Annexure-II

Guidelines for Environmental Management during Shale Gas/Oil Exploration and Production

1. Background:

With rapidly increasing demand for energy, the trend world over is to supplement conventional oil and gas production with other alternative/ unconventional energy fuel sources. Currently, oil and gas import in India constitutes about 80% and 45% of the domestic requirement respectively. Promotion and use of Shale gas is being perceived as a valuable addition to the basket of energy mix in India.

USA and Canada are ahead in Shale Gas/Oil exploration /exploitation compared to rest of the world. The first well was fractured for Shale Gas in 1947 in well Kelpper No. 1, located in Grant County, Kansas, USA. Subsequent to the development of directional drilling technology in 1970's, the first successful multi-stage fracture in a horizontal well was completed in 1986. After a gap of 12 years, the first economical shale fracture using slick-water technology had been successfully completed in 1998. Subsequent to the drilling of thousands of wells, mainly horizontal, the shale gas production picked up and constituted to a higher extent of about 20% of total gas production since 2010.

With a view to enhancing domestic oil and gas production and to improve energy mix, the Government of India has initiated steps for exploration and exploitation of Shale Gas and Oil. The Ministry of Petroleum and Natural Gas (MoPNG) vide letter dated 14.10.2013 has announced a policy for Shale Gas and Oil exploration and exploitation by the National Oil Companies in their nomination blocks. Oil and Natural Gas Corporation Ltd (ONGC) and Oil India Ltd (OIL) have been given the responsibility of exploration and exploitation of Shale Gas and Oil in 50 and 06 blocks respectively for assessment under Phase-I of the said policy, which is presently in progress. A total numbers of 57 wells are envisaged to be drilled by ONGC (1 well in a block of 200 sq.km or less, 2 wells for blocks having area more than 200 sq.km) in phase I. The proposed wells are mostly vertical wells for collecting conventional cores for laboratory investigations in respect to geochemical, geomechanical, adsorption studies etc. Assessment of the blocks from Shale Gas and Oil point of view will be carried out at the culmination of phase –I.

India has several Shale formations indicating the presence of Shale Gas/ Oil. Indian Shale Gas/Oil is expected in six on-land basins namely Cambay, Krishna-Godavari, Cauvery, Assam-Arakan, Ganga and Gondwana based on the geoscientific data gathered for conventional oil & gas exploration. Currently, there is no commercial production of Shale Gas/Oil in the country.

A recent study by Energy Information Administration, USA indicates that there are significant Shale Gas/Oil reserves in the world. The report assessed 48 Shale Gas basins in 32 countries. India is one of those covered in the report along with Canada, Mexico, China, Australia and Brazil etc. The study has further assessed risked gas-in–place of 290 Trillion Cubic feet (TCF) with a technically recoverable resource of 63 TCF from 4 of 26 Indian sedimentary basins. Further, as per United States Geological Survey (USGS) study which was conducted in compliance of MOU with Govt. of India, technically recoverable Shale Gas/Oil reserve is 6.1 TCF in Cambay, Krishna-Godavari(KG) and Cauvery Basins.

2. Shale Gas and Oil

Shale Gas is a natural gas that is trapped within shale rock formations. Shale is a fine-grained sedimentary rock and has low permeability, so production in commercial quantities from Shale requires fractures to provide permeability. The primary differences in conventional gas and oil and Shale Gas and Oil exploitation are the extensive use of modern technology in the form of multiple hydraulic fracturing and horizontal drilling in shale section. Hydraulic fracturing is done to create artificial fractures inside the shale and increase effective permeability in the shale reservoir. Hydraulic fracturing is also used in conventional gas/oil reservoir but the scale of hydraulic fracturing job is lower.

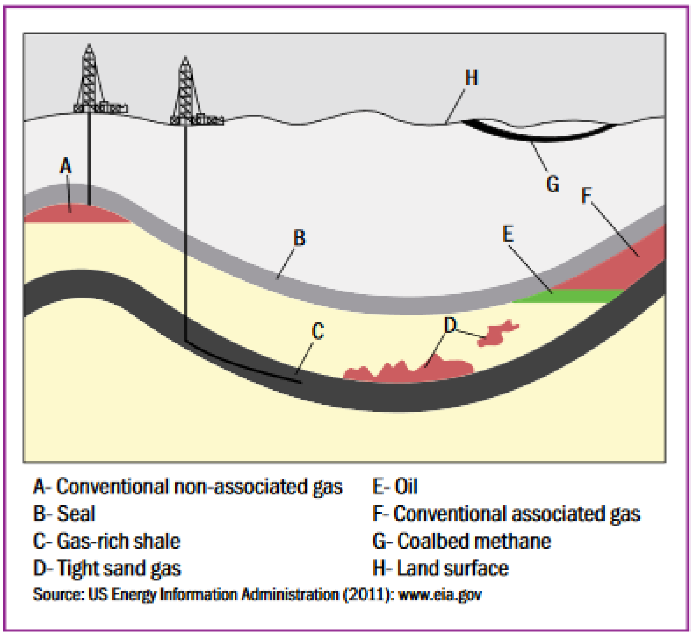

Figure 1: Shale gas extraction
Source: TERI, Policy Brief, 2013

Fracturing fluid with more than 98% water and proppant with a small proportion of additives is injected at high pressures into the rock strata at the depth of interest (may vary from 2 to 4.5 km). The high rate pumping of fluid creates fractures in the rock while the proppant being carried by the fracturing fluid in the fracture keeps the cracks open, ultimately allowing the flow of natural gas/oil to the well bore.

It is also to be noted here that overall volume of fracture fluid is 5 to 10 times that of conventional hydraulic fracturing but it is also to be emphasized that fracturing treatment is a collection of multiple fracturing treatments of the size used in conventional wells.

Like the development of any energy resource, there are concerns about environmental footprints for the development of Shale Gas & Oil. These are mainly associated with the use of a large quantity of water for hydraulic fracturing, protection of water aquifers, disposal of produced water after hydraulic fracturing, impact on communities, biodiversity and ecosystems. There are also issues concerning pollution due to air, noise etc which are generally associated with multiple hydraulic fracturing operations. The ability to drill multiple wells from a single pad has minimized surface disturbances and associated impacts to wildlife, dust, noise and traffic to certain extent.

