Pre-Feasibility Report

For

Offshore Oil and Gas Exploration & Appraisal in Block GS-OSHP-2017/2 in Gulf of Kutchh, Gujarat

<u>**VEDANTA LTD. (CAIRN OIL & GAS)**</u>

March, 2019

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1. Executive Summary

Vedanta (erstwhile Cairn India Limited merged with Vedanta Limited w.e.f. April 11, 2017, pursuant to NCLT order dated March 23, 2017) is a globally diversified natural resources company with interest in Zinc, Iron Ore, Aluminium, Copper, Power and Oil & Gas. Vedanta Ltd. (Cairn Oil & Gas) has been allocated the GS-OSHP-2017/2 hydrocarbon block for exploration and exploitation of hydrocarbons by MoP&NG, Govt. of India under the Revenue Sharing Contract (RSC) on 1st October 2018. The block covers an area of 674 Sq.Km in Gulf of Kutchh, Gujarat.

1.1 Project Details

1.1.1 Proposed Project

Vedanta Ltd (Cairn Oil & Gas) proposes to carry out seismic survey/data acquisition in the block and exploratory (including appraisal) drilling of 41 wells.

1.1.2 Justification of the project

The demand for petroleum has recorded a considerable increase over the last few years. There is a considerable increase in consumption of petroleum products due to the development activities in the country in the last few years. During the year 2016-17, the consumption of petroleum products in India was 194.60 MMT with a growth of 5.37% as compared to consumption of 184.67 MMT during 2015-16. The consumption of petroleum products during April-November, 2017 was at 134.60 MMT i.e. an increase of 3.40% over 130.17 MMT in April-November, 2016. The crude oil production for the year 2016-17 is at 36.01 Million Metric Tonnes (MMT) as against production of 36.94 MMT in 2015-16, showing a decrease of about 2.53%. Whereas Natural Gas production during the year 2016-17 is at 31.90 Billion Cubic Meters (BCM) which is 1.09% lower than production of 32.25 BCM in 2015-16. Import of crude oil during 2016-17 was 213.93 MMT valued at 470159 crore as against import of 202.85 MMT valued at 416579 crore in 2015-16 which marked an increase of 5.46% in quantity terms and 12.86% in value terms as compared to the import of crude oil during 2015-16.

Import of Crude Oil during April-November, 2017 was 144.72 MMT valued at 3,42,673 crore which marked an increase of 9.31% in quantity terms and 15.32% in value terms as against the imports of 143.81 MMT valued at 2,97,161 crore for the same period of last year. Therefore, India is largely dependent on import of petroleum goods to meet its requirements. Facing an environment of increasing consumption, static reserves, increasing imports and increasing costs of crude as well as decreasing value of the Indian Rupee vis-à-vis the US Dollar, it follows that any accretion of hydrocarbon reserves in the country, is welcome.

Vedanta’s proposed exploratory and appraisal drilling could possibly result in the discovery of hydrocarbon and in that case, would help in reducing India’s dependence on imports.

1.2 Site Analysis

The block lies entirely in offshore area. The two coastal districts near to the Block are Kutchh and Devbhumi Dwarka districts. The Dwarka major port is located ~35km to the east of the block. The coastal areas are well connected by rail, road and air.

1.2.1 Climate

The study area experiences a hot and dry climate. Predominantly being a dry land, Kutch experiences extreme climatic conditions characterized by sweltering summer and scanty rainfall. The summer season in Kutch is extremely hot and starts from the month of February and lasts till June. The Kutch region receives an average rainfall of around 14 inch every year. Compared to the other two seasons, the winter season in Kutch is pleasant. It starts from the month of October and lasts till January with average temperature ranging from 12°Celsius to 25°Celsius. Since the state has a long coastal belt, the winter is not very cold.

1.3 Water and power requirements

1.3.1 Water Requirement

A. Water Requirement during seismic survey

The water required during seismic operation 20-30 m3/day will be mostly for domestic use, which will be sourced locally from the nearest port authority.

B. Water requirement during exploratory and appraisal well drilling

Water is required at the drilling location for drinking, domestic use and preparation of drilling mud. An estimated 20-30 m^3 per day of water during drilling campaign will be used for domestic consumption depending on the type of MODU used. Water used for the preparation of drilling mud is generally known as drill water. The quantity of drill water required for preparation of Water Based Mud (WBM) will be approximately 600-1000 m^3 per well, while for Synthetic Based Mud (SBM), approximate drill water requirement will be 150-300 m^3 per well. Water requirements for miscellaneous use like engine cooling, washing, firefighting storage etc. will be approximately 25-50 m3/well/day. Water for drilling purposes will be sourced partially from sea. Other remaining water requirements will be met by water supplied through supply vessels from the nearest port and will be stored in water storage tanks.

1.3.2 Power requirement

A. Power requirement during seismic survey

The required power supply will be generated from diesel generators at the seismic vessel.

B. Power requirement during exploratory well drilling

The power requirement of offshore drill rig will be met by DG sets (4*2000 KVA) and another generator of 500 KVA will be standby for emergency purpose..

1.4 Pollution control measures

1.4.1 During Seismic Operations

A. Air Emissions and Control Measure

Air emissions from on-board DG set of seismic vessels.

B. Noise Emissions and Control Measure

Noise emission envisaged from DG sets, air guns and on-board vessels. The generated noise will be short term & transient in nature.

C. Wastes treatment and disposal

The food wastes will be mercerised and disposed offshore. Other domestic wastes and effluents, metal garbage, plastics, and paper will be collected and brought to onshore for appropriate disposal.

The hazardous wastes would include: waste oils, used oil, small quantities of chemicals (e.g. paint, thinners etc.) will be disposed through recyclers.

D. Discharges

The discharge from vessels like bilge water, sewage shall be complied with the requirements of MARPOL for disposal into sea.

1.4.2 During Drilling Operations

A. Air Emissions and Control Measure

The emissions to the atmosphere from the drilling operations shall be from the diesel generators associated with the drilling rigs and temporary from flaring activity (during testing).

B. Noise Emissions and Control Measure

The source of noise generation during this phase of operations would be the operation of rig and diesel generator sets, pumps and other equipment. Appropriate noise control measures will be taken to minimise exposure to drilling crew.

C. Waste treatment and disposal

The food wastes will be mercerised and disposed offshore. Non-biodegradable wastes like metals, plastics, and paper will be collected and brought to onshore for appropriate disposal.

The hazardous wastes would include: waste oils, used oil, small quantities of chemicals (e.g. paint, thinners etc.) will be disposed through recyclers.

