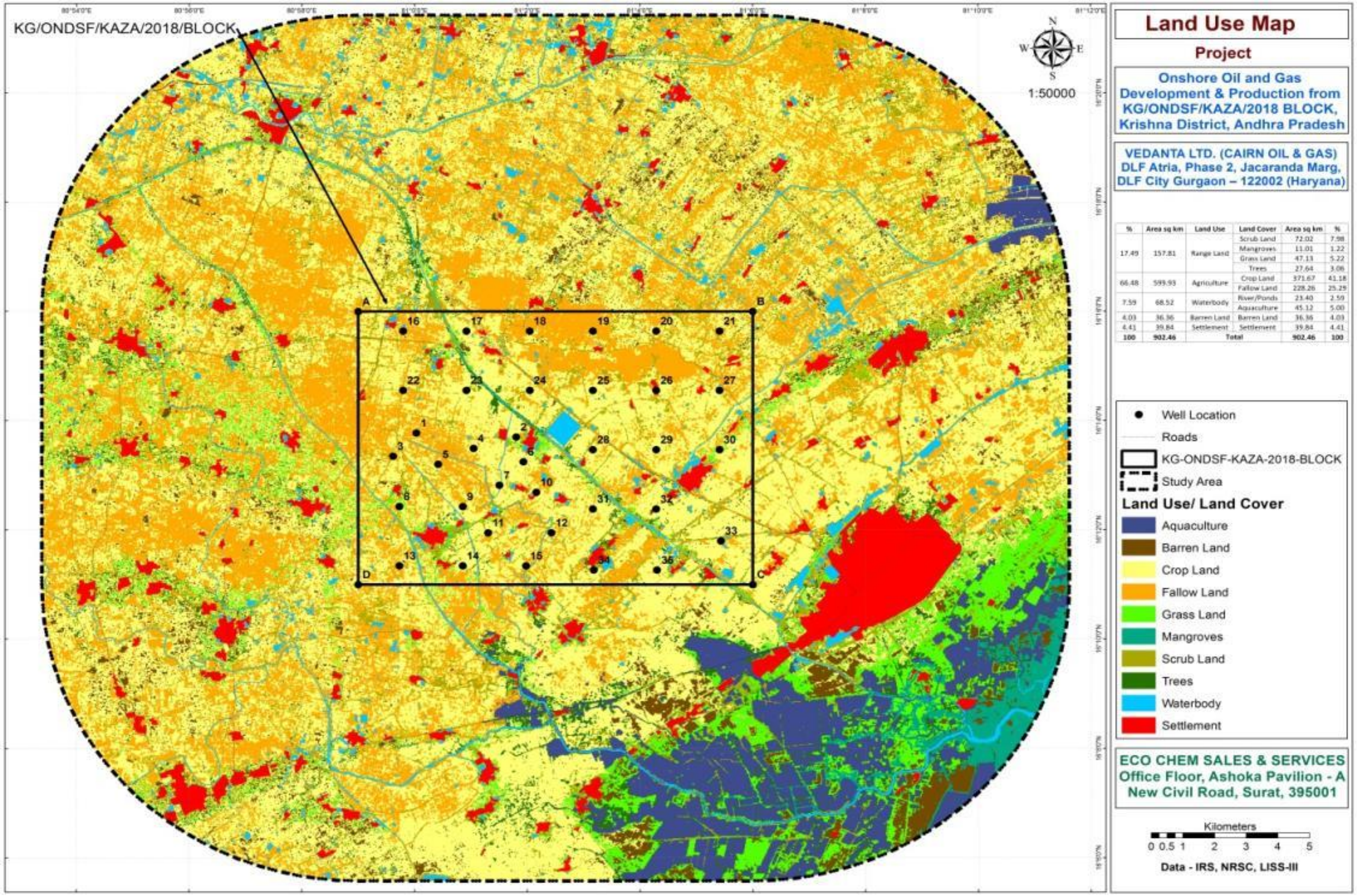



**Figure 3.13 Land Use Map**

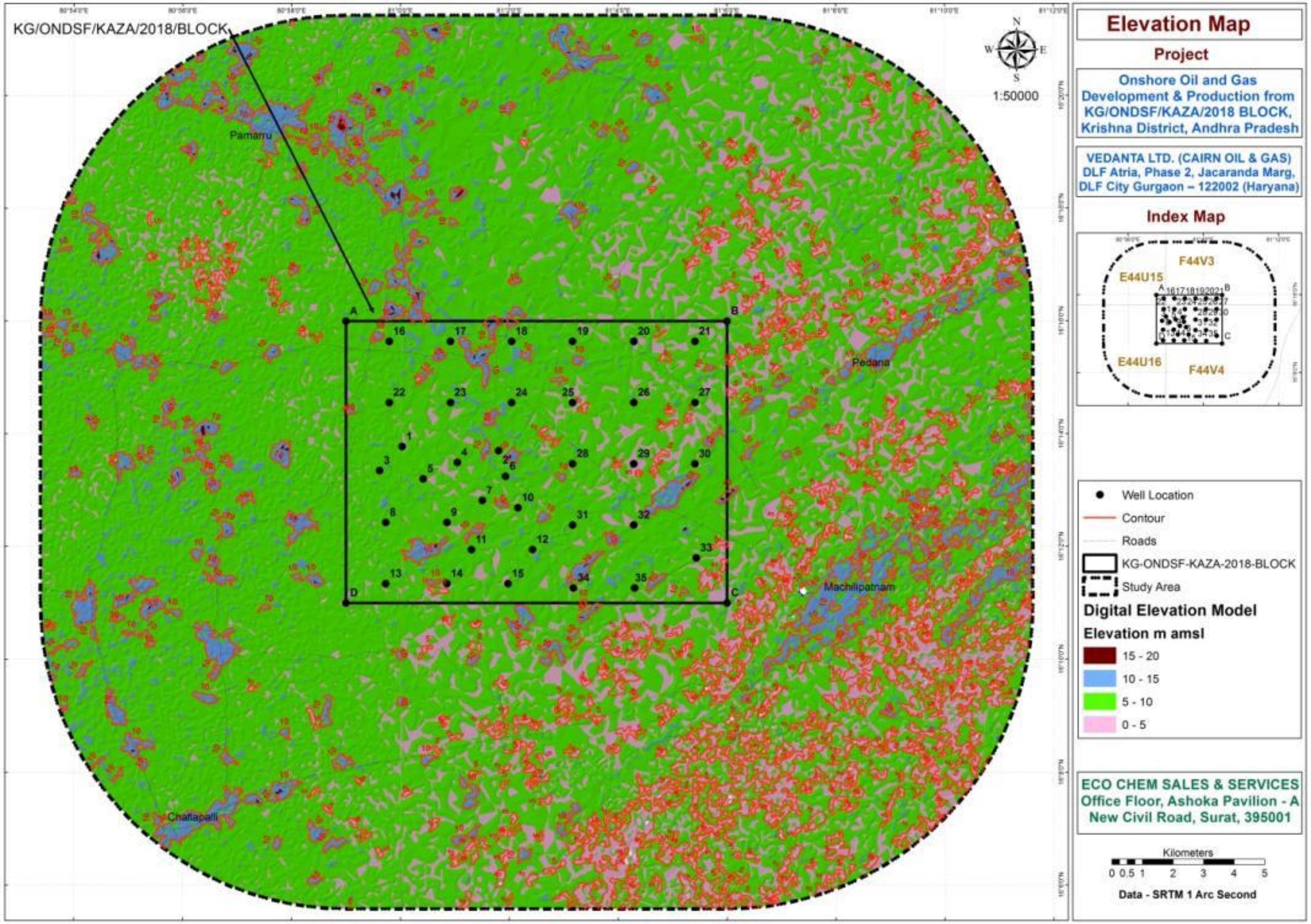



**Figure 3.14 Elevation Map**

**Table 3.11 Land use Statistics**

(Source: Land use mapping and primary survey of the area)

| % (Percentage) | Area (Sq.km) | Land Use | Land Cover | Area (Sq.km) | % (Percentage) |
|---|---|---|---|---|---|
| 17.49 | 157.81 | Range Land | Scrub Land | 72.02 | 7.98 |
| | | | Mangroves | 11.01 | 1.22 |
| | | | Grass Land | 47.13 | 5.22 |
| | | | Trees | 27.64 | 3.06 |
| 66.48 | 599.93 | Agriculture Land | Crop Land | 371.67 | 41.18 |
| | | | Fallow Land | 228.26 | 25.29 |
| 7.59 | 68.52 | Water body | River/Ponds | 23.40 | 2.59 |
| | | | Aquaculture | 45.12 | 5.00 |
| 4.03 | 36.36 | Barren Land | Barren Land | 36.36 | 4.03 |
| 4.41 | 39.84 | Settlement | Settlement | 39.84 | 4.41 |
| **100** | **902.46** | **Total** | | | **100** |

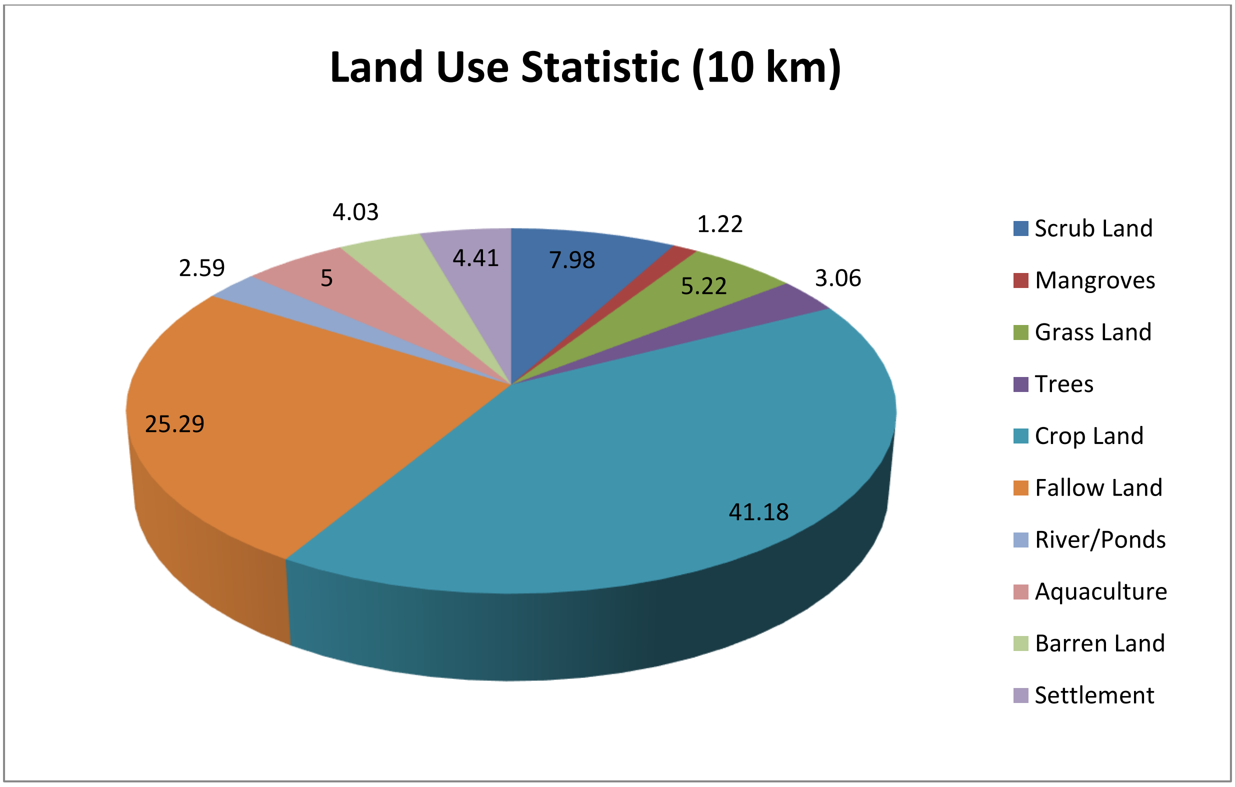



**Figure 3.15 Land use Statistics**

### 3.7.2 Summary and Interpretation of Land Use Map

As per Land use statics, it is found that maximum land is covered with Agriculture land. Total 66.48% has been covered by Agriculture land where crop land and fallow land are covering around 41.18% and 25.29% respectively of the total study area. Range land like Scrub land, Mangoves, Grass land and Trees are covering around 7.98%, 1.22%, 5.22% and 3.06% respectively of the total study area. Water body is covering around 7.59% of the total study area. Barren land is covering around 4.03% of the total study area. Settlement is covering around 4.41% of the total study area.

## 3.8 GEOLOGY

- **Geomorphologically & Soil**

Geomorphologically the district can be broadly divided into 3 distinct units, viz., Pediplain, Alluvial plains, and Coastal & Deltaic plains. The pediplain area i.e., northern part of the district consists of an undulated plain with broken ridges. Major part of the district in the southern part is represented by the alluvial plains forming the Krishna delta. The river Krishna and its tributaries have contributed to the formation of this alluvial plain. There is no significant surface drainage in these alluvial plains. The delta is relatively a flat area. The alluvial plains along the major course of rivers form the flood plain deposits. The coastal and deltaic alluvial plain extends from Challapalli on the west to Kolletikota on the east and upto the coast line on the south. The main geomorphic units exist in these plains are palaeo-channels, beach ridges, lagoons, sand spits and sand barriers. Krishna river divides itself at Avanigadda and south of Nagayalanka into four branches forming an arcuate delta. The deltaic coast protrudes towards open sea at the mouths of these four branches forming a cuspate foreland.

The predominant soils in the district are black cotton soils/deltaic soils, red loamy soils and sandy soils. Red clayey soils with sandy loam to clayey loam in texture and occur in the northern part of the district. The deltaic alluvium is grey brown to black in color with fine to medium texture and poorly permeable. They are fertile soils. The coastal sandy soils occur all along the coast, highly porous and lack of binding material.

***Source : CGWB, Krishna District***

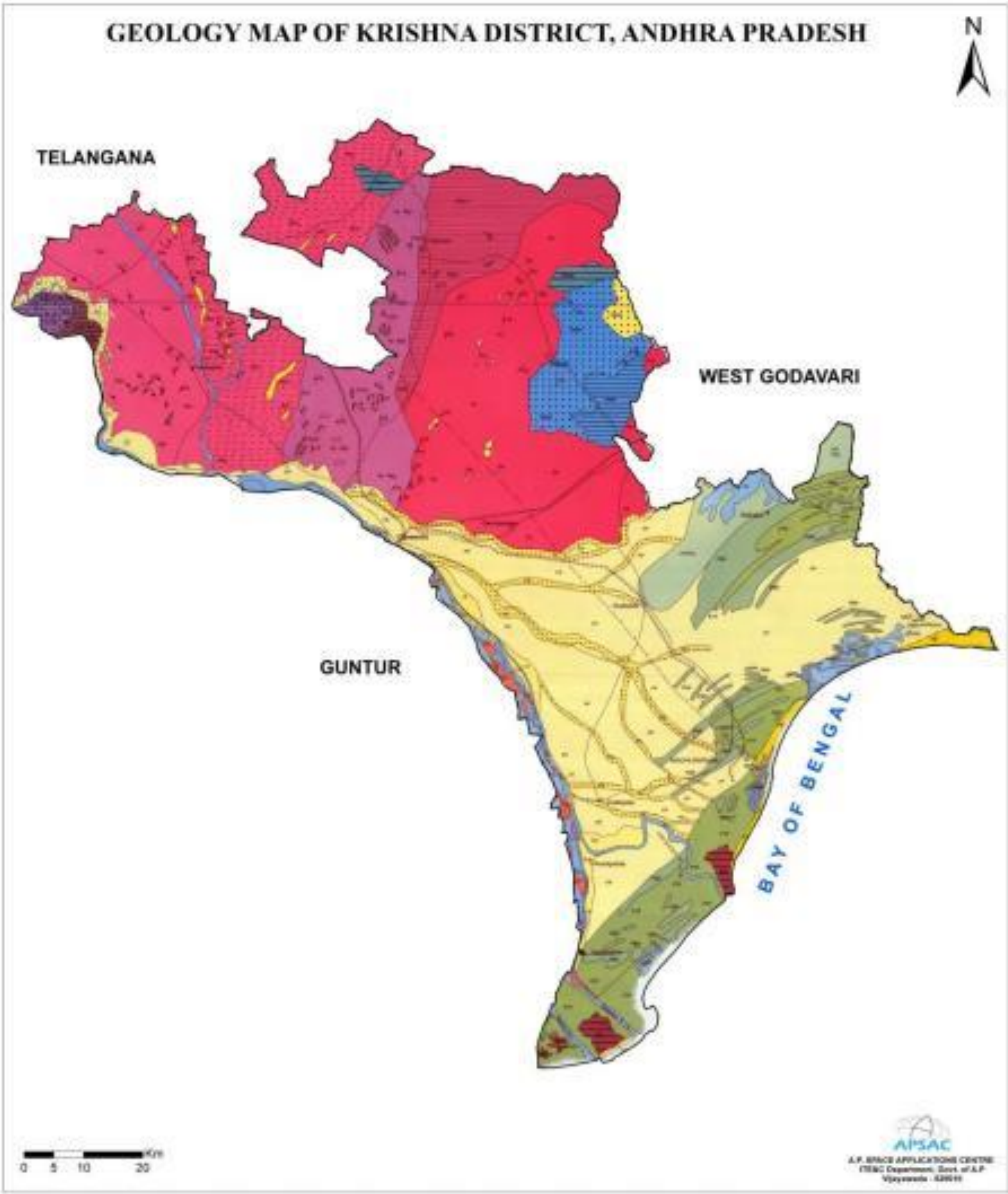



**Figure 3.16 Geology Map (Krishna District)**

***Source: District Survey Report 2018***

## 3.9 HYDROGEOLOGY

The district is underlain by variety of geological formations comprising from the oldest Archaeans to Recent Alluvium. Hydrogeologically these formations are classified as consolidated (Hard), semi-consolidated (Soft) and unconsolidated (Soft) formations. The consolidated formations include crystallines (khondalites, charnockites and granitic gneisses) and metasediments (Limestones, shales, phyllites and quartzites) of Archaean and Pre-cambrian periods respectively. The semi consolidated formations are represented by Tertiary formations (Rajahmundry & Gollapalli sandstones) and unconsolidated formations comprise deltaic alluvial deposits of Quaternary period.

Consolidated formations occur in the northern part of the district. Among consolidated formations occurrence of metasediments is restricted to NW part of the district i.e., in parts of Jaggayyapeta, Penuganchiprolu, Nandigama and Chandralapadu mandals. Semiconsolidated formations occur in the northeastern part of the district and its extension is limited to small area i.e., in parts of Musunuru, Nuzividu, Bapulapadu and Gannavaram mandals. Unconsolidated formations occur in the southern part of the district i.e., in the delta area. Ground water occurs in all most all geological formations and its potential depends upon the nature of geological formations, geographical setup, incidence of rainfall, recharge and other hydrogeological characters of the aquifer.

In consolidated formations ground water occurs under unconfined to semiconfined conditions. Ground water is developed in these formations by dug wells, dug cum bore wells and bore wells tapping weathered and fractured zones. The yields are in the range of 20 to 70 m3 /day. The occurrence of fractures in the crystalline formations is limited down to 30 to 40 m bgl and occasionally extends down to 70 - 100 m bgl. The bore wells constructed in the crystalline formations generally tap the weathered and fractured zones. The yields of the bore wells generally range between 80 to 400 m3 /day. The higher yields are limited to the available thickness of fractured and jointed zones. In the metasediments the yields are very limited and are in the range of 10 to 80 m3 /day. Higher yields occur in limestone formations.

Ground water in semi-consolidated formations occurs under unconfined to confined conditions. Ground water is developed in these formations by dug cum tube wells and tube wells. These formations are potential aquifers. The yields of the dug cum tube wells are in the range of 30 to 45 m3 /day. Granularity of the sandstone bed is the deciding factor of the yield potential as the higher yields are recorded in the Rajahmundry sandstones tapping coarse sandstone beds. The yields of the tube wells in Gollapalli sandstones and Rajahmundry sandstones are in the range of 60 to 200 m3 /day and 600 1500 m3 /day respectively. The deltaic area is underlain by alluvium of recent age consisting of varying proportions of clay, silt, sand and gravel. The thickness of alluvium ranges from few meters to about 600 m followed by tertiary formations. In deltaic area ground water occurrence is controlled by landforms. In deltaic area also a lot of heterogenity in hydrogeological conditions exist both spatially and vertically. Fresh water is generally limited to shallow to moderate depths only, whereas in the southern part of the delta it occurs as pockets and lenses. Deep aquifers are generally saline. Palaeochannels are favourable locations for fresh water aquifers. Ground water occurs under phreatic to confined conditions and is developed through shallow dug wells, filter point wells and shallow tube wells. The depth of dug wells ranges from about 2 to 7 m, while the depth of filter point wells varies from 5 to 13 m and the depth of tube wells varies from 40 to 80 m. The yields generally range in this aquifer between 250 to 400 m3 /day. Occasionally high yields upto 15 lps exist in the palaeochannels. The transmissivity value of the aquifer in the semi & unconsolidated formations varies from 2.5 to 5560 m2 /day.

- **Water Level Scenario**

The depth to water levels during pre-monsoon season (May, 2012) in the district ranges between 2 and 10 m bgl. Water levels more than 5 m bgl occur in the parts of Gannavaram, Jagayyapet, Reddygudem, Visannapeta and Tiruvuru mandals, whereas, water levels less than 2 m bgl occur in parts of the Kalidindi and Ibrahimpatnam mandals. The depth to water level during post monsoon season (Nov, 2012) in general is less than 2m bgl, whereas in parts of Jaggayyapeta, Vijayawada, Musunuru water levels are more 2m bgl.

Ground water levels fluctuate considerably in response to the recharge and draft conditions of ground water reservoir. Overall rise in water levels from pre-monsoon to post-monsoon in the range of 0.83 to 9.37 m exist in the district. Magnitude of the fluctuation is less in the deltaic area when compared to northern part of the district. Long-term trend of water level (2001 to 2011) indicates that during pre-monsoon a raise in the range of 0.0102 to 0.3456 m/yr in Gampalagudem, Vissannapeta, Ibrahimpatnam and Challapalli areas, whereas in the majority of the district a fall in the range of 0.0003 to 0.2379 m/yr is recorded. During post monsoon period a raise in the range of 0.0091 to 0.2217 m/yr and a fall in the range of 0.0016 to 0.2070 m/yr exists in the district.

***Source : CGWB, Krishna District***

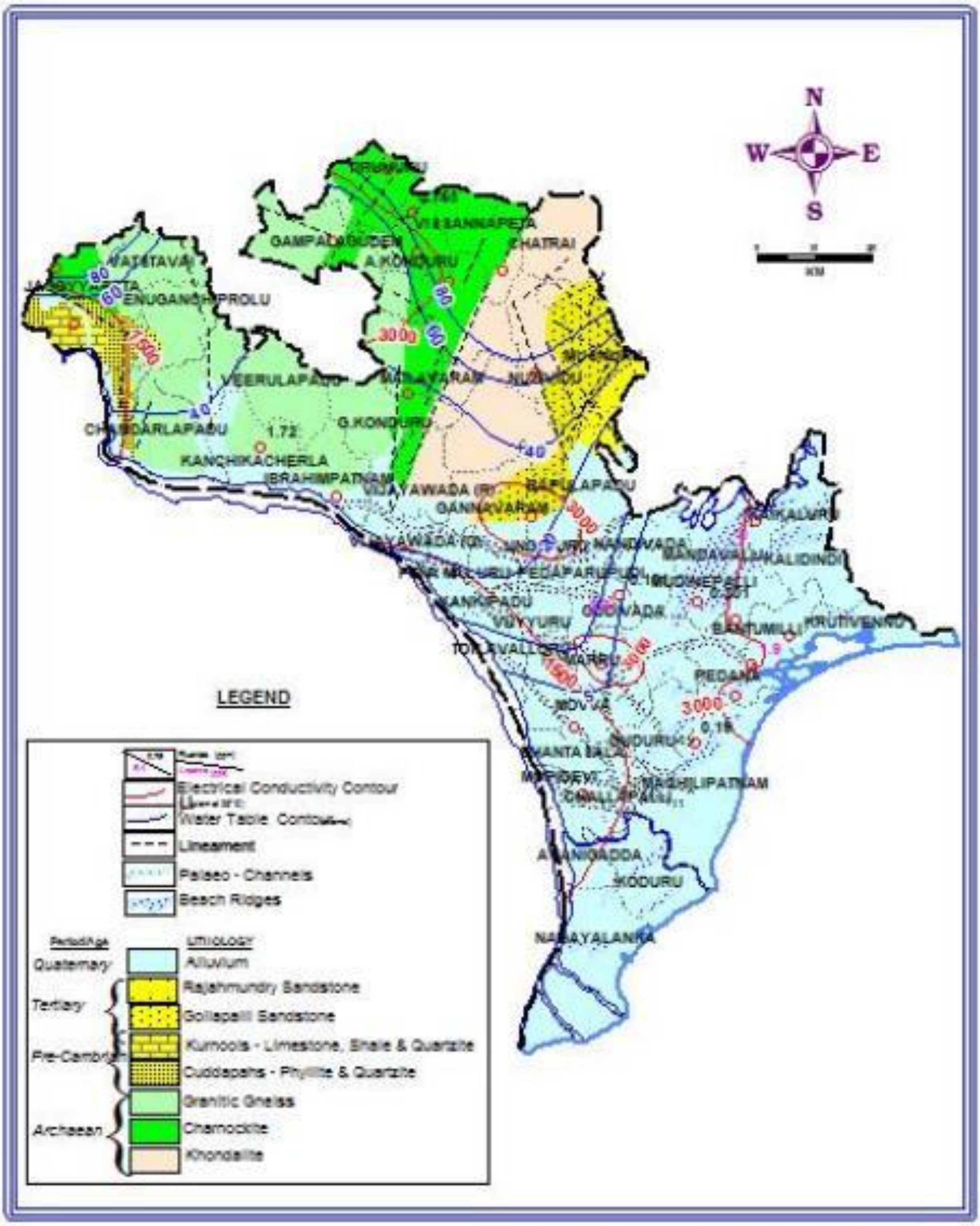



**Figure 3.17 Hydrogeology Map (Krishna District)**

## 3.10 TOPOGRAPHY

Krishna district is one of the 9 coastal districts of Andhra Pradesh and agriculturally it is an important district. The district has a coastline of 88 km. It is endowed by good rainfall and surface water. The district lies between North latitude of 15° 43’ and 17° 10’ and East longitudes of 80° 00’ and 81° 33’ with an aerial extent of 8797 km2 . It is bounded by the Bay of Bengal on the southeast, West Godavari district on the East, Khammam district on the North and Guntur & Nalgonda districts on the West. Howrah – Chennai broad gauge railway line and NH-5 are passing through the district. In addition to the surface transport the district has aerodrome at Gannavaram and sea port at Machilipatnam.

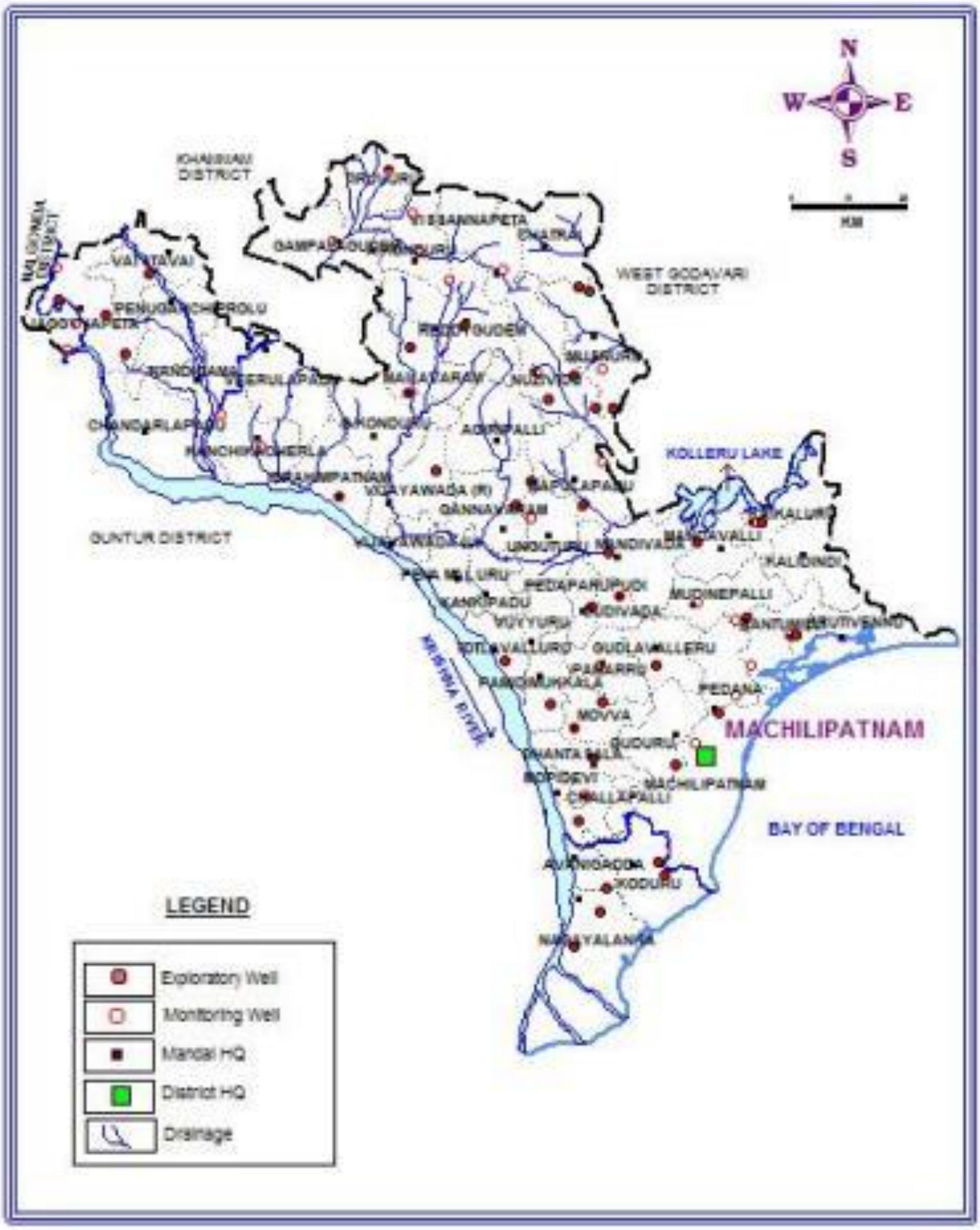



**Figure 3.18 Topography Map – Krishna District**

## 3.11 PHYSIOGRAPHY

Geomorphologically the district can be broadly divided into 3 distinct units, viz., Pediplain, Alluvial plains, and Coastal & Deltaic plains. The pediplain area i.e., northern part of the district consists of an undulated plain with broken ridges. Major part of the district in the southern part is represented by the alluvial plains forming the Krishna delta. The river Krishna and its tributaries have contributed to the formation of this alluvial plain. There is no significant surface drainage in these alluvial plains. The delta is relatively a flat area. The alluvial plains along the major course of rivers form the flood plain deposits. The coastal and deltaic alluvial plain extends from Challapalli on the west to Kolletikota on the east and upto the coast line on the south. The main geomorphic units exist in these plains are palaeo-channels, beach ridges, lagoons, sand spits and sand barriers. Krishna river divides itself at Avanigadda and south of Nagayalanka into four branches forming an arcuate delta. The deltaic coast protrudes towards open sea at the mouths of these four branches forming a cuspate foreland.

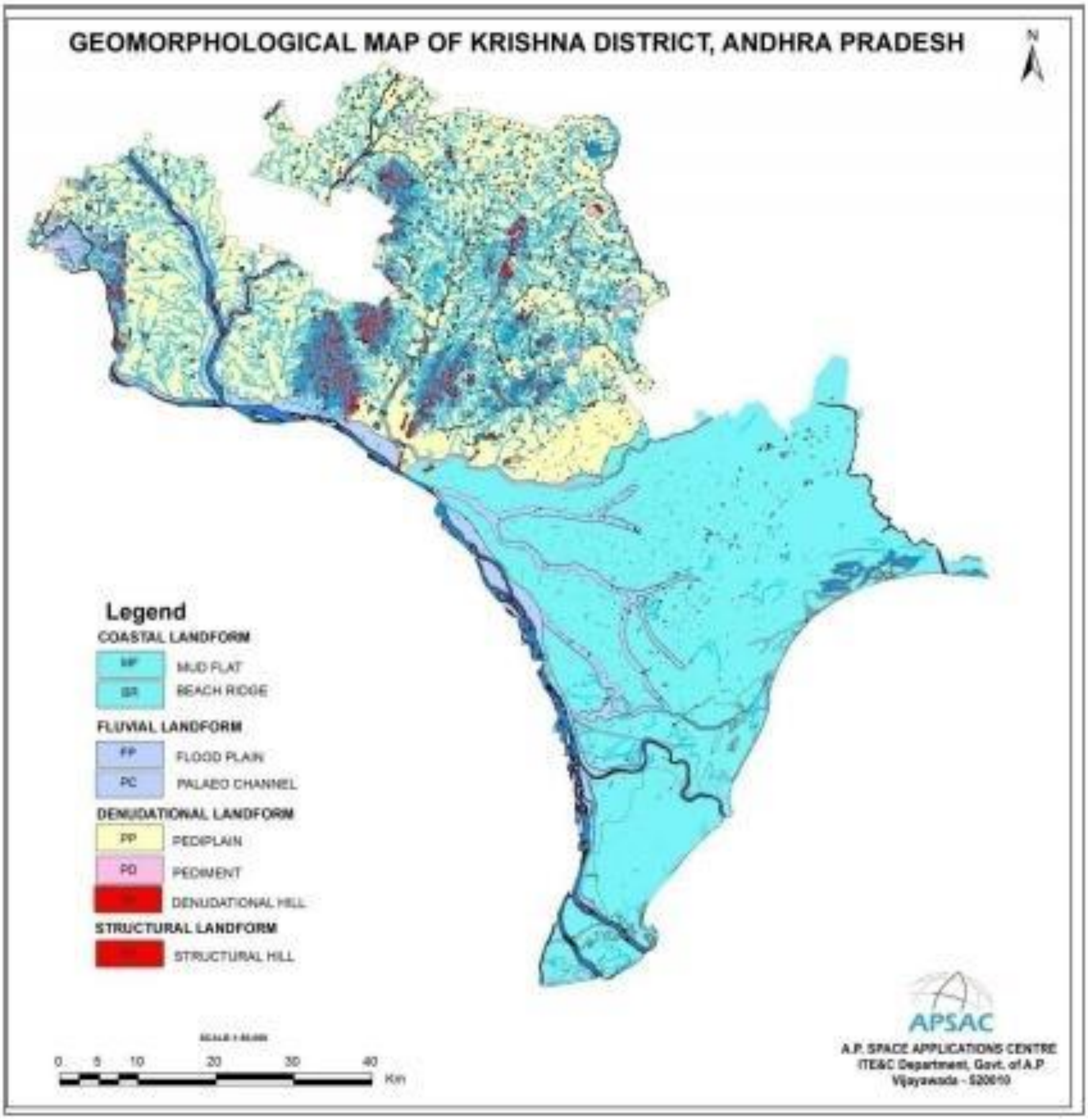



**Figure 3.19 Physiography Map – Krishna District**

## 3.12 DRAINAGE

The Krishna is the major river which drains the district; it is perennial in nature and flows along the western boundary of the district. South of Avanigadda the river bifurcates into four branches before it debouches into the Bay of Bengal. The other important rivers flowing in the district are Muniyeru, Tammileru and Budameru. The general drainage pattern is dendritic to sub-dendritic. The drainage density is high in consolidated formations, low in semi-consolidated formations, whereas in alluvial areas the density is meager. Kolleru lake is located between Krishna and Godavari delta and spans into two districts - Krishna and West Godavari. Asia.The Lake serves as a natural flood-balancing reservoir for these two rivers. The lake is fed directly by water from the seasonal Budameru and Tammileru rivers, and is connected to the Krishna and Godavari systems by over 68 inflowing drains and channels. The lake is an important habitat for an estimated 20 million resident and migratory birds. It is known the world over for the famous Kolleru Bird Sanctuary.

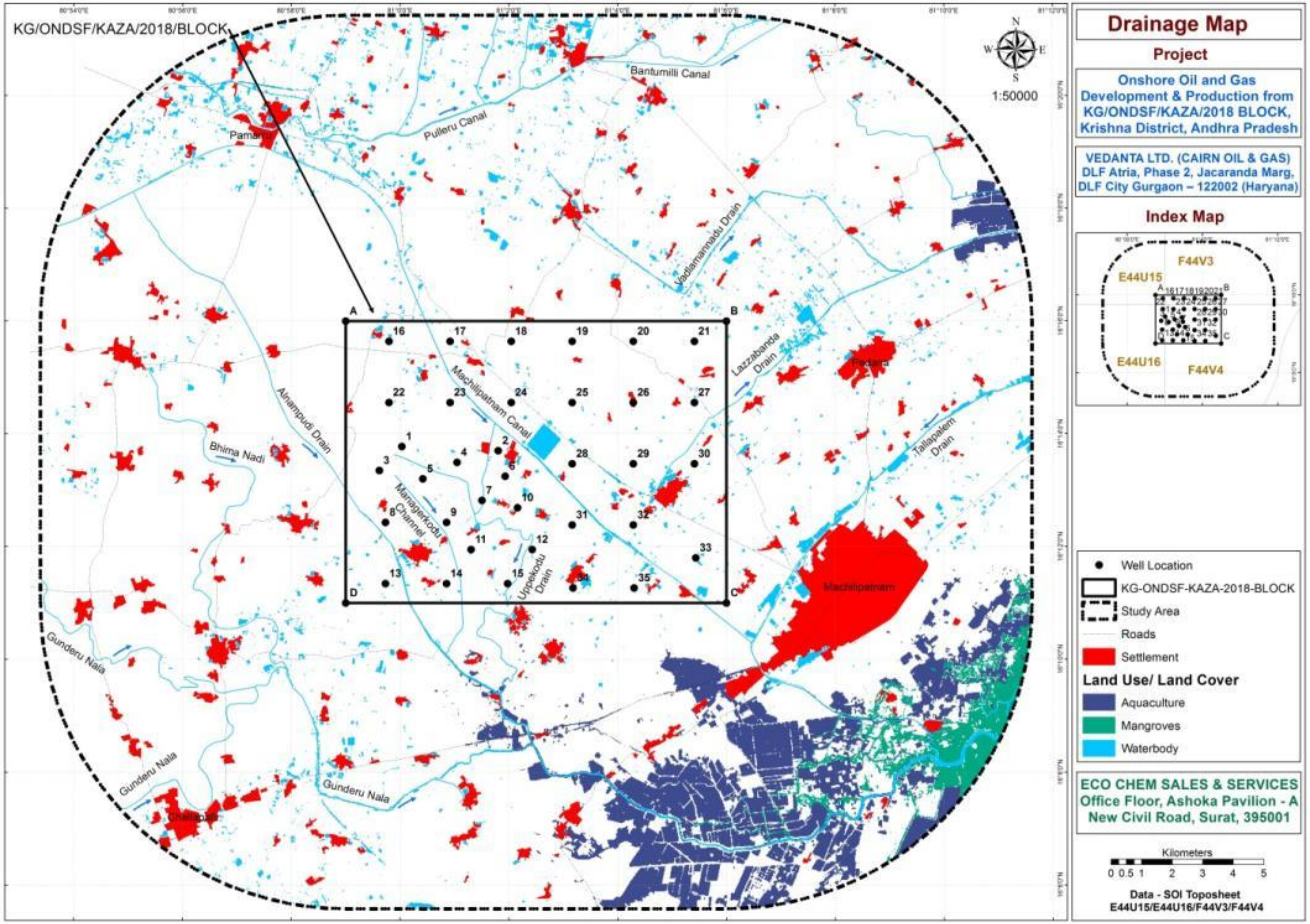



**Figure 3.20 Drainage Map**

## 3.13 VULNERABILITY OF THE STUDY

### 3.13.1 Seismicity

The Geological Survey of India (G. S. I.) first published the seismic zoning map of the country in the year 1935. With numerous modifications made afterwards, this map was initially based on the amount of damage suffered by the different regions of India because of earthquakes. Color coded in different shades of the color red, this map shows the four distinct seismic zones of India. Following are the varied seismic zones of the nation, which are prominently shown in the map:

- Zone - II: This is said to be the least active seismic zone.
- Zone - III: It is included in the moderate seismic zone.
- Zone - IV: This is considered to be the high seismic zone.
- Zone - V: It is the highest seismic zone.


**Figure 3.21 Seismicity Map of India**

As per Seismicity map of india, Andra pradesh comes under the Seismicity Zone II & III which indicates towards the Least active and moderate risk with the point of Seismicity.

### 3.13.2 Cyclones and Floods

Cyclones are intense low pressure areas, from the centre of which pressure increases outwards. The amount of the pressure drop in the centre and the rate at which it increases outwards gives the intensity of the cyclones and the strength of winds. These are very strong winds circulating around it in anticlockwise direction in the Northern Hemisphere and in clockwise direction in the Southern Hemisphere.

**Table 3.12 List of cyclones and heavy cyclones in Andhra Pradesh (1971-2010)**

| Year | Place or No of districts | Population effected in lakhs | Loss of life | Missing people | Loss of livestock | Crop damage in Lakh(ha) | Houses damaged | Monitory losses | Property loss in crore |
|---|---|---|---|---|---|---|---|---|---|
| 1971-1975 | 4 | NA | 270 | NA | 1600 | NA | NA | Damage to houses, crops, telecommunications | NA |
| 1976-1980 | 4 | 40 | 10755 | NA | 302700 | 34.09 | NA | NA | 353.9 |
| 1981-1985 | 3 | NA | 91301 | NA | NA | 3.13 | 643546 | Damage to roads | NA |
| 1986-1990 | 3 | NA | 1086 | NA | 3.65 million | 15.03 | 1647112 | NA | 14 |
| 1991-1995 | 2 | NA | 172 | 93 | NA | 3.97 | 81851 | 81 boats affected | NA |
| 1996-2000 | 54 | 30.73 | 1630 | 1668 | 17637 | 21005.11 | 132062 | 6464 boats lost, 1380 village affected | 4343.63 |
| 2001-2005 | 21 | 392.6 | 270 | NA | 116740 | 817707 | 135765 | NA | 3463.89 |
| 2006-2008 | 66 | 13067.77 | 434 | NA | 429422 | 1424737 | 1251594 | NA | 15902.16 |
| 2008-2010 | 5 | 450000 | 136 | 55 | 367 | NA | 435 | Damage to roads, electricity and telecommunications | 13166 |

Andhra Pradesh has a long coastline stretching approximately 1,030Kms and equally long history of cyclones of varying intensity over the past 100 years. The total number of villages perched along the coastline is 2482. Of these, 500 are within 5 kms swathe extending inside from the coast, 601 are within 5- 10km and 1381 villages are between 10-20 km. Coastal Andhra Pradesh covers an area of 92,906 sqkms with a total population of 3.15 crore. The land on either side of the Godavari and the Krishna rivers consists of extensive, flat delta plains levelled between 4-6 feet above mean sea level. These areas are most vulnerable to storm surges. The coastal districts are primarily agricultural; Guntur, Krishna, East Godavari and West Godavari have highly productive network of irrigation canals founded on the Krishna and Godavari rivers. These four districts, along with Srikakulam, also face the brunt of floods during the monsoons. The coastline ranging from Srikakulam in the north and Nellore in the south is affected by at least one cyclone every year. The entire state suffers the consequences of cyclones and floods, because each district except Vizianagaram, West Godavari and Guntur, has one or more faces with over 100 km of very vulnerable seacoast. The area immediately close to the coast is relatively less populated, less accessible due to poor communication. The people living in the belt of 20 kms from the coast generally comprise fisher folk and weaker sections. Majority of them live in thatched houses which are vulnerable to the wind pressures of cyclonic gale which exceed 100 kms per hour.

The major impact of cyclones can be broadly categorized as below:

1. Loss of lives, injuries and other health consequences such as epidemics, and post-traumatic stress disorders.
2. Loss of habitat.
3. Loss of cattle and damage to crops and agricultural fields.
4. Damage to public utilities.
5. Disturbance and damage to the ecosystem.

Table 3.12 gives the details of cyclones that have occurred for the past 4 decades .The loss of life in the years 1976-1980, 1981-1985 and 1986-1990 is more. The loss of livestock is more in the years 1986-1990. The damage in crop is more in the years 1986-1990. Damage to houses is more in years 1986- 1990 and 2006-2008. Property loss is more in the years 2006-2008. Most of the lives are lost during a cyclone on account of floods and the devastating storm surge that often accompany cyclones. In case of severe cyclonic storms with storm surges, more than 90% of the fatalities occur due to drowning, either during the incoming water phase or during the out surges. In severe cyclonic storms without storm surges, the deaths are more or less evenly divided between drowning and the collapse of buildings. The most common health problems include water borne diseases such as diarrhea, dysentery, typhoid, viral hepatitis, respiratory diseases such as pneumonia and whooping cough, measles, gastroenteritis, cholera, conjunctivitis and fever.

**Source: Disaster Mitigation and Management for Andhra Pradesh, India: An Appraisal**

### 3.13.3 Drought

Drought is defined in many ways, such as “a period of dry weather”, “a condition when precipitation is insufficient to meet established human needs”, “comparison of normal precipitation months and years”, “a prolonged dry weather causing hydrologic imbalance”, “a time-space duration distribution of percent of normal precipitation” etc.

Drought sets off a vicious cycle of socio-economic impacts beginning with crop yield failure, unemployment, erosion of assets, decrease in income, worsening of living conditions, poor nutrition and, subsequently, decreased risk absorptive capacity; thus, increasing vulnerability of the poor to another drought and other shocks. The mitigation of the impacts of drought has been a key area of focus of the Government of India (GOI) since 1950s, as evident through programs such as the Drought Prone Areas Programme, Desert Development Programme, National Watershed Management Programmer for Rain fed Areas, National Calamity Contingency Fund, and the National Agricultural Crop Insurance Scheme. However, the human and social costs of droughts remain devastating.

Andhra Pradesh is one of the states in India which has historically been most severely affected by drought. The failure of monsoons has had a disastrous affect on the states’ sizable agriculture sector and a large share of the population dependent on agriculture for livelihood. This study focuses on the eight (out of total 23) districts in AP, which are particularly vulnerable to drought: Anantapur, Chittoor, Cuddapah and Kurnool in Rayalaseema region: Rangareddi, Mahbubnagar and Nalgonda in Teleangana region and Prakasam in coastal Andhra. Together, these districts are home to about 30 million people and account for about 70% of stat-wide crop production loss due to drought. They also include some of the poorest areas and communities in the state. Due to the grossly deficient rainfall received in the catchment areas of irrigation sources, the water levels in the major and medium reservoirs and minor irrigation sources got severely depleted there by adversely affecting the supply of drinking water as well as vital irrigation needed for wet and irrigated dry crops. Groundwater utilization for domestic and irrigation purposes has been increased, due to its dependable supply even during droughts, the number of wells increased from 8.0 lakhs during 1975 to 26.0 lakhs by 2002. Commensurate increase is also registered in the area irrigated through groundwater from 8.0 lakh hectares to

26.0 lakh hectares during the same period. During the year 2002-03 (both Kharif and Rabi) total cropped area sown was 103.46 lakh ha. As against 116.45 lakh ha. Of normal area and the decline was 11%. This was due to inadequate rainfall received during the crop sowing period i.e., in the month of July, 2002 and also non receipt of water in major reservoirs. The total production of food grains was 105.59 lakh MTs in 2002-03 as against a normal of 140.34 lakh MT showing a decline of 24.76%.

The demographic structure of Andhra Pradesh exhibits that a massive 73% of the total population lives in rural areas. The State has a predominantly agrarian economy with about 65% of the population depending upon agriculture, directly or indirectly, as a source of livelihood. The widespread drought in the year 2002 seriously affected the rural economy because of the enormous loss of agricultural production. As a result nearly 2/3rd of the total Agricultural labour force of 1.38 crores suffered from loss of employment of varying degrees. Due to drought 38,735 habitations suffered from drinking water scarcity due to drying up of spot sources as well as insufficient water storage in drinking water storage tanks fed either by rain water or by canal system. Owing to drought conditions, fodder production was depleted resulting in fodder scarcity. Such condition led to increase in the demand for the supply of fodder with accompanied hike in prices. Added to these factors the fodder had to be transported from surplus areas to the deficit areas and the transportation cost being added made fodder very costly.

**Source: Disaster Mitigation and Management for Andhra Pradesh, India: An Appraisal**

### 3.13.4 Multi Hazard Zones

Andhra Pradesh is located in central part of Peninsular Indian Shield. Though Peninsular Region considered to be stable has been experiencing major damaging earthquakes for the last few decades. As the Indian plate hitting against the mass of the Eurasian plate, which is situated in the north, inter plate movement occurring in weak planes along existing fault in peninsular region lead to earthquakes. According to seismic zonation of India given in IS 1893-2002 (Criteria for earthquake resistant design of structure), 34% of Andhra Pradesh (AP) falls in zone III which is having the possibility of earthquakes up to intensity VII (MSK) or more. The recent Latur Earthquake of 1993 and Jabalpur earthquake of 1997 have proven that the faults in peninsular region are active and can cause earthquakes. Active zones in the state are the Eastern Ghat belt and Godavari Valley. From table 3 recorded seismic history of Andhra Pradesh shows that the state has experienced earthquake of magnitude up to 5.7 on the Richter scale i.e., Vizianagaram (M5.5 1917), Ongole (M5.4, 1967) and Badrachalam (M5.7 1969). Totally 80 earthquakes have occured from 1800 to 1999, 43 of them are of magnitude less than 4, and 28 of them are less than 5 and only 9 of them are greater than 5 magnitude.Though not much of damage occurred due to these events,the earthquake in Killari (M6.3 1993) brought to the forefront the possibility of high risk to urban areas of Andhra Pradesh, where building construction activity is growing at phenomenal rate. And also according to IS 1893-2002 the state is in the proximity of zone III areas of Maharashtra, Orissa, Tamilnadu and Karnataka apart from being near to Andaman & Nicobar Islands which fall in zone V. Major urban centers of the state with mushrooming apartments and commercial complexes are Hyderabad (Zone II) with population over 7.5 million, Visakhapatnam (zone II) with population of over 2.0 million and Vijayawada (zone III) with population over 1.8 million. Other important towns which fall in zone III are Tirupati, Nellore and Cuddapah. Earthquakes in Andhra Pradesh are being monitored through five seismic stations at Vishakhapatnam Hyderabad, Nagarjunasagar, Srisailam and Sriramsagar.

Since most of the area of Andhra Pradesh is Zone II and Zone III state government is not taken any special linitiatives so far. However, due to rapid growth in urban infrastructure, such as high rise buildings there is a serious need to consider earthquake forces which design and construction of buildings.

**Source: Disaster Mitigation and Management for Andhra Pradesh, India: An Appraisal**

## 3.14 TRAFFIC STUDY

Traffic surveys aim to capture data that accurately reflects the real traffic situation in the area. It may be counting the number of vehicles using a road or collecting journey time information. Any development/Expansion of commercial project, directly or indirectly affect the traffic. Proposed project is adjacent to NH-65 (Nr. Nimmakuru), NH-65 (Nr. Tarakatru), NH-65 (Nr. Guduru) and NH-261. Proposed project will attract to commercial vehicles as a result traffic load will also increase on highways. Traffic data helps in planning and design of road construction, renovation or maintenance works, and for assessing the economic feasibility of future road works. To assess the traffic load, 4 no. of surveyors were appointed to survey for NH-65 (Nr. Nimmakuru), NH-65 (Nr. Tarakatru), NH-65 (Nr. Guduru) and NH-261.

Traffic data collected continuously for 24 hours by visual observation and counting of vehicles under three categories, viz., heavy motor vehicles, light motor vehicles and two/three wheelers. As traffic densities on the roads are high, two persons were deployed simultaneously at each station during each shift- one person on each of the two directions for counting the traffic. At the end of each hour, fresh counting and recording was undertaken. Total numbers of vehicles per hour under the three categories were determined. Traffic study is conducted on NH-65 (Nr. Nimmakuru), NH-65 (Nr. Tarakatru), NH-65 (Nr. Guduru) and NH-261.

### Table 3.13 (A) Traffic Study Report

| S. No. | Vehicles Distribution | No. of Vehicles/Day | | | | Passenger Car Unit (PCU) | Total No. of Vehicle in PCU | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | NH-65 (Nr. Guduru) | NH-65 (Nr. Tarakatru) | NH-65 (Nr. Nimmakuru) | NH-261 | | NH-65 (Nr. Guduru) | NH-65 (Nr. Tarakatru) | NH-65 (Nr. Nimmakuru) | NH-261 |
| 1. | Cars | 22485 | 23142 | 26258 | 18472 | 1.0 | 22485 | 23142 | 26258 | 18472 |
| 2. | Buses | 445 | 432 | 472 | 366 | 3.0 | 1335 | 1296 | 1416 | 1068 |
| 3. | Trucks | 682 | 714 | 756 | 562 | 3.0 | 2046 | 2142 | 2268 | 1686 |
| 4. | Two wheelers | 6561 | 7420 | 8048 | 5184 | 0.5 | 3281 | 3710 | 4024 | 2592 |
| 5. | Three wheelers | 1582 | 1632 | 1866 | 1056 | 0.75 | 1187 | 1224 | 1400 | 792 |
| **Total** | | **31755** | **33340** | **37400** | **25640** | | **30334** | **31514** | **35366** | **24610** |

### Table 3.13 (B) Traffic Study Report

| Vehicles Distribution | Total No. of Vehicle (PCU)/Hour | | | |
|---|---|---|---|---|
| | NH-65 (Nr. Guduru) | NH-65 (Nr. Tarakatru) | NH-65 (Nr. Nimmakuru) | NH-261 |
| Cars | 937 | 964 | 1094 | 770 |
| Buses | 56 | 54 | 59 | 45 |
| Trucks | 85 | 89 | 95 | 70 |
| Two wheelers | 137 | 155 | 168 | 108 |
| Three wheelers | 49 | 51 | 58 | 33 |
| **Total** | **1264** | **1313** | **1474** | **1026** |

**Table 3.14 Existing Traffic Scenario with respect to LOS**

| Road | V (Volume in PCU/hr) | C (Capacity in PCU/hr) | Existing V/C Ratio | LOS |
|---|---|---|---|---|
| **NH-65 (Nr. Guduru)** | 1264 | 3000 | 0.42 | C |
| **NH-65 (Nr. Tarakatru)** | 1313 | 3000 | 0.44 | C |
| **NH-65 (Nr. Nimmakuru)** | 1474 | 3000 | 0.49 | C |
| **NH-261** | 1026 | 3000 | 0.34 | B |

| V/C | LOS | Performance |
|---|---|---|
| 0.0-0.2 | A | Excellent |
| 0.2-0.4 | B | Very Good |
| 0.4-0.6 | C | Good/Average/Fair |
| 0.6-0.8 | D | Poor |
| 0.8-1.0 | E | Very Poor |

**Source: Indian Road Congress**

### 3.14.1 Interpretation of Traffic Study

LOS values have been calculated based on traffic data on NH-65 (Nr. Guduru), NH-65 (Nr. Tarakatru), NH-65 (Nr. Nimmakuru) & NH-261 and it has been found 0.42, 0.44, 0.49 & 0.34 respectively. LOS value indicates that the performance of NH-65 (Nr. Guduru), NH-65 (Nr. Tarakatru), NH-65 (Nr. Nimmakuru) are good and NH-261 are very good w.r.t. traffic load.

## 3.15 SOIL QUALITY

12 numbers of samples were collected from different locations of study to assess the baseline status of soil. Analysis was also carried out for physico-chemical parameters as well as the parameters to define the texture class. Soil samples were collected by using Khurpi, Augar and Core cutter. Samples were brought to the laboratory in polythene bags. Standard procedures have been followed for soil sampling and analysis. Soil sampling locations are presented in Figure 3.22 and tabulated in Table 3.15. Results are presented in Table 3.16. Photograph of sampling activity are presented in Figure 3.23.