The appropriate operating practices are to be formulated to address environmental issues concerned with Shale Gas/Oil operations with emphasis on the following,

- Requirement of multilateral horizontal wells and multistage hydraulic fracturing to stimulate oil and gas production
- Requirement of the large volume of water 5000- 9000 m^3 per well depending upon the well type and shale characteristics
- Water after hydraulic fracturing flows back to surface (30-40%) and may have a high content of dissolved solids (TDS) and other contaminants.
- Possibility of contamination of aquifers (both surface and subsurface) from hydrauic fracturing and produced water disposal.

The Shale Gas/Oil policy accordingly requires to address the following:

- Clearance and approvals
- Regulation for safety
- Environmental concerns
- Provisions related to water issues

It is realized that Shale Gas and Oil exploration is water intensive project and management of water use, efficiency and proper disposal of produced water are key to the environmental management. In this background, existing Shale Gas and Oil Policy, 2013 for nomination blocks has specific clauses to address these concerns:

- A baseline Environment Impact Assessment (EIA) Study, including sourcing of water and its subsequent disposal, is to be carried out by the Company (Operator).
- The Company shall be responsible for all activities related to Health, Safety and Environment (HSE) and site restoration in respect of Shale Gas and Oil operations in line with guidelines/ rules stipulated by MoPNG, Ministry of Environment and Forests (MoEF) or by any statutory authority from time to time.
- Multiple casing program with competent and reliable cementing (at least 2 casings) as per Good International Petroleum Industry Practices (GIPIP), at a depth deeper by 100 m or as specified from time to time than the deepest fresh water aquifer, shall be a mandatory requirement across all sub-surface fresh water aquifers identified by local / government bodies, in all Shale Gas and Oil wells, as well as, in effluent disposal wells.
- The Company shall follow GIPIP as being brought out by reputed international organizations viz. American Petroleum Institute (API), Society of Petroleum Engineers (SPE), International Standards Organization (ISO), etc., including API Guidance document HF3, January 2011 "Practices for Mitigating Surface Impacts Associated with Hydraulic Fracturing", along with API HF2-June 2010 and API HF1-October 2009, as amended and updated from time to time.
- The Company shall disclose the fracture fluid content, volume and chemical composition for both injection and flow back fluids to the statutory agencies such as MoEF, State Pollution Control Board-SPCB etc. and DGH on a regular basis and may also disclose such details on the Company's website for public viewing.
- EIA studies would be carried out by competent agencies from the list of agencies authorized by MOEF, at the cost of the project proponent.
- The company will need to ensure adequate availability of water suitable for hydraulic fracturing before Shale Gas and Oil exploration and exploitation in any field. Approval of the Central Ground Water Authority (CGWA), State Ground Water Authority (SGWA) and other regulatory institutions will be a pre-requisite.

3. Environment related legislations in India

Presently, the regulations, standards and procedures for addressing environmental concerns have been framed by MoEF&CC for conventional onshore and offshore oil and gas exploration, development and production. As per Environmental Impact Assessment Notification of Sept, 2006 of Ministry of Environment, Forest and Climate Change (MoEF&CC) the offshore and onshore oil and gas exploration, development and production activities are covered under item 1(b) of the Schedule to the said notification and Oil and Gas projects, being category 'A', is appraised in MoEF&CC. No differentiation has been made in the EIA notification between conventional and unconventional oil and gas exploration in this sector. EIA studies are required to be carried out by a competent agency from the list of agencies authorised by Quality Council of India (QCI)/ National Accreditation Board for Education & Training (NABET), as the cost of project proponent.

In addition, following legislations also apply to Gas/ Oil exploration:

- Wildlife (Protection) Act, 1972 and amendments made from time to time.
- Forest (Conservation) Act, 1980 and amendments made from time to time.
- Environment (Protection) Act, 1986 and standards notified for air emissions, noise levels, for quality and quantity of water to be disposed of and for disposal of solid waste, drill cuttings and drilling fluids etc.
- Hazardous and Other Waste (Management and Trans-boundary Movement) Rules, 2016.

The consent to establish and operate and authorization are required to be obtained from the respective State Pollution Control Boards under:

- The Water (Prevention and Control of Pollution) Act, 1974, The Air (Prevention and Control of Pollution) Act, 1981 , and
- Authorization under Hazardous and Other Waste (Management and Trans-boundary Movement) Rules, 2016.

Details of the procedure for obtaining environment related clearances are available at MoEF&CC/ DGH websites.

4. Regulatory framework in various countries:

The development and production of oil and gas in USA, including Shale Gas, are regulated under a set of federal, State and local laws that address every aspect of exploration and operations. All of the laws, regulations, and permits that apply to conventional oil and gas exploration and production activities also apply to Shale Gas development. A series of federal laws govern most of the environmental aspects of Shale Gas development. The federal laws, amongst other, include the Clean Water Act (CWA), the Safe Drinking Water Act (SDWA), the Clean Air Act (CAA) etc. State regulations of the environment practices related to Shale Gas, usually with federal oversight, address the regional and location-specific character. The States may adopt their own standards; however, these must be as protective as federal standards and may even be more protective. In addition to federal and State requirement, the additional requirement of other levels of government is also added to permits in specific locations.

In the United Kingdom, the Onshore Operators Group has detailed the requirements of clearances and permits. The majority of exploration and appraisal boreholes fall under “Schedule 2 development” for which EIA is required as it is likely to give rise to significant effects on the environment particularly for projects near sensitive areas which include National Parks, areas of Outstanding Natural Beauty, World Heritage sites. Scoping for the preparation of EIA is a part of the process. The regulations which are relevant include the Environmental Protection Act, 1995, the Water Resources Act, 1991, the Hazardous Waste Regulations (England and Wales) 2005, Special Waste Regulation, 1996 and the Water Environment (Controlled Activities) (Scotland) Regulations, 2011 etc.

In China, at least half-dozen ministries and agencies play a role in Chinese Shale Gas policy. The National Development and Reform Commission (NDRC) shapes overall policy and regulates natural gas prices. The National Energy Administration (NEA) establishes Shale Gas production targets. The Ministry of Land and Resources (MLR) controls mineral rights and runs the bid rounds for Shale Gas. The Ministry of Finance (MOF) administers a Shale Gas production subsidy. The Ministry of Science and Technology (MOST) funds research and development in Shale Gas technologies. The Ministry of Environmental Protection (MEP) establishes rules to protect air and water quality. Under current resources legislation, applicants for natural gas exploration and prospecting licenses are required to submit an environmental assessment report to the MLR for approval. This must be prepared by a qualified third-party environment assessment institution. However, since there has not yet been any national standard for dealing with environmental issues, it may not be possible to carry out effective and accurate environmental assessments. It is reported that the Ministry of Environmental Protection might commence a study for the drafting of a Shale Gas Environmental Assessment Standard. The work is expected to be continued for at least three years.