250-750 MT / well of drill cuttings with WBM and 500-1500 MT / well of drill cuttings with SBM and 250-500 MT of spent drilling mud shall be generated at site per well during drilling operations. Drill cuttings and spent drilling mud will be disposed offshore as per the guidelines listed by CPCB/MOEFCC for the drilling and extraction of oil and gas industry.

Used /waste Oil – During the drilling approx. 1-2 tons/wells of spent oil shall be generated per well. This oil shall be sent to authorized recyclers.

Domestic waste of 25-30 kg/day per well shall be generated on-board drilling rigs. Additionally Non-combustible waste containing metallic residues, glass etc. of 1-2 ton/well, Left over chemicals and materials, scrap metal etc. of 5-6 ton/well and Cement, grit, blasting and painting wastes of 5-6 ton/well will be generated and disposed following the suitable government guidelines.

D. Waste Water Treatment

Drilling rigs and drilling logistics will comply with the MARPOL requirements for disposal of the bilge water, sewage into the sea.

1.5 Project schedule and cost estimate

Vedanta Ltd. (Cairn Oil & Gas) planned to drill 41 exploration and appraisal wells in the next 10-12 years of exploration phase.

The cost of the project is estimated is given below:

1) Physical Surveys Cost estimated to be approximately INR 62.30 Crore.
2) Average Cost per well for exploratory & appraisal well is estimated to be INR 49 Crore.

1.6 Employment Generation

The seismic surveys are expected to take about 4-6 months to complete and will require a crew of approximately 60-80 persons. During the drilling phase, about 80-100 workmen will be working on site.

1.7 Rehabilitations and Resettlements

For the proposed offshore exploration project, no land requirement and R&R is not envisaged.

2. Introduction of the project

2.1 Identification of the project

Vedanta Ltd (Cairn Oil & Gas) has been allocated the GS-OSHP-2017/2 hydrocarbon block under the OALP (Open Acreage Licensing Policy) by MoP&NG, Govt. of India. RSC (Revenue Sharing Contract) has been signed between Vedanta Ltd and MoP&NG on 1st October, 2018 for the exploration and exploitation of hydrocarbons. Vedanta Ltd (Cairn Oil & Gas) proposes to carry out exploration (including seismic surveys, exploratory and appraisal well drilling) of oil and gas in the block. The wells will be tested by flowing hydrocarbons to assess the quality and commercial viability ascertain reserve oil parameter, as a part of exploration and appraisal. In case of a discovery, the wells will be tested for extended durations by flowing hydrocarbons to assess the quality and commercial viability.

2.2 Brief description of nature of the project

The proposed project is green field in nature. The proposed project involves oil and gas exploratory (including appraisal) drilling and well testing.

2.3 Need for the project and its importance to country and region

India is largely dependent on import of petroleum goods to meet its requirements. Facing an environment of increasing consumption, static reserves, increasing imports and increasing costs of crude as well as decreasing value of the Indian Rupee vis-à-vis the US Dollar, it follows that any accretion of hydrocarbon reserves in the country, is welcome.

Vedanta's proposed exploratory drilling project could possibly result in the discovery of hydrocarbon and subsequent development and production would help in reducing India's dependence on imports. Consequently, the need for the project is evident. The proposed project would also contribute to the state Government of Gujarat in terms of royalty through the mining lease. Additionally the proposed project would generate direct and indirect employment in the region.

2.4 Demand-supply Gap

As on 1.4.2017, In-place hydrocarbon volume of 10454 million tonnes of oil and oil equivalent gas could be established through exploration by ONGC, OIL and Private/JV companies. So, about 75% of resources are under "yet to find" category. Out of 10454 MMT of oil and oil equivalent gas of In-place volumes, the ultimate reserves which can be produced are about 4017 MMT of oil and oil equivalent gas since inception. The balance recoverable reserves are of the order of 1787 MMT of oil and oil equivalent gas.

2.4.1 Production and Consumption

The crude oil production for the year 2016-17 is at 36.01 Million Metric Tonnes (MMT) as against production of 36.94 MMT in 2015-16, showing a decrease of about 2.53%. Whereas Natural Gas production during the year 2016-17 is at 31.90 Billion Cubic Meters (BCM) which is 1.09% lower than production of 32.25 BCM in 2015-16. The demand for petroleum has recorded a considerable increase over the last few years due to the development activities in the country in the last few years.

During the year 2016-17, the consumption of petroleum products in India was 194.60 MMT with a growth of 5.37% as compared to consumption of 184.67 MMT during 2015-16. The consumption of petroleum products during April-November, 2017 was at 134.60 MMT i.e. an increase of 3.40% over 130.17 MMT in April-November, 2016

Therefore, India is largely dependent on import of petroleum goods to meet its requirements. Vedanta's proposed exploratory drilling project could possibly result in the discovery of hydrocarbon and in that case, would help in reducing India's dependence on imports.

2.4.2 Imports

Import of crude oil during 2016-17 was 213.93 MMT valued at 470159 crore as against import of 202.85 MMT valued at 416579 crore in 2015-16 which marked an increase of 5.46% in quantity terms and 12.86% in value terms as compared to the import of crude oil during 2015-16. Import of Crude Oil during April-November, 2017 was 144.72 MMT valued at 3,42,673 crore which marked an increase of 9.31% in quantity terms and 15.32% in value terms as against the imports of 143.81 MMT valued at 2,97,161 crore for the same period of last year.

2.5 Import versus indigenous production and export

India imports more than 80% of the petroleum products of its daily requirement.

2.6 Domestic Markets

The Oil & Gas produced in case of commercially viable discovery and subsequent development will be utilized for domestic purpose only. There is enough demand in domestic market.

2.7 Employment generation

The seismic surveys are expected to take about 4-6 months to complete and will require a crew of approximately 60-80 persons. During the drilling phase, about 80-100 workmen will be working on site.

3 Project Description

3.1 Type of project

The proposed project is a green field project. There is no interlinked and inter-dependent project.

3.2 Location with co-ordinates

This block GS-OSHP-2017/2 is located offshore in the Arabian Sea. The major coastal towns near to the Block are in Kutchh and Devbhumi Dwarka districts. The Dwarka major port is located ~35km to the east of the block. It encloses an area of 674 sq. km. and is bounded by the points having following coordinates (Table-3.1). A map of the area is shown in Figure 3.1.