**Table 3.15 Details of Soil sampling location**

| Code | Location | Latitude | Longitude |
|---|---|---|---|
| S1 | Chataripalem | 16°09'53.2"N | 81°02'19.2"E |
| S2 | S N Gollapalem | 16°11'22.3"N | 81°06'32.2"E |
| S3 | Lellagaruvu | 16°16'43.2"N | 81°05'49.7"E |
| S4 | Nimmakuru | 16°16'11.3"N | 80°59'56.1"E |
| S5 | Nidumolu | 16°15'23.5"N | 81°01'03.4"E |
| S6 | Chitturu | 16°10'06.1"N | 81°00'13.1"E |
| S7 | Tummalapalem | 16°14'41.5"N | 81°04'09.8"E |
| S8 | Tarakaturu | 16°13'59.6"N | 81°01'55.8"E |
| S9 | Maklavaripalem | 16°13'42.3"N | 81°01'20.8"E |
| S10 | Kaza | 16°11'58.2"N | 80°59'49.4"E |
| S11 | Guduru | 16°13'16.1"N | 81°05'09.5"E |
| S12 | Palankipadu | 16°14'35.4"N | 80°59'04.7"E |

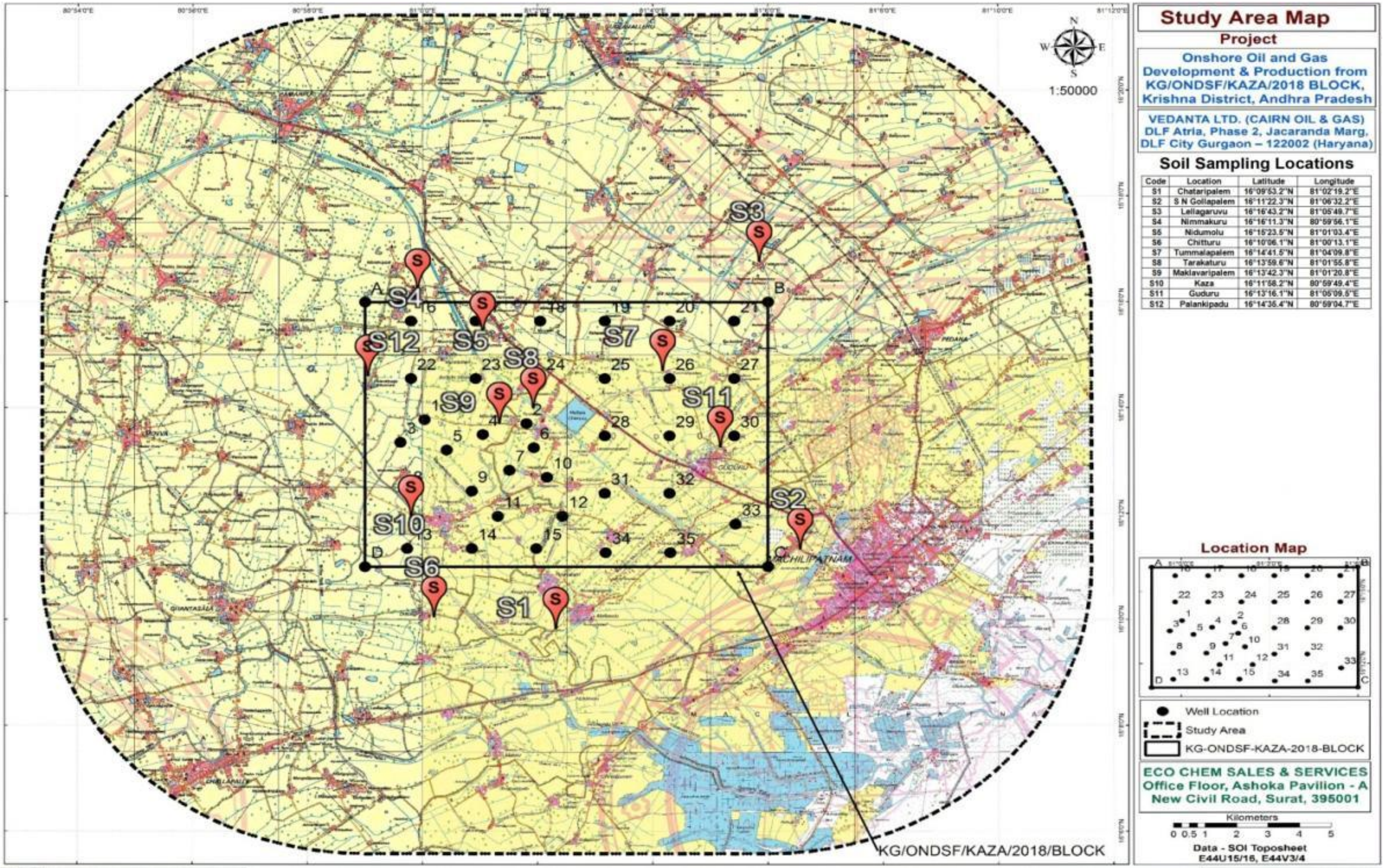



**Figure 3.22 Map showing the study region location of Soil**


**Soil – Chitrapalem**


**Soil –Guduru**


**Soil – Lellagaruvu**


**Soil - Nidumolu**

**Figure 3.23 Photographs of Soil sampling**

### Table 3.16 Soil Sample Analysis Result

| S. No | Parameters | Unit | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 | S11 | S12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Water Holding Capacity | % | 44.2 | 45.1 | 49.3 | 47.2 | 43.1 | 53.4 | 43.2 | 50.6 | 47.1 | 42.3 | 43.4 | 45.8 |
| 2 | Porosity | % | 41.4 | 42.6 | 44.2 | 43.3 | 40.4 | 46.3 | 39.8 | 45.8 | 43.6 | 38.6 | 40.1 | 42.6 |
| 3 | Bulk Density | gm/cc | 1.62 | 1.56 | 1.38 | 1.44 | 1.54 | 1.26 | 1.58 | 1.30 | 1.46 | 1.64 | 1.52 | 1.48 |
| 4 | Moisture | % | 8.5 | 7.6 | 8.9 | 9.5 | 7.7 | 10.2 | 8.5 | 9.3 | 8.1 | 8.8 | 10.4 | 9.4 |
| 5 | Specific Gravity | - | 2.76 | 2.72 | 2.39 | 2.54 | 2.42 | 2.34 | 2.62 | 2.40 | 2.59 | 2.67 | 2.54 | 2.58 |
| 6 | Infiltration capacity | mm/hr | 30.5 | 15.5 | 5.5 | 4.5 | 17.5 | 5.6 | 35.5 | 5.8 | 4.5 | 35.5 | 17.5 | 5.5 |
| 7 | Particle Size Distribution | | | | | | | | | | | | | |
| a. | Sand | % | 82.4 | 67.7 | 11.8 | 30.8 | 53.6 | 30.1 | 90.1 | 28.4 | 32.4 | 91.2 | 58.2 | 33.8 |
| b. | Silt | % | 7.2 | 14.9 | 46.1 | 54.0 | 30.6 | 30.3 | 3.1 | 33.1 | 50.2 | 3.4 | 25.2 | 50.0 |
| c. | Clay | % | 10.4 | 17.4 | 42.1 | 15.2 | 15.8 | 39.6 | 6.8 | 38.5 | 17.4 | 5.4 | 16.6 | 16.2 |
| 8 | Texture | - | Loamy sand | Sandy loam | Silty clay | Silty loam | Sandy loam | Clay loam | Sandy | Clay loam | Silty loam | Sandy | Sandy loam | Silty loam |
| 9 | pH | - | 7.62 | 7.90 | 7.67 | 7.70 | 7.42 | 7.90 | 7.56 | 7.62 | 7.60 | 7.80 | 8.00 | 7.38 |
| 10 | Electrical Conductivity | dS/m | 1.12 | 0.84 | 1.34 | 0.86 | 1.16 | 0.92 | 0.82 | 1.26 | 0.76 | 0.98 | 1.24 | 0.88 |
| 11 | Calcium | meq/100g | 5.2 | 6.3 | 10.5 | 7.1 | 5.8 | 15.6 | 4.8 | 18.4 | 9.6 | 5.1 | 6.2 | 8.5 |
| 12 | Magnesium | meq/100g | 2.1 | 2.4 | 5.8 | 2.6 | 2.2 | 6.2 | 1.6 | 7.8 | 4.2 | 1.8 | 2.6 | 3.2 |
| 13 | Sodium | meq/100g | 1.2 | 1.1 | 2.4 | 1.3 | 1.4 | 1.8 | 1.0 | 2.6 | 1.3 | 1.2 | 1.5 | 1.3 |
| 14 | Potassium | meq/100g | 0.6 | 0.5 | 0.8 | 0.6 | 0.7 | 0.8 | 0.4 | 1.1 | 0.6 | 0.7 | 0.8 | 0.6 |
| 15 | Cation Exchange Capacity (CEC) | meq/100g | 9.1 | 10.3 | 19.5 | 11.6 | 10.1 | 24.4 | 7.8 | 29.9 | 15.7 | 8.8 | 11.1 | 13.6 |
| 16 | SAR | - | 0.9 | 0.7 | 1.2 | 0.8 | 1.0 | 0.8 | 0.8 | 1.0 | 0.7 | 0.9 | 1.0 | 0.8 |
| 17 | ESP | % | 13.2 | 10.7 | 12.3 | 11.2 | 13.9 | 7.4 | 12.8 | 8.7 | 8.3 | 13.6 | 13.5 | 9.6 |
| 18 | Carbonate as CaCO3 | mg/100g | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 19 | Nitrogen | % | 0.049 | 0.038 | 0.023 | 0.029 | 0.032 | 0.041 | 0.026 | 0.047 | 0.021 | 0.023 | 0.034 | 0.021 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | Phosphorus | mg/100g | 13.6 | 12.8 | 11.6 | 9.2 | 8.6 | 12.4 | 9.2 | 14.6 | 9.4 | 10.1 | 9.5 | 10.2 |
| 21 | Chloride | mg/100g | 16.4 | 20.1 | 16.7 | 18.2 | 19.2 | 17.4 | 15.2 | 18.4 | 20.4 | 16.3 | 14.4 | 16.7 |
| 22 | Sulphate | mg/100g | 6.3 | 5.8 | 7.6 | 9.4 | 8.2 | 7.1 | 6.3 | 9.2 | 10.1 | 6.6 | 8.4 | 7.6 |
| 23 | Organic matter | % | 0.98 | 0.76 | 0.46 | 0.59 | 0.64 | 0.81 | 0.52 | 0.93 | 0.41 | 0.46 | 0.69 | 0.41 |
| 24 | Organic carbon | % | 0.57 | 0.44 | 0.27 | 0.34 | 0.37 | 0.47 | 0.30 | 0.54 | 0.24 | 0.27 | 0.40 | 0.24 |
| 25 | Boron | mg/100g | 1.9 | 2.3 | 2.1 | 1.8 | 2.6 | 3.2 | 2.5 | 2.2 | 1.6 | 2.8 | 2.4 | 1.6 |
| 26 | Arsenic | mg/100g | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 27 | Cadmium | mg/100g | 0.12 | 0.1 | 0.18 | 0.15 | 0.21 | 0.25 | 0.20 | 0.14 | 0.18 | 0.22 | 0.20 | 0.13 |
| 28 | Mercury | mg/100g | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 29 | Nickel | mg/100g | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 30 | Manganese | mg/100g | 0.84 | 0.90 | 0.78 | 0.94 | 1.1 | 0.86 | 0.92 | 1.3 | 0.76 | 0.68 | 0.76 | 0.84 |
| 31 | Hexavalent Chromium | mg/100g | 0.58 | 0.6 | 0.82 | 0.64 | 0.87 | 0.71 | 0.52 | 0.39 | 0.62 | 0.31 | 0.47 | 0.68 |
| 32 | Lead | mg/100g | 0.74 | 0.81 | 0.96 | 0.76 | 0.91 | 0.85 | 0.66 | 0.51 | 0.68 | 0.42 | 0.55 | 0.84 |
| 33 | Iron | mg/100g | 720 | 680 | 672 | 710 | 691 | 705 | 684 | 652 | 718 | 602 | 726 | 814 |
| 34 | Copper | mg/100g | 0.28 | 0.21 | 0.34 | 0.18 | 0.38 | 0.24 | 0.42 | 0.16 | 0.29 | 0.35 | 0.17 | 0.32 |
| 35 | Zinc | mg/100g | 9.4 | 8.1 | 8.5 | 7.4 | 9.2 | 10.5 | 7.7 | 9.4 | 8.1 | 8.8 | 7.1 | 9.6 |
| 36 | Sb | mg/100g | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 37 | Br | mg/100g | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 38 | $Cr^{+3}$ | mg/100g | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 39 | Co | mg/100g | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 40 | Mo | mg/100g | 0.01 | 0.20 | 0.05 | 0.03 | 0.12 | 0.05 | 0.01 | 0.02 | 0.06 | 0.02 | 0.04 | 0.03 |
| 41 | Cyanide | mg/100g | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 42 | Thiocyanate | mg/100g | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |

**Table 3.17 Soil remediation intervention value as per Dutch standards**

| S. No. | Parameter | Intervention Values (mg/kg dry matter) |
|---|---|---|
| 1 | Zinc | 720 |
| 2 | Arsenic | 76 |
| 3 | Lead | 530 |
| 4 | Cadmium | 13 |
| 5 | Copper | 190 |
| 6 | Mercury (inorganic) | 36 |
| 7 | Nickel | 100 |

*Source: Soil Remediation Circular 2009, Minister of Housing, Spatial Planning and Environment, Netherlands*.
Note: Concentrations are shown for standard soil (10% organic matter and 25% clay)

**Table 3.18 Standard soil classification**

| Sl. No. | Soil Test | Classification |
|---|---|---|
| 1. | pH | <4.5 Extremely acidic<br>4.51- 5.50 Very strongly acidic<br>5.51-6.0 Moderately acidic<br>6.01-6.50 Slightly acidic<br>6.51-7.30 Neutral<br>7.31-7.80 Slightly alkaline<br>7.81-8.50 Moderately alkaline<br>8.51-9.0 Strongly alkaline<br>9.01 Very strongly alkaline |
| 2. | Salinity Electrical Conductivity (mmhos/cm)<br>(1 ppm = 640 mmho/cm) | Up to 1.00 Average<br>1.01-2.00 Harmful to germination<br>2.01-3.00 Harmful to crops (sensitive to salts) |
| 3. | Organic Carbon | Up to 0.2 very less<br>0.21-0.4 Less<br>0.41-0.5 Medium,<br>0.51-0.8 On an average sufficient<br>0.81-1.00 Sufficient<br>>1.0 More than sufficient |
| 4. | Nitrogen (kg/ha) | Up to 50 Very less<br>51-100 Less<br>101-150 Good<br>151-300 Better |
| 5. | Phosphorous (kg/ha) | Up to 15 Very less<br>16-30 Less<br>31-50 Medium<br>51-65 On an average sufficient<br>66-80 Sufficient<br>>80 More than sufficient |
| 6. | Potash (kg/ha) | 0-120 Very less |

| | | |
|---|---|---|
| | | 120-180 Less<br>181-240 Medium<br>241-300 Average<br>301-360 Better<br>>360s More than sufficient |

**Source:** Handbook of Agriculture, ICAR, New Delhi

### 3.15.1 Summary of Soil Data

- The soils are categorized as loamy sand to clay loam based on different soil separates (sand, silt and clay). They have moderate water holding capacity (42.3 to 50.6 %) and porosity varied from 38.6 – 46.3 %, and very fast to moderate drainage (infiltration rate 4.5 to 35.5 mm/hr) capacity as texture is sandy to clay loam.
- The pH of the soil samples narrowly ranged from 7.38 to 8.00 during the study period.
- The soil EC varied from 0.76 to 1.34 dS/m and ESP ranged from 7.4 to 13.6. These parameters indicate that soils are neutral to alkaline in reaction, non-saline to saline (EC > 0.8 dS/m) and non-sodic, as pH is <8.5 and ESP is < 15.
- Among exchangeable basic cations, predominance of Calcium (4.8 to 15.6 meq/100 g soil) was seen followed by magnesium (1.6 to 7.8 meq/100 g), Na (1.0 to 2.6 meq/100 g soil) and K (0.4 to 1.1 meq/100 g soil).
- The loss on ignition (0.24 to 0.57 % OC) indicate that soils are low (<0.50 % OC) to medium (0.50 to 0.75 % OC) in organic carbon status. This shows that soils are low to medium in nitrogen status.
- Considering only 2% available phosphorus based on total P, soils are classified as poor (>28 kg $P_2O_5$/ha) in available P. On the basis of exchangeable potassium values soils are categorized as high (>280 kg $K_2O$/ha) in potassium status. Based on CEC (8.8 to 29.9 meq/100 g soil) soils are categorized as poor to moderate with respect to productivity.
- The results relating to total micronutrients (Fe, Cu, Cr, B and Zn) and heavy metals do not show alarming concentrations in different soil samples.

### 3.15.2 Interpretation of Soil Data

Based on soil analysis data it is concluded that soil at the project site is slightly saline (EC>0.8 dS/m). The soils are low to medium in nitrogen, low in phosphorus and high in available potassium status. The levels of total Fe, Cu, Cr, B and Zn are within the limits. However, for successful greenbelt development liberal quantity of organic manure (50 tons/ha) and recommended doses of N and double the recommended dose of P fertilizers should be applied. The potassium is adequate; hence 20 % less than the recommended dose for green belt should be applied. Soil at the site is having good fertility based on CEC value. The soil at the project site should be periodically monitored for EC, pH and ESP as well as OC (organic carbon), available P and K status post monsoon.

## 3.16 WATER ENVIRONMENT

Physical, Chemical and Microbiological factors influencing water quality are so interrelated that a change in any water quality parameter may trigger other changes in a complete network of interrelated variables. Selected water quality parameters for surface and ground water resources along with biological indicators within study region have been used for water environment and assessing the impact on it by proposed project. A study on water environment aspects of ecosystem plays an important role in environmental assessment to identify water related sensitive issues.

### 3.16.1 Reconnaissance

As a significant part of predefined framework of the present study water samples were collected from selected locations. The Reconnaissance survey was undertaken and monitoring locations were finalized based on:

- Presence, Location and uses of major water bodies in the region,
- Type and Location of Industrial/residential areas, their intake and effluent disposal locations,
- Likely areas that can represent baseline conditions.

### 3.16.2 Water Quality

With the start of water quality study, the water resources in the study area were divided into two categories for getting ideal upshot of baseline status of water quality of the region. These two categories as determined are:

- Ground water resources (tube well, open well, springs etc.)
- Surface water resources - Pond, canal, Lake

### 3.16.3 Sampling and Analysis

All the water samples were collected and analyzed as per "Standard Methods for Examination of Water & Wastewater", APHA 23rd edition, 2017. Water Samples for the analysis of physico-chemical parameters were collected in plastic carboy and parameter wise preserved onsite as per the technique defined in the book of APHA, 23rd edition, 2017. Temperature, pH and DO were analyzed onsite and samples were brought to the laboratory for the analysis of remaining parameters.

### 3.16.4 Ground Water

To assess the quality of ground water, samples were collected from 19 numbers of locations for the analysis of physico-chemical and microbiological parameters. Ground water sampling locations are presented in Table 3.19 and Figure 3.24. Analysis results are presented in Table 3.20. Photograph of sampling activity are presented in Figure 3.25.

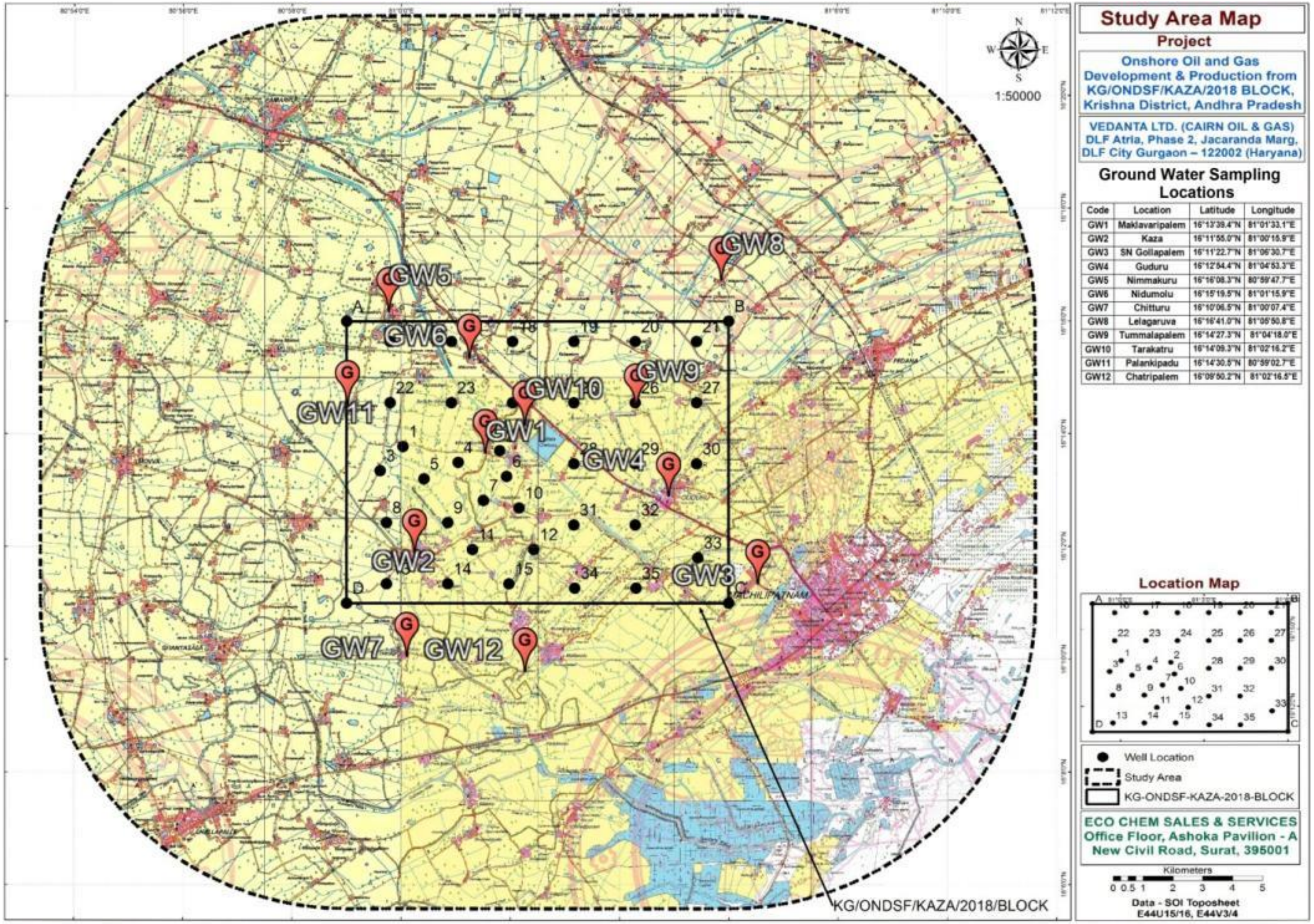



**Figure 3.24 Map showing the study region with locations for Ground Water**

**Table 3.19 Details of Ground Water sampling locations**

| Code | Location | Latitude | Longitude | Source |
|---|---|---|---|---|
| GW1 | Maklavaripalem | 16°13'39.4"N | 81°01'33.1"E | Open well |
| GW2 | Kaza | 16°11'55.0"N | 81°00'15.9"E | Hand Pump |
| GW3 | SN Gollapalem | 16°11'22.7"N | 81°06'30.7"E | Open well |
| GW4 | Guduru | 16°12'54.4"N | 81°04'53.3"E | Open well |
| GW5 | Nimmakuru | 16°16'08.3"N | 80°59'47.7"E | Open well |
| GW6 | Nidumolu | 16°15'19.5"N | 81°01'15.9"E | Open well |
| GW7 | Chitturu | 16°10'06.5"N | 81°00'07.4"E | Open well |
| GW8 | Lellagaruva | 16°16'41.0"N | 81°05'50.8"E | Open well |
| GW9 | Tummalapalem | 16°14'27.3"N | 81°04'18.0"E | Open well |
| GW10 | Tarakatru | 16°14'09.3"N | 81°02'16.2"E | Open well |
| GW11 | Palankipadu | 16°14'30.5"N | 80°59'02.7"E | Bore well |
| GW12 | Chatripalem | 16°09'50.2"N | 81°02'16.5"E | Bore well |


**Ground water – Kaza**


**Ground water –Tummalapalem**


**Ground water – Chitturu**


**Ground water – Nidumolu**

**Figure 3.25 Photographs of Ground water sampling**

## Table 3.20 (a) Ground water Analysis Results

| S. No. | Parameters | Unit | GW1 | GW2 | GW3 | GW4 | GW5 | GW6 | Drinking Water Specification IS 10500: 1992 (Reaffirmed 2012) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Desirable Limit | Permissible Limit |
| 1. | Temperature | $^0C$ | 25.5 | 26.0 | 26.5 | 26.0 | 27.0 | 25.0 | -- | -- |
| 2. | pH @ $25^0C$ | pH Unit | 7.41 | 7.45 | 7.57 | 7.54 | 7.30 | 7.30 | 6.5 – 8.5 | No Relaxation |
| 3. | Colour | Hazen | <5 | <5 | <5 | <5 | <5 | <5 | 5 | 15 |
| 4. | Odour | -- | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable |
| 5. | Taste | -- | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable |
| 6. | TDS @ $180^0C$ | mg/L | 850 | 3214 | 4856 | 934 | 932 | 612 | 500 | 2000 |
| 7. | Conductivity | µmho/cm | 1322 | 4665 | 7540 | 1468 | 1456 | 956 | -- | -- |
| 8. | Salinity | ppt | 0.34 | 2.0 | 3.7 | 0.46 | 0.49 | 0.26 | -- | -- |
| 9. | Turbidity | NTU | 0.6 | 0.9 | 1.2 | 0.5 | 0.6 | 0.2 | 1 | 5 |
| 10. | TSS | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | -- | -- |
| 11. | Total Hardness as $CaCO_3$ | mg/L | 400 | 940 | 1250 | 384 | 350 | 290 | 200 | 600 |
| 12. | Calcium | mg/L | 84 | 140 | 160 | 78 | 38 | 66 | 75 | 200 |
| 13. | Total Alkalinity as $CaCO_3$ | mg/L | 340 | 780 | 570 | 314 | 330 | 240 | 200 | 600 |
| 14. | Chloride | mg/L | 200 | 1190 | 2319 | 284 | 300 | 156 | 250 | 1000 |
| 15. | Magnesium | mg/L | 46 | 143 | 207 | 46 | 62 | 30 | 30 | 100 |
| 16. | Sulphate | mg/L | 116 | 279 | 226 | 82 | 70 | 66 | 200 | 400 |
| 17. | Total Phosphorus ($PO_4$-P) | mg/L | 0.6 | 1.0 | 2.3 | 0.8 | 0.8 | 0.7 | -- | -- |
| 18. | Sodium | mg/L | 140 | 810 | 1410 | 180 | 188 | 105 | -- | -- |
| 19. | Potassium | mg/L | 42 | 130 | 112 | 42 | 58 | 22 | -- | -- |
| 20. | Chloramine | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 4.0 | No Relaxation |
| 21. | Fluoride | mg/L | 0.2 | 0.3 | 0.5 | 0.1 | 0.3 | 0.4 | 1.0 | 1.5 |
| 22. | Phenolic Compound | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.001 | 0.002 |
| 23. | Mineral oil | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.5 | No Relaxation |
| 24. | Dissolved Oxygen | mg/L | 5.0 | 4.9 | 5.4 | 4.9 | 5.1 | 4.9 | -- | -- |
| 25. | COD | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | -- | -- |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 26. | BOD (3 days @ 27$^0$C) | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | -- | -- |
| 27. | Nitrate | mg/L | 0.54 | 0.62 | 0.84 | 0.42 | 0.34 | 0.28 | 45 | No Relaxation |
| 28. | Total Nitrogen | mg/L | 1.3 | 1.5 | 1.9 | 1.0 | 0.92 | 0.84 | -- | -- |
| 29. | Free Ammonia | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.5 | No Relaxation |
| 30. | Residual Chlorine | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | -- | -- |
| 31. | Anionic detergent | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.2 | 1.0 |
| 32. | Barium | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.7 | No Relaxation |
| 33. | Selenium | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.01 | No Relaxation |
| 34. | Cyanide | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.05 | No Relaxation |
| 35. | Molybdenum | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.07 | No Relaxation |
| 36. | PAH | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.0001 | No Relaxation |
| 37. | Polychlorinated biphenyls | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | -- | -- |
| 38. | SAR | -- | 3.04 | 11.45 | 17.25 | 3.98 | 4.35 | 2.68 | -- | -- |
| 39. | Iron | mg/L | 0.12 | 0.20 | 0.28 | 0.14 | 0.08 | 0.05 | 0.3 | No Relaxation |
| 40. | Copper | mg/L | 0.05 | 0.06 | 0.09 | 0.05 | 0.06 | 0.07 | 0.05 | 1.5 |
| 41. | Hexavalent Chromium | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.05 | No Relaxation |
| 42. | Zinc | mg/L | 0.16 | 0.12 | 0.24 | 0.18 | 0.15 | 0.14 | 5 | 15 |
| 43. | Arsenic | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.01 | 0.05 |
| 44. | Cadmium | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.003 | No Relaxation |
| 45. | Mercury | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.001 | No Relaxation |
| 46. | Nickel | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.02 | No Relaxation |
| 47. | Manganese | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.1 | 0.3 |
| 48. | Lead | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.01 | No Relaxation |
| 49. | Aluminum | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.03 | 0.2 |
| 50. | Total Coliform | Present/ Absent | Absent | Absent | Absent | Absent | Absent | Absent | Shall not be detected in any 100 ml sample | |
| 51. | Fecal Coliform | Present/ Absent | Absent | Absent | Absent | Absent | Absent | Absent | | |

## Table 3.20 (b) Ground water Analysis Results

| S. No. | Parameters | Unit | GW7 | GW8 | GW9 | GW10 | GW11 | GW12 | Drinking Water Specification IS 10500: 1992 (Reaffirmed 2012) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Desirable Limit | Permissible Limit |
| 1. | Temperature | $^0C$ | 25.5 | 26.5 | 26.0 | 26.0 | 25.5 | 25.0 | -- | -- |
| 2. | pH @ $25^0C$ | pH Unit | 7.50 | 7.53 | 6.98 | 7.40 | 7.42 | 7.33 | 6.5 – 8.5 | No Relaxation |
| 3. | Colour | Hazen | <5 | <5 | <5 | <5 | <5 | <5 | 5 | 15 |
| 4. | Odour | -- | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable |
| 5. | Taste | -- | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable | Agreeable |
| 6. | TDS @ $180^0C$ | mg/L | 1166 | 582 | 708 | 1402 | 948 | 1042 | 500 | 2000 |
| 7. | Conductivity | µmho/cm | 1760 | 910 | 1124 | 2212 | 1462 | 1612 | -- | -- |
| 8. | Salinity | ppt | 0.51 | 0.20 | 0.28 | 0.70 | 0.48 | 0.50 | -- | -- |
| 9. | Turbidity | NTU | 0.5 | 0.4 | 0.5 | 0.6 | 0.6 | 0.5 | 1 | 5 |
| 10. | TSS | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | -- | -- |
| 11. | Total Hardness as $CaCO_3$ | mg/L | 512 | 350 | 320 | 560 | 418 | 438 | 200 | 600 |
| 12. | Calcium | mg/L | 94 | 76 | 66 | 114 | 68 | 86 | 75 | 200 |
| 13. | Total Alkalinity as $CaCO_3$ | mg/L | 470 | 300 | 350 | 480 | 318 | 354 | 200 | 600 |
| 14. | Chloride | mg/L | 304 | 120 | 162 | 442 | 306 | 316 | 250 | 1000 |
| 15. | Magnesium | mg/L | 67 | 39 | 38 | 67 | 60 | 54 | 30 | 100 |
| 16. | Sulphate | mg/L | 118 | 51 | 55 | 110 | 92 | 98 | 200 | 400 |
| 17. | Total Phosphorus ($PO_4$-P) | mg/L | 0.8 | 0.7 | 0.9 | 1.2 | 0.6 | 0.8 | -- | -- |
| 18. | Sodium | mg/L | 210 | 82 | 120 | 260 | 180 | 190 | -- | -- |
| 19. | Potassium | mg/L | 66 | 16 | 34 | 78 | 46 | 58 | -- | -- |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 20. | Chloramine | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 4.0 | No Relaxation |
| 21. | Fluoride | mg/L | 0.3 | 0.4 | 0.4 | 0.5 | 0.3 | 0.2 | 1.0 | 1.5 |
| 22. | Phenolic Compound | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.001 | 0.002 |
| 23. | Mineral oil | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.5 | No Relaxation |
| 24. | Dissolved Oxygen | mg/L | 5.2 | 5.3 | 5.1 | 5.2 | 5.0 | 5.1 | -- | -- |
| 25. | COD | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | -- | -- |
| 26. | BOD (3 days @ 27$^0$C) | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | -- | -- |
| 27. | Nitrate | mg/L | 0.68 | 0.74 | 0.34 | 0.48 | 0.56 | 0.42 | 45 | No Relaxation |
| 28. | Total Nitrogen | mg/L | 1.7 | 1.8 | 1.0 | 1.2 | 1.3 | 1.1 | -- | -- |
| 29. | Free Ammonia | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.5 | No Relaxation |
| 30. | Residual Chlorine | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | -- | -- |
| 31. | Anionic detergent | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.2 | 1.0 |
| 32. | Barium | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.7 | No Relaxation |
| 33. | Selenium | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.01 | No Relaxation |
| 34. | Cyanide | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.05 | No Relaxation |
| 35. | Molybdenum | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.07 | No Relaxation |
| 36. | PAH | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.0001 | No Relaxation |
| 37. | Polychlorinated biphenyls | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | -- | -- |
| 38. | SAR | -- | 4.03 | 1.90 | 2.90 | 4.76 | 3.82 | 3.94 | -- | -- |
| 39. | Iron | mg/L | 0.15 | 0.10 | 0.08 | 0.06 | 0.16 | 0.20 | 0.3 | No Relaxation |
| 40. | Copper | mg/L | 0.05 | 0.08 | 0.06 | 0.05 | 0.07 | BDL | 0.05 | 1.5 |
| 41. | Hexavalent Chromium | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.05 | No Relaxation |
| 42. | Zinc | mg/L | 0.10 | 0.24 | 0.20 | 0.16 | 0.18 | 0.22 | 5 | 15 |
| 43. | Arsenic | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.01 | 0.05 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 44. | Cadmium | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.003 | No Relaxation |
| 45. | Mercury | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.001 | No Relaxation |
| 46. | Nickel | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.02 | No Relaxation |
| 47. | Manganese | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.1 | 0.3 |
| 48. | Lead | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.01 | No Relaxation |
| 49. | Aluminum | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | 0.03 | 0.2 |
| 50. | Total Coliform | Present/ Absent | Absent | Absent | Absent | Absent | Absent | Absent | Shall not be detected in any 100 ml sample | |
| 51. | Fecal Coliform | Present/ Absent | Absent | Absent | Absent | Absent | Absent | Absent | | |

**Note :** 1) Qualitative analysis (spot test) has been carried out for color, cyanide, residual chlorine and phenolic compound.

2) BDL : Below detection limit , Detection range of laboratory i s below the permissible limit for drinking water.

### 3.16.5 Summary of Ground Water Quality

- pH was observed in the range of 6.98 – 7.57, which meets with drinking water desirable norms.
- Total Dissolved Solid (TDS) were recorded in the range of 582 - 4856 mg/L with minimum at Leggagaruva village and maximum at SN Gollapalem village.
- Conductivity varies from 910 to 7540 µmho/cm. The ratio of TDS to conductivity was observed in the range of 0.6 to 0.65 which is within the desired range.
- Total Hardness was in the range of 290 - 1250 mg/L with minimum at Nidumolu village and maximum at SN Gollapalem village.
- Total Alkalinity was found in the range of 240 - 780 mg/L with minimum at Nidumolu village and maximum at SN Gollapalem village.
- Chloride was found in the range of 120 to 2319 mg/L and Sulphate varies from 51 to 279 mg/L.
- Iron was found in the range of 0.05 - 0.28 mg/L.
- As microbiological parameters Total coliform and Fecal coliform was also carried out and it was found absent.

### 3.16.6 Interpretation of Ground Water Quality Data

During the analysis it was observed that results of all tested parameters are within the permissible limit as per IS 10500: 2012 except Kaza and S.N. Gollapalem. Test results of the parameter Total Hardness, TDS and Chloride for the water sample collected from Kaza and S.N. Gollapalem do not meet with the drinking water norms. Ground water sources for Kaza and S.N.Gollapalem should not be used in drinking purpose but they can be utilized in other domestic purposes as well as in irrigation. Results of water sample collected from other locations are within the permissible range as per IS 10500:2012. These water sources can be used in all domestic purposes and they can also be used in drinking purpose in absence of alternate source as results are within the permissible range but they are not in desirable range. It is suggested that wherever the results of alkalinity and Total Hardness are more than desired limit, water should pass through RO to bring the results within the desired limit. This interpretation relate to the sample collected from particular location only.

### 3.16.7 Surface Water

To assess the quality of Surface water, samples were collected from 12 numbers of locations for the analysis of physico-chemical, Heavy metal, microbiological and biological parameters. Frequency of sampling was once during the study period. Sampling and analysis was carried out as per "Standard Methods for Examination of Water and Wastewater 23rd edition, 2017. Surface water sampling locations are presented in the Table 3.21 and Figure 3.26. Analysis results are presented in Table 3.22 & 3.23. Photograph of sampling activity are presented in Figure 3.27.

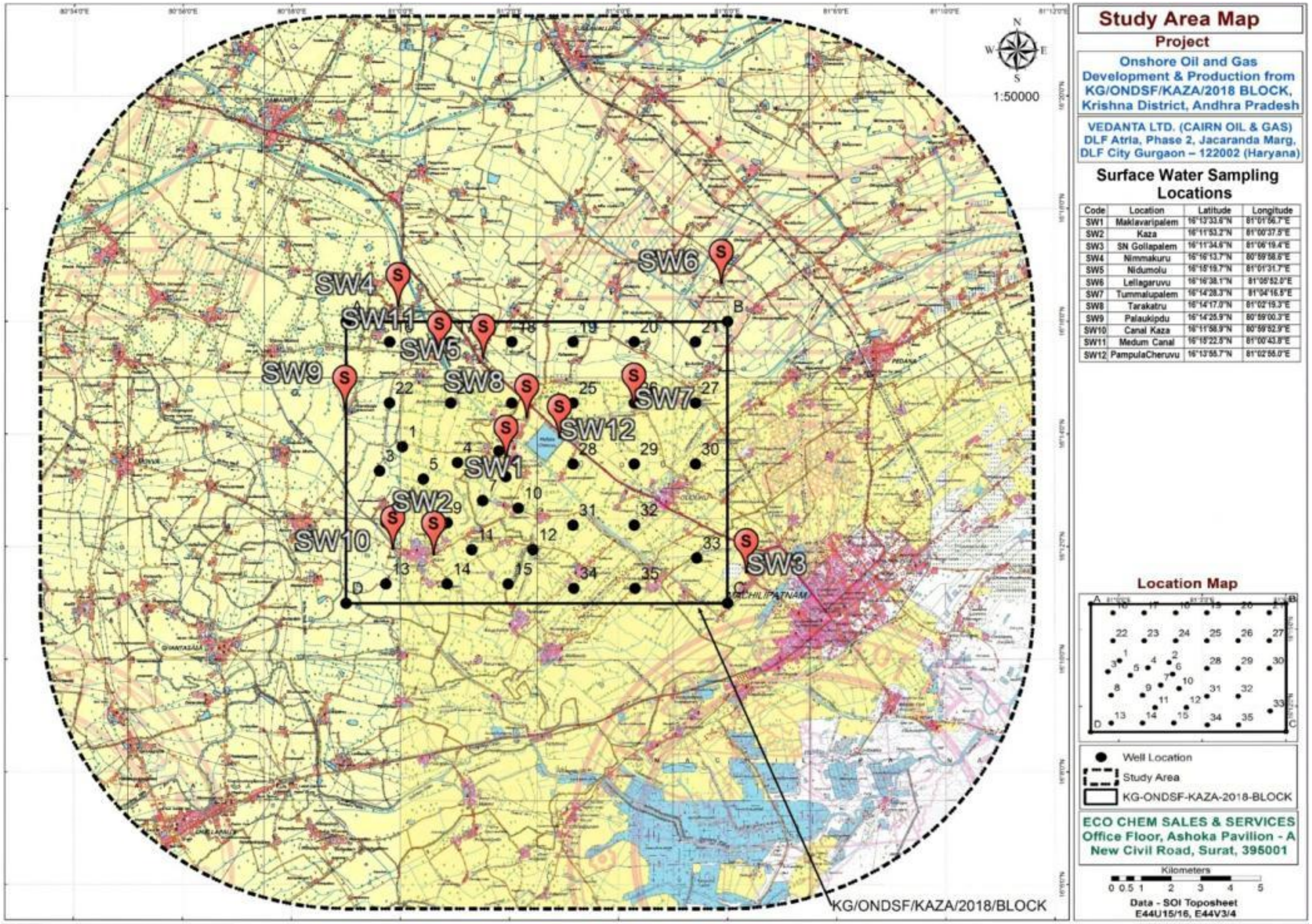



**Figure 3.26 Map showing the locations for Surface water**

**Table 3.21 Details of Surface Water Sampling Locations**

| Code | Location | Latitude | Longitude | Source |
|---|---|---|---|---|
| SW1 | Maklavaripalem | 16°13'33.6"N | 81°01'56.7"E | Pond |
| SW2 | Kaza | 16°11'53.2"N | 81°00'37.5"E | Pond |
| SW3 | SN Gollapalem | 16°11'34.6"N | 81°06'19.4"E | Pond |
| SW4 | Nimmakuru | 16°16'13.7"N | 80°59'58.6"E | Pond |
| SW5 | Nidumolu | 16°15'19.7"N | 81°01'31.7"E | Pond |
| SW6 | Lellagaruva | 16°16'38.1"N | 81°05'52.0"E | Pond |
| SW7 | Tummalupalem | 16°14'28.3"N | 81°04'16.5"E | Pond |
| SW8 | Tarakatru | 16°14'17.0"N | 81°02'19.3"E | Pond |
| SW9 | Palankipdu | 16°14'25.9"N | 80°59'00.3"E | Pond |
| SW10 | Kaza | 16°11'58.9"N | 80°59'52.9"E | Canal |
| SW11 | Medum Canal | 16°15'22.5"N | 81°00'43.8"E | Canal |
| SW12 | Pampula Cheruvu | 16°13'55.7"N | 81°02'55.0"E | Lake |


**Surface water – Maklavaripalem**


**Surface water - Pampula Cheruvu**


**Surface water – Nimmakuru**


**Surface water – SN Gollapalem**

**Figure 3.27 Photographs of Surface water sampling**

## Table 3.22 Surface water Analysis Results

| S. No. | Parameters | Unit | SW1 | SW2 | SW3 | SW4 | SW5 | SW6 | SW7 | SW8 | SW9 | SW10 | SW11 | SW12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Temperature | $^0C$ | 25.5 | 26.5 | 26.0 | 26.0 | 26.5 | 25.0 | 24.5 | 25.0 | 25.5 | 26.0 | 25.0 | 25.5 |
| 2. | pH @ $25^0C$ | pH Unit | 7.04 | 7.60 | 6.95 | 7.72 | 7.31 | 7.15 | 7.19 | 7.15 | 7.60 | 7.74 | 7.36 | 7.24 |
| 3. | Colour | Hazen | 7 | 8 | 10 | 5 | 8 | 7 | 6 | 5 | 8 | 8 | 5 | 6 |
| 4. | Odour | -- | Un | Un | Un | Un | Un | Un | Un | Un | Un | Un | Un | Un |
| 5. | Taste | -- | Ag | Ag | Ag | Ag | Ag | Ag | Ag | Ag | Ag | Ag | Ag | Ag |
| 6. | TDS @ $180^0C$ | mg/L | 482 | 486 | 342 | 426 | 362 | 456 | 368 | 452 | 472 | 714 | 756 | 310 |
| 7. | Conductivity | µmho/cm | 752 | 742 | 548 | 630 | 578 | 722 | 582 | 708 | 728 | 1156 | 1210 | 462 |
| 8. | Salinity | ppt | 0.20 | 0.19 | 0.12 | 0.13 | 0.12 | 0.16 | 0.14 | 0.14 | 0.19 | 0.33 | 0.36 | 0.11 |
| 9. | Turbidity | NTU | 3.2 | 4.1 | 5.2 | 4.5 | 3.5 | 6.1 | 3.3 | 5.2 | 6.1 | 6.8 | 4.0 | 4.5 |
| 10. | TSS | mg/L | 8 | 10 | 12 | 10 | 8 | 14 | 8 | 10 | 12 | 14 | 10 | 12 |
| 11. | Total Hardness as $CaCO_3$ | mg/L | 260 | 280 | 220 | 282 | 220 | 260 | 200 | 296 | 250 | 310 | 340 | 180 |
| 12. | Calcium | mg/L | 46 | 48 | 42 | 54 | 46 | 58 | 36 | 62 | 48 | 66 | 66 | 36 |
| 13. | Total Alkalinity as $CaCO_3$ | mg/L | 210 | 240 | 180 | 250 | 166 | 240 | 170 | 248 | 200 | 290 | 300 | 140 |
| 14. | Chloride | mg/L | 124 | 110 | 72 | 75 | 78 | 90 | 84 | 90 | 115 | 192 | 212 | 65 |
| 15. | Magnesium | mg/L | 35 | 39 | 28 | 36 | 26 | 28 | 27 | 34 | 32 | 35 | 42 | 22 |
| 16. | Sulphate | mg/L | 42 | 40 | 30 | 34 | 36 | 36 | 35 | 35 | 52 | 38 | 58 | 40 |
| 17. | Total Phosphorus ($PO_4$-P) | mg/L | 1.4 | 1.1 | 1.0 | 1.5 | 1.8 | 2.1 | 1.6 | 1.5 | 2.4 | 1.3 | 1.8 | 2.0 |
| 18. | Sodium | mg/L | 72 | 70 | 35 | 48 | 44 | 66 | 56 | 52 | 72 | 140 | 150 | 42 |
| 19. | Potassium | mg/L | 18 | 12 | 8 | 12 | 8 | 14 | 12 | 10 | 14 | 26 | 34 | 8 |
| 20. | Chloramine | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 21. | Fluoride | mg/L | 0.4 | 0.5 | 0.3 | 0.6 | 0.3 | 0.4 | 0.5 | 0.3 | 0.3 | 0.4 | 0.4 | 0.5 |
| 22. | Phenolic Compound | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 23. | Mineral oil | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 24. | Dissolved Oxygen | mg/L | 4.8 | 4.2 | 4.4 | 4.5 | 4.7 | 4.1 | 4.9 | 4.6 | 4.4 | 4.0 | 4.5 | 4.2 |
| 25. | COD | mg/L | 20 | 36 | 32 | 30 | 24 | 36 | 20 | 24 | 28 | 36 | 24 | 32 |
| 26. | BOD (3 days @ $27^0C$) | mg/L | 8 | 10 | 9 | 10 | 8 | 11 | 7 | 8 | 8 | 10 | 8 | 9 |
| 27. | Nitrate | mg/L | 1.8 | 3.2 | 2.6 | 2.1 | 2.0 | 3.5 | 1.4 | 1.9 | 2.2 | 3.0 | 2.8 | 2.4 |
| 28. | Total Nitrogen | mg/L | 2.6 | 4.5 | 3.4 | 2.8 | 2.6 | 4.8 | 2.1 | 2.8 | 3.1 | 4.1 | 3.6 | 3.2 |
| 29. | Free Ammonia | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 30. | Residual Chlorine | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 31. | Anionic detergent | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 32. | Barium | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 33. | Selenium | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 34. | Cyanide | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 35. | Molybdenum | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 36. | PAH | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 37. | Polychlorinated biphenyls | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 38. | SAR | -- | 1.94 | 1.81 | 1.02 | 1.24 | 1.28 | 1.77 | 1.71 | 1.31 | 1.97 | 3.45 | 3.54 | 1.35 |
| 39. | Iron | mg/L | 0.11 | 0.08 | 0.05 | 0.18 | 0.12 | 0.10 | 0.14 | 0.20 | 0.10 | 0.08 | 0.21 | 0.18 |
| 40. | Copper | mg/L | 0.08 | 0.05 | 0.07 | 0.08 | 0.09 | 0.05 | 0.06 | 0.08 | 0.09 | 0.05 | 1.0 | 0.09 |
| 41. | Hexavalent Chromium | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 42. | Zinc | mg/L | 0.15 | 0.21 | 0.22 | 0.14 | 0.12 | 0.10 | 0.18 | 0.21 | 0.1 | 0.24 | 0.22 | 0.16 |
| 43. | Arsenic | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 44. | Cadmium | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 45. | Mercury | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 46. | Nickel | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 47. | Manganese | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 48. | Lead | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 49. | Aluminum | mg/L | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |

***Un- Unobjectionable, Ag- Agreeable**

**Note:** 1) Qualitative analysis (spot test) has been carried out for color, cyanide, residual chlorine and phenolic compound.

2) BDL: Below detection limit, Detection range of laboratory is below the permissible limit for drinking water.

**Table 3.23 Microbiological Analysis of surface Water**

| Code | Total coliform | Fecal coliform |
|---|---|---|
| | Most Probable No (MPN): No/100 Ml | |
| SW1 | 32 | 24 |
| SW2 | 38 | 28 |
| SW3 | 40 | 30 |
| SW4 | 36 | 26 |
| SW5 | 34 | 22 |
| SW6 | 35 | 20 |
| SW7 | 33 | 24 |
| SW8 | 35 | 22 |
| SW9 | 38 | 26 |
| SW10 | 34 | 26 |
| SW11 | 40 | 28 |
| SW12 | 36 | 24 |

**Table 3.24 Inland Surface Water Classification (CPCB Standards)**

| Sr. No. | Characteristics | Class | | | | |
|---|---|---|---|---|---|---|
| | | A | B | C | D | E |
| 1. | Dissolved Oxygen, mg/L, Min | 6 | 5 | 4 | 4 | - |
| 2. | Biochemical Oxygen Demand, mg/ L Max | 2 | 3 | 3 | - | - |
| 3. | Total Coliform Organisms* MPN/100 ml, Max | 50 | 500 | 5000 | - | - |
| 4. | Total Dissolved Solids mg/L Max | 500 | - | 1500 | - | 2100 |
| 5. | Chlorides (as CL), mg/L, Max | 250 | - | 600 | - | 600 |
| 6. | Colour, Hazen Units, Max | 10 | 300 | 300 | - | - |
| 7. | Sodium Absorption Ratio, Max | - | - | - | - | 26 |
| 8. | Boron (as B) mg/L Max | - | - | - | - | 2 |
| 9. | Sulphates (as $SO_4$), mg/L Max | 400 | - | 400 | - | 1000 |
| 10. | Nitrates (as $NO_3$), mg/L Max | 20 | - | 50 | - | - |
| 11 | Free Ammonia (as N), mg/L Max | - | - | - | 12 | - |
| 12. | Conductivity at $25^0$C, micromhos/cm, Max | - | - | - | 1000 | 2250 |
| 13. | pH value | 6.5-8.5 | 6.5-8.5 | 6.5-8.5 | 6.5-8.5 | 6.5-8.5 |
| 14. | Iron (as Fe), mg/l, Max | 0.3 | - | 50 | - | - |
| 15. | Fluorides (as F), mg/L, Max | 1.5 | 1.5 | 1.5 | - | - |
| 16. | Copper (as Cu), mg/L, Max | 1.5 | - | 1.5 | - | - |

* If the Coliform is found to be more than the prescribed tolerance limits, the criteria for Coliform shall be satisfied if not more than 20 percent of samples show more than the tolerance limit specified, and not more than 5 percent of samples show values more than 4 times the tolerance limits. Further, the facal Coliform should not be more than 20 percent of the Coliform.

**Source: Indian Standard (IS: 2296 – 1982)**

A' Drinking water surface without conventional treatment but after disinfection

B' Outdoor bathing (organized)

C' Drinking water source with conventional treatment followed by disinfection

D' Propagation of wild life, fisheries

E' Irrigation, industrial, cooling, controlled waste disposal

### 3.16.8 Summary of Surface Water Quality

The following description is based on the analysis of the samples:

- During the analysis pH of the samples was found in the range of 6.95 – 7.74.
- TDS analysis was also carried out for surface water sample and it was found in the range of 310 - 756 mg/L.
- TSS was found in the range of 8 – 14 mg/L.
- Total Hardness ranges from 180 – 340 mg/L with minimum in the water sample of Pampula Cheruvu and maximum at Medum Canal.
- DO is one of the important parameter to indicate towards the contamination of organic matter. DO level decrease as soon as organic contamination increases. During analysis DO was found in the range of 4.0-4.9 mg/L.
- COD and BOD analysis was also carried out during the study period and results were found more than the expected value for the surface water. Various literatures show that BOD should be less than 4.0 mg/L for the better survival of aquatic life.
- Total Nitrogen was found in the range of 2.6 – 4.5 mg/L.
- Iron was found in the range of 0.05-0.21 mg/L.
- MPN test was also carried out for the surface water sample and it was found positive.

### 3.16.9 Interpretation of Surface Water Quality Data

Based on test result data comparison study with CPCB Standards (Inland Surface Water Classification), it is interpreted that surface water quality meets with the class D & E. This water can be used for Propagation of wild life, fisheries and Irrigation, industrial, cooling, controlled waste disposal purpose. COD and BOD have been reported more than 4 mg/L, it indicates towards the organic contamination in water bodies. Looking to the pollution load it is suggested that untreated domestic/industrial water should not be reach in water bodies.

## 3.17 ECOLOGY AND BIODIVERSITY

Ecology is the scientific study of the relations that living organisms have with respect to each other and their natural environment. Producer, consumer and decomposer govern whole cycle of ecology. Plant and animal both are interdependent to each other. Producer is necessary for each consumer. Plant plays their role in ecology as producer. Plant, animals and microorganism together with the environment in which they live make an independent unit called the Ecosystem. The main objective of the ecological survey is aimed to find out baseline status of flora and fauna of the study region. An ecological survey of the study area was conducted particularly with reference to listing of species and assessment of the existing baseline ecological (terrestrial and marine ecosystem) conditions in the study area.

### 3.17.1 Methodology

Primary survey has been conducted up to 5 km surrounding the studied well. The importance of primary data collection in all ecological work cannot be over-emphasized as without good survey data. Before starting the survey, Toposheet of study area was taken from client to decide the survey area and sampling spot points. Secondary data information was also collected for desktop study purpose and preparing the list of probable flora and fauna. Secondary data was also collated from the authenticated sources in the public domain. Sources of secondary data mainly comprise standard field guides, published research papers or articles, governmental publications and websites of internationally recognized conservation organizations such as International Union for Conservation of Nature and Natural Resources (IUCN), Birdlife International, Conservation International,

Wildlife Conservation Society (WCS) and World Wildlife Fund (WWF). Supplementary information was obtained through informal interactions with local communities.
Data Collection: Following steps were considered for the collection of secondary data and generation of primary data while carrying out ecological survey of the study area.

**Step 1: Defining the study area**
The study area was larger than the development site as it included adjacent areas that might be directly or indirectly affected by the proposal.

**Step 2: Stratifying the site**
When designing a field survey, the study area was stratified (i.e. divide the area into relatively homogenous units - often referred to as 'environmental sampling units' or 'stratification units'). Stratified sampling provides a logical, objective and efficient method of undertaking surveys and ensures that the full range of potential habitats and vegetation types will be systematically sampled.

**Step 3: Visiting the site**
A preliminary site visit was conducted by our in-house field area experts to refine the initial stratification units, determine the vegetation types present at the site to assess the vegetation condition and conduct a habitat assessment.

**Step 4: Survey**
Qualitative surveys of flora have been done by recording the plant species through visual observation only. Higher floristic species, namely angiosperms were covered. In case of faunal species, qualitative data was collected mainly at each sampling site. Any species recorded outside the sampling sites were ascribed to the nearest sampling site Vegetation measurement was done from points rather than in an area with boundaries for trees, shrubs and herbs. Faunal survey was conducted by adopting the method opportunistic observation/ species list method/direct sighting /intensive search/ bird calls/nests, burrows, dropping or scats and conformation with local public. Species covered under the faunal survey are mammal, reptile & amphibian and birds. Primary data was collected through most of the diurnal period from early morning till late evening. Photograph of the sampling activities are presented in **Figure 3.28.**

Aquatic ecology and biodiversity data have been recorded for zooplankton, Phytoplankton and benthos. Random sampling has been conducted in the water body for the said parameters as per APHA 23rd Edition, 2017.

We had used methodology as per our QMS Quality Procedure for Ecology and Biodiversity for conducting ecology and biodiversity study.
**Study area:** 902.46 Sq.km.
**Study period:** Dec 2019 to Feb 2020
**List of villages:** Chataripalem, S N Gollapalem, Lellagaruvu, Nimmakuru, Nidumolu, Chitturu, Tummalapalem, Tarakaturu, Maklavaripalem, Kaza, Guduru, Palankipadu


EB Survey –Guduru


EB Survey – Kaza


EB Survey – Lellagaruvu


EB Survey – Maklavaripalem

**Figure 3.28 Photographs of Ecology & Biodiversity Survey**

### 3.17.2 Floral Diversity of the Study Area

The objective of this floral inventory of the study area is to provide necessary information on floristic structure in the study area for formulating effective management and conservation measures. The climatic, edaphic and biotic variations with their complex interrelationship and composition of species, which are adapted to these variations, have resulted in different vegetation cover, characteristic of each region (Ohasi, 1975). The tree species, herbs, shrubs, climbers and major crops, were documented during this base line study (Jain, 1968; 1991).

## Flora

**Trees:** Total *37* species of trees belong to 17 families are enumerated from the study area.

**Table 3.25 List of Trees in the study area**

| Sr. No. | Scientific name | Common name |
|---|---|---|
| **1.** | **Mimosaceae** | |
| *1/1* | *Acacia nilotica* | Babool |
| *2/2* | *Albizia lebbeck* | Siris |
| *3/3* | *Acacia auriculiformis* | Australian Babool |
| *4/4* | *Prosopis chilensis* | Junglee kikar |
| *5/5* | *Prosopis juliflora* | Gando baval |
| *6/6* | *Prosopis spicigera* | Khejri |
| **2.** | **Fabaceae** | |
| *7/1* | *Dalbergia sissoo* | Sissoo |
| *8/2* | *Delonix regia* | Gulmohar |
| *9/3* | *Samanea saman* | Vilaiti siris |
| *10/4* | *Tamarindus indica* | Imli |
| *11/5* | *Leucaena leucocephala* | Safed babool |
| *12/6* | *Pithecolobium dulce* | Kachanal |
| **3.** | **Moraceae** | |
| *13/1* | *Ficus hispida* | *Gobla* |
| *14/2* | *Ficus racemosa* | *Gular* |
| *15/3* | *Ficus riligiosa* | *Pipal* |
| **4.** | **Simaroubaceae** | |
| *16/1* | *Alilanthus excelsa* | Maharukh |
| **5.** | **Anacardiaceae** | |
| *17/1* | *Anacardium occidentale* | Kaju |
| **6.** | **Annonaceae** | |
| *18/1* | *Annona squamosa* | Sitaphal |
| *19/2* | *Polyalthia longifolia* | Ashok |
| **7.** | **Moraceae** | |
| *20/1* | *Artocarpus heterophyllus* | Kathal |
| **8.** | **Poaceae** | |
| *21/1* | *Bambusa arundinacea* | Bamboo |
| **9.** | **Euphorblaceae** | |
| *22/1* | *Breynia retusa* | Khaja |
| *23/2* | *Jatropha curcas* | Jamal ghota |
| *24/3* | *Phyllanthus reticulatus* | Pancoli |
| **10.** | **Verbansceae** | |
| *25/1* | *Gmelina arborea* | Gamhar |
| *26/2* | *Premna tomentosa* | Bastard Teak |
| **11.** | **Myrtaceae** | |
| *27/1* | *Callistemon citrinus* | Cheel |
| *28/2* | *Eucalyptus globulus* | Safeda |

| | | |
|---|---|---|
| *29/3* | *Syzygium cumini* | Jamun |
| **12.** | **Bignoniaceae** | |
| *30/1* | *Kigelia africana* | Balam Khira |
| *31/2* | *Tabebuia argentea* | |
| **13.** | **Lythraceae** | |
| *32/1* | Lawsonia inermis | Mehendi |
| **14.** | **Rutaceae** | |
| *33/1* | *Limonia acidissima* | Kaith |
| *34/2* | *Psidium guajava* | Amrood |
| **15.** | **Apocynaceae** | |
| *35/1* | *Nerium oleander* | Kaner |
| **16.** | **Papilionaceae** | |
| *36/1* | *Pongamia pinnata* | Karanj |
| **17.** | **Combretaceae** | |
| *37/1* | *Terminalia arjuna* | Arjun |

**Shrub:** Total 7 species of Shrub belong to 6 families are enumerated from the study area.

**Table 3.26 List of Shrub in the study area**

| Sr. No. | Scientific name | Common Name |
|---|---|---|
| **1.** | **Malvaceae** | |
| *1/1* | *Abutilon indicum* | Kanghi |
| **2.** | **Solanaceae** | |
| *2/1* | *Datura stramonium* | Datura |
| **3.** | **Asclepiadaceae** | |
| *3/1* | *calotropis procera* | Rubber Bush |
| *4/2* | *calotropis gigantea* | Crown Flower |
| **4.** | **Lamiaceae** | |
| *5/1* | *Hypus suaveolens* | Pignut |
| **5.** | **Verbenaceae** | |
| *6/1* | *Lantana camara* | Common lantana |
| **6.** | **Anacardiaceae** | |
| *7/1* | *Anarcardium occidentale* | Cashew |

**Herbs:** Total 11 species of Herbs belong to 9 families are enumerated from the study area.

**Table 3.27 List of Herbs in the study area**

| Sr. No. | Scientific Name | Common Name |
|---|---|---|
| **1.** | **Amaranthaceae** | |
| *1/1* | *Achyranthes aspera* | Aghara |
| *2/2* | *Aerva lanata* | Chhaya |
| **2.** | **Asteraceae** | |
| *3/1* | *Ageratum conyzoides* | Jangli Pudina |
| **3.** | **Fabaceae** | |
| *4/1* | *Albizia amara* | Krishna Siris |

| | | |
|---|---|---|
| **4.** | **Asphodelaceae** | |
| *5/1* | *Aloe vera* | Gwarpatha |
| **5.** | **Cannaceae** | |
| *6/1* | *Canna indica* | Sarvajjaya |
| **6.** | **Loranthaceae** | |
| *7/1* | *Dendrophthoe falcata* | Banda |
| **7.** | **Astreraceae** | |
| *8/1* | *Eclipta alba* | Bhringaraj |
| **8.** | **Acanthaceae** | |
| *9/1* | *Hygrophila auriculata* | Tinpatia |
| **9.** | **Lamiaceae** | |
| *10/1* | *Leucas aspera* | Chhota halkusa |
| *11/2* | *Leucas cephalotis* | bishkhapru |

**Fauna Diversity of the Study Area**

There was no endangered species observed during faunal survey, list of fauna detail summarized in **Table 3.28 to 3.32.**

**Table 3.28 List of Mammals in the study area**

| Sr. No. | Scientific Name | Common Name | Schedule as per 1972 |
|---|---|---|---|
| 1. | *Funambulus palmarum* | Three striped palm squirell | - |
| 2. | *Bandicota bengalensis* | Indian mole rat | - |
| 3. | *Mus booduga* | Little Indian Field Mouse | - |
| 4. | *Mus musculus* | House Mouse | - |
| 5. | *Rattus rattus* | House rat | - |
| 6. | *Herpestes edwardsii* | Common Indian Mangoose | Schedule II |
| 7. | *Rhinopoma hardwickii* | Lesser Mouse Tailed Bat | - |
| 8. | *Cynopterus brachyotis* | Short Nosed Fruit Bat | Schedule V |
| 9. | *Pipistrellus coromandra* | Indian Pipistrelle | - |

**Source: Primary data and Forest Department, Krishna district**

**Table 3.29 List of Birds in the study area**

| Sr. No. | Scientific Name | Common Name | Schedule as per 1972 |
|---|---|---|---|
| 1. | *Accipiter badius* | Shikra | Schedule IV |
| 2. | *Acridotheres tristis* | Common Myna | Schedule IV |
| 3. | *Acrocephalus agricola* | Paddy field warblers | Schedule IV |
| 4. | *Anthus rufulus* | Paddy pipet | Schedule IV |
| 5. | *Apus nipalensis* | House swift | Schedule IV |
| 6. | *Ardeola grayii* | Pond heron | Schedule IV |
| 7. | *Athene brama* | Spotted owlet | Schedule IV |
| 8. | *Bubulcus ibis* | Cattle Egret | Schedule IV |
| 9. | *Ceryle rudis* | Pied Kingfisher | Schedule IV |
| 10. | *Charadrius leschenaultii* | Large sand plover | Schedule IV |
| 11. | *Cinnyris asiaticus* | Purple sunbird | Schedule IV |

| | | | |
|---|---|---|---|
| 12. | *Coracias benghalensis* | Indian Roller | Schedule IV |
| 13. | *Corvus splendens* | House crow | Schedule IV |
| 14. | *Cuculus micropterus* | Indian Cuckoo | Schedule IV |
| 15. | *Cypsiurus balasiensis* | Asian palm swift | Schedule IV |
| 16. | *Dicrurus macrocercus* | Black Drongo | Schedule IV |
| 17. | *Egretta garzetta* | Little Egret | Schedule IV |
| 18. | *Eudynamys scolopaceus* | Asian Koel | Schedule IV |
| 19. | *Euodice malabarica* | White Throated Munia | Schedule IV |
| 20. | *Fulica atra* | Common coot | Schedule IV |
| 21. | *Gracupica contra* | Asian pied starling | Schedule IV |
| 22. | *Halcyon smyrnensis* | White Breasted Kingfisher | Schedule IV |
| 23. | *Himantopus himantopus* | Black winged stilt | Schedule IV |
| 24. | *Lonchura punctulata* | Spotted Munia | Schedule IV |
| 25. | *Orthotomus sutonus* | Tailor bird | Schedule IV |
| 26. | *Microcarbo niger* | Little cormorant | Schedule IV |
| 27. | *Prinia socialis* | Ashy Warblers | Schedule IV |
| 28. | *Psittacula krameri* | Rose ringed parakeet | Schedule IV |
| 29. | *Pycnonotus cafer* | Red vented Bulbul | Schedule IV |
| 30. | *Saxicoloides fulicatus* | Indian Robin | Schedule IV |
| 31. | *Spilopelia chinensis* | Spotted dove | Schedule IV |
| 32. | *Sturnia pagodarum* | Bramhiny Starlings | Schedule IV |
| 33. | *Sturnia malabarica* | Grey headed myna | Schedule IV |
| 34. | *Tordoides caudata* | Common Bubbler | Schedule IV |
| 35. | *Vanellus indicus* | Red wattled Lapwing | Schedule IV |
| 36. | *Vanellus malabaricus* | Yellow wattled Lapwing | Schedule IV |

**Source: Primary data and Forest Department, Krishna district**

**Table 3.30 List of Reptile in the study area**

| **Sr. No.** | **Scientific Name** | **Common Name** | **Schedule as per 1972** |
|---|---|---|---|
| 1. | *Calotes versicolor* | Common garden Lizard | - |
| 2. | *Sitana ponticeriana* | Fan throated Lizard | - |
| 3. | *Dendrelaphis tristis* | Common indian bronze back | - |
| 4. | *Lycodon aulicus* | Common wolf snake | - |
| 5. | *Ptyas mucosa* | Indian Rat Snake | - |
| 6. | *Naja naja* | Indian Cobra | Schedule II |
| 7. | *Hemidactylus brookii* | Brook's Gecko | - |
| 8. | *Mabuya carinata* | Common skink | - |
| 9. | *Varanus bengalensis* | Indian Monitoring Lizard | - |

**Source: Primary data and Forest Department, Krishna district**

**Table 3.31 List of Insects in the study area**

| Sr. No. | Scientific Name | Common Name |
|---|---|---|
| 1. | *Discolampa ethion* | Banded blue Pierrot butterfly |
| 2. | *Tarucus extricatus* | Rounded Pierrot butterfly |
| 3. | *Euploea core* | Common Indian crow butterfly |
| 4. | *Pieris rapae* | Cabbage white butterfly |
| 5. | *Apis sp.* | Honey Bee |
| 6. | *Zygoptera sp.* | Damsel fly |
| 7. | *Anisoptera sp.* | Dragon fly |

**Source: Primary data and Forest Department, Krishna district**

**Table 3.32 List of Amphibians in the study area**

| Sr. No. | Scientific Name | Common Name |
|---|---|---|
| 1. | *Duttaphrynus melanostictus* | Common Indian Toad |
| 2. | *Euphlyctis hexadactylus* | Indian Pond Frog |
| 3. | *Euphlyctis cyanophlyctis* | Skittering Frog |
| 4. | *Polypedates leucomystax* | Common Tree Frog |

**Source: Primary data and Forest Department, Krishna district**

**Table 3.33 Details of Fishes**

| Sr. No. | Scientific Name | Species |
|---|---|---|
| 1 | *Anguilliformes sp.* | Eel |
| 2 | *Channa striata* | Murrel |
| 3 | *Etroplus suratensis* | Pearl spot |
| 4 | *Siluriformes sp.* | Cat fish |
| 5 | *Lates calcarifer* | Giant prech |
| 6 | *Dendrobranchiata sp.* | Prawn |
| 7 | *Mastacembelidae sp.* | Spiny eel |
| 8 | *Gobiidae sp.* | Gobids |
| 9 | *Silonia silonia* | Silonia |
| *10* | *Oreochromis niloticus* | Tilapia |

**Source: Primary data and Fisheries Department, Krishna district**

- **Aquatic Biodiversity**

Aquatic biodiversity has enormous economic and aesthetic value and is largely responsible for maintaining and supporting overall environmental health. Humans have long depended on aquatic resources for food, medicines, and materials as well as for recreational and commercial purposes such as fishing and tourism. Aquatic organisms also rely upon the great diversity of aquatic habitats and resources for food, materials, and breeding grounds.