In Mexico, following the passing of the Energy Reform, many have raised concerns about the environmental effects of hydraulic fracturing. Mexico’s agenda includes regulating hydraulic fracturing. The Secretariat of Environment and Natural Resources (SEMARNAT) published the Environmental Guideline for Shale E&P Activities that introduces the process of hydraulic fracturing, details the environmental impacts that may result from inefficient operating conditions. There are also a series of Mexico's official standards on environmental matters to be considered by operators in the gas sector that contain general criteria with specific recommendations for oil operators during exploration, drilling & well completion, extraction, closure and abandonment of the well. The Security, Energy and Environment Agency is a newly-created regulatory unit responsible for regulating and supervising industrial safety, operational safety, and environmental protection of the hydrocarbon sector activities. The Security, Energy and Environment Agency shall participate in the design, regulation, and supervision of industrial and operational safety; the decommissioning and abandonment of facilities; and the integral control of waste and emissions.

5. Drilling technologies in Conventional and unconventional Gas/Oil exploration and production

Following table gives the comparative differences in conventional and unconventional Shale Gas & Oil exploration & production activities.

Comparative table of Conventional and Unconventional Shale Gas and Oil exploration and production methods

S. No.	Parameter	Conventional Oil and Gas exploration & production	Unconventional Shale Gas & Oil exploration & production
1.	Rock type	Sedimentary	Sedimentary
2.	Permeability	High to Medium	Very low
3.	Depth of drilling involved	1000-4000 m	1000-4000 m
4.	Techniques deployed in production	One stage HF selectively	Multistage HF
5.	Freshwater requirement per well (Typical well)	1500-2500 m^3	5000-9000m^3 (for multi-stage frac)
6.	Quality of water required	Freshwater	Freshwater
7.	Flowback water likely to be generated per well	40-70% of fluid pumped	30-40% of fluid pumped
8.	Quality of produced water	Highly Contaminated	Highly Contaminated

Environmental issues of Shale Gas extraction

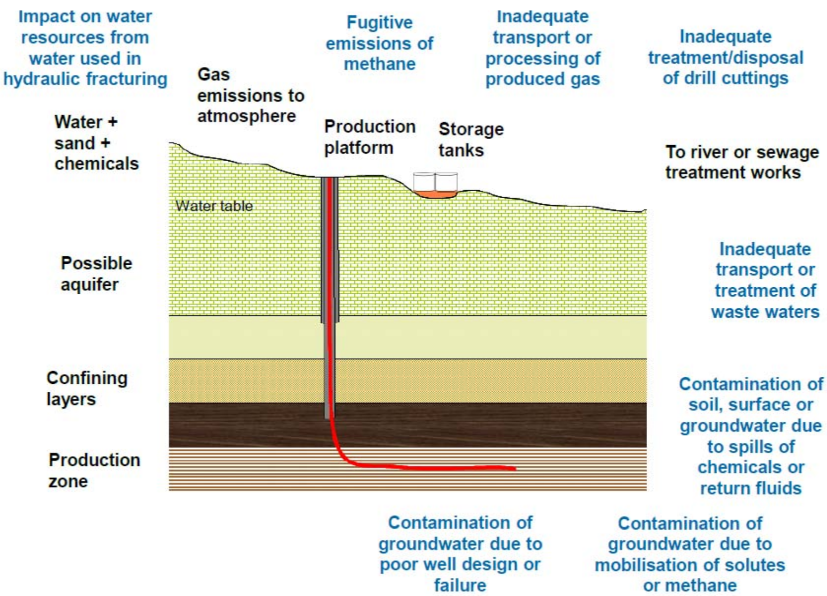

Figure:2 Environmental issues from shale gas exploratory activities

Source: An Environmental Assessment for shale gas exploratory operations in England
Version 1, August 2013

6. Operating Guidelines for environmental management in Shale Gas/Oil Exploration

In this document/ guidelines, efforts have been made to collate best practices and provide working guidelines for operator/ contractor for the adoption of better environmental management approaches for Shale Gas and Oil. For majority issues, good practices for Shale Gas and Oil would be identical to those for conventional operations for which MoEF&CC have notified the Terms of Reference for EIA studies and a guidance document also exists. The major and prime difference being in the hydraulic fracturing technologies requiring a large volume of water. The activities are likely to deplete water sources and cause pollution due to the disposal of flowback water.

In the following, therefore, procedures to be adopted in environmental management are suggested, which are in addition to the conventional E&P sector for managing potential issues and impacts. Protecting the environment and ensuring safety are necessary at every stage of Shale Gas and Oil exploration and production by adopting good practices.

(i) Water management

Water requirement in hydraulic fracturing of Shale Gas and Oil reservoir and management of produced water have been at the core of the debate on the viability of Shale Gas/ Oil production. It is reported that water requirement per Shale Gas/Oil well is almost 3-4 times more than in conventional well. It is estimated that total water requirement is about 5000-9000 m^3 per well. The water use is directly linked to the rock formation, selection of technology, methods adopted for its reuse, water use efficiency and most importantly the management practices. It is reported that potential Shale Gas bearing areas, such as Cambay, Gondwana, Krishna-Godavari, Cauvery and the Indo-Gangetic plains are also areas that will experience water stress by 2030*. Safe water management practices and disposal of drilling fluids and produced water are vital in protecting surface and ground water.

The application of the following good practices may help address the water management issues:

- Follow GIPIP as being brought out by reputed organizations viz. American Petroleum Institute (API), Society of Petroleum Engineers(SPE), International Standards Organisation (ISO), etc. including API Guidance document HF2-June 2010 "Water Management Associated with Hydraulic Fracturing" as amended and updated from time to time.
- Assess the water availability in the region including ground water reserves and their levels, both seasonally and spatially.
- Ensure that drinking water sources are not used for fracking activities.
- Assess the impact of water withdrawal on the quality of water of the source and compile baseline water composition, particularly at development stage.
- Permission should be obtained from the Central Ground Water Authority (CGWA) and respective State Ground Water Authority (SGWA), as the case may be
- Work with engineers, ecologists, environment experts to obtain and analyze the information on depths and location of aquifers
- Endeavor to design unified and centralized system of entire water management including storage, distribution, transportation and disposal, particularly at development stage as part of field development plan.
- Avoid single cycle use of water to avoid conflict with the local requirement of drinking water and other priority uses.
- Explore the possibility of sea water or brackish water use or from the Effluent Treatment Plant (ETP) where it is disposed and prepare a comprehensive plan for sourcing of water, particularly in the development stage.
- Explore the possibility of reinjection of produced water after treatment and disposal of waste water in deep sump well.
- Keep appropriate and adequate spill response equipment readily available at the site.
- Disclose fracture fluid content, volume and chemical composition for injection for each well and it should be disclosed for the information of the public.