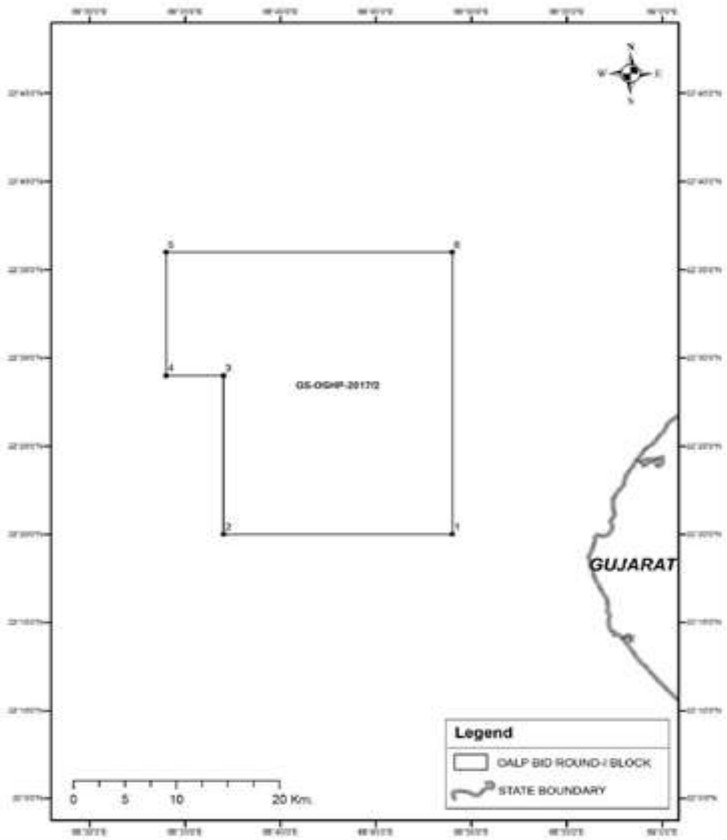


Figure-3.1: Location map of block GS-OSHP-2017/2 with state boundary

Table-3.1: Apex Co-ordinates of Block (GS-OSHP-2017/2) boundary (as per RSC)

Points	Longitude	Latitude
1	68° 49'	22° 20'
2	68° 37'	22° 20'
3	68° 37'	22° 29'
4	68° 34'	22° 29'
5	68° 34'	22° 36'
6	68° 49'	22° 36'

Locations of the intended well along-with the preliminary leads are shown in figure 3.2 and with google map view in shown in figure 3.3. Table 3.2 indicates the coordinates of the proposed wells. Exploratory & appraisal wells will be drilled using Jack-Up or semi-submersible rigs, based on the water depth profile.

3.3 Details of alternate site considered and the basis of selecting the proposed site

The block is allocated by the Government of India under the Revenue Sharing Contract (RSC). Vedanta Ltd. (Cairn Oil & Gas) is the Operator for this block. Drilling locations are proposed based on geo-scientific information and alternate sites cannot be considered for the proposed project facilities due to the following reasons:

The location is within the existing RSC boundary of the block. The locations of wells are selected considering the drilling configuration (reach to reservoirs).

3.4 Size / magnitude of operation

The proposed offshore oil and gas exploration & appraisal project is expected to carry out

1. 674 sq km of seismic data acquisition

2. Drilling of 41 exploratory including appraisal wells and testing.
3. Depth of the Exploratory & Appraisal wells will be 2000-2200 m.

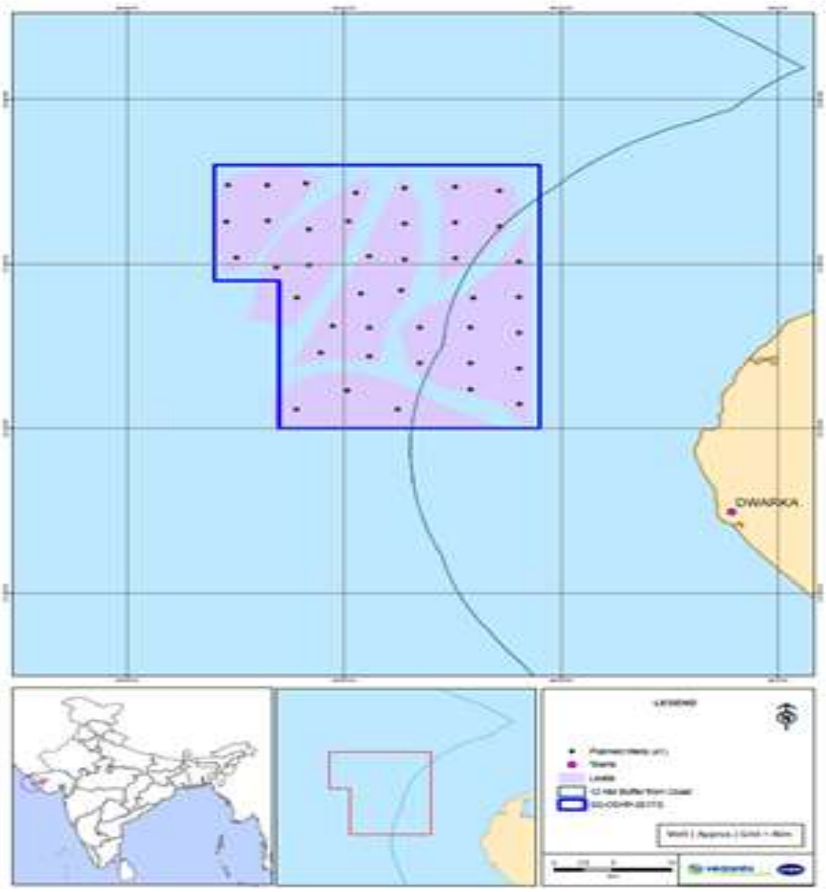


Figure-3.2: Maps showing Exploratory including appraisal well locations.