For the study of aquatic biodiversity, samples for phytoplankton, zooplankton and benthos were collected from 12 surface water body, which flow within the study region.

- **Phytoplankton**

Phytoplankton plays their role as producer in water ecosystem. They play an important role in maintaining the food cycle for aquatic environment. The phytoplankton occurs as unicellular, colonial or filamentous fonn. Phytoplankton has long been used as indicator of water quality. Some species flourishes in highly eutrophic waters while others are very sensitive to organic and/or chemical wastes.

Phytoplankton samples were collected from the depth of 0.5m of water body with the help of depth sampler. Lugol's iodine was added @ 0.3ml/100 ml for the preservation of phytoplankton. To study the complete phytoplankton concentration, sample was concentrated by centrifuging it in the laboratory. Phytoplankton counting was done by using the Sedgwick-Rafter (S-R) Cell Method at magnification up to 200 x.

Frequency of the sampling and analysis was once during the study period. Sampling locations of Phytoplankton are presented in **Table 3.34** & **Figure 3.29** and Test results are presented in **Table 3.35 and 3.36.**

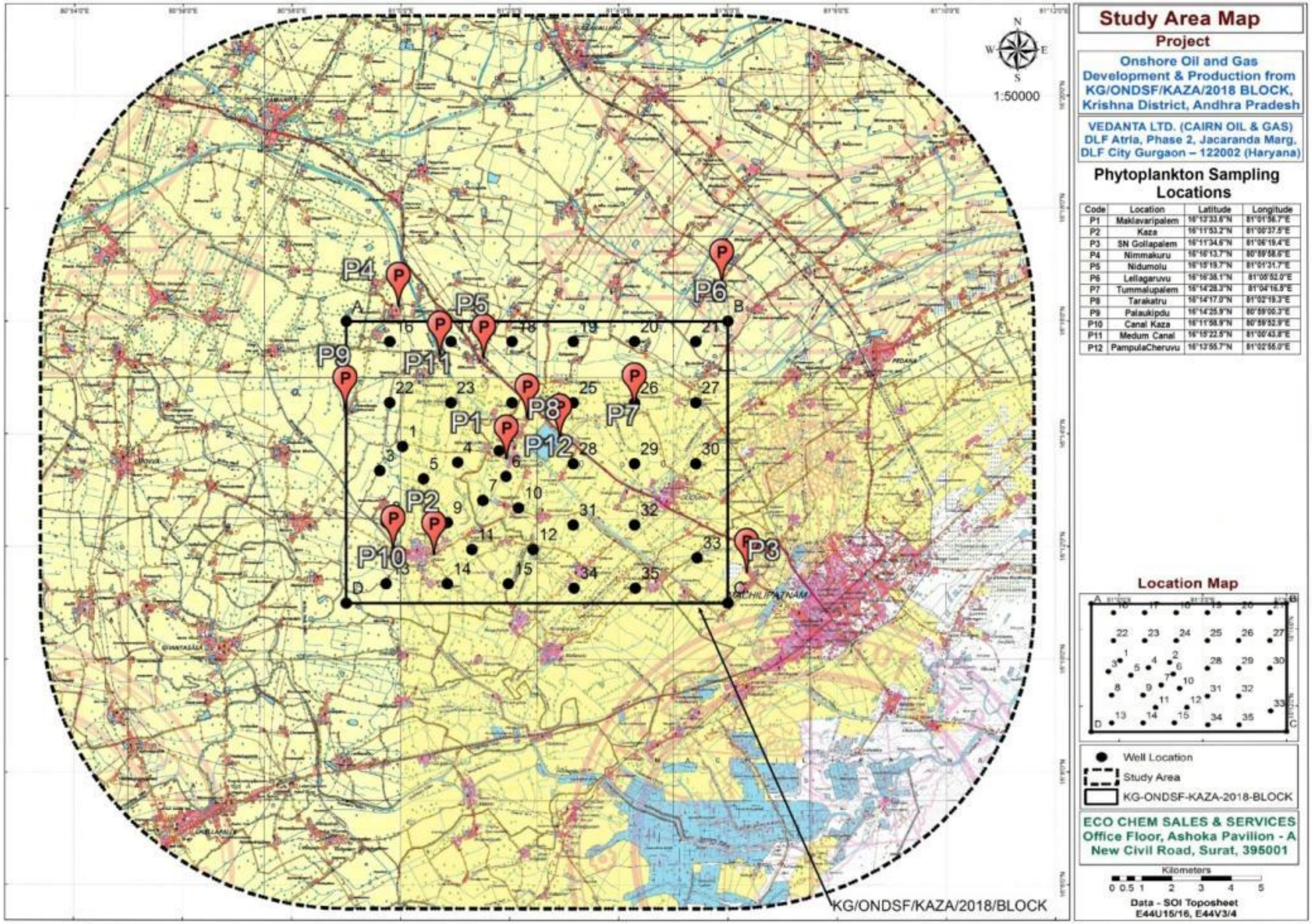



**Figure 3.29 Map showing the locations for Phytoplankton sampling**

**Table 3.34 Details of Phytoplankton sampling locations**

| Code | Location | Latitude | Longitude |
|---|---|---|---|
| P1 | Maklavaripalem | 16°13'33.6"N | 81°01'56.7"E |
| P2 | Kaza | 16°11'53.2"N | 81°00'37.5"E |
| P3 | SN Gollapalem | 16°11'34.6"N | 81°06'19.4"E |
| P4 | Nimmakuru | 16°16'13.7"N | 80°59'58.6"E |
| P5 | Nidumolu | 16°15'19.7"N | 81°01'31.7"E |
| P6 | Lellagaruva | 16°16'38.1"N | 81°05'52.0"E |
| P7 | Tummalupalem | 16°14'28.3"N | 81°04'16.5"E |
| P8 | Tarakatru | 16°14'17.0"N | 81°02'19.3"E |
| P9 | Palaukipdu | 16°14'25.9"N | 80°59'00.3"E |
| P10 | Canal Kaza | 16°11'58.9"N | 80°59'52.9"E |
| P11 | Medum Canal | 16°15'22.5"N | 81°00'43.8"E |
| P12 | Pampula Cheruvu | 16°13'55.7"N | 81°02'55.0"E |

**Table 3.35 Phytoplankton Analysis**

| Location | Total Count/L | Group percentage | | | Shanon Weiner Index |
|---|---|---|---|---|---|
| | | Chlorophyceae | Cyanophyceae | Bacelleriophyceae | |
| P1 | 710 | 45 | 8 | 47 | 3.3 |
| P2 | 825 | 40 | 11 | 49 | 3.4 |
| P3 | 760 | 38 | 8 | 54 | 3.2 |
| P4 | 652 | 36 | 10 | 54 | 3.1 |
| P5 | 680 | 42 | 9 | 49 | 3.5 |
| P6 | 790 | 46 | 10 | 44 | 3.2 |
| P7 | 1010 | 40 | 7 | 43 | 3.1 |
| P8 | 680 | 42 | 8 | 50 | 2.8 |
| P9 | 913 | 40 | 11 | 49 | 3.0 |
| P10 | 712 | 38 | 10 | 52 | 3.4 |
| P11 | 680 | 35 | 10 | 55 | 3.3 |
| P12 | 705 | 45 | 9 | 46 | 3.6 |

**Table 3.36 Phytoplankton species and Group**

| Group | Dominant species | No. of species | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 | P11 | P12 |
| Chlorophyceae | *Cladophora glomerata* *Chlorell* sp., *Spirogyra* sp, *Ankistrodesmus* sp., *Chara braunii,* | 12 | 10 | 14 | 8 | 12 | 12 | 11 | 9 | 10 | 8 | 10 | 8 |
| Cyanophyceae | *Anabaena circinalis* *Lyngbya* sp. *Oscillotoria* *Chroococcus sp.* | 7 | 8 | 7 | 8 | 6 | 7 | 9 | 5 | 8 | 10 | 7 | 6 |
| Bacelleriophyceae | *Nitschia* sp., *Cymbella acuta,* *Synedra sp.* *Navicula* sp. *Diatoma* sp. , | 16 | 14 | 12 | 14 | 16 | 15 | 12 | 16 | 14 | 12 | 11 | 10 |

- **Zooplankton**

The occurrence and abundance of zooplankton depends on its productivity, which in turn is influenced by abiotic factors and the level of nutrients in the water. Zooplankton forms the microscopic animals that play an important role in an aquatic food chain as they are largely consumed by fishes and other higher organisms in food chain.

Zooplankton samples were collected from the depth of 0.5m of water body with the help of depth sampler. Formalin solution was added @ 5ml/L for the preservation of zooplankton. To study the complete zooplankton concentration, sample was concentrated by centrifuging it in the laboratory. Zooplankton counting was done by using the Sedgwick-Rafter (S-R) Cell Method.

Frequency of the sampling and analysis was once during the study period. Sampling location of Zooplankton are presented in **Table 3.37** & **Figure 3.30** and Test results are presented in **Table 3.38**.

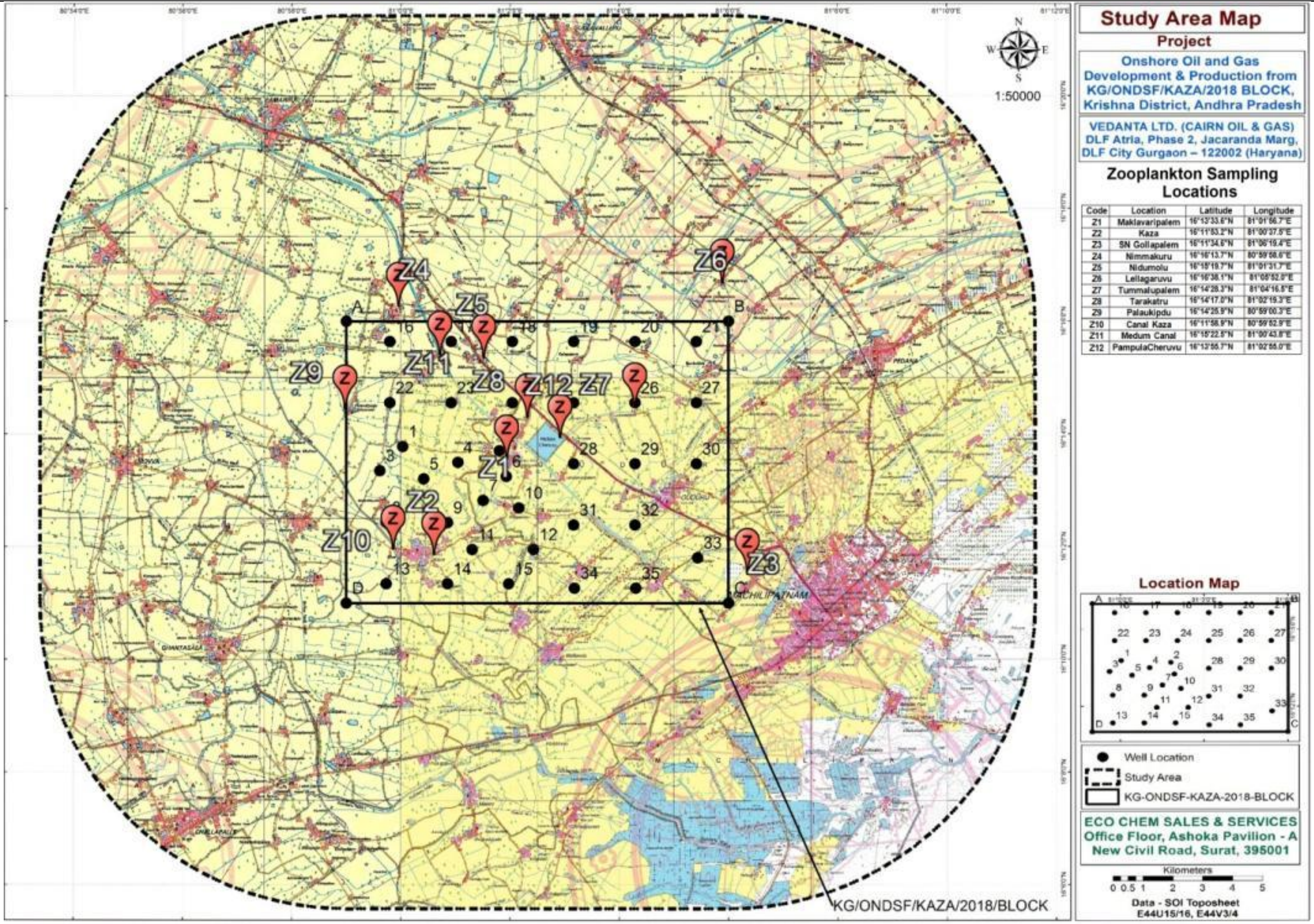



**Figure 3.30 Map showing the locations for Zooplankton sampling**

**Table 3.37 Details of Zooplankton sampling locations**

| Code | Location | Latitude | Longitude |
|---|---|---|---|
| Z1 | Maklavaripalem | 16°13'33.6"N | 81°01'56.7"E |
| Z2 | Kaza | 16°11'53.2"N | 81°00'37.5"E |
| Z3 | SN Gollapalem | 16°11'34.6"N | 81°06'19.4"E |
| Z4 | Nimmakuru | 16°16'13.7"N | 80°59'58.6"E |
| Z5 | Nidumolu | 16°15'19.7"N | 81°01'31.7"E |
| Z6 | Lellagaruva | 16°16'38.1"N | 81°05'52.0"E |
| Z7 | Tummalupalem | 16°14'28.3"N | 81°04'16.5"E |
| Z8 | Tarakatru | 16°14'17.0"N | 81°02'19.3"E |
| Z9 | Palaukipdu | 16°14'25.9"N | 80°59'00.3"E |
| Z10 | Canal Kaza | 16°11'58.9"N | 80°59'52.9"E |
| Z11 | Medum Canal | 16°15'22.5"N | 81°00'43.8"E |
| Z12 | Pampula Cheruvu | 16°13'55.7"N | 81°02'55.0"E |

**Table 3.38 Zooplankton Analysis**

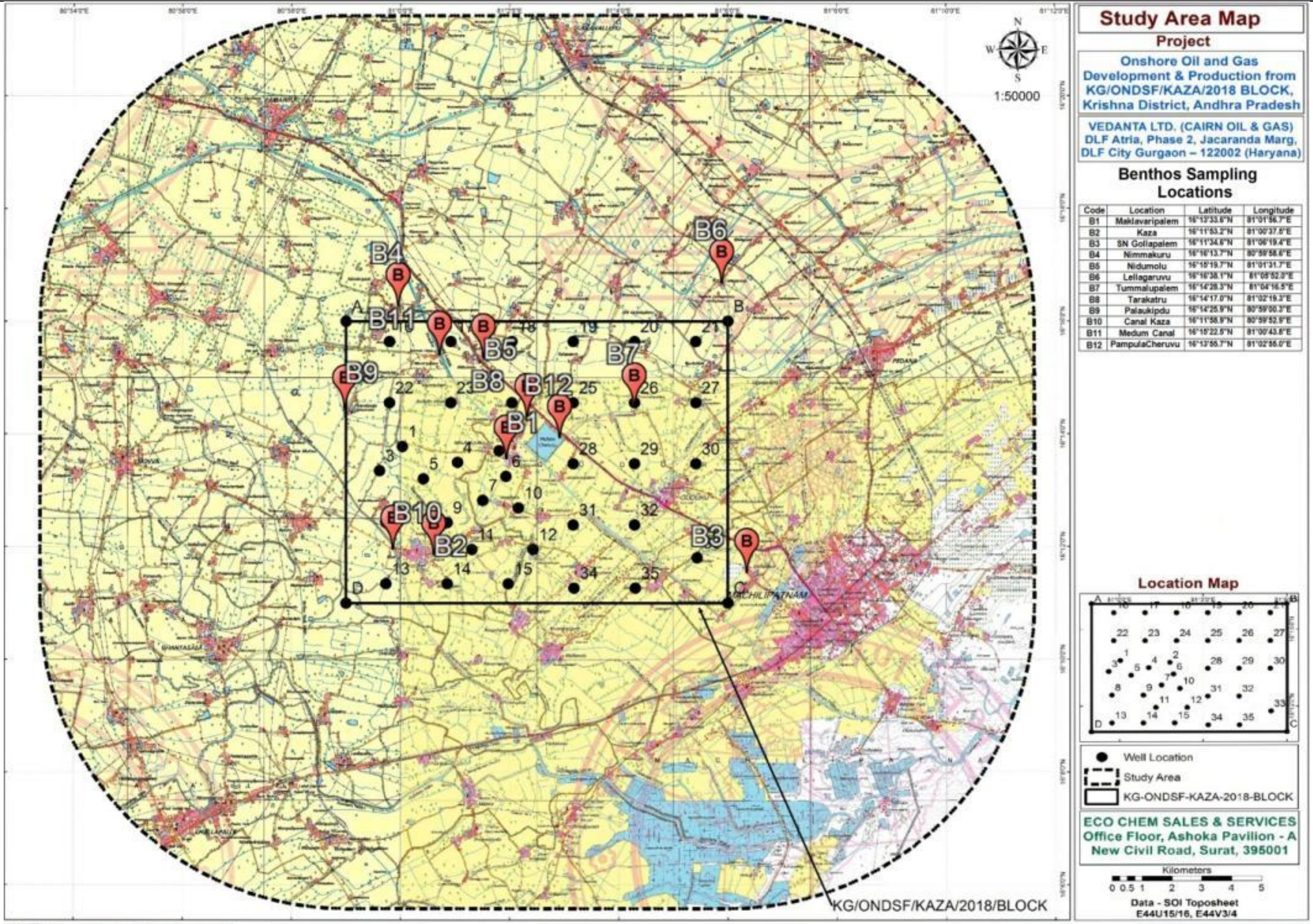
| Sampling Code | Total Count/L | Protozoa in % | Rotifers in % | Copepods % | Shanon Weiner Index |
|---|---|---|---|---|---|
| Z1 | 128 | 45 | 20 | 35 | 3.5 |
| Z2 | 150 | 42 | 12 | 46 | 4.0 |
| Z3 | 126 | 41 | 15 | 44 | 3.6 |
| Z4 | 130 | 40 | 18 | 42 | 4.1 |
| Z5 | 156 | 42 | 12 | 46 | 4.4 |
| Z6 | 174 | 40 | 16 | 44 | 4.3 |
| Z7 | 182 | 44 | 14 | 42 | 2.8 |
| Z8 | 145 | 43 | 12 | 45 | 3.0 |
| Z9 | 132 | 42 | 16 | 42 | 3.5 |
| Z10 | 177 | 44 | 12 | 44 | 4.2 |
| Z11 | 166 | 45 | 18 | 37 | 3.6 |
| Z12 | 154 | 45 | 15 | 40 | 2.9 |

Total species distribution was 20 -25.

- **Benthos**

Benthos is the biological species which are attached with the substratum of water body and they play major role in balancing the aquatic eco system. Diatom, algae and nano planktons are food for the benthos**.**

Benthos is collected from the substratum of the water body with the help of benthic sampler. After the sampling they were transferred in polyethylene bag. Samples were preserved with 10% formalin solution. During the analysis sediment was passed through a series of sieves. Macro invertebrate were separate with the help of scrapper and spatula and slurry was brought under microscopic observation for micro fauna identification. Sampling locations of Benthos are presented in **Table 3.39 & Figure 3.31.** Qualitative data of zooplanktons are presented in **Table 3.40.**




| Code | Location | Latitude | Longitude |
|---|---|---|---|
| B1 | Maklavaripalem | 16°13'33.6"N | 81°01'56.7"E |
| B2 | Kaza | 16°11'53.2"N | 81°00'37.5"E |
| B3 | SN Gollapalem | 16°11'34.6"N | 81°06'19.4"E |
| B4 | Nimmakuru | 16°16'13.7"N | 80°59'58.6"E |
| B5 | Nidumolu | 16°15'19.7"N | 81°01'31.7"E |
| B6 | Lellagaruvu | 16°16'38.1"N | 81°05'52.0"E |
| B7 | Tummalupalem | 16°14'28.3"N | 81°04'16.5"E |
| B8 | Tarakatru | 16°14'17.0"N | 81°02'19.3"E |
| B9 | Palaukipdu | 16°14'25.9"N | 80°59'00.3"E |
| B10 | Canal Kaza | 16°11'58.9"N | 80°59'52.9"E |
| B11 | Medum Canal | 16°15'22.5"N | 81°00'43.8"E |
| B12 | PampulaCheruvu | 16°13'55.7"N | 81°02'55.0"E |

**Figure 3.31 Map showing the locations for Benthos sampling**

**Table 3.39 Details of Benthos sampling locations**

| Code | Location | Latitude | Longitude |
|---|---|---|---|
| B1 | Maklavaripalem | 16°13'33.6"N | 81°01'56.7"E |
| B2 | Kaza | 16°11'53.2"N | 81°00'37.5"E |
| B3 | SN Gollapalem | 16°11'34.6"N | 81°06'19.4"E |
| B4 | Nimmakuru | 16°16'13.7"N | 80°59'58.6"E |
| B5 | Nidumolu | 16°15'19.7"N | 81°01'31.7"E |
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| B7 | Tummalupalem | 16°14'28.3"N | 81°04'16.5"E |
| B8 | Tarakatru | 16°14'17.0"N | 81°02'19.3"E |
| B9 | Palaukipdu | 16°14'25.9"N | 80°59'00.3"E |
| B10 | Canal Kaza | 16°11'58.9"N | 80°59'52.9"E |
| B11 | Medum Canal | 16°15'22.5"N | 81°00'43.8"E |
| B12 | Pampula Cheruvu | 16°13'55.7"N | 81°02'55.0"E |

**Table 3.40 Qualitative analysis of Benthos**

| Systematic Group | B1 | B2 | B3 | B4 | B5 | B6 | B7 | B8 | B9 | B10 | B11 | B12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Polychaetes | + | + | + | + | + | + | + | + | + | + | + | + |
| Mysids | _ | _ | _ | + | _ | _ | _ | _ | + | _ | _ | + |
| Ostracods | _ | _ | _ | _ | _ | _ | + | + | _ | _ | _ | _ |
| Isopodes | _ | + | + | - | + | + | _ | + | + | - | + | + |
| Amphipodes | _ | _ | _ | + | _ | _ | _ | _ | _ | + | _ | _ |
| Brachyurans | _ | _ | + | _ | _ | + | + | + | + | + | + | _ |
| Insects | - | - | + | - | + | + | + | + | + | + | _ | _ |
| Gastropodes | - | - | - | - | - | - | - | - | - | - | - | - |
| Pelecypodes | + | - | - | + | - | - | - | - | - | - | - | - |

### 3.17.3 Interpretation on Ecology and Biodiversity

Farley rich forestic biodiversity is present in the core and buffer zone in the study area. There was no endemic and threatened plant species was observed in the study region during the survey. There is no declared sanctuary park and reserve forest in the study region. In case of avi fauna only schedule IV species have been recorded from the study region and in case of reptile schedule II species like cobra has been observed. No protected/threatened fauna was cited during the survey.

## 3.18 SOCIO-ECONOMIC ENVIRONMENT

**Socioeconomics** (also known as **socio-economics** or **social economics**) is the social science that studies how economic activity affects social processes. In general it analyses how societies progress, stagnate, or regress because of their local or regional economy, or the global economy.

In order to assess and evaluate the likely impacts arising out of any new or existing projects in socio-economic environment, it is necessary to gauge the apprehension of the people in the surrounding areas. Socio-economic survey serves as an effective tool for fulfilling this requirement.

The rapid industrialization of the study region has greatly influenced the socio economic and health environment in the villages. Increasing industrialization and population density has increased pressure on resources, civic amenities and public infrastructure. Economic conditions of the local people have improved with the increasing industrialization and greater employment opportunities.

The socio-economic environment includes demography structure, population density, literacy level, and employment levels. The data establish a baseline for the prediction of likely impacts of the proposed activity on the socio-economic environment. Secondary information pertaining to the study area villages was collected from Government Agencies, Census data for the year 2011, and statistical abstracts to compile the socio-economic data.

### 3.18.1 Socio-Economic Survey Methodology

Socio-economic survey tools provide a means of improving understanding of local resource management systems, resource use and the relative importance of resources for households and villages. They can also be used to elicit insights on interaction with government decision-making systems, community perceptions of trends and priority issues, and community-based institutions and their role in the sustainable use and conservation of natural resources.

**Data Collection:** Following steps were considered for the collection of primary data:

**1. Identification of Study Area:** The study area was identified before carrying out the survey. All the related information which could affect the prosperity, development & literacy were also collected.

**2. Site Visit:** Location wise survey plan & format for data collection were prepared for site visit. Data regarding Land Characteristics, Population, Literacy, Workers and Amenities were collected during the survey.

**Analysis of Data:** The data collected by primary survey were verified with secondary data collected from sources like Government Agencies, Census data for the year 2011, and statistical abstracts. Photographs of Socio economic survey are presented in **Figure 3.32.**


**SE Survey –Chitturu**


**SE Survey- Kaza**


SE Survey – Tarakaturu


SE Survey – Gududru

**Figure 3.32 Photographs of Socioeconomic Survey**

### 3.18.2 Demography

Almost all villages in the study area are experiencing a rapid growth of population due to industrialization. The total population of study region is summarized in **Table 3.40.**

### 3.18.3 Population Density

Population density in the study area varies from 86–6017 person/sq. km. Details of the same are tabulated in **Table 3.41.**

**Table 3.41 Details of Population in Study Area**

| Villages | No. of Household | Total Population | Total SC | Total ST | Total area (Sq.km) | Population density (Person/sq.km) |
|---|---|---|---|---|---|---|
| Tarakaturu | 1083 | 3680 | 511 | 98 | 8.30 | 443 |
| Maddipatla | 161 | 556 | 143 | 10 | 2.59 | 215 |
| Kanchakodur | 345 | 1162 | 417 | 0 | 2.75 | 423 |
| Rayavaram | 776 | 2633 | 209 | 27 | 4.75 | 554 |
| Akumarru | 190 | 635 | 271 | 1 | 1.63 | 390 |
| Chittiguduru | 308 | 1100 | 501 | 2 | 2.43 | 453 |
| Guduru | 1888 | 6786 | 1194 | 80 | 10.63 | 638 |
| Kokanarayanapalem | 344 | 1305 | 3 | 24 | 5.41 | 241 |
| Narikedalapalem | 244 | 786 | 112 | 9 | 2.04 | 385 |
| Kalapatam | 135 | 445 | 207 | 0 | 1.97 | 226 |
| Pinagudurulanka | 96 | 397 | 0 | 0 | 2.26 | 176 |
| Kankatava | 600 | 2141 | 554 | 63 | 10.98 | 195 |
| Polavaram | 1022 | 3345 | 264 | 100 | 0.51 | 6559 |
| Mallavolu | 2105 | 6886 | 497 | 80 | 25.56 | 269 |
| Lellagaruvu | 231 | 726 | 0 | 0 | 1.82 | 399 |
| Kappaladoddi | 889 | 3142 | 185 | 41 | 3.27 | 961 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Jakkamcherla | 178 | 583 | 110 | 0 | 1.80 | 324 |
| Mukkollu | 582 | 2020 | 222 | 9 | 11.60 | 174 |
| Palankipadu | 222 | 649 | 54 | 0 | 2.42 | 268 |
| Kaza | 2344 | 7687 | 2311 | 69 | 24.84 | 309 |
| Nidumolu | 1739 | 5999 | 1679 | 427 | 19.31 | 311 |
| Pedamuttevi | 1059 | 3300 | 1265 | 80 | 12.40 | 266 |
| Kosuru | 1563 | 5099 | 1236 | 72 | 12.81 | 398 |
| Sultannagaram Gollapalem | 1862 | 6005 | 468 | 55 | 11.85 | 507 |
| Rudravaram | 455 | 1779 | 858 | 47 | 10.49 | 170 |
| Arisepalle | 732 | 2570 | 145 | 9 | 9.70 | 265 |
| Endakuduru | 356 | 1205 | 310 | 15 | 7.18 | 168 |
| Chitturu | 267 | 897 | 198 | 1 | 6.09 | 147 |
| Pushadam | 333 | 956 | 217 | 0 | 3.63 | 263 |
| Mallampalle | 582 | 1957 | 127 | 36 | 2.95 | 663 |
| Nemmikuru | 391 | 1818 | 384 | 65 | 5.78 | 315 |
| Kapavaram | 212 | 745 | 239 | 0 | 3.89 | 192 |
| Nimmaluru | 328 | 1000 | 365 | 17 | 5.17 | 193 |
| Yelakurru | 348 | 1144 | 58 | 53 | 1.95 | 587 |
| Dokiparru | 1670 | 5909 | 2348 | 178 | 15.84 | 373 |
| Nagavaram | 66 | 229 | 60 | 0 | 0.87 | 263 |
| **Total** | **25706** | **87276** | **17722** | **1668** | **257.47** | **18683** |

### 3.18.4 Sex Ratio

The sex ratio i.e. the number of females per 1000 males is in range of 781 - 1140 with lowest in Rudravaram and highest in Nagavaram. The Sex ratio i.e. the number of females per 1000 males indirectly reveals certain sociological aspect in relation to female births, infant mortality among female children. Details of the same are tabulated in **table 3.42.**

**Table 3.42 Details of Sex Ratio in Study Area**

| Zone of Study | Male Population | Female Population | Total Population | Sex Ratio (Female to 1000 Male) |
|---|---|---|---|---|
| Tarakaturu | 1858 | 1822 | 3680 | 981 |
| Maddipatla | 280 | 276 | 556 | 986 |
| Kanchakodur | 591 | 571 | 1162 | 966 |
| Rayavaram | 1310 | 1323 | 2633 | 1010 |
| Akumarru | 307 | 328 | 635 | 1068 |
| Chittiguduru | 554 | 546 | 1100 | 986 |
| Guduru | 3367 | 3419 | 6786 | 1015 |
| Kokanarayanapalem | 666 | 639 | 1305 | 959 |
| Narikedalapalem | 385 | 401 | 786 | 1042 |
| Kalapatam | 232 | 213 | 445 | 918 |
| Pinagudurulanka | 199 | 198 | 397 | 995 |
| Kankatava | 1125 | 1016 | 2141 | 903 |
| Polavaram | 1677 | 1668 | 3345 | 995 |
| Mallavolu | 3455 | 3431 | 6886 | 993 |
| Lellagaruvu | 368 | 358 | 726 | 973 |
| Kappaladoddi | 1555 | 1587 | 3142 | 1021 |
| Jakkamcherla | 305 | 278 | 583 | 911 |
| Mukkollu | 1024 | 996 | 2020 | 973 |

| | | | | |
|---|---|---|---|---|
| Palankipadu | 324 | 325 | 649 | 1003 |
| Kaza | 3974 | 3713 | 7687 | 934 |
| Nidumolu | 3067 | 2932 | 5999 | 956 |
| Pedamuttevi | 1626 | 1674 | 3300 | 1030 |
| Kosuru | 2577 | 2522 | 5099 | 979 |
| Sultannagaram Gollapalem | 3049 | 2956 | 6005 | 969 |
| Rudravaram | 999 | 780 | 1779 | 781 |
| Arisepalle | 1316 | 1254 | 2570 | 953 |
| Endakuduru | 617 | 588 | 1205 | 953 |
| Chitturu | 443 | 454 | 897 | 1025 |
| Pushadam | 494 | 462 | 956 | 935 |
| Mallampalle | 1001 | 956 | 1957 | 955 |
| Nemmikuru | 937 | 881 | 1818 | 940 |
| Kapavaram | 354 | 391 | 745 | 1105 |
| Nimmaluru | 484 | 516 | 1000 | 1066 |
| Yelakurru | 561 | 583 | 1144 | 1039 |
| Dokiparru | 2982 | 2927 | 5909 | 982 |
| Nagavaram | 107 | 122 | 229 | 1140 |
| **Total** | **44170** | **43106** | **87276** | - |

### 3.18.5 Literacy Rate

The literacy level of the study area is summarized in **table 3.43** and graphically presented in **figure 3.33.**

## Table 3.43 Details of Literacy Rate in Study Area

| Villages | Literate | | | Illiterate | | | Literate (%) | | | Illiterate (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Male | Female | Total | Male | Female | Total | Male | Female | Total | Male | Female | Total |
| Tarakaturu | 1354 | 1218 | 2572 | 504 | 604 | 1108 | 72.87 | 66.85 | 69.89 | 27.13 | 33.15 | 30.11 |
| Maddipatla | 179 | 146 | 325 | 101 | 130 | 231 | 63.93 | 52.90 | 58.45 | 36.07 | 47.10 | 41.55 |
| Kanchakodur | 434 | 373 | 807 | 157 | 198 | 355 | 73.43 | 65.32 | 69.45 | 26.57 | 34.68 | 30.55 |
| Rayavaram | 958 | 839 | 1797 | 352 | 484 | 836 | 73.13 | 63.42 | 68.25 | 26.87 | 36.58 | 31.75 |
| Akumarru | 228 | 250 | 478 | 79 | 78 | 157 | 74.27 | 76.22 | 75.28 | 25.73 | 23.78 | 24.72 |
| Chittiguduru | 411 | 357 | 768 | 143 | 189 | 332 | 74.19 | 65.38 | 69.82 | 25.81 | 34.62 | 30.18 |
| Guduru | 2536 | 2426 | 4962 | 831 | 993 | 1824 | 75.32 | 70.96 | 73.12 | 24.68 | 29.04 | 26.88 |
| Kokanarayanapalem | 459 | 357 | 816 | 207 | 282 | 489 | 68.92 | 55.87 | 62.53 | 31.08 | 44.13 | 37.47 |
| Narikedalapalem | 253 | 249 | 502 | 132 | 152 | 284 | 65.71 | 62.09 | 63.87 | 34.29 | 37.91 | 36.13 |
| Kalapatam | 158 | 120 | 278 | 74 | 93 | 167 | 68.10 | 56.34 | 62.47 | 31.90 | 43.66 | 37.53 |
| Pinagudurulanka | 163 | 145 | 308 | 36 | 53 | 89 | 81.91 | 73.23 | 77.58 | 18.09 | 26.77 | 22.42 |
| Kankatava | 804 | 611 | 1415 | 321 | 405 | 726 | 71.47 | 60.14 | 66.09 | 28.53 | 39.86 | 33.91 |
| Polavaram | 1311 | 1069 | 2380 | 366 | 599 | 965 | 78.18 | 64.09 | 71.15 | 21.82 | 35.91 | 28.85 |
| Mallavolu | 2146 | 1900 | 4046 | 1309 | 1531 | 2840 | 62.11 | 55.38 | 58.76 | 37.89 | 44.62 | 41.24 |
| Lellagaruvu | 264 | 228 | 492 | 104 | 130 | 234 | 71.74 | 63.69 | 67.77 | 28.26 | 36.31 | 32.23 |
| Kappaladoddi | 1104 | 963 | 2067 | 451 | 624 | 1075 | 71.00 | 60.68 | 65.79 | 29.00 | 39.32 | 34.21 |
| Jakkamcherla | 232 | 182 | 414 | 73 | 96 | 169 | 76.07 | 65.47 | 71.01 | 23.93 | 34.53 | 28.99 |
| Mukkollu | 688 | 681 | 1369 | 336 | 315 | 651 | 67.19 | 68.37 | 67.77 | 32.81 | 31.63 | 32.23 |
| Palankipadu | 231 | 198 | 429 | 93 | 127 | 220 | 71.30 | 60.92 | 66.10 | 28.70 | 39.08 | 33.90 |
| Kaza | 2787 | 2225 | 5012 | 1187 | 1488 | 2675 | 70.13 | 59.92 | 65.20 | 29.87 | 40.08 | 34.80 |
| Nidumolu | 2171 | 1850 | 4021 | 896 | 1082 | 1978 | 70.79 | 63.10 | 67.03 | 29.21 | 36.90 | 32.97 |
| Pedamuttevi | 1115 | 1017 | 2132 | 511 | 657 | 1168 | 68.57 | 60.75 | 64.61 | 31.43 | 39.25 | 35.39 |
| Kosuru | 1919 | 1713 | 3632 | 658 | 809 | 1467 | 74.47 | 67.92 | 71.23 | 25.53 | 32.08 | 28.77 |
| Sultannagaram Gollapalem | 2047 | 1755 | 3802 | 1002 | 1201 | 2203 | 67.14 | 59.37 | 63.31 | 32.86 | 40.63 | 36.69 |
| Rudravaram | 806 | 472 | 1278 | 193 | 308 | 501 | 80.68 | 60.51 | 71.84 | 19.32 | 39.49 | 28.16 |
| Arisepalle | 954 | 833 | 1787 | 362 | 421 | 783 | 72.49 | 66.43 | 69.53 | 27.51 | 33.57 | 30.47 |
| Endakuduru | 411 | 349 | 760 | 206 | 239 | 445 | 66.61 | 59.35 | 63.07 | 33.39 | 40.65 | 36.93 |
| Chitturu | 327 | 326 | 653 | 116 | 128 | 244 | 73.81 | 71.81 | 72.80 | 26.19 | 28.19 | 27.20 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pushadam | 339 | 304 | 643 | 155 | 158 | 313 | 68.62 | 65.80 | 67.26 | 31.38 | 34.20 | 32.74 |
| Mallampalle | 660 | 528 | 1188 | 341 | 428 | 769 | 65.93 | 55.23 | 60.71 | 34.07 | 44.77 | 39.29 |
| Nemmikuru | 821 | 714 | 1535 | 116 | 167 | 283 | 87.62 | 81.04 | 84.43 | 12.38 | 18.96 | 15.57 |
| Kapavaram | 297 | 297 | 594 | 57 | 94 | 151 | 83.90 | 75.96 | 79.73 | 16.10 | 24.04 | 20.27 |
| Nimmaluru | 340 | 326 | 666 | 144 | 190 | 334 | 70.25 | 63.18 | 66.60 | 29.75 | 36.82 | 33.40 |
| Yelakurru | 394 | 375 | 769 | 167 | 208 | 375 | 70.23 | 64.32 | 67.22 | 29.77 | 35.68 | 32.78 |
| Dokiparru | 1950 | 1722 | 3672 | 1032 | 1205 | 2237 | 65.39 | 58.83 | 62.14 | 34.61 | 41.17 | 37.86 |
| Nagavaram | 90 | 101 | 191 | 17 | 21 | 38 | 84.11 | 82.79 | 83.41 | 15.89 | 17.21 | 16.59 |
| **Total** | **31341** | **27219** | **58560** | **12829** | **15887** | **28716** | **-** | - | - | - | - | - |

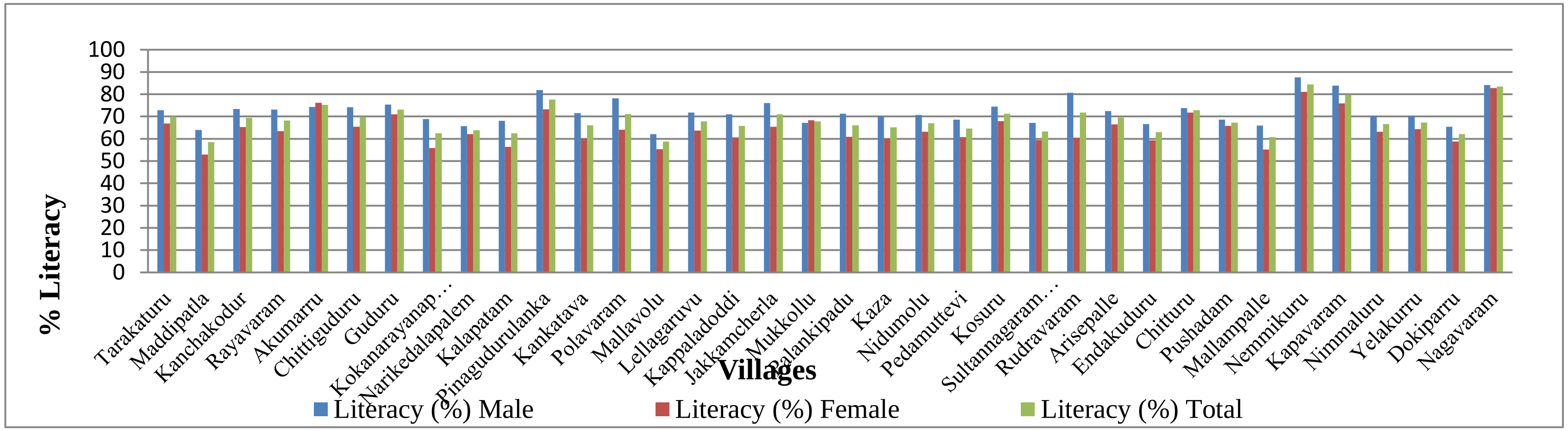


**Figure 3.33 Graph of Literacy Rate**

Among all the villages of study area Nemmikuru is having high literacy rate i.e. 84.43%. There is not much difference between female literacy rate and male literacy rate in the study region. Female literacy rate is an important indicator for social change.

### 3.18.6 Economic Aspects

Economic aspects of the study area include the economic structure of the people of the surrounding area. It can be predicted that economic structure of the study area will be improved with time, because it consists large industrial estate and hence there are more employment opportunities.

According to working status, whole population of the study area is divided into

- Marginal workers
- Non-workers
- Main workers

Census department has defined 10 categories of workers in Main workers. It consists of cultivators, agricultural, labourer those engaged in livestock, forestry, fishing, mining and quarrying, manufacturing, processing and repairs in household industries and other services. Workers engaged in the work for a period less than 6 month during the reference year falls under marginal workers. Workers engaged in unpaid household duties e.g. students, retired person, dependents etc. falls under non-workers. Detail of occupational structure is shown in **table 3.44.**

**Table 3.44 Details of Occupational Structure**

| Zone of Study | Total Workers | | |
|---|---|---|---|
| | Non-Workers (%) | Main Workers (%) | Marginal Workers (%) |
| Tarakaturu | 56.68 | 36.30 | 7.01 |
| Maddipatla | 48.92 | 30.04 | 21.04 |
| Kanchakodur | 46.13 | 13.08 | 40.79 |
| Rayavaram | 37.75 | 53.13 | 9.12 |
| Akumarru | 42.36 | 57.17 | 0.47 |
| Chittiguduru | 61.00 | 31.64 | 7.36 |
| Guduru | 56.09 | 31.14 | 12.78 |
| Kokanarayanapalem | 39.39 | 40.23 | 20.38 |
| Narikedalapalem | 55.09 | 41.98 | 2.93 |
| Kalapatam | 49.89 | 50.11 | 0.00 |
| Pinagudurulanka | 62.22 | 35.01 | 2.77 |
| Kankatava | 46.66 | 42.60 | 10.74 |
| Polavaram | 42.27 | 57.19 | 0.54 |
| Mallavolu | 39.97 | 49.33 | 10.70 |
| Lellagaruvu | 44.35 | 45.87 | 9.78 |
| Kappaladoddi | 38.35 | 60.09 | 1.56 |
| Jakkamcherla | 66.21 | 32.76 | 1.03 |
| Mukkollu | 59.46 | 36.09 | 4.46 |
| Palankipadu | 38.06 | 36.52 | 25.42 |
| Kaza | 44.40 | 44.97 | 10.63 |
| Nidumolu | 43.59 | 55.81 | 0.60 |
| Pedamuttevi | 43.67 | 53.58 | 2.76 |
| Kosuru | 46.62 | 48.13 | 5.26 |
| Sultannagaram Gollapalem | 45.80 | 43.35 | 10.86 |
| Rudravaram | 49.41 | 50.25 | 0.34 |

| | | | |
|---|---|---|---|
| Arisepalle | 48.87 | 50.31 | 0.82 |
| Endakuduru | 35.27 | 58.67 | 6.06 |
| Chitturu | 45.04 | 54.07 | 0.89 |
| Pushadam | 47.80 | 46.55 | 5.65 |
| Mallampalle | 39.35 | 56.82 | 3.83 |
| Nemmikuru | 64.74 | 19.86 | 15.40 |
| Kapavaram | 43.36 | 54.50 | 2.15 |
| Nimmaluru | 51.00 | 45.30 | 3.70 |
| Yelakurru | 46.94 | 50.79 | 2.27 |
| Dokiparru | 45.20 | 40.06 | 14.74 |
| Nagavaram | 40.61 | 29.26 | 30.13 |

Kappaladoddi have significant employment i.e. 60.09% as main workers, while the lowest employment as main workers in Kanchakodur i.e. 13.08%. Almost all the villages have more than 50 % people as non-workers. Rapid industrialization in the last two decades has resulted in significant changes in the occupational profile of the local people. There is an overall trend among the youth to opt for employment in service sector and move away from traditional occupation.

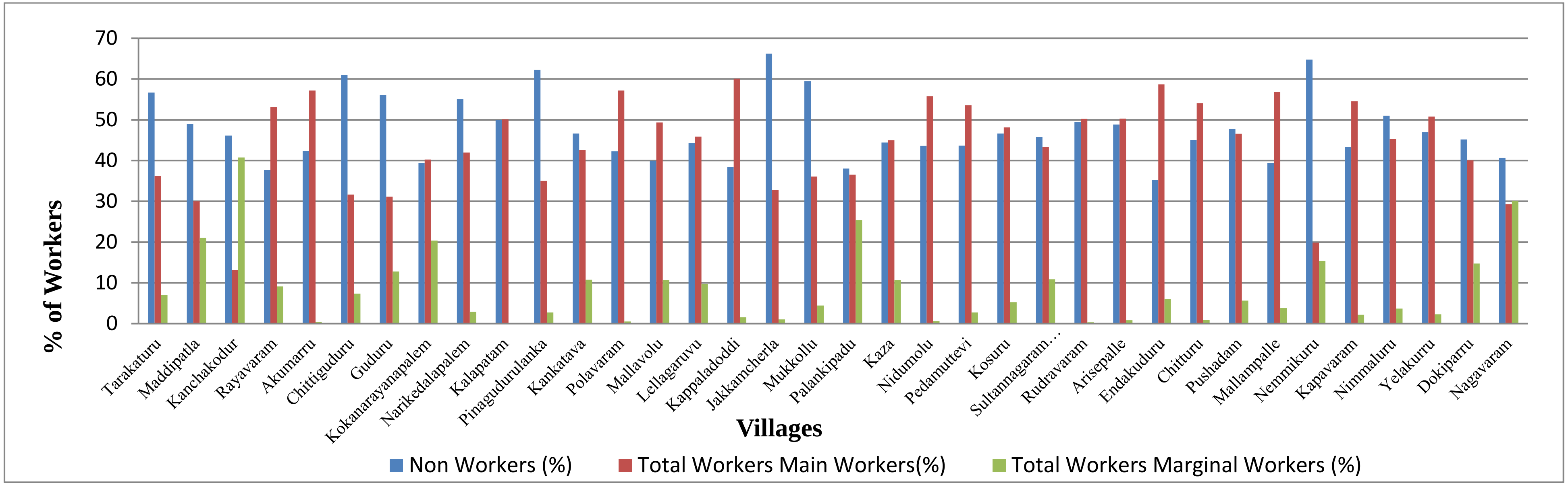


**Figure 3.34 Occupational Structure of Study Area**

### 3.18.7 Amenities

Village-wise detail of infrastructural facilities with appreciate to training, scientific facility, water deliver, conversation and transportation facility and power supply, and banking centres are presented in following Analysis of statistics of 36 villages indicates that infrastructural facilities/simple amenities are to be had in most of the villages, as summarized below:

The significant features of these important parameters for each study area are discussed as follows:

**Education**

As per 2011 village directory record, almost all villages having education facility in the form of primary schools, and middle school are as follows.

| Govt Primary School | Govt Middle School | Govt Secondary School | Govt Senior Secondary School |
|---|---|---|---|
| 36 | 26 | 19 | 1 |

**Medical/Primary Health Care**

Medical facilities in terms of community health workers are available in some of the villages. Primary health centre is available in few villages.

| Community Health Centre | Primary Health Centre | Primary Health Sub Centre | Dispensary | Mobile Health Clinic | Non-Government Medical facilities Medicine Shop |
|---|---|---|---|---|---|
| 1 | 1 | 18 | 1 | 10 | 12 |

**Drinking Water**

The water supply in the region is through dug wells, hand pumps, taps and other allied sources.

| Tap Water-Treated | Tap Water Untreated | Covered Well | Uncovered Well | Hand Pump | Tube Wells/ Borehole | Tank/Pond/Lake |
|---|---|---|---|---|---|---|
| 30 | 5 | 3 | 32 | 21 | 6 | 7 |

**Drainage and Sanitation Facilities**

Drainage and sanitation facilities were not adequate in the study area. Mostly Open drainage, and open kuccha drainage observed in the village.

| Open Drainage | No Drainage | Open Pucca Drainage Covered with Tiles Slabs | Open Pucca Drainage Uncovered | Open Kuccha Drainage |
|---|---|---|---|---|
| 22 | 14 | 1 | 3 | 22 |

**Communication**

Communication facility is fairly good in this region. Near about 50% villages having telephone connectivity and having post office.

| Post Office | Sub Post Office | Telephone (landlines) | Public Call Office /Mobile (PCO) |
|---|---|---|---|
| 9 | 17 | 36 | 29 |

**Transportation**

A well planned and efficient network of transport is an essential component for a developing country. In the absence of efficient network of transport, a State's economy would suffer from major grid lock in terms of overall growth potential of that area. In village public bus facility was availed and other facilities were private bus.

| Public Bus Service | Private Bus Service | Auto/Modified Autos | Taxi | Vans | Tractors |
|---|---|---|---|---|---|
| 29 | 12 | 32 | 10 | 3 | 21 |

**Road Approach Facilities**

Road condition facility was found in village from following.

| Black Topped (pucca) Road | Gravel (kuchha) Roads | Foot path |
|---|---|---|
| 33 | 36 | 36 |

**Bank Facilities**

Banking and credit society facility was found in village. Self-help group activities were performed by the women groups

| Commercial Bank | Cooperative Bank | Agricultural Credit Societies |
|---|---|---|
| 9 | 2 | 18 |

**Power Supply**

Almost all villages are electrified in the region and electricity is available for both domestic and agriculture.

| Power Supply For Domestic Use | Power Supply For Agriculture Use | Power Supply For Commercial Use | Power Supply For All Users |
|---|---|---|---|
| 36 | 36 | 36 | 36 |

**Source:** DCHB 2011, GOI

### 3.18.8 Tourism, Heritage and Cultural Resources

Panduranga Swamy Temple Is A Famous Temple In Chilakalapudi, Machilipatnam, Krishna District In The State Of Andhra Pradesh. This Temple Was Constructed In 1929 By Sri Bhakta Narasimham. It Has A Spiritual Significance Among The People Of Machilipatnam. The Deity And The Garbhagriha Of The Temple Are Very Similar To Pandaripur Temple. An Idol Of Sri Abhayanjaneya Swami (An Incarnation Of Lord Hanuman) Is Installed In Front Of The Lord. Every Year During The Kartika Month There Will Be A Festival Celebrated At This Temple.

The Durga temple is located on the top of a hill called Indrakeeladri at the entrance of the city. This holy shrine of Goddess Durga is a Swayambhu (self-manifested) and is the second largest temple in Andhra Pradesh. The “Dasara” festival is celebrated in a very big way here with large number of pilgrims taking part in the festivities. A holy dip in river Krishna (2 kms from RTC Bus stand) is also a big highlight of the place.

Sri Pandurangaswamy Karthika Uthsavams commence on Karthika Suddha Dasami and conclude on Purnima (October-November) after six days at Sri Pandurangaswamy temple at Machilipatnam near Krishna.

### 3.18.9 Stakeholder Consultation

After the discussion with the objective of identifying key stakeholder groups; studying their profile, characteristics and the nature of their stakes; gauging their influence on the project; and understanding the specific issues, concerns as well as expectations of each group from the project. Following key issues were noted and they are described as under.

➢ **Key Issues**

- Unemployment is an emerging reason among the youths of the villages, which has been discussed during a consultation with a group of young people.

- The facilities from governmental scheme are not thoroughly distributed, to all the villagers.

### 3.18.10 Interpretation of Socio Economic Data

During the primary survey it was observed that almost pakka road facility is available in all villages within 10 km radius. Literacy rate of the study region is from 58.45 to 84.43%. On the basis of survey for literacy rate data it is interpreted that there is need to promote educate more and more people. Almost all the villages have more than 50 % people as non-workers. It indicates that the problem of unemployment can be solved by providing proper training and education. There is also need to establish more industries so that maximum number of employment can be generated. Basic amenities like Education facilities Health care facilities, water supply, electric power supply, mode of transportation etc. are available in all villages.

## 3.19 SUMMARY

| **Ambient Air Quality Monitoring** | | | | | | |
|---|---|---|---|---|---|---|
| **Sr. No.** | **Criteria Pollutants** | **Unit** | **Maximum Value** | **Minimum Value** | **98th Percentile Value** | **Prescribed Standard** |
| 1. | $PM_{10}$ | µg/m$^3$ | 65.3 | 40.3 | 63.9 | 100 |
| 2. | $PM_{2.5}$ | µg/m$^3$ | 35.3 | 19.0 | 35.3 | 60 |
| 3. | $SO_2$ | µg/m$^3$ | 18.5 | 11.1 | 18.2 | 80 |
| 4. | $NO_X$ | µg/m$^3$ | 22.6 | 14.2 | 22.5 | 80 |
| All the results of ambient air quality parameters have been found well within the limit as per NAAQS. Based on comparison study of results for tested parameters with NAAQS, it is interpreted that ambient air quality of studied locations is good. This interpretation relate to the results found for particular locations and study period. | | | | | | |

| **Noise Monitoring** | | | | | |
|---|---|---|---|---|---|
| **Sr. No.** | **Parameter** | **Unit** | **Maximum Value** | **Minimum Value** | **Prescribed Standard** |
| 1. | Leq (Day) | dB(A) | 52.2 | 50.6 | 55 |
| 2. | Leq(Night) | dB(A) | 42.1 | 40.5 | 45 |
| Based on noise level data obtained during the survey, it is interpreted that noise levels are within the standard norms prescribed by MoEF & CC. Looking towards the increase in noise generating sources it is suggested that there is need to apply noise reducing devices at noise generating sources and generate public awareness. | | | | | |

| **Soil Quality and Characteristics** | | | | |
|---|---|---|---|---|
| **Sr. No.** | **Parameter** | **Unit** | **Maximum Value** | **Minimum Value** |
| 1. | pH | - | 8.00 | 7.38 |
| 2. | Electrical Conductivity | dS/m | 1.34 | 0.76 |
| 3. | Sodium | meq/100gm | 2.6 | 1.0 |
| 4. | Potassium | meq/100gm | 1.1 | 0.4 |
| 5. | Phosphorous | mg/100g | 14.6 | 9.2 |
| 6. | Total Nitrogen | % | 0.049 | 0.021 |

Based on soil analysis data it is concluded that soil at the project site is slightly saline (EC>0.8 dS/m). The soils are low to medium in nitrogen, low in phosphorus and high in available potassium status. The levels of total Fe, Cu, Cr, B and Zn are within the limits. However, for successful greenbelt development liberal quantity of organic manure (50 tons/ha) and recommended doses of N and double the recommended dose of P fertilizers should be applied. The potassium is adequate; hence 20 % less than the recommended dose for green belt should be applied. Soil at the site is having good fertility based on CEC value. The soil at the project site should be periodically monitored for EC, pH and ESP as well as OC (organic carbon), available P and K status post monsoon.

**Ground Water**

| Sr. No. | Parameter | Unit | Maximum Value | Minimum Value | Desirable Limit | Permissible Limit |
|---|---|---|---|---|---|---|
| 1. | pH | - | 7.57 | 6.98 | 6.5-8.5 | No Relaxation |
| 2. | TDS | mg/L | 4856 | 582 | 500 | 2000 |
| 3. | TSS | mg/L | BDL | BDL | - | - |
| 4. | Total Hardness | mg/L | 1250 | 290 | 200 | 600 |
| 5. | Chloride | mg/L | 2319 | 120 | 250 | 1000 |
| 6. | Total Alkalinity | mg/L | 780 | 240 | 200 | 600 |
| 7. | Fluoride | mg/L | 0.5 | 0.1 | 1.0 | 1.5 |
| 8. | Iron | mg/L | 0.28 | 0.05 | 0.3 | No Relaxation |

During the analysis it was observed that results of all tested parameters are within the permissible limit as per IS 10500: 2012 except Kaza and S.N. Gollapalem. Test results of the parameter Total Hardness, TDS and Chloride for the water sample collected from Kaza and S.N. Gollapalem do not meet with the drinking water norms. Ground water sources for Kaza and S.N.Gollapalem should not be used in drinking purpose but they can be utilized in other domestic purposes as well as in irrigation. Results of water sample collected from other locations are within the permissible range as per IS 10500:2012. These water sources can be used in all domestic purposes and they can also be used in drinking purpose in absence of alternate source as results are within the permissible range but they are not in desirable range. It is suggested that wherever the results of alkalinity and Total Hardness are more than desired limit, water should pass through RO to bring the results within the desired limit. This interpretation relate to the sample collected from particular location only.

**Surface Water**

| Sr. No. | Parameter | Unit | Maximum Value | Minimum Value | Inland Surface Water Classification (CPCB Standards) |
|---|---|---|---|---|---|
| 1. | pH | - | 7.74 | 6.95 | 6.5-8.5 |
| 2. | TDS | mg/L | 756 | 310 | 2100 |
| 3. | DO | mg/L | 4.9 | 4.0 | - |
| 4. | COD | mg/L | 11 | 7 | - |
| 5. | BOD | mg/L | 36 | 20 | - |

Based on test result data comparison study with CPCB Standards (Inland Surface Water Classification), it is interpreted that surface water quality meets with the class D & E. This water can be used for Propagation of wild life, fisheries and Irrigation, industrial, cooling, controlled waste disposal purpose. COD and BOD have been reported more than 4 mg/L, it indicates towards the organic contamination in water bodies. Looking to the pollution load it is suggested that untreated domestic/industrial water should not be reach in water bodies.