* Policy brief June 2013 (TERI): R K Batra

- Maintain and display the Material Safety Data Sheet at site location for all hazardous material for planning and execution during an emergency.
- Undertake analysis of produced water from each well-covering quantity and quality to plan for disposal options.
- Treat waste water to meet SPCB/MoEF&CC notified standards and finalize the disposal method in initial stage only rather than disposing of haphazardly without a proper plan. The land use in the project area may be kept in view before making disposal plan.
- Ensure sufficient planning to minimize fluid transportation movement and distances, particularly in development stage.
- Disclose quantity and compositions of all chemicals stored at the site.
- Display regulatory approvals and compliance records at well site.
- Support and undertake suitable R&D project for reducing the use of fresh water.

(ii) Surface and ground water protection.

Fluids used for hydraulic fracturing are typically more than 98 percent fresh water and sand by volume, with the remainder made up of chemicals that improve the treatment‘s effectiveness, such as thickeners, friction reducers, corrosion inhibitors and biocides. The fluids in each fracturing treatment may contain a different subset of these chemicals, which may require to be suitably and safely handled. Following practices may be considered for adoption:

- Follow GIPIP including API Guidance document HF3-January 2011 relating to “Practices for Mitigating Surface Impacts Associated with Hydraulic Fracturing”.
- Monitor regularly leakages/spills from storages in to water sources
- Ensure scientific construction of disposal/storages pits of produced water, its regular maintenance and proper closure after it is abandoned.
- Consider employing diversionary structures/ stormwater management practices to handle storm water flow at well pad.
- Make comprehensive plan to address the emergencies due to the accidents while treating or transporting the produced water.
- Collect baseline data of water quality of both surface and ground resources using recognized laboratories and analyze using standard analytical methods.

- Undertake rain water harvesting in a suitable area in the block as per the relevant guidelines of the Govt. As far as possible, river, rain or non-potable water should only be utilized for hydro-fracturing jobs.
- Reuse/ recycling of water should be the preferred method of water management.
- Establish a scientific network of water quality monitoring stations near well sites before commencing the drilling activities. Put in place a protocol for frequency and type of sampling of water for its quality monitoring.
- Proper disposal of drill cuttings & spent drilling mud as per notified national standards must be ensured.
- For awareness of local community, display the data on water quality on a regular basis through a dedicated portal of the operator.

(iii) Well integrity:

The operations of conventional and unconventional exploration and production in oil and gas sector remain similar in most of the activities including the well integrity. As such maintaining the well integrity over the lifetime of wells is essential for environmental protection and safety through adoption of proper design and construction. For this engineering aspect, various international standards have been formulated and upgraded based on technological improvements. The Good International Petroleum Industry Practices in Conventional E&P sector have been published by Directorate General of Hydrocarbons and are displayed on its portal www.dghindia.gov.in. Some of practices as enumerated below may be considered for adoption:

- Follow GIPIP as also API Guidance document HF1, October 2009 on "Hydraulic Fracturing Operations-Well Construction and Integrity Guidelines.
- Incorporating multiple casing program with competent and reliable cementing (at least 2 casings) as per Good International Petroleum Industry Practices (GIPIP), at a depth deeper by 100 m or as specified from time to time than the deepest fresh water aquifer shall be a mandatory requirement across all sub-surface fresh water aquifers identified by local/ government bodies, in all the Shale Gas and Oil wells, as well as, the effluent disposal wells.
- Identify the location-specific physical and chemical environment for each well during design and construction.
- Review construction sequencing and staging before breaking ground and reduce erosion by using control structures and methods

- Customize good practices for each individual well and field taking into consideration potential gas migration, cement bonding, and pressure build up etc.
- Design pressure relief and control systems for anticipated flow rates.
- Design and construct wells with proper barriers to isolate and protect ground water.
- Monitor closely the system pressure during drilling and completion activities.
- Follow well abandonment standards at the end of well life.

(iv) Air pollution:

Oil and gas exploration and various associated activities like use of generator sets for running equipments have potential to emit pollutants into the atmosphere. These gasses include VOCs, CO_2, NO_x,SO_2, particulate matter, H_2S etc. In addition, natural gas, whose main component is methane, is itself a greenhouse gas more potent than carbon dioxide and could represent a significant source of emissions during the gas production process. Emissions of gaseous pollutants that contribute to local air pollution, public health risks and climate change can be reduced by using available control technologies, improved monitoring, and more efficient production operations. The operations, therefore, should be so designed and implemented to reduce such pollutants to protect air quality by adopting better practices such as:

- Plan and design operations to reduce air pollution.
- Ensure that methane emissions are reduced and possible methane recovery methods may be explored.
- As enhanced use of trucks and tankers adds to air pollution, undertake the scientific management of transport facilities and also ensure that these vehicles are maintained properly and have the Pollution Under Control (PUC) certification.
- To suppress dust and to reduce particulate matter, sprinkle recycled water regularly on the haul roads and ensures that roads are properly surfaced. Further, undertake avenue plantations of green belt for reducing pollution by selection of proper species of trees in consultation with the forest department.
- Undertake air quality monitoring through a proper network of monitoring stations, based on the wind rose pattern, for preparation of management plan.
- Examine the possibility of use of pipelines and rail transport instead of trucks, wherever possible to reduce air pollution

- Have a systematic plan to address emergencies due to leak and failure of equipment etc by Leak Detection and Repair (LDAR) system.
- Ensure that tankers, trucks and other vehicles are also emission standard compliant and that fuel used is not adulterated to reduce emissions of toxic gasses.
- As far as possible avoid venting and long term flaring unless required for safety purposes for minimizing fugitive emissions
- Operators should display air quality data on a regular basis on the portal of the company.

(v) Noise pollution management.

Noise levels get highly elevated in work zone environment near drill site due to the use of heavy duty pumps, other fracking units in operation, maintenance and repair works. In addition, the movements of trucks, machinery, tankers for carrying water for drilling work add to the local noise levels. Use of generator sets also adds to noise levels. Such prolonged exposure to high levels of noise is detrimental to health and local people may face difficulties. To avoid inconvenience to people at work and people in vicinity following may be ensured.