Well_id	Longitude	Latitude
1	68° 37' 47.917" E	22° 21' 9.479" N
2	68° 40' 8.871" E	22° 22' 18.494" N
3	68° 42' 27.644" E	22° 21' 10.021" N
4	68° 45' 49.690" E	22° 22' 22.242" N
5	68° 48' 4.101" E	22° 21' 28.975" N
6	68° 38' 55.225" E	22° 24' 35.931" N
7	68° 41' 9.670" E	22° 24' 23.129" N
8	68° 43' 29.570" E	22° 23' 58.293" N
9	68° 45' 49.471" E	22° 23' 58.514" N
10	68° 48' 3.917" E	22° 23' 39.065" N
11	68° 39' 28.715" E	22° 26' 14.384" N
12	68° 41' 9.378" E	22° 26' 8.127" N
13	68° 43' 29.314" E	22° 26' 8.383" N
14	68° 45' 49.251" E	22° 26' 8.604" N
15	68° 48' 3.733" E	22° 25' 49.156" N
16	68° 37' 49.113" E	22° 27' 57.199" N
17	68° 40' 46.175" E	22° 28' 11.670" N
18	68° 42' 37.784" E	22° 28' 23.926" N
19	68° 45' 56.667" E	22° 27' 55.785" N
20	68° 48' 3.549" E	22° 27' 59.246" N
21	68° 35' 2.223" E	22° 30' 22.969" N
22	68° 36' 52.775" E	22° 29' 47.326" N
23	68° 38' 22.601" E	22° 29' 56.377" N
24	68° 41' 8.791" E	22° 30' 28.304" N
25	68° 42' 47.345" E	22° 30' 16.560" N
26	68° 45' 7.355" E	22° 30' 21.146" N
27	68° 48' 3.364" E	22° 30' 9.335" N
28	68° 34' 34.546" E	22° 32' 34.145" N
29	68° 36' 28.408" E	22° 32' 37.776" N
30	68° 38' 22.270" E	22° 32' 6.464" N
31	68° 40' 11.769" E	22° 32' 36.209" N
32	68° 42' 47.087" E	22° 32' 26.648" N
33	68° 45' 7.133" E	22° 32' 31.234" N
34	68° 47' 9.725" E	22° 32' 17.241" N
35	68° 34' 38.506" E	22° 34' 47.503" N
36	68° 36' 28.040" E	22° 34' 47.862" N
37	68° 38' 14.302" E	22° 34' 53.642" N
38	68° 40' 32.202" E	22° 34' 20.114" N
39	68° 42' 46.829" E	22° 34' 36.735" N
40	68° 45' 6.911" E	22° 34' 41.322" N
41	68° 47' 9.540" E	22° 34' 27.329" N

Table-3.2: Co-ordinates of the proposed wells.

Figure-3.3: Well head position superimposed on google map view.

Note: Actual geo-graphical surface coordinates of exploratory and appraisal well locations will be within 4000 m radius of the proposed coordinates

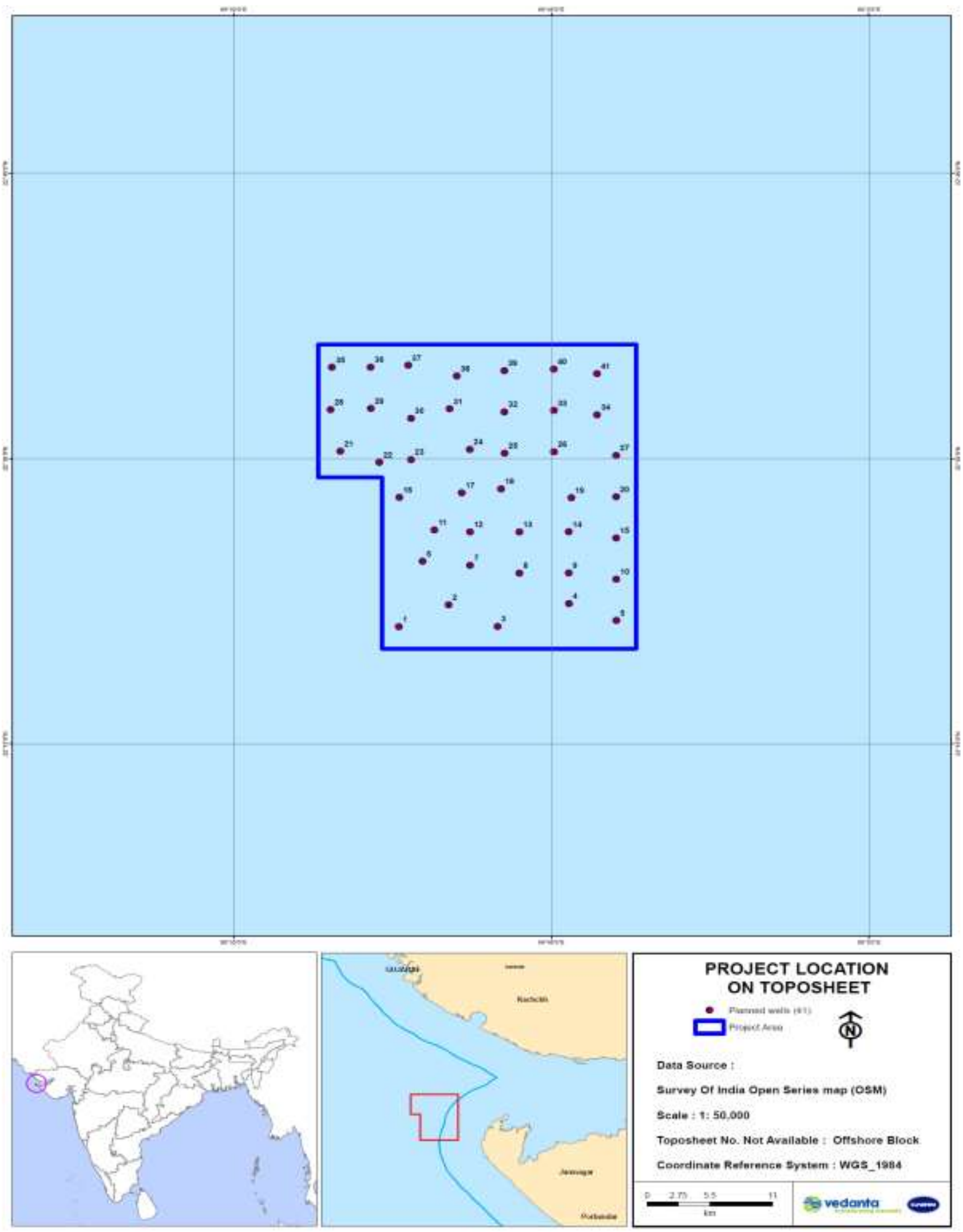


Figure 3.4: Topograhy map of nearby coastal areas

3.5 Project description with process details

3.5.1 2D & 3D Seismic survey:

Seismic surveys are a primary tool utilized during the exploration of hydrocarbons over land and water. A seismic survey is conducted by creating an energy wave commonly referred to as a 'seismic wave' on the surface of the ground/ over water along a predetermined line, using an energy source. This wave travels into and through the earth strata, where it is reflected and refracted by various subsurface formations, and returns to the surface where receivers called geophones are used to detect the waves and convey them to a recorder for analysis. Seismic waves in offshore is generally induced by airgun powered by a compressor. Generally offshore seismic surveys are conducted by trawling arrays behind a ship which explodes every 10-15 seconds. By analyzing the time it takes for the seismic waves to reflect off subsurface formations and return to the surface formations can be mapped and potential oil or gas deposits identified. 2D/3D surveys are acquired by laying out energy source points and receiver points (hydrophone in offshore in conventional seismic) in a grid over the area to be surveyed. The receiver points - to record the reflected vibrations from the source points - are laid down in parallel lines (receiver lines), and the source points are laid out in parallel lines that are approximately perpendicular to the receiver lines. The spacing of the source and receiver points is determined by the design and objectives of the survey. In case of 2D seismic survey the receiver points to record the reflected vibration from the source points, are to be laid down in between the receiver lines.