**Ecology and Biodiversity**

Farley rich forestic biodiversity is present in the core and buffer zone in the study area. There was no endemic and threatened plant species was observed in the study region during the survey. There is no declared sanctuary park and reserve forest in the study region. In case of avi fauna only schedule IV species have been recorded from the study region and in case of reptile schedule II species like cobra has been observed. No protected/threatened fauna was cited during the survey.

| Socio Economic |
| --- |
| During the primary survey it was observed that almost pakka road facility is available in all villages within 10 km radius. Literacy rate of the study region is from 58.45 to 84.43%. On the basis of survey for literacy rate data it is interpreted that there is need to promote educate more and more people. Almost all the villages have more than 50 % people as non-workers. It indicates that the problem of unemployment can be solved by providing proper training and education. There is also need to establish more industries so that maximum number of employment can be generated. Basic amenities like Education facilities Health care facilities, water supply, electric power supply, mode of transportation etc. are available in all villages. |

# CHAPTER 4
# ANTICIPATED ENVIRONMENTAL IMPACT AND MITIGATION MEASURES

This chapter presents the identified environmental impacts due to the proposed project and outlines alternatives any mitigation measures for minimizing adverse impacts.

## 4.1 IMPACT ASSESSMENT METHODOLOGY

An environmental impact identification matrix has been developed to present an overview of possible interactions between project and operation aspects and components of the environment, which may get affected. The matrix considers physical, biological and socio-economic components of the environment on one axis (X axis) and activities of the proposed drilling and operation aspects on the other side (Y axis). Aspects and impacts on environmental components, which would be relevant to the different phases of the project e.g. pre-drilling activities, drilling, production and decommissioning have been addressed in the matrix. Environmental and socio-economic components were identified based on reviewing of applicable legislations project specific features and baseline environment, site reconnaissance visits, discussions with stakeholders.

Potential environmental impacts that may result from any of the identified project activity has been identified in a matrix based on activity-component interaction and is presented in Section 4.2 of this Chapter. The impact which has been identified in the matrix has been assessed for its significance based on significance criteria delineated in the below sections.

## 4.2 IMPACT CRITERIA AND RANKING

Once all project environmental aspects were comprehensively identified for the different activities of the project, the level of impact that may result from each of the activity-component interactions has been assessed based on subjective criteria. For this, three key elements have been taken into consideration based on standard environmental assessment methodologies:

- Severity of Impact: Degree of damage that may be caused to the environmental components concerned;
- Extent of Impact: Geographical spread of impact around project location and corridors of activities; and
- Duration of Impact: Time for which impact lasts taking project life-cycle into account.

These elements have been ranked in three levels viz. 1 (low), 2 (moderate) and 3 (high) based on the following criteria provided in Table 4.1 below:

**Table 4.1 Impact Prediction Criteria**

| S. No | Category | Description of category | Impact | |
|---|---|---|---|---|
| | | | Adverse | Beneficial |
| 1. | No impact | - | 0 | 0 |
| 2. | No appreciable impact | Short term reversible | -1 | 1 |
| 3. | Significant impact | Long term reversible | -2 | 2 |
| 4. | Major impact | Irreversible but of lesser extent | -3 | 3 |
| 5. | High impact | Irreversible but of medium extent | -4 | 4 |
| 6. | Permanent impact | Severe irreversible impact | -5 | 5 |

| S. No. | Cumulative Score | Meaning |
|---|---|---|
| 1. | +ve / -ve | Beneficial impact / adverse impact |
| 2. | 0-150 | No appreciable Beneficial impact / adverse impact |

| | | |
|---|---|---|
| 3. | 151-300 | Appreciable but reversible adverse impact-mitigation measures are needed |
| 4. | 301-450 | Significant adverse impacts: most of the impacts are reversible. Mitigation measures are crucial. |
| 5. | 451-600 | Major adverse impacts; most of the impacts are reversible. Alternative site selection to be considered. |
| 6. | >600 | Permanent irreversible impact; alternatives to the project need to be explored |

## 4.3 IMPACT SIGNIFICANCE

The significance of impact has been determined based on a multiplicative factor of three element rankings. The Table 4.2 (below) depicts impact significance in a scale of LOW-MEDIUM-HIGH and will be used for delineation of preventive actions, if any, and management plans for mitigation of impacts.

Impact significance has been determined considering measures which have been factored in the design and planning phase of the project. Legal issues have been taken into account, wherever appropriate in the criterion sets, to aid in Vedanta Limited (Division: Cairn Oil & Gas) effort to comply with all relevant legislation and project HSE requirements.  Additionally, the results of quantitative impact prediction exercise, wherever undertaken, have also been fed into the process.

| | | | Impact | | | | |
|---|---|---|---|---|---|---|---|
| | | | Very low 1 | Low 2 | Medium 3 | High 4 | Very High 5 |
| Probability | Very High | 5 | 5 | 10 | 15 | 20 | 25 |
| | High | 4 | 4 | 8 | 12 | 16 | 20 |
| | Medium | 3 | 3 | 6 | 9 | 12 | 15 |
| | Low | 2 | 2 | 4 | 6 | 8 | 10 |
| | Very Low | 1 | 1 | 2 | 3 | 4 | 5 |

**Figure 4.1: Impact Quantification Chart**

To assist in determining and presenting significance of an impact, an impact evaluation matrix (Table 4.3) has been developed. In addition to ranked weights, significance of impacts has been depicted using colour codes for easy understanding. In case, an environmental component is impacted by more than one project activity or the activity would impact a sensitive receptor e.g. settlement, school, hospitals, forest etc. a high significance ranking of “>12” has been considered. A second evaluation matrix presents significance of impacts after considering that proposed mitigation measures will be implemented. The impacts on each of the environmental components and its significance during the different stages of the project have been discussed in detail in the following section. This is followed by a point wise outline of mitigation measures recommended.

**Table 4.2 Impact Identification Matrix**

| Activities | Environmental Attributes | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Air | Water | Soil | Noise | LU/LC | Hydro geology | Geology | Risk & Hazardous | Ecology and Biodiversity | Socio Economic |
| **A. Pre-drilling Activities** | | | | | | | | | | |
| Site & Access road development | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | - | - | ✔ | ✔ |
| Transportation of drilling Rig, Materials and ancillaries | ✔ | - | ✔ | ✔ | - | - | - | ✔ | ✔ | ✔ |
| **B. Well Drilling and development** | | | | | | | | | | |
| Operation of DG sets and machineries | ✔ | - | ✔ | ✔ | - | - | - | - | - | - |
| Casing and cementing of exploratory well | - | ✔ | ✔ | ✔ | - | ✔ | - | - | - | - |
| Preparation of drilling fluid (Mud) and drill cutting disposal | - | ✔ | ✔ | - | - | ✔ | - | ✔ | ✔ | - |
| Well drilling | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | - | ✔ | ✔ | ✔ |
| Well testing & Flaring | ✔ | - | ✔ | - | - | - | - | ✔ | ✔ | ✔ |
| Greenbelt development | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | - | - | ✔ | - |
| Recruitment/Employment | - | ✔ | ✔ | - | - | - | - | - | - | ✔ |
| **C. Operation of Well Pad/Production facilities** | | | | | | | | | | |
| Flaring of Gas | ✔ | - | - | - | - | - | - | - | - | - |
| DG/GEG Set of Emission | ✔ | - | - | ✔ | - | - | - | - | - | - |
| Produced Water | - | ✔ | - | - | - | - | - | - | - | - |
| Laying of Pipeline | ✔ | | | | | | | ✔ | | |
| **D. Decommissioning and Reinstatement** | | | | | | | | | | |
| Dismantling of rig & associated Machineries | - | - | ✔ | ✔ | - | - | - | - | - | - |
| Transportation of drilling facilities | ✔ | - | - | ✔ | - | - | - | - | ✔ | - |

## 4.4 IMPACT ASSESSMENT

This section discusses the impacts of the project activities on the environmental receptors that stand to get affected adversely by the project. It discusses probable impacts during various phases of the project lifecycle on the environmental and socio-economic components. Rankings for every activity – component interaction is based on the criterion set earlier and resulting environmental significance with necessary justification that has been recorded below for every set of impacts and the same has been represented in evaluation matrices. In broader context, it is however important to remember that operations related to drilling, testing and completion activities also include positive socio-economic impacts in terms of increase in local business opportunities and on a larger perspective, by providing potential energy security at a national level.

**Table 4.3: Environmental Impact Assessment Matrix without Mitigation Measures**

| Activities | Environmental Attributes | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Air | Water | Soil | Noise | LU/LC | Hydro geology | Geology | Risk Hazardous | Ecology and Biodiversity | Socio Economic | |
| **A. Pre-drilling Activities** | | | | | | | | | | | |
| Site & Access road development | -9 | -6 | -4 | -9 | -6 | -4 | - | - | -6 | -4 | **-48** |
| Transportation of drilling Rig, Materials and ancillaries | -8 | - | -4 | -8 | - | - | - | -6 | -4 | -4 | **-34** |
| **B. Well Drilling and Testing** | | | | | | | | | | | |
| Operation of DG sets and machineries | -6 | - | -4 | -6 | - | - | - | - | - | - | **-16** |
| Casing and cementing of exploratory well | - | -9 | -6 | -8 | - | -4 | - | - | - | - | **-27** |
| Preparation of drilling fluid (Mud) and drill cutting disposal | - | -12 | -9 | - | - | -4 | | -12 | -4 | - | **-41** |
| Well drilling | -16 | -9 | -4 | -12 | -9 | -4 | - | -12 | -6 | -4 | **-76** |
| Well testing & Flaring | -9 | - | -6 | - | - | - | - | -12 | -6 | -4 | **-37** |
| Greenbelt development | +6 | -4 | +6 | +4 | +4 | +2 | - | - | +6 | +4 | **+28** |
| Recruitment/Employment | - | -4 | - | - | - | - | - | - | - | +25 | **+21** |
| **C. Operation of Well Pad/Production facilities** | | | | | | | | | | | |
| Flaring of Gas | -9 | - | - | -8 | - | - | - | - | -6 | - | **-23** |
| DG/GEG Set of Emission | -9 | - | - | -6 | - | - | - | - | - | - | **-15** |
| Produced Water | - | -9 | -6 | - | - | - | - | - | - | - | **-15** |
| **D. Decommissioning and Reinstatement** | | | | | | | | | | | |
| Dismantling of rig & associated machineries | - | - | -4 | -9 | - | - | - | - | - | - | **-13** |
| Transportation of drilling facilities | -6 | - | - | -6 | - | - | - | - | -4 | - | **-16** |
| **Total** | **-66** | **-53** | **-41** | **-68** | **-11** | **-14** | **-** | **-42** | **-30** | **+13** | **-312** |

Total Cumulative Score for various Environmental Parameters without mitigation measures is -312 i.e. Significant adverse impacts: most of the impacts are reversible. Mitigation measures are crucial.

## 4.5 AIR ENVIRONMENT

### 4.5.1 Air Quality Modelling

The flue gas stack is considered as a point source to predict the impact on ambient air quality during the operational phase. The prediction has been done by using AERMOD View Gausian Plume Dispersion model.

**Methodology**

The methodology for Air Quality Modeling using AERMOD View Gausian Plume Dispersion model is given in Figure below:

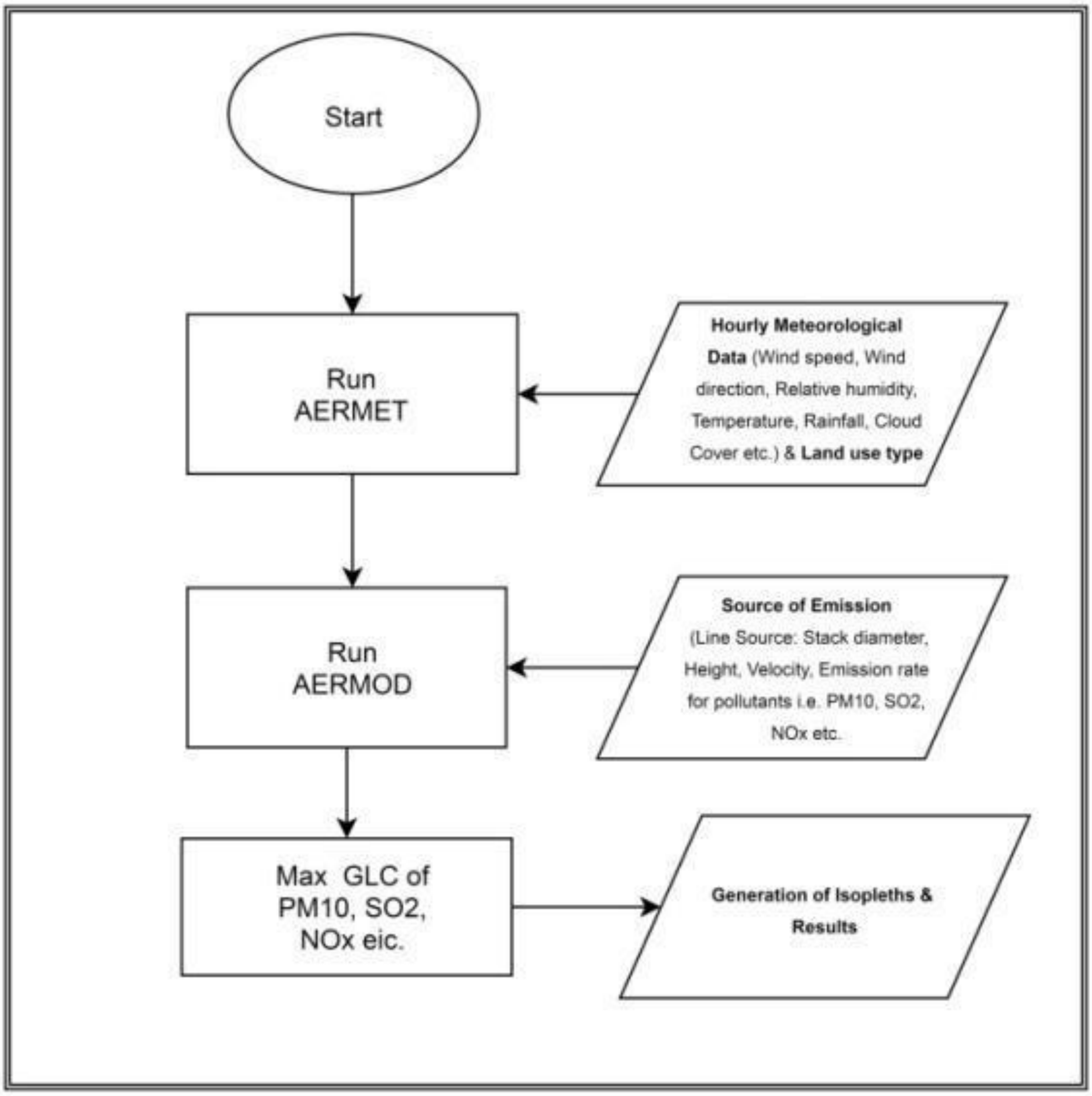


**Figure 4.2: Methodology for AQM**

**Meteorological Parameters**

Surface meteorological data at project site was collected for 1st December 2019 – 29th February 2020. The hourly meteorological data considered during this period were:

- Wind Speed & Direction;
- Ambient atmospheric temperature;
- Cloud cover;
- Relative humidity.

**Following parameters were considered for dispersion modeling – Point Source**

- Quantity of fuel;

- Emission rate of pollutants;
- Stack:
  - Internal diameter at top; and height from ground level;
  - Exit gas velocity;
  - Exit gas temperature.

**Source of Emission**

**Point Source**

- Emission of PM, SO2, NOx from the stack attached to DG Sets & PM, SO2, NOx, HC, CO from the Gas (NG) flare during drilling phase.
- Emission of PM, SO2, NOx, HC from Flare stack during Production phase.

**Assumptions**

The dispersion modeling assumptions considered are as follows:

- The emission rate for PM & $SO_2$ ,CO was calculated based on the specification of HSD (Ash content 0.01 % and Sulphur content 0.25 %) and the $NO_x$ & HC was calculated based on flue gas emission standards.
- The terrain of the study area was considered as flat.

The mathematical equations used for the dispersion modeling assumes that the earth surface acts as a perfect reflector of plume and physic-chemical processes such as dry and wet deposition and chemical transformation of pollutants are negligible.

Input data for the modeling is as follows:

| Stack No. | Scenario | Stack Attached to | Height (m) | Diameter (m) | Exit Gas Temperature (°K) | Exit Gas Velocity (m/s) | Emission Rate (gm/s) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | PM | $SO_2$ | NOx | HC | CO |
| 1. | **Scenario – 1** Emission during Drilling (At each Well) | D G Set (150 KVA) | 2.5 | 0.152 | 523 | 15.93 | 0.004 | 0.006 | 0.124 | 0.018 | 0.047 |
| 2. | | D G set (1500 KVA) | 30 | 0.3 | 758 | 23.36 | 0.067 | 0.042 | 0.880 | 0.075 | 0.405 |
| 3. | | D G set (500 KVA) | 3.5 | 0.1 | 655 | 18.9 | 0.010 | 0.013 | 0.290 | 0.041 | 0.111 |
| 4. | | Flare stack | 30 | 0.762 | 1008 | 40.0 | - | - | 2.0 | - | - |
| | | | | | | | | | | | |
| 1. | **Scenario – 2** Emission during Production | D G set (150 KVA) | 2.5 | 0.152 | 523 | 15.93 | 0.004 | 0.006 | 0.124 | 0.018 | 0.047 |
| 2. | | GEG (500 KVA) | 7.0 | 0.3 | 680 | 10.88 | - | - | 0.444 | - | 0.389 |
| 3. | | Flare stack | 30 | 0.762 | 1008 | 40.0 | - | - | 2.0 | - | - |

## Isopleths & Results

The isopleth of PM, $SO_2$ , NOx , CO and HC during drilling phase is given below:

**Scenario – 1 : Emission during Drilling Phase**

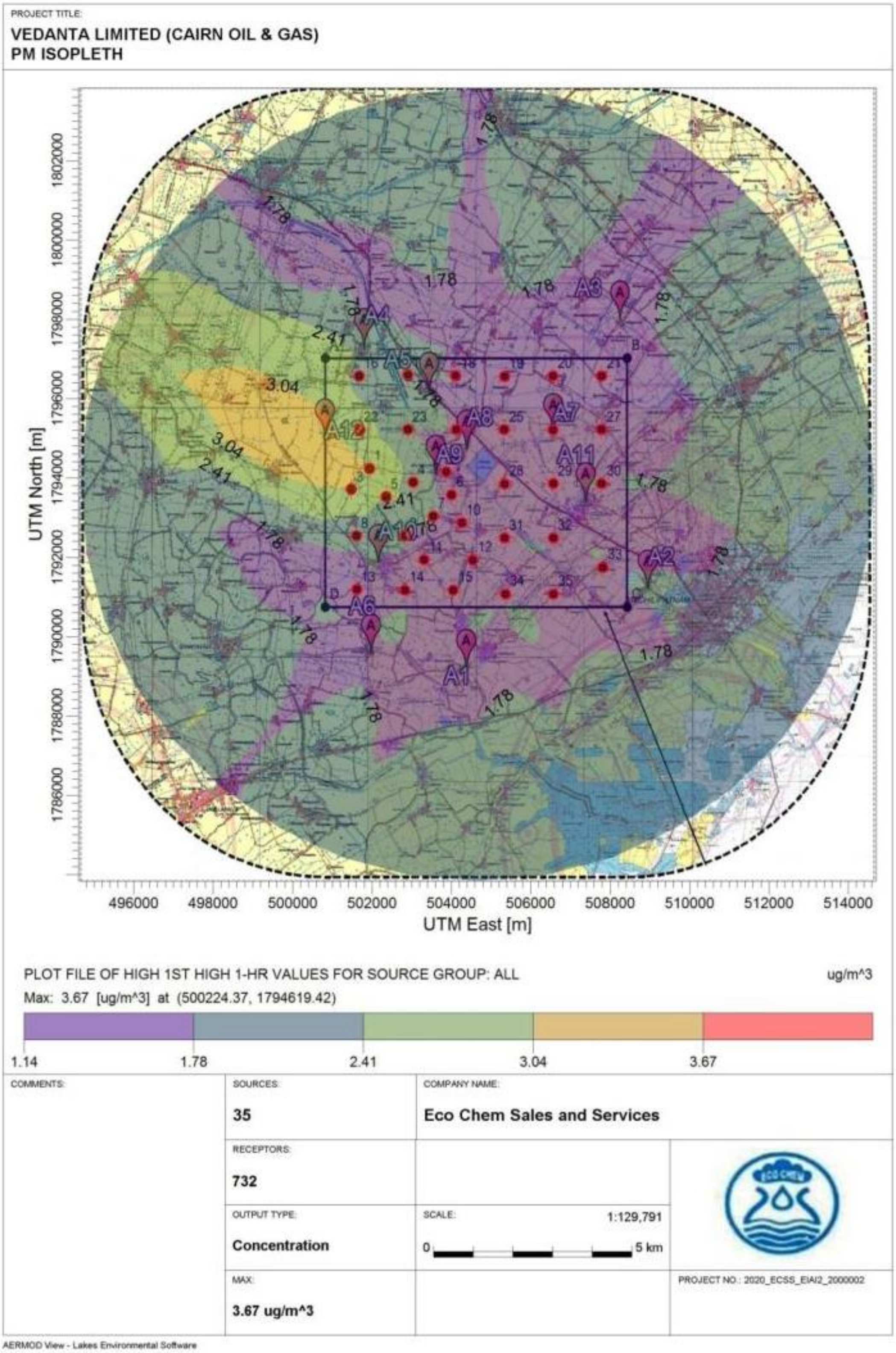


**Figure 4.3: Isopleth for PM emitted from flue gas stacks**

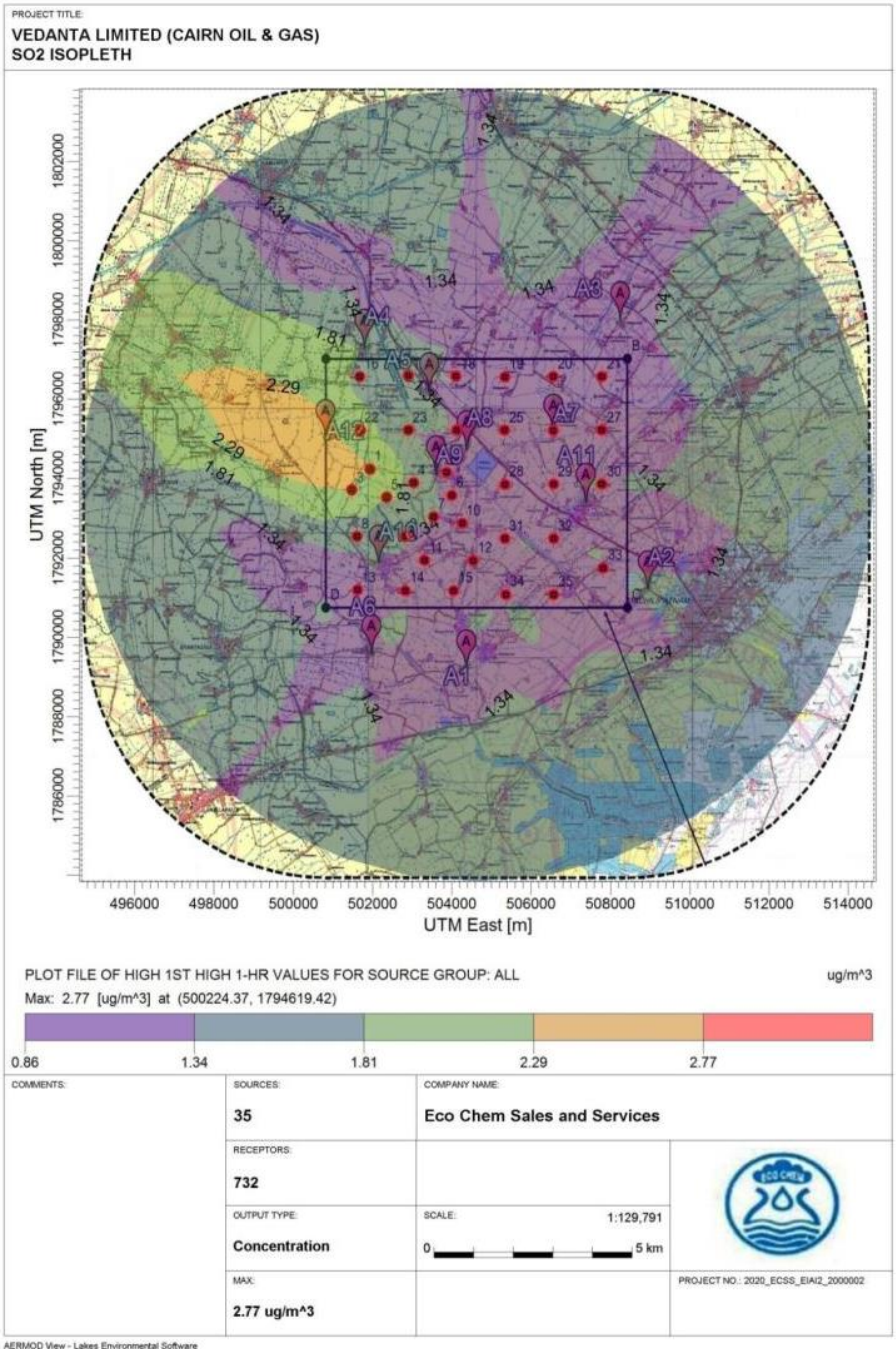


**Figure 4.4: Isopleth for SO2 emitted from flue gas stacks**

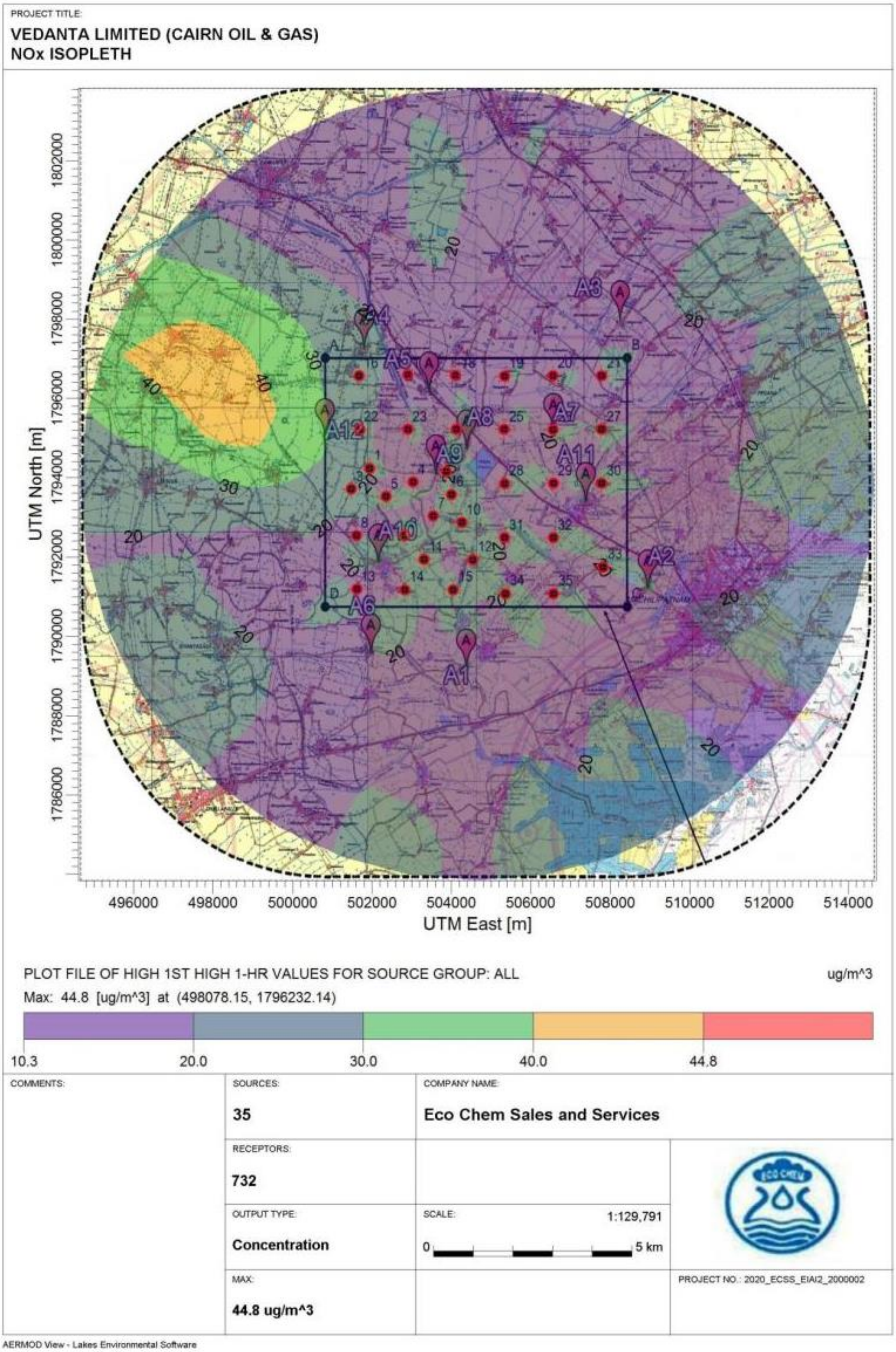


**Figure 4.5: Isopleth for NOx emitted from flue gas stacks**

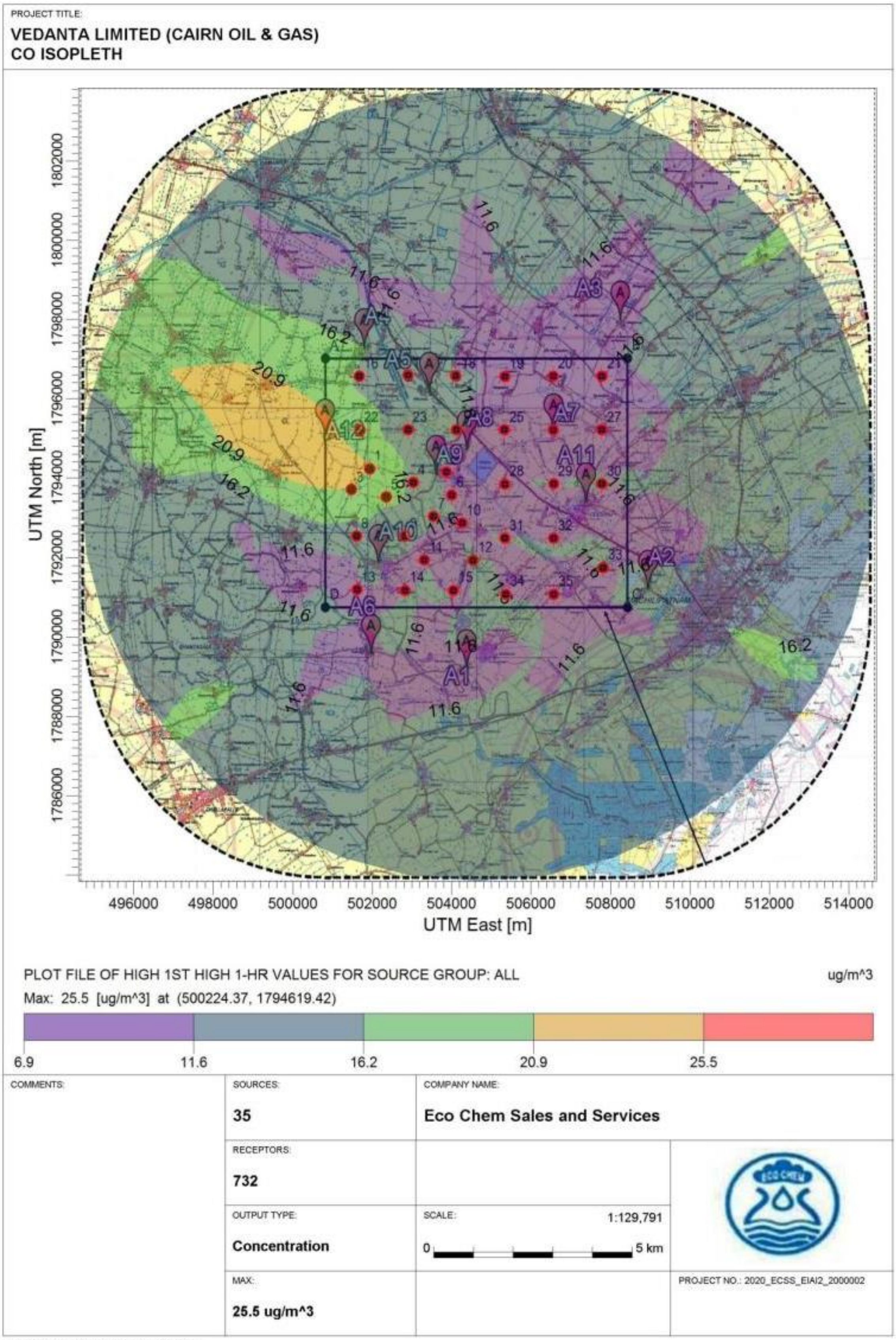


**Figure 4.6: Isopleth for CO emitted from flue gas stacks**

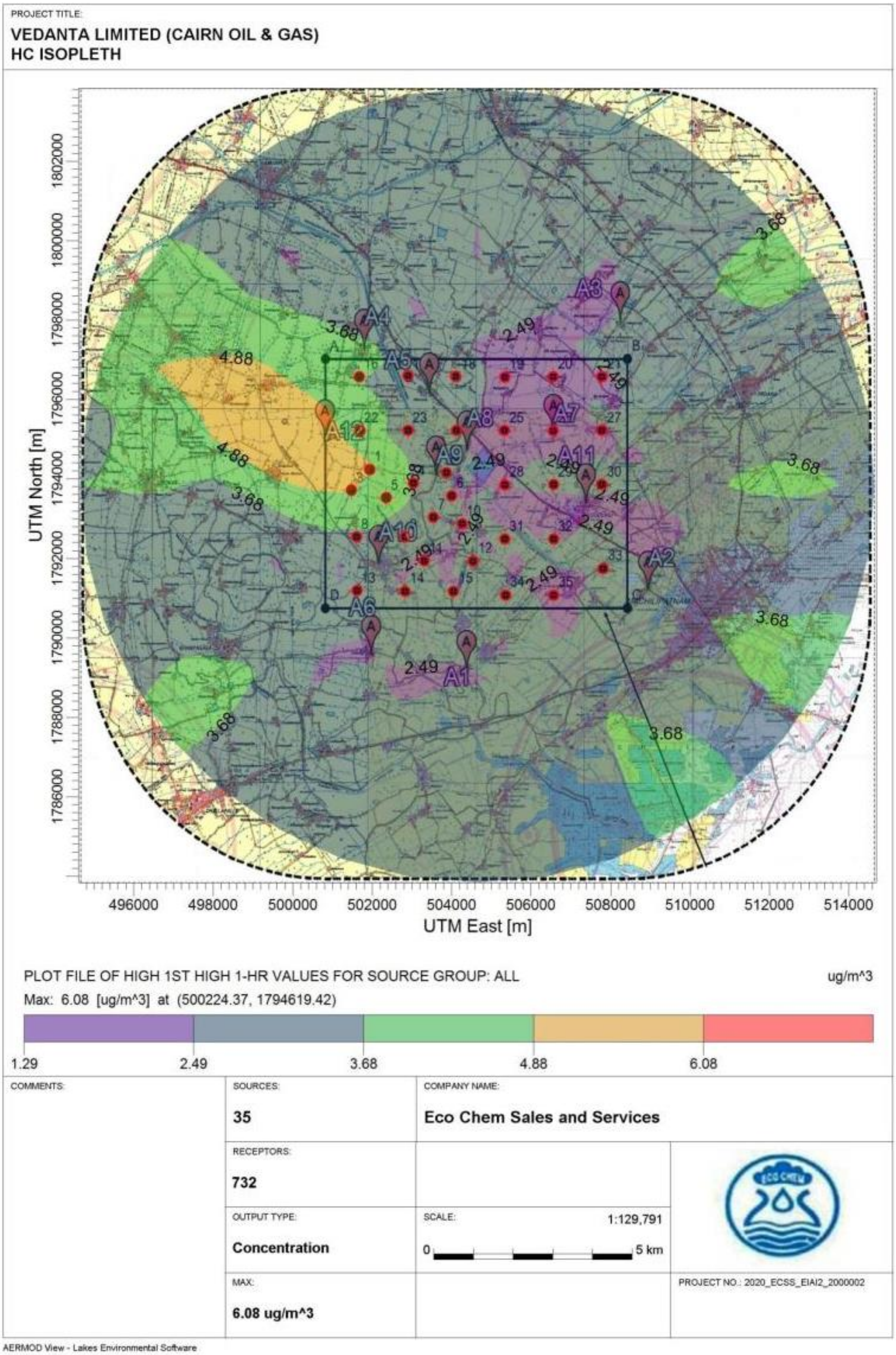


**Figure 4.7: Isopleth for HC emitted from flue gas stacks**

The maximum of 24 hourly highest GLC's of PM, SO2, NOx & HC due to flue gas emission through the stacks attached to DG sets & Flare (Point source) during drilling phase is summarised in Table 4.6 below:

**Table 4.4: Maximum resultant concentration during Drilling Phase**

| S. No. | Ambient Air Monitoring Location | Pollutant | 98th Percentile Baseline Concentration (µg/m³) | Incremental Concentration (µg/m³) | Total GLC (µg/m³) | NAAQS Concentration Limit (µg/m³) |
|---|---|---|---|---|---|---|
| 1 | Chataripalem | $PM_{10}$ | 53.0 | 0.88 | 53.88 | 100 |
| | | $PM_{2.5}$ | 27.4 | 0.59 | 27.99 | 60 |
| | | $SO_2$ | 16.1 | 1.11 | 17.21 | 80 |
| | | $NO_X$ | 19.3 | 18.32 | 37.62 | 80 |
| | | HC | - | 2.44 | 2.44 | - |
| | | CO | 316 | 10.25 | 326.25 | 2000 |
| 2 | S N Gollapalem | $PM_{10}$ | 57.2 | 1.13 | 58.33 | 100 |
| | | $PM_{2.5}$ | 29.3 | 0.76 | 30.06 | 60 |
| | | $SO_2$ | 16.8 | 1.42 | 18.22 | 80 |
| | | $NO_X$ | 19.9 | 20.53 | 40.43 | 80 |
| | | HC | - | 3.12 | 3.12 | - |
| | | CO | 293 | 13.12 | 306.12 | 2000 |
| 3 | Lellagaruvu | $PM_{10}$ | 62.8 | 0.94 | 63.74 | 100 |
| | | $PM_{2.5}$ | 33.0 | 0.63 | 33.63 | 60 |
| | | $SO_2$ | 17.6 | 1.18 | 18.78 | 80 |
| | | $NO_X$ | 22.2 | 17.37 | 39.57 | 80 |
| | | HC | - | 2.59 | 2.59 | - |
| | | CO | 445 | 10.88 | 455.88 | 2000 |
| 4 | Nimmakuru | $PM_{10}$ | 51.0 | 1.40 | 52.40 | 100 |
| | | $PM_{2.5}$ | 26.8 | 0.93 | 27.73 | 60 |
| | | $SO_2$ | 16.2 | 1.76 | 17.96 | 80 |
| | | $NO_X$ | 19.0 | 22.60 | 41.60 | 80 |
| | | HC | - | 3.86 | 3.86 | - |
| | | CO | 303 | 16.22 | 319.22 | 2000 |
| 5 | Nidumolu | $PM_{10}$ | 60.2 | 1.04 | 61.24 | 100 |
| | | $PM_{2.5}$ | 31.3 | 0.69 | 31.99 | 60 |
| | | $SO_2$ | 17.3 | 1.31 | 18.61 | 80 |
| | | $NO_X$ | 20.0 | 15.03 | 35.03 | 80 |
| | | HC | - | 2.87 | 2.87 | - |
| | | CO | 318 | 12.07 | 330.07 | 2000 |
| 6 | Chitturu | $PM_{10}$ | 63.0 | 0.80 | 63.80 | 100 |
| | | $PM_{2.5}$ | 35.3 | 0.53 | 35.83 | 60 |
| | | $SO_2$ | 18.2 | 1.01 | 19.21 | 80 |
| | | $NO_X$ | 22.5 | 19.72 | 42.22 | 80 |
| | | HC | - | 2.21 | 2.21 | - |
| | | CO | 391 | 9.29 | 400.29 | 2000 |
| 7 | Tummalapalem | $PM_{10}$ | 52.1 | 0.90 | 53.00 | 100 |
| | | $PM_{2.5}$ | 27.5 | 0.60 | 28.10 | 60 |
| | | $SO_2$ | 16.6 | 1.13 | 17.73 | 80 |
| | | $NO_X$ | 19.4 | 17.46 | 36.86 | 80 |
| | | HC | - | 2.48 | 2.48 | - |

| S. No. | Ambient Air Monitoring Location | Pollutant | 98th Percentile Baseline Concentration (µg/m³) | Incremental Concentration (µg/m³) | Total GLC (µg/m³) | NAAQS Concentration Limit (µg/m³) |
|---|---|---|---|---|---|---|
| | | CO | 324 | 10.40 | 334.40 | 2000 |
| 8 | Tarakaturu | $PM_{10}$ | 55.4 | 0.90 | 56.30 | 100 |
| | | $PM_{2.5}$ | 28.8 | 0.59 | 29.39 | 60 |
| | | $SO_2$ | 16.6 | 1.12 | 17.72 | 80 |
| | | $NO_X$ | 19.2 | 18.79 | 37.99 | 80 |
| | | HC | - | 2.46 | 2.46 | - |
| | | CO | 291 | 10.33 | 301.33 | 2000 |
| 9 | Maklavaripalem | $PM_{10}$ | 63.9 | 1.02 | 64.92 | 100 |
| | | $PM_{2.5}$ | 33.7 | 0.68 | 34.38 | 60 |
| | | $SO_2$ | 17.6 | 1.27 | 18.87 | 80 |
| | | $NO_X$ | 22.0 | 19.52 | 41.52 | 80 |
| | | HC | - | 2.80 | 2.80 | - |
| | | CO | 383 | 11.76 | 394.76 | 2000 |
| 10 | Kaza | $PM_{10}$ | 52.4 | 1.18 | 53.58 | 100 |
| | | $PM_{2.5}$ | 27.0 | 0.79 | 27.79 | 60 |
| | | $SO_2$ | 16.3 | 1.49 | 17.79 | 80 |
| | | $NO_X$ | 19.6 | 22.42 | 42.02 | 80 |
| | | HC | - | 3.26 | 3.26 | - |
| | | CO | 282 | 13.71 | 295.71 | 2000 |
| 11 | Guduru | $PM_{10}$ | 58.1 | 0.78 | 58.88 | 100 |
| | | $PM_{2.5}$ | 28.7 | 0.52 | 29.22 | 60 |
| | | $SO_2$ | 16.9 | 0.98 | 17.88 | 80 |
| | | $NO_X$ | 20.3 | 16.82 | 37.12 | 80 |
| | | HC | - | 2.16 | 2.16 | - |
| | | CO | 263 | 9.07 | 272.07 | 2000 |
| 12 | Palankipadu | $PM_{10}$ | 64.5 | 1.94 | 66.44 | 100 |
| | | $PM_{2.5}$ | 33.7 | 1.29 | 34.99 | 60 |
| | | $SO_2$ | 18.1 | 2.43 | 20.53 | 80 |
| | | $NO_X$ | 21.6 | 30.79 | 52.39 | 80 |
| | | HC | - | 5.34 | 5.34 | - |
| | | CO | 392 | 22.44 | 414.44 | 2000 |

**Table 4.5: Summary of Point Source Modeling during Drilling Phase**

| Pollutant | Max. Concentration (µg/m³) | Distance (km) | Direction |
|---|---|---|---|
| PM | 3.67 | 4.5 | WNW |
| $SO_2$ | 2.77 | 4.5 | WNW |
| NOx | 44.8 | 7.0 | WNW |
| HC | 6.08 | 4.5 | WNW |
| CO | 25.5 | 4.5 | WNW |

**Conclusion:**

- $PM_{10}$ concentration is observed in the range of 52.40 – 66.44 µg/m³, which is well within the standard limit.

- $PM_{2.5}$ concentration is observed in the range of 27.73 – 35.83 µg/m$^3$, which is well within the standard limit.
- $SO_2$ concentration is observed in the range of 17.21 – 20.53 µg/m$^3$, which is well within the standard limit.
- NOx concentration is observed in the range of 35.03 – 52.39 µg/m$^3$, which is well within the standard limit.
- HC concentration is observed in the range of 2.16 – 5.34 µg/m$^3$.
- CO concentration is observed in the range of 272.07 – 455.88 µg/m$^3$, which is well within the standard limit.

**Scenario – 2: Emission during production stage**

The isopleth of PM, $SO_2$ , NOx , CO and HC during Production phase is given below:

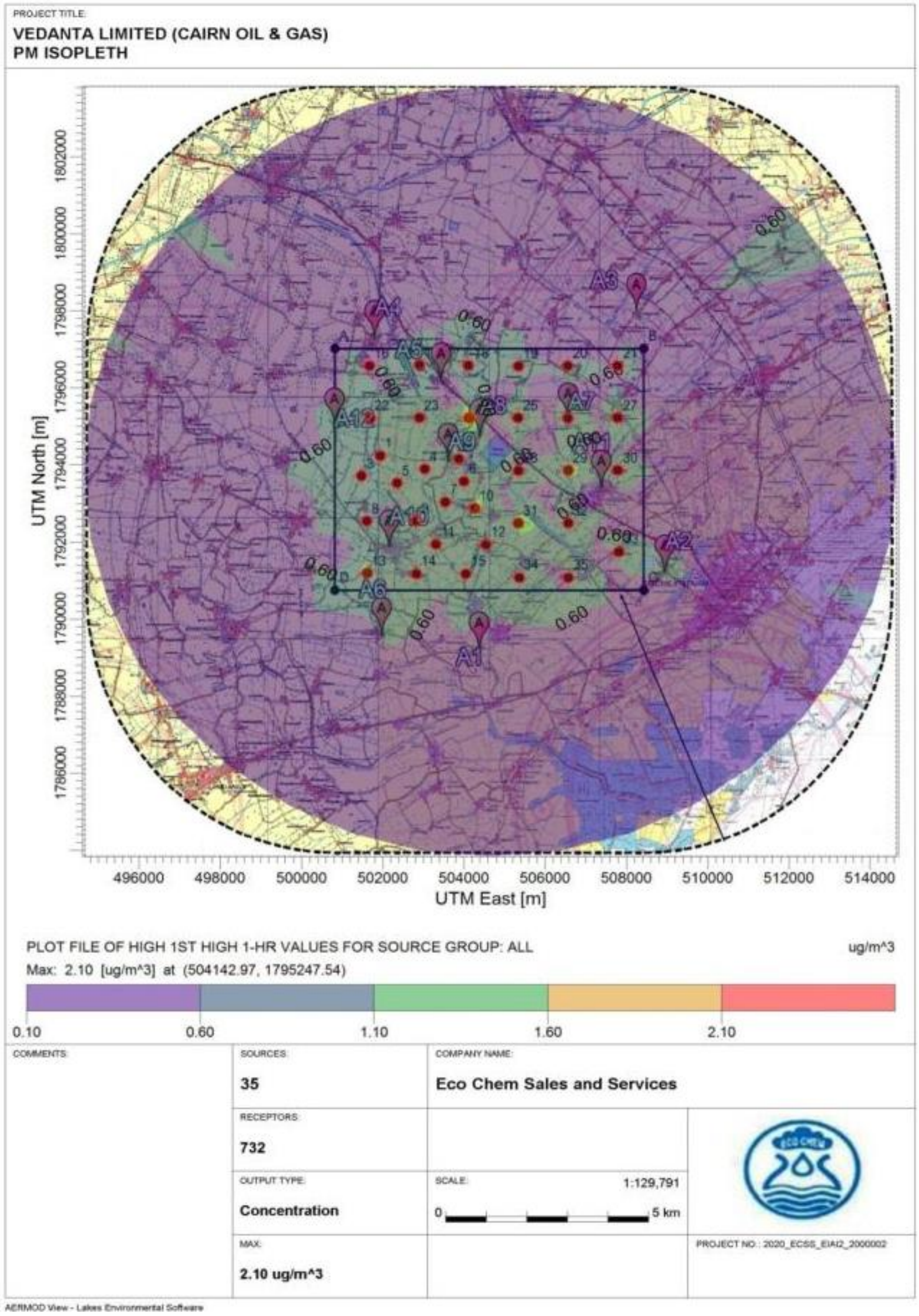


**Figure 4.8: Isopleth for PM10 emitted from flue gas stacks**

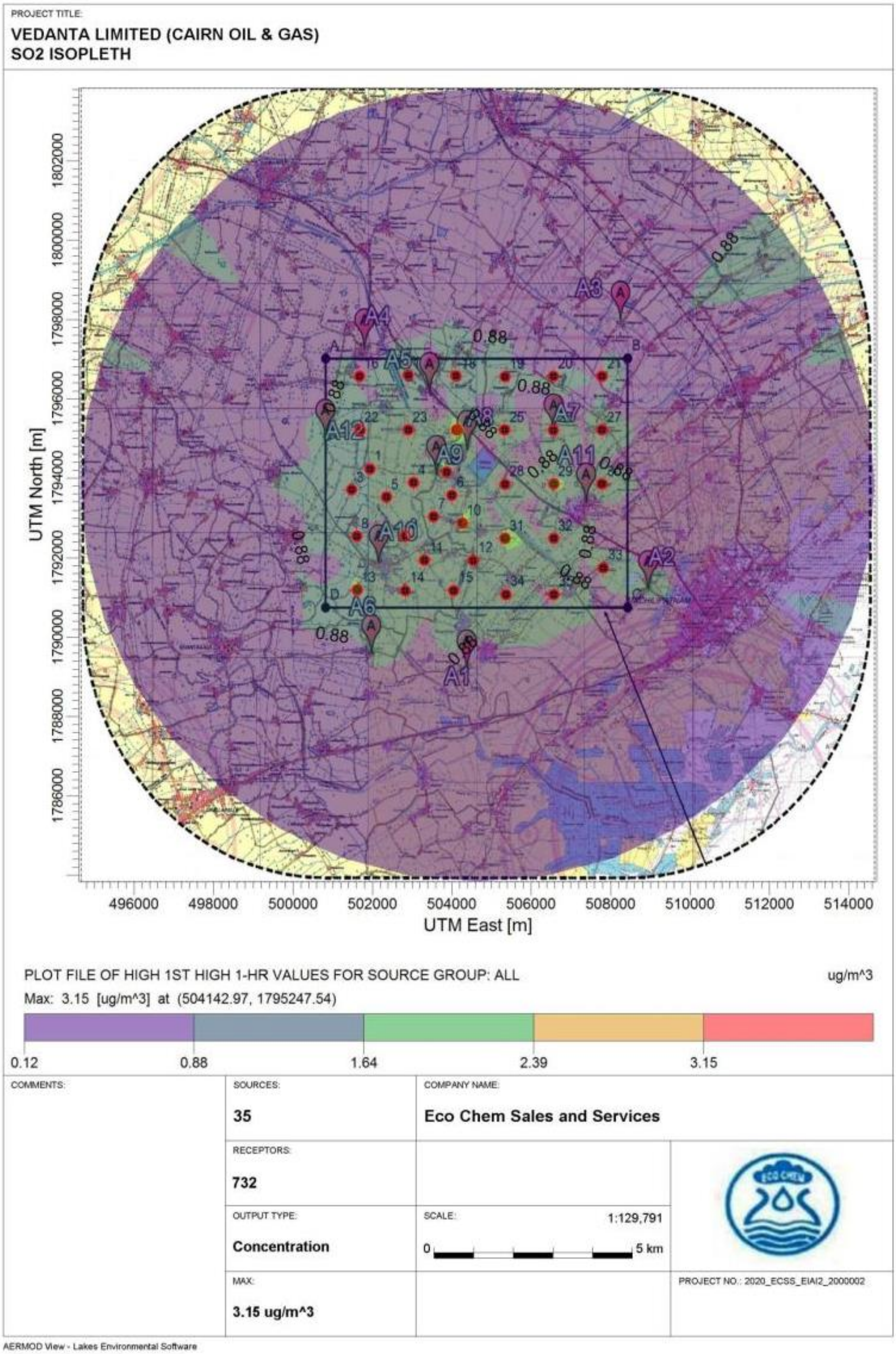


**Figure 4.9: Isopleth for SO2 emitted from flue gas stacks**

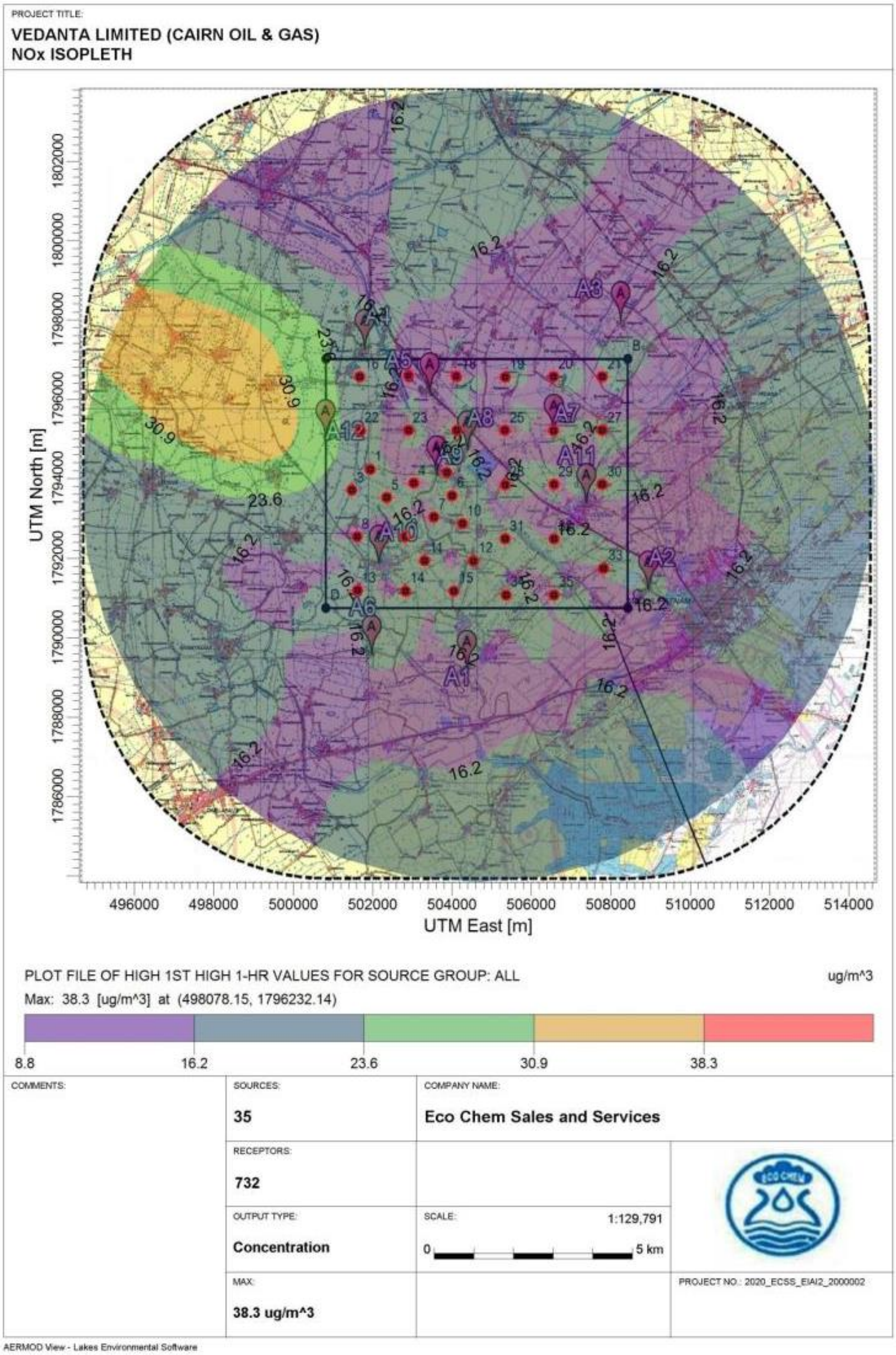


**Figure 4.10: Isopleth for NOx emitted from flue gas stacks**

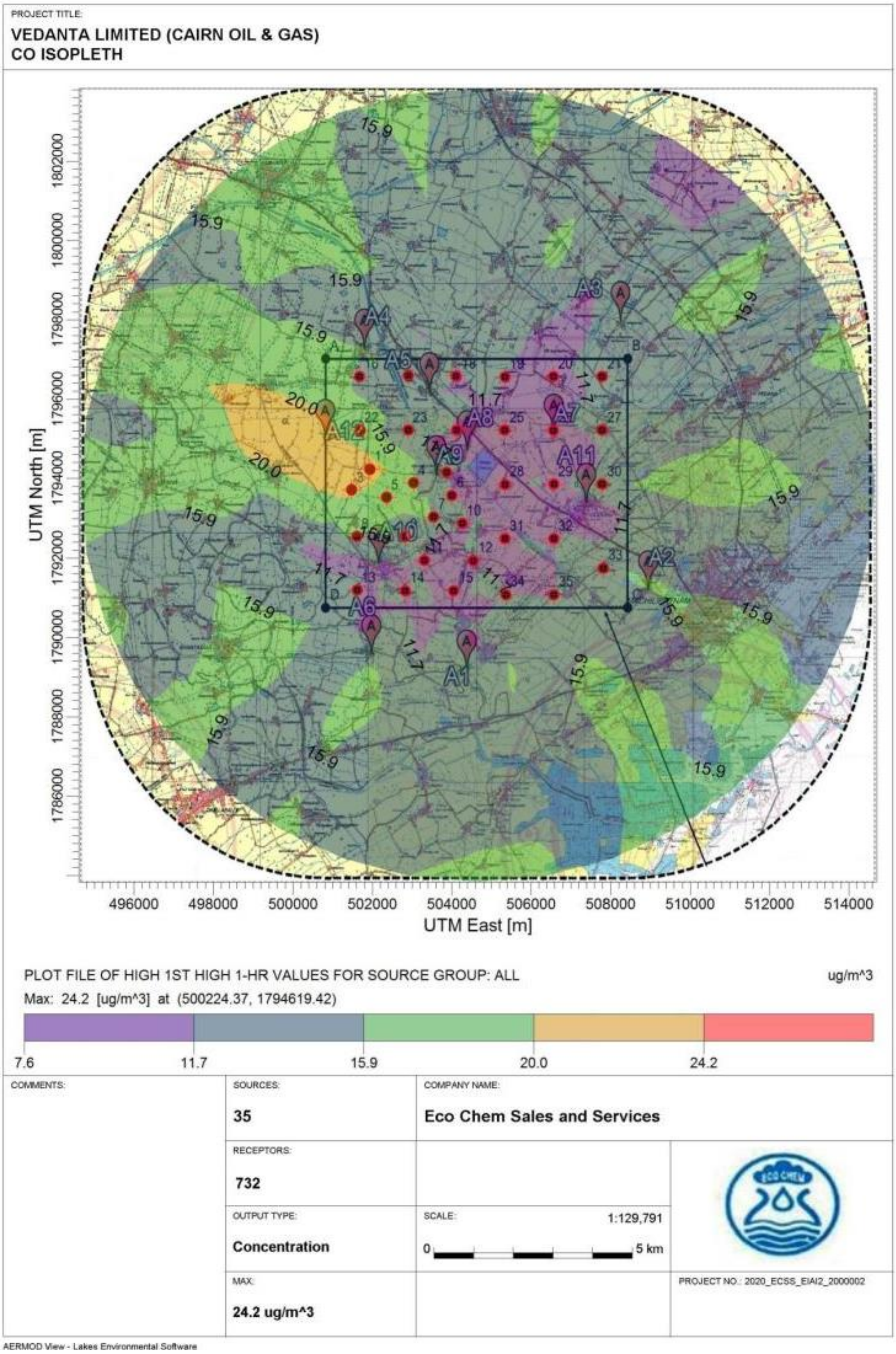


**Figure 4.11: Isopleth for CO emitted from flue gas stacks**

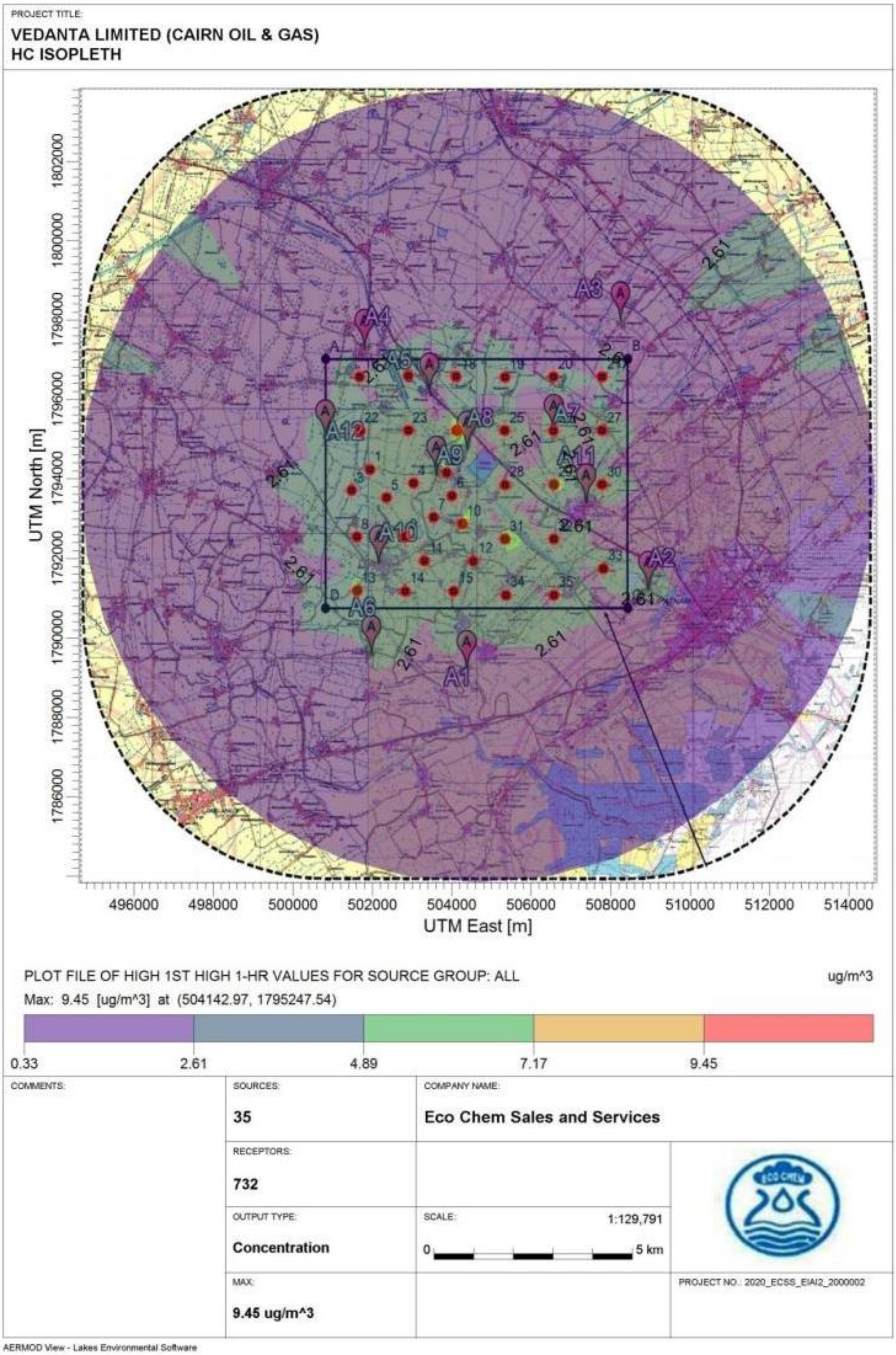


**Figure 4.12: Isopleth for HC emitted from flue gas stacks**

The maximum of 24 hourly highest GLC's of PM, SO2, NOx & HC due to flue gas emission through the stacks attached to DG sets & Flare (Point source)during Production phase is summarised in Table 4.6 below:

**Table 4.6: Maximum resultant concentration during Production Phase**

| S. No. | Ambient Air Monitoring Location | Pollutant | 98th Percentile Baseline Concentration (µg/m³) | Incremental Concentration (µg/m³) | Total GLC (µg/m³) | NAAQS Concentration Limit (µg/m³) |
|---|---|---|---|---|---|---|
| 1 | Chataripalem | $PM_{10}$ | 53.0 | 0.30 | 53.30 | 100 |
| | | $PM_{2.5}$ | 27.4 | 0.20 | 27.60 | 60 |
| | | $SO_2$ | 16.1 | 0.75 | 16.85 | 80 |
| | | $NO_X$ | 19.3 | 15.68 | 34.98 | 80 |
| | | HC | - | 2.24 | 2.24 | - |
| | | CO | 316 | 14.25 | 330.25 | 2000 |
| 2 | S N Gollapalem | $PM_{10}$ | 57.2 | 0.41 | 57.61 | 100 |
| | | $PM_{2.5}$ | 29.3 | 0.27 | 29.57 | 60 |
| | | $SO_2$ | 16.8 | 1.01 | 17.81 | 80 |
| | | $NO_X$ | 19.9 | 17.57 | 37.47 | 80 |
| | | HC | - | 3.04 | 3.04 | - |
| | | CO | 293 | 15.87 | 308.87 | 2000 |
| 3 | Lellagaruvu | $PM_{10}$ | 62.8 | 0.28 | 63.08 | 100 |
| | | $PM_{2.5}$ | 33.0 | 0.19 | 33.19 | 60 |
| | | $SO_2$ | 17.6 | 0.70 | 18.30 | 80 |
| | | $NO_X$ | 22.2 | 14.87 | 37.07 | 80 |
| | | HC | - | 2.09 | 2.09 | - |
| | | CO | 445 | 13.58 | 458.58 | 2000 |
| 4 | Nimmakuru | $PM_{10}$ | 51.0 | 0.26 | 51.26 | 100 |
| | | $PM_{2.5}$ | 26.8 | 0.17 | 26.97 | 60 |
| | | $SO_2$ | 16.2 | 0.65 | 16.85 | 80 |
| | | $NO_X$ | 19.0 | 19.34 | 38.34 | 80 |
| | | HC | - | 1.96 | 1.96 | - |
| | | CO | 303 | 15.67 | 318.67 | 2000 |
| 5 | Nidumolu | $PM_{10}$ | 60.2 | 0.29 | 60.49 | 100 |
| | | $PM_{2.5}$ | 31.3 | 0.19 | 31.49 | 60 |
| | | $SO_2$ | 17.3 | 0.73 | 18.03 | 80 |
| | | $NO_X$ | 20.0 | 12.86 | 32.86 | 80 |
| | | HC | - | 2.19 | 2.19 | - |
| | | CO | 318 | 11.83 | 329.83 | 2000 |
| 6 | Chitturu | $PM_{10}$ | 63.0 | 0.36 | 63.36 | 100 |
| | | $PM_{2.5}$ | 35.3 | 0.24 | 35.54 | 60 |
| | | $SO_2$ | 18.2 | 0.89 | 19.09 | 80 |
| | | $NO_X$ | 22.5 | 16.88 | 39.38 | 80 |
| | | HC | - | 2.66 | 2.66 | - |
| | | CO | 391 | 13.78 | 404.78 | 2000 |
| 7 | Tummalapalem | $PM_{10}$ | 52.1 | 0.34 | 52.44 | 100 |
| | | $PM_{2.5}$ | 27.5 | 0.23 | 27.73 | 60 |
| | | $SO_2$ | 16.6 | 0.84 | 17.44 | 80 |
| | | $NO_X$ | 19.4 | 14.95 | 34.35 | 80 |
| | | HC | - | 2.53 | 2.53 | - |
| | | CO | 324 | 10.46 | 334.46 | 2000 |
| 8 | Tarakaturu | $PM_{10}$ | 55.4 | 0.36 | 55.76 | 100 |
| | | $PM_{2.5}$ | 28.8 | 0.24 | 29.04 | 60 |
| | | $SO_2$ | 16.6 | 0.89 | 17.49 | 80 |
| | | $NO_X$ | 19.2 | 16.08 | 35.28 | 80 |

| S. No. | Ambient Air Monitoring Location | Pollutant | 98th Percentile Baseline Concentration (µg/m³) | Incremental Concentration (µg/m³) | Total GLC (µg/m³) | NAAQS Concentration Limit (µg/m³) |
|---|---|---|---|---|---|---|
| | | HC | - | 2.66 | 2.66 | - |
| | | CO | 291 | 10.46 | 301.46 | 2000 |
| 9 | Maklavaripalem | $PM_{10}$ | 63.9 | 0.58 | 64.48 | 100 |
| | | $PM_{2.5}$ | 33.7 | 0.39 | 34.09 | 60 |
| | | $SO_2$ | 17.6 | 1.45 | 19.05 | 80 |
| | | $NO_X$ | 22.0 | 16.71 | 38.71 | 80 |
| | | HC | - | 4.34 | 4.34 | - |
| | | CO | 383 | 13.56 | 396.56 | 2000 |
| 10 | Kaza | $PM_{10}$ | 52.4 | 0.52 | 52.92 | 100 |
| | | $PM_{2.5}$ | 27.0 | 0.35 | 27.35 | 60 |
| | | $SO_2$ | 16.3 | 1.31 | 17.61 | 80 |
| | | $NO_X$ | 19.6 | 19.19 | 38.79 | 80 |
| | | HC | - | 3.93 | 3.93 | - |
| | | CO | 282 | 12.96 | 294.96 | 2000 |
| 11 | Guduru | $PM_{10}$ | 58.1 | 0.30 | 58.40 | 100 |
| | | $PM_{2.5}$ | 28.7 | 0.20 | 28.90 | 60 |
| | | $SO_2$ | 16.9 | 0.75 | 17.65 | 80 |
| | | $NO_X$ | 20.3 | 14.40 | 34.70 | 80 |
| | | HC | - | 2.24 | 2.24 | - |
| | | CO | 263 | 11.13 | 274.13 | 2000 |
| 12 | Palankipadu | $PM_{10}$ | 64.5 | 0.43 | 64.93 | 100 |
| | | $PM_{2.5}$ | 33.7 | 0.29 | 33.99 | 60 |
| | | $SO_2$ | 18.1 | 1.07 | 19.17 | 80 |
| | | $NO_X$ | 21.6 | 26.36 | 47.96 | 80 |
| | | HC | - | 3.21 | 3.21 | - |
| | | CO | 392 | 21.36 | 413.36 | 2000 |

**Table 4.7: Summary of Point Source Modeling during Production Phase**

| Pollutant | Max. Concentration (µg/m³) | Distance (km) | Direction |
|---|---|---|---|
| PM | 2.10 | 1.5 | WNW |
| $SO_2$ | 3.15 | 1.5 | WNW |
| NOx | 38.3 | 7.0 | WNW |
| HC | 9.45 | 1.5 | WNW |
| CO | 24.2 | 4.5 | WNW |

**Conclusion:**

- $PM_{10}$ concentration is observed in the range of 51.26 – 64.93 µg/m³, which is well within the standard limit.
- $PM_{2.5}$ concentration is observed in the range of 26.97 – 35.54 µg/m³, which is well within the standard limit.
- $SO_2$ concentration is observed in the range of 16.85 – 19.17 µg/m³, which is well within the standard limit.
- NOx concentration is observed in the range of 32.86 – 47.96 µg/m³, which is well within the standard limit.
- HC concentration is observed in the range of 1.96 – 4.34 µg/m³.
- CO concentration is observed in the range of 274.13 – 458.58 µg/m³, which is well within the standard limit.

**Table 4.8: Potential Impact on Air Environment and Mitigation Measures**

| Project Activity | Impact | Mitigation Measures |
|---|---|---|
| **A. Pre-drilling Activities** | | |
| • Site and access road development<br>• Transportation of drilling Rig, Materials and ancillaries | • Fugitive dust emissions due to the proposed project will be principally associated with emissions of dust during the site preparation.<br>• During the short period of site preparation mechanical shovels and earthmovers will be used for vegetation clearance, cut and fill and other site levelling activities. These activities could generate dust particles which will be mobilized by wind, and deteriorate the ambient air conditions.<br>• Exhaust emissions from vehicles deployed is also likely to result in marginal increase in the levels of $SO_2$, $NO_x$ and PM which leads to respiratory ailments like asthama and other dust related problems to the human health.<br>• However, these activities will be only temporary and with the loamy sand to clay loam nature of the soil, the impact to ambient air quality would be within the close proximity of well site. | • To minimize emission of fugitive dusts the following measures would be adopted:<br>• Carry out regular water sprinkling at the site during dry season especially during the site preparation and access road development activities;<br>• During site preparation, the approach road will be kept clean, free from mud and slurry to prevent any entrainment of dust;<br>• Proper handling of materials to ensure minimal emission of dust.<br>• Excavated soil and debris will be sprinkled with water and kept moist.<br>• All vehicles used for transportation of loose and friable materials will not be loaded over the freeboard limit and will be covered.<br>• Only PUC vehicle shall be used for the transportation of drilling Rig, Materials and ancillaries.<br>• Construction materials will be covered with tarpaulin sheets throughout the construction phase to avoid dust generation.<br>• Personnel Protective Equipment (PPEs) will be provided to the construction workers. Hence there will be no significant impacts on their health due to the dust particle.<br>• The impact will be confined within the project boundary and is expected to be negligible outside the plant boundaries. |
| **B. Development Well Drilling and Testing** | | |
| • Operation of DG sets and machineries<br>• Well drilling<br>• Well testing & Flaring<br>• Greenbelt development | • Air pollution from point sources will be principally contributed by the operation of various capacities of diesel generators (DG) during the drilling phase. The primary pollutants emitted by a DG set consist of particulate matter, Oxides of Sulphur and Nitrogen, and Carbon monoxide.<br>• Dispersion of these air pollutants | • An air pollutant dispersion modelling exercise has been undertaken to predict the ground level concentrations of pollutants at various distances from the source in order to assess and evaluate possible air quality impacts that may arise from the combined DG set and flaring operation.<br>• No cold venting will be resorted |

| Project Activity | Impact | Mitigation Measures |
|---|---|---|
| | have minor or negligible health impacts of receptors viz. village settlements located in near vicinity of the well site.<br>• Flaring of gases primarily during the drilling testing phase involves high temperature oxidation process to burn combustible gases that may be generated from the proposed well sites which will contribute to additional air pollution.<br>• Positive impact due to greenbelt development as it will act natural barrier for dust emission. | instead flaring will be done with combustion efficient elevated flare tip.<br>• Location of Flare stacks will be chosen by considering the sensitive receptors adjoining the site.<br>• Proper engineering controls will be adopted to ensure complete combustion of gas<br>• 25 to 33% of greenbelt area at each well pad unit will be developed. Selection of tree species will be done as per the CPCB guidelines. |
| **C. Operation of Well Pad/Production facilities** | | |
| • Flaring of Gas<br>• DG/GEG Set of Emission | • The major sources of emissions during operations will include emissions from flaring, operation of power generation & compressor facilities. Dispersion of these air pollutants may affect the health of receptors viz. village settlements located in near vicinity of the well site.<br>• Dust will also be generated due to excavation and trenching, back filling activities for pipeline laying which will deteriorate surrounding air quality leading to contribute to additional air pollution. | • No cold venting will be resorted instead flaring will be done with combustion efficient elevated flare tip.<br>• Location of Flare stacks will be chosen by considering the sensitive receptors adjoining the site.<br>• The flare stack shall be of 30m height to meet regulatory requirement.<br>• All emission sources shall be monitored regularly to ensure compliance.<br>• Regular water sprinkling will be done to avoid dust generation during laying of pipeline.<br>• Peripheral green belt will be developed. |
| **D. Decommissioning and Reinstatement** | | |
| • Transportation of drilling facilities | • Emission of gaseous air pollutant during transportation of drilling waste.<br>• Fugitive emissions due to re-entrainment of dust during transport of drilling facilities | • Vehicle / equipment air emissions will be controlled by good practice procedures (such as turning off equipment when not in use); and Vehicle / equipment exhausts observed emitting significant black smoke in their exhausts will be serviced/ replaced.<br>• Approach road will be sprinkled daily with water. |

## 4.6 NOISE ENVIRONMENT

**Assessment of Noise Impacts due to Site Activities**

Driller rotors and the power generators and pumps would be the main sources of noise pollution during the drilling activity. Noise due to vehicular movement will be intermittent but will also add to the background noise levels. The well site during excavation phase of the site preparation where heavy earth moving machinery will be in operation, noise level of the vehicle should not be more than the 90 dB (A). Typically, the noise generating sources for the onshore drilling activity are provided below (in the immediate vicinity)

- GEG/Diesel Generator: 75 dB(A)
- Pumps at the Rig: 85 to 90 dB(A)
- Mud pumps: 73.3-80.5 dB(A)
- Control Room & Quarters: 50 to 60 dB(A)
- Drilling: 85-90 dB(A)
- Test Flaring: 86.0 dB(A)

In order to predict ambient noise levels due to the proposed drilling of wells. The preparative modeling has been done. For computing the noise levels at various distances with respect to the proposed site, noise levels are predicted using an user friendly model the details of which is elaborated below.

**Mathematical Model for Sound Wave Propagation During Operation**

For an approximate estimation of dispersion of noise in the ambient from the source point, a standard mathematical model for sound wave propagation is used. The sound pressure level generated by noise sources decreases with increasing distance from the source due to wave divergence. An additional decrease in sound pressure level with distance from the source is expected due to atmospheric effect or its interaction with objects in the transmission path.

For hemispherical sound wave propagation through homogenous loss free medium, one can estimate noise levels at various locations, due to different sources using model based on first principles, as per the following equat

$$Lp2 = Lp1 - 20\log (r2 / r1) \qquad (1)$$

Where Lp2 and Lp1 are Sound Pressure Levels (SPLs) at points located at distances r2 and r1 from the source. The combined effect of all the sources then can be determined at various locations by the following equation.

$$Lp(total) = 10 \times LOG10 (SUM[10^{(L1/10)} + 10^{(L2/10)} \ldots \qquad (2)$$

Where, Lp1, Lp2, Lp3 are noise pressure levels at a point due to different sources. Based on the above equations an user friendly model has been developed. The details of the model are as follows:

Based on the above equations an user friendly model has been developed. The details of the model are as follows:

- Noise levels can be predicted at any distance specified from the source;
- Model is designed to take topography or flat terrain;
- Coordinates of the sources in meters;
- Maximum and Minimum levels are calculated by the model;
- Output of the model in the form of isopleths; and
- Environmental attenuation factors and machine corrections have not been incorporated in the model but corrections are made for the measured Leq levels.

**Input for the Model**

The incremental increase in noise levels due to the operation phase of the drilling has been done. Noise levels are mainly generated from DG sets, air compressors, pumps and ancillary equipment. The noise sources have been defined with respect to center of drill site. The input data pertaining to corresponding noise level are tabulated below.

**Table 4.9 Input Data for Noise Modelling**

| Sr. No. | Location | Noise Levels db(A) at 3m distance from source |
|---|---|---|
| 1 | GEG/Diesel Generator ( 2 DG set) | 75 |
| 2 | Pumps at the Rig | 85 |
| 3 | Mud pumps | 70 |
| 4 | Control Room & Quarters | 50 |
| 5 | Drilling | 85 |
| 6 | Flaring | 86 |

*Source: https://www.cpcb.nic.in/displaypdf.php?id=SW5kdXN0cnktU3BlY2lmaWMtU3RhbmRhcmRzL0VmZmx1ZW50LzUwMS5wZGY=), www.vurup.sk/petroleum-coal*

**Presentation of Results**

The predicted noise level at 500 m distance from the boundary of well site is 42.98 dB (A) and are tabulated in Table 4.10.

**Table 4.10 Predicted Noise Levels**

| Name of Source | Noise Levels at 3m distance from source L1 [dB(A)] | X (Distance in m) | Noise Levels at X distance L2 [dB(A)] |
|---|---|---|---|
| Diesel Generator/GEG | 75 | 50 | 56 |
| | | 100 | 50 |
| | | 200 | 44 |
| | | 500 | 16 |
| Diesel Generator | 75 | 50 | 56 |
| | | 100 | 50 |
| | | 200 | 44 |
| | | 500 | 16 |
| Pumps at the Rig | 85 | 50 | 61 |
| | | 100 | 55 |
| | | 200 | 49 |
| | | 500 | 41 |
| Mud pumps | 70 | 50 | 46 |
| | | 100 | 40 |
| | | 200 | 34 |
| | | 500 | 26 |
| Control Room & Quarters | 50 | 50 | 26 |
| | | 100 | 20 |
| | | 200 | 14 |
| | | 500 | 6 |
| Drilling | 85 | 50 | 61 |
| | | 100 | 55 |

| Name of Source | Noise Levels at 3m distance from source L1 [dB(A)] | X (Distance in m) | Noise Levels at X distance L2 [dB(A)] |
|---|---|---|---|
| | | 200 | 49 |
| | | 500 | 41 |
| Flaring | 86 | 50 | 62 |
| | | 100 | 56 |
| | | 200 | 50 |
| | | 500 | 42 |

**Table 4.11 Attenuated Noise Level**

| Distance (m) | Predicted Noise Levels dB(A) | Prescribed Noise levels at Day time of the Residential Area dB(A) | Prescribed Noise levels at Night time of the Residential Area dB(A) |
|---|---|---|---|
| 50 | 62.98 | 55 | 45 |
| 100 | 56.96 | 55 | 45 |
| 200 | 50.94 | 55 | 45 |
| 500 | 42.98 | 55 | 45 |

Further, considering drilling to be a continuous operation, noise generated from aforesaid equipment has the potential to cause discomfort to the local communities residing in proximity (within 100m) of the rig facility. So settlements located close to majority of the wells will face discomfort due to drilling operation. Vedanta Limited. (Division Cairn Oil & Gas) will ensure that well location is located away from the human habitat / sensitive receptors.

Occupational health and safety impacts viz. Noise Induced Hearing Loss (NIHL) is also anticipated on personnel working close to such noise generating equipment. However, drilling activities will be undertaken for short duration and necessary noise prevention and control measures viz. use of acoustic barriers, provisions for proper PPEs, regular preventive maintenance of equipment etc. will be implemented by the proponent to reduce the noise impact on the communities residing in proximity to the well sites.

**Table 4.12: Potential Impact on Noise Quality and Mitigation Measures**

| Project Activity | Impact | Mitigation Measures |
|---|---|---|
| **A. Pre-drilling Activities** | | |
| • Site and Access road development<br>• Transportation of drilling Rig, Materials and ancillaries | • Noise emission from the vehicles & machineries may create temporary noise impact on resident near the drill site.<br>• Noise emission from the vehicles during material transportation may create Temporary adverse impact on noise quality of areas adjoining transport routes | • All noise generating operations will be restricted to daytime, Vehicle & machinery should have appropriate engineering controls at source.<br>• Preventive maintenance of Vehicles will be undertaken to reduce noise level as & when required.<br>• All vehicular movements for hauling materials will be undertaken during daytime only.<br>• Restriction on unnecessary use of horns |

| Project Activity | Impact | Mitigation Measures |
|---|---|---|
| | | by trucks and vehicle in settlement area. |
| **B. Well Drilling and Testing** | | |
| • Operation of DG sets and machineries<br>• Casing & cementing of well<br>• Well drilling<br>• Greenbelt development | • Emission of Noise from DG sets, operation of the rig and during preparation of cement slurry may Temporary increase of work place noise level<br>• Noise from mud pump during preparation of drilling mud may temporary increase of the ambient & work place noise level.<br>• Plant parts such as stems, leaves, branches, wood, etc. absorb sound. Rough bark and thick, fleshy leaves are particularly effective at absorbing sound with their dynamic surface area for absorbing sound. | • All workers working near high noise generating equipment to be provided with Personal Protective equipment<br>• Preventive maintenance of DG Set and machinery will be undertaken as per manufacturers schedule<br>• Installation of sufficient engineering control (mufflers) to reduce noise level at source<br>• 25 to 33% of total well pad area shall be developed for the greenbelt plantation. Selection of tree species will be done as per the CPCB guidelines.<br>• Regular Maintenance of the greenbelt will be done. |
| **C. Operation of Well Pad/Production facilities** | | |
| • Operation of DG/GEG Set | • Emission of Noise from operation of compressors, circulation pumps, steam turbines, and generators may Temporary increase of work place noise level. | • Peripheral green belt shall be developed around all the well pads;<br>• Signages shall be provided to demarcate high noise areas;<br>• Use of PPEs such as earplugs and earmuffs in high noise areas by the work force shall be enforced;<br>• Regular maintenance of equipment and machinery shall be carried out to minimize noise levels;<br>• Acoustic enclosures and mufflers shall be provided for DG sets;<br>• Noise and vibration controls shall be provided on machinery deployed in the facilities;<br>• Occupational noise monitoring shall be carried out at periodic intervals.<br>• Prolonged exposure to high noise areas will be prevented by job rotation |
| **D. Decommissioning and Reinstatement** | | |

| Project Activity | Impact | Mitigation Measures |
|---|---|---|
| • Dismantling of rig & associated machineries<br>• Transportation of drilling facilities | • Emission of Noise during dismantling rig and transportation of drilling machineries may temporary deteriorate of ambient noise quality resulting in discomfort to the workers and surrounding residents. | • All noise generating operations, except drilling, will be restricted to daytime.<br>• Restriction on unnecessary use of horns by trucks and vehicle in settlement area. |

## 4.7 LAND ENVIRONMENT

**Table 4.13: Potential Impact on Land Use and Mitigation Measures**

| Project Activity | Impact | Mitigation Measures |
|---|---|---|
| **A. Pre-drilling Activities** | | |
| • Site and Access road development | • Approximately 9.0 Hectare of land will be allocated of each well pad to carryout drilling of various wells within the Kaza Block. An approach road (with a width of 2-3 m) would need to be made from the road head to the well pad. The land would be acquired on permanent acquisition basis or for lease.<br>• Change in visual characteristics of the area due to development of well site may temporarily change in landscape till one set of monsoon is witnessed. | • On completion of work all temporary structure, surplus materials and waste will be completely removed. |
| **B. Well Drilling and Testing** | | |
| • Well drilling<br>• Greenbelt development | • Change in visual characteristics of the area due to installation of drilling setup may temporarily change in landscape.<br>• Green belt development will lead to permanent change in land cover pattern at the well pad as a direct impact. | • On completion of work all temporary structure, surplus materials and waste will be completely removed. Only structure required for the safety purpose will be retained on the well pad.<br>• Greenbelt area will be developed along the periphery of the well pad, which will result in beneficial impacts on land cover of the project area. |

## 4.8 SOIL ENVIRONMENT

**Table 4.14: Potential Impact on Soil Quality and Mitigation Measures**

| Project Activity | Impact | Mitigation Measures |
|---|---|---|
| **A. Pre-drilling Activities** | | |
| • Site and Access road development<br>• Transportation of drilling Rig, Materials and ancillaries | • Stripping of top soil and temporary storage may potential loss of fertility of soil<br>• Lands may get contaminated from the spillage of chemicals such as fuels, oils, paints and other construction chemicals and concrete. This normally happens when these materials are transported in open or loosely capped containers. | • Topsoil would be stripped and separately stockpiled for future use/reused for landscape development.<br>• Control measures will be needed for oily residues such as transformer oil and lubricants in the case of accidental or unexpected release. Transformer oil is supplied in drums from an imported source<br>• Vehicle transporting material will not be over loaded<br>• Loose materials will be covered during transportation<br>• Oily residues and fuel and any contaminated soil residues will be captured at source and refuelling and maintenance will take place in dedicated areas away from surface water resources. Contaminated residues and waste oily residues will be disposed to APPCB authorized TSDF facilities. |
| **B. Well Drilling and Testing** | | |
| • Operation of DG set and Machineries<br>• Preparation of drilling fluid (Mud) and drill cutting disposal<br>• Casing and cementing of well<br>• Well testing & Flaring<br>• Well drilling<br>• Recruitment/Employment<br>• Greenbelt development | • Accidental spillage of the fuel, chemicals during preparation of the drilling mud may contaminate the soil which results the loss of soil nutrients and micro-organisms.<br>• Accidental spillage of process waste (unused cement slurry, return mud & drill cuttings) at the temporary storage site may contaminate the soil.<br>• Unmanaged sewage can also contribute to contamination of soil. | • Proper spill management plan will be prepared and followed. All chemicals and fuel will be stored in the secondary containment area.<br>• Proper engineering controls for the drilling and cementing operations will be prepared and followed.<br>• The greenbelt development will control the soil erosion due to wind and runoff water.<br>• Sewage will be disposed to the septic tanks followed by soak pits designed as per IS 2470: 1986.<br>• Regular maintenance of greenbelt will |

| Project Activity | Impact | Mitigation Measures |
|---|---|---|
| | • Positive impact of greenbelt development as improvement in soil texture due to binding of top soil materials and root structure. | be done. |
| **D. Decommissioning and Reinstatement** | | |
| • Dismantling of rig & associated machineries | • Decommissioning at the end of project life/drilling will have some adverse impacts in terms of increase in soil erosion | • Drill sites will be restored to near original conditions and top soil will be spread back to its original place. |

## 4.9 WATER ENVIRONMENT

**Table 4.15 Potential Impact on Water Quality and Mitigation Measures**

| Project Activity | Impact | Mitigation Measures |
|---|---|---|
| **A. Pre-drilling Activities** | | |
| • Site and Access road development | • Site clearance and stripping of top soil during site preparation and road development activities will result in an increase in soil erosion potential leading to an increase sediment load in the surface run-off during monsoon. | • Construction activities viz. stripping, excavation etc., during rainy days will be restricted to the extent possible. |
| **B. Well Drilling and Testing** | | |
| • Casing and cementing of well<br>• Preparation of drilling fluid (Mud) and drill cutting disposal<br>• Well drilling<br>• Recruitment/Employment<br>• Greenbelt development | • Water resource depletion due to the local water used for preparing drilling mud and for domestic needs.<br>• surface run off from drilling waste such as cuttings and drilling mud), hazardous waste (waste oil, used oil etc.) and chemical storage, areas on open soil is likely to be contaminated leading to the pollution of receiving water bodies viz. natural drainage channels, small to medium sized village ponds etc., which are used by the | • The water requirement is primarily depended upon the depth of the proposed well and time required for drilling the well.<br>• The drilling fluid will be recycled and fresh water will be used as makeup water and for general washing and daily maintenance. The water requirement is proposed to be met from the authorized local sources through water tankers.<br>• Since the drilling activity being temporary and water requirement is meager, no adverse impact on ground/surface water resources is envisaged. |

| Project Activity | Impact | Mitigation Measures |
|---|---|---|
| | villagers for washing and other domestic purposes<br>• Wastewater would be generated from the proposed project operation including minor quantities from washing and cleaning of rig floor and other equipment. Water based drilling mud is non-hazardous in nature. The primary pollutants in the wastewater would be suspended solids, dissolved solids and traces of floating oil from washing of rig floor and other equipment.<br>• Effluents can cause significant pollution to water bodies especially ponds and lakes if disposed untreated.<br>• Accidental spillage of oil & greases & chemicals may cause contamination to surface water body and surrounding agricultural lands.<br>• Water resource depletion due to consumption of water for developmental activities and green belt development. | • The drilling operation would generate wastewater in the form of drilling fluid, wash water due to washing of equipment, string and cuttings etc. The other source of wastewater generated from drilling operation is domestic wastewater around 8 $m^3$/day, which shall be disposed through septic tanks/soak pits in the well pads. It is expected that wastewater in the form of Drill cutting washing + Rig washing etc. shall be generated at an average rate of around 30 $m^3$/day during the drilling operations from a single well. This wastewater will be treated and used back for mud preparation and the final wastewater will be discharged in HDPE lined evaporation pit for natural evaporation.<br>• All spills to be reported and & contained to prevent entry of spilled chemicals/fuels to any surface water body or drainage channel.<br>• Site to be selected away from surface water body<br>• Garland drains to be constructed along the disposal site to collect the runoff<br>• All runoff should be treated at Oil water separator and Sedimentation tank before discharge<br>• Wastage of water will be strictly avoided.<br>• Awareness for conservation of water will be spread to the labours.<br>• Storm water will be collected and reused for conservation of water. |
| **C. Operation of Well Pad/Production facilities** | | |
| • Produced Water | • Produced water generated from the well pad can cause significant pollution to water | • The produced water generated from the well fluid separation activities as part of the production will be treated to |

| Project Activity | Impact | Mitigation Measures |
|---|---|---|
| | bodies especially ponds and lakes if disposed untreated. | achieve MoEF&CC/ CPCB/ APPCB specification (discharge standards) and will be accordingly disposed. The treated effluent (produced water) may also be disposed through deep dump wells (also abandoned wells) having depth > 1000 m after treating for oil (< 10 ppm) & total suspended solids (< 100 ppm) and or solar/ mechanical evaporators depending on quantity of produced water generation and actual site feasibility. |

## 4.10 HYDROGEOLOGY

**Table 4.16 Potential Impact on Hydrogeology and Mitigation Measures**

| Project Activity | Impact | Mitigation Measures |
|---|---|---|
| **A. Pre-drilling Activities** | | |
| • Site and Access road development | • There is a probability that during excavations, especially if conducted immediately after monsoon may lead to development of springs which may have to be dewatered. | • The occupation of the area is temporary and the area experiences high rainfall and thereby high recharge potential, the effect on the groundwater regime of the area will not affect water availability in neighboring wells and tube wells and any resulting conflict with other users of groundwater in the area. |
| **B. Well Drilling and Testing** | | |
| • Casing and cementing of well<br>• Preparation of drilling fluid (Mud) and drill cutting disposal<br>• Well drilling<br>• Greenbelt development | • Abstraction of ground water for project use may result in depletion of ground water resources.<br>• The compaction of the working areas for setting up heavy machineries and equipment like the rig may lead to increased runoff and reduced infiltration, thereby affecting localised subsurface ground water recharge.<br>• Accidental spillage of chemical during preparation of mud may contaminate the ground water drainage. | • Optimized use of water during drilling operation.<br>• Regular record keeping and audit will be done for the water consumption.<br>• Proper spill management plan will be prepared and the entire spill will be contained so that it does not reach any drainage channel.<br>• Proper engineering controls during cementing operation to prevent migration of drilling mud and cement slurry into ground water aquifer.<br>• Cairn will be using water based non-toxic biodegradable fluids with inhibitive and encapsulate characteristics as drilling mud. SBM based drilling mud will be used only in the second casing policy (after reaching down the water table). Additionally, the drilling mud collection and recirculation pond is lined with impervious layer to prevent seepage and |

| | | |
|---|---|---|
| | • Loss of drilling mud and cement slurry during casing of well may potential contaminate the ground water aquifer.<br>• Tree roots improve drainage because each root acts as an underground water channel to help water penetrate the soil. | loss of drilling fluid into the subsoil. Further, proper casing installation and cementing will ensure least groundwater contact.<br>• Selection of trees should be as per guidelines prescribed by APPCB/CPCB/MoEF&CC. |

## 4.11 ECOLOGY AND BIODIVERSITY

**Table 4.17 Potential Impact on Ecology and biodiversity and mitigation Measures**

| Project Activity | Impact | Mitigation Measures |
|---|---|---|
| **A. Pre-drilling Activities** | | |
| • Site and Access road development<br>• Transportation of drilling Rig, Materials and ancillaries | • The flora and faunal habitats in the study area may be affected due to Tree/vegetation removal<br>• Transportation of drilling Rig, Materials and ancillaries by the trucks/dumper will disturb the movement of animal and birds.<br>• Fugitive emission from vehicle movement, Site stripping will form a layer in leaves thus reducing the gaseous exchange process. This ultimately affects the growth of plants | • Avoid uprooting trees and other plants where possible so as to facilitate subsequent re-growth.<br>• All bulldozer operators involved in site preparation shall be carried out only in the defined site boundaries.<br>• Transportation should be minimized to daytime.<br>• If possible, big trees shall be planned for transplanting as much as feasible.<br>• The proposed activities do not envisage destruction of habitat and feeding or breeding area of faunal species.<br>• Water sprinkling will be done to prevent dust emission. |
| **B. Well Drilling and Testing** | | |
| • Preparation of drilling fluid (Mud) and drill cutting disposal<br>• Well drilling<br>• Well testing & Flaring<br>• Green belt Development | • Discharge of untreated process water/ run-off from drilling site may contaminate the surface water and aquatic ecosystem<br>• Frequent vehicular movement, from drill site, light and noise generation during drilling phase may impact the local flora and fauna abutting the drill sites and transportation routes<br>• Greenbelt development may cause positive impacts on the flora by | • All discharges from the drill site would be adequately treated to comply with the CPCB discharge standards before disposal<br>• As drilling activity, would be conducted temporarily for three months in a particular well pad, will not hamper ecological balance of the area and will not cause permanent shifting of birds or faunal habitats.<br>• Hunting and wildlife trapping is forbidden. Removal or disturbance to |

| | | |
|---|---|---|
| | enhancement of green spaces<br>• Generation of habitats for avifauna i.e. positive impact. | nesting or breeding birds and animals, their eggs or young is strictly prohibited.<br>• Regular watering and maintenance of the greenbelt for sustained plant growth. |
| **D. Decommissioning and Reinstatement** | | |
| • Transportation of drilling facilities | • Noise generation during drilling phase may impact the local flora and fauna abutting the drill sites and transportation routes. | • Transportation will be done during day time only.<br>• Restriction on unnecessary use of horns by trucks and vehicle. |

## 4.12 SOCIO-ECONOMIC ENVIRONMENT

**Table 4.18 Potential Impact and Mitigation Measures on Socioeconomic Environment**

| Project Activity | Impact | Mitigation Measures |
|---|---|---|
| **A. Pre-drilling Activities** | | |
| • Site and Access road development<br>• Transportation of drilling Rig, Materials and ancillaries | • The project will result in loss of land and may impact the livelihood of the land contributors.<br>• Influx manpower & immigrant labour force to nearby villages.<br>• Possibility Cultural and behavioural conflict | • Vedanta Ltd. (Division: Cairn Oil & Gas) will set up Contractor Engagement Cell in which the profile of all the land contributors is maintained and Cairn will advocate for employing the land losers as local labour based on their skill sets.<br>• Vedanta will set up a Vendor Development Cell, wherein the local vendors can get registered with Vedanta and can receive the tenders related to Kaza Block developmental activities.<br>• Agricultural land shall be avoided to the extent possible.<br>• Vedanta Land Team shall assess the prevailing rates and expectations of the land owners, in consultation with the Land Acquisition Officer, to finalize the compensation rates.<br>• CSR shall extend its existing CSR initiatives to the all affected families. The activities will be done in affected villages of Movva, Gudur, Kalidindi and Machilipatnam mandals i.e. Palankipadu, Kanchakodur, makulavaripalem, Matlamullapalli, Maddipatla, Paddarayuduthota , Kaza, Kollapalem, Reddy naidu Agaraharam, Racharlapalem, Avurupudi Nidumolu, kalapatam, Gurjepalle, kanktav,Veerayelanka, Pinagudurulanka, Parnasala,Tarakaturupalem, Narikedalapalem, |

| Project Activity | Impact | Mitigation Measures |
|---|---|---|
| | | Chittiguduru, Guduru, Kokanarayanapalem, Akumarru, Gulabpura, Chittiguduru, Sultannagaram ,Gollapalem, Rayavaram.<br>• The internal village roads will be strengthened for transportation of machineries, equipment and drilling crew members. Additionally, strengthening of the existing approach road to the site will be done if required for transportation of drilling rig & associated equipment. Although, the level of existing communications and support services in the area are considered adequate based on the population density, establishment of the proposed project would be a distinct beneficial impact. The overall impact is considered to be positive.<br>• Considering the sparse vehicular movement in the Kaza block as a whole, the above anticipated traffic volume and the resulting emissions will be well within the stipulated ambient air quality norms.<br>• Preference will be given to employ the local labour based on the skill set available. |
| **B. Well Drilling, Testing and Operational activities** | | |
| • Well drilling<br>• Well testing & Flaring<br>• Recruitment/ Employment | • Impact on health due to emissions and noise from drilling activity<br>• During well testing, flaring will take place continuously for 14-21 days period. This activity will cause a significant change in the background levels of light due to glare in the local vicinity of the site, especially during the night and also may cause disturbance to the nearby villagers. | • Employees working at the well site would be provided with ear protective devices like ear plugs/earmuffs for ensuring minimum impact on noise to the human health.<br>• The duration of the flare testing will be relatively short, it is anticipated that the impact will be of temporary nature with no residual impacts after the well testing has been completed.<br>• Also, appropriate shading of the light will be provided to prevent scattering. |

## 4.13 RISK AND HAZARD

**Table 4.19 Potential Risk & Hazard and Mitigation Measures**

| Project Activity | Impact | Mitigation Measures |
|---|---|---|
| **A. Pre-drilling Activities** | | |
| • Transportation of drilling Rig, Materials and ancillaries | • Chances of accident may increase due to proposed construction activity. | • All the activities will be carried out under the supervision and control of the management.<br>• The Vehicles will be maintained in good repairs and checked thoroughly by Cairn appointed Road Transport safety Officer. |
| **B. Well Drilling and Testing** | | |
| • Preparation of drilling fluid (Mud) and drill cutting disposal<br>• Well drilling<br>• Well testing & Flaring | • Safety concerns for workers involved in handing of hazardous materials due to accidental spillage during storage and handling of materials.<br>• During drilling operations, the consequences of leaks or kicks with sour gas or crude can be very serious. Personnel can be incapacitated by relatively low concentrations of $H_2S$ in a very short time and equipment can suffer catastrophic failure due to $H_2S$ embrittlement.<br>• Probability of accidental leakage of gas/ liquid hydro-carbons due to failure of safety devices may have adverse impact on personnel, environment & assets. | • Personal protective equipment to be provided to workers involving in handling of hazardous materials.<br>• Proper engineering controls to prevent leakage of sour gases<br>• Obtain an early warning of emergency conditions so as to prevent a negative impact on personnel, the environment, and assets.<br>• Safeguard personnel to prevent injuries or loss of life by either protecting personnel from the hazard and/or evacuating them from the facilities.<br>• Minimize the impact of such an event on the environment and the facilities by mitigating the potential for escalation and, where possible, containing the release.<br>• A contingency plan will be drawn up when $H_2S$ may be expected during well operations.<br>• Proper evacuation procedures will be developed to handle emergency situations |

| **C. Operation of Well Site/Production facilities** | | |
|---|---|---|
| • Flaring of Gas<br>• DG/GEG Set of Emission | • Cold venting of gases will cause health impacts to the workforce and the people staying in the surrounding villages.<br>• Uncontrolled fire may lead damage to the surrounding villages and also may cause major explosion due to the presence of oil and gas.<br>• Oil spillage during loading may cause spill over in the well pad and also leading spill to the surrounding receptors. | • There shall be no intentional cold venting as per the design of the well pad facility. All vent gases will be route to the flare.<br>• All safety measures will be adopted to ensure safe shutdown of the well pad wells and operation facilities to avoid any leakage to the atmosphere.<br>• Well pad will have necessary firefighting provisions built in such as heat & smoke detectors, fire hydrants, fire tenders, fire extinguishers etc., followed as per the relevant design standards. |

**Table 4.20 Impact Significance Matrix (with mitigation)**

| Activities | Environmental Attributes | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Air | Water | Soil | Noise | LU/LC | Hydro geology | Geology | Risk Hazardous | Ecology and Biodiversity | Socio Economic | |
| **A. Pre-drilling Activities** | | | | | | | | | | | |
| Site & Access road development | -4 | -4 | -4 | -4 | -6 | -4 | - | - | -2 | -4 | **-32** |
| Transportation of drilling Rig, Materials and ancillaries | -6 | - | -2 | -4 | - | - | - | -4 | -4 | -4 | **-24** |
| **B. Well Drilling and Testing** | | | | | | | | | | | |
| Operation of DG sets and machineries | -4 | - | -4 | -4 | - | - | - | - | - | - | **-12** |
| Casing and cementing of well | - | -4 | -6 | -6 | - | -2 | - | - | - | - | **-18** |
| Preparation of drilling fluid (Mud) and drill cutting disposal | - | -6 | -6 | - | - | -4 | | -4 | -2 | - | **-22** |
| Well drilling | -4 | -2 | -2 | -6 | -6 | -4 | - | -6 | -4 | -2 | **-36** |
| Well testing & Flaring | -2 | - | -6 | - | - | - | - | -6 | -4 | -2 | **-20** |
| Greenbelt development | +16 | -4 | +9 | +16 | +6 | +2 | - | - | +16 | +16 | +77 |
| Recruitment | - | -4 | - | - | - | - | - | - | - | +25 | +21 |
| **C. Operation of Well Pad/Production facilities** | | | | | | | | | | | |
| Flaring of Gas | -6 | - | - | -4 | - | - | - | - | -4 | - | **-14** |
| DG/GEG Set of Emission | -6 | - | - | -6 | - | - | - | - | - | - | **-12** |
| Produced Water | - | -4 | -4 | - | - | - | - | - | - | - | **-8** |
| **D. Decommissioning and Reinstatement** | | | | | | | | | | | |
| Dismantling of rig & associated machineries | - | - | -4 | -4 | - | - | - | - | - | - | **-8** |
| Transportation of drilling facilities | -4 | - | - | -4 | - | - | - | - | -4 | - | **-12** |
| **Total** | **-20** | **-28** | **-29** | **-26** | **-6** | **-12** | **-** | **-20** | **-8** | **+29** | **-120** |

Highest total score (+29) received for Green belt development as it supports directly and indirectly for mitigating various pollution. Total Cumulative Score for various Environmental Parameters with mitigation measure is -120; which is not appreciable adverse impacts during operation phase. Most of the impacts are Short term, temporary and reversible in nature.

## 4.14 SUMMARY

The proposed project has no major adverse impact on surrounding environment. During the movement of trucks, fugitive emissions will be minimized by water sprinkling on roads and regular vehicular maintenance. Trucks used for transportation will be closed/ covered with tarpaulin sheet to avoid dust dispersion at site. Only PUC vehicle will be used for the transportation. The emission from the proposed project would not be significant to cause any damage to the people as all necessary and efficient modern air pollution control technologies are already planned to prevent impacts on people of the nearby area. The final gaseous emissions will be well within the permissible limits prescribed by APPCB/CPCB/MoEF&CC. Effluent will be treated in mobile ETP/STP. Proper sanitation facilities shall be provided within the premises to prevent contamination of water due to runoff. Solid/hazardous waste generated from the process shall be properly handled with adequate solid/hazardous waste management facilities. All the solid/hazardous waste generated shall be packed in HDPE bags and stored in Hazardous Waste Storage Facility having impervious layer. The collection, storage and disposal of solid/hazardous waste shall be carried out as per Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016. The adequate greenbelt shall be developed which shall greatly serve as an efficient barrier for prevention of air and Noise pollution.

# CHAPTER 5

# ANALYSIS OF ALTERNATIVES

Consideration of alternatives to a project proposal is a requirement of the EIA process. During the scoping process, alternatives to a proposal can be considered or refined, either directly or by reference to the key issues identified. A comparison of alternatives helps to determine the best method of achieving the project objectives with minimum environmental impacts or indicate the most environmentally friendly and cost-effective options. The consideration of alternatives is most useful when the EIA is undertaken early in the projects phase. The type and range of alternatives open for consideration include:

- Site alternatives (e.g. advantage of proposed well pad, details of any other sites, if explored, etc)
- Pipeline route (e.g. avoidance of major crossings such as lakes, ponds etc)
- Input or supply alternatives (e.g. use of raw materials, sourcing, etc)
- Technology alternatives (e.g. feasibility of different technologies available such as deviational drilling and advantage of proposed technology, etc)

After analysis of the various factors the most environmentally compatible alternative is selected. Reference may be made to available technologies, policy objectives, social attitudes, environmental and site constraints, projects economic etc.

This section provides an analysis of alternatives in relation to the conception and planning phase of the project. This includes the following:

## 5.1 NO PROJECT SCENARIO

The no project scenario has been analyzed to understand what would be reasonably expected to occur in the near future if the proposed development drilling of hydrocarbons and production of hydrocarbon are not conducted in the area. In such a scenario, there would not be any pressure on use of local resources and infrastructure, and no adverse effect on local ecology or incremental pollution to baseline environmental components (air, water and noise levels). At the same time, there would not be any positive impact on socioeconomic status of the area resulting from direct/ indirect employment and economic benefits that such a project can provide.

With no project scenario, dependence of the country on import of crude oil and demand for foreign exchange will grow. 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.

## 5.2 ALTERNATIVES FOR PROJECT SITE

The Kaza block is allocated by the Government of India Discovered Small Fields (DSFs) spread with the prime objective of monetizing discovered fields to boost domestic Oil and Gas production. These DSFs fields have already been discovered by India's National Oil Companies (NOCs) and are now being offered under exclusive policy which is designed to be investor friendly and is based on an easy to administer Revenue Sharing Contract model in tune with the Government's policy of 'Ease of doing business' in India. Vedanta Limited. (Division Cairn Oil & Gas) is the Operator for this block. Drilling locations are proposed based on geo-scientific information and alternate sites cannot be considered as the surface locations of hydrocarbon wells are selected considering the drilling configuration (reach to potential reservoirs).

## 5.3 ALTERNATIVES FOR WELL LOCATION

The 2D/3D seismic data interpretation would decide the exact locations of the drilling well. The proposed drilling well site have been identified based on the study, already available data based on the previous drilling carried out by ONGC and interpretation of the stratigraphy and other available data. Within the identified location of the Kaza block area, the actual well drilling site (called as well pad) will be selected based on the following factors:

- Located at a suitable distance from the nearest habitat / sensitive receptors
- Located at a safe distance from public road.
- Ensure natural drainage channels are avoided or drainage channels rerouted to ensure unhindered flow of rain / flood water. Where necessary adequate erosion control measures will be provided.

Road and pipeline alignment is a multidisciplinary process. Goals of the planning effort will include affected resource values and safety, and avoidance of haphazard development of roads. Total infrastructure that may later be developed should be considered during the selection process. Government agencies, landowners, tenants, and other users will be consulted during the planning process. Alternative alignments will be developed considering the following parameters as appropriate:

- topography;
- hydrology, drainage, and watercourses, whether seasonal or perenial;
- engineering properties of soils;
- location and amounts of excavation and fill materials;
- type and location of materials for road construction;
- air, water, and noise pollution;
- consistency with community character and local government needs and plans;
- proximity to dwellings or other permanent structures occupied or used by the public;
- visual sensitivity; and
- power lines and pipelines.

## 5.4 ALTERNATIVE OF TECHNOLOGY

The technical and process related alternatives are discussed in the section.

### 5.4.1 Use of Water Based Mud and Synthetic Based Mud

During drilling operation, drilling mud will be used, which is essential to lubricate and cool drill bits, removal of drilled rock (i.e. cuttings) from the bottom of the hole and transporting it to the surface and maintaining hydrostatic head in the well to counter natural formation pressures.

Drilling mud is basically a suspension / mixture of solids suspended in a liquid phase, which is blended with clays, polymers, salts and weighting agents. The main component/ solvent of drilling fluid are water, oil or synthetic and accordingly they are called as oil-based, water-based, and synthetic-based muds (OBMs, WBMs, and SBMs). All the three types of muds have certain advantages and disadvantages as discussed below.

Though the WBMs is a least cost option and widely used but is not found efficient in high temperature and also for water sensitive substrata, i.e., shales and mud. To overcome these limitations, OBM and SBM are used and of the two, SBM is preferred choice and it may be used in different set of environments like high temperatures, hydratable shales, high-angle, extended-reach wells, high-density mud and drilling through salt.

**Table 5.1 Ranks/Comparison of Different Types of Mud**

| Aspects | Water Based Mud | Oil Based Mud | Synthetic Based Mud |
|---|---|---|---|
| Least Cost | 1 | 2 | 3 |
| Quantity of Waste discharge | 3 | 2 | 1 |
| Least Quantity of Water Required for Preparation | 3 | 2 | 1 |
| Toxicity | 1 | 3 | 2 |
| Reduced drill time | 3 | 2 | 1 |

*Note: - 1: Preferable, 2: Less Preferable, 3: Least Preferable*

The WBM produces large quantity of drill waste as the mud is not recyclable. Moreover, the clay in WBM absorbs water and expands to disperse into the drilling fluid. These fine clay particles increase mud viscosity and inhibit its upward flow. To lower the mud viscosity, water is added to lower the concentration of fine solids and mud products are added to give the drilling fluid the correct density and flow properties. As a result, large volumes of mud are produced to be discharged as waste. On the other hand, the OBM and SBM are recycled several times and only drill cutting are disposed off.

The water requirement of SBM is highest as compared to OBM and WBM. Though, OBM are considered more efficient and has wider application in different conditions but their use is restricted due to environmental considerations. OBM are considered toxic due to the use of hydrocarbons as solvents and need a proper disposal through land fill. The water-based muds are considered safest in this regard followed by SBM.

If all the three types of mud are compared on the drill time, SBM is far superior then OBM and WBM. The less drill time mean shorter operation and hence less emissions from various drilling equipment and limited engagement of workforce.

The SBMs have the potential to drill wells more quickly and efficiently than WBMs, while avoiding some of the disposal costs and environmental difficulties associated with OBMs.

Water based mud will be used for initial, shallower sections where massive shales are not encountered. The deeper and difficult to drill formations will be drilled using synthetic base mud (SBM) including the water table. Synthetic base mud can be re-used. At the end of drilling a well almost the entire amount of the SBM is collected for re-use in next drilling operation. SBM systems promote good hole cleaning and cuttings suspension properties.

### 5.4.2 Directional Drilling

If a site is shifted to a new location due to proximity to sensitive receptors like habitation, water body, vegetation etc, an option of Horizontal Directional Drilling (HDD) will be used to tap the identified reservoir beneath the sensitive areas which cannot be reached through the vertical drilling. HDD is an expensive option, where a curved well is drilled to reach a target direction which is not vertically located. This can reduce ecological foot print of oil exploration due to the following reasons:

- Reduced need for excavations and many well heads can be clubbed together at one location
- Reduces land requirement as many well can be operated from one site.
- All facilities may be centralized and handling of waste is efficient
- Less disturbance to the surroundings and hence low social impacts

## 5.5 SUMMARY

- This project is of national importance as it helps to achieve energy security of the country. The project will have positive benefits in terms of revenue generation to state and central government, increase in job opportunity.
- Site selection would be carried out taking into consideration the least impact to habitation, proximity to any sensitive receptor and natural drainage.
- In addition, Vedanta Limited (Div: Cairn Oil & Gas) will ensure that the final site selection is made after due consideration to all environmental considerations mentioned. Also use of alternate method/technology to avoid sensitive locations will be made to the extent possible. Consideration of these alternatives with strict compliance to the Environment Management and Monitoring Plans suggested in this study report will be implemented to have minimal impact on the Environment.

# CHAPTER 6

# ENVIRONMENTAL MONITORING PROGRAM

## 6.0 GENERAL

Monitoring is one of the most important components of a management system. Continuous monitoring needs to be carried out for regulatory requirements, to monitor the environmental quality and to determine performance of proposed mitigation measures. Monitoring indicators have been developed for each of the activity considering the mitigation measures proposed. The monitoring programme has been developed taking into consideration of the following activities proposed in the Kaza Block.

- Construction of ten well pads;
- Drilling of 35 hydrocarbon wells;
- Setting up the oil & gas production facilities within the well pads including storage and evacuation of oil & gas from the well pads through road tankers, cascade mount trailers, pipleines;
- Construction / upgradation of site access and approach roads; and
- Laying of onshore pipeline for evacuation of oil & gas.

Monitoring results will be documented, analyzed and reported internally to Health, Safety and Environment (HSE) department of Cairn (Oil & Gas). Monitoring requirements have been described in the Table 6.1. Frequency of monitoring and responsibility of carrying out the monitoring have also been also been included. An Environmental Monitoring Programme shall be scheduled for the following major objectives:

- To verify the result of the impact assessment study in particular with regards to new developments.
- To follow the trend of parameters which have been identified as critical.
- To check or assess the efficiency of controlling measures.
- To monitor effectiveness of control measures.
- Regular monitoring of environmental parameters to find out any deterioration in environmental quality.

## 6.1 POST PROJECT ENVIRONMENTAL MONITORING PROGRAM

The below Table describes the proposed Environmental Monitoring Program, however any further addition to the monitoring program may be decided and carried out as suggested in Consent to Operate, Hazardous Waste Authorization, Environmental Clearance and any other regulatory requirements.

**Table 6.1: Environmental Monitoring Parameters and Frequency**

| S. No. | Environmental Indicator | Monitoring Parameter | Location | Period & Frequency | Responsibility |
|---|---|---|---|---|---|
| **ONSHORE ACTIVITIES** | | | | | |
| **A** | **Well pad site development and construction** | | | | |
| A.1 | Location and land required | Land parcels to be taken on lease and related compensations | Well pad sites, access roads and pipeline alignment | Once in project lifecycle | Land Acquisition Manager |
| A.2 | Approval / Authorization of quarries for sourcing of fill material | Validity of the Approvals for quarries supplying aggregates for site development and road works | Quarry area | Once in project lifecycle | Project Manager |
| A.3 | Topsoil stripping and storage | Area occupied for topsoil storage/ Area planned for topsoil storage | Onshore well pad sites, access roads and pipeline alignment | Once during each site preparation | Project Manager |

| S. No. | Environmental Indicator | Monitoring Parameter | Location | Period & Frequency | Responsibility |
|---|---|---|---|---|---|
| A.4 | Local drainage pattern | Cross drainage structures constructed to actual number of cross drainage structures designed | Onshore drill pad sites, access roads and pipeline alignment | Once in project lifecycle | Project Manager |
| A.5 | Fugitive emission of dust during site preparation | Visual observation of dust in air by haziness | Onshore well pad sites, access roads and pipeline alignment | Daily during site preparation | Project Manager |
| A.6 | Emissions from vehicles engaged | Ensure valid PUC Certificates from authorized PUC vendors | Vehicular exhausts | Annually for vehicles engaged | Project Manager |
| A.7 | Fugitive dust emission during material handling and storage | Visual observation of dust in air by haziness | Near stockpiles and storages | Daily during the entire project life cycle | Project Manager |
| A.8 | HSE Incident and Accident reporting | Number of incidents | Site & Haul Routes | Daily during the entire project life cycle | HSE Manager |
| A.9 | Groundwater Quality | Essential drinking water parameters as per IS:10500, 2012 | Three locations - surrounding receptor points | Once, prior to start of well pad development | Environment Manager – through NABL accredited lab |
| A.10 | Ambient Air Quality | Parameters mentioned in NAAQ Standard | Four locations - surrounding receptor points | Once, prior to start of well pad development | |
| A.11 | Ambient Noise quality | Equivalent day & night time Noise Levels in $L_{eq\ day}$ & $L_{eq\ night}$ dB(A) | Four locations - surrounding receptor points | Once, prior to start of well pad development | |
| A.12 | Soil Quality | Parameters pH, NPK ratio, Total Organic Carbon, heavy metals, TPH, organics, etc. | Four locations - onshore well pad sites & adjacent areas | Once, prior to start of well pad development | |
| **B.** | **Drilling & Testing** | | | | |
| B.1 | Gaseous pollutant emissions from diesel generators | Pollutant concentrations in gaseous emissions and maintenance parameters (air, fuel filters & air-fuel ratio) of DG sets influencing air emissions | Diesel generators deployed | Once in six months period | Project Manager |
| B.2 | Runoff from temporary storage areas | Supervision of functioning of conduits / drains, channels | Onshore drill sites, access roads and pipeline alignment | Fortnightly during drilling phase | Project Manager |
| B.3 | Fugitive emission of cement dust during handling and storage | Visual observation of cement dust in air by haziness | Near stockpiles and storages | Daily during the entire project life cycle | Project Manager |
| B.4 | Noise Levels | Equivalent day & night time Noise Levels in $L_{eq\ day}$ & $L_{eq\ night}$ dB(A) | Four locations - surrounding receptor points | Before and after the drilling period | Environment Manager – through NABL accredited lab |
| B.5 | Wastewater quantity & quality (wastewater, formation water etc.) | Volume estimate , CPCB General discharge parameters and Oil & Gas Extraction Industry Standards | At ETP discharge point | ETP operational records daily update and Monthly monitoring during drilling | |

| S. No. | Environmental Indicator | Monitoring Parameter | Location | Period & Frequency | Responsibility |
|---|---|---|---|---|---|
| B.6 | Drill cutting storage and disposal | Total volume generated, Concentration of hazardous constituents of SOBM and WBM as per Hazardous Waste Management and Handling Rules. CPCB Onshore discharge standards for Oil & Gas Extraction Industry, As per GSR 546 (E) | At storage location | Hazardous waste generation records daily update. Disposal within the stipulated period of 90 days from generation. | |
| B.7 | Ambient Air Quality | Parameters mentioned in NAAQ Standard | Four locations - surrounding receptor points | Before and after the drilling period | |
| B.8 | Stack Emission Monitoring | Measurement of $PM_{10}$, $PM_{2.5}$, NOx, $SO_2$, CO, HC | At DG sets within well pad site | Once during drilling | |
| B.9 | Soil quality | pH, NPK ratio, Total Carbon, heavy metals, TPH, organics, etc. | Site, adjacent areas and waste disposal sites three locations | Once in a year from the well pad / Kaza block. | |
| B.10 | Groundwater Quality | Analysis of parameters as per IS:10500: 2012 | At surrounding receptor points; three locations | Six monthly once in 2 – 4 locations, in and around the well pad / Kaza location. | |
| C | **Kaza Block Operation** | | | | |
| C.1 | Stack Emission | PM, $SO_2$, NOx, CO. | Natural gas engines as fuel | Quarterly | Environment Manager – through NABL accredited lab |
| C.2 | | PM, $SO_2$, NOx, CO, Non-methane Hydrocarbons. | Diesel engines as fuel | Quarterly | |
| C.3 | Ambient Air | All parameters as per NAAQ Standards and additional parameters of HC, NMHC, $H_2S$ and VOC | 4 to 6 locations within the Block operational and surrounding area | Quarterly | |
| C.4 | Ambient Noise | Equivalent day & night time Noise Levels in $L_{eq\ day}$ & $L_{eq\ night}$ dB(A), | 4 to 6 locations within the Block operational and surrounding area | Quarterly | |
| C.5 | ETP | Parameters as suggested in Consent to Operate | Untreated and treated effluent | Monthly | |
| C.6 | STP | Parameters as suggested in Consent to Operate | Untreated and treated effluent | Quarterly | |
| C.7 | Potable water | As per IS 10500: 2012 Standards | All key sources | Quarterly | |
| C.8 | Ground water | pH, Conductivity, TDS, Turbidity, Mineral Oil, Total Hardness, Total Alkalinity, Ca, Mg, Mn, B, Ba, Cl, $SO_4$, Sulphides, Fl, NO3, Ammonia, Phenolic Compounds, CN, Cd, As, Cu, Pb, Fe, Total Cr, Se, Zn, Hg, total pesticides, PAH, E. Coli, Total Coliform. | At surrounding receptor points; three locations | Quarterly | |
| C.9 | Surface water | pH, DO, BOD, Total Coliforms, Free Ammonia as N, Sodium Adsorption Ratio, Boron, Conductivity | At surrounding receptor points; three locations | Quarterly | |
| C.10 | Workplace noise | Sound pressure levels in dB(A) | All high noise generating areas | Quarterly | |
| C.11 | Soil | Bulk Density, Texture, pH, Conductivity, Cl, $SO_4$, Ca, Mg, Na, K, SAR, total N, P, Cd, Total Cr, Cu, Fe, Mn, Pb, Zn, As, Hg, B, Se, Organic Matter, TOC, Benzene, Toluene, Xylene, Ethyle Benzene, TPH, PAH | 4 locations within Kaza Block | Six monthly | |

## 6.2 SUMMARY

The environmental monitoring plan enables environmental management system with early sign of need for additional action and modification of ongoing actions for environment management, improvement and conservation. The environmental monitoring locations will be decided considering the environmental impacts likely to occur due to the operation of proposed project as the main aim of the monitoring program is to track, timely and regularly, the change in environmental conditions and to take timely action for protection of surrounding environment. Environmental sampling and monitoring will be done as per the guidelines provided by MoEF&CC /CPCB /APPCB. Along with other budgets, budget for environmental management will be prepared and revised regularly as per requirement.