- Provide noise protection gears, such as ear plugs etc to workers at site.
- Undertake medical tests for hearing loss, if any, to workers and accordingly change batch and duty hours.
- Ensure adherence to the Noise Standards notified by SPCB & MOEF&CC.
- Consider the possibility of erecting sound barriers around hydro fracking sites.
- Install generator sets which are compliant with National standards and acoustic enclosures.
- Plan the work schedule in such way that there is the least disturbance to local people, especially during night hours.

(vi) Workers health, safety and emergency response

As in any industry, the protection of workers, employees, contractors and the general local population is very important at every stage of exploration and production in Shale Gas/Oil sector. This aspect may be at par with conventional oil and gas industry. The goal should be to achieve zero accidents at workplace and neighbouring areas by adopting the following such as:

- Prepare a HSE manual, update it and ensure its continual improvement
- Prepare onsite and offsite emergency plan in coordination with local authorities and facilities.
- Conduct regular mock drills and training of workers in implementation of plans for emergency response and with specific responsibilities
- Ensure that all workers in work zones bear appropriate protective equipment and follow approved procedures.

(vii) Stakeholder engagement and community impacts.

Shale Gas and Oil exploration and production involves the creation of large infrastructure in terms of road network, pipelines for gas gathering & transportation, movements of trucks for carrying of machinery, for carrying water & the flow-back water after hydraulic fracturing, the establishment of labour camps, enhanced communicable diseases due to the migration of labour etc. The local population may be deprived of common resources and may lead to conflicts. To address these issues and for involving stakeholders it is desirable that negative impacts are reduced by adopting good practices.

- Recognize and respect traditional values and cultures of local people and also their rights.
- Provide adequate opportunities for skill development through training.
- Undertake needs assessment of local requirement for implementing social corporate responsibilities
- Plan the infrastructure in such a way that appropriate distances are maintained from sensitive establishments like school, hospitals, community roads, water resources, archaeological sites etc.
- For reducing dust during truck movement, ensure that recycled water is regularly sprinkled on the roads and a definite transport plan is drawn with modern transport management operations.
- Introduce tracking system for safety management and movement of hazardous substances.
- Reduce noise impact by well maintained vehicles and sound barriers, wherever possible.
- Extend health facilities under CSR created by the company to local people.
- While planning keep in view the post project use of infrastructure
- Encourage contractor to use local workers, goods, and services.

(viii) Management of fragmented ecological systems during development phase.

Shale Gas has larger footprints due to the density of wells required as against conventional oil and gas exploration, a large network of transport facilities, pipelines, land required for water storage and disposal facilities, labour camps etc. Such large infrastructure fragments the natural ecological systems. Maintenance of biodiversity and ecosystem integrity is of utmost importance for sustainability.

To minimize the impact following measures can be incorporated in the operational manuals.

- Use established impact assessment practices to recognize and manage potential operational impacts on biodiversity.
- Avoid ecological sensitive areas, forest areas etc even if it involves a small detouring.
- Plan in advance for plantations and eco-restoration measures with the adequate budget provision.
- Reduce potential intrusion of alien species.
- Study the area of influence with expert and consult local people for ground realities.
- Plan common corridors for pipelines, roads and examine various alternatives to minimize the ecosystem damages.
- Avoid infrastructures in migratory paths of wild animals, and in select stretches undertake underground laying of pipelines.
- Survey the area for identification of important wetlands so that the project activities in the area can be planned by leaving adequate distance. Prepare a conservation plan for wetlands with the involvement of local people.
- Continuously monitor the implementation of management plans.

(ix) Induced seismicity.

Induced seismicity is triggered when human activities alter the stability of geological structures. It is perceived that pumping of fluids into or out of the surface of the earth may have the potential for inducing seismic events. Presently, there is no conclusive proof of the link between induced seismicity and deep wells used for disposal of hydraulic fracturing fluids. In the induced seismicity the energy released is generally not large enough to trigger seismic events that could be felt on the surface. However following could be considered:

- Operator must keep records of net fluids balance i.e. the total balance of fluid introduced into or withdrawn from subsurface,
- Install seismic monitoring equipment in specific areas, if studies of local geology and surface conditions indicate potential of seismic activities,
- Evaluate wellbore placement and drilling design to account for subsurface site characterization

- Review the history, if any, of the local seismic activities and listen to stakeholders about their concerns. Explain them of proposed actions for no/ minimum impacts.
- As the work in the area would continue for a considerable time, sponsor some R&D project to understand and address the risks of induced seismicity.

(x) Naturally Occurring Radioactive Material (NORM)

Naturally Occurring Radioactive Material (NORM) describes radioactive elements that are found in low concentrations in the earth's crust. Shale rocks typically contain many different kinds of radioactive isotopes, such as uranium, lead, or potassium. NORM also exists in air, water, soil and rock. Generally, NORM found in shale operations is below the common safety limits of radioactive exposure. The waste produced in shale gas operations will usually contain low levels of NORM and operators can protect nature and people against unwanted exposure by following regulatory guidelines and best practices established by international organizations. Flow-back water from hydraulic fracturing may contain significantly high levels of NORM, so Shale Gas developers have to ensure that NORM is managed appropriately, especially within their water management plan. Following guidelines may be adopted to deal with NORM:

- A comprehensive water management plan including thorough wastewater monitoring should be prepared which will be able to account for these risks and will help the operators to identify feasible and cost-effective solutions.
- The environmental impact assessment, along with supporting baseline studies and geological investigations should be done which can then be used to identify which specific preventive measures can be used to mitigate the potential impact on the environment and to ensure the highest levels of workers' health and safety.
- Once an operation is underway, the risks from NORM should already be very small due to strong preventive measures put in place at earlier stages. As a project unfolds, however, operators should still use technologies to ensure the NORM risk is continually monitored, managed and kept at a minimal level.
- The measures for containment may include settlement tanks and water treatment facilities, which form part of any drilling and production operation. At the project planning stage, appropriate disposal and treatment routes should be identified.

7. Conclusion

Shale oil/ gas production stands out to be a viable energy option to supplement increasing energy requirement in the country. To make the beginning, national oil companies have been entrusted to undertake assessment of shale related resource without compromising on the environmental aspect. In accordance with the policy in place, national oil companies are required to maintain a detailed data on water use, water balance and disposal of effluent. A detailed analysis of data and information would also be undertaken for ascertaining the environmental issues and to put in place suitable process for mitigating adverse impact on environment, if any.