3D seismic surveys are generally conducted in a similar way to 2D seismic surveys but with the variation of setting up six or eight geophone/hydrophone cables side by side at the same time at a distance in most cases of about 100 to 400 metres apart. Several “shots” from calculated positions along and between the receiver lines are taken, before the cables are moved up and the process repeated. 3D seismic surveys must be conducted over a large area in order to provide sufficient data for accurate interpretation of the subsurface geology. These surveys can be conducted at different times and cover different but adjacent areas. The structures can be imaged properly using 3D reflection techniques in which a 3D volume (x,y,z) of crust is sampled and monitored using a planar, rather than a linear array of shots and receivers. The data collected can later be combined into a single data set for processing and analysis, provided there is sufficient overlap of the areas covered by the surveys. Computer analyses of the recorded seismic waves provide a profile of the underlying rock strata and offer the basis for identifying potential hydrocarbon traps. The analysis creates a three-dimensional picture that shows the subsurface geology of the earth’s strata along the line of the cable.

3.5.2. Exploratory & Appraisal well Drilling Process

The types of drilling rigs that will be used for oil and gas exploration and appraisal wells are described in sections given below:

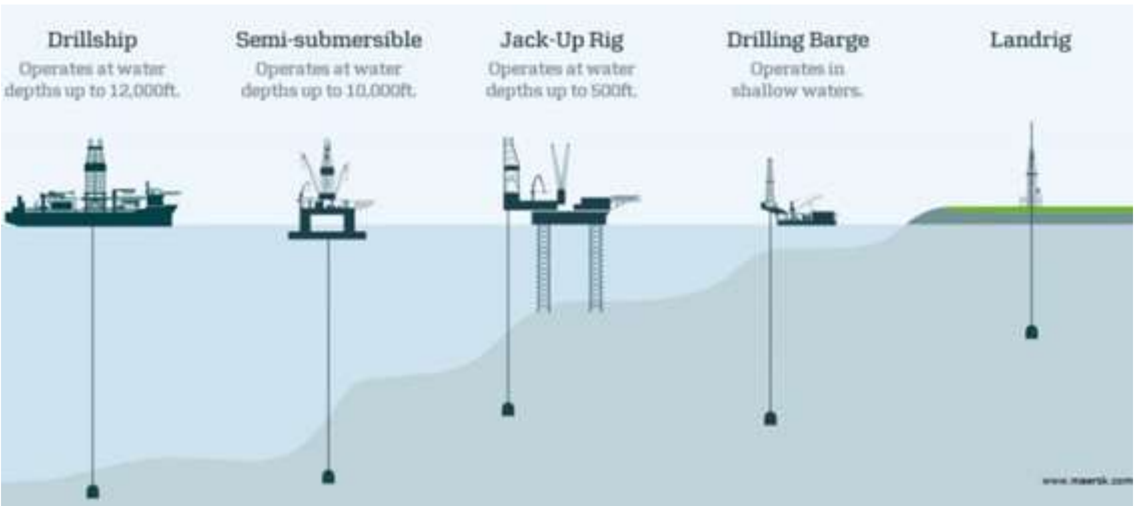


Figure 6: Type of drilling rigs used, based on water depth

Jack up Rig

Jack up rigs may be deployed where water depth is up to 100-120m. A Jack up rig is an offshore structure composed of a hull, legs and a lifting system that allows it to be towed to a site, lower its legs into the seabed and elevate its hull to provide a stable work deck.

Figure 7:A Typical View of Jack-up Rig

The hull of a jack up rig is a watertight structure that supports or houses the equipment, systems, and personnel, thus enabling the jack up rig to perform its tasks. When the jack up rig is afloat, the hull provides buoyancy and supports the weight of the legs and footings (spud cans), equipment, and variable load. The legs and footings of a jack up rig are steel structures that support the hull when the rig is in the elevated mode and provide stability to resist lateral loads. Footings are needed to increase the soil bearing area thereby reducing required soil strength. The legs and footings have certain characteristics which affect how the Unit reacts in the elevated and afloat modes, while going on location and in non-design events. When in the elevated mode, the legs of a jack up rig are subjected to wind, wave, and current loadings.

There are three main groups of equipment on a jack-up rig, the marine equipment, mission equipment, and elevating equipment. Marine equipment are not directly involved in drilling however are used for movement, positioning and communications. Marine equipment include items such as main diesel engines, fuel oil piping, electrical power distribution switchboards, lifeboats, radar, communication equipment, galley equipment, etc. Mission equipment refers to aboard a jack up rig, which are necessary for the jack up to complete the drilling process. Mission Equipment includes derricks, mud pumps, mud piping, drilling control systems, production equipment, cranes, combustible gas detection and alarms systems, etc. Elevating equipment refers to the equipment and systems aboard a jack up rig which are necessary for the jack up to raise, lower, and lock-off the legs and hull of the jack up.

Semi-Submersible Rig

A semisubmersible is a MODU designed with a platform-type deck that contains drilling equipment and other machinery supported by pontoon-type columns that are submerged into the water. Another type of drilling rig that can drill in ultra-deep waters, drillships are capable of holding more equipment; but semisubmersibles are chosen for their stability. The design concept of partially submerging the rig lessens both rolling and pitching on semisubs. Offshore drilling in water depth greater than around 100 meters requires that operations be carried out from a floating vessel, since fixed structures are not practical. With its hull structure submerged at a deep draft, the semi-submersible is less affected by wave loadings than a normal ship. The semi-submersible vessel was developed because of the need for vessels that could stay afloat and carry out their required functions in the high seas amidst the constant movement of the waves. Semi-submersible rigs make stable platforms for drilling for offshore oil and gas. They can be towed into position by a tugboat and anchored, or moved by and kept in position by their own azimuth thrusters with dynamic positioning. In simple terms, the semi-submersible vessel is supported by way of pontoons which are located under the water surface. Semisubmersibles do not rest on the sea floor like jack-up rigs. Instead, the working deck sits atop giant pontoons and hollow columns. These float high in the water when the rig is moved. At the drill site, the crew pumps seawater into the pontoons and columns to partially submerge the rig, hence the name semisubmersible. With much of its bulk below the water's surface, the semisubmersible becomes a stable platform for drilling, moving only slightly with wind and currents (this is termed wave transparency). Like jack-ups, most semisubmersibles are towed to the drill site.