# CHAPTER 7

# ADDITIONAL STUDIES

## 7.1 GENERAL

An additional study including Risk Assessment (RA), Disaster Management Plan, Occupational, Health and Safety has been carried out for the proposed project. The study has been incorporated in the EIA report to support the Environmental Management Plan.

## 7.2 PUBLIC CONSULTATION

The applicability of the S. O. 1533 for the proposed project was explored by considering different possibilities and provisions described in the said notification. Considering the products and project location of the proposed project, it is noticed that the proposed project falls under the item no. 1 (b) – Category 'A' according to EIA Notification, SO 1533 amended on 14$^{th}$ September 2006. Public hearing is applicable and it shall be carried out as per the procedure of Andhra Pradesh Pollution control Board and Minutes of the meeting for the same will be incorporated in the final EIA/EMP report.

## 7.3 RISK ASSESSMENT

### 7.3.1 Introduction

The objective of the RA study is to identify major risk contributing events, demarcate vulnerable zones and evaluate the nature of risk posed to nearby areas due to proposed drilling, production activity and hydrocarbon Storage, in addition to ensure compliance to statutory rules and regulations. The scope of work for the study is described below:

- Identify potential risk scenarios that may arise from the proposed drilling and other associated activities.
- Analyze the possible likelihood and frequency of such risk scenarios by reviewing historical accident related data.
- Predict the consequences of such potential risk scenarios and if consequences are high, establish the same by through application of quantitative simulations.
- Recommend feasible preventive and risk mitigation measures as well as provide inputs for drawing up of Emergency Response Plan (ERP) for the project.
- The assessments to be based on various existing documents including Emergency Response Plan (ERP), Disaster Management Plan (DMP).

The scope involves risk assessment of Well Pad including Diesel Day Tank located at project site that would have a detrimental impact to the personnel and plant properties.

### 7.3.2 Site Inventory

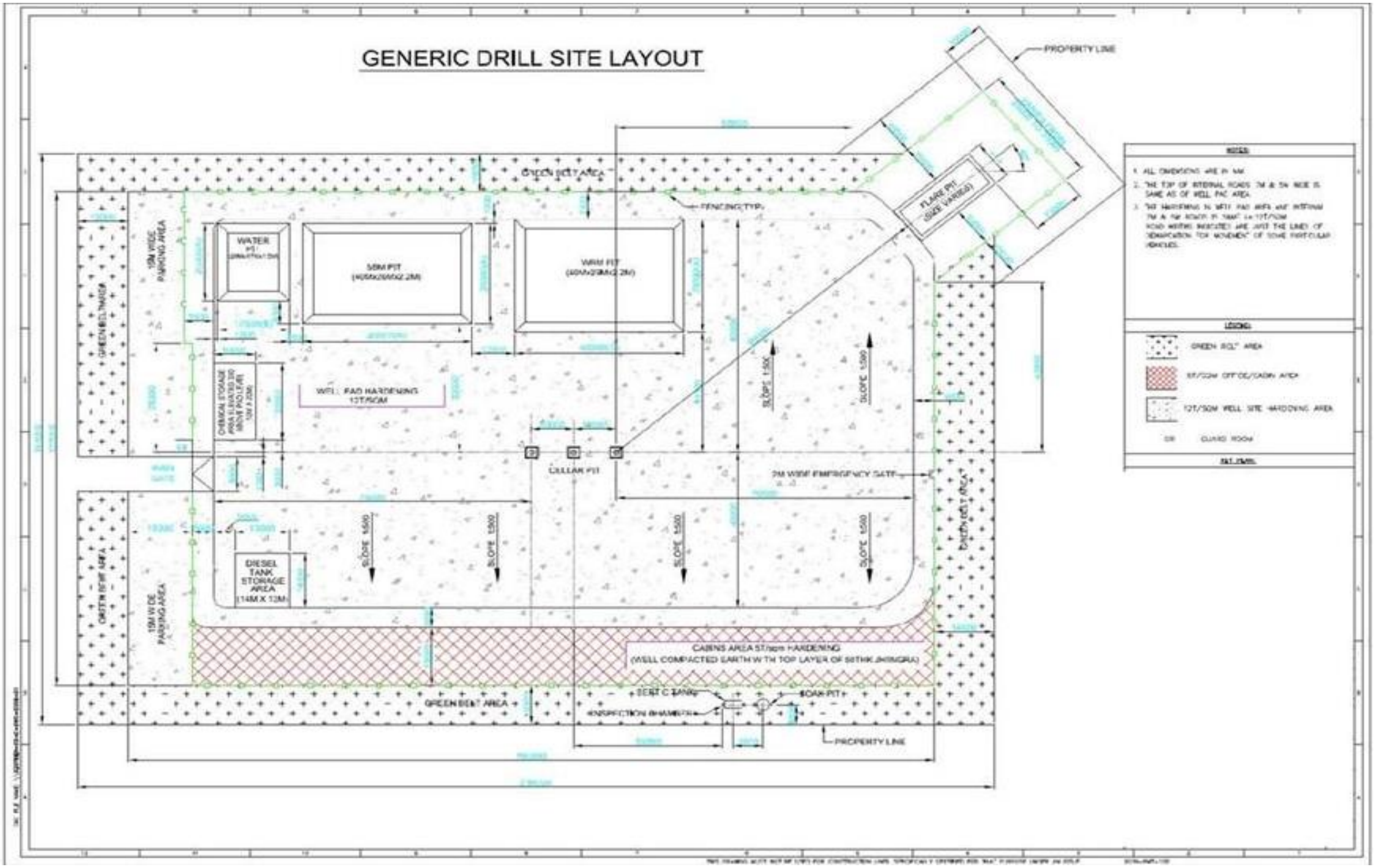


Figure 7.1: Typical well layout plan

### 7.3.3 Methodology & Approach

Risk analysis consists of hazard identification studies to provide an effective means to identify different types of hazard during the operation of the facility. This is followed by an assessment of the impacts of these hazards.

Hazard is present in any system, plant or unit that handles or stores flammable materials. The mere existence of hazards, however, does not automatically imply the existence of risk. Screening & ranking methodologies based on Preliminary Hazard Analysis (PHA) techniques have to be adopted for risk evaluation.

The approach and methodology followed for the Risk Assessment study are described hereunder:

The study comprises of the following stages:

- Identification of potential major hazard scenarios;
- Assessment of the likelihood and consequences of identified hazards;
- Estimation of the impact of identified hazards on personnel; and
- Assessment of the risks against tolerance criteria.

The Risk Assessment (RA) uses conventional risk assessment techniques as shown in Figure and described as follows:

- Identify the preliminary causes of major accidents associated with the process, and develop a list of representative potential events involving the release of hazardous materials or other events, which could lead to loss of life or damage to infrastructure.
- Model the possible scale of severity of the physical effects of each identified hazardous event. Predict the criticality of the damage that could be caused and the potential for escalation, developing rule sets and assumptions to form the basis of an analysis of the possible outcomes.
- For each identified hazard, use appropriate models and data to estimate its frequency, taking into account any site-specific features that may influence the likelihood of the scenarios. Compare the event frequency estimates with historical data to confirm the validity of the model.
- Combine the predicted consequences of each event with its frequency to estimate the risks to personnel. Assess the Individual Risk (IR) for the facilities.
- Compare the results of the study with Company Risk Tolerance Criteria to establish whether the operation of the project can be regarded as adequately safe. Consider the risk mitigation provided by other measures such as the gas detection and shutdown system.
- Propose additional Risk Reduction Measures (RRM).

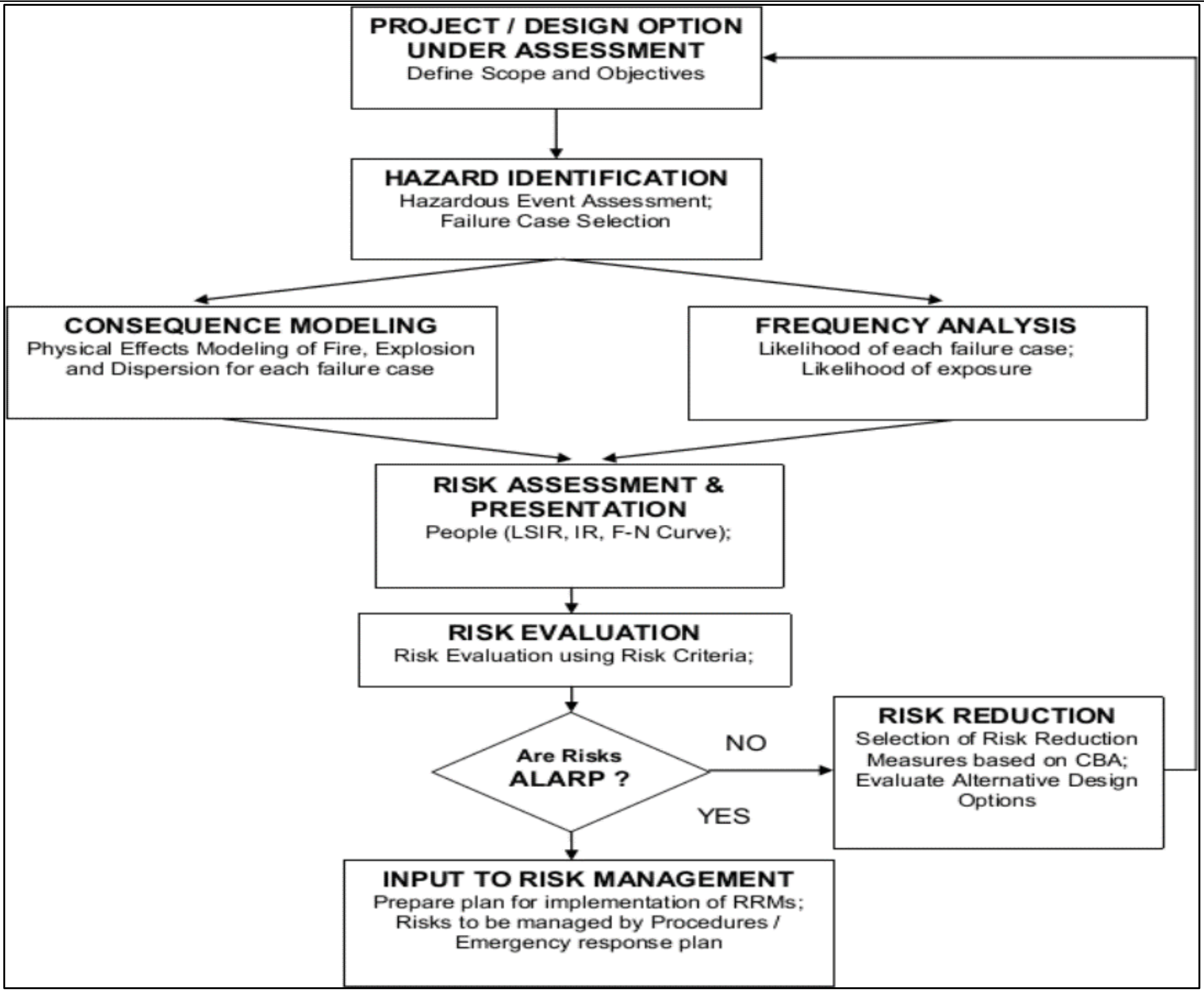


**Figure 7.2: Risk Assessment Methodology**

### 7.3.4 Hazard Identification

Hazard scenario development is carried out considering the activities at the facilities and the inherent hazardous properties of the material being handled.

The Hazard Identification looks into all incidents, which could result in possible fatalities. For drilling, such incidents typically include the following:

- Well fluid releases - small, medium and large well fluid releases from drilling of the wells. Possibilities include blowouts (due to either down hole or surface abnormality or possible cratering (a basin like opening in the Earth surface surrounding a well caused by erupted action of gas, oil or water flowing uncontrolled)) or other incidents involving drilling fluids, leakage from mud degassing stacks/ vents and others- these are the major category and are deliberated in this chapter.
- Possibility of dropped objects on the drilling platform due to lifting of heavy equipment including components like draw works, drilling pipe, tubing, drill bits, Kelly, mud equipment, shale shakers, BOP components, power generating equipment and others
- Single fatality occupational incidents such as trips and falls. These are more likely in drilling rigs due to the hazardous nature of operations and general high congestion and large extent of the manual operation

involved.

- Structural failure of the drilling rig due to excessive static or rotating loads, earthquake, and design defect, construction defect etc. It may be noted that rotating loads are induced due to the specific rotating actions of the rotary drilling mechanism (Drill string rotated by means of rotary table etc.).
- Loss of containment of fuels (HSD) and consequent pool fire on encountering an ignition source.

The HAZID would select the Scenarios for further modeling in the next sections. The HAZID is derived mainly from incidents in similar drilling installations based on worldwide experience and includes generic data sources.

**Table 7.1 : Accidents due to types of hazardous events**

| Type of Hazardous Event | Specific Accident Event included in RA |
|---|---|
| Hydrocarbon Release | • Uncontrolled Blow out-medium, large, small<br>• Release from diesel tanks- Catastrophic failure, medium and small risks |
| Occupational accidents | • Single fatality accidents suck as slips, trips, falls, dropped objectives etc. |
| Other Hazards during drilling Rig operation | Structural collapse of drilling rig due to static or rotating load, fatigue, construction defect, design defect, *earthquakes etc.*<br>– *Hazards during Installing the Auxiliary Equipment*<br>– *Hazard in Rigging Up the Circulating System*<br>– *Hazards during Setting Up the Rig Floor and Mast or Derrick*<br>• *Hazards During Preparation for Setting Up the Substructure* |

### 7.3.5 Hydrocarbon Release

The events of blowouts during drilling are divided in the databases according to the consequences and well control success. Such blowouts can be ignited or un-ignited. Blow outs are uncontrolled sudden expulsions of oil, gas, water or drilling fluids from wells to the surface which result in loss of control of the well.

Sources of hydrocarbon release during the drilling phase include the following:

- Dissolved gas which comes out of solution under reduced pressure often while drilling at near balance or under balance hydrostatically or as trip gas during a round trip to pull the drill string around from the hole. Such sources could include releases at bell nipple and around mud return flow line outlet, shale shakers and active mud pits.
- As a "kick", which occurs as the down hole formation pressure unexpectedly exceeds the hydrostatic head of the circulating mud column. Significant releases can occur from the vent lines of the mud /gas separator and other locations.
- From residual mud on the surface of the drill pipe being racked in the derrick during the round trip, or on production of coil tubing being withdrawn from the hole, or from core samples laid out for inspection. Usually any liquid hydrocarbon system entering the down hole under normal circumstances are very much diluted by the mud system. However, under conditions of under balanced drilling, the proportion of hydrocarbons in mud returns may be significant with a potential for continuous release.
- Small hydrocarbon release from rotating equipment, pipes and pump work occurring during normal operations/ maintenance during drilling. These are not likely to be significant in open derrick or mast structures.
- Possible shallow gas blowout - these may occur at sumps or drainage tanks and be conveyed by vents or

drains to areas of potential ignition sources resulting in fire/ explosion.

- Vapour present in oily drainage systems, vents, and ducting.
- Flammable materials used in drilling operations (Synthetic oil based drilling fluids) - release points could include high pressure mud points, mud degassing equipment, shale shaker, mud pits and active tanks etc.

### 7.3.6 Blowout Prevention

If the hydrostatic head exerted by the column of drilling fluid is allowed to drop below the formation pressure then formation fluids will enter the well bore (this is known as a kick) and a potential blowout situation has developed. Blowout means uncontrolled violent escape of hydrocarbon fluids from a well. Blowout followed by ignition, is a major hazard. Major contributors to blowout are:

**I. Primary**

- Failure to keep the hole full;
- Too low mud weight;
- Swabbing during trips;
- Lost circulation; and
- Failure of differential fill-up equipment.

**II. Secondary**

- Failure to detect and control a kick as quickly as possible;
- Mechanical failure of Blow Out Preventer (BOP);
- Failure to test BOP equipment properly;
- Damage to or failure of wellhead equipment;
- Failure of casing; and
- Failure of formation or cement bond around casing.
- Fast and efficient action by operating personnel in recognizing the above situations and taking precautionary measure can avert a blowout.

**Presence of Sour Gas (Hydrogen Sulphide-$H_2S$)**

Presence of Sour Gas ($H_2S$) in hydrocarbon during blowout of well can pose immediate dangers to life and health at and around the rig area. On ignition, $H_2S$ is converted to Sulfur dioxide ($SO_2$) which is highly toxic. Therefore, a safety system should be in place to monitor $H_2S$.

Hydrogen Sulphide gas ($H_2S$) is extremely toxic, and at even very low concentrations, it can be lethal depending upon the duration of exposure. Additionally it is corrosive and can lead to failure of the drill string or other tubular components.

Important characteristics of $H_2S$ gas are briefed below:

1. $H_2S$ is a toxic colorless gas heavier than air.
2. In concentrations greater than 100 ppm, it causes loss of senses in 3 to 15 minutes and death within 48 hours.
3. The safe concentration for a normal working period without protection is 10 ppm.
4. It has an odour of rotten eggs.
5. In concentration greater than 10 ppm, the olfactory fatigue (a person loses his ability to smell the gas even though it is still present) happen, hence need for detectors is apparent.
6. It dissolves in the blood and attacks through the nervous system.
7. It is very irritating for the eyes as it forms Sulphuric acid together with water.

8. It attacks the body through the respiratory organs.
9. The Occupational Safety and Health Act (OSHA) sets a 10 ppm ceiling for an (eight) hour continuous exposure (TWA limit), a limit of 15 ppm for short term exposure limit for 15 minutes (STEL) and a peak exposure concentration of 50 ppm for 10 minutes.
10. The best protection is breathing apparatus, with mask covering the whole face and a bottle containing breathing air.
11. $H_2S$ burns with a blue flame to form sulphur dioxide which is also dangerous
12. It forms an explosive mixture with air at concentrations from 4% to 46%.
13. Short exposure of high tensile steel to as little as 1 ppm in aqueous solution can cause failures.
14. Concentrations greater than 15 ppm can cause failure to steel harder than Rockwell C- 22. High stress levels and corrosive environments accelerate failures.
15. When pH is above 9 and solubility is relatively high, it is readily soluble in mud and especially in oil mud.
16. A 30% hydrogen peroxide solution will neutralize $H_2S$ gas in the mud or 20 gallons of $H_2O_2$ per 100 barrels of mud. It occurs together with natural gas in all oil provinces of the world.
17. Coughing, eye burning and pain, throat irritation, and sleepiness are observed from exposure to low concentrations of $H_2S$.
18. Exposure to high concentrations of $H_2S$ results in panting, pallor, cramps, paralysis of the pupil and loss of speech. This is generally followed by immediate loss of consciousness. Death may occur quickly from respiratory and cardiac paralysis.

**Table 7.2: Characteristics of H2S**

| Concentrations | Symptoms/ Effects |
|---|---|
| 100 ppm | Coughing, eye irritation, loss of smell after 2-15 minutes (Olfactory fatigue).<br>Altered breathing, drowsiness after 15-30 minutes, throat irritation after 1 hour.<br>Gradual increase in severity of symptoms over several hours. Death may occur after 48 hours. |
| Greater than 100 ppm | Loss of smell (olfactory fatigue or paralysis). |
| 500-700 ppm | Staggering, collapse in 5 minutes. Serious damage to the eyes in 30 minutes. Death after 30-60 minutes. |
| 700-1000 ppm | Rapid unconsciousness, "knockdown" or immediate collapse within 1 to 2 breaths, breathing stops, death within minutes. |
| 1000-2000 ppm | Nearly Instant Death |

As per available data, there is no chance of presence of $H_2S$ in the hydrocarbon present within block, however, in a hypothetical case, scenario of 3% H2S presence has been considered for consequence analysis.

### 7.3.7 Other Hazards during Drilling Rig Operations

**Hazards during Preparation for Setting up the Substructure**

Equipments are unloaded and positioned at or near the exact location of drilling point. The substructure is assembled, pinned together, leveled, and made ready for other rig components on the floor. Equipping the cellar begins but can be done throughout the rigging up process. This includes welding on a drilling nipple to the conductor pipe and attaching a flow line.

**Potential Hazards:**

- Pinched fingers when assembling equipment.
- Burns from cutting and welding on the drilling nipple.
- Temporary eye irritation from welding light flash.
- Falling from heights.

**Hazards during Setting up the Rig Floor and Mast or Derrick**

Once the substructure is set in place, the process of setting up the rig floor begins by installing stairways and guardrails to allow access to the rig floor. Then, the draw works is set in place and secured to the substructure. On mechanical rigs, the engines are set in place and the compound and associated equipment connected to the draw works. On electric rigs, the electric cables (lines) are strung to the draw works.

The bottom of the mast is raised to the rig floor and pinned in place. The crown section is then raised into place on the derrick stand. The "A-legs" are raised and pinned into place. The monkey board is pinned in place on the mast and all lines and cables are laid out to prevent tangling when the mast is raised. A thorough inspection of the mast should be made before raising the mast/derrick. The mast is now ready to be raised. The engines are started, and the drilling line is spooled onto the draw works drum. Once the mast has been raised and pinned, the remaining floor equipment can be set into place. If the rig has safety guy lines, they must be attached to the anchors and properly tensioned prior to continuing the rigging up process. A derrick emergency escape device is installed on the mast.

**Potential Hazards:**

- Falling or tripping during rigging up;
- Falling from rig floor;
- Being struck by swinging equipment;
- Being struck by falling tools;
- Being crushed or struck by equipment due to failure or overloading of hoisting equipment;
- Getting entangled in lines during rising of the derrick or mast;
- Failure to properly install derrick emergency escape device; etc.

**Hazard in Rigging up the Circulating System**

While one crew finishes preparing the rig floor, another crew might be rigging up the circulating system. The mud tanks and mud pumps are set into the pre-determined location. The mud lines are then connected and electric cords are strung.

**Potential Hazards:**

- Being struck by or crushed by equipment being set into place;
- Getting caught in pinch points;
- Being struck by crane, load, truck or forklift tipping;
- Being struck by hammer when connecting mud line unions; etc.

**Hazards during Installing the Auxiliary Equipment**

All remaining drilling and auxiliary equipment must be set into place and installed where needed. The catwalk and pipe racks are positioned and the pipe and drill collars are set on the racks.

**Potential Hazards:**

- Getting struck or pinched by, or caught in between, tubular being loaded onto racks.

- Having feet pinched or crushed when setting up the pipe racks and catwalk.

### 7.3.8 Consequence Analysis

Consequence analysis involves the calculation of the initial "release rate" and then predicting the consequence of the release through computer modeling- it forms an important ingredient in the RA approach. Consequence analysis is a complex procedure involving numerous calculations. It must also be noted that a single starting incident could have numerous outcomes depending upon factors such as escalation, ignition and others. The various factors of importance in this drilling rig study with respect to consequence analysis are described below.

**Table 7.3: List of Isolatable Sections**

| IS | Scenario |
|---|---|
| IS 01 | Well Fluid from Well to Inlet of Heater Separator |
| IS 02 | Heater Theater Separator - Oil Case |
| IS 03 | Oil from Heater Separator to inlet of Oil Storage Tanks including coaleser separator |
| IS 04 | Oil Transfer pump outlet to Road tanker loading |
| IS 05 | Road Tanker Failure |
| IS 06 | Diesel Storage Tank |
| IS 07 | Fuel Gas System |
| IS 08 | Flare System |

The Test Separator, Flare System including associated pumps, KODs are not included as the details (P&IDs, Operating Pressure, Operating Temperature, Composition, Flow rate, Flare datasheet, etc.) are not available during the execution of the project.

However, the same will be included in the next revision of the report.

Depending on the type of liquid handled and process conditions, one or more of the following potential hazards/consequences could be encountered due to loss of containment of hydrocarbons:

- Un-ignited release;
- Jet Fire;
- Pool Fire;
- Flash Fire;
- Vapour Cloud Explosion; and
- Toxic Impact (Not applicable for this project)

**UN-IGNITED GAS RELEASE / DISPERSION**

A vapour cloud may be formed when a vaporizing liquid is released for an extended duration. If the gas cloud does not immediately ignite, it disperses based on the prevalent wind direction, speed and stability category (i.e. degree of turbulence).

The cloud dispersion simulation is carried out to provide the distance (from the leak) at which the concentration of flammable material falls below the Lower Flammability Limit (LFL).

#### 7.3.8.1 Jet Fire

Jet fire causes damage due to the resulting heat radiation. The working level heat radiation impact will vary widely depending on the angle of the flame to the horizontal plane, which mainly depends on the location of the leak. The flame direction was considered horizontal for consequence analysis of leaks and ruptures from Piping and Tanks.

Upon accidental leakage, the pressurized fluid will disperse as a jet, initially moving forward in the spatial direction of the leak till the kinetic energy is lost and gravity slumping or lifting of the cloud occurs, dependent upon whether the fluid is heavier or lighter than air.

Source term modeling has been conducted for each identified study area at all the locations at the full stream operating pressure to determine the initial release rate. The release rates and material properties were used to calculate the flame length and distance to relevant heat radiation levels.

Two models are available for jet fire modeling in PHAST V 6.7 - the cone model and the API- RP 521 model, of which the cone model is considered to be more conservative, and presents the jet fire as a tilted cone frustum, as opposed to a banana shaped plume in the API-RP 521 model, i.e. tapered at the end and bent by the wind. Thus, the cone model has been selected for jet-fire modeling.

The primary hazard associated with jet fires is thermal radiation and potential for flame impingement on adjacent pipelines/equipment, resulting in escalation. High pressure releases have the potential to cover large areas due to its relatively large flame length. However, the effects of escalation are minimized if the flame length reduces to less than the separation distance between other equipment and the jet fire source.

#### 7.3.8.2 POOL FIRES

A liquid pool is formed during a prolonged leakage if the rate of leakage exceeds the rate of vaporization. On ignition, this would result in a pool fire whose size/radius would depend on the mass flow rate, ambient temperature, and heat of vaporization of material released, vapour pressure, duration of discharge and effects of containment or dykes.

The pool fire could cause damage to equipment or injury/fatality to personnel due to thermal radiation effects.

A pool fire is not envisaged for liquid systems which are highly pressurized. Any leak or rupture would result in a pressurized release leading to a liquid jet fire or flash fire.

#### 7.3.8.3 FLASH FIRE

The vapour/gas release from a pool would disperse under the influence of the prevailing wind; with material concentration in air reducing with distance. At a particular location downwind, the concentration will drop below its lower flammable level (LFL) value. If ignited within the flammable envelope, the mass of the material available between the LFL and ½ LFL will be likely to burn as a flash fire; rapidly spreading through the cloud from the point of ignition back to the source of release.

Although flash fires are generally low intensity transitory events, the burning velocity is quite high and escape following ignition is not possible. Flash fires often remain close to the ground, where most ignition sources are present. It is assumed that personnel caught inside a flash fire will not survive while those outside suffer no significant harm. If other combustible material is present within the flash fire it is also likely to ignite and a secondary fire could result.

#### 7.3.8.4 VAPOUR CLOUD EXPLOSION

The magnitude of the vapour cloud explosion is dependent on the size of the gas cloud that has formed and the degree of congestion in the area, as these determine the acceleration of the flame front. The TNO GAMES model is used for modelling of vapour cloud explosions, as the model incorporates the characteristics of the explosion, such as the type of fuel, its reactivity, the effect of obstacles in the congested region.

#### 7.3.8.5 TOXIC EFFECTS

There is no toxic impact in this project as there are no toxic materials handled.

#### 7.3.8.6 CONSEQUENCE IMPACT CRITERIA

The damage potential associated with the various hazardous outcomes described above is assessed based on pre-defined impairment criteria for losses.

Estimate of damage or impact caused due to thermal radiation, explosion overpressure and toxic effects is generally based on the published literature on the subject. Probit relations are used for these calculations. The actual potential consequences from these likely impacts can then be visualized by superimposing the damage effect zones on the proposed layouts and identifying the elements within the project which might be adversely affected, should one or more hazards materialize in practice. The damage criteria used in the present study is described in the following sections.

#### 7.3.8.7 THERMAL DAMAGE/ RADIATION DAMAGE

As per OGP-14;

| | |
|---|---|
| 4.73 kW/m$^2$ | Maximum radiant heat intensity in areas where emergency actions lasting 2 min to 3 min can be required by personnel without shielding but with appropriate clothing. Corresponds to of painful burns and blistering after 20 second exposure J0% lethality) |
| 6.31 kW/m$^2$ | Indicative of second degree burns after 20 second exposure J1% fatality) |
| 12.5 kW/m$^2$ | Indicative of piloted ignition for susceptible structures J50% fatality) |
| 37.5 kW/m$^2$ | Indicative of total asset loss J100% fatality) |

Hence, following heat radiation levels are considered to determine physical effects of hazard events:

1) 4.73 kW/m$^2$;
2) 6.31 kW/m$^2$,
3) 12.5 kW/m$^2$,
4) 37.5 kW/m$^2$

#### 7.3.8.8 FLASH FIRE

The consequence distances should be identified for the following Lower Explosive Limit:

- 50 % Lower Explosive Limit
- 100 % Lower Explosive Limit

#### 7.3.8.9 EXPL OSION

Blast peak overpressure from explosion for buildings should not exceed the following levels provided in Table below. Internationally recognized and globally accepted TNO Multi energy model was used for the explosion modeling for this Project.

**Table 7.4: Overpressure level criteria**

| Level of Concern | Type of Damage |
|---|---|
| 0.02068 bar | "Safe distance" (probability 0.95 of no serious damage1 below this value); projectile limit; some damage to house ceilings; 10% window glass broken. |
| 0.07 bar | General buildings, offices |
| 0.2068 bar | Partial collapse of wells, concreate Block wells, not reinforced, shattered |
| 1 bar | Range for 1-99% fatalities among exposed population due to direct blast effects |

Hence, following over pressure levels are considered to determine physical effects of hazard events:

- 0.02068 bar
- 0.07 bar

- 0.1379 bar
- 0.2068 bar
- 1 bar

#### 7.3.8.10 TOXIC GAS

No toxic gas dispersion envisaged in this project.

### 7.3.9 Consequence Analysis and Calculations

- **Hole Size Distribution**

For each isolatable section and its study areas, a range of leaks have been considered for the assessment of hydrocarbon hazards arising from facility is described in section, these leaks are defined on the basis of hole sizes.

- **Meteorological Data**

The consequences of material released being toxic and flammable are largely dependent on the prevailing weather conditions. For the assessment of various scenarios involving release of toxic or flammable materials, the most important meteorological parameters are those that affect the atmospheric dispersion of the leaking material. The crucial variables are wind direction, wind speed, atmospheric stability and temperature. Rainfall does not have any direct bearing on the results of the risk analysis; however, it can have beneficial effects by absorption/washout of released materials. Actual behavior of any release would largely depend on prevailing weather condition at the time of release.

- **Atmospheric Stability Classes**

The tendency of the atmosphere to resist or enhance vertical motion and thus turbulence is termed as stability. Stability is related to both the change of temperature with height (the lapse rate) driven by the boundary layer energy budget, and wind speed together with surface characteristics (roughness).
A neutral atmosphere neither enhances nor inhibits mechanical turbulence. An unstable atmosphere enhances turbulence, whereas a stable atmosphere inhibits mechanical turbulence.
Stability classes are defined for different meteorological situations, characterized by wind speed and solar radiation (during the day) and cloud cover during the night. The so called Pasquill-Turner stability classes' dispersion estimates include six (6) stability classes as below:

**A - Very Unstable, B – Unstable, C – Slightly Unstable, D – Neutral, E – Stable, F-Very Stable**

For the study purpose, following weather conditions are taken forward for modelling purposes:

- 2F - F stability class and wind speed of 2m/sec
- 5D - D stability class and wind speed of 5m/sec

- **Release Rates**

The release rates were determined based on the release size and the process conditions i.e. temperature and pressure. Depending on the operating conditions, the release state of the fluid could be liquid, gas or two-phase. The release rates were estimated using the software. The release rates and the phase would give an indication of severity of the leak and influence the flammable and toxic impacts.

#### A. Jet Fire Radiation Distances

The Jet Fire Radiation distances are not generated for the scenarios considered in this project.

**Table 7.5: Jet Fire Radiation Distances**

| IS No | Scenario | Weather | 4.73 kW/m2 [m] | 6.31 kW/m2 [m] | 12.5 kW/m2 [m] | 37.5 kW/m2 [m] |
|---|---|---|---|---|---|---|
| IS 01 | 5mm | 1.5F | 15.76 | 14.75 | 12.82 | 10.61 |
| | | 5D | 13.79 | 12.77 | 10.83 | 8.68 |
| | 25mm | 1.5F | 65.03 | 60.43 | 51.46 | 40.9 |
| | | 5D | 57.53 | 52.91 | 44 | 33.91 |
| | 100mm | 1.5F | 223.2 | 206.7 | 174.6 | 137.4 |
| | | 5D | 188.6 | 173.3 | 143.6 | 109.9 |
| | FBR | 1.5F | 319.7 | 295.9 | 249.6 | 195.9 |
| | | 5D | 260.4 | 239.4 | 198.8 | 152.4 |
| IS 02 | 5mm | 1.5F | 15.64 | 14.65 | 12.73 | 10.54 |
| | | 5D | 13.69 | 12.68 | 10.75 | 8.619 |
| | 25mm | 1.5F | 65.03 | 60.43 | 51.46 | 40.9 |
| | | 5D | 57.53 | 52.91 | 44 | 33.91 |
| | 100mm | 1.5F | 223.2 | 206.7 | 174.6 | 137.4 |
| | | 5D | 188.6 | 173.3 | 143.6 | 109.9 |
| | FBR | 1.5F | 319.7 | 295.9 | 249.6 | 195.9 |
| | | 5D | 260.4 | 239.4 | 198.8 | 152.4 |
| IS 03 | 5mm | 1.5F | 15.64 | 14.65 | 12.73 | 10.54 |
| | | 5D | 13.69 | 12.68 | 10.75 | 8.619 |
| | 25mm | 1.5F | 79.26 | 73.68 | 62.87 | 50.38 |
| | | 5D | 71.19 | 65.38 | 54.18 | 41.59 |
| | 100mm | 1.5F | 223.2 | 206.7 | 174.6 | 137.4 |
| | | 5D | 188.6 | 173.3 | 143.6 | 109.9 |
| | FBR | 1.5F | 319.7 | 295.9 | 249.6 | 195.9 |
| | | 5D | 260.4 | 239.4 | 198.8 | 152.4 |
| IS 04 | 5mm | 1.5F | 18.37 | 17.19 | 14.92 | 12.37 |
| | | 5D | 16.26 | 15.03 | 12.69 | 10.1 |
| | 25mm | 1.5F | 74.78 | 69.51 | 59.28 | 47.41 |
| | | 5D | 66.93 | 61.47 | 50.97 | 39.16 |
| | 100mm | 1.5F | 257.2 | 238.3 | 201.7 | 159.6 |
| | | 5D | 212.2 | 195.1 | 161.9 | 124.1 |
| | FBR | 1.5F | 363.8 | 337.1 | 285.2 | 225.5 |
| | | 5D | 293.2 | 269.8 | 224.3 | 172.3 |
| IS 05 | 10mm | 1.5F | 33.02 | 30.79 | 26.46 | 21.62 |
| | | 5D | 29.4 | 27.09 | 22.63 | 17.71 |
| | CR | 1.5F | NR | NR | NR | NR |
| | | 5D | NR | NR | NR | NR |
| | 5mm | 1.5F | 1.162 | 1.162 | 1.162 | NR |

| IS No | Scenario | Weather | 4.73 kW/m2 [m] | 6.31 kW/m2 [m] | 12.5 kW/m2 [m] | 37.5 kW/m2 [m] |
|---|---|---|---|---|---|---|
| IS 06 | | 5D | 1.119 | 1.119 | 1.119 | 1.119 |
| | 25mm | 1.5F | 1.567 | 1.567 | 1.567 | NR |
| | | 5D | 1.431 | 1.431 | 1.431 | 1.431 |
| | 50mm | 1.5F | 1.791 | 1.791 | 1.791 | NR |
| | | 5D | 1.631 | 1.631 | 1.631 | 1.631 |
| | CR | 1.5F | NR | NR | NR | NR |
| | | 5D | NR | NR | NR | NR |
| IS 07 | 5mm | 1.5F | NR | NR | NR | NR |
| | | 5D | 1.254 | 1.053 | NR | NR |
| | 25mm | 1.5F | NR | NR | NR | NR |
| | | 5D | 1.254 | 1.053 | NR | NR |
| | 100mm | 1.5F | 11.89 | 4.254 | NR | NR |
| | | 5D | 20.7 | 17.1 | 7.255 | NR |
| | CR | 1.5F | NR | NR | NR | NR |
| | | 5D | NR | NR | NR | NR |
| IS 08 | 5mm | 1.5F | NR | NR | NR | NR |
| | | 5D | 1.254 | NR | NR | 1.053 |
| | 25mm | 1.5F | NR | NR | NR | NR |
| | | 5D | 1.254 | NR | NR | 1.053 |
| | 100mm | 1.5F | 11.89 | NR | NR | 4.254 |
| | | 5D | 20.7 | 7.255 | NR | 17.1 |
| | CR | 1.5F | NR | NR | NR | NR |
| | | 5D | NR | NR | NR | NR |

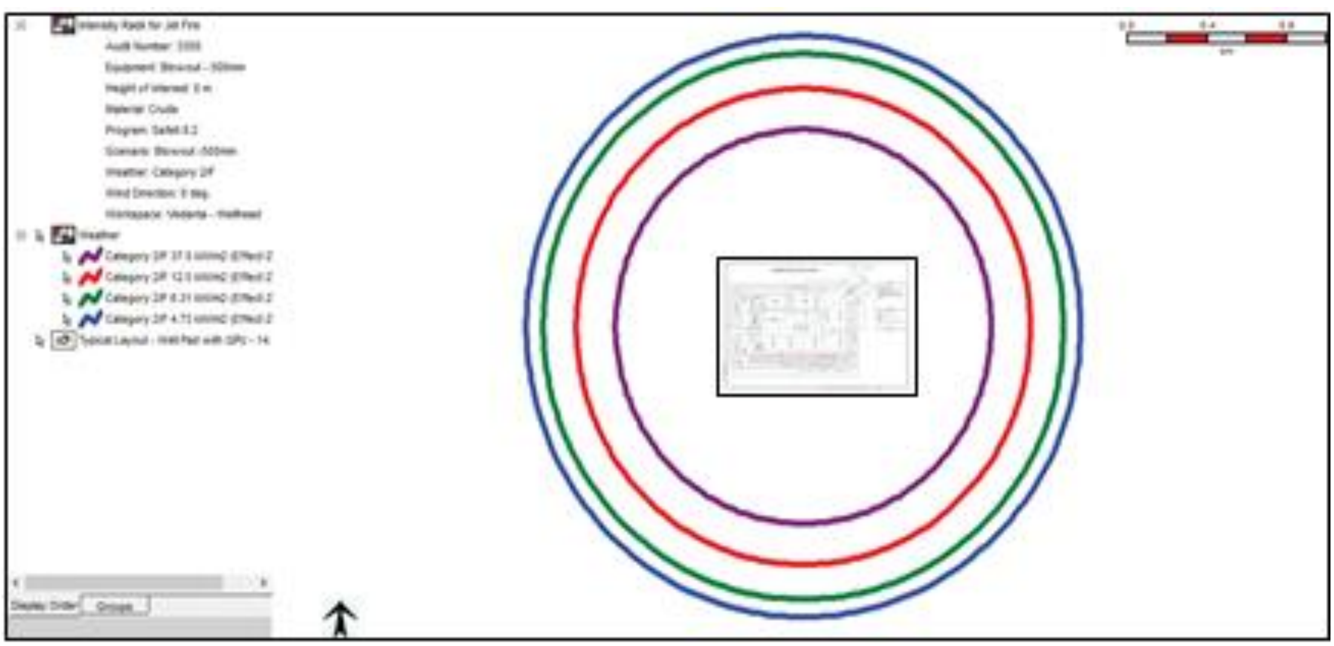

**Figure 1.3: Jet Fire Consequence Contour for Blowout Scenario**

### B. Pool Fire Radiation Distances

The Pool Fire Radiation Distances is provided below;

**Table 7.6 (A): Pool Fire Radiation Distances**

| IS No | Scenario | Weather | .73 kW/m2 [m] | .31 kW/m2 [m] | 12.5 kW/m2 [m] | 37.5 kW/m2 [m] |
|---|---|---|---|---|---|---|
| IS 01 | 5mm | 1.5F | NR | NR | NR | 19.35 |
| | | 5D | NR | NR | NR | NR |
| | 25mm | 1.5F | 32.94 | 30.78 | 25.96 | NR |
| | | 5D | NR | NR | NR | NR |
| | 100mm | 1.5F | 67.58 | 58.6 | 44.85 | NR |
| | | 5D | 83.55 | 71.63 | 49.76 | NR |
| | FBR | 1.5F | 73.49 | 64.01 | 49.86 | NR |
| | | 5D | 91.39 | 78.1 | 55.11 | NR |
| IS 02 | 5mm | 1.5F | NR | NR | NR | NR |
| | | 5D | NR | NR | NR | NR |
| | 25mm | 1.5F | 32.94 | 30.78 | 25.96 | 19.35 |
| | | 5D | NR | NR | NR | NR |
| | 100mm | 1.5F | 52.55 | 48.41 | 38.93 | 31.02 |
| | | 5D | 59.84 | 56.95 | 48.04 | 35.22 |
| | FBR | 1.5F | 57.15 | 52.75 | 42.75 | 35.16 |
| | | 5D | 65.84 | 62.64 | 52.06 | 39.78 |
| IS 03 | 5mm | 1.5F | NR | NR | NR | NR |
| | | 5D | NR | NR | NR | NR |
| | 25mm | 1.5F | NR | NR | NR | NR |
| | | 5D | NR | NR | NR | NR |
| | 100mm | 1.5F | 52.55 | 48.41 | 38.93 | 31.02 |
| | | 5D | 59.84 | 56.95 | 48.04 | 35.22 |
| | FBR | 1.5F | 57.15 | 52.75 | 42.75 | 35.16 |
| | | 5D | 65.84 | 62.64 | 52.06 | 39.78 |
| IS 04 | 5mm | 1.5F | NR | NR | NR | NR |
| | | 5D | NR | NR | NR | NR |
| | 25mm | 1.5F | NR | NR | NR | NR |
| | | 5D | NR | NR | NR | NR |
| | 100mm | 1.5F | 62.96 | 59.54 | 51.73 | 43.37 |
| | | 5D | 70.36 | 67.95 | 63.59 | 52.8 |
| | FBR | 1.5F | 71.64 | 67.7 | 58.66 | 50.54 |
| | | 5D | 83.33 | 80.7 | 73.67 | 60.35 |
| | 10mm | 1.5F | NR | NR | NR | NR |
| | | 5D | NR | NR | NR | NR |

| IS No | Scenario | Weather | .73 kW/m2 [m] | .31 kW/m2 [m] | 12.5 kW/m2 [m] | 37.5 kW/m2 [m] |
|---|---|---|---|---|---|---|
| IS 05 | | 1.5F | 51.01 | 40.54 | 25.44 | NR |
| | CR | 5D | 69.56 | 53.99 | 28.96 | NR |
| | | 1.5F | 15.36 | 13.91 | 11.22 | 7.089 |
| | 5mm | 5D | 16.12 | 14.92 | 12.55 | 8.956 |
| | | 1.5F | 23.13 | 20.49 | 14.77 | 6.556 |
| | 25mm | 5D | 24.95 | 22.53 | 17.93 | 7.467 |
| | | 1.5F | 23.13 | 20.49 | 14.77 | 6.557 |
| | 50mm | 5D | 24.95 | 22.53 | 17.93 | 7.467 |
| IS 06 | | 1.5F | 23.13 | 20.49 | 14.77 | 6.557 |
| | CR | 5D | 24.96 | 22.54 | 17.93 | 7.469 |
| | | 1.5F | NR | NR | NR | NR |
| | 5mm | 5D | NR | NR | NR | NR |
| | | 1.5F | NR | NR | NR | NR |
| | 25mm | 5D | NR | NR | NR | NR |
| | | 1.5F | NR | NR | NR | NR |
| | 100mm | 5D | NR | NR | NR | NR |
| IS 07 | | 1.5F | NR | NR | NR | NR |
| | CR | 5D | NR | NR | NR | NR |
| | | 1.5F | NR | NR | NR | NR |
| | 5mm | 5D | NR | NR | NR | NR |
| | | 1.5F | NR | NR | NR | NR |
| | 25mm | 5D | NR | NR | NR | NR |
| | | 1.5F | NR | NR | NR | NR |
| | 100mm | 5D | NR | NR | NR | NR |
| IS 08 | | 1.5F | NR | NR | NR | NR |
| | CR | 5D | NR | NR | NR | NR |

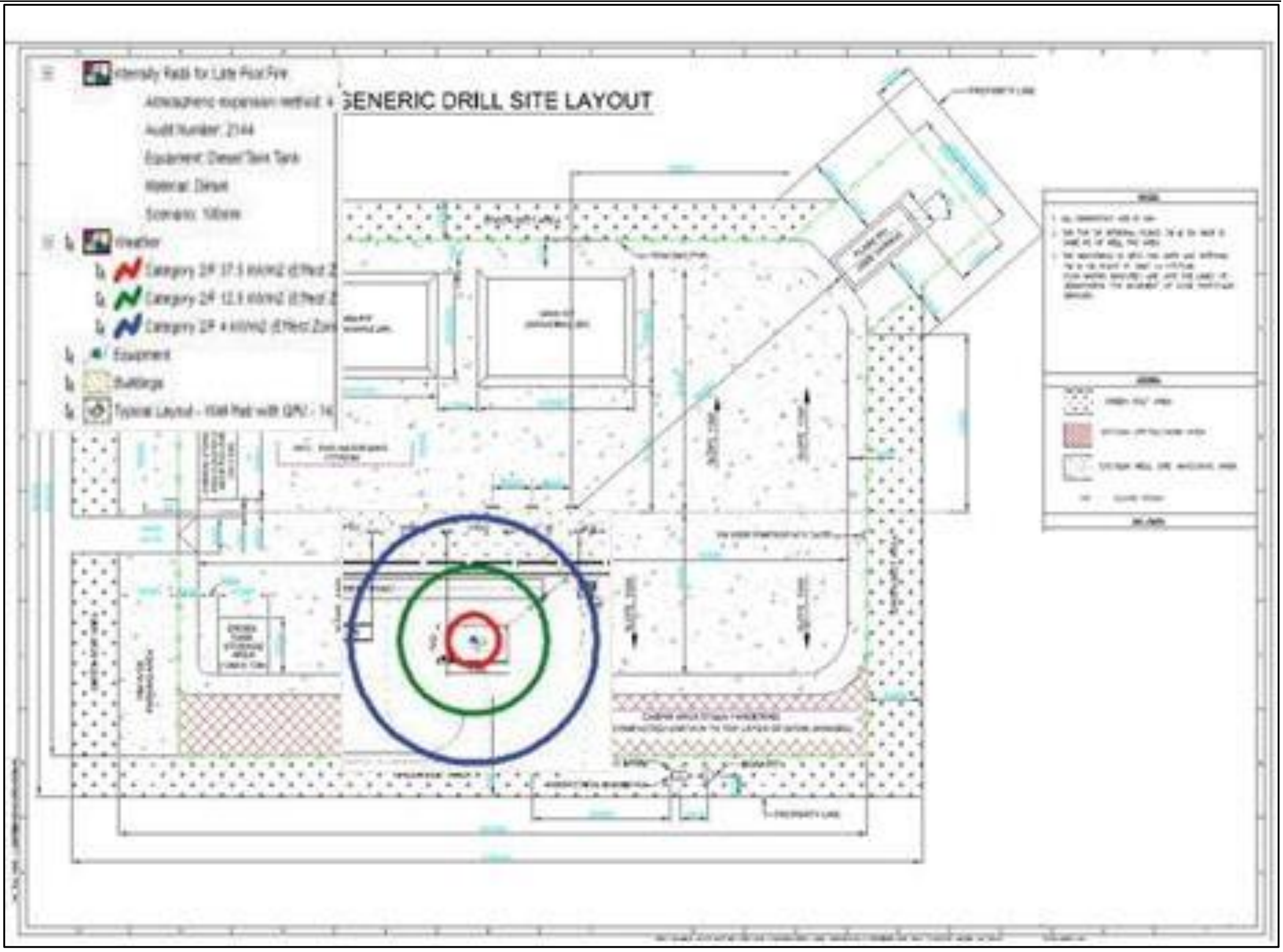


**Figure 7.4: Pool Fire Consequence Contour for Diesel Tank (100mm)**

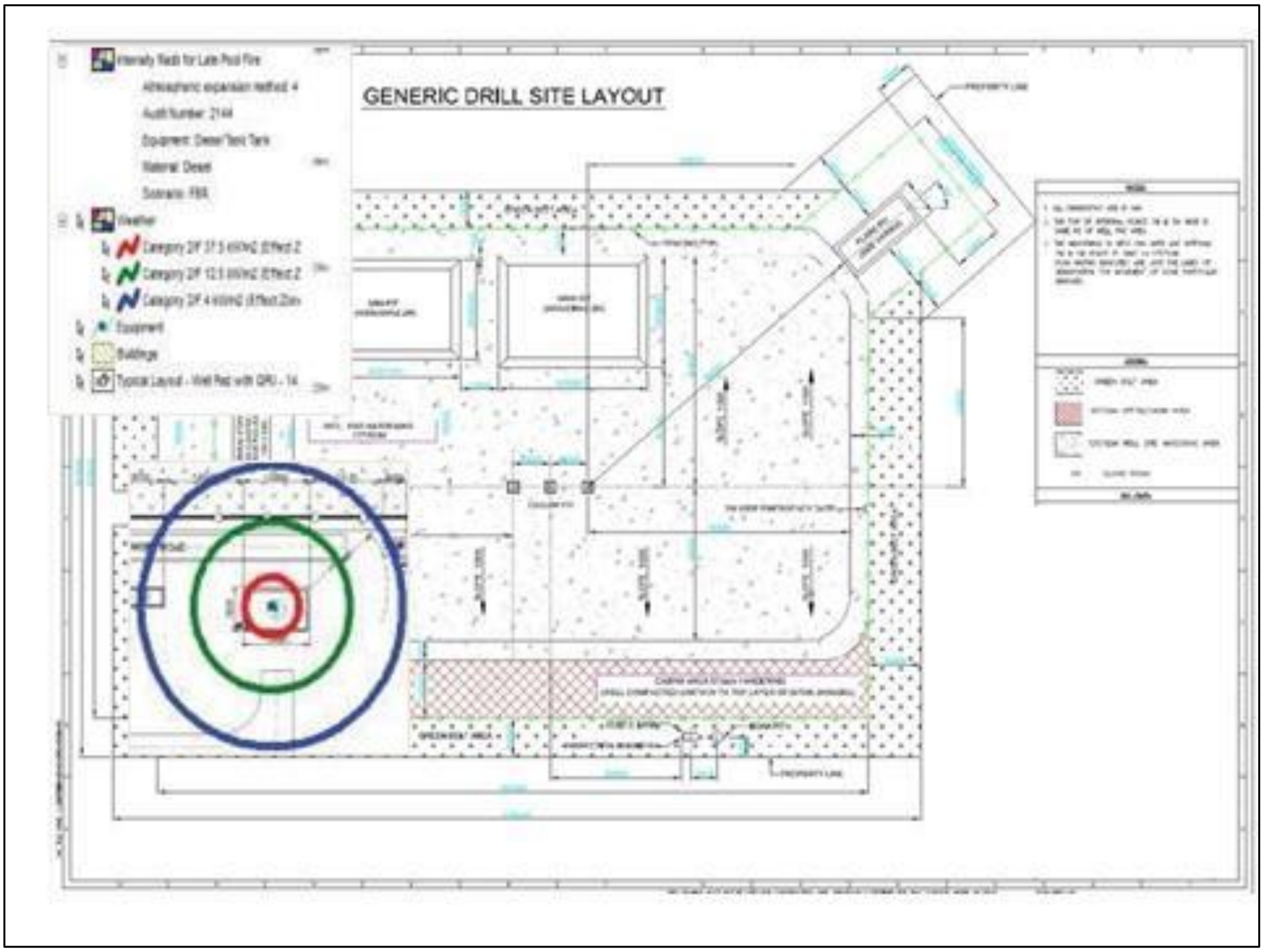


**Figure 7.5: Pool Fire Consequence Contour for Diesel Tank (Rupture)**

### C. Flash Fire Radiation Distances

Flammable Dispersion Distances are provided below;

**Table 1.6 (B): Flammable Dispersion Distances**

| IS No | Scenario | Weather | LFL [m] | LFL Fraction [m] |
|---|---|---|---|---|
| IS 01 | 5mm | 1.5F | 6.465 | 8.269 |
| | | 5D | 5.613 | 8.337 |
| | 25mm | 1.5F | 76.63 | 123.3 |
| | | 5D | 50.25 | 81.45 |
| | 100mm | 1.5F | 182.9 | 287.8 |
| | | 5D | 197.1 | 275.7 |
| | FBR | 1.5F | 156.4 | 210.8 |
| | | 5D | 255.5 | 338.1 |
| | 5mm | 1.5F | 6.424 | 8.345 |
| | | 5D | 5.522 | 8.26 |
| | 25mm | 1.5F | 76.63 | 123.3 |

| IS No | Scenario | Weather | LFL [m] | LFL Fraction [m] |
|---|---|---|---|---|
| IS 02 | | 5D | 50.25 | 81.45 |
| | 100mm | 1.5F | 83.34 | 99.62 |
| | | 5D | 134.8 | 174.1 |
| | FBR | 1.5F | 79.41 | 106.6 |
| | | 5D | 128.2 | 166.9 |
| IS 03 | 5mm | 1.5F | 6.424 | 8.345 |
| | | 5D | 5.522 | 8.26 |
| | 25mm | 1.5F | 85.34 | 140.9 |
| | | 5D | 73.3 | 113.8 |
| | 100mm | 1.5F | 83.34 | 99.62 |
| | | 5D | 134.8 | 174.1 |
| | FBR | 1.5F | 79.41 | 106.6 |
| | | 5D | 128.2 | 166.9 |
| IS 04 | 5mm | 1.5F | 8.449 | 12.36 |
| | | 5D | 6.88 | 11.05 |
| | 25mm | 1.5F | 87 | 144.2 |
| | | 5D | 66.05 | 103.3 |
| | 100mm | 1.5F | 98.65 | 124.7 |
| | | 5D | 158.1 | 204.8 |
| | FBR | 1.5F | 120.9 | 133 |
| | | 5D | 143.7 | 187.4 |
| IS 05 | 10mm | 1.5F | 23.01 | 51.29 |
| | | 5D | 15.75 | 29.88 |
| | CR | 1.5F | 59.2 | 73.21 |
| | | 5D | 124.3 | 174.7 |
| IS 06 | 5mm | 1.5F | 2.304 | 2.628 |
| | | 5D | 2.676 | 2.745 |
| | 25mm | 1.5F | 2.886 | 2.886 |
| | | 5D | 4.39 | 4.723 |
| | 50mm | 1.5F | 3.549 | 3.862 |
| | | 5D | 4.368 | 4.368 |
| | CR | 1.5F | 7.993 | 7.994 |
| | | 5D | 10.06 | 10.06 |
| IS 07 | 5mm | 1.5F | 0.005 | 0.006 |
| | | 5D | 0.005 | 0.006 |
| | 25mm | 1.5F | 0.005 | 0.006 |
| | | 5D | 0.005 | 0.006 |
| | 100mm | 1.5F | 0.124 | 0.127 |
| | | 5D | 0.116 | 0.122 |

| IS No | Scenario | Weather | LFL [m] | LFL Fraction [m] |
|---|---|---|---|---|
| | FBR | 1.5F | 2.002 | 2.634 |
| | | 5D | 2.115 | 3.214 |
| IS 08 | 5mm | 1.5F | 0.005 | 0.006 |
| | | 5D | 0.005 | 0.006 |
| | 25mm | 1.5F | 0.005 | 0.006 |
| | | 5D | 0.005 | 0.006 |
| | 100mm | 1.5F | 0.124 | 0.127 |
| | | 5D | 0.116 | 0.122 |
| | FBR | 1.5F | 2.002 | 2.634 |
| | | 5D | 2.115 | 3.214 |

### D. Toxic Dispersion

There is no toxic hazard in the facility.

### E. Vapour Cloud Explosion

A vapour cloud explosion involves a flame moving through a fuel-air mixture. In absence of turbulence generation, the cloud will burn as a flash fire without generation of high over pressure. However significant turbulence can be generated by obstacle encountered by a flame as it is propagated through the vapour cloud in obstructed region. It is that explosion that occurs in the presence of obstacle that can generate overpressure with potential for extensive damage.

In order to model vapour cloud explosion, the Obstructed Region Explosion Model available in SAFETI 6.7 has been used and a brief overview has been provided below.

OREM in PHAST would enable a user to model the blast effects from vapour clouds dispersing through regions containing obstacles.

Explosions in Obstructed Regions have been modeled in the Multi-Energy (ME) Model.

ME Obstruction set have been used for defining Obstructed Regions and it considers the following:

- Degree of expansion (2D/ 3D);
- Volume (Blockage ratio):
- Surface of area of obstruction source and Flame path length Late Explosion Overpressure Distances is provided below;

**Table 7.7: Late Explosion Overpressure Distances**

| IS No | Scenario | Weather | Overpressure (bar) | Distance (m) |
|---|---|---|---|---|
| IS 01 | 5mm | 1.5F | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | | 0.02068 | NR |

| IS No | Scenario | Weather | Overpressure (bar) | Distance (m) |
|---|---|---|---|---|
| | 25mm | 1.5F | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | 100mm | 1.5F | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | FBR | 1.5F | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| IS 02 | 5mm | 1.5F | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | 25mm | 1.5F | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | 100mm | 1.5F | 0.02068 | NR |

| IS No | Scenario | Weather | Overpressure (bar) | Distance (m) |
|---|---|---|---|---|
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | FBR | 1.5F | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| IS 03 | 5mm | 1.5F | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | 25mm | 1.5F | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | 100mm | 1.5F | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | FBR | 1.5F | 0.02068 | NR |

| IS No | Scenario | Weather | Overpressure (bar) | Distance (m) |
|---|---|---|---|---|
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| IS 04 | 5mm | 1.5F | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | 25mm | 1.5F | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | 100mm | 1.5F | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | FBR | 1.5F | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | | 0.02068 | 158.2 |

| IS No | Scenario | Weather | Overpressure (bar) | Distance (m) |
|---|---|---|---|---|
| IS 05 | 10mm | 1.5F | 0.07 | 111.8 |
| | | | 0.2068 | 95.67 |
| | | | 1 | 86.23 |
| | | 5D | 0.02068 | 81.6 |
| | | | 0.07 | 56.92 |
| | | | 0.2068 | 48.34 |
| | CR | | 1 | 43.31 |
| | | 1.5F | 0.02068 | 452.2 |
| | | | 0.07 | 272.5 |
| | | | 0.2068 | 214.8 |
| | | | 1 | 181.8 |
| | | 5D | 0.02068 | 422.9 |
| | | | 0.07 | 242.6 |
| | | | 0.2068 | 194 |
| | | | 1 | 179.1 |
| IS 06 | 5mm | 1.5F | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | 25mm | 1.5F | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | 50mm | 1.5F | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | | 0.02068 | NR |

| IS No | Scenario | Weather | Overpressure (bar) | Distance (m) |
|---|---|---|---|---|
| | CR | 1.5F | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| IS 07 | 5mm | 1.5F | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | 25mm | 1.5F | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | 100mm | 1.5F | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | CR | 1.5F | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | | 0.02068 | NR |

| IS No | Scenario | Weather | Overpressure (bar) | Distance (m) |
|---|---|---|---|---|
| IS 08 | 5mm | 1.5F | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | 25mm | 1.5F | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | 100mm | 1.5F | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | CR | 1.5F | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |
| | | 5D | 0.02068 | NR |
| | | | 0.07 | NR |
| | | | 0.2068 | NR |
| | | | 1 | NR |

### F. Fire Ball

Fire ball distances are provided below;

| IS No | Scenario | Weather | 4.73 kW/m² [m] | 6.31 kW/m² [m] | 12.5 kW/m² [m] | 37.5 kW/m² [m] |
|---|---|---|---|---|---|---|
| IS 07 | 5mm | 1.5F | NR | NR | NR | NR |
| | | 5D | NR | NR | NR | NR |
| | 25mm | 1.5F | NR | NR | NR | NR |
| | | 5D | NR | NR | NR | NR |

| IS No | Scenario | Weather | 4.73 kW/m2 [m] | 6.31 kW/m2 [m] | 12.5 kW/m2 [m] | 37.5 kW/m2 [m] |
|---|---|---|---|---|---|---|
| | 100mm | 1.5F | 18.44 | 16.01 | 11.39 | 6.336 |
| | | 5D | 18.44 | 16.01 | 11.39 | 6.336 |
| | FBR | 1.5F | 18.44 | 16.01 | 11.39 | 6.336 |
| | | 5D | 18.44 | 16.01 | 11.39 | 6.336 |
| IS 08 | 5mm | 1.5F | NR | NR | NR | NR |
| | | 5D | NR | NR | NR | NR |
| | 25mm | 1.5F | NR | NR | NR | NR |
| | | 5D | NR | NR | NR | NR |
| | 100mm | 1.5F | 18.44 | 16.01 | 11.39 | 6.336 |
| | | 5D | 18.44 | 16.01 | 11.39 | 6.336 |
| | FBR | 1.5F | 18.44 | 16.01 | 11.39 | 6.336 |
| | | 5D | 18.44 | 16.01 | 11.39 | 6.336 |

### 7.3.10 Failure Frequency Analysis

As a part of the process of determining risk the failure frequencies of the hazard events are calculated. Component failures are the primary initiating events for most hazards and accidents and there are various potential causes for component failure resulting in sources of leakage, which may release contained fluids to the atmosphere. Failure scenarios can range from small gasket leaks in a flange joint to rupture resulting in catastrophic failure of a pipeline section. Major failure modes associated with different operational areas are listed below:

- *Failure of weld joints / gaskets (sample points, instrument connections etc.);*
- *Valve gland leakages; and*
- *Leaks/ full bore rupture of the pipe work.*
- *Tank Rupture*

These part counts are combined with historical data from the OGP database to give an overall potential leak frequency for each isolatable section which are then divided into small, medium, large and full bore as described in the methodology section of this report.