The scope of environment management for Shale Gas/Oil related activities generally encompass a gamut of issues including underground risk assessment, well integrity, baseline reporting, operational practices and monitoring, disclosure of chemicals used in each well and capture of methane emissions etc, if any. Keeping in view these issues, the guidelines framework presented here provides an insight into the ground level environmental issues associated with Shale gas and oil project.

A study of present framework, as available on website of MoEF&CC, reveals that majority of environmental issues discussed in this report are already a part of Terms of Reference (TOR) issued by MoEF&CC for EIA study. The major contribution of this guideline, therefore, is not about defining the structure of EIA study but it is about the scope of study for each terms of TOR which might be approved by MoEF&CC for EIA study. A generalized structure of environmental clearance is presented here along with reference of existing TOR wherever available.

A. Assessment phase

If assessment involves drilling of dedicated shale or dual purpose wells involving coring or hydraulic fracturing or both, then the scope of Environment Clearance and related studies will be same as that of conventional hydrocarbon exploration. The basic understanding here is that coring and hydraulic fracturing in vertical wells are essentially part of core activities of a conventional exploration/ exploitation as practised in India and World-wide. The emphasis to maintain assessment phase beyond the scope of Shale Gas/ Oil resource development EIA study is important because assessment activities are neither related to multiple horizontal drilling nor multi-stage fracturing. In this stage, drilling of assessment well is a onetime activity with short duration and no commercial production is envisaged.

B. Pilot or development phase

I. This phase shall attract additional aspects of large scale water use, disposal requirement, chemical injection, noise and air pollution requirements.

II. The Contractor shall apply for environment clearance in the Application form downloaded from website or obtained from MOEF&CC.

III. Shale Gas and Oil development involves drilling and multiple hydraulic fracturing in factory mode i.e. a large of number of wells are drilled in predefined manner and multi-stage hydraulic fracturing per well are carried out sequentially in horizontal section wherein speedy implementation is key for techno-economics of the project. In this background, Environment Clearance may be considered by MoEF&CC for the whole Development area/ PML. – ***New***

IV. The application shall be made with documents:

a) Feasibility report
b) Map of the project area with land use (TOR: 1 (b) B2)
c) Coordinates of PEL/ PML grant, shale well site, ecologically sensitive areas (protected areas, National Parks, Wildlife Sanctuaries, reserved forest etc) (TOR: 1 (b)B5)
d) Proposed well completion (schematic) along with cement rise – ***New***
e) Proposed numbers of wells, well density and pad configuration – ***New***
f) Proposed schematic of horizontal section with details of fracturing stages for reference - ***New***
g) Detail of hydraulic fracturing operation at each stage including expected numbers of water tanks, capacity of water tanks, horsepower requirement, pressure ratings of equipment, water volume, sand volume, flow back volume, duration of operation including preparation time etc. - ***New***
h) Dimension and volume of pit for flow back / testing - ***New***
i) Description of effluent disposal system - New
j) Preliminary assessment report on water availability and their levels both seasonally and spatially (TOR: 1 (b)B11,20)

V. Terms of Reference (TOR) of the proposed EIA study should include following references:

a) Assessment of water availability – seasonal and spatial (TOR: 1 (b)B11)
b) Water balance sheet for both input water and flow back/fractured fluid. (TOR: 1 (b)B15,20)

c) Composition of chemicals and their quantity being injected for each well(1 (b)B25)
d) Adequacy of pit area with respect to flow back (after fracturing) and well testing – **New**
e) Analysis of return frac fluid/ well test fluids(1 (b)B22)
f) Reporting of toxic content of fluid injected in to well bore/ returned from well bore (1 (b)B22)
g) Well integrity with respect to ground water reservoir - ***New***
h) Vibration levels during hydraulic fracturing and mitigation plan such as provision of ear plugs etc.- ***New***
i) Compliance of noise standards for all equipments and machinery, including possibility of sound barriers. (TOR: 1 (b)B16,21)
j) Adequacy of Site / Approach road and dust control measures (TOR: 1 (b)B 19)
k) Environmental management plan for air quality during operations(TOR: 1 (b)B13)
l) Scope of effluent treatment plan during various phases of pilot/ full scale development (1 (b)B22)
m) Community sensitization plan - ***New***
n) A dedicated website / portal for disclosure to the stakeholders of fracture fluid content, volume & chemical composition for injection for each well, water quality data, Material Safety Data Sheet (MSDS), air quality data and regulatory approvals etc. - ***New***

VI. EIA study may indicate requirement of authorization from agencies/ authorities:

a) State Pollution Control Boards under The Water (Prevention and Control of Pollution) Act, 1974, The Air (Prevention and Control of Pollution) Act, 1981
b) Central Pollution Control Boards
c) Authorization under Hazardous and Other Waste (Management and Trans-boundary Movement) Rules, 2016.
d) Ground water authorities
e) Any other authorities as specified

The procedural structure as above is expected to serve as a base structure which may be considered by MoEF&CC while finalizing standard procedure for Environment Clearance of Shale Gas and Oil Exploration and Exploitation projects in India.

8. Glossary

Aquifer

A single underground geological formation, or group of formations, containing water.

Basin

Sedimentary basins are regions of Earth of long-term subsidence creating accommodation

Baseline

Dated information or data that establishes a reference point against which performance trends can be consistently assessed.

Borehole-

A generalized term for a shaft bored into the ground.

Brine

Water that has a higher salt content than normal seawater.

Casing

Pipe cemented in an oil or gas well to seal off formation fluids and to keep the borehole from caving in. Smaller diameter "strings" of casing are cemented inside larger diameter strings as a well is deepened.

Corrosion Inhibitor

A chemical compound that decreases the corrosion rate of a metal or an alloy.

Cuttings

Pieces of rock that are displaced by the drill bit as the rock is cut.

Drilling Mud

A fluid used to aid the drilling of boreholes.

Drilling Rig

Usually a large-standing structure employing a drill that creates holes or shafts in the ground for purposes of accessing and producing natural gas or oil from subsurface deposits.

Flaring

The controlled burning of natural gas that can't be processed for sale or used because of technical or economic reasons.

Flowback

Water used as a pressurized fluid during hydraulic fracturing that returns to the surface via the well. This occurs after the fracturing procedure is completed and pressure is released.

Fracturing Fluid

The primarily water-based fluid used to fracture shale. It is basically composed of 98 percent water, with the remainder consisting of sand and various chemical additives. Fracturing fluid is pumped into wells at very high pressure to break up and hold open underground rock

Friction Reducer

An additive that reduced the friction of a fluid as it flows through small spaces.