Because of their exceptional stability, "semis" are well suited for drilling in rough waters. Semisubmersibles can drill in water as deep as 10,000 feet. Because semis lack the legs of a jack-up, they must have a means of maintaining their position over the well during drilling. This is accomplished using either an eight or 12 point anchoring (mooring) systems. In deeper waters, some semis employ dynamic positioning (DP) systems to replace or supplement the mooring system. DP systems employ computer-controlled motor-driven propellers, called "thrusters," to adjust for the action of winds and waves. They respond automatically to satellite GPS signals coordinated with acoustic beacons placed on the sea floor.

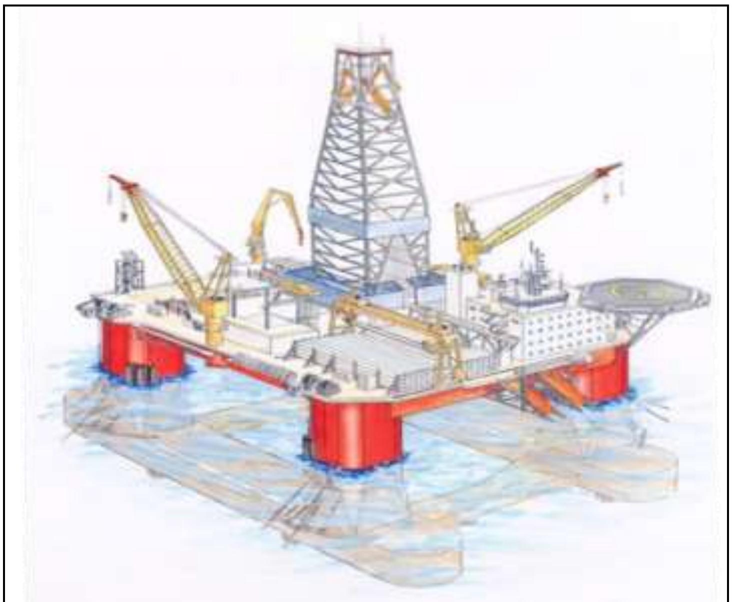


Figure 3.7A Typical View of Semi-Submersible Rig

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 must be 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 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. 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. They also suppress gas hydrate formation and exhibit improved conditions for well bore stability compared to most 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. The mud will be prepared onsite (drill location) using centrifugal pumps, hoppers and treatment tanks. The consumed fraction of the mud, which is mostly WBM will be discharged into sea intermittently in accordance with MoEFCC guidelines.

Drill Cuttings Disposal

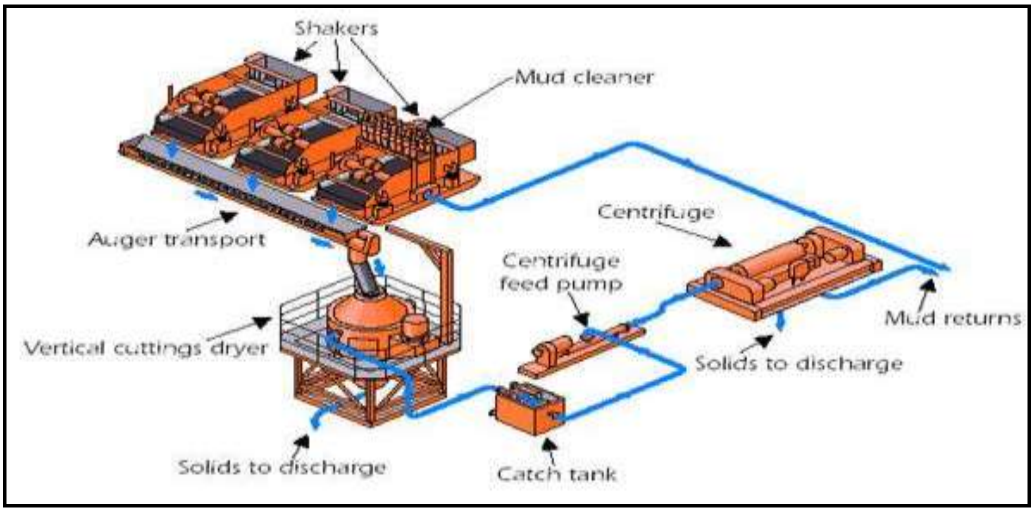


Figure 3.8A Typical View of Drill Cutting Separation & Treatment System

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.

Drill cuttings will be discharged off-shore into sea intermittently in accordance with MoEFCC guideline.

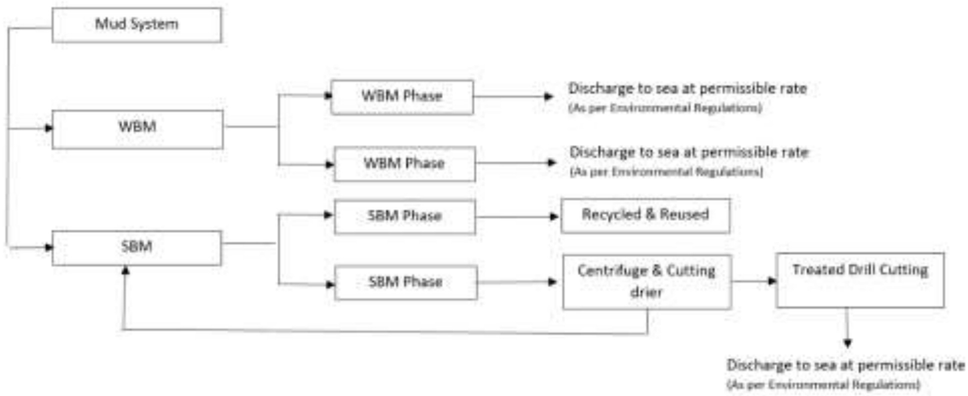


Figure 3.9Waste Disposal Plan - Offshore

- **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. 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.

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 20-25 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 (10 ft) below ground level.