The base failure frequency for Valves, Flanges and Pumps are sourced from OGP 434-1.

### 7.3.11 Calculation of Individual & Societal Risk

Individual Risk or IR represents the geographical distribution of risk to any individual.

Societal Risk is representing the risk the project poses to society as a whole. The Societal Risk or Group risk (F-N) curves indicate the cumulative frequency (F) of (N) number of fatalities.

Society is typically not willing to accept industrial installations that result in many fatalities, even with a low frequency rate!

The estimation of risks in the software is done through estimation of “risks” attributed to each failure case by determining the impact in terms of fatalities. In this step, the hazard or effect zone information, ignition source, population distribution, meteorological data and other relevant details are combined to determine risks.

In order to estimate risks (IR or SR), the number of fatalities for each incident outcome case is calculated and the frequencies of outcomes with equal fatalities summed up.

After determination of potential sources of accidents and their zone of effect, the risk is quantified in terms of likelihood of fatalities due to these accidents by combining the frequency and severity (consequences). The commonly used risk indicators for onshore facilities are:

- Individual Risk per Annum (IRPA),
- Potential Loss of Life (PLL) and
- Societal Risk for the facilities

The risk at any particular location is expressed as Location Specific Individual Risk (LSIR). The LSIR is then combined with personnel occupancy levels to obtain the fatality risk expressed as individual risk. The estimated risk levels are assessed against Company Individual risk tolerable criteria for existing facilities to establish whether the project facilities can be regarded as in compliance with them.

❖ **Individual Risk**

Individual risk is defined as the frequency at which a named individual would be killed as a result of exposure to a hazard.

**Individual Rick = LSIR X Occupancy**

Where,

'Occupancy' is the proportion of time the individual is exposed to the hazard.

❖ **Societal Risk**

Assessment of societal risks is even more important than assessment of individual risk because they involve the likelihood of multiple fatalities. Societal risk is the risk to any person or group of persons who are not connected to project facilities and are outside the facility fence line.

❖ **F-N Curve**

It is helpful to consider group risk in the demonstration that risks are ALARP. This allows consideration to be given to events, which, although low in frequency, may cause multiple injuries or fatalities. Group risk can be presented in the form of a plot of cumulative frequency versus number of fatalities (F-N curve).

*F = frequency (Experienced or predicted)*

*N = no. of multiple fatalities.*

'N' includes indirect deaths caused as a result of the main event occurring and can therefore be difficult to predict e.g. many people may die years after exposure to a toxic chemical.

### 7.3.12 Event Tree Analysis

This task involves a probabilistic risk assessment to determine the probability of occurrence of a hazardous outcome following a failure event e.g. the probability of occurrence of gas cloud, fire or explosion event following a leak.

Operational probability is considered as 1 as the facility is in operation continuously.

Event Trees for small, medium, large and rupture release sizes for the present study have been used for RA. Each route in the tree has a corresponding impact event tree, which contains probabilities for immediate ignition for obtaining different types of flammable effects and for dispersion of the un-ignited releases. Total ignition probabilities have been sourced from the IP database.

The potential for ignition mainly depends upon the size and composition of a given release and the number of potential ignition sources available. Electrical equipment in hazardous areas is usually designed such that it will not present a potential ignition source (e.g. Intrinsically Safe). As such, in most cases (excluding hot surfaces or auto ignition of gas due to static charge) a fault would have to be present in an item of equipment before it becomes a potential ignition source.

However, should a flammable mixture be of sufficient size, then non-rated equipment outside the hazardous area could provide source of ignition. The Event Tree adopted for this project is provided in the following Figures;

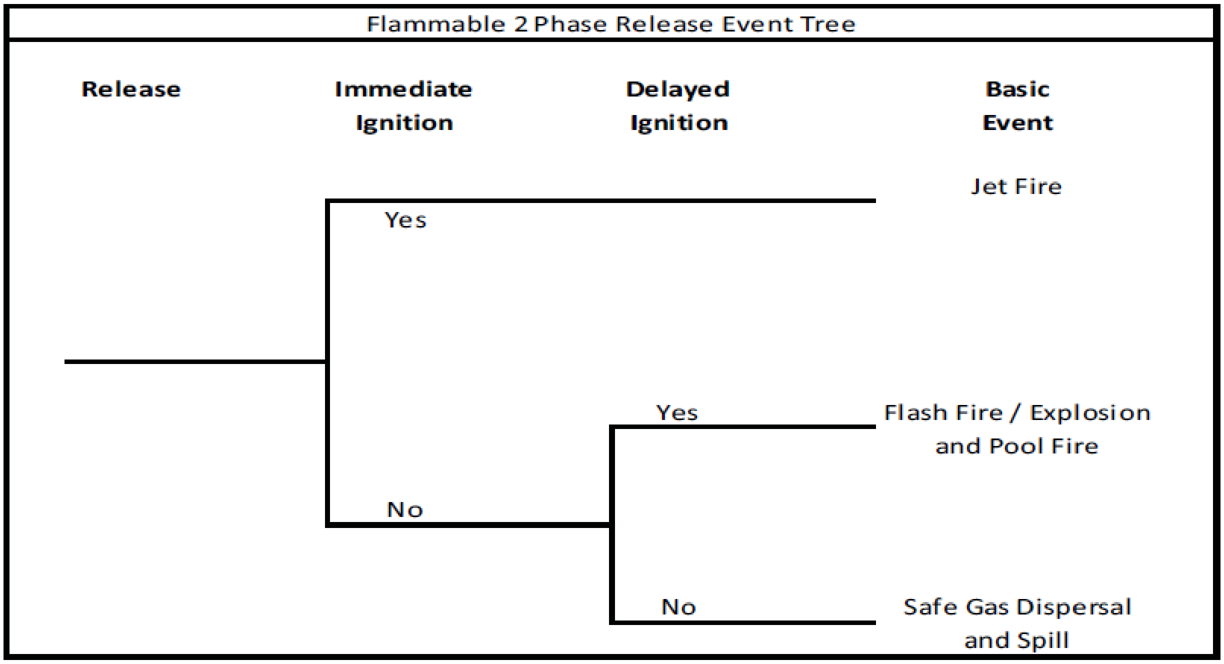


**Figure 7.6: Flammable 2 Phase Release Event Tree**

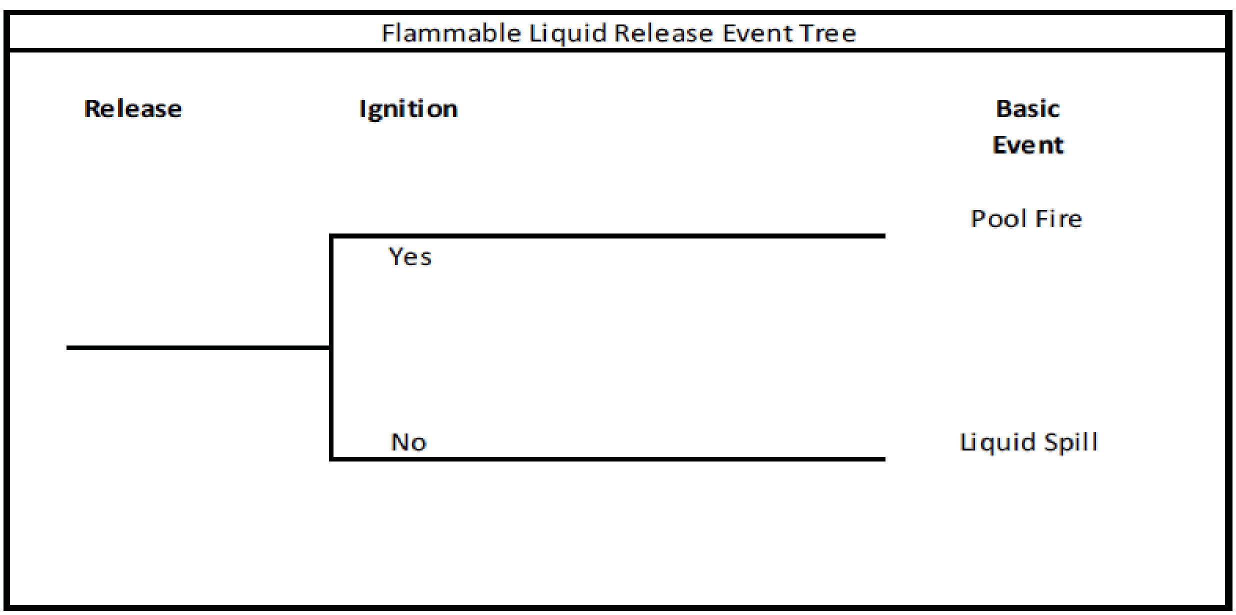


**Figure 7.7: Flammable Liquid Release Event Tree**

As described above, other potential ignition sources may be hot surfaces, sparks caused by mechanical impact or static charge auto ignition due to high pressure gas escaping through an orifice.

### 7.3.13 Comparison to Risk Acceptance Criteria

This penultimate step compares the estimated risk with respect to the Company's internal risk acceptability criteria or specific legislative or regulatory (as applicable in the country of operation) risk acceptability criteria. In this step, the risk "band" is determined- typically, the project risk band is determined to be negligible, acceptable, not acceptable are the risk assessment stage determines whether the risks are "Broadly Acceptable", "Intolerable" or "Tolerable if ALARP".

#### 7.3.13.1 Vedanta Limited (Division: Cairn Oil & Gas) Risk Acceptability Criteria

Risk acceptability criteria are derived from interpretation of the risk acceptability criteria published by UK HSE-92 and are applied when assessing the tolerability of risk to persons for facilities, sites, combined operations or activities. It broadly indicates as follows:

- Individual risk to any worker above $10^{-3}$ per annum shall be considered intolerable and fundamental risk reduction improvements are required.
- Individual risk below $10^{-3}$ for but above $10^{-6}$ per annum for any worker shall be considered tolerable if it can be demonstrated that the risks are As Low As Reasonably Practicable (ALARP).
- Individual risk below $10^{-6}$ per annum for any worker shall be considered as broadly acceptable and no further improvements are considered necessary provided documented control measures are in place and maintained.
- Individual risk to any member of the general public as a result of Site Businesses activities shall be considered as intolerable if greater than$10^{-4}$ per annum, broadly acceptable if less than $10^{-6}$ per annum and shall be reduced to As Low As Reasonably Practicable (ALARP) between these limits.
- For new facilities, it shall strive to achieve lower risks compared with that typical for existing facilities, down at least to an individual risk to any worker of $10^{-4}$ per annum, by the appropriate use of best practice including technology and management techniques.

#### 7.3.13.2 Individual Risk Criteria (IR)

CAIRN Individual Risk Criteria is provided below:

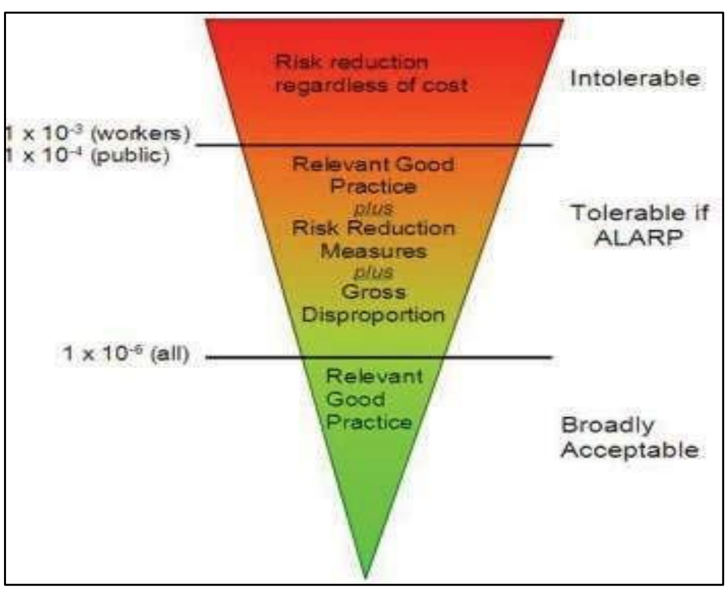

**Figure 7.8: Individual Risk Criteria**

### 7.3.13.3 Societal Rick Criteria

Societal risk criteria for CAIRN are used to limit the risks to a group of people and it is expressed as an F-N Curve.

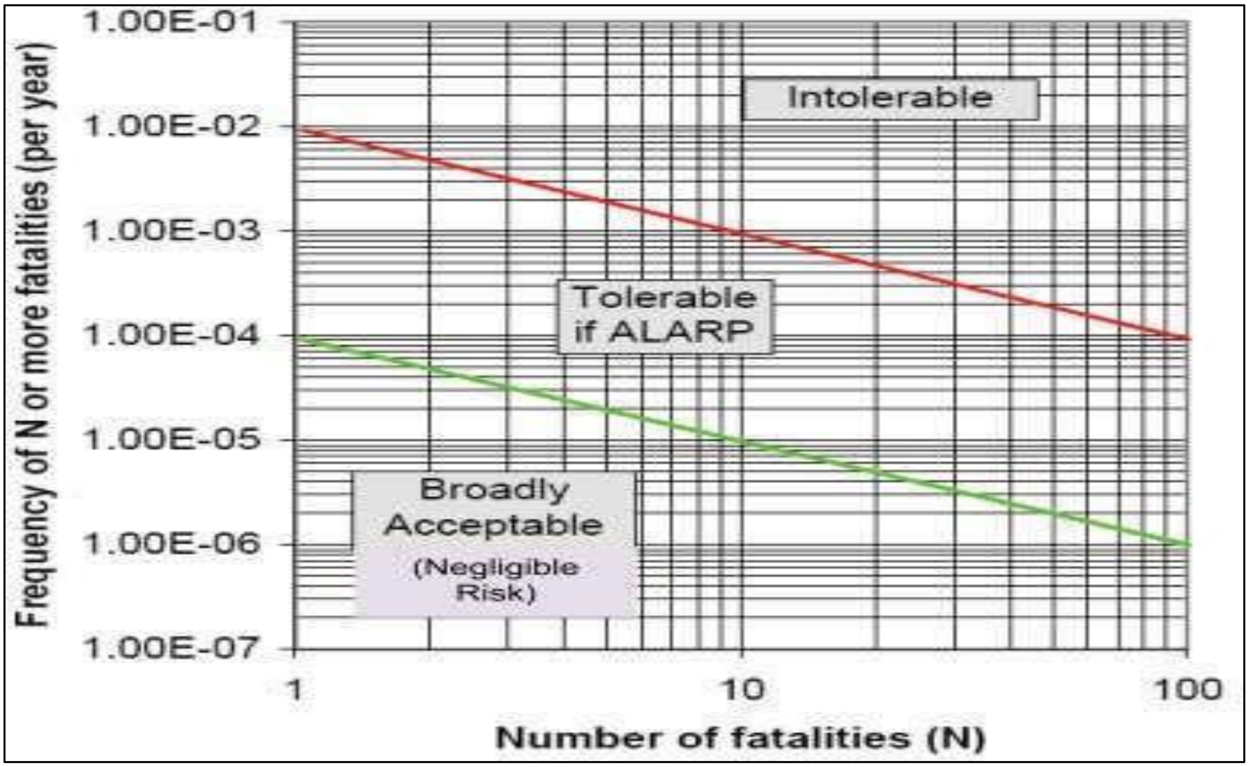


**Figure 7.9 : Societal Risk Criteria**

### 7.3.14 Failure Frequency Analysis

As a part of the process of determining risk the failure frequencies of the hazard events are calculated. Component failures are the primary initiating events for most hazards and accidents and there are various potential causes for component failure resulting in sources of leakage, which may release contained fluids to the atmosphere. Failure scenarios can range from small gasket leaks in a flange joint to rupture resulting in catastrophic failure of a pipeline section. Major failure modes associated with different operational areas are listed below:

- Failure of weld joints / gaskets (sample points, instrument connections etc.);
- Valve gland leakages; and
- Leaks/ full bore rupture of the pipe work.
- Tank Rupture

These part counts are combined with historical data from the OGP database to give an overall potential leak frequency for each isolatable section which are then divided into small, medium, large and full bore as described in the methodology section of this report.

The base failure frequency for Valves, Flanges and Pumps are sourced from OGP 434-1.

### 7.3.15 Ignition Probabilities

The potential for ignition mainly depends upon the size and composition of a given release and the number of potential ignition sources available. Electrical equipment in hazardous areas is usually designed such that it will not present a potential ignition source (e.g. flameproof/ intrinsically safe). As such, in most cases (excluding hot surfaces or auto ignition of gas due to static charge) a fault would have to be present in an item of equipment before it becomes a potential ignition source.

However, a flammable mixture is of sufficient size and then non-rated equipment outside the hazardous area could provide a source of ignition. Other potential ignition sources may be hot surfaces such as heaters, sparks caused by mechanical impact or static charge auto ignition due to high pressure gas escaping through an orifice.

Ignition Probabilities used for the RA study has been taken from Institute of Petroleum Database. The various ignition probabilities have been calculated based on the release rate of each identified scenarios.

The following Look-Up Curves from OGP 434-6 has been used to calculate the Ignition Probability;

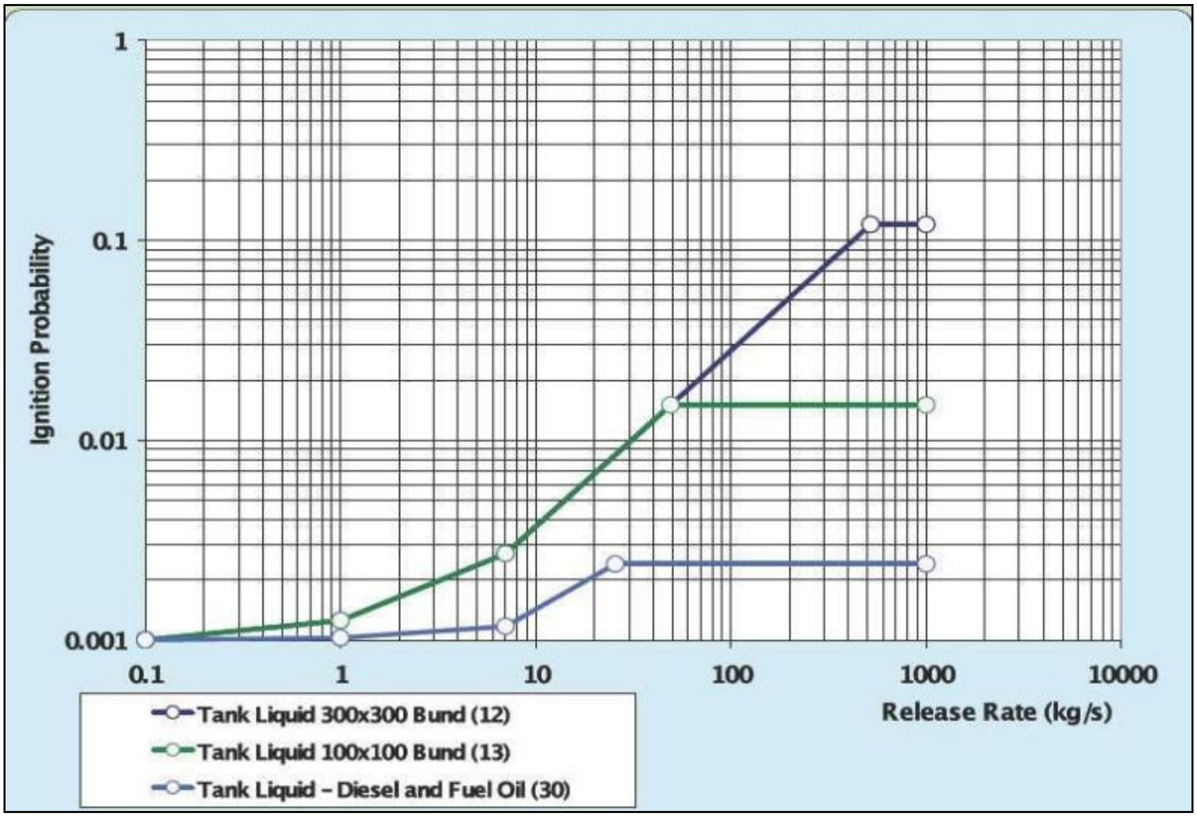


**Figure 7.10: IP Look up Curve**

This RA Study as per OGP 434-6 has considered immediate ignition probability as 0.001 and it is independent of the release rate. The delayed ignition probability is calculated based on the Total ignition probability taken from the Look up Curve and Immediate ignition probability.

### 7.3.16 Risk Estimation

The individual risk levels to personnel and potential loss of life levels at each study area were calculated by combining the consequences and frequencies of the accident scenarios; in accordance with the Company Risk Tolerable Criteria as described in earlier section. All the hazard scenarios that have the potential to impact these areas were included in the risk assessment.

#### 7.3.16.1 Location Specific Individual Risk

The LSIR was estimated based on component failure frequencies and event probability for release scenarios. Note that the LSIR levels represent the cumulative risk from all the major accident events at the project facilities without taking into account personnel exposure factor, vulnerability and probability of escape. The overall Location Specific Individual Risk contours and FN Curve are developed considering all scenarios pertaining to all Isolatable Sections and are provided in Sections below.

The LSIR levels at different locations are provided in the Table below:

**Table 7.8 : LSIR level at different locations**

| Location | Individual Risk Ranking values |
|---|---|
| Diesel Storage area | 3.94 E-05 |
| Oil Tank area | 2.034 E-04 |

| | |
|---|---|
| Process area | 1.87 E-04 |
| Rig area | 1.731 E-05 |
| Tanker area | 9.329 E-05 |
| Toilet Block | 1.137 E-06 |

The LSIR contour is provided in the below Figure below.

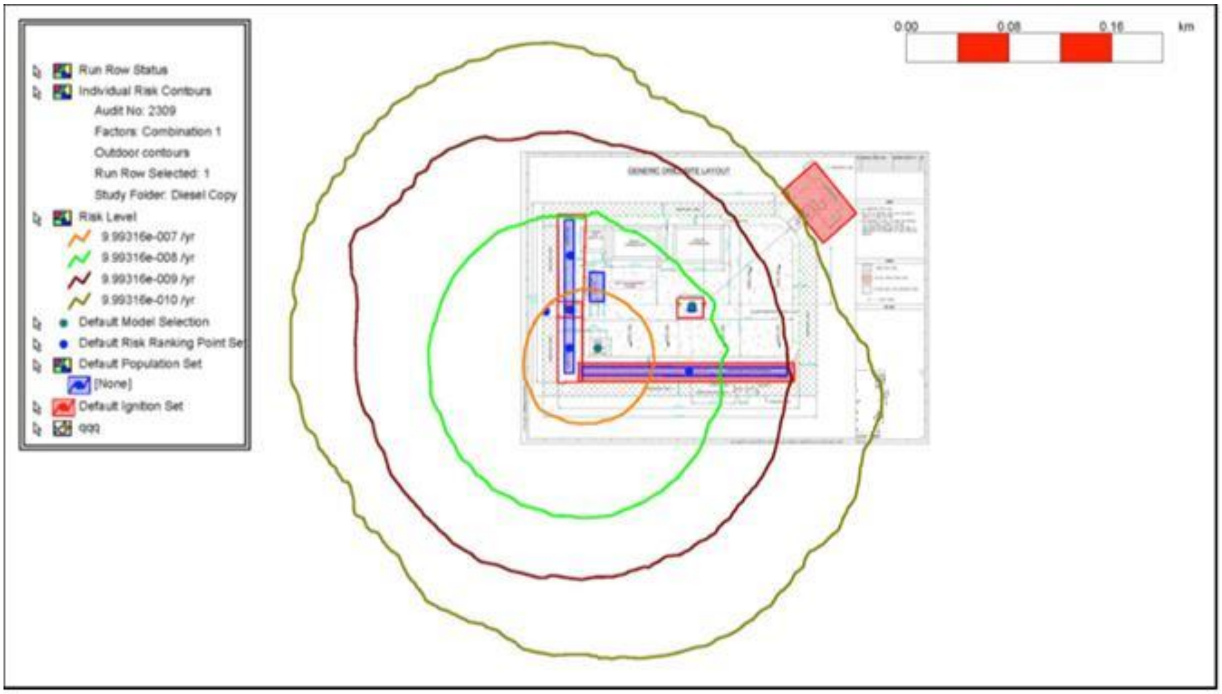


**Figure 7.11: LSIR Contour**

The above Risk Contour (LSIR) is generated on the basis that each target location considered is permanently inhabited by a single individual. LSIR Contours are indicative of the potential magnitude or intensity of the risk, but the risks will only be realised at a given location if personnel will be present at that location 24/7.

It may be noted that the above risk estimation is based on the basic failure frequency listed for the various components. Consequences were assessed based on the tank inventory. Some of the specific design aspects such as design overpressure and corrosion allowance, provision of PSVs, Material of Construction complying with NACE can bring down the failure frequency by an order of magnitude. Detection and control such as Fire & Gas detection systems which generate alarm drawing the attention of operators and/or activate safe shutdown with a minimum PFD of 1E-01 should also be considered as risk management hierarchy.

### 7.3.16.2 INCREMENTAL INDIVIDUAL RISK PER ANNUM

Individual Risk or Individual Risk Per Annum is determined on a case by case basis for each individual working. The individual risk levels have been calculated by multiplying the above LSIR levels by the exposure factor (Occupancy Level).

The results of these calculations based on worker groups are presented in below Table;

**Table 7.9: Incremental Individual Risk Per Annum (IRPA)**

| S. No. | Worker Groups | LSIR (Avg/ year) | Occupancy | IRPA (Avg/ Year) |
|---|---|---|---|---|
| 1 | Operators | 1.87E-04 | 0.22 | 4.11E-05 |
| 2 | Maintenance | 1.73E-05 | 0.33 | 5.71E-06 |

From the above Table, the Individual Risk is following into Acceptable Region.

#### 7.3.16.3 SOCIETAL RISK

The FN Curve is provided in the following Figure.

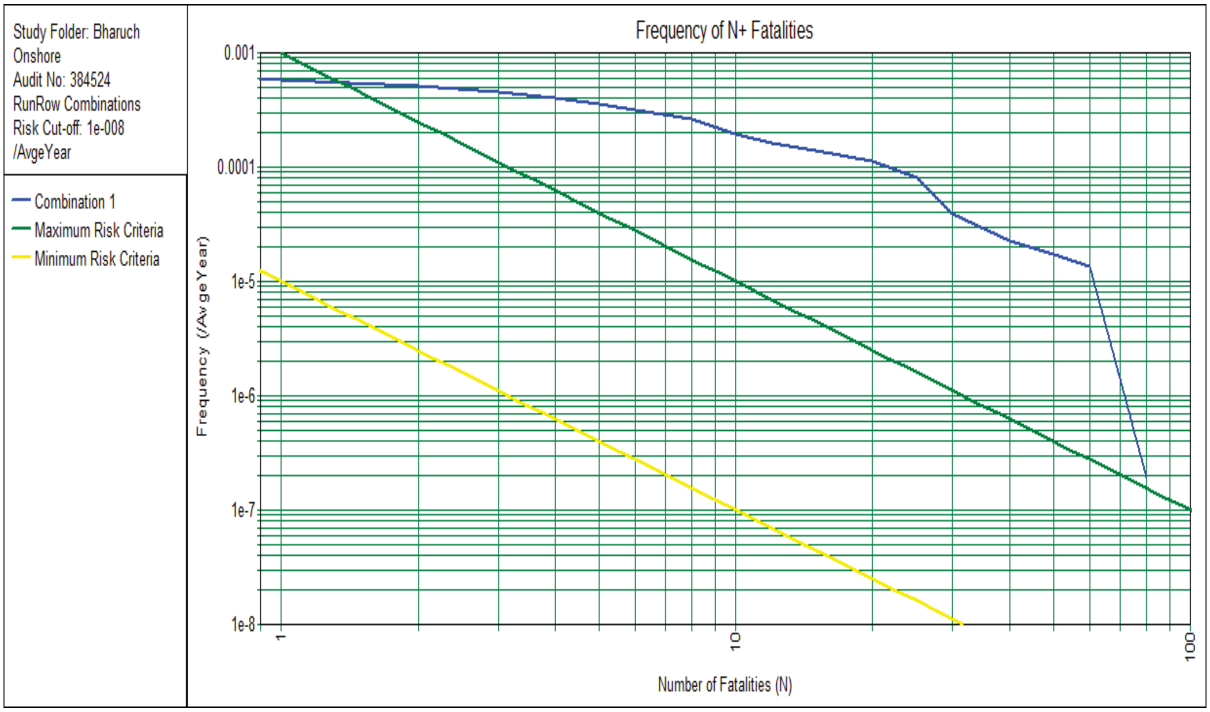


**Figure 7.12: FN Curve**

From the above Figure, the societal risk falls into Acceptable Region.

### 7.3.17 Risk Evaluation

As per Risk Tolerance Criteria for Individual Risk and Societal Risk, the Individual Risk and Societal Risk value for all Worker groups falls within the Acceptable Region.

### 7.3.18 ALARP Demonstration And Cost Benefit Analysis (CBA)

ALARP Demonstration is not necessary as the Individual Risk and Societal Risk falls in Acceptable Region.

### 7.3.19 Risk Reduction Measures

Though the risk falls under the Risk Tolerance Criteria for Individual and Societal Risk, the following recommendations are made with respect to continual improvement and to increase the reliability of the conditional modifiers:

- Ensure that the portable fire extinguishers are provided at strategic locations as per OISD-117 and it is inspected at regular intervals.
- Fire and Gas Detectors can be provided for early detection warning.
- As Operator Room are likely to be affected due to Blowout scenario, it is essential to ensure the upkeep of the safety devices (Smoke Detection, Fast Rescue Craft (FRC), escape routes and it must be ensured that Mock evacuation drills are carried out periodically.
- The correct installation of Safety Critical Equipment and their operational reliability are essential for the safety of the facility. In addition, initial and periodic testing of the Safety Critical Equipment before

installation and periodically is absolutely essential and the same must be ensured.

- Active fire protection should be provided for all equipment falling within the heat radiation intensity of 12.5 $KW/m^2$.
- The Closed Room such as Control Room, Operator Room, etc. should be positively pressurized higher than the atmospheric pressure.
- Ignition controls such as maintenance of electrical equipment is recommended as per Hazardous Area Classification Study.
- Detection arrangements for Bund fires for HSD Tank through leak detection within the bund and monitoring with CCTV cameras can be followed.
- Ensure that the bund provided can contain the entire Tank Capacity (110%).
- Periodic On Site Emergency Mock Drills and occasional Off Site Emergency Mock Drills to be conducted, so those staffs are trained and are in a state of preparedness to tackle any emergency.
- It must be ensured that Storage Tanks and Road Tankers are NOT overfilled (not more than 80%)- set points/SOP to capture the same.
- Emergency Response Plan should be prepared based on this QRA Study result identifying the required emergency facilities and the detailed procedure for Shutdown, Evacuation and Rescue.
- Permit to work system to be implemented 100 % for hazardous work in the plant.
- Manual call points for fire location identification to be installed in plant premises.
- Fire Fighting System to be made available.
- Escape routes for personnel must be properly protected and kept free of any debris/obstructions etc.
- Ensuring that the public in vicinity of the facility is made aware of the hazards and also the hazards of unplanned and irregular third-party activities- this may be done through frequent safety awareness programmes, warning signage, explicit display of Do’s and Don’ts etc.
- Key non-routine activities must be preceded by a Job Safety Analysis and Job or Task Risk Assessment involving key personnel that would be working on the facility.
- Trips and falls hazard, electrical hazards etc. must be minimized through periodic safety audits and site inspections using third party and Internal audit teams. Actions arising out of the audits must be implemented in a time bound manner and followed up for closure.
- CAIRN shall ensure suitable training to all personnel (Company as well as Contractor personnel) to help prevent incidents/accidents- such training must be refreshed periodically, and a list of trained personnel will be maintained by CAIRN.
- Ensure proper (metallic/metal braided) hoses gaskets etc. and Road tanker earthing are properly executed.

As the risk is acceptable, the above recommendations are not mandatory for life safety point of view and are aimed to mitigate the asset damage should the fire occur.

The safeguarding of human life is top most priority. To this effect, CAIRN has issued and implemented a comprehensive HSE POLICY backed up with appropriate safety management systems and procedures.

- CAIRN has operating procedures lay a strong focus on hazard identification and risk assessment covering each and every hazardous operation, procedure and equipment. Risks and mitigating measures for each are clearly carried out and measures implemented and monitored. This ensures risk minimization to the worker group.

- The facility is built based on the highest international standards and global best practice. Individual equipment is of highest quality, certified and of highest safety integrity. This ensures risk minimization to the worker group through operational and maintenance periods. In addition, equipment hazard identification has to be carried out for each of the equipment time to time.

The following are some of the protections provided for Blowout scenario.

- The primary protections against blow outs during drilling are the BOPs or Blow out Preventers. These are used to shut in and control the well in the event of gas or oil being encountered at pressures higher than those exerted by the column of mud in the hole.
- BOPs typically consist of 2-3 ram preventers designed at high pressures. The BOPs are hydraulically operated with a second remote control panel situated someway away from the rig for use in emergencies when the rig is unapproachable. Connected to the side of the ram type preventers (usually below the blind rams) are the kill and choke lines which are used to control the well in the event of any imbalance between the drilling fluid column pressure and the formation pressure. Both lines are high pressure 2-3 inch hydraulic pipes, the kill line being connected to the mud circulation system and the high pressure cement pumps and the choke line leading to a back pressure control Manifold and the mud degasser unit.
- In the event of the high pressure kick with the drill string in the hole, the BOP is closed around the drill pipe and the mud is circulated down the drill string and back to the mud tanks through the choke line and back pressure manifold. The manifold consists of a series of valves and chokes - the choke can be adjusted to give the orifice opening required such as to give a back pressure on the well in order to control it. There would be two chokes in order to allow maintenance on one.
- If a kick or blow out occurs with the drill string out of the hole, the blind rams are closed and heavy mud is pumped into the well through the kill line. Any gas can be bled off through the choke line and fluids are usually squeezed back into the formation.
- The correct installation of the drilling equipment and the operational reliability of the BOPs are essential for the safety of well drilling operation. In addition, initial and periodic testing of the BOPs, choke and kill manifolds, high pressure/ heavy mud system etc. before installation and periodically is absolutely essential. Most important is the presence of highly trained skilled personnel on the rig! In addition, the use of the correct drilling fluid in the circulatory system is extremely vital.
- The drilling fluid basically does the following:
  - To cool and lubricate the drilling bit and the drill string
  - To remove drill solids and allowing the release at their surface.
  - To form a gel to suspend the drill cuttings and any fluid material when the column is static
  - To control sub surface pressures
  - To prevent squeezing and caving if formations
  - To plaster the sides of the borehole
  - To minimize the damage to any potential production zone.
- Pressures associated with the sub surface oil, gas or water can be controlled by increasing the specific gravity of the fluid and thereby by reducing the hydrostatic head of the drilling fluid column. The squeezing of formations in the drilled hole can be checked by increasing the hydrostatic head of the drilling fluid. Special additives for the drilling fluid for controlling viscosity, lubricating properties,

gelling properties etc. play an important role in the drilling fluid integrity. Sealing agents such as cellulose, mica can also be added to make up the drilling fluid loss into the porous and fractured formations.

### 7.3.20 Safety System For Drilling Rigs

Operational Safety is the foremost concern while working on drilling rig. Derrick floor is the center stage of all the operations and it is most susceptible to accidents. Safety precaution with utmost care is required to be taken as per the prevailing regulation and practice so that accidents can be avoided. Due to advancement in technology, number of equipment has been developed over a period to cater the need of smooth operation on derrick floor. Various standards are required to be referred to cover the variety of equipment used for safe operation in drilling and become cumbersome at times to refer standards for each equipment as per given hereunder;

- Twin stop safety device (crown-o-matic and floor-o-matic);
- Fall prevention device on mast ladder with safety belt;
- Emergency Escape device for top man;
- First aid box with Stretcher and Blanket;
- Fire bell /siren;
- Emergency vehicle;
- Fire extinguishers;
- Flame proof portable hand lamp /safety torch;
- Railing with toe board;
- Guards on all moving parts;
- Breathing apparatus (wherever required);
- Gas detector for hydrocarbon gas &$H_2S$ gas (if required);
- Safety lines for power tongs;
- Rotary brake;
- Hoisting brake lever with safety chain;
- Emergency shutoff system for draw works;
- Safety chain for inclined ramp (to prevent fall of any person);
- Safety belt for top-man with lane yard;
- Railing on stair case at mud tank/walkways and derrick floor; etc.

### 7.3.21 General Safe Practices During Drilling Operation

- Penetration rate will be monitored. In case of any drilling break, stop rotary table, pull out the Kelly, stop mud pump and check for self-flow;
- Different type of drill pipes should not be mixed up during making up the string;
- Protectors should be used on drill pipes while lifting and laying down the pipes on catwalk;
- Drill pipe rubber protector should be installed on drill pipes body while being used inside the casing;
- Before starting drilling, hole should be centred to avoid touching of kelly with casing/ Wellhead and ensure that no damage is done to well head and BOP;
- Continuous monitoring of the gain/loss of mud during;

- BOP mock drill should be carried during drilling/tripping and under mentioned operations;
- Safe Working Conditions and Practices to be adopted during exploratory drilling operations; etc.

### 7.3.22 Emergency Preparedness

- BOP drills and trip drills should be done once a week;
- Deficiency observed in BOP drill should be recorded and corrective measures should be taken; etc

### 7.3.23 Fire Fighting Facility for Drilling Rig

For the drilling rigs following fire-fighting system/equipment should be provided:

- Fire water system; and
- First aid fire-fighting system

### 7.3.24 Control of Hydrocarbon Release And Subsequently Fire & Explosion During Drilling And Testing

To detect the release of hydrocarbon during exploratory drilling and testing, hydrocarbon detectors should be placed, so that control measures may be taken to prevent fire and explosion.

Emergency control measures should also be adopted as per Mines Act 1952, Oil Mines Regulation 1984 and Oil Industry Safety Directorate Standard 2000.

As per Oil Industry Safety Directorate (OISD) Standard, for the drilling rigs and well testing following fire-fighting system/equipment will be provided:

- Fire water system; and
- First aid fire-fighting system.

A temporary closed grid hydrant system with monitors, hydrant points and fire hose boxes will be installed to cover well location, and oil and diesel fuel storage tanks. Portable fire extinguishers of DCP, mechanical foam and CO2 types of sufficient capacity and in sufficient numbers along with sand buckets will also be placed at strategic locations. Electrical and manual siren systems will be provided at the Security Gate of the experimental production facility. Electrically operated siren of 500 m range along with push buttons at appropriate locations to operate the siren will be installed.

Adequate personal protective equipment including sufficient number of breathing apparatus must also be kept ready in proper working condition.

**Fire Water System**

- One water tank/pit of minimum capacity of 50 Kl should be located at the approach of the drilling site.
- For experimental production testing, one additional tank/pit of 40 Kl should be provided.
- One diesel engine driven trailer fire pump of capacity 1800 lpm should be placed at the approach area of drilling site.
- One fire water distribution single line with minimum 4 “ size pipe/casing should be installed at drilling site with a minimum distance of 15 m from the well.

**First Aid Fire Fighting Equipment at Drilling Rig**

Portable fire extinguisher on the drilling rig will be installed in line with IS: 2190.

### 7.3.25 Minor Oil Spill

During drilling of wells and testing operations, details of classification of possible oil spill scenario (s) and respective activities are as follows:

**Table 7.10: Classification of Oil spill during Drilling**

| Classification of spill | Extent of spill | Impact | Scenarios | Preventive Measures |
|---|---|---|---|---|
| ***Tier 1***<br>***Response can be adequately addressed using equipment and material available at the cite.*** | Spill contained on site. | Minor equipment damage.<br>Brief disruption to operations. | • Diesel fuel refueling (i.e. drill rig hose leaks, overfilling or connection/disconnection incidents).<br>• Drilling fluid (i.e. leaks from tanks, pumps or other associated equipment within the closed loop circuit system).<br>• Drilling fluid chemicals (i.e. chemicals used during drilling; note that the volumes are limited by the storage containers used i.e. 200 L drums etc.).<br>• Hydraulic oil (i.e. leaks from a split hydraulic hose or failed connector; moderate pressure, low volume lines). | One of the following preventive systems or its equivalent shall be used as a minimum for onshore facilities:<br>• Dykes, berms or retaining walls sufficiently impervious to contain spilled oil |
| ***Tier 2***<br>***Response require additional oversight expertise, equipment, and materials available*** | Localized spill with potential for escaping the site or that has escaped the site but is of limited extent | Moderate to major equipment damage/loss. Partial or short-term shutdown of operations. | • Transportation incidents associated with the delivery of diesel fuel to the drill-site or loaded crude oil tanker toppling /rollover or collision or<br>• Complete failure of an on-site storage tank (e.g. diesel fuel for generators). | |
| ***Tier 3***<br>***Response requires oversight, expertise, equipment and materials available*** | Major incident or a spill that has extended beyond the site. | Extensive equipment damage/loss.<br>Long-term shutdown of operations. | • Uncontrolled fluid flow (blowout) from a well during drilling phase in case oil is part of fluid. | |

Spill response strategies for combating incidents include:

- **Prevent or reduce further spillage:** One of the first response actions, if safe to do so, is the isolation of the source and prevention of further discharge.
- **Monitoring and evaluation:** Monitoring and evaluation are used to determine the location and movement (if any) of the spill, its appearance, its size and quantity, changes in the appearance and distribution of the spill over time and potential threat to the environment and the resources required to combat the spill (i.e. a more effective and coordinated response).
- **Mechanical containment and recovery:** Restriction of spill movement using physical barriers (e.g. bunds, booms, diversion swales). Containment would be followed by the physical removal of the spilled material. This may be accomplished using sorbent pads, vacuum trucks, skimmers or other mechanical means appropriate to the material spilled. One oil rescue team with vehicle will be kept ready at few locations depending the amount of crude oil tankers flying in the route to handle any oil spill leakage emergencies. The rescue vehicle will have all necessary oil spill response equipment in place.
- **Protection of sensitive areas:** Bunds or booms will be used to prevent spills from migrating down a watercourse or stream.
- **Clean-up:** This involves earthmoving equipment used to recover the absorbed spill and affected soil. Such operations may involve the collection of significantly greater volumes of material than was originally released.
- Combinations of the above strategies.

Affected area due to oil spill will be isolated. Spilled oil will be recovered and stored. Contaminated earth will be collected and disposed to the TSDF facility authorized by Andhra Pradesh.

### 7.3.26 Medical Facilities

First aid medical facilities will be made available at the drilling site along with the medic and or doctor along with 24 hour standby ambulance for quick transfer of any injured personnel to the nearest hospital, in case any emergency. Prior arrangements will be made with the various hospitals to accommodate the injured persons.

### 7.3.27 Recommendations

#### 7.3.27.1 Project and Drilling Operations

A majority of accidents occur during drilling operation on the drill floor and may be associated with moving heavy tubular, which may strike or crush personnel. Being struck by objects, falling and crushing usually make up maximum occupational risk of fatality. Mechanical pipe handling, minimizing the requirement of personnel on the drill floor exposed to high level of risk, may be an effective way of reducing injuries and deaths. Good safety management, strict adherence to safety management procedures and competency assurance will reduce the risk. Some of the areas in drilling operations where safety practices are needed to carry out jobs safely and without causing any injury to self, colleagues and system are given below:

#### 7.3.27.2 Maintenance of Mud Weight

It is very crucial for the safety of drilling well. Drilling Mud Engineer should check the in- going & out-coming mud weight at the drilling well, at regular intervals. If mud weight is found to be less, barytes should be added to the circulating mud, to raise it to the desired level. Failure to detect this decrease in level may lead to well kick and furthermore, a well blow out, which can cause loss of equipments and injury to or death of the operating personnel.

#### 7.3.27.3 Monitoring of Active Mud Tank Level

Increase in active tank level indicates partial or total loss of fluid to the well bore. This can lead to well kick. If any increase or decrease in tank level is detected, shift personnel should immediately inform the Shift Drilling Engineer and take necessary actions as directed by him.

#### 7.3.27.4 Monitoring of Hole Fill-up / return mud volume during tripping

During swabbing or pulling out of string from the well bore, the hole is filled with mud for metallic displacement. When this string runs back, the mud returns back to the pit. Both these hole fill up & return mud volumes should be monitored, as they indicate any mud loss or inflow from well bore, which may lead to well kick.

#### 7.3.27.5 Monitoring of Inflow

Any inflow from the well bore during tripping or connection time may lead to well kick. So, it is needed to keep watch on the flow nipple during tripping or connection time.

#### 7.3.27.6 Monitoring of operational and maintenance activities

All the activities within the well pad shall be carried out as per the implemented HSE Management system. All operation and maintenance activities will be carried out as per the established standard operating procedures (SOPs). All non-routine activities shall be carried out only after obtaining the necessary PTW (Permit to Work) system. PTW shall have the risk assessment / job safety assessment duly carried out and complied.

## 7.4 DISASTER MANAGEMENT PLAN

In view of the hazardous nature of products / process handled in this project, Disaster Management Plans (DMPs) has been prepared at high level. However, the detailed specific DMP needs to be prepared before the startup of the operation with site specific information. These plans are based on various probable scenarios like Fire, Explosion, Natural Calamities, etc. The consequence arising out of such incidents are accurately predicted with the help of latest technique available by various Risk Analysis Studies. To minimize the extent of damage consequent to any disaster and restoration of normalcy is the main purpose of DMP. The onsite Emergency Plans would deal with handling of the emergency within boundary of the plants mainly with the help of industry’s own resources. Also, when the damage extends to the neighboring areas, affecting local population beyond boundaries of plant, Off- site Emergency plans would be put into action in which quick response and services of many agencies are involved e.g. District Authorities, Fire Services, Civil Defense, Medical, Police, Voluntary Organizations etc.

### 7.4.1 Objective of DMP

The following are the main objective of Disaster Management Plan:

- Safeguarding lives both at installations and in neighbourhood.
- Containing the incident & bringing it under control.
- Minimizing damage to property & environment.
- Resuscitation & treatment of causalities.
- Evacuating people to safe area.
- Identifying persons and to extend necessary welfare assistance to causalities.
- Finally, when situation is controlled, efforts would be made to return to normal or near normal conditions.

### 7.4.2 Emergency Identified

Typical emergency situations which has been identified that could occur within its field of operations are:

- Fire / Explosion
- Hydrocarbon Leakages.
- Natural disaster such as earthquake, floods, storms, etc.
- Human injuries from accidents, falls, etc.
- Motor vehicle, road incidents and
- Security incidents such as hold-ups, kidnapping, bomb threats, etc.

### 7.4.3 Emergency Classification - Tiers of Emergency Response

Response strategies shall be commensurate with the nature, scale and associated hazards and risks for relevant emergency event.

The emergencies are classified as Tier 1, 2 & 3 and Tier wise examples are given below.

**Table 7.11: Emergency Classification Tier wise**

| Emergency Levels | Category | Response | Health & Safety | Environment | Security / Community |
|---|---|---|---|---|---|
| *Tier 1 Local Reactive* | ✓ A minor Incident where site / location team requires no external assistance and can control the incident with local resources<br>✓ Incident Controller must notify the leader of the ERT or EMT as applicable | ✓ Emergency Response Teams (IRT)/(ERT) | ✓ Minor medical or injury case requiring no external support<br>✓ Equipment damage with loss of production<br>✓ Minor fire with minor injury or plant damage<br>✓ Rescue of trapped and injured personnel | ✓ Minor oil spill < 100T(700b bls)<br>✓ Onsite environmental Exposure contained with internal efforts e.g. chemical spill<br>✓ Notification of cyclone within 72 hrs | ✓ Minor security breach<br>✓ Theft from site<br>✓ Local unrest |
| *Tier 2 Tactical* | ✓ Substantial Incident<br>✓ EMT leader decides to activate EMT<br>✓ EMT leader must notify CMT Leader | ✓ Emergency Management Team (EMT) | ✓ Any incident requiring additional/external resources<br>✓ Fire or Explosion<br>✓ Injury or illness requires evacuation<br>✓ Traffic accident requires external assistance<br>✓ Well blow out | ✓ Oil spill from >100T but <1000T (700-7000bbls)<br>✓ Environmental exposure requiring outside help<br>✓ Earthquake<br>✓ Flood or Cyclone warning Yellow alert –within 12 hours | ✓ Community protest or security breach<br>✓ Major criminal activity |
| *Tier 3 Strategic* | ✓ Crisis situation<br>✓ CMT leader decides to activate CMT CMT leader must notify the Chief Executive Officer | ✓ Crisis Management Team (CMT) | ✓ Incident leading to loss of facility<br>✓ Incident leading to significant financial loss<br>✓ Incident leading to multiple injuries or fatality<br>✓ Well blowout<br>✓ Incident which could lead to international media interest<br>✓ Major traffic incident with multiple casualties | ✓ Oil spill more than 1000T (7000bbls)<br>✓ Major Earthquake | ✓ Terrorist activities/bomb threat<br>✓ Kidnap or extortion/threat<br>✓ Major civil unrest/community protest |

### 7.4.4 On-site Emergency Response Plan

The scope of On-site Emergency Preparedness Plan is to evaluate the various types of emergencies that can occur at rig installations and processing/production facilities including hydrocarbon storage and transportation. To formulate emergency plans, procedures that can be implemented by CAIRN, the offsite Emergency plan shall be activated concurrently with the help of District administration.

Based on the incident classification and response team matrix mentioned above, Incident Response Team, Emergency Response Team and Emergency Management Team gets involved.

### 7.4.5 Tier 1 Incident Response Team (IRT):

- The emergency or incident can be effectively and safely managed, and contained within the site, location or facility by local staff.
- Emergency or incident has no impact outside the site, location or facility. IRT may provide support through effective interaction with local stakeholders.
- Loss of life or severe environmental damage or material loss of asset or organisation's reputation is not a consequence of event / emergency.
- Tier 1 incidents are managed by Site IRT, each site has own IRT.

### 7.4.6 Tier 1 Emergency Response Team (ERT):

- The ERT provide assistance and local support to the IRT's in relevant area.
- The ERT have access to local outside site / external emergency services.
- For Tier 2 emergency events.

### 7.4.7 Tier 2 Emergency Management Team (EMT)

- The incident cannot be effectively and safely managed or contained at the site location or facility by operational local staff and additional support is required.
- The incident is having or has potential of impact beyond the site, location or facility and external support may be required.
- Loss of life or severe environment damage or loss of asset or organisation's reputation is possible consequence of event / emergency.
- IRT may provide support through effective interactions with local stakeholders.
- Tier 2 EMT is primarily for tactical response to the incident but may on occasions required to act in reactive mode.

### 7.4.8 Tier 3 Crisis Management Team (CMT):

- The incident has escalated to a level having potential of loss of life, adverse effect on public or company's operations / reputation.
- Incident may have requirement of immediate action / guidance. From Top Management. Tier 3 incidents are incident escalating to the point requiring involvement of CMT.

### 7.4.9 Responsibilities of the Individual Response Organization

The Incident Response Team is responsible for managing all incidents and emergencies which may occur at or in close proximity to their operational area. For emergencies, where additional / external support is required, then the person in charge of the incident response or the Incident Controller at a remote location/site/facility must notify and request support and assistance from the next level in the emergency management organization. The ERT / EMT would be notified of all incidents within 30 minutes of the IRT activation at a remote location, site or facility. The key role and responsibilities of the IRT Leader is

- To manage all incident or emergencies at the Site, Plant or Field Location
- To Control the incident by preventing escalation and minimizing risk to personnel
- Direct and coordinate the activities of the Incident Control and Forward Response Teams.
- Ensuring sufficient trained and competent personnel are available to support the Response Teams.
- Ensuring the safety of all personnel working at the Site, Plant or Field location
- Evaluate and initiate immediate actions, to contain and mitigate effects of the incident or emergency.

Monitor the situation & determine need for evacuation.

- Establish head count and potential whereabouts of any missing personnel and if necessary prepare search, rescue and recovery plan.
- Follow Incident Response Plan and if required develop a plan of action to deal with the incident or emergency and communicating this plan to the IRT members

### 7.4.10 Emergency Response Team (ERT) (Reactive/Tactical)

ERT is responsible for coordinating overall incident and emergency response for Kaza block related incident . The roles and responsibilities of the ERT Leader would be:

- Co-ordination and Support of responses for all incident and emergency situations for the Kaza block;
- Reporting all incident and emergency situations in the Kaza operations to the EMT Leader in line with notification requirements;
- Provide and deploy additional resources as needed by the Incident Controller;
- Ensure all direct communications with the EMT;
- Determine the actual and possible impact of the incident;
- Ensure that information associated with the incident is promptly considered by the Support Team;

### 7.4.11 Emergency Management Team (EMT) – Tactical/Strategic Response

In the event of an incident or emergency, the Emergency Management Team Leader would make a decision whether or not to mobilize the EMT. If the decision is taken to mobilize the EMT then all EMT duty personnel are required to proceed promptly to the Emergency Management Team Room and manage emergency in accordance with their role, responsibility and as directed by the duty EMT Leader. Delegation of Authority (DOA) shall be nominated for absence. The EMT organization has following roles and responsibilities:

- EMT Leader – In overall in-charge / team leader, responsible for Company's tactical response to all emergency situations in respective SBU. They are also responsible for reporting incidents to the regulating authorities.
- Human Resources Coordinator – Responsible for providing HR services advice and support
- Logistics Co-ordinator – Responsible for providing transport and logistics support as required
- Operation and Technical Coordinator – Responsible for providing operational and technical support and advice
- Finance – Responsible for providing financial support and advice.
- HSE Coordinator – Responsible for providing health, safety, environmental support and response.
- Recorder – Responsible for maintaining a timed log of key events and actions
- Security Coordinator – Responsible for providing security support advice and assisting others as required by EMT Leader

The above list identifies a number of key EMT roles, following additional supporting roles may be called on when as and when required, typical roles being:

- Air Medevac Nodal Officer – Responsible for facilitating air medevac.
- IT/Telecommunication Co-ordinator – Responsible for providing the EMT with technical support associated with the communications hardware and software
- Company Medical Officer – Responsible for providing advice and assistance on health and medical issues.
- Legal – Responsible for providing support on legal / regulatory aspects.
- Public Relation / Corp Com – Responsible for communication with media and external stake holders.

- Contractor's representatives – who may be called in to assist the EMT would the incident involve members of their organization

### 7.4.12 Crisis Management Team (CMT) Roles

The Crisis Management Team is comprised of small core of senior executives. The CMT would collectively have responsibility for all major actions taken before; during, and after the crisis situation has occurred.
The role and responsibilities of the CMT would be:

- Select additional specialist resources to join the CMT or to advise the CMT during a crisis, depending on the nature of the crisis
- Develop and implement crisis management strategy
- Develop and communicate the operating mandate of the CMT to those with responsibility for the on-scene activities
- Nominate spokesperson to cover media interviews
- Establish contact and communicate with appropriate government or other agencies
- Prepare to coordinate business continuity and recovery strategy

### 7.4.13 Emergency Response Strategies / Evacuation Plan

Emergency response strategies (ERS) are the documented decisions on required emergency response measures for identified emergencies, based on risk evaluation and assessment process. It shall consider all statutory requirements applicable to the installations.
The objective of ERS is to identify the means would be used to secure adequate emergency response. It provides basis for monitoring of the adequacy of the emergency response measures so that they can be modified when essential. ERS would include appropriate standard of performance for response measures associated with each type of identified major accident hazard and installation specific factors. ERS would include the following elements:

- Organization
- Procedures
- Equipment
- Information
- Competency building measures (Training & refresher courses and Drills & exercises)
- The role of any other measure essential for achieving successful emergency response

Emergency response measures shall consider the available resources as below:

- Installation resources: They are immediately available on the installation and are under control of installation Manager / In-charge. These include personnel and equipment that can be assigned emergency role.
- Area resources: These resources are available on the installations in the vicinity, within same area and are not under control of Installation In-charge. The resources may be available by a mutual aid or cooperation agreement.
- External resources: These resources are available by a mutual aid or cooperation agreement at regional, national or international level and include Organisations, professional bodies and resource persons.

The general requirements as per CAIRN on Emergency and Crisis Management are:

- Crisis situations shall be managed centrally by CAIRN in accordance with the requirements outlined in the standard.

- SBU operations shall also have procedures in place to ensure crisis situations are escalated to CAIRN.
- Emergency situations shall be managed CAIRN.
- Incidents shall be managed reported in accordance with Hydrocarbon Transfer operation, CAIRN and regulatory reporting requirements.
- Emergency Preparedness and Response Plans shall be developed, implemented and maintained by CAIRN to deal with incidents, emergencies and crisis situations.

Additional requirements are:

- The objective of emergency response planning is to have clear written procedures for expected actions during anticipated emergencies. Emergency response plan includes operational and procedural requirements for various emergency scenarios that are relevant for the installation.
- Ensure that appropriate resources and incident / emergency response plans are prepared, practiced and available. The procedures shall include provision for emergency arrangements with contractors.
- Critical resources of emergency response would include:
  - Emergency power systems
  - Fire and gas detection systems
  - Active fire protection
  - Passive fire protection
  - Shutdown system
  - Explosion mitigation and protection systems
  - Evacuation escape and rescue arrangements
- Every Cairn business unit (including projects and offices) shall be covered by trained Incident and Emergency Management Teams who would manage and execute the emergency plans.
- All members of the emergency Organisations would be trained and competent to perform their assigned role within the incident response (IRT) / emergency response (ERT) / emergency management (EMT).
- Arrangements for emergency medical treatment shall consider injuries to persons as a result of minor accidents & major accidental events, illness of persons on installation, transportation & evacuation of sick and injured personnel.
- Controlled medicines shall be stored in a secure place accessible only to those who are trained to administer these.
- The level of medical facilities and trained personnel provided would be in line with the requirements identified in emergency response strategy. Key points would be considered is identification of medical facilities / hospitals
- Emergency response plans shall comply with all relevant legislative and regulatory requirements to ensure emergency capabilities are maintained and achieved.
- Procedure for designing emergency response measures would be based on:
- Integration of emergency response with / into design and operations
- Automatic or remotely operated safety systems to mitigate the effects of an incident
- Emergency response organization structure
- Wherever applicable offsite emergency response / disaster management plans shall be ensured.
- Essential safety system (such as control stations, temporary refuge, muster areas, fire pumps) shall be located where they are least likely would be affected by fires and explosions.
- Emergency shutdown (ESD) system shall be designed such, that it is capable of fulfilling its function

under the conditions of incident. If installation is in operation, the essential shutdown functions shall be available during maintenance activities, which affect the operation of the ESD system. ESD system shall contain facilities for testing of both input / output devices and internal functions.

- Evacuation and escape routes shall be provided from all areas of an installation where personnel may be expected would be present during their normal activities. Alternative means to allow persons to safely leave the installation in an emergency shall be provided.
- Evacuation and escape routes shall have adequate illumination with emergency lighting and shall be marked to ensure that 'they can be used during emergency conditions. All escape routes shall be unobstructed (including vertical clearance) and readily accessible.
- Personal protective equipment for use in major accident hazards would be suitable for the circumstances in which it may have would be used and the individuals who may have to use it.
- PPE for use in an emergency would be for all persons on the installation for use in condition of fire, heat, gas release or smoke to enable them to reach muster areas, temporary refuges and evacuation or escape points. Those with specific emergency duties shall also be provided appropriate PPE for use like fire suits and breathing apparatus etc.
- During an emergency, security arrangements shall ensure that unauthorized persons do not enter the incident site by controlling assess and if need arises the area around the site can be evacuated and cordoned to ensure safety of the persons.
- Environmental emergency response would consider:
  - Oil-pollution control equipment that would be located on the installation
  - Environmental conditions that may be present when the equipment is deployed
  - Capacity of the oil recovery system
  - Characteristics of the oil / emulsion would be recovered
  - Means to identify the extent of the spill
  - Facilities to handle any recovered oil.
- International conventions have introduced the requirements to develop national plans for oil-spill response in offshore, and Offshore Assets / SBUs / Operations would ensure that their installations' emergency response plans are aligned with the national requirements.