Fugitive Emissions

According to a study by The United States Department of Energy's Argonne National Laboratory, a primary air quality concern from natural gas production (including shale gas) is leaking and venting throughout the supply chain. These fugitive emissions can potentially result in releases of methane, the primary constituent of natural gas and a potent greenhouse gas (GHG). In addition, fugitive emissions of natural gas can release volatile organic compounds (VOCs) and hazardous air pollutants (HAPs), according to the study.

Groundwater

The supply of usually fresh water found beneath the surface usually in aquifers, which are a body of permeable rock containing water and supplying wells and springs with drinking water.

Horizontal Drilling

The process of drilling the deeper portion of a well horizontally to enable access to more of the target formation. Horizontal drilling can be oriented in a direction that maximizes the number of natural fractures present in the shale, which provide pathways for natural gas to escape once the hydraulic fracturing operation takes place. The more generic term, “directional drilling,” refers to any non-vertical well.

Hydraulic Fracturing

The use of water, sand and chemical additives pumped under high pressure to fracture subsurface non-porous rock formations such as shale to improve the flow of natural gas into the well. Hydraulic fracturing is a mature technology that has been used for 60 years and today accounts for 95 percent of all new wells drilled.

Induced seismicity

Seismic waves are generated when sudden slips occur along a fault. This sudden slip can be due to release of strain accumulation from tectonic loading, stress changes and/or pore pressure changes. It has been previously reported that induced or triggered seismicity has occurred due to many industrial activities, including reservoir impoundment, mining, construction, wa ste disposal, and oil and gas operations. These occurrences can be detected with very sensitive special seismic instruments and are not normally noticeable at the surface.

Material safety data sheets (MSDS)

Sometimes called ‘safety data sheets’ (SDS). A document that contains information on the potential hazards (health, fire, reactivity and environmental) and how to work safely with a chemical product. It contains information on the use, storage, handling and emergency procedures all related to the hazards of the material. MSDS/SDSs are prepared by the supplier or manufacturer of the material.

NORM-

Naturally occurring radioactive elements like uranium, radium and radon that are dissolved in very low concentrations during normal reactions of water with rock or sand.

On-Site Water Treatment

A practice employed by many shale gas producers to facilitate reuse of flowback fluids. In this instance, mobile and fixed treatment units are employed using processes such as evaporation, distillation, oxidation, and membrane filtration for recycling and reuse. On-site treatment technologies may be capable of returning 70-80 percent of the initial water to potable water standards, making it immediately available for reuse.

Permeability

The measure of the ability of a material, such as rock, to allow fluids to pass through it.

Produced Water

Naturally occurring water found in shale formations; it generally flows to the surface during the entire lifespan of a well, often along with natural gas. Produced water and flowback from natural gas extraction may be reused in hydraulic fracturing operations; disposed of through underground injection discharged to surface waters as long as it doesn't degrade water quality standards; or transferred to a treatment facility if necessary, processed and discharged into a receiving water body in compliance with effluent limits.

Proppant-

A material that keeps a fracture open. A proppant can be gel, foam or slickwater-based.

Relevant stakeholder

People likely to be affected by a project or who can impact a project; representatives of local communities, interest groups, NGOs, government agencies, funding institutions, employees, and contractors. Identified stakeholders should be assessed for their ability to influence the project or operation or their vulnerability to negative impacts arising from it. This evaluation can help prioritise and develop appropriate and feasible engagement strategies with each stakeholder. Time scales for effective engagement can be lengthy particularly in areas new to oil and gas activities, therefore early engagement is encouraged.

Shale

Shale is a fine-grained sedimentary rock that is formed from compacted mud. Black shales sometimes breakdown to form natural gas or oil.

Stakeholder

People that affect, or are affected by company activities or operations (*e.g.* customers, shareholders, management, employees, suppliers, local communities, advocacy groups and government).

Surface Water

Water that naturally occurs on land, like lakes, streams, rivers and reservoirs.

Surfactant

Compounds that lower the surface tension of a liquid.

TCF

Trillion Cubic Feet

VOC

Volatile organic compound.

Venting

Venting typically refers to the release of natural gas into the atmosphere during the extraction process. Drilling operations may vent different types of gases, including methane, benzene, toluene, and volatile organic compounds (VOCs). Venting is an intentional act, usually performed when oil is recovered, and operators are not economically compelled to recover the less valuable natural gas.

Well Pad

A single location on which multiple wells are drilled.

Wellbore

The drilled hole including the open or uncased portion of the well.

9. References

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2. An Environmental Risk Assessment for shale gas exploratory operations in England Version 1, August 2013, Published by: Environment Agency Horizon house, Deanery Road, Bristol BS1 5AH
3. Colorado Hydraulic Fracturing State Review, October, 2011
4. Environmental Considerations of Shale Gas Development, Trevor Smith, Gas Technology Institute, August, 2012
   Environmental Impacts of Shale Gas Extraction in Canada, ISBN 978-1-926558-78-3 (pdf), 2014 Council of Canadian Academies
5. Exploration and production of hydrocarbons (such as shale gas) using high volume hydraulic fracturing in the EU, {COM(2014) 23 final}, {SWD(2014) 22 final}

6 Good practice guidelines for the development of shale oil and gas, OGP Report No. 489, December 2013

7. Hydraulic Fracturing, Unlocking America's Natural Gas Resources, July 2014
8. Modern Shale Gas Development in the United States: A Primer, April 2009
10. Shale Gas in India: Look Before You Leap, Policy brief, June 2013, The Energy and Resources Institute
11. Shale gas handbook: A quick-reference guide for companies involved in the exploitation of unconventional gas resources, Second edition, A Norton Rose Fulbright guide, June 2015
12. Shale gas exploration and production Key issues and responsible business Practices, Guidance note for financiers, March 2013
13. Shale Gas: Opportunities And Challenges Between Mexico And The United States, Mariana Y. Villanueva González
14. UK Onshore Shale Gas Well Guidelines, Issue 1 February 2013, Exploration and appraisal phase

Flow chart for Environmental Clearance

Application (on line) to MOEFCC in Form-1, Pre-feasibility Report & draft TOR proposed by operator (Standard ToR issued by MoEFCC for Onshore oil and gas exploration projects enclosed.)

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Proposal for ToR to be considered by EAC, MoEFCC

↓

MoEFCC issues TOR for preparation of EIA report.

↓

Intimation of final TOR to operator and displayed on Website.