- All concrete structures will be broken up, and the debris disposed off as per the regulatory requirements.
- All other waste products, solid and liquid, will be disposed of in accordance with the requirements of the EIA and will be treated to render them harmless.
- All fencing and access gates will be removed and all pits whose contents will show regulatory compliance for on-site disposal, at the time of site closure, will be backfilled and closed out as per the legal requirements.
- Restoration of unusable portion of the access track, removal of pilings and landscaping.

3.6 Raw materials required and source

Multiple vessels will be used for seismic data acquisition. No raw materials are required during the seismic acquisitions.

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 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.

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 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.

3.7 Resource optimazation/ recycling and reuse envisaged in the project

- Resource Conservation
- Elimination of Waste Streams
- Minimizing Waste
- Reuse/Recycle
- Synthetic base mud will be re-used in further drilling activities.

3.8 Water and power requirement

3.8.1 Water Requirement

Seismic Operations

The water required during seismic operation will be mostly for domestic use, which will be sourced locally from the nearest port authority.

Drilling Operations:

The water requirement in drilling rig is mainly meant for preparation of drilling mud apart from washings and domestic use. While former constitutes majority of water requirement, latter or the water requirement for domestic and wash use is minor. Water for both process and domestic uses would be procured through surface water sources. The water requirement per well is shown in Table 2.4.

Table no. 2.4Water requirement per well

Description	Quantity
Total water requirement during drilling phase	600-1000 m^3/well for WBM and 150-300 m^3/well for SBM
Drilling water consumption for mis. use	25-50 m^3/day

Water for domestic use	20-30 m^3/day

3.8.2 Power Requirement

Seismic Operations

The vessel to be deployed for seismic acquisition will be equipped with diesel generators.

Drilling Operations

Power will be required on the MODU for undertaking drilling operations and to provide lighting to the living quarters on the MODU. Continuous power supply shall be made available through 4 main diesel generator (DG) sets (4*2000 KVA), normally installed as part of the MODU design / infrastructure. There will also be one diesel generator (500 KVA) catering to the emergency auxiliary power supply. It is estimated that approximately 4 MW of power will be required for the drilling activities on daily basis. Supply vessels will transport the required fuel from the port. The support vessels will have their individual power generation equipment as per the engine capacity for the class of marine vessel.

3.9 Quantity of waste to be generated and its disposal

The expected waste generation from well drilling will be as per Table 3.9.1.

Table 3 Waste Generation from Well Drilling

S.No.	Nature of waste	Quantity during Drilling Activities
A	**Hazardous Waste**	
1	Drill cuttings associated with WBM	250-750 tons/ well
2	Drill cuttings associated with SBM	500-1500 tons/well
3	Residual drilling mud, sludge and other drilling waste	250-500 tons/well
4	Sludge containing oil & other drilling wastes	250-500 tons/well
3	Used oil	1-2 tons/ well
B	**Non Hazardous Waste**	
4	Food waste	25-30 kg per day
5	Non-combustible waste containing metallic residues, glass	1000-1200 kg/well
6	Packaging wastes including drums, wooden pallets, plastic containers, plastic foils.	500-600 kg/ well
7	Left over chemicals and materials, scrap metal, sludges, scales, batteries, spent acids, spent lubricants, filters etc.	250-300 kg/ well
8	Cement, grit, blasting and painting wastes.	500-600 kg/ well

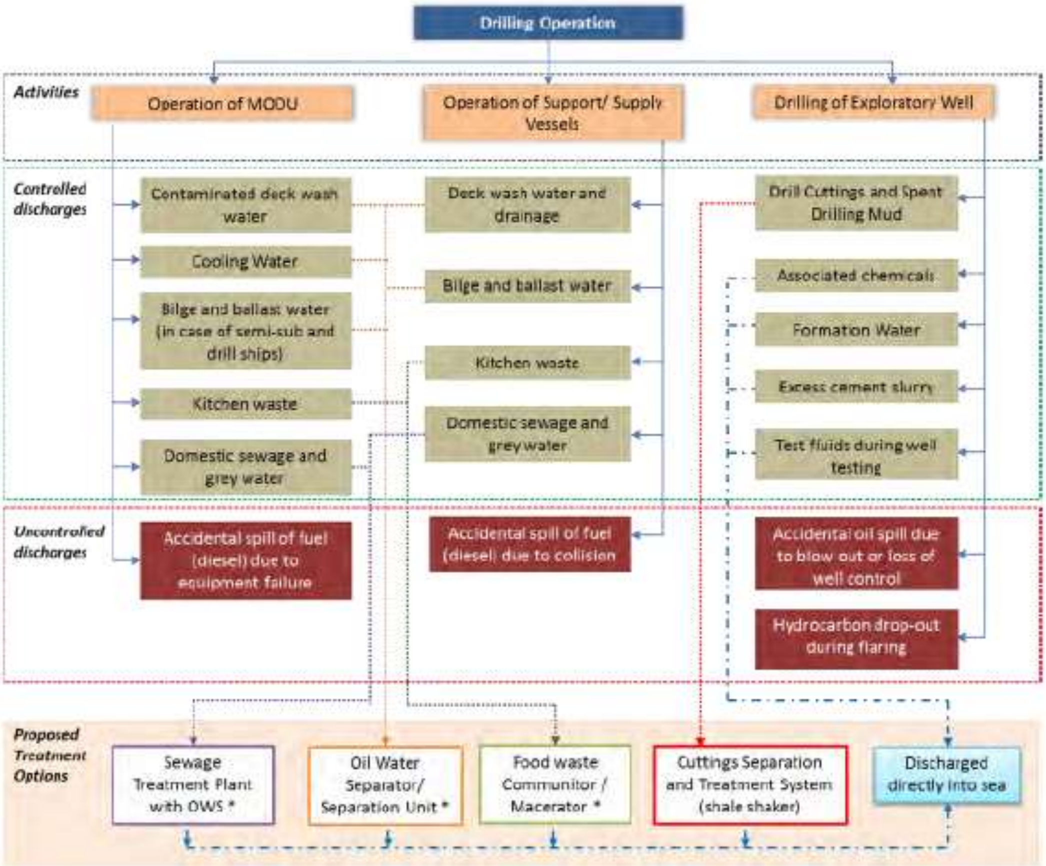
Disposal of wastes will be as per MOEFCC guidelines.

Domestic wastewater from kitchen, shower, toilets and laundry area on board drilling rig will be approximately 15-25 m3/day. Domestic wastewater will be treated in on board Sewage treatment plant (STP). Bilge water consisting of rainwater/seawater containing diesel and oil will be 10m3/well. Bilge water will be collected into a sludge tank and then to a water/oil separator on board drilling rig before offshore disposal with less than 15 mg/l of oil and grease content.