### 7.4.14 Responsibilities of the Employees

The establishment and maintenance of best possible conditions of work is, no doubt, the responsibility of the Project Management. It is also necessary that each employee follows prescribed safe methods of work. He would take reasonable care for the health and safety of himself, or his fellow employees and of other persons who may be affected by his action at work. With this in mind, employees shall be trained would be health and safety conscious in the following aspects:

**Table 7.12: Health and Safety Aspects**

| Report | Potential Hazards |
|---|---|
| Observe | Safety rules, procedures and codes of practice |
| Use | Tools and equipment with all care and responsibility |
| Participate | In safety training course when called upon to do so. |
| Make | Use Of safety suggestion schemes. |
| Take | An active and personal interest in promoting health and safety |

Each unit shall identify and document the resources required to ensure the effective implementation of the emergency and crisis management procedures. Resource requirements shall meet the requirements of CAIRN on Leadership, Responsibilities and Resources. The following resources shall be considered and made available as necessary:

- Trained and competent personnel;
- Equipment and other materials including Personal Protective Equipment (PPE);
- Warning devices;
- Medical services, including personnel trained in first aid, and medical equipment that is appropriate to the type of operation;
- Emergency services support; and
- Emergency funding, along with an appropriate mechanism for delivering funds.

The capacity of external resources, such as local firefighting capacity, shall be assessed, and additional resources acquired and maintained at the operation where external resources are deemed insufficient.

The resources identified shall be maintained and tested on a regular basis, and their adequacy reviewed periodically.

### 7.4.15 Communication Systems

Emergency response relies upon effective and reliable communication between all personnel involved in response. Communication systems shall:

- Provide sufficient reliable information / alarm to personnel on the installation to enable them to take the appropriate emergency actions.
- Provide means for those on the installation to communicate with the person in overall charge.
- Provide reliable arrangements to allow the person in overall charge to communicate with all personnel on the installation regarding the nature of any emergency and the actions they are required to take.
- Provide reliable means to allow the person in overall charge to communicate with area and external resources that have a role in emergency response.
- Suitable equipment, information processing and procedures shall be in place to enable effective communications. The means of communication shall be selected based on the need for communication in likely scenarios including operational conditions under which they are to function like, noise, ambient conditions and susceptibility to damage. So far as reasonable, communication arrangements would remain available throughout the emergency
- Alarm signals used, and their meanings would be described in the emergency response plan along with the procedures would be followed in the event of an alarm. Persons would be provided with adequate information to allow them to, initiate alarms where necessary, distinguish between alarms and respond to alarms.
- Adequate alarms and warning devices, along with other forms of communication, shall be maintained to reliably alert persons across the whole site in the event of an emergency.
- Independent secondary / back-up communications systems shall be provided in case the emergency incident makes the normal communication system inoperable.
- Ensure that the means are in place to alert to the connected installations, the local community / neighbouring businesses in the event of an emergency that has the potential interface with them.

### 7.4.16 Training and Emergency Response Drills

All persons on the installation or in connected activities (including contractor’s personnel) shall be trained periodically for emergency response and evacuation procedures. Training for employees having assigned roles in emergency response shall be completed before they are called upon to perform in real emergencies.

Emergency response organization structure (IRT/ERT/EMT/CMT) shall ensure command by competent persons, which can be maintained, so far as is practicable, throughout an emergency.

- Key persons such as the Installation In-charge and Shift In-charge / control room operator shall be assessed for required competence to perform emergencies duties before assigning of duties. As far as possible, assessment would be under simulated emergency conditions.
- Competency and training needs shall meet the requirements of the CAIRN management Standard on Competency, Training and Awareness
- An emergency response table top exercise / emergency response drill is a focused activity that places the participants in a simulated situation requiring them to function in the capacity that would be expected of them in a real event. Its purpose is to ensure preparedness by testing policies and plans and by training personnel. One objective of an exercise is would be able to identify problem areas for resolution/ corrective action before an actual emergency occurs.
- The drills need to address the readiness of personnel and their familiarity / proficiency with emergency equipment and procedures. All personnel on the installation involved including contractor's employees would participate in the drills.
- The drills and table top exercises shall be carried out as often as appropriate, against documented schedule. Would be scheduled regularly, at least once a year for full drills and six monthly for desk-based exercises, although the exact frequency and type of drills may depend on the nature and scale of the operations, and the associated risks.
- Emergency response plan shall be reviewed and revised as appropriate in line with the findings from drills and table top exercises.
- Involve external emergency response agencies and other external stakeholders, where appropriate.

### 7.4.17 Performance Measures

- Key elements of functionality, survivability, reliability and availability shall be included in performance standards. Achievability of performance standards would be validated.
- Effective operations, inspection, testing and maintenance procedures shall be established to ensure that the functional requirements of the equipment and systems provided for emergency escape, evacuation and rescue response are maintained.
- A written scheme shall be prepared; detailing the inspection, testing and maintenance routines and frequencies would be followed. All emergency equipment and systems shall be thoroughly inspected, following established procedures. Adequate records of the results of the inspection, testing and maintenance shall be kept and shall be periodically reviewed to confirm that the written scheme is appropriate and is being adequately implemented.

### 7.4.18 Monitoring, Evaluation and Review

Documented reviews would be carried out after all drills and actual emergency responses to determine the effectiveness of the Emergency Preparedness and Response Plans, with a full debrief to identify what worked well and what aspects require improvement.

Lessons learned following exercises or actual emergency situations/incidents shall be documented, and any gaps in planning and implementation shall be addressed in revised versions of the Emergency Preparedness and Response Plans. Lessons learned shall be shared across where appropriate.

All Emergency Preparedness and Response Plans shall be reviewed and updated periodically, at least on an annual basis, to ensure they remain appropriate and relevant. Reviews shall also meet the requirements of the CAIRN on Management Review and Continual Improvement.

### 7.4.19 Preventive Measures for Handling Natural Gas

The natural gas is a colorless, odorless, flammable gas, mainly methane which may cause flash fire. Electrostatic charge may be generated by flow, agitation etc. No occupational exposure limits have been established for natural gas. The preventive measures would be taken to avoid impact due to leakages are

- Provide local exhaust ventilation system: Ventilation equipment would be explosion-resistant if explosive concentrations of material are present.
- Gloves: Wear appropriate chemical resistant gloves.
- Respirator: Under conditions of frequent use or heavy exposure, respiratory protection may be needed.

### 7.4.20 Preventing Fire and Explosion Hazards

Fire is one of the major hazards, related to oil and natural gas well. Fire prevention and code enforcement is the area of responsibility of the fire service. Safe operating practices reduce the probability of an accidental fire on a platform. Personnel would understand their duties and responsibilities and be attentive to conditions that might lead to fire. The following precautions are recommended:

- Fire control cannot be achieved until the source of fuel and ignition is isolated. Fire control cannot be achieved until the source of fuel and ignition is isolated. An emergency shutdown (ESD) system shall be provided to isolate the installation from the major hydrocarbon inventories within pipelines and reservoirs, which if released on failure, would pose an intolerable risk to personnel, environment and the equipment / assets.
- There would be provision for safe handling and storage of dirty rags, trash and waste oil. Flammable liquids and chemicals spilled on platform would be immediately cleaned.
- Platform equipment would be maintained in good operating condition and kept free from external accumulation of dust and hydrocarbons. Particular attention would be given to crude oil pump, seals, diesel and gas engines which could be potential source of ignition in the event of a failure
- The Disaster Management Plan would address the issue of a fire event at any location on the well and the procedure would be adopted in the very unlikely event of this occurring. If a fire starts in any well, that section of the well would be isolated by closing the section (Block) valves, as quickly as possible and surrounding facilities would be cooled with water.

### 7.4.21 Off-site Emergency Plan

The Off-Site Emergency Plan is a compilation of various emergency scenarios and also includes the probable impact off-site locations due to emergency and the action plan to combat / mitigate the consequences of a disaster situation. Emergency is a sudden unexpected event, which can cause serious damage to personnel life, property and environment as a whole, which necessitate evolving off-site emergency plan to combat any such eventuality. Emergencies can be handled by an organized multi-disciplinary approach. If it becomes necessary to evacuate people, then this can be done in orderly way.

Under the Environmental (Protection) Act 1986, the responsibility of preparation of Off-Site Emergency Plan lies with the State Government. The Collector/ Deputy Collector by virtue of their occupation are normally nominated by the concerned State Government to plan Off-Site Emergency Plan. The different agencies involved in evacuation of people are civil administration (both state and central) and police authorities.

### 7.4.22 Purpose

- To save life and prevent/reduce loss of properties
- To make explicit inter related set of actions would be undertaken in the event of an accident posing hazards to the community

- To plan for rescue and recuperation of casualties and injuries. To plan for relief and rehabilitation
- To plan for prevention of harms, total loss and recurrence of disaster. It would be ensured that absolute safety and security is achieved within the shortest time

The activities of the government, Non-Government organizations and concerned personnel involved in off-site disaster management plan are as follows:

These would include the safety procedures would be followed during emergencies such as posters, talks and mass media in different languages including local language. Leaflets containing do's/ don'ts would be circulated to educate the people in vicinity

Medical Help consisted of doctors and supporting staff for medical help to the injured persons because of disaster would be formed. Functions and duties of the committee include, providing first Said treatment for injured at the spot or at some convenient place and shift those to nearby hospitals for further treatment if required

The police would assist in controlling of the accident site, organizing evacuation and shifting of injured people to nearby hospitals.

The fire brigade shall organize to put out fires other than gas fires and provide assistance as required. Approach roads to accident site and means of escape would be properly identified. Chief fire officer would co-ordinate entire fire control measures. Routine training of firefighting equipment and special rescue equipment would be carried out. Concerned officer would ensure adequate supply of fire water and firefighting agents at the site of emergency. Maintenance of standby equipment / personnel for firefighting would be ready at any given time.

### 7.4.23 Mutual Aid

Disaster / emergency / risk, when becomes difficult to control by in house team / management, help from nearby industries, institutions, etc. can be taken. A group of mutual aid can be formed where emergency control systems like ambulance, firefighting equipment, medical & fire-fighting team, etc. can be shared in the event of need.

### 7.4.24 Post Emergency Relief to the Victims

The Public Liability Insurance (PLI) Act, 1991 provides for the owner who has control over handling hazardous substances to pay specified amount of money to the victims as interim relief by taking insurance policy for this purpose. The District Collector has definite role in implementation of this act. After proper assessment of the incident, he shall invite applications for relief, conduct an enquiry into the claims and arrange payment of the relief amount to the victims.

### 7.4.25 General Health and Safety

The project would adhere to health & safety norms of Oil Mine Rules, 2017 as applicable along with Best Industry Practices. General health and safety issues during various project activities are similar to those of most large infrastructure and industrial facilities and their prevention and control. These issues include among others, exposure to dust and hazardous materials, hazardous materials components, and physical hazards associated with the use of heavy equipment, etc. Specific health and safety issues primarily include the following:

- Physical hazards
- Chemical hazards
- Confined spaces

Physical Hazards - The main sources of physical hazards are associated with machinery and vehicles. General electrical equipment safety, working in confined spaces, hot work, high temperature areas are expected would be present.

Chemical Hazards - workers may be exposed to chemical hazards especially if their work entails direct contact with fuels or chemicals, flare & DG set emission or depending on the nature of activities. Work with fuels may present a risk of exposure to volatile organic compounds (VOC) via inhalation or skin contact during normal use or in the case of spills.

Noise - Noise sources include drilling, DG operations, including vehicular traffic, and boats. In order to evaluate the impacts of proposed project on the health of workers, baseline health studies would be carried out on every worker before joining their duties.

The hierarchy of control specific for health & safety (in order of priority):

- Eliminate the use of a harmful product or substance and use a safer one;
- Substituting wherever reasonably practicable, a non-hazardous material which presents no risk to health, where a hazardous material is used intentionally, i.e. use a safer form of the product;
- Modifying a process to eliminate the use of risk, the production of a hazardous by-product or waste product, including reducing the quantities of the hazardous material which are used & stored, i.e. change the process to emit less of the substance;
- Enclose the process so that the product does not escape;
- Extract emissions of the substance near the source;
- Provide personal protective equipment (PPE) such as gloves, coveralls and a respirator. PPE must fit the wearer.

### 7.4.26 Personal Protective Equipment

Often it is not possible, or practicable, to eliminate exposure to materials hazardous to health completely. In such cases, operations would consider how to prevent employees being exposed and the prevention of exposure would be achieved by measures other than the use of PPE or Respiratory Protective Equipment (RPE), which is the last line of Defense. Situations where PPE/RPE would normally be necessary include:

- where adequate control of exposure cannot be achieved solely by good practice and the application of operational or engineering measures;
- where new or revised assessment shows that PPE/RPE is necessary until adequate control is achieved by other means;
- where there is temporary failure to achieve adequate control of the process, e.g. because of plant failure, and the only practicable solution to maintain adequate control in the time available may be the provision and use of suitable PPE/RPE; and
- Where maintenance operations have would be carried out. Key personal protective equipment would include:
- Body suit
- Hand gloves
- Helmet
- Safety shoes
- Safety harness
- Breathing apparatus
- Eye shield
- Earmuffs

### 7.4.27 First Aid

Medical services, including personnel trained in first aid, and medical equipment that is appropriate to the type of operation would be provided at project. All the key persons on an installation (well pad) would have at least basic training in emergency response, basic first aid, use of life saving appliances and firefighting. Individual competencies shall be periodically tested to identify further requirement of training and knowledge to perform emergency duties.

It would be ensured that any auxiliary medical teams e.g. nurse and first aid personnel are fully trained and conversant with their roles and responsibilities. Contact details & capacities of nearby medical facilities and medical experts would be made available at strategic locations.

## 7.5 SUMMARY

A risk assessment exercise has been carried out for the Project. It was observed that the risks to personnel at site and staff within occupied facilities are well within the 'Acceptable Band' of 1E-06 per year. Risks to the community were also assessed to be well within the acceptable range. The maximum damage distance for 6.31 $kW/m^2$and 37.5 $kW/m^2$ which corresponds to 1% lethality level for a 30 sec exposure for the Gas Pipeline catastrophic rupture has been estimated as 293.2 m and 172.3 m respectively. For the export oil tank, the damage distance has been estimated as 91.39 m. No extra risk reduction options need to be implemented. Detailed emergency response plan in consultation with the district administration shall be prepared before commencement of the work in the Block.

# CHAPTER 8

# PROJECT BENEFITS

The proposed Onshore Oil and Gas Development & Production project will establish the potential of hydrocarbons in the Block. The development of the oil Block will result in considerable growth of service sector and will also generate direct/indirect employment and business opportunities in the area. The major benefits of the project include reduction of the oil import bill of the nation as well as reduction of the imbalance in oil production and consumption.

The commercial development will also lead to investment in Andhra Pradesh , bringing oil and gas revenues both to the State and to the Central Government. The presence of Cairn Oil & Gas in the region will substantially improve the socio-economic conditions of the region. Employment opportunity for local people as contract/daily wages in nearby areas.

## 8.1 EMPLOYMENT POTENTIAL

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 operation phase for few hundreds of people directly and indirectly.

It is envisaged that the following persons will be directly engaged during various stages of Kaza block development.

- Project phase (construction of single well pad & associated activities) – 80 no’s
- Drilling of well and operation of single rig – 100 no’s
- Operation of the each well pad to produce oil & gas including the hydrocarbon transportation through trucks / cascade mounted trailers – 25 no’s

## 8.2 CORPORATE SOCIAL RESPONSIBILITY (CSR)

Vedanta Limited (Division Cairn Oil & Gas) will take up various CSR initiatives in and around present operational areas for the benefit of the local residents in consultation with the District Collector, Krishna District of Andhra Pradesh. CSR is an integral element of Cairn India’s business, as we believe that sustainable development in our area of operation is essential for inclusive growth. We conduct CSR programs with the following two interlinked objectives:

- Improvement in socio-economic status of the local community in our area. It should be measurable through key socio-economic indicators e.g. HDI (Human Development Index) and various other sector specific indicators.
- Continuous engagement will the local community to partner with them on various development activities such as developing vendors

Vedanta Limited has well established CSR team based in Andhra Pradesh with two main functions, which includes Community Management & support to Asset; and CSR Welfare & Community Development Programs.

The team working on **Community Management** is responsible to facilitate the interaction between the community and Cairn. They are also responsible for running engagement cell to address any grievances and get proposals for community benefits. They work closely with the technical teams and our contractors to ensure local resources (employment, contractors and vendors) are engaged.

**The Welfare Programs** team is responsible to execute CSR programs to meet our overall objectives in health, education, livelihood, environment and other areas as identified based on the need assessment program. The team work closely with community members, district administration and NGO partners to implement our long-term CSR programs. Based on these interactions, programs are planned and implemented under four thematic streams - health, education, livelihoods and community infrastructure.

**Guiding Principles**

- Programs are designed to cover all segments of the household. Thematic areas include economic development, health and education, the impact of which is measurable through socio-economic indicators such as HDI.
- Primary focus in programs is partnership with the government, using existing government institutions where possible to ensure that reach is extended to the last mile at the grass roots.
- Community participation is essential. We will conduct engagement sessions at village and Panchayat level. The activities will be done in affected villages of Movva, Gudur, Kalidindi and Machilipatnam mandals i.e. Palankipadu, Kanchakodur, makulavaripalem, Matlamullapalli, Maddipatla, Paddarayuduthota , Kaza, Kollapalem, Reddy naidu Agaraharam, Racharlapalem, Avurupudi Nidumolu, kalapatam, Gurjepalle, kanktav,Veerayelanka, Pinagudurulanka, Parnasala,Tarakaturupalem, Narikedalapalem, Chittiguduru, Guduru, Kokanarayanapalem, Akumarru, Gulabpura, Chittiguduru, Sultannagaram ,Gollapalem, Rayavaram at periodic intervals to ensure community ownership of programs, and work with them to develop capacity for sustenance.
- We will also conduct one-on-one interaction through the Engagement Cells, where any community member can openly discuss grievances related to issues as diverse as local resource engagement for business to social programs that could benefit the larger community.

**CSR key focus areas will be**

**Health**

- Access and usage of quality primary and secondary care by everyone
- Availability of safe drinking water
- Improvement in overall health indicators (IMR. MMR, etc.) by 40%

**Livelihood / Income Enhancement**

- To improve productivity of local workforce through training and local employment
- To enhance large section of population through productivity improvement of farming & livestock
- To increase Increased green cover and water conservation in Cairn operational area

**Education**

- To improve the status of education such as increase in the student enrolment, especially of girls.
- To increase the retention of students in the schools
- To improve the academic performance – especially in science, mathematics & English

**Infrastructure**

Complement Govt. programs and schemes to create community assets as required.

## 8.3 SUMMARY

The project activity and the management are will support the local villagers and provide other forms of assistance for the development of public amenities in this region. The management will recruit skilled and unskilled workers from the nearby villages. Housing facilities, transportation, medical, educational and other civic amenities as a part of CSR activities will get a boost in future. This is envisaged as a major positive benefit to this area.

# CHAPTER 9

# ENVIRONMENTAL COST BENEFIT ANALYSIS

## 9.0 GENERAL

Environmental Cost Benefit Analysis (CBA) is an analytical way to make an educated decision regarding the commencement of an industrial activity or similar trade/commercial/infrastructure activity. This involves a comparison of the costs of an action with considerations of the benefits associated with that action. CBA assists the regulators to evaluate the benefits and challenges imposed by the upcoming activity in commercial terms with respective to the impact on the environmental scenario such as human wellbeing, quality of life and environmental wellbeing.

An important component of a CBA is a base situation which is a situation when no changes take place. All decisions are then compared to the base situation. Once the base and a relevant time period are established, benefits and costs can be calculated in terms of human and environmental well-being. In this case, a benefit is defined as anything that increases human well-being, and a cost is anything that decreases it. CBA aims to maximize economic efficiency at a point where marginal benefits and marginal costs are equal.

## 9.1 APPLICABILITY OF CBA AND SUMMARY

Environmental cost-benefit analysis (CBA) is the application of CBA to projects or policies that have the deliberate aim of environmental improvement or actions that somehow affect the natural environment as an indirect consequence. With reference to Kaza Block, Government of India has offered Discovered Small Fields (DSFs) spread with the prime objective of monetizing discovered fields to boost domestic Oil and Gas production. These DSFs fields have been discovered by India's National Oil Companies (NOCs) such as Oil and Natural Gas Corporation Limited (ONGC) and Oil India Limited (OIL) and are now being offered under exclusive policy which is designed to be investor friendly and is based on an easy to administer Revenue Sharing Contract model in tune with the Government's policy of 'Ease of doing business' in India. These Discovered Small fields have over 625 MMBBL of Oil and oil equivalent Gas. Thus, development of this project have positive social cost benefit analysis and environment degradation shall be minimum, if the EMPs suggested in this study is implemented and monitored effectively.

# CHAPTER 10

# ENVIRONMENT MANAGEMENT PLAN

## 10.0 GENERAL

Any industrial development is associated with certain positive impacts as well as some negative impacts on the environment. At the same time adverse impacts cannot be neglected. An Environmental Management Plan shall be formulated for mitigation of the adverse impacts and is based on the present environmental conditions and the environmental impact appraisal. This plan helps in formulation, implementation and monitoring of the environmental parameters during and after commissioning of the project.

## 10.1 INTRODUCTION

This chapter describes the Environmental Management Plan (EMP) proposed for the Kaza block developmental activities including drilling. The EMP is formulated to mitigate the adverse environmental and social impacts that are identified and quantified through the EIA process. EMP also ensures that the resources are utilised efficiently, waste generation is minimised, residuals are treated adequately, and by-products recycled to the extent possible. The EMP is aimed at managing and monitoring the environmental in a sustainable manner. The detail of EMP is mentioned in the Table 10.1.

Prior to start of Project components, Cairn will also ensure that the Safety Management Systems (SMSs) are in place as per the requirement of Petroleum and Natural Gas (Safety in Offshore Operations) Rules, 2008, Oil Mine Rules, 2017, OISD Guidelines and Standards to cover the following elements:

1) Hazard Identification Control of Hazards Establishing Barriers,
2) Contractor Safety,
3) Competency of Personnel,
4) Management of Change procedures,
5) Emergency Response Plan,
6) Maintenance Practices,
7) Operating Procedures on safety and other requirements,
8) Incident Reporting,
9) Performance Monitoring,
10) Regulatory Requirements, and
11) HSE Organisation and Risk Register

## 10.2 ENVIRONMENT MANAGEMENT PLAN

## Table 10.1 Environmental Management Plan

| Ref No. | Project Stage / Affected Aspect | Project Activity | Potential Impacts | Proposed Mitigation Measures | Responsibility for Implementation |
|---|---|---|---|---|---|
| A1.1 | Land Use | ▪ Land requirement for drill sites, site approach road and onshore pipeline corridor | Permanent / temporary loss of land | ▪ Cairn will enter agreement for lease or permanently acquire the land for their activity. The suitable compensation shall be paid as laid down by the Government appointed Land Acquisition Officer.<br>▪ Cairn will compensate all affected landowners for any loss of land resulting out of the proposed onshore drilling program;<br>▪ Landowners shall be paid with adequate compensation for the trees, if any present before acquisition of the land;<br>▪ Cairn should ensure that livelihood of local community, if any affected by the proposed land take are identified and compensated through adequate compensation and other livelihood restoration activities directly or indirectly through CSR activities | Land Acquisition Manager |
| | | ▪ Long term lease / procurement of land for onshore well pad and site approach road;<br>▪ Temporary loss of agricultural activity during laying of pipeline;<br>▪ Restriction of land use along | Conversion of agricultural fields into industrial land | ▪ Immediate restoration of acquired land for pipeline to its best achievable original state after completion of the buried pipeline laying activity, thus, to merge it with the best achievable surrounding land use.<br>▪ Remove all wastes from area surrounding onshore well pad sites and site approach road and pipeline corridor | Project Manager |

| Ref No. | Project Stage / Affected Aspect | Project Activity | Potential Impacts | Proposed Mitigation Measures | Responsibility for Implementation |
|---|---|---|---|---|---|
| | | the pipeline corridor. | | | |
| | | ▪ Removal of vegetation and cutting of trees; | Loss of floral habitat & plant species distribution | ▪ Restrict the construction within the site;<br>▪ Avoid the felling of trees, as practical as possible;<br>▪ Efforts for replantation of larger tree species to be explored;<br>▪ At least 25 to 33% of the total well pad area shall be developed for the greenbelt plantation with local plant species;<br>▪ Greenbelt plantation shall be carried out in all the well pads with local plant/ pollutant abatement species as per "Guidelines for developing Greenbelt", published by CPCB;<br>▪ The vegetation removal should be guided by an ecologist to ensure preconstruction bird nest surveys. In case active nests are discovered nest relocations with assistance from the forest department should be undertaken. For felling of trees any prior approval required from authorities would be sought and records would be maintained;<br>▪ For every tree removal in pipeline condor, shall be planted with ten (10) new species towards compensatory plantation in consultation with District Forest Officer. | Project Manager |
| A1.2 | Physiography and Drainage | ▪ Raising of well pad sites;<br>▪ Construction of site approach | Site elevation may disturb drainage. Temporary | ▪ Provide adequate drainage system for the well pads to maintain the micro-drainage of | Project Manager |

| Ref No. | Project Stage / Affected Aspect | Project Activity | Potential Impacts | Proposed Mitigation Measures | Responsibility for Implementation |
|---|---|---|---|---|---|
| | | road<br>▪ Laying of onshore pipelines; crossing of drainage channels/ canals (minor drainage streams), etc. | disturbance of micro drainage channel due to the construction of site approach road and laying of pipeline | area;<br>▪ Reclaim and reinstate the land after completion of the pipeline laying;<br>▪ Maintain the cross-drainage structure along the pipeline route;<br>▪ Design site approach road with due consideration of micro drainage. | |
| A1.3 | Soil Quality | ▪ Disposal of construction waste/ Municipal Solid Waste (MSW) in non-designated area;<br>▪ Spillage of chemical, spent mud, hazardous waste, etc.;<br>▪ Surface runoff from material & waste storage areas and oil spillage area<br>▪ Disposal of decommissioning waste materials in open soil | Soil contamination | ▪ Topsoil shall be removed, preserved and reused in the disturbed area;<br>▪ Restricted project and related activities during monsoon season;<br>▪ Drainage system at site is to be provided separate for storm water drainage and closed drain for carrying secondary containment water. Both the drainage shall not mix over;<br>▪ Manage spills of contaminants on soil using spill kits;<br>▪ Storage of construction waste/ MSW in designated areas within well pads;<br>▪ Adopt best practices e.g. use pumps and dispensing nozzle for transfer of fuel, use drip trays etc.<br>▪ Testing of drill cutting as per EPA Rules (GSE 546 E) to determine if they are hazardous in nature and accordingly planning for their disposal. | Project Manager and Environment Manger |
| A1.4 | Air Quality | ▪ Site development and | Fugitive emission and | ▪ Minimise movement of construction vehicles | Project Manage / |

| Ref No. | Project Stage / Affected Aspect | Project Activity | Potential Impacts | Proposed Mitigation Measures | Responsibility for Implementation |
|---|---|---|---|---|---|
| | | construction of site approach road;<br>▪ Operation of vehicles and construction machinery;<br>▪ Transportation, storage, handling of construction material, disposal of construction waste;<br>▪ Operation of diesel generators and gas engine generators;<br>▪ Flaring of hydrocarbon during well testing;<br>▪ Dust generation during loading of bulk solids;<br>▪ Transport of de-mobilised rigs and machineries;<br>▪ Emission of air pollutants from<br>Crude stabilisation;<br>▪ Fugitive emissions of VOCs from crude oil storage | emission of gases with potential to degrade the ambient air quality; impacts are expected to be localised and over a short period. | and enforce a speed limit around the construction site;<br>▪ Regularly maintain all diesel-powered equipment and reduce idling time to avoid emissions of NOx, PM10 and SO2;<br>▪ Vehicle / equipment exhausts observed to be emitting significant black smoke from their exhausts should be serviced/ replaced.<br>▪ Carry out regular water sprinkling at the site during dry season especially during the construction and decommissioning activities;<br>▪ Efforts would be made to maintain the stockpile against the wall or obstruction so that it works as a windbreak and the fugitive emissions by strong winds can be avoided;<br>▪ The trucks used for transport of fill material during the site preparation and debris shall be provided with impervious sheeting;<br>▪ During construction, the approach road will be kept clean, periodic sprinkle of water, free from mud and slurry to prevent any entrainment of dust;<br>▪ Maintenance of diesel power generators to achieve efficient combustion, fuel efficiency and therefore reduce emissions;<br>▪ High efficiency flare tips to be installed in all flares; | Operations Manager / Environment Manger |

| Ref No. | Project Stage / Affected Aspect | Project Activity | Potential Impacts | Proposed Mitigation Measures | Responsibility for Implementation |
|---|---|---|---|---|---|
| | | | | ▪ Install low NOx generating new gas turbine generators to reduce NOx emissions;<br>▪ Fugitive emissions shall be controlled through proper preventive maintenance. Carry out Fugitive emission leakage study at least once in two years period to check for the fugitive emission leakage, so that immediate action to stop the leakage can be considered;<br>▪ 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.;<br>▪ Use of low sulphur diesel oil<br>▪ No cold venting to be resorted during well testing. Management of the well test programme by dedicated team for prevention of trips in product supply to the flare and flame out. Many of the above measures including checking of methane emissions, which may occur during well testing, are incorporated into management of the drilling operations. The well testing procedure involves the dedicated observation of the flare to avoid cut off;<br>▪ The elevated flare shall be located for dispersion of the flare plume.<br>▪ Compliance to GSR 546 (E) and EPA Rules | |

| Ref No. | Project Stage / Affected Aspect | Project Activity | Potential Impacts | Proposed Mitigation Measures | Responsibility for Implementation |
|---|---|---|---|---|---|
| | | | | shall eb followed specific to upstream operations. | |
| | | ▪ $H_2S$ generation from the wells and process may be possible (only confirmation after testing of the well) | Effect on the human health and other living beings | ▪ Effective control of $H_2S$ emission by addition of suitable scavenger chemicals.<br>▪ Monitoring partial pressure of $H_2S$ in the system and wells | |
| A1.5 | Noise | ▪ Operation of machineries & equipment;<br>▪ Vehicular traffic;<br>▪ Operation of DG sets.<br>▪ Demobilization activity | Increase in ambient noise levels | ▪ All vehicle and equipment involved in site development and drilling activity will be provided with noise control measures;<br>▪ Regular maintenance of equipment including lubricating moving parts, tightening loose parts and replacing worn out components should be conducted;<br>▪ Low noise equipment should be used as far as practicable;<br>▪ All DG/GEG sets would be provided with acoustic enclosures; and<br>▪ Appropriate PPEs (e.g. earplugs / earmuffs) will be used for by workers while working near high noise generating equipment. | Drilling Contractor/ Operation Manager |
| A1.6 | Road and Traffic | ▪ Transportation of construction materials and manpower;<br>▪ Transportation of drilling rig and machineries<br>▪ Transportation of drilling chemical and fuel | Damage of road and potential to impact community health & safety | ▪ Avoid the traffic movement during school hours and market times;<br>▪ Regular maintenance of the access roads;<br>▪ Deploying traffic marshals at important road junctions and near sensitive receptors (e.g. schools) for management of project traffic | Drilling Contractor/ Operation Manager |

| Ref No. | Project Stage / Affected Aspect | Project Activity | Potential Impacts | Proposed Mitigation Measures | Responsibility for Implementation |
|---|---|---|---|---|---|
| | | ▪ Transportation of manpower | | | |
| A1.7 | Surface Water Quality | ▪ Surface runoff from construction sites, spill areas, drill sites;<br>▪ Generation and disposal of domestic wastewater from construction camp;<br>▪ Generation and disposal of domestic wastewater from drill sites;<br>▪ Hydrotest water during pipeline testing;<br>▪ Accidental discharge from waste pit | Increased sediment content of surface water;<br><br>Contamination of surface water | ▪ Construction activities viz. stripping, excavation etc., during monsoon season will be restricted to the extent possible;<br>▪ Channelize all surface runoff from the construction site through storm water drainage system and provide adequate size double chambered sedimentation tank;<br>▪ Proper treatment of all wastewater to ensure that they comply with criteria set by APPCB / MoEFCC prior to disposal;<br>▪ Hydrotest water will be treated and disposed.<br>▪ All chemical and fuel storage areas, process areas will have proper bunds so that contaminated run-off cannot escape into the storm-water drainage system;<br>▪ An oil-water separator will be provided at the storm water drainage outlet, to prevent discharge of contaminated run-off;<br>▪ Spill kits to be used for removal of any oil or chemical spillage on site;<br>▪ Impervious pits will be constructed within the well pad to store the produced water | Drilling Contractor/ Operation Manager |

| Ref No. | Project Stage / Affected Aspect | Project Activity | Potential Impacts | Proposed Mitigation Measures | Responsibility for Implementation |
|---|---|---|---|---|---|
| | | | | generated after the well fluid separation.<br>▪ Septic tanks with soak pits shall be constructed as per IS 270: 1986;<br>▪ Process wastewater and drilling fluids would be treated in Effluent Treatment Plant (ETP) at drill sites. | |
| A1.8 | Ground Water Resource | Sourcing of water for drilling (60 $m^3$/day/well) | Depletion of ground water | ▪ Approved local water only supply shall be sourced and no borewell shall be drilled without obtaining permission from APWALTA/CGWA;<br>▪ ETP treated water will be utilised in mud preparation in the drill sites. | Project Manager/ Drilling Contractor/ Operation Manager |
| A1.9 | Ground Water Quality | ▪ Generation of sewage;<br>▪ Storage and handling of chemicals;<br>▪ Storage and handling of hazardous waste;<br>▪ Drilling and use of mud; | Contamination of groundwater | ▪ The drill cutting along with spent mud will be stored in HDPE lined pit.<br>▪ During the drilling activity, this waste will be periodically evacuated for disposal as applicable. All measures shall be ensured to avoid seepage of wastewater through the HDPE liner and cause land pollution.<br>▪ Impervious secondary containment storage area to be provided for storing fuel & lubricant, chemical, hazardous waste etc.<br>▪ Prevent & mitigate spill of paint/fuel/chemical in construction site;<br>▪ Conduct all the fuel transfer operations in paved areas;<br>▪ Regularly monitoring the ground water | Project Manager/ Drilling Contractor/ Operation Manager |

| Ref No. | Project Stage / Affected Aspect | Project Activity | Potential Impacts | Proposed Mitigation Measures | Responsibility for Implementation |
|---|---|---|---|---|---|
| | | | | quality in the vicinity of the well sites. | |
| A1.10 | Solid waste management (Hazardous and non-hazardous) | ▪ Generation of hazardous and non-hazardous waste;<br>▪ Storage, handling, transportation and disposal of the hazardous waste;<br>▪ Drilling cutting and drilling mud disposal; and<br>▪ Safe disposal of e-waste, lead acid battery and bio medical waste | Contamination of groundwater | ▪ The generated hazardous waste shall be disposed within the stipulated period of 90/180 days as specified in the hazardous waste authorization;<br>▪ Metals and non-metals shall be segregated and disposed to the authorized recyclers<br>▪ All recyclable hazardous and other waste such as waste oil, used oil, used barrels, lead acid batteries, e-waste shall be disposed to the authorized recyclers<br>▪ Two separate Drill cutting disposal pits to be provided for WBM and SBM cuttings;<br>▪ Drill waste pits to be provided with HDPE lining on bottom and side surfaces;<br>▪ WBM to be tested for hazardous characteristic and disposed accordingly;<br>▪ Site specific waste management plan to be prepared considering project & operational activities;<br>▪ All non-recyclable hazardous waste such as oily filters, filter media, synthetic oil-based mud drill cuttings etc shall be disposed for co-processing towards AFR (Alternate Fuel and Raw material) and or in authorized TSDF facility (Treatment Storage and Disposal Facility) | Environment Manger |

| Ref No. | Project Stage / Affected Aspect | Project Activity | Potential Impacts | Proposed Mitigation Measures | Responsibility for Implementation |
|---|---|---|---|---|---|
| | | | | ▪ Non-hazardous waste such as water-based mud drill cutting shall be used for the soil compaction or road binding material within Cairn own premises.<br>▪ All hazardous waste shall be transported through hazardous waste authorized vehicles. | |
| A1.11 | Hydro testing | ▪ Possibility of Hydro testing conduct in the wells at multiple zone. | ▪ Water resource consumption<br>▪ Movement of tankers<br>▪ Potential for groundwater contamination | ▪ Water to be sourced only from the approved water supply sources.;<br>▪ Wastewater from fracking to be disposed for solar evaporation or to be stored in tankers and reused for fracking of other wells or treated in the ETP for final disposal;<br>▪ In case of significant volume of back flow, the effluent shall be solar evaporated and if required shall be treated using mobile effluent treatment plant at the well site.; | Petroleum Engineering Manager |
| A1.12 | Hazardous chemicals | ▪ Usage of the hazardous chemicals without approval<br>▪ Improper storage | Spillage causing land and water pollution;<br>Occupation health hazard | ▪ All the hazardous chemicals shall be used only as per the MSIHC Rules;<br>▪ Material safety data Sheet shall be used and followed for all chemical handling<br>▪ Materials to be used for the drilling fluid preparation shall comply with GSR 546 (E) and EPA Rules.<br>▪ All hazardous materials shall be stored in the secondary container/bund to avoid spillage. | Operation Manager |
| A1.13 | Ecology | ▪ Raising of the well pad from | Habitat Loss and Habitat | ▪ Night activities to be avoided to the extent | Project Manager/ |

| Ref No. | Project Stage / Affected Aspect | Project Activity | Potential Impacts | Proposed Mitigation Measures | Responsibility for Implementation |
|---|---|---|---|---|---|
| | | the current elevation above inundation level;<br>▪ Construction of approach road to these well pad locations;<br>▪ Construction of pipeline from these well pad locations to main pipeline; and | Disturbance | possible, if the same is unavoidable the low lights and minimum illumination should be used;<br>▪ Construction activities should be limited to well pad;<br>▪ Any areas for storage of construction material should be left scrap free post construction phase;<br>▪ Cairn has prepared a Site-Specific Biodiversity Conservation Plan – the same shall be implemented. | Drilling Contractor/ Operation Manager |
| A1.14 | Livelihood and Economic Opportunities | ▪ Site development works | Opportunities for semi-skilled and unskilled labour during the construction phase;<br>Economic opportunities due to labour influx and income generation due to expenditure on supplies and equipment, which together with rentals etc. will provide minor inputs to the local economy. | ▪ Cairn's policy on local content will be implemented for this Project. As per Cairn, wherever possible, engagement of local contractors and workers during the construction/ development phase will be preferred | CSR Manager |
| A1.15 | Occupational Health and Safety | ▪ Construction of well pads;<br>▪ Drilling Activity<br>▪ Changes to/existing environmental conditions; | Occupational Health and safety of construction workforce | ▪ The Contractor will prepare and implement a Health and Safety Plan prior to commencing work. This plan will include method statements for working methods, plant | HSE Manager |

| Ref No. | Project Stage / Affected Aspect | Project Activity | Potential Impacts | Proposed Mitigation Measures | Responsibility for Implementation |
|---|---|---|---|---|---|
| | | ▪ Site decommissioning | | utilisation, construction sequence and safety arrangements;<br>▪ All work shall be carried out only as per Cairn HSE permit and management system;<br>▪ Measures will be implemented to reduce the likelihood and consequence of the following hazards:<br>− falling from height;<br>− entanglement with machinery;<br>− tripping over permanent obstacles or temporary obstructions;<br>− slipping on greasy oily walkways;<br>− falling objects;<br>− contact with dangerous substances;<br>− electric shock;<br>− variable weather conditions;<br>− lifting excessive weights;<br>− A Permit to Enter system will be established to ensure that only authorised persons gain entry to the site;<br>▪ All persons working on site will be provided information about risks on site and arrangements will be made for workers to discuss health and safety with the Contractor;<br>▪ All workers will be properly informed, consulted and trained on health, safety and | |

| Ref No. | Project Stage / Affected Aspect | Project Activity | Potential Impacts | Proposed Mitigation Measures | Responsibility for Implementation |
|---|---|---|---|---|---|
| | | | | environment issues;<br>▪ Personal Protective Equipment (PPE) shall always be worn on the Site.<br>▪ Before starting work all the appropriate safety equipment and the first-aid kit will be assembled and checked as being in working order;<br>▪ All lifting equipment and cranes will be tested and inspected regularly. All hoist ways will be guarded;<br>▪ Safety hoops or cages will be provided for ladders with a height in excess of two metres;<br>▪ The Contractor shall provide appropriate safety barriers with hazard warning signs attached around all exposed openings and excavations when the work is in progress;<br>▪ Vedanta shall implement its sustainability initiative through Vedanta Sustainability Assurance Program (VSAP) and its fatal risk controls. | |
| A1.16 | Community Health and Safety | ▪ Road transportation<br>▪ Influx of construction workers;<br>▪ Potential exposure to spills, fires and blowouts<br>▪ Exposure to air and noise pollution | Accident in road;<br>Communicable diseases | ▪ Water sprinkling at the access roads and construction sites would reduce dust emission;<br>▪ To reduce noise related impacts the vehicles should not blow horns near settlements and night-time movement of vehicle and construction activities will also be restricted | Project Manager / CSR Manager |

| Ref No. | Project Stage / Affected Aspect | Project Activity | Potential Impacts | Proposed Mitigation Measures | Responsibility for Implementation |
|---|---|---|---|---|---|
| | | ▪ Changes to existing environmental conditions; | | and all Cairn vehicles shall be administered through Journey management Plan;<br>▪ Introduce the traffic restriction along the traffic hotspots;<br>▪ Place traffic regulatory signage along the site access and approach roads;<br>▪ The grievance redressal process should be regularly tracked and monitored as part of the management function;<br>▪ Emergency preparedness and response plan; Oil Spill Contingency & Response Plan and Disaster management Plan that considers the role of communities and community infrastructure as appropriate should be developed. | |
| A1.17 | Visual Quality | ▪ Storage of construction materials;<br>▪ Storage and disposal of construction waste, municipal waste;<br>▪ Physical presence of rig and associate equipment;<br>▪ Dust deposition in the nearby property/ vegetation<br>▪ Unplanned disposal of decommissioning waste materials in the vicinity of the | Visual and aesthetic impact on the nearby villages<br><br>Disposal of MSW/ construction waste/ de-commissioning waste in open area around the village will create nuisance. | ▪ All the construction activities will be restricted within the designated site;<br>▪ Fugitive dust will be supressed with periodic water sprinkling;<br>▪ On completion of work all temporary structures, surplus materials and wastes will be completely removed from site and disposed at a designated area;<br>▪ Construction wastes, decommissioning waste and municipal solid waste temporarily stored at the sites will be transported to the designated disposal site/facility at regular | Project Manager |

| Ref No. | Project Stage / Affected Aspect | Project Activity | Potential Impacts | Proposed Mitigation Measures | Responsibility for Implementation |
|---|---|---|---|---|---|
| | | well sites; | | intervals;<br>▪ The pipelines once laid will be covered with burrowed soil and levelled as per the surrounding land. | |
| A1.18 | Ground water quality | ▪ Injection of water in the reservoir;<br>▪ Spillage of fuel and chemical storage, hazardous waste storage. | Potential to contaminate the ground water resources | • The injection water is treated in injection water treatment system to meet the required water quality;<br>• If produced water is not injected back to the reservoir, then the same shall be stored in impervious layer laid pit and then periodically transported to Ravva or nearby terminal for final disposal or disposal shall be carried out as per the deep dump well permitted in the EPA Rules meeting depth > 1000 m below ground level (water to be treated to meet < 10 ppm of Oil and < 100 ppm of total suspended solids before disposal to dump well)<br>• All storage facilities have been provided with | Environment Manager |

| Ref No. | Project Stage / Affected Aspect | Project Activity | Potential Impacts | Proposed Mitigation Measures | Responsibility for Implementation |
|---|---|---|---|---|---|
| | | | | adequate containment system to prevent contamination of soil and subsurface aquifer;<br>• Cairn will ensure periodic integrity testing of areas surrounding all process and storage tank and hazardous waste storage areas.<br>• Cairn will ensure periodic integrity testing of well fluid transport pipeline;<br>• In case of any accidental spills at the well pad or during trucking, Cairn will recover any spilled crude oil/chemical or fuel oil and adequately treat the area to prevent any subsurface contamination.<br>• Cairn is to periodically monitor the groundwater quality in the surrounding area to ascertain any impact of groundwater quality. | |
| B1.1 | Decommissioning and Abandonment | ▪ Demolition<br>▪ Plugging and abatement of the wells<br>▪ Removal of the pipelines; and<br>▪ Restoration of the sites | | • All drill cuttings, spent mud, waste oil and other waste to be completely removed from the site and sent to designated disposal place prior to commencement of demolition work.<br>• Unused chemicals at the site to be shifted to another site or contractor's storage area prior to demobilization.<br>• All concrete or steel installations will be removed to at least 1 m below ground level, | Project Manager and Environment manager |

| Ref No. | Project Stage / Affected Aspect | Project Activity | Potential Impacts | Proposed Mitigation Measures | Responsibility for Implementation |
|---|---|---|---|---|---|
| | | | | to ensure that there will be no protruding surface structures. The casing wellhead and the top joint of the casings will be cut below the ground level and capped with a cement plug.<br>• All the hydrocarbon wells (producers and injectors) shall be plugged and abandon as per OISD standards.<br>• Prior to commencement of any demolition, a planned programme of site clearance will be formulated. All pits, cellars and holes will be removed and filled to ground level, any oil or otherwise contaminated soil will be removed and disposed to Landfill.<br>• Roads and other paving will be removed to enough depth to allow soil replacement and revegetation. Any remaining topsoil that has been stocked during the site clearance will be re-spread over appropriate portions of the site. Plantation, if possible, will be commenced in and around the site.<br>• As applicable the scale of environmental impact, separate EIA study may be required to be carried out, if the entire Block is to be reinstated. | |

## 10.3 SOCIAL WELFARE ACTIVITIES

Before starting up the activity in Kaza block, Cairn oil & gas will take up various social initiatives in and around Kaza block for the benefit of the locals.

As per the OM of MOEFCC vide F.No.22-65/2017-IA.III dated 30th September 2020, Vedanta Ltd. (Division: Cairn Oil & Gas) will allocate the budget for compliance to the issues identified/addressed during the public hearing. The compliance status to the issues raised during the public hearing will be submitted in the six monthly progressive Environmental Compliance report.

The broad areas proposed to be focused under the this plan would include;

i) Children's Well-being & Education
j) Skill development
k) Health Care
l) Drinking Water & Sanitation
m) Agriculture & Animal Husbandry
n) Development of Community Infrastructure
o) Participate in the community development programs initiated by central government and Andhra Pradesh state government and
p) any other program identified based on the social need-based assessment

The exact amount of the budget and timeline to be spent on above mentioned projects or any other areas would be decided after consultation with the District Collector, Krishna District, Andhra Pradesh. The activities will be done in affected villages of Movva, Gudur, Kalidindi and Machilipatnam mandals i.e. Palankipadu, Kanchakodur, makulavaripalem, Matlamullapalli, Maddipatla, Paddarayuduthota , Kaza, Kollapalem, Reddy naidu Agaraharam, Racharlapalem, Avurupudi Nidumolu, kalapatam, Gurjepalle, kanktav,Veerayelanka, Pinagudurulanka, Parnasala,Tarakaturupalem, Narikedalapalem, Chittiguduru, Guduru, Kokanarayanapalem, Akumarru, Gulabpura, Chittiguduru, Sultannagaram ,Gollapalem, Rayavaram.

## 10.4 BUDGET FOR EMS

Approximately around 5% of the total project cost, which is around Rs. 33 Crores is being earmarked towards implementing the proposed EMP. This cost will include meeting the project related expenses towards Pollution Control Measures; Environmental, Health and Safety management measures; environmental and social monitoring; and any contingency cost towards managing the environment and social protection of the proposed Project.

## 10.5 ENVIRONMENTAL MANAGEMENT SYSTEM & POLICY

### 10.5.1 Corporate Health safety & Environment Policy

Vedanta Limited has a well laid down Corporate HSE Policy that includes the commitment to HSE legal compliances and well established standard operating procedures (SOP) for reporting on the performance of environmental management system for continual improvement. Further, the administrative order of company to deal with the environmental issues and the reporting mechanism of non-compliance /violation of environmental norms is well established. Various environmental and social related policies such as HSE policy, CSR Policy, Biodiversity Policy, Water Policy, Energy & Carbon Policy, HIV / AIDS Policy and Human Rights Policy is attached as **Annexure II.**

HSE policy comprises of the following:

- Comply with applicable national, regional and local Health, Safety and Environment ('HSE') regulations and statutory obligations and other requirements as appropriate. The company develops, implements and maintains HSE management systems aligned with the organization sustainable development commitments. The organization drive continuous improvement in HSE through setting and reviewing objectives & targets, assessing and reporting HSE performance, using appropriate best available practices and providing all employees with appropriate training;

- Prevent injury and ill health to the company's employees and contractor' s employee's by providing a safe and healthy work environment and by minimising risks associated with occupational hazards;
- Improve and enhance environmental conditions and avoid, reduce, mitigate or compensate the environmental impacts to neighbouring communities in which it operates including air, water emissions and noise;
- Conserve natural resources through adopting environmentally friendly and energy efficient technology and process improvements. The Company is committed to managing waste that arise from its operations and adopt the principles of waste avoidance, reuse, recycling and beneficial utilisation to minimise discharge and disposal to the environment;
- Promote a positive HSE culture within the organisation through effective communication, participation and consultation with employees in the workplace;
- Implement regular health surveillance and risk-based monitoring of all employees;
- Influence the contractors and suppliers to adopt principles and practices that company comply with;
- Communicate periodically with all the stakeholders on the HSE progress and performance.

### 10.5.2 Environmental Management Cell (EMC)

Vedanta Limited onshore operations has already established the Environmental Management Cell for managing their day to day operations. The same EMC with additional manpower will support the proposed project and operations at later stage. The company has a well-defined hierarchical system or administrative order to deal with the environmental issues and for ensuring compliance with the EMP, Public hearing commitments, EC and Consent order conditions. EMC will coordinate in implementation of the technical and statutory environmental requirements/issues that arise during the project and operational requirements. The system is in place to report any non-compliances/violations of environmental norms to the Board of Directors of the company and/or shareholders or stakeholders. EMC organogram is detailed below.

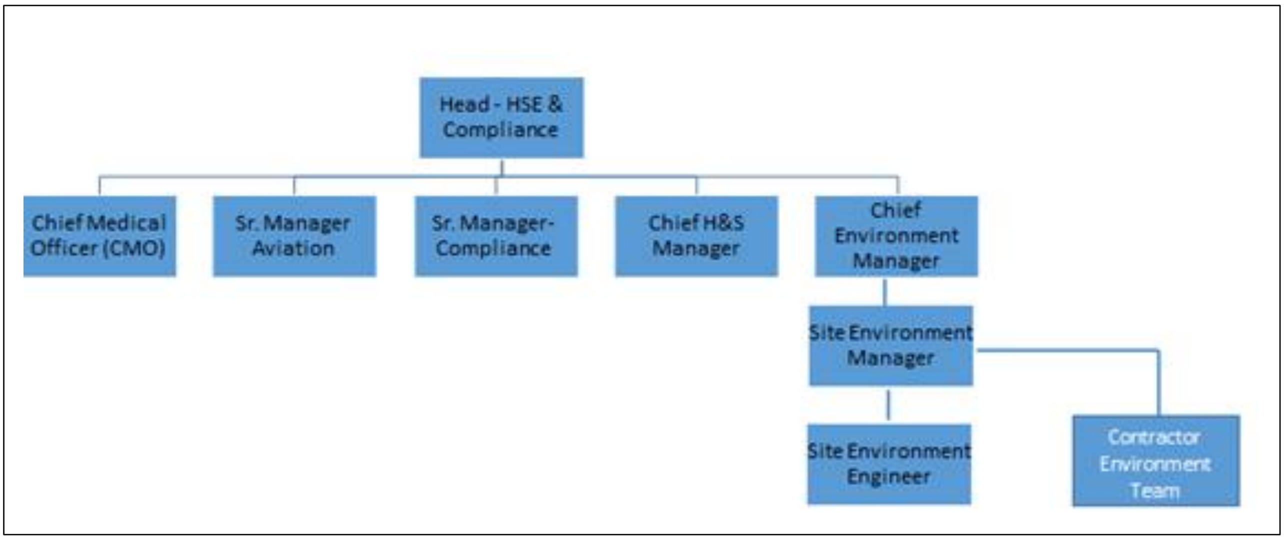


**Figure 10.11: EHS/HSE Organization Chart**

**Role and Responsibility of EMC**

The major duties and responsibilities of EMC are:

- To implement the EMP.
- Ensuring that the Project and subcontractors operate in accordance with applicable environmental and social regulatory requirements and plans. Monitor implementation of environmental and social protection measures.
- To assure regulatory compliance with all relevant rules and regulations stipulated by APPCB/CPCB/MoEF&CC.
- To ensure regular operation and maintenance of air pollution control devices
- To initiate environmental monitoring as per approved schedule;
- Review and interpretation of monitoring results and corrective measures in case monitored results are above the specified limit
- To plan and schedule environmental conservation and protection activities for the purpose of achieving environmental standards and to improve methods of environmental management practices.
- To improve working environment for employees by implementing mitigation/control measures for Occupational Health and Safety and by improving condition of workplace environment.
- To make budgetary provision and allocate funds for environment management system and to ensure timely revision of budgetary provisions.
- To implement and ensure effective implementation of planned mitigations including R&D program for innovative technologies for better environment, resource conservation / recovery / recycling / reuse specially to promote waste utilization.
- To encourage and inspire employees and contractor for highest performance and attentive response for environmental conservation, protection and improvement.
- Maintain documentation of good environmental practices and applicable environmental laws as ready reference
- Maintain environment related records
- Coordination with regulatory agencies, external consultant, monitoring laboratories
- Maintain log and grievance register of public complain and the action taken.

## 10.6 SUMMARY

The main purpose of EMP is to minimize the identified potential environmental impacts to be generated from the proposed project & operation and to mitigate the consequences. Construction activities will be carried out during daytime only. Regular water sprinkling will be done to reduce Particulate Matter concentration in the atmosphere. PPEs will be provided to workers and first aid facilities shall be kept at designated locations during construction phase. During operation phase the industry shall maintain comprehensive environment management plan in place for the proposed unit, which shall cover all the environment protection measures to mitigate improvised environmental impact as suggested in the EMP of this report. Solid/Hazardous Waste Management will be done as per HW (Management, Handling and Trans boundary Movement)–2016. Noise level will be measured regularly, and necessary protective measures will be implemented. Cairn India has already developed an Environmental and safety Management Cell (EMC) as an integrated managerial body from various disciplines to co-ordinate the project activities concerned with implementation of environment control measures and management.

# CHAPTER 11

# CONCLUSION AND RECOMMENDATION

KG/ONDSF/KAZA/2018 is onshore Block located in Krishna District of Andhra Pradesh. ONGC has drilled three exploratory wells in the year 1985 in the Kaza structure. Out of the three wells, two wells were found to be dry wells and one well found to have gas discovery. The successful exploration well has discovered gas in Raghavapuram sands, possibility of occurrence of oil cannot be ruled out. Based on the data obtained from the successful gas well, the reservoir properties are moderate. It was noted that further gas extraction is possible through hydro-fracture of the well. All the earlier wells were drilled in the depth of ~ 2300 m below the ground level. It is understood that the accumulated hydrocarbons are due to long distance migration from the deeper parts of the depression adjacent to the Kaza high.

As per Environmental Impact Assessment EIA Notification dated 14th September, 2006, the project falls under category 'A' of Schedule 1(b) - Offshore and onshore oil and gas exploration, development & production which requires prior Environmental Clearance (EC), which is to be obtained from MoEF&CC before the commencement of ground activity. The application for prior EC (Form-1 and Pre-feasibility Report) had been submitted to MoEF&CC on 12th February 2020. In this regard, under the provisions of the EIA Notification 2006 as amended, the Standard TOR has been granted by MOEF&CC vide letter reference F.No. No. IA-J-11011/52/2020-IA-II (I) dated 02nd April 2020 for the preparation of draft environment impact assessment report and environment management plan. This is the Draft EIA report has been prepared for conducting the public hearing.

The draft EIA report has assessed the overall significance of environmental impacts likely to arise from Drilling of proposed exploratory and appraisal wells. The overall impacts from the individual drilling sites is have been assessed to be of moderate to minor in nature when appropriate mitigation measures are would be implemented with proper planning and design.

To adequately address the impacts, mitigation measures and management plans suggested are as per the best practices followed in the Oil & Gas Industry. These plans include environmental management plan, monitoring plan, labor management plan, traffic management plan. Vedanta Limited (Cairn Oil & Gas) shall put in place a robust mechanism with adequate resources to implement the suggested mitigation measures and management plans. The measures will help to prevent any deterioration contamination of air, soil, groundwater and surface water quality beyond the prevailing status. Adequate safety measures would be adopted along with suitable emergency response and disaster management plan to safeguard against all man-made and natural disasters. Environmental monitoring of ambient air quality, noise levels, surface & groundwater etc. would be carried out at regular intervals to monitor and prevent any deterioration of baseline environmental quality due to the proposed project.

Compliance to all legal requirements and adherence to the suggested mitigation measures and plans will also enable Vedanta Limited (Cairn Oil & Gas) in minimizing its impact on environmental and social parameter. This Report would be finalized after obtaining the comments and observations of public during the hearing to modify and strengthen any mitigation measures as required before same is submitted to MoEF&CC for obtaining Environmental Clearance (EC) of the project.

# CHAPTER 12

# DISCLOSURE OF CONSULTANT ENGAGED

Vedanta Limited (Division: Cairn Oil & Gas) has appointed Eco Chem Sales and Services (ECSS) for carrying out this Environmental Impact Assessment Study as per the EIA notification, 2006 as amended till date. Eco Chem Sales and Services has approved EIA coordinators and Field Area Experts for undertaking Environmental and related studies in twenty one (21) approved sectors by NABET, Quality Council of India, New Delhi.

## 12.1 BRIEF RESUME AND NATURE OF CONSULTANCY

ECO CHEM SALES and SERVICES (ECSS) is one of the leading companies in the field of Environmental Consultancy Service providers in India. We are NABET Accredited consultant for conducting Environmental Impact Assessment Studies (EIA) and obtaining Environmental Clearances. We also take up services which include and are not limited to Environment Monitoring and Testing, Environment Audit, Risk Assessment Studies, Turnkey solutions, Operation and Maintenance contracts and obtaining various statutory clearances from Ministry of Environment, Forest and Climate Change (MoEFCC) and State Pollution Control Boards. ECSS also has branch offices in Vapi, Dahej and Vadodara, Gujarat.

The accreditation certificate number NABET/EIA/1720/SA 085 is valid up to 26th October 2020.

## 12.2 EIA TEAM MEMBER

Work presented in this report was carried out by Eco Chem Sales and Services with active co-operation from Vedanta Limited (Division: Cairn oil & Gas). The name of the team members associated in the preparation and studies of EIA/EMP is mentioned in Table 12.1.

**Table 12.1: EIA Team Member**

| Name of Internal Team Member | Activity/ Area | Involvement<br>Actual Work Performed | Under Approved Expert |
|---|---|---|---|
| Mrs. Rekha Shah<br>Mrs. Dipti Patel | Quality Check & Project Coordinator | Understanding of project; Guidance in writing & modification in Contents; Impact Assessment; Review of EIA/EMP report. | EIA Coordinator |
| Ms. Pruthvi Patoliya | Assisting in EIA Report Writing and Meteorology, Air Quality Modeling & prediction(AQ) | Coordination for data collection, data analysis, coordination with FAEs, team members; compiling the primary & secondary data for EIA report; EIA/EMP report preparation, assistance in report preparation to FAE.<br>Assisted FAE for Evaluation of meteorological data with collected secondary data, Air quality modeling and prediction and report writing. | EC, All FAEs |
| Mr. Dhaval Shah | Meteorology, Air Quality Modeling & prediction(AQ) | Assisted FAE for Evaluation of meteorological data with collected secondary data, Air quality modeling and prediction and report writing. | FAE AQ |
| Mr. Jenish Barot | Risk and hazards (RH) | Assisted FAE for preparation of Risk Assessment and report writing | FAE RH |
| Mr. Vinay patil | Ecology and Biodiversity (EB) | Report writing, assisting in ecological survey and preparation of status report for rare endangered and threatened species of animals and plants and also species protected under national laws, assessment | FAE EB |

| Name of Internal Team Member | Activity/ Area | Involvement<br>Actual Work Performed | Under Approved Expert |
|---|---|---|---|
| | | of the impacts of proposed project activities on the biological environment | |

## 12.3 LABORATORY INVOLVED FOR BASELINE MONITORING AND OTHER ANALYSIS

One season baseline monitoring and analysis has been done by Ecosystem Resource Management Pvt. Ltd., NABL accredited Laboratory, Certificate No. TC – 6603, dated 15/11/2019 which is valid up to 14/11/2021. MoEFCC Recognition letter no. 15018/46/2015-CPW dated 08/03/2018 valid for five years.

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**Annexure I TOR Letter**

**Annexure II Environmental and Social related Policies**

**Annexure III TSDF Membership Certificate**

# Annexure IV Overview of the HSE Regulatory and Policy Framework applicable to this Project