↓

Operator to prepare draft EIA report as per ToR by engaging consultant accredited by Quality Council of India (QCI) .

↓

Submit draft EIA report to the Member Secretary, State Pollution Control Board/Union Territory Pollution control Committee for conducting Public Hearing(PH).

↓

After public hearing, proceedings are intimated to operator and displayed at office of Panchayats, SPCB website etc.

↓

Operator is required to address issues raised in PH and annex their response in final EIA report

↓

Final EIA report and proceedings of PH to be submitted (on line) by operator to MoEF&CC for appraisal and Environmental Clearance.

↓

On receipt of complete information, project is listed for consideration by EAC and date of meeting is displayed on MoEFCC website.

↓

Operator is, generally , invited to participate in the EAC meetings for furnishing necessary clarification .

↓

EAC makes its recommendation to MoEF&CC for grant of prior environmental clearance on stipulated terms and conditions or rejection with reasons for the same.

↓

Minutes of EAC meeting are displayed on the website of MoEF&CC and case is then processed for final decision .

↓

Environmental clearance letter is uploaded on MoEFCC website and operator is also conveyed of the decision.

↓

Environmental clearance letter is uploaded on MoEFCC website and operator is also conveyed of the decision.

Time frame and flow chart for environment clearance

The Ministry of Environment, Forest and Climate Change (MoEF&CC) has notified the Environmental Impact Assessment (EIA) Notification, 2006 (www.environmentclearance.nic.in) making Environmental Clearance (EC) mandatory for various projects and activities, including oil and gas exploration. The offshore and onshore oil and gas exploration, development and production activities are covered under item 1(b) of the Schedule to the said notification and being category 'A' project is appraised in MoEF&CC.

Environment clearance process under the Environmental Impact Assessment Notification of September, 2006 comprises of four stages viz.

Stage (1)	Screening (Only for Category 'B' projects and activities);
Stage (2)	Scoping for deciding the Terms of Reference (ToR) for preparation of Environmental Impact Assessment (EIA) report
Stage (3)	Public Consultation; and
Stage (4)	Appraisal by the Expert Appraisal Committee (EAC) of the Ministry of Environment , Forest and Climate Change (MoEFCC) for Environmental Clearance

The environmental clearance process for oil and gas projects and activities comprises of Scoping, Public Consultation and Appraisal, as screening is only for category ‘B’ projects.

The timelines for these 3 stages , as per EIA notification , 2006 ,is as following.

Terms of Reference (TOR) by MOEFCC	: 30days.
Public Hearing by State Pollution Control Board	: 45 days
Environmental Clearance by MOEFCC	: 105 days.
Total	**: 180 days.**

STANDARD TOR FOR ONSHORE OIL AND GAS EXPLORATION, DEVELOPMENT & PRODUCTION

1) Executive summary of a project.
2) Project description, project objectives and project benefits.
3) Cost of project and period of completion.
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 Topo sheet of 1:40000 scale, superimposing the well locations and other structures of the projects. Topography of the project site.
5) Details of sensitive areas such as National Park, Wildlife sanctuary and any other eco-sensitive area along with map indicating distance.
6) Approval for the forest land from the State/Central Govt. under Forest (Conservation) Act, 1980, if applicable.
7) Recommendation of SCZMA/CRZ clearance as per CRZ Notification dated 6th January, 2011 (if applicable).
8) Distance from nearby critically/severely polluted area as per Notification, if applicable. Status of moratorium imposed on the area.
9) Does proposal involve rehabilitation and resettlement? If yes, details thereof.
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.
11) Baseline data collection for air, water and soil for one season leaving the monsoon season in an area of 10 km radius with centre of Oil Field as its centre covering the area of all proposed drilling wells.
12) Climatology and Meteorology including wind speed, wind direction, temperature rainfall relative humidity etc.
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.
14) Soil sample analysis (physical and chemical properties) at the areas located at

5 locations.

15) Ground and surface water quality in the vicinity of the proposed wells site.
16) Measurement of Noise levels within 1 km radius of the proposed wells.
17) Vegetation and land use; flora/fauna in the block area with details of endangered species, if any.
18) Incremental GLC as a result of DG set operation, flaring etc.
19) Potential environmental impact envisaged during various stages of project activities such as site activation, development, operation/ maintenance and decommissioning.
20) Actual source of water and 'Permission' for the drawl of water from the Competent Authority. Detailed water balance, wastewater generation and discharge.
21) Noise abatement measures and measures to minimize disturbance due to light and visual intrusions.
22) Details on wastewater generation, treatment and utilization /discharge for produced water/ formation water, cooling waters, other wastewaters, etc. during all project phases.
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.
24) Disposal of spent oil and lube.
25) Storage of chemicals and diesel at site. Hazardous material usage, storage and accounting.
26) Commitment for the use of water based mud (WBM) only.
27) Oil spill emergency plans for recovery/ reclamation.
28) H_2S emissions control.
29) Produced oil/gas handling, processing and storage/transportation.
30) Details of control of air, water and noise pollution during production phase.
31) Measures to protect ground water and shallow aquifers from contamination.
32) Whether any burn pits being utilised 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.

34) Environmental management plan.
35) Total capital and recurring cost for environmental control measures.
36) Emergency preparedness plan.
37) Decommissioning and restoration plans.
38) Documentary proof of membership of common disposal facilities, if any.
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 environment.
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 26th April, 2011 available on the Ministry's website.
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.

Indicative list of reports/ documents to be enclosed.

- Project feasibility report.
- Map of Project area with clear demarcation of protected areas, national Parks, wildlife sanctuaries, tiger reserves, eco-sensitive zone etc.,
- Note on hydraulic fracturing operations and technologies proposed to be adopted in the Shale oil and Gas exploration /development .
- EIA* report based on TORs issued by MoEFCC.
- Water availability studies, water requirement, wastewater generation & disposal along with the approvals /permissions from State Irrigation Department / State Ground Water Authority , as the case may be.
- Environmental Management Plan (EMP), specially with reference to water related issues .
- Risk Assessment studies.

* **Generic structure of EIA Report**

- Introduction
- Project Description
- Baseline Data with description of study area
- Anticipated Environmental Impacts and Mitigation Measures.
- Analysis of Alternatives(Technology and site)
- Mitigation Plan and environmental monitoring program.
- Additional studies such as risk assessment, social impact assessment
- Response to public consultation proceedings
- Project Benefits
- Environmental Management Plan(EMP)
- Summary and Conclusion
- Disclosure of Consultant engaged.