The drilling of an offshore exploratory well and associated activities are likely to result in discharges into the sea water. Drilling activity generates drill cuttings and spent mud as the main discharges into sea. Other discharges to sea from the MODU and support vessels will comprise of food waste, bilge water, cooling water, deck drainage, sewage and grey water. While such discharges will be controlled, there may also be uncontrolled releases from drilling activities such as accidental oil spills and flare drop-out.

All discharges will be handled, treated and disposed as per the requirements of applicable Indian regulations/ standards and requirements of MARPOL Convention.

Various controlled and uncontrolled discharges to sea water and their proposed treatment options are listed below:



* *On board the respective MODU or support/supply vessel*

Figure 3.11 denotes the various controlled and uncontrolled discharges to sea water and their proposed treatment options

4. Site Analysis

4.1 Connectivity

The Block is entirely an offshore block. The major districts near to the Block are Kutchh and Devbhumi Dwarka districts. Nearest airport is in Bhuj. Dwarka is the nearest port which is situated at a distance of ~35 Km. the coastal areas are well connected by rail, road and air.

4.2 Land form, land use and land ownership

The block lies entirely in offshore water of the Arabian Sea.

4.3 Topography (along with map)

The block lies entirely in offshore water. The topography map of nearby coastal areas has been shown in Figure 3.4 in previous section.

4.4 Existing land use pattern and relative location of protected areas

The block is entirely offshore, the Project site falls within CRZ IV i.e. within 12 NM from shoreline, therefore requires CRZ Clearance under the CRZ Notification, 2019.

4.5 Existing infrastructure / industries

No existing infrastructure with in the block.

4.6 Climate data from secondary sources

Kachchh climate is unique in Gujarat State as it is surrounded by Arabian Sea in the south and the harsh Rann in the north and eastern boundary. The higher evaporation in the Rann area influences the microclimate of the mainland making it arid and the cool sea breeze makes it more comfortable weather in the coastal regions. The climate of this district is characterized by hot summer and dryness in the non-rainy season. The period from March to May is the hottest and the temperature rises to more than 40°C. The cold season is from December to February and experiences low temperature. Winds are light to moderate and follow the pattern of Indian sub-continent.

4.7.1 Wind

Monthly average wind distribution ranged from 9.8 km/hour in December to 22.0 km/hr in July. The Average Predominant wind directions were mostly from West to South

4.7.2 Storms and Cyclones

The rainfall pattern in Indian coast is governed by the cyclones and its intensity. The interpretation of the data points out that number of cyclones hitting Kachchh district has increased in period 1990 to 2010 and a total of 10 cyclones were reported during this span of 20 years. Prior to 1990s, the maximum number of cyclones recorded within a span of two decades was only 5. The years of heavy rainfall is closely associated with cyclones during that year.

4.7.3 Rainfall

The rainfall data from period of 1932 to 2010, the average rainfall has been increased. For the entire period of 78 years (1932 to 2010) 50% of the years had period of drought of different intensities and around 30% of the year were with excessive rainfall. The scenario is typical to that of arid climate of Kachchh, but in the last decades (2000-2010) the rainfall has increased and the drought years have come down. The annual average rainfall in the area during the period of 1971 to 2000 is about 273.2 mm with considerable variations from year to year.

4.7.4 Temperature and humidity

The Kutch region receives an average rainfall of around 14 inch every year. Compared to the other two seasons, the winter season in Kutch is pleasant. It starts from the month of October and lasts till January with average temperature ranging from 12°Celsius to 25°Celsius. Since the state has a long coastal belt, the winter is not very cold.

4.8 Coastal Environment

4.8.1 Tide

The Gulf has mixed and predominantly semidiurnal type tides with a large diurnal inequality. This is because of complex bathymetry, rough bottom topography and undulation in the shoreline which produce highly non-linear tidal interactions. The mean spring tidal range increases from mouth to head, 3.06m at Okha, 4.67m at Sikka, 5.82m at Kandla and 6.43m at Navalaki. Bathymetry, funnel shape of the Gulf, coastal configuration and orientation of the coast are the reasons for amplification of tides.

4.8.2 Currents

Currents in the Gulf are driven mainly by tides, except during a short spell (July-August) when the surface currents are influenced by monsoon winds. In general surface currents vary from 0.75 to 1.25ms-^{1} at the head and reach top a maximum of 2.5 ms-^{1} in the central channel.

4.8.3 Waves

The tidal waves are entering from the west side and the tidal amplitude increases considerably in the upstream of Vadinar due to shallow inner regions and narrowing cross-section.

4.8.4 Water quality

The suspended solids (SS) are highly variable, spatially and largely resulted from the dispersion of fine sediment from the bed and the intertidal mudflats due to tidal movements. Obviously, near shore shallow region, invariably sustain higher suspended solids as compared to the central zones. The region between Okha and Sikka has high variable suspended solids (4-308 mg/L). The pH range of the Gulf water is remarkably constant (8.0-8.3) though wide variations (7.6-8.8) are not iced sometimes. The average DO is fairly high (35 mg/L) most of the times and the BOD is low (<0.1-6.3 mg/L) indicating good oxidizing conditions. The nutrients (PO43–-P, NO3-N, NO2-N, NH4+-N) are more or less uniformly distributed in the Okha-Sikka-Mundra segment and their concentrations indicate healthy natural waters.

5. Planning Brief

The project is a green field offshore oil and gas exploration in GS-OSHP-2017/2 block. This block is adjoining to the coast of Kutchh and Devbhumi Dwarka District of Gujarat. For the proposed offshore exploration project, no physical and social infrastructure envisaged.

6. Proposed Infrastructure

For the proposed offshore exploration project, no physical and social infrastructure envisaged.

7. Rehabilitation and resettlement (R&R) Plan

For the proposed offshore exploration project, no land requirement and R&R is envisaged.

8. Project schedule and cost estimate

8.1 Project schedule

Vedanta Limited (Cairn oil and gas) plans to carry-out the oil and gas exploration (including appraisal) over the period of 10-12 years.

8.2 Project cost

The cost of the project is estimated is given below:

1) Physical Surveys Cost estimated to be approximately INR 62.30 Crore.
2) Average Cost per well for exploratory & appraisal well is estimated to be INR 49 Crore.

9. Analysis of Proposals

The implementation of this project will not have any adverse effect on the environment as appropriate pollution control measures will be taken from the initial stage itself.

Proposed drilling activities will result in direct and indirect employment opportunities.